HUMAN COMPUTER INTERACTION

(CS408)
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Lecture 1. Introduction to Human Computer Interaction – Part I

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Answer what is the significance of Human Computer Interaction (HCI)
- Discuss and argue about why Human computer Interaction (HCI) is important with reference to the way in which technology has developed during past forty years
- Describe a formal definition of HCI.

At the end of this lecture you will be told about the course contents. This will be a brief overview of the topics that we will discuss in this course and the structure of the course.

Run for your lives---invasion has begun---the computers are invading.

Now it is twenty first century and during the past thirty years technology has advanced to such an extent that almost everyone come in contact with computers in one way or another. Look around yourself how many things are there which have some kind of computer embedded in them? Think about a minute about what you use in a typical day; ATM, cell phone, VCR, remote control, ticketing machine, digital personal organizers, calculator, watch, photocopier, toaster, bank, air conditioner, broadcasting, satellite, microwave, medical equipment, factories, companies….the list is endless. Computers are everywhere. We are surrounded by computers. Now they are part of our everyday life.

Traditional notion of computers is no more. Unlike in the early days of computing, when only highly skilled technical people used computers, nowadays the range of knowledge and experience of different users is very broad. Computers are no more just on your table. Now computer has become a tool of everyday use. They are everywhere, at everyplace and in everything. They are penetrating in every aspect of our life. They are taking our lives.

When computers first appeared on the commercial scene in the 1950s, they were extremely difficult to use, cumbersome and at times unpredictable. There were a number of reasons for this;
They were very large and expensive machines, so that by comparison human labor (that is, ‘people time’) was an inexpensive resource. They were used only by technical specialists – scientists and engineers – who were familiar with the intricacies of off-line programming using punch cards. Little was known about how to make them easier to use.

None of these conditions holds today: computers have become much less expensive, users come from every walk of life, and we understand a great deal more about how to fit the machines to people’s needs and their work.

Dramatic decrease in the cost of computing resources have resulted from new technological advances, the most significant being the development of the silicon chip. The ability not only to miniaturize circuits but also to pack large number of them on to tiny, individual chips paved the way for his development of powerful computers with large storage capacity. In less than thirty years computers changed from being huge machines housed in large, air-conditioned rooms to much smaller machines, including some that can easily be carried around by children. Computers have also become more reliable and today’s machines do not suffer from overheating like their ancestors. Computing has entered a new era and is becoming ubiquitous.

The development of the first personal computers in the 1970s was a major landmark because these machines provided interactive computing power for individual users at low cost. Consequently, instead of just a handful of highly experienced programmers being the only users, people from all walks of life – commerce, farming, education, retailing, defense, manufacturing and entertainment – began using computer systems. Computers are becoming increasingly powerful.

Computers are performing more and more tasks. These changes in technology have opened up a wide range of new possibilities for the way in which computers can be used. The sheer costliness and time required to run programs on the early machines dictated the kinds of commercial application in which computers could be used. Business such as banking and accounting, with large-scale record keeping activities, were the first to take up computing technology. Companies that were involved in activities with ‘fast’ cycles, such as transaction processing for airlines and retailing, could not make use of these machines. They were not sufficiently fast or responsive, but this is not a problem with modern computers.

Computers have also found a place in many private homes. In fact, such has been their pervasiveness that now just about everyone, young or old, able or disabled, skilled or unskilled, is using or is directly affected by computers in one way or another. Machines are leaking into every aspect of lives. So now the concept of life, without computer is same as concept of life without electricity, and obviously it is hard to live without light as well as with computer!

Run for your lives---invasion has begun---the computers are invading.
As computers are penetrating in our daily life, it has some results. The bright side of this invasion is:

Computers are enabling new discoveries
Leading to efficiencies  
Making our life easy and convenient  

On the not so bright side the result is:  

Computers are annoying us  
They are infuriating us  
They even kill a few of us.  

In turn, we will be tempted to kill our computers, but we won’t dare because we are already utterly, irreversibly dependent on these hopeful monsters that make modern life possible. So we will have to think about them. We will have to think how we can make them better. We need to fundamentally rethink how human and machines interact. And rethink the relationship in deep and novel ways, for the fault for our burgeoning problems lies not with our machines, but with us.

1.1 Riddles for the Information Age

What do you get when you cross a computer with an Airplane?

In December 1995, American Airlines Flight 965 departed from Miami on a regularly scheduled trip to Cali, Columbia. On the landing approach, the pilot of the 757 needed to select the next radio navigation fix, named “ROZO”. He entered an “R” into his navigation computer. The computer returned a list of nearby navigation fixes starting with “R” and the pilot selected the first of these, whose latitude and longitude appeared to be correct. Unfortunately, instead of “ROZO”, the pilot selected “ROMEO”, 132 miles to the northeast. The jet was southbound descending into a valley that runs north-south, and any lateral deviation was dangerous. Following indications on the flight computer, the pilots began an easterly turn and slammed into a granite peak at 10,000 feet. One hundred and fifty two passengers and all eight crewmembers aboard perished. Four passengers survived with serious injuries.

What do you get when you cross a computer with a Camera?
Here is a riddle for the information age: what do you get when you cross a computer with a camera? Answer: A computer! Thirty years ago, a 35mm Pentax Model H, had a small battery in it that powered the light meter. Like a wristwatch battery, I merely swapped in a new one every couple of years. Fifteen years ago, an electronic camera, a 35mm Canon T70, used two AA batteries to power its rather simple exposure computer and its automatic film drive. It had a simple On/Off switch, so that the batteries wouldn’t wear down needlessly.

Five years ago, a first-generation digital camera, had a similar On/Off switch, but this time it had the smarts of a rudimentary computer inside it. So if I forgot to turn it off, it automatically shut down after one minute of inactivity.

One year ago, second-generation digital camera, a Panasonic PalmCam, had an even smarter computer chip inside it. It was so smart that its On/Off switch had evolved into an Off/Rec/Play switch. It now had modes: it had to put into Rec mode to take pictures and Play mode to view them on its small video display.

The newest camera, a Nikon CoolPix 900, is a third-generation digital camera and the smartest yet. In fact, it has a full-blown computer that displays a Windows-like hourglass while it “boots up”. Like some mutant fish with extra heads, its On/Off switch has now grown to have four settings: Off/ARec/MRec/Play. “ARec” means “automatic record” and “MRec” means “manual record.” as far as I can figure out how to turn it on without a lengthy explanation.

The new camera is very power-hungry, and its engineers thoughtfully provided it with a sophisticated computer program that manages the consumption of battery power. A typical scenario goes like this: I turn the evil off/etc. switch to “MRec,” wait about seven long seconds for the camera to boot up, then point it at my subject. I aim the camera and zoom in to properly frame the image. Just as I’m about to press the shutter button, the camera suddenly realizes that simultaneously running the zoom, charging the flash, and energizing the display has caused it to run out of power. In self-defense, it suspends its ability to actually take pictures. But I don’t know that because I’m liking through the viewfinder, waving my arms and saying “Smile” and pressing the shutter button. The computer detects the button press, but it simply cannot obey. In a misguided effort to help out, the power management program instantly takes over and makes an executive decision: shed load. It shuts down the power-greedy LCD video display. I look at the camera quizzically, wondering why it didn’t take the picture, shrug my shoulders, and let my arm holding the camera drop to my side. But as soon as the LCD is turned off, there is more battery power available for other systems. The power management program senses this increase and realizes that it now has enough electricity to take pictures. It now returns control to the camera program, which is
waiting patiently to process the command it received when I pressed the shutter button, and it takes a nicely auto-focused, well-exposed, high-resolution digital picture of my kneecap.

That old mechanical Pentax had manual focusing, manual exposure, and manual shutter-speed, yet it was far less frustrating to use than the fully computerized modern Nikon CoolPix 900, which has automatic focusing, exposure, and shutter-speed. Camera may still take pictures, but it behaves like a computer instead of a camera.

**What do you get when you cross a computer with an alarm clock?**

A computer! I just purchased an expensive new clock-radio for my bedroom, a JVC FS-2000. It has a very sophisticated computer brain, and offers high fidelity, digital sound, and lots of features. It wakes me up at a preset time by playing a compact disc, and it has the delicacy and intelligence to slowly fade up the volume when it begins to play at six o’clock in the morning. This feature is really pleasant and quite unique, and it compensates for the fact that I want to hurl the infuriating machine out the window.

It’s very hard to tell when the alarm is armed, so it occasionally fails to wake me up on a Monday and rousts me out of bed early on a Saturday. Sure, it has an indicator to show the alarm is set, but that doesn’t mean it’s useful. The clock has a sophisticated alphanumeric liquid crystal display (LCD) that displays all of its many functions. The presence of a small symbol in the upper left corner of the LCD indicates the alarm is armed, but in a dimly lit bedroom the clock symbol visible, but the backlight comes on when the CD or radio is explicitly turned on. There’s a gotcha, however, as the alarm simply won’t ever sound while the CD is explicitly left on, regardless of the setting of the alarm. It is this paradoxical operation that frequently catches me unaware.

It is simple to disarm the alarm: Simply press the “Alarm” button once, and the clock symbol disappears from the display. However to arm it, I must press the “Alarm” button exactly five times. The first time I press it, the display shows me the time of the alarm. On press tow, it shows the time when it will turn the sound off. On press three, it shows me whether it will play the radio or the CD. On press four, it shows me the preset volume. On press five, it returns to the normal view, but with the alarm now armed. But with just one additional press, it disarms the alarm. Sleepy, in a dark bedroom, it is quite difficult to perform this little digital ballet correctly. The alarm clock may still wake me up, but it behaves like a computer.
By contrast, my old non-computerized alarm clock woke me up with a sudden, unholy buzzing. When it was armed, a single red light glowed. When it was not armed, the red light was dark. I didn’t like this old alarm clock for many reasons, but at least I could tell when it was going to wake me up.

Because it is far cheaper for manufacturers to use computers to control the internal functioning of devices than it is to use older, mechanical methods, it is economically inevitable that computers will insinuate themselves into every product and service in our lives. This means that the behavior of all of our products will be the same as most obnoxious computers, unless we try something different.

**What do you get when you cross a computer with a car?**

A computer! Porsche’s beautiful new high-tech sports car, the Boxster, has seven computers in it to help manage its complex systems. One of them is dedicated to managing the engine. It has special procedures built into it to deal with abnormal situations. Unfortunately, these sometimes backfire. In some early models, if the fuel level in the gas tank got very low—only a gallon or so remaining—the centrifugal force of a sharp turn could cause the fuel to collect in the side of the tank, allowing air to enter the fuel lines. The computer sensed this as a dramatic change in the incoming fuel mixture, and interpreted it as a catastrophic failure of the injection system. To prevent damage, the computer would shut down the ignition and stop the car. Also to prevent damage, the computer would not let the driver restart the engine until the car had been towed to a service center.

When owners of early Boxsters first discovered this problem, the only solution Porsche could devise was to tell them to open the engine compartment and disconnect the battery for at least five minutes, giving the computer time to forget all knowledge of the hiccup. The sports car may still speed down those too-lane blacktop roads, but now, in those turns, it behaves like a computer.

**What do you get when you cross a computer with a warship?**
In September of 1997, while conducting fleet maneuvers in the Atlantic, the USS Yorktown, one of the Navy’s new Aegis guided-missile cruisers, stopped dead in the water. A Navy technician, while calibrating an on-board fuel valve, entered a zero into one of the shipboard management computers, a Pentium Pro running Windows NT. The program attempted to divide another number by that zero—a mathematically undefined operation—which resulted in a complete crash of the entire shipboard control system. Without the computers, the engine halted and the ship sat wallowing in the swells for two hours and fifty-five minutes until it could be towed into port. Good thing it wasn’t in a war zone.

What do you get when you cross a computer with a warship? Admiral Nimitz is rolling in his grave! Despite this setback, the Navy is committed to computerizing all of its ships because of the manpower cost savings, and so deflect criticism of this plan, it has blamed the “incident” on human error. Because the software creation process is out of control, the high-tech industry must either bring its process to heel or it will continue to put the blame on ordinary users while ever-bigger machines sit dead in the water.

So here you saw the result of integrating computers in our lives. As I said early, computers will annoy us, infuriate us, and even kill a few of us. In turn, we will be tempted to kill our computers, but we won’t dare because we are already utterly, irreversibly dependent on these hopeful monsters that make modern life possible. So we will have to think about them. We will have to think how we can make them better. We need to fundamentally rethink how human and machines interact. And rethink the relationship in deep and novel ways, for the fault for our burgeoning problems lies not with our machines, but with us.

1.2 Role of HCI
Here comes the role of HCI. Human designed the interfaces we hate; human continue to use dysfunctional machines even as the awkward interfaces strain their eyes, ache their backs, and ruin their wrist tendons. HCI plays a role to bridge up the gape between the interfaces of machines and human understanding that we have seen in the previous examples.

Definition of HCI
“Human-Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”
-ACM/IEEE
Lecture 2. Introduction to Human-Computer Interaction – Part II

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Describe the significance of HCI, particularly adverse impact of computer technology on humans and reasons for these adverse effects
- Describe the nature of humans and computers
- Understand the Paradox of the computing phenomena
- Differentiate between focus of SE and HCI

2.1 Definition of HCI
“Human-Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”
- ACM/IEEE

2.2 Reasons of non-bright Aspects

Airplane + Computer
In last lecture we were discussing the incident of airplane. Today we will look at the reason of such a fatal incident.

The National Transportation Safety Board investigated, and ---as usual---declared the problem human error. The navigational aid the pilots were following was valid but not
for the landing procedure at Cali. In the literal definition of the phrase, this was indeed human error, because the pilot selected the wrong fix. However, in the larger picture, it was not the pilot’s fault at all.

The front panel of the airplane’s navigation computer showed the currently selected navigation fix and a course deviation indicator. When the plane is on course, the needle is centered, but the needle gives no indication whatsoever about the correctness of the selected radio beacon. The gauge looks pretty much the same just before landing as it does just before crashing. The computer told the pilot he was tracking precisely to the beacon he had selected. Unfortunately, it neglected to tell him the beacon the selected was a fatal choice.

The flight computer on Flight 965 could easily have told the pilots that ROMEO was not an appropriate fix for their approach to Cali. Even a simple hint that it was “unusual” or “unfamiliar” could have saved the airplane. Instead, it seemed as though the computer was utterly unconcerned with the actual flight and its passengers. It cared only about its own internal computations.

**Joke in Computer Industry**

There is a widely told joke in the computer industry that goes like this: A man is flying in a small airplane and is lost in the clouds. He descends until he spots an office building and yells to a man in an open window, “Where am I?” The man replies, “You are in an airplane about 100 feet above the ground.” The pilot immediately turns to the proper course, spots the airport and lands. His astonished passenger asks how the pilot figured out which way to go. The pilot replies, “The answer the man gave me was completely correct and factual, yet it was no help whatsoever, so I knew immediately he was a software engineer who worked for Microsoft and I know where Microsoft’s building is in relation to the airport.”

When seen in the light of the tragedy of Flight 965, the humor of the joke is macabre, yet professionals in the digital world tell it gleefully and frequently because it highlights a fundamental truth about computers:

*They may tell us facts but they don’t inform us.*

They may guide us with precision but they don’t guide us where we want to go. The flight computer on Flight 965 could easily have told the pilots that ROMEO was not an appropriate fix for their approach to Cali. Even a simple hint that it was “unusual” or “unfamiliar” could have saved the airplane. Instead, it seemed as though the computer was utterly unconcerned with the actual flight and its passengers. It cared only about its own internal computations.

Communication can be precise and exacting while still being tragically wrong. This happens all too frequently when we communicate with computers, and computers are invading every aspect of our modern lives. From the planes we fly to just about every consumer product and service, computers are ubiquitous, and so is their characteristically poor way of communicating and behaving.[1]
I-Drive Car Device

It takes automotive computer power to a whole new level. Computer systems provide the car with BMW's most powerful engine, a silky smooth ride and what is supposed to be the simplest in-dash control system available. But what is created for the sake of simplicity can often time creates the most confusion.

Many controls are operated with a single large, multifunction knob located in the console between the front seats. The control consists of a combination rotary and push button for selecting functions. Confirmation of the selected mode is displayed on a dash-mounted screen.

Users can change functions -- from communications to climate control, navigation or entertainment -- by pushing the console knob forward or back, or side-to-side. By twisting the knob, they can scroll through menus. And by clicking a button located in the middle of the knob, they can select functions.

"iDrive" takes into account the fact that comfort, communication and driver assistance functions are only rarely adjusted while driving. The operating unit in the center console gives the driver direct access to many other driving functions and information and communication options. Several hundred functions can be controlled with this device.

A computer-type monitor is positioned directly within the driver's line of vision to the road ahead. The large monitor in the center of the dashboard displays all the information the driver needs, apart from the speedometer and tachometer, which are conventional analog instruments.

![Image of BMW dashboard with iDrive system]

The driver slides the dial to choose between multiple control menus displayed on an in-dash LCD screen. The driver rotates the dial to move through lists and pushes the dial axially to select a list item.

After reading that I didn't feel like I had any sort of idea what 'axially' meant, but I suppose this video helps. What concerns me about this is the interaction with this little device requires the driver, hurtling down the road, to look at a screen. They say there is force feedback that indicates the menu, but that's only half the equation, because there are things in the menus. So, I'm guessing the driver needs to memorize the menus, which are sure to be short, so think about the mental modeling here.

To really keep your eyes on the road, you have to be able to do everything by feel and pattern. Is this easier than hot-cold air sliders, vent selection buttons and radio dials?
It takes 15 minutes to change a Radio Channel. The fundamental flaw: you absolutely have to take your eyes off the road to change settings. Result is constant Calls to Help Desk

**Feature Shock**
Every digital device has more features than its manual counterpart, but manual devices easier to use. Hi-tech companies add more features to improve product. Product becomes complicated

Bad process can’t improve product

**Computer + Bank**
A computer! Whenever I withdraw cash from an automatic teller machine (ATM), I encounter the same sullen and difficult behavior so universal with computers. If I make the slightest mistake, it rejects the entire transaction and kicks me out of the process. I have to pull my card out, reinsert it, reenter my PIN code, and then re-assert my request. Typically, it wasn’t my mistake, either, but the ATM computer finesse me into a misstep. It always asks me whether I want to withdraw money from my checking, saving, or money market account, even though I have only checking account. Subsequently, I always forget which type it is, and the question confuses me. About once a month I inadvertently select “savings”, and the infernal machine summarily boots me out of the entire transaction to start over the beginning. To reject “savings”, the machine has to know that I don’t have a saving account, yet it still offers it to me as a choice. The only difference between me selecting “saving” and the pilot of Flight 965 selecting “ROMEO” is the magnitude of the penalty.

The ATM has rules that must be followed, and I am quite willing to follow them, but it is unreasonably computer-like to fail to inform me of them, giving me contradictory indications, and then summarily punish me for innocently transgressing them. This behavior---so typical of computers---is not intrinsic to them. Actually nothing is intrinsic to computers: they merely act on behalf of their software, the program. And programs are as malleable as human speech. A person can speak rudely of politely, helpfully or sullenly. It is as simple for a computer to behave with respect and courtesy as it is for a human to speak that way. All it takes is for someone to describe how. Unfortunately, programmers aren’t very good at teaching that to computers.

In order to solve some of these problems, here comes the relatively new and emerging field of Human Computer Interaction (HCI).[1]

### 2.3 Human verses Computer

**Human species**
Human beings are the most interesting and fascinating specie on planet. They are the most complex living being on the earth. It has very much diversity in its nature. It is intelligent in its deeds. Human beings think and decide according to their own will. Yes, they are free in nature. They like freedom. They think on a problem dynamically and they can find many solutions that may not exist before. They can invent. They are not only rational but they also have emotions. They also think emotionally. They act
emotionally. And fortunately or unfortunately they make mistakes. They make mistakes which some time become fatal for them and some time they become blessing for them.

**Computer species**

On contrast, computers are the invention of human being. They are also complex but they are also pretty dumb. It can also think but it can’t think on its own will, it thinks how it has been directed to think. No doubt its speed is marvelous. It does not tire. It is emotionless. It has no feelings, no desires. It works how it has been commanded to work. And they do not make mistakes.

Before penetration of computers in our daily life, human beings were performing their tasks at their on responsibility. In a business domain human beings were dealing and interacting with each other’s. For example a store manager was dealing with all the workers performing their different duties in the store. Some one was registering the new arrivals of products, some one was numbering the products and many more…and store manager has to interact with all these human beings. If some one was a salesperson, he used to interact with different clients and used to deal with them according to their mood and desire. He could judge their mood with their tone, their attitude and with their body language. He could provide answers relevant to their questions.

But now in this age of information technology we are expecting computers to mimic human behavior e.g. ECommerce systems, now there is no need for a salesperson. Web sites are behaving as a salesperson or as a shopping mal. That is now; a dumb, unintelligent and inanimate object will perform the complex task which was performed by some human being.

### 2.4 Software Apartheid

**Apartheid**

Racial segregation; specifically: a policy of segregation and political and economic discrimination against non-European groups in the Republic of South Africa. [Definition of apartheid]

**Software Apartheid**

Institutionalizing obnoxious behavior and obscure interactions of software-based products. [Definition of software apartheid]

Programmers generally work in high-tech environments, surrounded by their technical peers in enclaves like Silicon Valley. Software engineers constantly encounter their peers when they shop, dine out, take their kids to school and relax, while their contact with frustrated computer users is limited. What’s more, the occasional unfocused gripes of the users are offset by the frequent enthusiasm of the knowledgeable elite. We forget how far removed our peers and we are from the frustration and inability of the rest of the country (not to mention the world) to use interactive tools.
We industry insiders toss around the term “computer literacy”, assuming that in order to use computers; people must acquire some fundamental level of training. We see this as a simple demand that is not hard and is only right and proper. We imagine that it is not much to ask of users that they grasp the rudiments of how the machines work in order to enjoy their benefits. But it is too much to ask. Having a computer literate customer base makes the development process much easier—of their can be no doubt—but it hampers the growth and success of the industry and of society. Apologists counter with the argument that you must have training and a license to drive a car, but they overlook the fact that a mistake with software generally does not. If cars were not so deadly, people would train themselves to derive the same way they learn excel.

It has another, more insidious effect. It creates a demarcation line between the haves and have-nots in society. If you must master a computer in order to succeed in America’s job Market beyond a burger-flipper’s carriers, then the difficulty of mastering interactive systems forces many people into menial jobs rather than allowing them to matriculate into more productive, respected and better-paying jobs.

Users should not have to acquire computer literacy to use computer for common, rudimentary task in everyday life. Users should not have to possess a digital sensitivity to work their VCR, microwave oven, or to get e-mail. What’s more, should not have to acquire computer literacy to use computer for enterprise applications, where the user is already trained in the application domain. An accountant for example, who is trained in the general principles of accounting, should not have to become computer literate to use a computer in her accounting practice. Her domain knowledge should be enough to see her through.

As our economy shifts more and more onto information bases, we are inadvertently creating a divided society. The upper class is composed of those who have mastered the nuances of differentiating between “RAM” and “Hard Disk”. The lower class is that who treat the difference inconsequential. The irony is that the difference really is inconsequential to any one except a few hard-core engineers. Yet virtually all-contemporary software forces its users to confront a file system, where your success fully dependent on knowing the difference between RAM and disk.

Thus the term “computer literacy” becomes a euphemism for social and economic apartheid. Computer literacy is a key phrase that brutally bifurcates our society.

But about those people who are not inclined to pander to technocrats and who can not or will not become computer literate? These people, many by choice, but most by circumstances, are falling behind in the information revolution. Many high-tech companies, for example, would not even consider for employment any applicant who does not have an e-mail address. I’m sure that there are many otherwise qualified candidates out there who cannot get the hired because they are not yet wired. Despite the claims of the Apologists, using e-mail effectively is difficult and involves a significant level of computer literacy. Therefore, it artificially segregates the work force. It is the model equivalent of the banking technique of “red lining”. In this illegal procedure, all houses in a given neighborhood are declared unacceptable as controller for a housing loan. Although the red lines on the map are ostensibly drawn
around economic contours, they tend to follow racial lines all too closely bankers protest that they are not racists, but the effect is the same.

When programmers speak of “computer literacy”, they are drawing red lines around ethnic groups, too, yet few have pointed this out. It is too hard to see what is really happening because the issue is obscured by technical mythology. It is easy to see—regardless of how true—that a banker can make a loan on one house as easily as on another. However, it is not easy to see that a programmer can make interactive products easy enough for people from lower socio-economic backgrounds to use.

“Acceptable levels of quality for software engineers are far lower than are those for traditional engineering disciplines”

“Software-based products not INHERENTLY hard to use Wrong process is used to develop them” [1]

Software Engineering and HCI

There is a basic fundamental difference between the approaches taken by software engineers and human-computer interaction specialists. Human-computer interface specialists are user-centered and software engineers are system-centered.

Software engineering methodologies are good at modeling certain aspects of the problem domain. Formal methods have been developed to represent data, architectural, and procedural aspects of a software system. Software engineering approaches deal with managerial and financial issues well. Software engineering methodologies are useful for specifying and building the functional aspects of a software system.

Human-computer interfaces emphasize developing a deep understanding of user characteristics and a clear awareness of the tasks a user must perform. HCI specialists test design ideas on real users and use formal evaluation techniques to replace intuition in guiding design. This constant reality check improves the final product.

References

- [1] The Inmates are running the asylum by Alan Cooper.
Lecture 3. Introduction to Human-Computer Interaction – Part III

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Discuss the effect of bad tools
- Discuss and argue about why Human computer Interaction (HCI) is important with reference to the way in which technology has developed during past forty years
- Describe requirement of new economy era.

Effect of Bad Tools
Not only are computers taking over the cockpit of jet airliners, they are taking over the passenger cabin, too, behaving in that same obstinate, perverse way that is so easy to recognize and so hard to use. Modern jet planes have in-flight entertainment (IFE) systems that deliver movies and music to airline passengers. These IFEs are merely computers connected with local area network, just like in your office. Advanced IFE systems are generally installed only on larger airplanes flying transoceanic routes.

One airline’s IFE was so frustrating for the flight attendants to use that many of them were bidding to fly shorter, local routes to avoid having to learn and use the difficult systems. This is remarkable considering that the time-honored airline route-bidding process is based on seniority, and that those same long-distance routes have always been considered the most desirable plums because of their lengthy layovers in exotic locales like Singapore or Paris. For flight attendants to bid for unglamorous, unromantic yo-yo flights from Denver-to-Dallas or LA-to-San Francisco just to avoid the IFE indicated a serious morale problem. Any airline that inflicted bad tools on its most prized employee—the ones who spent the most time with the customer—was making a foolish decision and was profligately discarding money, customer loyalty, and staff loyalty.

The computer-IFE of another large airline was even worse. The airline had created an in-flight entertainment system that linked movie delivery with the cash collection function. In a sealed et airplane flying at 37,000 feet, cash collection procedures had typically been quite laissez-faire; after all, nobody was going to sneak out the back door. Flight attendants delivered goods and services when it was convenient and collected cash in only a very loosely coupled fashion. This kept them from running unnecessarily up and down the narrow aisles. Sure there were occasional errors, but
never more than a few dollars were involved, and the system was quite human and forgiving; everyone was happy and the work was not oppressive.

With cash-collection connected to content delivery by computer, the flight attendant had to first get the cash from the passenger, then walk all the way to the head-end of the cabin, where the attendant’s console was, enter an attendant password, then perform a cash register-like transaction. Only when that transaction was completed could the passenger actually view a movie or listen to music. This inane product design forced the flight attendants to walk up and down those narrow aisles hundreds of extra times during a typical trip. Out of sheer frustration, the flight attendants would trip the circuit breaker on the in-flight entertainment system at the beginning of each long flight, shortly after departure. They would then blandly announce to the passengers that, sorry, the system was broken and there would be no movie on this flight.

The airline had spent millions of dollars constructing a system so obnoxious that its users deliberately turned it off to avoid interacting with it. The thousands of bored passengers were merely innocent victims. And this happened on long, overseas trips typically packed with much-sought-after frequent flyers. I cannot put a dollar figure on the expense this caused the airline, but I can say with conviction that it was catastrophically expensive.

The software inside the IFEs worked with flawless precision, but was a resounding failure because it misbehaved with its human keepers.

3.1 An Industry in Denial

We are a world awash in high-tech tools. Computers dominate the workplace and our homes, and vehicles are filling up with silicon-powered gadgets. All of these computerized devices are wildly sophisticated and powerful, but every one of them is dauntingly difficult and confusing to use.

The high-tech industry is in denial of a simple fact that every person with a cell phone or a word processor can clearly see: our computerized tools are hard to use. The technologists who create software and high-tech gadgets are satisfied with their efforts. The software engineers who create them have tried as hard as they can to make them easy to use and they have made some minor progress. They believe that their products are as easy to use as it is technically possible to make them. As engineers, their belief is in technology, and they have faith that only some new technology, like voice recognition or artificial intelligence, will improve the user’s experience.

Ironically, the thing that will likely make the least improvement in the ease of use of software-based products is new technology. There is little difference technically between a complicated, confusing program and a simple, fun, and powerful product. The problem is one of culture, training, and attitude of the people who make them,
more than it is one of chips and programming languages. We are deficient in our development process, not in our development tools.

The high-tech industry has inadvertently put programmers and engineers in charge, so their hard-to-use engineering culture dominates. Despite appearances, business executives are simply not the ones in control of the high-tech industry. It is the engineers who are running the show. In our rush to accept the many benefits of the silicon chip, we have abdicated our responsibilities. We have let the inmates run the asylum.

When the inmates run the asylum, it is hard for them to see clearly the nature of the problems that bedevil them. When you look in the mirror, it is all too easy to single out your best features and overlook the warts. When the creators of software-based products examine their handiwork, they see how rich the product is in features and functions. They ignore how excruciatingly difficult it is to use, how many mind-numbing hours it takes to learn, or how it diminishes and degrades the people who must use it in their everyday lives.

3.2 Techno-Rage

An article in a recent issue of the Wall Street Journal described an anonymous video clip circulated widely by email that showed as “…Mustachioed Everyman in a short sleeved shirt hunched over a computer terminal, looking puzzled. Suddenly, he strikes the side of his monitor in frustration. As a curious co-worker peers over his cubicle, the man slams the keyboard into the monitor, knocking it to the floor. Rising from his chair, he goes after the fallen monitor with a final ferocious kick.” The article went on to say that reaction to the clip had been “intense” and that it had apparently tapped into a powerful undercurrent of techno-rage”.

It’s ironic that one needs to be moderately computer savvy to even send or view this video clip. While the man in the video may well be an actor, he touches a widespread, sympathetic chord in our business world. The frustration that difficult and unpleasant software-based products are bringing to our lives is rising rapidly.

Joke email circulates on private lists about “Computer Tourette’s.” This is a play on the disorder known as Tourette’s syndrome, where some sufferers engage in uncontrollable bouts of swearing. The joke is that you can walk down the halls of most modern office buildings and hear otherwise-normal people sitting in front of their monitors, jaws clenched, swearing repeatedly in a rictus of tense fury. Who knows what triggered such an outburst: a misplaced file, an inaccessible image, or a frustrating interaction. Or maybe the program just blandly erased the user’s only copy of a 500-page manuscript because he responded with a “Yes” to a confirmation dialog box, assuming that it had asked him if he wanted to “save your changes?” when it actually asked him if he wanted to “discard your work?”

**Novatech survey**

One in every four computers has been physically attacked by its owner, according to a survey.
The survey, conducted by British PC manufacturer Novatech, was intended to take a lighthearted look at embarrassing experiences -- those little technical bloopers that happen even to ubergeeks, like forwarding a personal love letter to an entire office mailing list.

But instead, a much darker story emerged in the 4,200 replies. Innocent computers are being beaten on a regular basis, often by technically challenged users who decide to take their frustrations out on their helpless machines.

"We decided to do some research into people's relationships with their computers and we were amazed by some of the results," Novatech managing director David Furby said. "As computers become more and more a part of our daily lives, we obviously share more experiences with them."

Many technical support people from the United States, Canada and parts of Europe have sobering stories of brutalized computers being brought in for repair by sad -- or in some cases, smug -- owners who had smacked, kicked or otherwise deliberately injured their machines.

"The incidences of willful neglect have always been high," said David Tepper, owner of the Village Computer Shop in New York. "We've always had to deal with computers damaged by people who dumped their refreshing beverage on the computer's keyboard, or got tangled up in the cords and bringing (sic) the computer crashing down off their desk."

"But there have also always been a small -- but significant -- number of machines that were obviously intentionally damaged."

"Hopefully as technology improves and computers become ever more user-friendly, these attacks will become less frequent," Furby said.

**Computer rage**

There is a technology-based scourge afoot...maybe. It’s not a virus; it’s not a denial of service attack; it’s computer rage, and according to the latest reports, it is out to destroy the physical health, the emotional stability, and if left unchallenged, the economic strength of whatever population it strikes.

Security software vendor Symantec, working with Britain’s National Opinion Poll, recently found that when confronted with technical problems, more than 40 percent of British users surveyed have sworn at, kicked, or otherwise abused their computers, monitors, and the most victimized of all computer components, their keyboards.

In similar surveys conducted last year, Marlborough, Mass-based Concord Communications discovered that 83 percent of 150 U.S. respondents witnessed such attacks, and the international market research firm Mori found that 40 percent of 1250 British workers had watched as their colleagues leveled verbal and physical abuse at their computers.
Stress related to computer rage, the Symantec study claims, has resulted in a loss of productivity for most respondents.

Robert Edelmann, clinical psychologist and author of Interpersonal Conflicts at Work, is worried. “Frustration with IT should be taken seriously as a modern malaise,” he says. “It is affecting both our work and our home lives to the extent that computer rage is now much more prolific than road rage.”

Computers increasingly commonplace in offices

As the reliance on computers in the workplace continues to grow, people in the UK are resorting to violence when their PCs break down, say researchers. When faced with technical problems, most people shouted at colleagues, hit the PC or even threw parts of the computers. The most frustrating hitch was when people lost their work after their computer crashed or froze.

The problems seem to be widespread with more than a quarter of those working with computers experience problems with their PC on a weekly basis.

"Over half of all working days lost to sickness in the UK are related to workplace stress," said Fiona Dennis, a stress management trainer with Priory Healthcare. "Being heavily reliant on IT to speed up our lives means that performance is hampered greatly when it fails, causing an over-reaction and stress."

70% swear at PCs

The study by the National Opinion Poll and the software company Symantec, found that nearly half of all computer users had become angry at some time. Almost a third of people had physically attacked a computer, 67% experienced frustration, exasperation and anger and more than 70% swore at their machines.

Technology rage is the latest rage to emerge in Britain and follows road rage, trolley rage and air rage. There was a dramatic rise in air rage incidents last year, with 174 people detained at Heathrow and Gatwick alone. In 1998 the number of air rage arrests for the whole country was 98.

3.3 Success Criteria in the New Economy

The successful professional for the twenty-first century is either a business savvy technologist or a technology-savvy businessperson.

The technology-savvy businessperson knows that his success is dependent on the quality of the information available to him and the sophistication with which he uses it. The business-savvy technologist, on the other hand, is an entrepreneurial engineer or scientist trained for technology, but possessing a knee business sense and an awareness of the power of information. Both of these new archetypes are coming to dominate contemporary business.

You can divide all businesspeople into two categories: those who will master high technology and those who will soon be going out of business. No longer can
executive delegate information processing to specialists. Business is information processing. You differentiate yourself today with the quality of your information-handling systems, not your manufacturing systems. If you manufacture anything, chances are it has a microchip in it. If you offer a service, odds are that offer it with computerized tools. Attempting to identify businesses that depend on high technology is as futile as trying to identify businesses that depend on the telephone. The high-tech revolution has invaded every business, and digital information is the beating heart of your workday.

It has been said, “to err is human; to really screw up, you need a computer.”

Inefficient mechanical systems can waste couple cents on every widget you build, but you can lose your entire company to bad information processes. The leverage that software-based products—and the engineers that build them—have on your company is enormous.

Sadly, our digital tools are extremely hard to learn, use, and understand, and they often cause us to fall short of our goals. This wastes money, time, and opportunity. As a business-savvy technologist/technology-savvy businessperson, you produce software-based products or consume them—probably both. Having better, easier-to-learn, easier-to-use high-tech products is in your personal and professional best interest. Better products don’t take longer to create, nor do they cost more to build. The irony is that they don’t have to be difficult, but are so only because our process for making them is old-fashioned and needs fixing. Only long-standing traditions rooted in misconceptions keep us from having better products in today.

Consider a scenario: a website is developed of ecommerce system. The site is aesthetically very beautiful, technically it has no flaw and it has wonderful animated content on it. But if user is unable to find its desired information about the products or even he is unable to find the product out of thousands of products, so what of it’s use. It is useless from the business point of view.

**Here are some facts and figures:**

Users can only find information 42% of the time  
– Jared Spool

62% of web shoppers give up looking for the item they want to buy online  
– Zona Research

50% of the potential sales from a site are lost because people cannot find the item they are looking for  
– Forrester Research

40% of the users who do not return to a site do so because their first visit resulted in a negative experience  
– Forrester Research
80% of software lifecycle costs occur after the product is released, in the maintenance phase - of that work, 80% is due to unmet or unforeseen user requirements; only 20% is due to bugs or reliability problems.

- IEEE Software

Around 63% of software projects exceed their cost estimates. The top four reasons for this are:
– Frequent requests for changes from users
– Overlooked tasks
– Users' lack of understanding of their own requirements
– Insufficient user-analyst communication and understanding

- Communications of the ACM

BOO.com, a $204m startup fails
– BBC News

Poor commercial web sites will kill 80% of Fortune 500 companies within a decade
- Jakob Nielsen

So all above given facts reveals that the product with the bad user experience deserve to die!

The serious financial implications of today’s digital products should not in any ways be underestimated.

The table given below depicts two scenarios of potential of sales from an e-commerce web site. In scenario A, users can easily find items they are looking for, so 0% sales are lost, so the actual revenue is $100 million. In scenario B, users cannot easily find the items they are looking for, therefore, the actual revenue is $50 million, thus causing a loss of $50 million.

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3.4 Computer + Information
What do you get when you cross a computer with information?

In 2000, the Olympic Games were held in Sydney. Before the Olympic games could begin, a lawsuit was filed against the Olympic Committee. The case was called Bruce Lindsay Maguire vs Sydney Organizing Committee for the Olympics Games (SOCOG). On 7 June 1999 the complainant, who is blind, complained to the Commission that he was unlawfully discriminated against by the respondent in three respects:

- the failure to provide Braille copies of the information required to place orders for Olympic Games tickets;
- the failure to provide Braille copies of the Olympic Games souvenir programmed; and
- The failure to provide a web site which was accessible to the complainant.

It was alleged that the SOCOG was in breach the Disability Discrimination Act 1992 by failing to make accessible to him key parts of its web site.

According to the law of many European and western countries, organizations with a web site must ensure that their web site is (within certain limits) accessible by disabled persons. However, this was not the case in the matter of the official Olympic Games web site. Could this have been avoided? Certainly: by applying a few very simple techniques, the developers of the web site could have made it accessible to people with vision-impairment. But as is usually the case, this was not done.

Result: the complainant won the case and was awarded a sum of money in damages. This was very embarrassing for both the SOCOG and also the company that developed the web site.

References

2. [http://comment.cio.com/soundoff/061400.html](http://comment.cio.com/soundoff/061400.html)
Lecture 4. Goals & Evolution of Human Computer Interaction

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Describe the goals of HCI
- Define Usability goals
- Define User Experience goals
- Discuss the History and Evolution of HCI

Definition of HCI
“Human-Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”
-ACM/IEEE

4.1 Goals of HCI
The term Human Computer Interaction (HCI) was adopted in the mid-1980s as a means of describing this new field of study. This term acknowledged that the focus of interest was broader than just the design of the interface and was concerned with all those aspects that relate to the interaction between users and computers.

The goals of HCI are to produce usable and safe systems, as well as functional systems. These goals can be summarized as ‘to develop or improve the safety, utility, effectiveness, efficiency and usability of systems that include computers’ (Interacting with computers, 1989). In this context the term ‘system’ derives from systems theory and it refers not just to the hardware and software but to the entire environment---be it organization of people at work at, home or engaged in leisure pursuits---that uses or is affected by the computer technology in question. Utility refers to the functionality of a system or, in other words, the things it can do. Improving effectiveness and efficiency are self-evident and ubiquitous objectives. The promotion of safety in relation to computer systems is of paramount importance in the design of safety-critical systems. Usability, a key concept in HCI, is concerned with making systems easy to learn and easy to use. Poorly designed computer system can be extremely annoying to users, as you can understand from above described incidents. [2]

Part of the process of understanding user’s needs, with respect to designing an interactive system to support them, is to be clear about your primary objective. Is it to design a very efficient system that will allow users to be highly productive to their
work, or is to design a system that will be challenging and motivating so that it supports effective learning, or is it some thing else? We call these talk-level concerns usability goals and user experience goals. The two differ in terms of how they are operational zed, i.e., how they can be met and through what means. Usability goals are concerned with meeting specific usability criteria (e.g., efficiency) and user experience goals are largely concerned with explicating the quality of the user experience (e.g., to be aesthetically pleasing).

**Usability goals**

To recap, usability in generally regarded as ensuring that interactive products are easy to learn, effective to use, and enjoyable from user perspective.

It involves optimizing the interactions people have with interactive product to enable them to carry out their activities at work, school, and in their everyday life. More specifically, usability is broken down into the following goals:

- Effective to use (effectiveness)
- Efficient to use (efficiency)
- Safe to use (safety)
- Have good utility (utility)
- Easy to learn (learnability)
- Easy to remember how to use (memorability)

For each goal, we describe it in more detail.

**Effectiveness**

It is a very general goal and refers to how good a system at doing what it is suppose to do. [1]

**Efficiency**

It refers to the way a system supports users in carrying out their tasks. [1]

**Safety**

It involves protecting the users from dangerous conditions and undesirable situations. In relation to the first ergonomics aspect, it refers to the external conditions where people work. For example, where there are hazardous conditions---like x-rays machines or chemical plants---operators should be able to interact with and control computer-based system remotely. The second aspect refers to helping any kind of user in any kind of situation avoid the danger of carrying out unwanted action accidentally. It also refers to the perceived fears users might have of the consequences of making errors and how this effects their behavior to make computer-based system safer in this sense involves:

- Preventing the user from making serious error by reducing the risk of wrong keys/buttons being mistakenly activated (an example is not placing the quit or delete-file command right next to the save command on a menu.) and
- Providing users with various means of recovery should they make errors. Save interactive systems should engender confidence and allow the users the opportunity to explore the interface to carry out new operations.
Other safety mechanism include undo facilities and confirmatory dialog boxes that give users another chance to consider their intentions (a well-known used in email application is the appearance of a dialog box after the user has highlighted the messages to be deleted, saying: “are you sure you want to delete all these messages?”)

**Utility**
It refers to the extent to which the system provides the right kind of functionality so that user can do what they need or want to do. An example of a system with high utility is an accounting software package providing a powerful computational tool that accountants can use to work out tax returns. An example of a system with low utility is a software drawing tool that does not allow users to draw free hand but forces them to use a mouse to create their drawings, using only polygon shapes. [1]

**Learnability**
It refers to how easy a system is to learn to use. It is well known that people do not like spending a long time learning how to use a system. They want to get started straight away and become competent at caring out tasks without to much effort. This is especially so far interactive products intended for everyday use (for example interactive TV, email) and those used only infrequently (for example, video conferencing) to certain extent, people are prepared to spend longer learning more complex system that provide a wider range of functionality (for example web authoring tools, word processors) in these situations, CD ROM and online tutorials can help by providing interactive step by step material with hands-on exercises. However many people find these tedious and often difficult to relate to the tasks they want to accomplish. A key concern is determining how much time users are prepared to spend learning a system. There seems little point in developing a range of functionality if the majority of users are unable or not prepared to spend time learning how to use it. [1]

**Memorability**
It refers to how easy a system is to remember how to use, once learned. This is especially important for interactive systems that are used infrequently. If users haven’t used a system or an operation for a few months or longer, they should be able to remember or at least rapidly be reminded how to use it. Users shouldn’t have to keep relearning how to carry out tasks. Unfortunately, this tends to happen when the operation required to be learning are obscure, illogical, or poorly sequenced. Users need to be helped to remember how to do tasks. There are many ways of designing the interaction to support this. For example, users can be helped to remember the sequence of operations at different stages of a task through meaningful icons, command names, and menu options. Also, structuring options and icons so they are placed in relevant categories of options (for example, placing all the drawing tools in the same place on the screen) can help the user remember where to look to find a particular tool at a given stage of a task. [1]

“Don’t Make me THINK, is the key to a usable product”

**User experience goals**
The realization that new technologies are offering increasing opportunity for supporting people in their everyday lives has led researchers and practitioners to
consider further goals. The emergence of technologies (for example, virtual reality, the web, mobile computing) in diversity of application areas (e.g., entertainment, education, home, public areas) has brought about a much wider set of concerns. As well as focusing primarily on improving efficiency and productivity at work, interaction design is increasingly concerning itself with creating systems that are:

- Satisfying
- Enjoyable
- Fun
- Entertaining
- Helpful
- Motivating
- Aesthetically pleasing
- Supportive of creativity
- Rewarding
- Emotionally fulfilling

The goals of designing interactive products to be fun, enjoyable, pleasurable, aesthetically pleasing and so on are concerned primarily with the user experience. By this we mean what the interaction with the system feels like to the users. This involves, explicating the nature of the user experience in subjective terms. For example, a new software package for children to create their own music may be designed with the primary objectives of being fun and entertaining. Hence, user experience goals differs from the more objective usability goals in that they are concerned with how user experience an interactive product from their perspective, rather than assessing how useful or productive a system is from its own perspective. The relationship between two is shown in figure.

Recognizing and understanding the trade-offs, between usability and user experience goals, is important. In particular, this enables designers to become aware of the consequences of pursuing different combinations of them in relation to fulfilling different users’ needs. Obviously, not all of the usability goals and user experience goals apply to every interactive product being developed. Some combination will also be incompatible. For example, it may not be possible or desirable to design a process control system that is both safe and fun. [1]
4.2 Evolution of HCI

Figure shows the main topics that make up the discipline of HCI. All HCI takes place within a social and organizational context. Different kinds of applications are required for different purposes and care is needed to divide tasks between humans and machines, making sure that those activities and routine are allocated to machines. Knowledge of human psychological and physiological abilities and, more important still their limitations is important.

As shown in figure, this involves knowing about such things as human information processing, language, communication, interaction and ergonomics. Similarly it is essential to know about the range of possibilities offered by computer hardware and software so that knowledge about humans can be mapped on to the technology appropriately. The main issues for consideration on the technology side involve input techniques, dialogue technique, dialogue genre or style, computer graphics and dialogue architecture. This knowledge has to be brought together some how into the design and development of computer systems with good HCI, as shown at the bottom of the figure. Tools and techniques are needed to realize systems. Evolution also plays an important role in this process by enabling designers to check that their ideas really are what users want.
Three systems that provide landmarks along this evolutionary path are the Dynabook, the Star and the Apple Lisa, predecessor of today’s Apple Macintosh machines. An important unifying theme present in all three computer systems is that they provided a form of interaction that proved effective and easy for novices and experts alike. They were also easy to learn, and provided a visual-spatial interface whereby, in general, objects could be directly manipulated, while the system gave immediate feedback.

**Dynabook**

Alan Kay designed the first object-oriented programming language in the 1970s. Called Smalltalk, the programs were the basis for what is now known as windows technology—the ability to open more than one program at a time on a personal computer. However, when he first developed the idea, personal computers were only a concept. In fact, the idea of personal computers and laptops also belongs to Kay. He envisioned the Dynabook—a notebook-sized computer, with a keyboard on the bottom and a high-resolution screen at the top.

**Star**

The Xerox Star was born out of PARC’s creative ferment, designing an integrated system that would bring PARC’s new hardware and software ideas into a commercially viable product for use in office environments. The Star drew on the ideas that had been developed, and went further in integrating them and in designing for a class of users who were far less technically knowledgeable than the engineers
who had been both the creators and the prime users of many PARC systems (one of PARC's favorite mottoes was "Build what you use, use what you build.") The Star designers were challenged to make the personal computer usable for a community that did not have previous computer experience.

From today's perspective, the Star screen looks rather unremarkable, and perhaps a bit clumsy in its graphic design—a boxy model-T when compared to the highly styled look of today's Taurus or Jaguar. What is notable from a historical perspective, of course, is how much the Star does look like current screens and how little it looks like the character-based and vector-drawing screens that preceded it.

The Star (Viewpoint) screen image The Star pioneered the now-familiar constellation of icons, moveable scrollable windows, and inter-mixed text and graphic images. The widely used graphic user interfaces (GUIs) of today are all variants of this original design. (Source: Reprinted by permission from Jeff Johnson et al. Xerox Star, a retrospective. IEEE Computer 22:9 (September, 1989), p. 13.)

The visible mechanisms on the Star display were backed up with a set of design principles that grew out of a user-oriented design methodology and by a great deal of empirical testing. Several principles were central to the Star design:

**Direct manipulation**
The core concept that distinguished Star (and other Alto programs) from the conventional computer interfaces of their time was the use of a bitmapped screen to present the user with direct visual representations of objects. In the Star's desktop metaphor, documents, printers, folders, collections of folders (file drawers and cabinets), in and out boxes, and other familiar office objects were depicted on the screen. To print a document, for example, the user could point (using the mouse) to the icon for the document and the icon for the printer, while using a key on the keyboard to indicate a Copy operation.

**WYSIWYG (what you see is what you get)**
In previously available programs for producing sophisticated graphical output—such as drawings or page layout with multiple fonts—the user created and edited a representation that looked like a programming language, and then compiled the resulting program into a visible form. Alto programs pioneered a new style that Star unified, in which the user works directly with the desired form, through direct manipulation. The user makes changes by operating on a direct representation of what
will appear on the printed page. The Star user could intermix text, tables, graphs, drawings, and mathematical formulas. In fact, most of the popular microcomputer applications of today have not yet reached the degree of integration that Star offered more than a decade ago.

**Consistency of commands**

Because a single development group developed all Star applications in a unified way, it was possible to adhere to a coherent and consistent design language. The Star keyboard embodied a set of generic commands, which were used in a consistent way across all applications: Move, Copy, Delete, Open, Show Properties, and Same (copy properties). Evoking one of these commands produced the same behavior whether the object is being moved or copied, for example, was a word of text, a drawing element, or a folder of documents. Through the use of property sheets the user could manipulate the aspects that were specific to each element, such as the font of a text character, or the brush width of a painted line. The Open command was the basis for applying a technique of progressive disclosure—showing the user only the relevant information for a task at hand, and then providing a way to reveal more possibilities, as they were needed.

In addition to these three key concepts, many specific design features made the Star unique, including its attention to the communicative aspects of graphic design, its integration of an end-user scripting language (CUSP), and its underlying mechanisms for internationalization—from the very beginning, Star versions were developed in several languages, including non-European languages with large character sets, non–left-to-right orthography, and so on.

Some of the aspects that led to the Star's design quality may have also hampered its commercial success—in particular Xerox's dependence on development groups within a single company to produce all the applications software.

**Lisa by Apple**

The GUI (Graphical User Interface) that started it all. If you are sitting in front of a computer with a mouse and pull down menus you owe it to this machine. Windows proponents will tell you that Xerox PARC developed GUIs and Apple stole it from them, therefore what Mr. Gates has done is okay. Xerox had the core idea, but I've seen video of the early PARC work. It was advanced but it was not nearly what the Lisa (and later the Mac) became.

The first Apple Lisa was equipped with dual 5.25 inch floppy drives in addition to a huge external hard drive (shown here). The Apple Lisa 2/10 moved the hard drive inside the case. It lost one floppy drive and the Macintosh the newer 3.5-inch floppy shared the remaining one.

My Lisa is the later variety. In fact I have no way of knowing how mine was sold but the Lisa was later marketed as the Macintosh XL: a bigger sister to the little Macintosh. Lisa lacked the ROM toolbox built into every Macintosh so it had to do Macintosh emulation through a new operating system known as MacWorks. It allowed Lisa to pretend she was a Macintosh. Why do this when you could just buy a
Mac? Lisa offered more RAM (1 meg) a hard drive (10 meg) and some businesses had already bought them.

While giving credit to the workers at Xerox it should also be mentioned that much of the groundwork was done in the 1960s and early 1970s. One influential researcher was Licklider (1960), who visualized a symbiotic relationship between humans and computers. He envisaged computers that would be able to do more than simply handle information: the partnership of computer and human brain would greatly enhance thinking processes and lead to more creative achievements. Another influential development was the pioneering work of Sutherland (1963), who developed the Sketchpad system at MIT. The Sketchpad system introduced a number of powerful new ideas, including the ability to display, manipulate and copy pictures represented on the screen and the use of new input devices such as the light pen.

Alongside developments in interactive graphic interface, interactive text processing systems were also evolving at a rapid rate. Following in the footsteps of line and display editors was the development of systems that allowed users to create and edit documents that were represented fully on the screen. The underlying philosophy of these systems is captured by the term WYSIWYG, which stands for ‘what you see is what you get’ (pronounced ‘whizzee-wig’). In other words, the documents were displayed on the screen exactly as they would look in printed form. This was in stark contrast to earlier document editors, where commands were embedded in the text and it was impossible to see what document would look like without printing it.

Interestingly, difference in research and development interests could be discerned on the two sides of the Atlantic. Pioneers of HCI in the USA were primarily concerned with how the computer could enrich our lives and make them easier. They foresaw it as a tool that could facilitate creativity and problem solving. In Europe, in 1980 researchers began to be more concerned with constructing theories of HCI and developing methods of design which would ensure that the needs of users and their tasks were taken into account. One of the major contributions from the European side was an attempt to formalize more fully the concept of usability and to show how it could be applied to the design of computer systems (Shackel, 1981).

During the technology explosion of the 1970s the notion of user interface, also known as the Man-Machine Interface (MMI), became a general concern to both system designers and researchers. Moran defined this term as ‘those aspects of the system that the user comes in contact with’ (1981, p.4), which in turn means ‘an input language for the user, an output language for the machine, and a protocol for interaction’ (Chi, 1985, p.671).
Academic researchers were concerned about how the use of computer might enrich the work and personal lives of people. In particular, they focused on the capabilities and limitations of human users, that is, understanding the ‘people side’ of the interaction with computer systems. At that time this primarily meant understanding people’s psychological processes when interacting with computers. However, as the field began to develop it soon became clear that other aspects impinge on users and management and organizational issues and health hazards are all important factors contributing to the success or failure of using the computer systems. [2]

Reference:
[1] About Face 2.0 the essentials of interaction design by Alan Cooper
Lecture 5. Discipline of Human Computer Interaction

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Describe the relationship of Usability and quality
- Understand HCI Discipline

Human-computer Interaction is the kind of discipline, which is neither the study of human, nor the study of technology, but rather the bridging between those two. So you always have to have one eye open to the question: what can the technology do? How can you build it? What are the possibilities? And one eye open to the question: what are people doing and how would this fit in? What they would do with it? If you lose sight of either of those, you fail to design well. And of course they require different ways of thinking. So I think the challenge is to keep knowledge of both the technology and the people playing off against each other in order to develop new things.

If you build something you need to consider not just ‘I’m building something because I need to build it’, but ‘what effect is it going to have on the way people work and the way people live?’

5.1 Quality
Let us firstly look at a general definition of quality.

According to the American Heritage Dictionary “characteristic or attribute of something.” As an attribute of an item, quality refers to measurable characteristics---things we are able to compare to know standards such as length, color, electrical properties, malleability, and so on.

Now as we are concerned with software quality so let us look at some other definitions:

According to British Defense Industries Quality Assurance Panel “Quality is conformance to specifications”. So, according to this definition quality is the measure of degree to which the design specifications are followed during manufacturing. The greater the degree of conformance, the higher the level of quality is.

Philip Crosby describes, “Quality is conformance to requirements.” Here software requirements are the foundation from which quality is measured. Lack of conformance to requirements is lack of quality.

Juran says, “Quality is fitness for purpose or use”

“Quality is a predictable degree of uniformity and dependability, at low cost and suited to the market”, defined by Edward Deming.
By R J Mortiboys “Quality is synonymous with customer needs and expectations.”
“Quality is meeting the (stated) requirements of the customer- now and in the future.” By Mike Robinson.
“Quality is the total composite product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product and service in use will meet the expectations by the customer” (Armand Feigenbaum)
“Totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.”

(ISO 8402 : 1994)

All above-mentioned definitions refer quality as a conformance to requirements or conformance to specification or as a synonymous with customer needs and expectations etc. In my point of view or with respect to HCI, quality is something beyond meeting the specifications, requirements or customer expectations. For example, consider a scenario, as you know, there is always a quality assurance department in any software house which checks the final products with reference to their specification or requirements. The products that do not fulfill their specifications or requirements they are considered bugged. In my scenario, what will be the matter if the specifications or requirements, which are being used to measure quality, are not complete? That’s why, I think, quality is beyond the conformance to specifications or requirements or even the customer expectations.

I think quality cannot be measured just by the requirements or specifications described by the customer rather you should approach to that end user who will use this product. The expectations or needs of the end user can be the measure of quality. So, we can say, as much as the product will be useable for end user as much higher will be its quality.

To understand the relationship of quality and usability in a software reference, look at the definition of software quality. “The extent to which a software product exhibits these characteristics”

- Functionality
- Reliability
- Usability
- Efficiency
- Maintainability
- Portability

5.2 **Interdisciplinary nature of HCI**
The main factors that should be taken into account in HCI design are shown in above figure. Primarily, these relate directly to users, such as comfort and health, or are concerned with users’ work, the work environment or the technology being used. What makes the analysis even more complex is that many factors inevitably interact with each other. For example, if changes are made to improve productivity, this may have undesirable effects on users’ motivations and levels of satisfaction because issues relating to job design and work organization are ignored.

**Case Study – Ticketing System**

A small travel agency with a number of shops distributed throughout the country decides that, in order to survive in the travel industry, it needs to install an efficient ticketing system. Current practice involves sales staff in a lengthy procedure for issuing tickets to customers. First they have to call an airline to check if there are any vacant seats for the time when the customer wishes to fly. Then they have to check with the customer which of the available seats is suitable before making a reservation with the airline. The ticket is then written out by hand. In addition, the customer needs a receipt and an itinerary, which are also written by hand. One of the biggest problems with this practice is getting a telephone connection to the airline. This means that customers often have to wait while a frustrated sales assistant keeps trying in vain. To overcome this problem it is common practice to ask the customers to come back later in the hope that the sales staff will manage to get through to the airline in the meantime. Another time-consuming job is accounting for each ticket that has been issued, and the sales staff has to do this by hand every two weeks.
Before deciding to get new system the branch manager does some background research into how the agency really functions. She starts by visiting branches in a sister company that is using a computerized ticketing system. After talking to the staff for just a short time she discovers that there are problems. The sales staff complains that the computer is always going wrong and that they don’t trust it. Furthermore, they can’t understand some of the messages that it produces when they make errors. In fact, they wish they could go back to the old un-computerized way of working. Sales figures since the new system was installed are also disappointing and a large number of staff have left the office. Not surprisingly, the manager is consultants examine the users’ needs and how they currently go about their work in detail and also find out exactly what the goals of the company are. They then recommend a system with the following characteristics:

- Immediate ticket booking via a computer connection (alleviating the problem of engaged phone line),
- Automatic print-out of tickets, itineraries and receipts (eliminating the need to write these by hand and thereby reducing the possibility of errors and illegibility while speeding up the process),
- Direct connection between the booking system and accounting (speeding up the process of accounting),
- Elimination of booking forms (reducing overheads as less paper and time are used).

The consultants suggest making the interface to the system mimic the non-computerized task, so menus and forms are used, which means that the sales assistant only has to select options and fill in the resulting forms by typing at a keyboard.

The consultants are optimistic that customer satisfaction will improve because customer will get their tickets on the spot. They point out to the manager, however, that in order to get the most out of the new system the layout of the agency needs to be changed to make it comfortable for the sales staff to operate the compute, while still providing scope for direct contact with customers. Staff will also need training, and some careful changes to existing jobs are needed too—job design. In particular, technology means that they will need support during the period of change. Staff will also need to know how to cope when an airline’s computer malfunctions. Changes in employment conditions must also be examined. For instance, if staff is expected to carry out more transactions in less time, are they going to be rewarded for this extra activity? Staff relations with other staff in the company who will not be using the computerized system must also be taken into account. For example, problems associated with technology power such as feelings of elitism among staff that know how to use the new technology, will need to be resolved.

HCI understands the Complex Relationship between Human and Computers, which are two distinct ‘Species’. Successful Integration is dependent upon a better understanding of both Species. Hence HCI borrows and establishes its roots in Disciplines concerned with both.

**Human**

- Cognitive Psychology
Cognitive Psychology

Psychology is concerned primarily with understanding human behavior and the mental processes that underlie it. To account for human behavior, cognitive psychology has adopted the notion of information processing. Everything we see, feel, touch, taste, smell and do is couched in terms of information processing. The objective cognitive psychology has been to characterize these processes in terms of their capabilities and limitations. [2]

Social and Organizational psychology

Social psychology is concerned with studying the nature and causes of human behavior in a social context. Vaske and Grantham identify the four core concerns of social psychology as:

- The influence of one individual on another person’s attitudes and behavior
- The impact of a group on its members’ attitude and behavior
- The impact of a member on a group’s activities and structure
- The relationship between the structure and activities of different groups.

The role of social and organizational psychology is to inform designers about social and organizational structures and about how the introduction of computers will influence working practices. [2]

Ergonomics or human factor

Ergonomics, or human factor, developed from the interests of a number of different disciplines primarily during World War II. Its purpose is to define and design tools and various artifacts for different work, leisure and domestic environments to suit the capabilities and capacities of users.

The role of ergonomist is to translate information from the above sciences into the context of design, whether for a car seat or a computer system. The objective is to
maximize an operator’s safety, efficiency and reliability of performance, to make a
task easier, and to increase feelings of comfort and satisfaction. [2]

**Linguistics**
Linguistics is the scientific study of language (Lyons, 1970). From the point of view
of HCI there are several issues that may be better understood by applying knowledge
and theories from linguistics. For example, in the early days of command languages
there was some debate about whether or not the object to which a command applied
should come before or after the command itself. When deleting a file called ‘xyz’, for
example, should you type delete ‘xyz’ or ‘xyz’ delete. [2]

**Philosophy, Sociology and Anthropology**
A major concern of these disciplines until relatively recently has been to consider the
implication of the introduction of IT to society. More recently, attempts are being
made to apply methods developed in the social sciences to the design and evaluation
of systems. The reason for applying social science methods of analysis to HCI, it is
argued, are that a more accurate description of the interaction between users, their
work, the technology that they use and the environment in which they are situated can
be obtained. One application of social science methods has been to characterize
computer supported cooperative writing (CSCW), which is concerned with sharing
software and hardware among groups of people working together. The is to design
tools and ways of working which optimize the shared technology so that maximum
benefit can be obtained by all those who use or are affected by it. [2]

**Artificial Intelligence**
Artificial Intelligence (AI) is concerned with the design of intelligent computer
programs which simulate different aspects of intelligent human behavior. The
relationship of AI to HCI is mainly concerned with user’s needs when interacting with
an intelligent interface. These include, for example, the use of natural language and
speech as a way of communicating with a system and the need for system to explain
and justify its advice. [2]

**Computer Science**
One of the main contributions of computer science to HCI is to provide knowledge
about the capabilities of technology and ideas about how this potential can be
harnessed. In addition, computer scientists have been concerned about developing
various kinds of techniques to support software design, development and
maintenance. In particular, there has been a strong interest in automating design and
development when feasible. [2]

**Engineering and design**
Engineering is an applied science, which relies heavily on model building and
empirical testing. Design contributes creative skills and knowledge to this process. In
many respects the greatest influence of engineering on HCI and subsequently on
interface and system development is through software engineering.
Design too is a well-established discipline in its own right, which has potential benefits when applied to HCI problems. An obvious example is graphic design.[2]

References:
- Human-Computer Interaction by Jenny Preece
- Software Engineering: A Practitioner's Approach by Roger S. Pressman
- Definitions of Quality - Sandeep's Quality Page.htm
Lecture 6. Cognitive Frameworks

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand the importance of Cognition
- Understand different cognitive frameworks in HCI

6.1 Introduction
Imagine trying to drive a car by using just a computer keyboard. The four arrow keys are used for steering, the space bar for braking, and the return key for accelerating. To indicate left you need to press the F1 key and to indicate right the F2 key. To sound your horn you need to press the F3 key. To switch the headlights on you need to use the F4 key and, to switch the windscreen wipers on, the F5 key. Now imagine as you are driving along a road a ball is suddenly kicked in front of you. What would you do? Bash the arrow keys and the space bar madly while pressing the F4 key? How would rate your chance of missing the ball?
Most of us would bald at the very idea of driving a car this way. Many early video games, however, were designed along these lines: the user had to press an arbitrary combination of function keys to drive or navigate through the game. More recently, computer consoles have been designed with the user’s capabilities and demands of the activity in ming. Much better way of controlling and interacting, such as through using joysticks and steering wheels, are provided that map much better onto the physical and cognitive aspects of driving and navigating.
We have to understand the limitations of the people to ease them. Let us see what is cognitive psychology and how it helps us.

Cognitive Psychology
Psychology is concerned primarily with understanding human behavior and the mental processes that underlie it. To account for human behavior, cognitive psychology has adopted the notion of information processing. Everything we see, feel, touch, taste, smell and do is couched in terms of information processing. The objective cognitive psychology has been to characterize these processes in terms of their capabilities and limitations. For example, one of the major preoccupations of cognitive psychologists in the 1960s and 1970s was identifying the amount of information that could be processed and remembered at any one time. Recently, alternative psychological frameworks have been sought which more adequately characterize the way people work with each other and with the various artifacts, including computers, that they have use. Cognitive psychology have attempted to apply relevant psychological principles to HCI by using a variety of methods,
including development of guidelines, the use of models to predict human performance and the use of empirical methods for testing computer systems.

**Cognition**

The dominant framework that has characterized HCI has been cognitive. Let us define cognition first:

Cognition is what goes on in our heads when we carry out our everyday activities. In general, cognition refers to the processes by which we become acquainted with things or, in other words, how we gain knowledge. These include understanding, remembering, reasoning, attending, being aware, acquiring skills and creating new ideas.

As figure indicates there are different kinds of cognition.

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**What goes on in the mind?**

- perceiving..
- thinking..
- remembering..
- learning..
- understanding others talking with others manipulating others
- planning a meal imagining a trip painting writing composing
- making decisions solving problems daydreaming...

The main objective in HCI has been to understand and represent how human interact with computers in terms of how knowledge is transmitted between the two. The theoretical grounding for this approach stems from cognitive psychology: it is to explain how human beings achieve the goals they set.

Cognition has also been described in terms of specific kinds of processes. These include:

- Attention
- Perception and recognition
- Memory
- Learning
- Reading, speaking, and listening
- Problem solving, planning, reasoning, decision-making.
It is important to note that many of these cognitive processes are interdependent: several may be involved for a given activity. For example, when you try to learn material for an exam, you need to attend the material, perceive, and recognize it, read it, think about it, and try to remember it. Thus cognition typically involves a range of processes. It is rare for one to occur in isolation.

### 6.2 Modes of Cognition

Norman (1993) distinguishes between two general modes:
1. Experiential cognition
2. Reflective cognition

#### Experiential cognition

It is the state of mind in which we perceive, act, and react to events around us effectively and effortlessly. It requires reaching a certain level of expertise and engagement. Examples include driving a car, reading a book, having a conversation, and playing a video game.

#### Reflective cognition

Reflective cognition involves thinking, comparing, and decision-making. This kind of cognition is what leads to new ideas and creativity. Examples include designing, learning, and writing a book.

Norman points out that both modes are essential for everyday life but that each requires different kinds of technological support.

#### Information processing

One of the many other approaches to conceptualizing how the mind works, has been to use metaphors and analogies. A number of comparisons have been made, including conceptualizing the mind as a reservoir, a telephone network, and a digital computer. One prevalent metaphor from cognitive psychology is the idea that the mind is an information processor.

During the 1960s and 1970s the main paradigm in cognitive psychology was to characterize humans as information processors; everything that is sensed (sight, hearing, touch, smell, and taste) was considered to be information, which the mind processes. Information is thought to enter and exit the mind through a series of ordered processing stages. As shown in figure, within these stages, various processes are assumed to act upon mental representations. Processes include comparing and matching. Mental representations are assumed to comprise images, mental models, rules, and other forms of knowledge.

Stage 1 encodes information from the environment into some form of internal representation. In stage 2, the internal representation of the stimulus is compared with memorized representations that are stored in the brain. Stage 3 is concerned with
deciding on a response to the encoded stimulus. When an appropriate match is made the process passes on to stage 4, which deals with the organization of the response and the necessary action. The model assumes that information is unidirectional and sequential and that each of the stages takes a certain amount of time, generally thought to depend on the complexity of the operation performed.

To illustrate the relationship between the different stages of information processing, consider the sequence involved in sending mail. First, letters are posted in a mailbox. Next, a postman empties the letters from the mailbox and takes them to central sorting office. Letters are then sorted according to area and sent via rail, road, air or ship to their destination. On reaching their destination, the letters are further sorted into particular areas and then into street locations and so on. A major aspect of an information processing analysis, likewise, is tracing the mental operations and their outcomes for a particular cognitive task. For example, let us carry out an information processing analysis for the cognitive task of determining the phone number of a friend.

Firstly, you must identify the words used in the exercise. Then you must retrieve their meaning. Next you must understand the meaning of the set of words given in the exercise. The next stage involves searching your memory for the solution to the problem. When you have retrieved the number in memory, you need to generate a plan and formulate the answer into a representation that can be translated into a verbal form. Then you would need to recite the digits or write them down.

**Extending the human information processing model**

Two main extensions of the basic information-processing model are the inclusion of the processes of attention and memory. Figure shows the relationship between the different processes. [3]

![Diagram of the extended human information processing model]

In the extended model, cognition is viewed in terms of:

1. how information is perceptual processors
2. how that information is attended to, and
3. how that information is processed and stored in memory.
6.3 Human processor model

The information-processing model provides a basis from which to make predictions about human performance. Hypotheses can be made about how long someone will take to perceive and responds to a stimulus (also known as reaction time) and what bottlenecks occur if a person is overloaded with too much information. The best-known approach is

the human processor model, which models the cognitive processes of a user interacting with a computer. Based on the information-processing model, cognition is conceptualized as a series of processing stages where perceptual, cognitive, motor processors are organized in relation to one another. The model predicts which cognitive processes are involved when a user interacts with a computer, enabling calculations to be made how long a user will take to carry out various tasks. This can be very useful when comparing different interfaces. For example, it has been used to compare how well different word processors support a range of editing tasks.

The information processing approach is based on modeling mental activities that happen exclusively inside the head. However, most cognitive activities involve people interacting with external kinds of representations, like books, documents, and computers—not to mentions one another. For example, when we go home from wherever we have been we do not need to remember the details of the route because we rely on cues in the environment (e.g., we know to turn left at the red house, right when the road comes to a T-junction, and so on.). Similarly, when we are at home we do not have to remember where everything is because information is “out there.” We decide what to eat and drink by scanning he items in the fridge, find out whether any messages have been left by glancing at the answering machine to see if there is a flashing light, and so on. [2]

6.4 GOMS

Card et al. have abstracted a further family of models, known as GOMS (goals, operations, methods and selection rules) that translate the qualitative descriptions into quantitative measures. The reason for developing a family of models is that it enables various qualitative and quantitative predictions to be made about user performance.

Goals

These are the user’s goals, describing what the user wants to achieve. Further, in GOMS the goals are taken to represent a ‘memory point’ for the user, from which he can evaluate what should be done and to which he may return should any errors occur. [1]

Operators

These are the lowest level of analysis. They are the basic actions that the user must perform in order to use the system. They may affect the system (e.g., press the ‘X’ key) or only the user’s mental state (e.g., read the dialogue box). There is still a degree of flexibility about the granularity of operators; we may take the command level “issue the select command” or be more primitive; “move mouse to menu bar, press center mouse button….” [1]
Methods
As we have already noted, there are typically several ways in which a goal can be split into sub goals. [1]

Selection
Selection means of choosing between competing methods [1]
One of the problems of abstracting a quantitative model from a qualitative description of user performance is ensuring that two are connected. In particular, it has been noted that the form and contents of GOMS family of models are relatively unrelated to the form and content of the model human processor and it also oversimplified human behavior. More recently, attention has focused on explaining:

- Knowledge Representation Models
  How knowledge is represented

- Mental Models
  How mental models (these refer to representation people construct in their mind of themselves, others, objects and the environment to help them know what to do in current and future situations) develop and are used in HCI

- User Interaction Learning Models
  How user learn to interact and become experienced in using computer system.

With respect to applying this knowledge to HCI design, there has been considerable research in developing:

Conceptual Models
Conceptual models are (these are the various ways in which systems are understood by different people) to help designers develop appropriate interfaces.

Interface Metaphor
Interface metaphors are (these are GUIs that consists of electronic counterparts to physical objects in the real world) to match the knowledge requirements of users.

6.5 Recent development in cognitive psychology
With the development of computing, the activity of brain has been characterized as a series of programmed steps using the computer as a metaphor. Concept such as buffers, memory stores and storage systems, together with the type of process that act upon them (such as parallel verses serial, top-down verses down-up) provided psychologist with a mean of developing more advanced models of information processing, which was appealing because such models could be tested. However, since the 1980s there has been a more away from the information-processing framework with in cognitive psychology. This has occurred in parallel with the reduced importance of the model human processor with in HCI and the development other theoretical approaches. Primarily, these are the computational and the connectionist approaches. More recently other alternative approaches have been developed that has situated cognitive activity in the context in which they occur. [3]
Computational Approaches
Computational approaches continue to adopt the computer metaphor as a theoretical framework, but they no longer adhere to the information-processing framework. Instead, the emphasis is on modeling human performance in terms of what is involved when information is processed rather than when and how much. Primarily, computational models conceptualize the cognitive system in terms of the goals, planning and action that are involved in task performance. These aspects include modeling: how information is organized and classified, how relevant stored information is retrieved, what decisions are made and how this information is reassemble. Thus tasks are analyzed not in terms of the amount of information processed per se in the various stages but in terms of how the system deals with new information. [3]

Connectionist Approaches
Connectionist approaches, otherwise known as neural networks or parallel distributed processing, simulate behavior through using programming models. However, they differ from conceptual approaches in that they reject the computer metaphor as a theoretical framework. Instead, they adopt the brain metaphor, in which cognition is represented at the level of neural networks consisting of interconnected nodes. Hence all cognitive processes are viewed as activations of the nodes in the network and the connections between them rather than the processing and manipulation of information. [3]

6.6 External Cognition
External cognition is concerned with explaining the cognitive processes involved when we interact with different external representations. A main goal is to explicate the cognitive benefits of using different representations for different cognitive activities and the processes involved. The main one include:
1. externalizing to reduce memory load
2. computational offloading
3. annotating and cognitive tracing.

Externalizing to reduce memory load
A number of strategies have been developed for transforming knowledge into external representations to reduce memory load. One such strategy is externalizing things we find difficult to remember, such as birthdays, appointments and addresses. Externalizing, therefore, can help reduce people’s memory burden by:
- reminding them to do something (e.g., to get something for their mother’s birthday)
- reminding them of what to do (e.g., to buy a card)
- reminding them of when to do something (send it by a certain date)

Computational offloading
Computational offloading occurs when we use a tool or device in conjunction with an external representation to help us carry out a computation. An example is using pen or paper to solve a math problem.[2]
Annotating and cognitive tracing
Another way in which we externalize our cognitions is by modifying representations to reflect changes that are taking place that we wish to mark. For example, people often cross think off in to-do list to show that they have been completed. They may also reorder objects in the environment, say by creating different piles as the nature of the work to be done changes. These two kinds of modification are called annotating and cognitive tracing:
  - Annotating involves modifying external representations, such as crossing off underlining items.
  - Cognitive tracing involves externally manipulating items different orders or structures.

Information Visualization
A general cognitive principle for interaction design based on the external cognition approach is to provide external representations at the interface that reduce memory load and facilities computational offloading. Different kinds of information visualizations can be developed that reduce the amount of effort required to make inferences about a given topic (e.g., financial forecasting, identifying programming bugs). In so doing, they can extend or amplify cognition, allowing people to perceive and do activities that they couldn’t do otherwise. [2]

6.7 Distributed cognition
Distributed cognition is an emerging theoretical framework whose goal is to provide an explanation that goes beyond the individual, to conceptualizing cognitive activities as embodied and situated within the work context in which they occur. Primarily, this involves describing cognition as it is distributed across individuals and the setting in which it takes place. The collection of actors (more generally referred to just as ‘people’ in other parts of the text), computer systems and other technology and their relations to each other in environmental setting in which they are situated are referred to as functional systems. The functional systems that have been studied include ship navigation, air traffic control, computer programmer teams and civil engineering practices.

A main goal of the distributed cognition approach is to analyze how the different components of the functional system are coordinated. This involves analyzing how information is propagated through the functional system in terms of technological cognitive, social and organizational aspects. To achieve this, the analysis focuses on the way information moves and transforms between different representational states of the objects in the functional system and the consequences of these for subsequent actions.[3]

References:
[1] Human Computer Interaction by Alan Dix
[2] Interaction Design by Jenny Preece
Lecture 7. Human Input-Output Channels – Part I

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand role of input-output channels
- Describe human eye physiology and
- Discuss the visual perception

7.1 Input Output channels
A person’s interaction with the outside world occurs through information being received and sent: input and output. In an interaction with a computer the user receives information that is output by the computer, and responds by providing input to the computer – the user’s output become the computer’s input and vice versa. Consequently the use of the terms input and output may lead to confusion so we shall blur the distinction somewhat and concentrate on the channels involved. This blurring is appropriate since, although a particular channel may have a primary role as input or output in the interaction, it is more than likely that it is also used in the other role. For example, sight may be used primarily in receiving information from the computer, but it can also be used to provide information to the computer, for example by fixating on a particular screen point when using an eye gaze system.

Input in human is mainly though the senses and output through the motor control of the effectors. There are five major senses:
- Sight
- Hearing
- Touch
- Taste
- Smell

Of these first three are the most important to HCI. Taste and smell do not currently play a significant role in HCI, and it is not clear whether they could be exploited at all in general computer systems, although they could have a role to play in more specialized systems or in augmented reality systems. However, vision hearing and touch are central.

Similarly there are a number of effectors:
- Limbs
In the interaction with computer, the fingers play the primary role, through typing or mouse control, with some use of voice, and eye, head and body position.

Imagine using a personal computer with a mouse and a keyboard. The application you are using has a graphical interface, with menus, icons and windows. In your interaction with this system you receive information primarily by sight, from what appears on the screen. However, you may also receive information by ear: for example, the computer may ‘beep’ at you if you make a mistake or to draw attention to something, or there may be a voice commentary in a multimedia presentation. Touch plays a part too in that you will feel the keys moving (also hearing the ‘click’) or the orientation of the mouse, which provides vital feedback about what you have done. You yourself send information to the computer using your hands either by hitting keys or moving the mouse. Sight and hearing do not play a direct role in sending information in this example, although they may be used to receive information from a third source (e.g., a book or the words of another person) which is then transmitted to the computer.

7.2 Vision

Human vision is a highly complex activity with range of physical and perceptual limitations, yet it is the primary source of information for the average person. We can roughly divide visual perception into two stages:

- the physical reception of the stimulus from outside world, and
- the processing and interpretation of that stimulus.

On the one hand the physical properties of the eye and the visual system mean that there are certain things that cannot be seen by the human; on the other interpretative capabilities of visual processing allow images to be constructed from incomplete information. We need to understand both stages as both influence what can and can not be perceived visually by a human being, which in turn directly affect the way that we design computer system. We will begin by looking at the eye as a physical receptor, and then go onto consider the processing involved in basic vision.

The human eye

Vision begins with light. The eye is a mechanism for receiving light and transforming it into electrical energy. Light is reflected from objects in the world and their image is focused upside down on the back of the eye. The receptors in the eye transform it into electrical signals, which are passed to brain.
The eye has a number of important components as you can see in the figure. Let us take a deeper look. The cornea and lens at the front of eye focus the light into a sharp image on the back of the eye, the retina. The retina is light sensitive and contains two types of photoreceptor: rods and cones.

**Rods**
Rods are highly sensitive to light and therefore allow us to see under a low level of illumination. However, they are unable to resolve fine detail and are subject to light saturation. This is the reason for the temporary blindness we get when moving from a darkened room into sunlight: the rods have been active and are saturated by the sudden light. The cones do not operate either as they are suppressed by the rods. We are therefore temporarily unable to see at all. There are approximately 120 million rods per eye, which are mainly situated towards the edges of the retina. Rods therefore dominate peripheral vision.

**Cones**
Cones are the second type of receptor in the eye. They are less sensitive to light than the rods and can therefore tolerate more light. There are three types of cone, each sensitive to a different wavelength of light. This allows color vision. The eye has approximately 6 million cones, mainly concentrated on the fovea.
Fovea
Fovea is a small area of the retina on which images are fixated.

Blind spot
Blind spot is also situated at retina. Although the retina is mainly covered with photoreceptors there is one blind spot where the optic nerve enter the eye. The blind spot has no rods or cones, yet our visual system compensates for this so that in normal circumstances we are unaware of it.

Nerve cells
The retina also has specialized nerve cells called ganglion cells. There are two types:

X-cells
These are concentrated in the fovea and are responsible for the early detection of pattern.

Y-cells
These are more widely distributed in the retina and are responsible for the early detection of movement. The distribution of these cells means that, while we may not be able to detect changes in pattern in peripheral vision, we can perceive movement.

7.3 Visual perception
Understanding the basic construction of the eye goes some way to explaining the physical mechanism of vision but visual perception is more than this. The information received by the visual apparatus must be filtered and passed to processing elements which allow us to recognize coherent scenes, disambiguate relative distances and differentiate color. Let us see how we perceive size and depth, brightness and color, each of which is crucial to the design of effective visual interfaces.

Perceiving size and depth
Imagine you are standing on a hilltop. Beside you on the summit you can see rocks, sheep and a small tree. On the hillside is a farmhouse with outbuilding and farm vehicles. Someone is on the track, walking toward the summit. Below in the valley is a small market town.

Even in describing such a scene the notions of size and distance predominate. Our visual system is easily able to interpret the images, which it receives to take account of these things. We can identify similar objects regardless of the fact that they appear to us to be vastly different sizes. In fact, we can use this information to judge distance. So how does the eye perceive size, depth and relative distances? To understand this we must consider how the image appears on the retina. As we mentioned, reflected light from the object forms an upside-down image on the retina. The size of that image is specified as visual angle. Figure illustrates how the visual angle is calculated.
If we were to draw a line from the top of the object to a central point on the front of the eye and a second line from the bottom of the object to the same point, the visual angle of the object is the angle between these two lines. Visual angle is affected by both the size of the object and its distance from the eye. Therefore, if two objects are at the same distance, the larger one will have the larger visual angle. Similarly, if two objects of the same size are placed at different distances from the eye, the furthest one will have the smaller visual angle, as shown in figure.
Visual angle indicates how much of the field of view is taken by the object. The visual angle measurement is given in either degrees or minutes of arc, where 1 degree is equivalent to 60 minutes of arc, and 1 minute of arc to 60 seconds of arc.

**Visual acuity**

So how does an object’s visual angle affect our perception of its size? First, if the visual angle of an object is too small we will be unable to perceive it at all. Visual acuity is the ability of a person to perceive fine detail. A number of measurements have been established to test visual acuity, most of which are included in standard eye tests. For example, a person with normal vision can detect a single line if it has a visual angle of 0.5 seconds of arc. Spaces between lines can be detected at 30 seconds to 1 minute of visual arc. These represent the limits of human visual perception.

**Law of size constancy**

Assuming that we can perceive the object, does its visual angle affect our perception of its size? Given that the visual angle of an object is reduced, as it gets further away, we might expect that we would perceive the object as smaller. In fact, our perception of an object’s size remains constant even if its visual angle changes. So a person’s height I perceived as constant even if they move further from you. This is the law of size constancy, and it indicated that our perception of size relies on factors other than the visual angle.

One of these factors is our perception of depth. If we return to the hilltop scene there are a number of cues, which can use to determine the relative positions and distances of the objects, which we see. If objects overlap, the object that is partially covered is perceived to be in the background, and therefore further away. Similarly, the size and height of the object in our field of view provides a cue to its distance. A third cue is familiarity: if we expect an object to be of a certain size then we can judge its distance accordingly.

**Perceiving brightness**

A second step of visual perception is the perception of brightness. Brightness is in fact a subjective reaction to level of light. It is affected by luminance, which is the amount of light emitted by an object. The luminance of an object is dependent on the amount of light falling on the object’s surface and its reflective prosperities. Contrast is related to luminance: it is a function of the luminance of an object and the luminance of its background.

Although brightness is a subjective response, it can be described in terms of the amount of luminance that gives a just noticeable difference in brightness. However, the visual system itself also compensates for changes in brightness. In dim lighting, the rods predominate vision. Since there are fewer rods on the fovea, object in low lighting can be seen easily when fixated upon, and are more visible in peripheral vision. In normal lighting, the cones take over.

Visual acuity increases with increased luminance. This may be an argument for using high display luminance. However, as luminance increases, flicker also increases. The eye will perceive a light switched on and off rapidly as constantly on. But if the speed
of switching is less than 50 Hz then the light is perceived to flicker. In high luminance flicker can be perceived at over 50 Hz. Flicker is also more noticeable in peripheral vision. This means that the larger the display, the more it will appear to flicker.

Perceiving color
A third factor that we need to consider is perception of color. Color is usually regarded as being made up of three components:

- hue
- intensity
- saturation

Hue
Hue is determined by the spectral wavelength of the light. Blues have short wavelength, greens medium and reds long. Approximately 150 different hues can be discriminated by the average person.

Intensity
Intensity is the brightness of the color.

Saturation
Saturation is the amount of whiteness in the colors.

By varying these two, we can perceive in the region of 7 million different colors. However, the number of colors that can be identified by an individual without training is far fewer.

The eye perceives color because the cones are sensitive to light of different wavelengths. There are three different types of cone, each sensitive to a different color (blue, green and red). Color vision is best in the fovea, and worst at the periphery where rods predominate. It should also be noted that only 3-4 % of the fovea is occupied by cones which are sensitive to blue light, making blue acuity lower.

Finally, we should remember that around 8% of males and 1% of females suffer from color blindness, most commonly being unable to discriminate between red and green.

The capabilities and limitations of visual processing
In considering the way in which we perceive images we have already encountered some of the capabilities and limitations of the human visual processing system. However, we have concentrated largely on low-level perception. Visual processing involves the transformation and interpretation of a complete image, from the light that is thrown onto the retina. As we have already noted, our expectations affect the way an image is perceived. For example, if we know that an object is a particular size, we will perceive it as that size no matter how far it is from us.

Visual processing compensates for the movement of the image on the retina which occurs as we around and as the object which we see moves. Although the retinal image is moving, the image that we perceive is stable. Similarly, color and brightness of objects are perceived as constant, in spite of changes in luminance.

This ability to interpret and exploit our expectations can be used to resolve ambiguity. For example consider the image shown in figure ‘a’. What do you perceive? Now
consider figure ‘b’ and ‘c’. the context in which the object appears allow our expectations to clearly disambiguate the interpretation of the object, as either a B or 13.

However, it can also create optical illusions. Consider figure ‘d’. Which line is longer?

A similar illusion is the Ponzo illusion as shown in figure

the Muller Lyer illusion
Another illusion created by our expectations compensating an image is the proofreading illusion. Example is shown below

![The quick brown fox jumps over the lazy dog.]

The way that objects are composed together will affect the way we perceive them, and we do not perceive geometric shapes exactly as they are drawn. For example, we tend to magnify horizontal lines and reduce vertical. So a square needs to be slightly increased in height to appear square and line will appear thicker if horizontal rather than vertical.

Optical illusions also affect page symmetry. We tend to see the center of a page as being a little above the actual center – so if a page is arranged symmetrically around the actual center, we will see it as too low down. In graphic design this is known as the optical center.

These are just a few examples of how the visual system compensates, and sometime overcompensates, to allow us to perceive the world around us.

Lecture

8

Lecture 8. Human Input-Output Channels
Part II

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand role of color theory in design
- Discuss hearing perception
- Discuss haptic perception
- Understand movement

8.1 Color Theory
Color theory encompasses a multitude of definitions, concepts and design applications. All the information would fill several encyclopedias. As an introduction, here are a few basic concepts.
A color circle, based on red, yellow and blue, is traditional in the field of art. Sir Isaac Newton developed the first circular diagram of colors in 1666. Since then scientists and artists have studied and designed numerous variations of this concept. Differences of opinion about the validity of one format over another continue to provoke debate. In reality, any color circle or color wheel, which presents a logically arranged sequence of pure hues, has merit.

**Primary Colors**
In traditional color theory, these are the 3 pigment colors that cannot be mixed or formed by any combination of other colors. All other colors are derived from these 3 hues

**Secondary Colors**
These are the colors formed by mixing the primary colors.

**Tertiary colors**
These are the colors formed by mixing one primary and one secondary color.
TERTIARY COLORS
Yellow-orange, red-orange, red-purple, blue-purple, blue-green and yellow-green.

Color Harmony

Harmony can be defined as a pleasing arrangement of parts, whether it be music, poetry, color, or even an ice cream sundae.

In visual experiences, harmony is something that is pleasing to the eye. It engages the viewer and it creates an inner sense of order, a balance in the visual experience. When something is not harmonious, it's either boring or chaotic. At one extreme is a visual experience that is so bland that the viewer is not engaged. The human brain will reject under-stimulating information. At the other extreme is a visual experience that is so overdone, so chaotic that the viewer can't stand to look at it. The human brain rejects what it cannot organize, what it cannot understand? The visual task requires that we present a logical structure. Color harmony delivers visual interest and a sense of order.

In summary, extreme unity leads to under-stimulation, extreme complexity leads to over-stimulation. Harmony is a dynamic equilibrium.

Some Formulas for Color Harmony

There are many theories for harmony. The following illustrations and descriptions present some basic formulas.

Analogous colors

Analogous colors are any three colors, which are side by side on a 12 part color wheel, such as yellow-green, yellow, and yellow-orange. Usually one of the three colors predominates.
**Complementary colors**

Complementary colors are any two colors, which are directly opposite each other, such as red and green and red-purple and yellow-green. In the illustration above, there are several variations of yellow-green in the leaves and several variations of red-purple in the orchid. These opposing colors create maximum contrast and maximum stability.

**A color scheme based on complementary colors**

Nature provides a perfect departure point for color harmony. In the illustration above, red yellow and green create a harmonious design, regardless of whether this combination fits into a technical formula for color harmony.

**Natural harmony**

A color scheme based on nature

**Color Context**

How color behaves in relation to other colors and shapes is a complex area of color theory. Compare the contrast effects of different color backgrounds for the same red square.
Red appears more brilliant against a black background and somewhat duller against the white background. In contrast with orange, the red appears lifeless; in contrast with blue-green, it exhibits brilliance. Notice that the red square appears larger on black than on other background colors.

Different readings of the same color

As we age, the color of lens in eye changes. It becomes yellow and absorb shorter wavelengths so the colors with shorter wavelength will not be visible as we aged. So, do not use blue for text or small objects. As we age, the fluid between lens and retina absorbs more light due to which eye perceive lower level of brightness. Therefore older people need brighter colors.

Different wavelengths of light focused at different distances behind eye’s lens this require constant refocusing which causes fatigue. So, be careful about color combinations. Pure (saturated) colors require more focusing then less pure. Therefore do not use saturated colors in User interface unless you really need something to stand out (danger sign).

Guidelines

• Opponent colors go well together (red & green) or (yellow & blue)
• Pick non-adjacent colors on the hue circle
• Size of detectable changes in color varies. For example, it is hard to detect changes in reds, purples, & greens and easier to detect changes in yellows & blue-greens
• Older users need higher brightness levels to distinguish colors
• Hard to focus on edges created by color alone, therefore, use both brightness & color differences
• Avoid red & green in the periphery due to lack of RG cones there, as yellows & blues work in periphery
• Avoid pure blue for text, lines, & small shapes.
- Blue makes a fine background color
- Avoid adjacent colors that differ only in blue
- Avoid single-color distinctions but mixtures of colors should differ in 2 or 3 colors; e.g., 2 colors shouldn’t differ only by amount of red

Accurate color discrimination is at ±60 degree of straight head position. Limit of color awareness is ±90 degree of straight head position.

8.2 Stereopsis

Introduction

3D vision, binocular vision and stereopsis all mean the same thing: That remarkable power of the visual sense to give an immediate perception of depth on the basis of the difference in points of view of the two eyes. It exists in those animals with overlapping optical fields, acting as a range finder for objects within reach. There are many clues to depth, but stereopsis is the most reliable and overrides all others. The sensation can be excited by presenting a different, properly prepared, view to each eye. The pair of views is called a stereopair or stereogram, and many different ways have been devised to present them to the eye. The appearance of depth in miniature views has fascinated the public since the 1840's, and still appears now and then at the present time. There was a brief, but strong, revival in the 1990's with the invention of the autostereogram. Stereopsis also has technical applications, having been used in aerial photograph interpretation and the study of earth movements, where it makes small or slow changes visible.

The word stereopsis was coined from the Greek στερεος, solid or firm, and οψις, look or appearance. Since terms derived from Greek are often used in this field, it may be useful to have a brief discussion. Single and double vision are called haplopia and diplopia, respectively, from ἄπλος (haplous) and διπλος (diploos), which mean "single" and "double". Haplopia is the happy case; with diplopia we are seeing double. The use of a Greek term removes the connotations that may attach to a common English word, and sounds much more scientific. Note that the "opia" part of these words refers to "appearance", and does not come from a word for "eye". The -s- has been dropped for euphony. Otherwise, the closest Greek to "opia" means a cheese from milk curdled with fig juice. "Ops", for that matter is more usually associated with cooked meat or evenings. In fact, words like "optic" come from ὡπτικος, meaning "thing seen", from the future ὁψομαι of ὁραω (horao) "to see", not from a reference to the eye. The Latin oculus does mean "eye" and is used in many technical terms, like binocular, which combines Greek and Latin.

Stereopsis
Stereopsis is the direct sensing of the distance of an object by comparing the images received by the two eyes. This is possible only when the eyes of a creature look in the same direction, and have overlapping fields. The placing of the two eyes this way gives up the opportunity of a wide field of view obtained with eyes on the sides of the head. Predators find it best to have eyes in front, prey to have them on the sides. Stereopsis yields benefits for close work, such as fighting for cats and hand work for humans. Note that normal binocular vision is single, so that the two images have been fused by the brain. There is no evidence that the image resulting from the many simple eyes of an insect is not also fused in a similar way.

Visual perception makes use of a large number of distance clues to create its three-dimensional picture from the two-dimensional retinal images. Strong clues are the apparent sizes of objects of known size, overlapping and parallax, shadows and perspective. Weaker clues are atmospheric perspective (haze and scattering), speed of movement, and observed detail. The strongest clue of all, however, is stereopsis, which overrides all other evidence save touch itself. The convergence of the optic axes of the two eyes, and their distance accommodation, when fixated on an object, do not seem to be strong clues, though some have believed them to be. Although we have two eyes, we usually have only one visual world, which is a remarkable and important fact calling for explanation. Stereopsis gives a reliable distance clue as far away as 450 metres, Helmholtz estimated. The fineness of the comparison that must be made by the visual system is remarkable.

The interpretation of retinal images to produce stereopsis is entirely mental, and must be learned. When the images on the eyes are consistent with the observation of a single object, the two flat images fuse to form a vivid three-dimensional image. With practice, fusion can be achieved with two pictures side by side and the eyes voluntarily diverged so that each eye sees its picture straight ahead, though accommodated for the actual distance. Both the original pictures remain in view, but a third, fused, image appears before them when the concentration is diverted to it that appears strikingly solid. The brain regards this fused image as the real one, the others as mere ghosts. This skill is called free fusion, and requires considerable practice to acquire. In free fusion, both the convergence of the eyes, and their distance accommodation, are inconsistent with the actual location of the image, and must be overridden by stereopsis. It shows, incidentally, that convergence of the optic axes is not a strong depth cue. By the use of a stereoscope, one can achieve fusion without diverging the eyes, or focusing on a close object with the eyes so diverged, so no practice or skill is required. A stereoscope mainly changes the directions in which the two images are seen so that they can both be fixated by normally converged eyes. The two images are called a stereo pair.

When the images on the retinas are too different to be views of the same object, rivalry occurs, and either one image is favoured and the other suppressed, or a
patchwork of parts of the two images is seen. When everything corresponds except
the illumination or colour, the fused image exhibits lustre.

The fundamentals of stereopsis were discovered by Charles Wheatstone in 1836,
when stereopairs had to be created by drawing (this could be aided with the camera
obscura, but was very difficult except for stick images). The methods of descriptive
geometry can be used to create stereopairs. He designed the mirror stereoscope, which
directs the view of the images into the eyes with plane mirrors and reflection at about
45°. David Brewster invented the prism stereoscope, which used prisms to deviate
the light, which made a more compact and convenient apparatus. Lenses can also be
used to decrease the viewing distance and make fixation easier. Photography was the
natural way to create stereopairs. A stereopair can also be drawn in two colours with
the views superimposed. When this anaglyph is viewed through coloured filters that
present one image to each eye, fusion is easy. A similar method is to project the two
images in orthogonal polarizations, and to view them through polarizing filters. Both
of these methods have been used to project 3D films and transparencies before an
audience. A small fraction of people, perhaps 4%, have defective stereopsis.

The pattern above demonstrates the stereoscopic wallpaper illusion, which was first
discovered by H. Meyer in 1842, and also noted by Brewster. When viewed with the
eyes parallel, a strong stereoscopic effect is seen. The green fleurs-de-lis are farthest
away, the blue discs closest, and the red crosses at an intermediate distance. This is an
autostereogram, a single figure that gives stereoscopic images to the two eyes. Since
the figures in a line are identical, when the eyes are turned for free fusion, two
different figures are assumed to be parallactic views of the same object. The eye finds
it preferable to fuse the images rather than report double vision. It is easier to fuse this
autostereogram than a normal stereopair, so it is good practice for developing the
useful skill of free fusion.

The mind does not have to recognize the object in a stereopair for fusion to occur. The
pattern can be random, but the stereopair must represent the same random pattern as
seen from the different positions of the eyes (Julesz, 1960). Even more strikingly, a
single apparently random pattern can be fused autostereographically to give a three-
dimensional image. No image is seen until fusion occurs. Each point on the image
must be capable of interpretation as two different points of a stereopair. These
random-dot autostereograms were widely enjoyed in the 1980's. An autostereogram
requires free fusion, which must be learned in order to appreciate them. Many people
found this difficult, so the autostereograms were usually presented as a kind of puzzle.
Psychologists have argued about stereopsis for many years, but most of their musings
are not worth repeating. A widely held theory was that the two retinas were somehow
mapped point-by-point, and differing image positions with respect to this reference
frame was interpreted stereoptically. It seems more likely to me that the images are
compared by the visual sense for differences, than by their absolute locations on the
retina. In the past, psychologists have preferred mechanical explanations, where the
brain and retina are created with built-in specializations and functions, spatially
localized, rather than regarding the organs as canvases, which the cognitive powers organize as necessary.

I have not discussed the broad and interesting field of optical illusions here, since they tell us nothing definite about the inner workings of the visual sense, only give examples of its operation, and also because the 'reasons' for them are controversial, and the arguments are not especially enlightening. Illusions are discussed at length in another article on this website. The oldest and most widely known illusion is the horizon illusion, in which the moon appears larger on the horizon than at the zenith. This illusion was known and discussed in antiquity, and is still the subject of much study. Its explanation is not known. For the application of the visual sense to investigation and appreciation of the world around us, Minnaert's book is outstanding.

8.3 Reading
So far we have concentrated on the perception of images in general. However, the perception and processing of text is a special case that is important to interface design, which inevitably requires some textual display.

There are several stages in the reading process. First the visual pattern of the word on the page is perceived. It is then decoded with reference to an internal representation of language. The final stages of language processing include syntactic and semantic analysis and operate on phrases or sentences.

We are most interested with the first two stages of this process and how they influence interface design. During reading, the eye makes jerky movement called saccades followed by fixations. Perception occurs during the fixation periods, which account for approximately 94% of the time elapsed. The eye moves backwards over the text as well as forwards, in what are known as regressions. If the text is complex there will be more regressions.

8.4 Hearing
The sense of hearing is often considered secondary to sight, but we tend to underestimate the amount of information that we receive through our ears.

The human ear
Hearing begins with vibrations in the air or sound waves. The ear receives these vibrations and transmits them, through various stages, to the auditory nerves. The ear comprises three sections commonly known as the outer ear, middle ear and inner ear.
The outer ear is the visible part of the ear. It has two parts: the pinna, which is the structure that is attached to the sides of the head, and the auditory canal, along which sound waves are passed to the middle ear. The outer ear serves two purposes. First, it protects the sensitive middle ear from damage. The auditory canal contains wax, which prevents dust, dirt and over-inquisitive insects reaching the middle ear. It also maintains the middle ear at a constant temperature. Secondly, the pinna and auditory canal serve to amplify some sounds.

The middle ear is a small cavity connected to the outer ear by the tympanic membrane, or eardrum, and to the inner ear by the cochlea. Within the cavity are the ossicles, the smallest bones in the body. Sound waves pass along the auditory canal and vibrate the ear drum which in turn vibrates the ossicles, which transmit the vibrations to the cochlea, and so into the inner ear.

The waves are passed into the liquid-filled cochlea in the inner ear. Within the cochlea are delicate hair cells or cilia that bend because of the vibrations in the cochlear liquid and release a chemical transmitter, which causes impulses in the auditory nerve.

**Processing sound**

Sound has a number of characteristics, which we can differentiate.

**Pitch**

Pitch is the frequency of the sound. A low frequency produces a low pitch, a high frequency, a high pitch.

**Loudness**

Loudness is proportional to the amplitude of the sound; the frequency remains constant.

**Timber**

Timber related to the type of the sound
Sounds may have the same pitch and loudness but be made by different instruments and so vary in timber.

**Sound characteristics**

Audible range is 20 Hz to 15 KHz. Human ear can distinguish between changes less than 1.5 Hz but less accurate at higher frequencies. Different frequencies trigger neuron activity causing nerve impulses. Auditory system filters sounds e.g., Cocktail Party Effect

8.5 **Touch**

The third sense is touch or haptic perception. Although this sense is often viewed as less important than sight or hearing, imagine life without it. Touch provides us with vital information about our environment. It tells us when we touch something hot or cold, and can therefore act as a warning. It also provides us with feedback when we attempt to lift and object.

Haptic perception involves sensors in the skin as well as the hand and arm. The movement that accompanies hands-on exploration involves different types of mechanoreceptors in the skin (involving deformation, thermoreception, and vibration of the skin), as well as receptors in the muscles, tendons, and joints involved in movement of the object (Verry, 1998). These different receptors contribute to a neural synthesis that interprets position, movement, and mechanical skin inputs. Druyan (1997) argues that this combination of kinesthesics and sensory perception creates particularly strong neural pathways in the brain.

**Haptics vs. Visual**

For the science learner, kinesthesics allows the individual to explore concepts related to location, range, speed, acceleration, tension, and friction. Haptics enables the learner to identify hardness, density, size, outline, shape, texture, oiliness, wetness, and dampness (involving both temperature and pressure sensations) (Druyan, 1997; Schiffman, 1976).

When haptics is compared to vision in the perception of objects, vision typically is superior with a number of important exceptions. Visual perception is rapid and more wholistic—allowing the learner to take in a great deal of information at one time. Alternatively, haptics involves sensory exploration over time and space. If you give a student an object to observe and feel, the student can make much more rapid observations than if you only gave the student the object to feel without the benefit of sight. But of interest to science educators is the question of determining what a haptic experience adds to a visual experience. Researchers have shown that haptics is superior to vision in helping a learner detect properties of texture (roughness/smoothness, hardness/softness, wetness/dryness, stickiness, and slipperiness) as well as microspatial properties of pattern, compliance, elasticity, viscosity, and temperature (Lederman, 1983; Zangaladze, et al., 1999). Vision dominates when the goal is the perception of macrogeometry (shape) but haptics is superior in the perception of microgeometry (texture) (Sathian et al., 1997; Verry, 1998). Haptics and vision together are superior to either alone for many learning contexts.
While vision provides information about an object geometric feature, touch is unparalleled in its ability to extract information about materials. For a surgeon trying to decide where to begin excising a patch of cancerous tissue, it might be helpful to feel the texture and compliance, and not just rely on the shape.

**Haptic Learning**

Haptic learning plays an important role in a number of different learning environments. Students with visual impairments depend on haptics for learning through the use of Braille as well as other strategies.

8.6 Movement

Before leaving this section on the human’s input-output channels, we need to consider motor control and how the way we move affects our interaction with computers. A simple action such as hitting a button in response to a question involves a number of processing stages. The stimulus is received through the sensory receptors and transmitted to the brain. The question is processed and a valid response generated. The brain then tells the appropriate muscles to respond. Each of these stages takes time, which can be roughly divided into reaction time and movement time.

Movement time is dependent largely on the physical characteristics of the subjects: their age and fitness, for example. Reaction time varies according to the sensory channel through which the stimulus is received. A person can react to an auditory signal in approximately 150ms, to a visual signal in 200ms and to pain in 700ms.

**Movement perception**

Assume that while you are staring at the bird, a racing car zooms by. The image of the car will travel across your retina as indicated by the dotted line with the arrow. This image movement will cause you to say that the car moves from your right to your left. Now suppose you were looking at the car and followed its movement as it passes in front of you. This time you are following the car by moving your eyes from right to left. Just as before, your percept is that of the car moving from right to left. This is true even though the image remains on the fovea during the motion of the car and your eyes. Third illustration shows that another way to follow the racing car is to keep the eyes steady and to move just the head. This causes the image to project to exactly the same retinal location at each instant (assuming you move your head at precisely the correct angular velocity) as the car moves from right to left.

Once again, the percept is of the car moving from right to left. This percept will be the same as the two previous illustrations. How the brain distinguishes these different
ways of following moving objects is the subject of much research. One more thing, although I have presented three distinct ways of following moving objects, these illustrations are gross simplifications. In point of fact, when we follow moving objects we use various combinations of head and eye movements.

The illustrations that, undoubtedly you have been looking at demonstrate that motion perception is very complex. Recall that we perceive motion if we hold our heads and eyes still as a moving object passes in front of us. If we decide to hold our heads still and let our eyes follow the object we still see it move. Finally, we could even decide to hold our eyes steady and move only our head to follow an object. The interesting thing is all three modes of viewing a moving object result in about the same perception.

So far we have been concerned with perceiving real movement. By real movement I mean that the physical stimulus is actually moving and we perceive it as moving. It is possible to perceive motion when the stimulus is not moving. An example is the motion after effect (MAE) demonstration that was loaned to me by Dr. Ben Bauer, Trent University.

Here is a demonstration you can observe for yourself. If you have the opportunity to view a waterfall, (e.g., Niagara Falls) look at the falling water for about a minute and then allow your gaze to fall on any stationary object. A building would be excellent. If you do this, the texture of the building, perhaps even the windows will appear to move up. Waterfalls usually are not readily available. However, you can easily build your own MAE apparatus. Take a round paper plate. Draw a dozen or so heavy lines radiating out from the middle of the plate. Then with a pin attach the plate through its center to the eraser end of a pencil. Now spin the plate at a moderate speed. Don't spin it so fast that the lines become an indistinct blur. After viewing the spinning plate for about a minute stop it and continue to look at the radiating lines. What do you suppose you will see? If you see what most people notice the radiating lines, which are actually stationary, will appear to rotate in the direction opposite to that which you spun the plate originally. If that is way you saw you witnessed the MAE. It is useful to try this demonstration with the paper plate because it will convince you that there are no special tricks involved with the MAE demo I mentioned above.

The phenomenon of Motion After Effects (MAE) has been studied intensively by visual scientists for many years. One explanation of how the MAE works is the following. The visual system has motion detectors that, like most neurons, undergo
spontaneous activity. You normally do not see motion when there is none because the spontaneous activity is in balance. However, when you viewed the downward motion of the black bars you adapted the motion detectors for motion in the downward direction. When the real motion stopped, the spontaneous activity was no longer in balance, the upward spontaneous activity being slightly stronger and thus the black bars appear to drift upward. The adaptation effect lasts for a short time, the motion detection system quickly becomes balanced again and the apparent movement stops.

Another example of motion being seen, when there is no physical motion, is the phi phenomenon. To those unacquainted with the field of vision research this phenomenon is probably unknown. However, all of you have seen it. The simplest demonstration of the phi phenomenon is to have two illuminated spots of light about 6 to 8 inches apart. When these lights alternately go on and off one usually sees a single spot of light moving back and forth.

This principle is used in many movie marquees where one sees a pattern of lights moving around the display. In fact, there is no physical motion, only a series of lights going on and off. Then, of course there are the movies. Movies are a series of single frames presented in rapid succession. No one would doubt the perception of movement seen in the cinema. Yet, if you analyze the strips of film that yield these images all you would see is a series of frames each with a slightly different image. When they are rapidly projected on to the viewing screen motion is seen.
A similar technique is used with cartoons. The illustrator actually draws a series of pictures. When they are rapidly presented to the viewer motion of the cartoon characters is seen.

There are two other instances when movement is perceived. Have you ever sat in a train or bus station patiently waiting to get moving? Then all of a sudden, low and behold there you go. Or are you? You feel no vibration, something feels wrong. Then you notice that it is the vehicle (train or bus) right next to you that is moving and it just felt as if you were moving. This is called induced motion.

Finally, (and this is an experiment you can try at home) view a small very dim light in an otherwise completely dark room. Make sure that the light is in a fixed position and not moving. After sometime in the dark, the small light will appear to move somewhat randomly. This is called autokinetic movement.

Here is another little experiment you can try. Look around your surroundings freely moving your eyes. As you move your eyes around are the stationary objects moving? Probably not. Now look at some object and with your finger rapidly press against your eyeball by pushing on your eyelid. (Don't push directly against the white (sclera) area). As you force your eye to move you will probably notice that whatever you are looking at starts to jump around. So you can see that it makes a difference whether you move your eyes normally or cause them to move in an unusual manner.
Electrophysiologists are scientists who insert tiny electrode into the brain of experimental subjects. They have discovered that there are cortical neurons which are specialized for movement. In fact, these neurons often are so specialized that they will respond best when the motion is in a specific direction. E. Bruce Goldstein presents a neural model in his textbook, which shows how the early retinal neural processing could occur which results in a signal being sent to the brain which say that movement has occurred in a specific direction.

**How to use MAE**

Fixate the red square in the center of the diagram as the black bars move down. When the black bars stop moving down, continue to fixate the red square and pay attention to the black bars. What if anything do the black bars appear to be doing? If they do not appear to do anything, try running the demonstration again by clicking on the refresh icon at the top of your screen. If the black bars appeared to be drifting upwards you witnessed the motion after effect. If you have a slow computer, a 486 machine or older, this demo may not work very well and you won't experience the MAE.

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

Understand attention
Describe memory models
To day is first lecture on cognitive processes out series of two lectures on the same topic. In our previous lectures we have in detail talked about the cognitive psychology and cognitive frame works. Now is this lecture and in next coming lectures we will talk about a detail about the cognitive processes. As we have already discussed that cognition can be described in terms of specific kinds of processes. These include:
Attention
Memory
Perception and recognition
Learning
Reading, speaking and listening
Problem solving, planning, reasoning, decision-making.

Here in this lecture we will study the first two cognitive processes named attention and memory. The importance of these two you have seen in the Extended Human Processing model, studied in Lecture No. 6, as shown in figure

9.1 Attention
Attention is the process of selecting things to concentrate on, at a point in time, from the range of possibilities available.
A famous psychologist, Williams James says, “Everyone knows what attention is. It is the taking possession of mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought... it requires withdrawal from some things in order to deal effectively with others.”

Attention involves our auditory and/or visual senses an example of auditory attention is waiting in the dentist’s waiting room for our name to be called out to know when it is our time to go in. Auditory attention is based on pitch, timber and intensity. An example of attention involving the visual senses in scanning the football results in a newspaper to attend to information about how our team has done. Visual attention is based on color and location.

Attention allows us to focus on information that is relevant to what we are doing. The extent to which this process is easy or difficult depends on
Whether we have clear goals and
Whether the information we need is salient in the environment.

Our goals
If we know exactly what we want to find out, we try to match this with the information that is available. For example, if we have just landed at an airport after a long flight and want to find out who has won the World Cup, we might scan the headlines at the newspaper stand, check the web, call a friend, or ask someone in the street.

When we are not sure exactly what we are looking for we may browse through information, allowing it to guide our attention to interesting or salient items. For example, when we go to restaurant we may have the general goal of eating a meal but only a vague idea of what we want to eat. We peruse the menu to find things that whet our appetite, letting our attention be drawn to the imaginative descriptions of various dishes. After scanning through the possibilities and imagining what each dish might be like (plus taking into account other factors, such as cost, who we are with, what the specials are, what the waiter recommends, whether we want a two-or- three-course meal, and so on.), we may then make a decision.

Information presentation
The way information is displayed can also greatly influence how easy or difficult it is to attend to appropriate pieces of information. Look at the figure below, two different ways of structuring the same information at the interface: one makes it much easier to find information than the other. Look at the top screen and (i) find the price for a double room at the Holiday Inn in Lahore: (ii) find the phone number of the Sheraton in the Karachi. Then look at the bottom screen and (i) find the price of for a double room at the Pearl Continental in Faisalabad; (ii) find the phone number of the Holiday Inn in the Islamabad. Which took longer to do. Experiments showed that the two screens produced quite different results: it took an average of 3.2 seconds to search the top screen and 5.5 seconds to find the same kind of information in the bottom screen. Why is this so, considering that the both displays have the same density of information? The primary reason is the way the characters are grouped in the display; in the top they are grouped into vertical categories of information that have columns of space between them. In the bottom screen the information is bunched up together, making it much harder to search through.
Models of Attention
There are two models of attention:

- Focused attention
- Divided attention

Focused Attention
Our ability to attend to one event from what amounts to a mass of competing stimuli in the environment have been psychologically termed as focused attention. The streams of information we choose to attend to will tend to be relevant to the activities and intentions that we have at that time. For example, when engaged in a conversation it is usual to attend to what the other person is saying. If something catches our eye in the periphery to our vision, for example, another person we want to talk to suddenly appear, we may divert our attention to what she is doing. We may then get distracted from the conversation we are having and as a consequence have to ask the person we are conversing with to repeat themselves. On the other hand, we may be skilled at carrying

on the conversation while intermittently observing what the person we want to talk to is doing.

Divided Attention
As we said, we may be skilled at carrying on the conversation while intermittently observing what the person we want to talk to is doing. When we attempt to attend to more than one thing at a time, as in the above example, it is called divided attention. Another example that is often used to illustrate this attentional phenomenon is being able to drive while holding a conversation with a passenger.

Voluntary attention
A further property of attention is that can be voluntary, as when we make a conscious effort to change our attention.

Involuntary attention
Attention may also be involuntary, as when the salient characteristics of the competing stimuli grab our attention. An everyday example of an involuntary act is being distracted from working when we can hear music or voices in the next room. Another thing is that frequent actions become automatic actions, that is, they do not need any conscious attention and they require no conscious decisions.

**Focusing attention at the interface**

What is the significance of attention for HCI? How can an understanding of attentional phenomena be usefully applied to interface design? Clearly, the manner in which we deploy our attention has a tremendous bearing on how effectively we can interact with a system. If we know that people are distracted, often involuntarily, how is it possible to get their attention again without allowing them to miss the ‘window of opportunity’? Moreover, how can we focus people’s attention on what they need to be looking at or listening to for any given stage of task? How can we guide their attention to the relevant information on display?

**Structuring Information**

One way in which interfaces can be designed to help users find the information they need is to structure the interface so that it is easy to navigate through. Firstly, this requires presenting not too much information and not too little on a screen, as in both cases the user will have to spend considerable time scanning through either a cluttered screen or numerous screens of information. Secondly, instead of arbitrarily presenting data on the screen it should be grouped and ordered into meaningful parts capitalizing on the perceptual laws of grouping, information can be meaningfully structured so that it is easier to perceive and able to guide attention readily to the appropriate information. Help user to:

- attend his/her task not the interface.
- decide what to focus on, based on their tasks, interest, etc.
- stay focused, do not provide unnecessary distractions.
- structure his/her task, e.g. help
- Create distraction, when really necessary!
- Use alerts (only) when appropriate!

Some other considerations are as under:

- Make information salient when it needs attending to
- Use techniques that make things stand out like colour, ordering, spacing, underlining, sequencing and animation
- Avoid cluttering the interface - follow the google.com example of crisp, simple design
- Avoid using too much because the software allows it

**9.2 Memory**

Indeed, much of our everyday activities rely on memory. As well as storing all our factual knowledge, our memory contains our knowledge of actions or procedures. It allows us to repeat actions, to use language, and to use new information received via our senses. It also gives us our sense of identity, by preserving information from our past experiences. If want to understand the working of our memory, it is necessary to understand the structure of memory. Let us look at a memory model.

**Memory Model**
It is generally agreed that there are three types of memory or memory functions:
sensory buffers, short-term memory or working memory and long-term memory. It is
also called the multi-store model of memory. The main characteristics of the multi-
store model of memory are the various types of memory stores. These are:

**Sensory store**  
modality-specific, hold information for a very brief period of time (a few
tenths of a second),

**Short-term memory store** holds limited information for a short period of time (a few
seconds),

**Permanent long-term memory store** hold information indefinitely.

Let us have a detailed look of this model.

### Sensory memory

The sensory memories act as buffer for stimuli received through the senses. A sensory memory exists
for each sensory channel: iconic memory for visual stimuli, echoic memory for aural stimuli and haptic
memory for touch. These memories are constantly overwritten by new information coming in on these
channels.

We can demonstrate the existence of iconic memory by moving a finger in front of
the eye. Can you see it in more than one place at once? This indicates a persistence of
the image after the stimulus has been removed. A similar effect is noticed most
vividly at firework displays where moving sparklers leave a persistent image.

Information remains in iconic memory very briefly, in the order of 0.5 seconds.

Similarly, the existence of echoic memory is evidenced by our ability to ascertain the
direction from which a sound originates. This is due to information being received by
both ears. However, since this information is received at different times, we must
store the stimulus in the meantime. Echoic memory allows brief playback of
information. Have you ever had someone ask you a question when you are reading?
You ask them to repeat the question only to realise that you know what was asked
after all. This experience, too, is evidence of the existence of echoic memory.

Information is passed from sensory memory into short-term memory by attention,
thereby filtering the stimuli to only those, which are of interest at a given time.

Attention is the concentration of the mind on one out of a number of competing
stimuli or thoughts. It is clear that we are able to focus our attention selectively,
choosing to attend to one thing rather than another. This is due to the limited capacity
of our sensory and mental processes. If we did not selectively attend to the stimuli
coming into our senses, we would be overloaded. We can choose which stimuli to
attend to, and the choice is governed to an extent by our arousal, our level of interest
or need. This explains the cocktail party phenomenon. According to cocktail party
effect we can attend to one conversation over the background noise, but we may
choose to switch our attention to a conversation across the room if we hear our name
mentioned. Information received by sensory memories is quickly passed into a more
permanent memory store, or overwritten and lost.

### Short term memory
Short-term memory or working memory acts as a scratch pad for temporary recall of information. It is used to store information which is only required fleetingly. For example, calculate the multiplication $35 \times 6$ in your head. The chances are that you will have done this calculation in staged, perhaps $5 \times 6$ and then $3 \times 6$ and added the results. To perform calculations such as this we need to store the intermediate stages for use later. Or consider reading. In order to comprehend this sentence you need to hold in your mind the beginning of the sentence as you read the rest. Both of these tasks use short-term memory.

Short-term memory can be accessed rapidly, in the order of 70ms. However, it also decays rapidly, meaning that information can only be held there temporarily, in the order of 200ms.

Short-term memory also has a limited capacity. There are two basic methods for measuring memory capacity. The first involves determining the length of a sequence, which can be remembered in order. The second allows items to be freely recalled in any order. Using the first measure, the average person can remember $7\pm2$ digits. This was established in experiments by Miller. Try it look at the following number sequence:

$54988319814237$

Now write down as much of the sequence as you can remember. Did you get it all right? If not, how many digits could you remember? If remembered between five and nine digits your memory span is average.

Now try the following sequence:

$22 \ 55 \ 36 \ 8998 \ 30$

did you recall that more easily? Here the digits are grouped or chunked. A generalization of the $7\pm2$ rule is that we can remember $7\pm2$ chunks of information. Therefore chunking information can increase the short-term memory capacity. The limited capacity of short-term memory produces a subconscious desire to create chunks, and so optimise the use of the memory. The successful formation of a chunk is known as closure. This process can be generalized to account for the desire to complete or close tasks held in short-term memory. If a subject fails to do this or is prevented from doing so by interference, the subject is liable to lose track of what she is doing and make consequent errors.

Recency effect

In experiments where subjects were able to recall works freely, evidence shows that recall of the last words presented is better than recall of those in the middle. This is known as recency effect. Recency effect can be defined as: ‘better recall for items at the end of the list because these items are still active in STM (and possibly SM) at time of recall’.

However, if the subject is asked to perform another task between presentation and recall the recency effect is eliminated. The recall of other words is unaffected. This suggests that short-term memory recall is damaged by interference of other information.

Primacy effect

‘Better recall for items at the beginning of the list (because these items have been rehearsed more frequently than other items and thus have a greater chance of being placed in LTM).’

Long Term Memory

If short-term memory is our working memory or ‘scratch-pad’, long-term memory is our main resource. Here we store factual information, experiential knowledge, and
procedural rules of behavior— in fact, everything that we know. It differs from short-
term memory in a number of significant ways. First, it has a huge, if not unlimited,
capacity. Secondly, it has a relatively slow access time of approximately a tenth of a
second. Thirdly, forgetting occurs more slowly in long-term memory, if at all.
Long-term memory is intended for the long-term storage of information. Information
is placed there from working memory through rehearsal. Unlike working memory
there is little decay: long-term recall after minutes is the same as that after hours or
days.

Long-term memory structure
There are two types of long-term memory: episodic memory and semantic memory.

Episodic memory
Episodic memory represents our memory of events and experiences in a serial form. It
is from this memory that we can reconstruct the actual events that took place at a
given period of our lives.

Semantic memory
Semantic memory is structured record of facts, concepts and skills that we have
acquired. The information in semantic memory is derived from that in our episodic
memory, such that we can learn new facts or concepts from our experience.
Semantic memory is structured in some way to allow access to information,
representation of relationships between pieces of information, and inference. One
model for the way in which semantic memory is structured is as a network. Items are
associated to each other in classes, and may inherit attributes from parent classes. This
model is known as a semantic network. As an example, knowledge about dogs may be
stored in a network such as that shown in figure.
Specific breed attributes may be stored with each given breed, yet general dog
information is stored at a higher level. This allows us to generalize about specific
cases. For instance, we may not have been told that the sheepdog Shadow has four
legs and a tail, but we can infer this information from our general knowledge about
sheepdogs and dogs in general. Note also that there are connections within the
network which link into other domains of knowledge, for example cartoon characters

A number of other memory structures have been proposed to explain how we
represent and store different types of knowledge. Each of these represents a different
aspect of knowledge and, as such, the models can be viewed as complementary rather
than mutually exclusive. Semantic networks represent the associations and
relationship between single items in memory. However, they do not allow us to model
the representation of more complex objects or events, which are perhaps composed of
a number of items of activities. Structured representations such as frames and scripts
organize information into data structures. Slots in these structures allow attribute
values to be added. Frame slots may contain default, fixed or variable information. A
frame is instantiated when the slots are filled with appropriate values. Frame and
scripts can be linked together in networks to represent hierarchical structured
knowledge.
Script for a visit to the vet

Entry conditions: dog ill
vet open
owner has money

Result: dog better
owner poorer
vet richer

Props: examination table
medicine
instruments

Roles: vet examines
diagnoses
treats
owner brings dog in
pays
takes dog out

Scenes: arriving at reception
waiting in room
examination
paying

Tracks: dog needs medicine
dog needs operation

**DOG**

Fixed
- legs: 4

Default
- diet: carnivorous
- sound: bark

Variable
- size:

**COLLIE**

Fixed
- breed of: DOG
- type: sheepdog

Default
- size: 65 cm

Variable
- colour
9.3 **Revised Memory Model**

According to revised memory model Working memory is a subset of LTM. Some other characteristics are as under:

- Items are semantically linked.
- Items in working memory are activated.
- Activation is supplied from other linked chunks and from sensory input.

As we know human processor consists of three interacting systems: the perceptual system, the motor system and the cognitive system. Each has its own memory and process as shown in figure. Similar to the notions of human information processing, human performance is viewed as a series of processing stages, whereby the different processors and memories are organized in a particular way.
Lecture 10. Cognitive Processes - Part II

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand learning
- Discuss planning, reasoning, decision making
- Understand problem solving

Today is part second of our two parts series lecture on Cognitive Process. As we have earlier seen that cognition involves following processes:
- Attention
- Memory
- Perception and recognition
- Learning
- Reading, speaking and listening
- Problem solving, planning, reasoning, decision-making.

Today we will learn about learning and thinking. Let us first look at learning.

10.1 Learning
Learning can be consider in two terms:
- Procedural
- Declarative

Procedural
According to procedural learning we come to any object with questions like how to use it? How to do something? For example, how to use a computer-based application?

Declarative
According to declarative learning we try to find the facts about something. For example, using a computer-based application to understand a given topic.

Jack Carroll and his colleagues have written extensively about how to design interfaces to help learners develop computer-based skills. A main observation is that people find it very hard to learn by following sets of instructions in a manual. For example, when people encounter a computer for the first time their most common reaction is one of fear and trepidation. In contrast, when we sit behind the steering
wheel of a car for the first time most of us are highly motivated and very excited with the prospect of learning to drive. Why, then is there such a discrepancy between our attitudes to learning these different skills? One of the main differences between the two domains is the way they are taught. At the end of the first driving lesson, a pupil will have usually learned how to drive through actually doing. This includes performing a number of complex tasks such as clutch control, gear changing, learning to use the controls and knowing what they are. Furthermore, the instructors are keen to let their pupils try things out and get started. Verbal instruction initially is kept to minimum and usually interjected only when necessary. In contrast, someone who sits in front of a computer system for the first time may only have a very large manual, which may be difficult to understand and poorly presented. Often training and reference materials are written as a series of ordered explanations together with step by step exercises, which may cause the learner to feel overloaded with information or frustrated at not being able to find information that she wants. One of the main developing usable training materials and helps facilities. There is general assumption that having read something in the manual users can immediately match it to what is happening at the interface and respond accordingly. But as you may have experienced, trying to put into action even simple descriptions can sometimes be difficult.

Experienced users also appear to be reluctant to learn new methods and operations from manuals. When new situations arise that could be handled more effectively by new procedures, experienced users are more likely to continue to use the procedures they already know rather than try to follow the advanced procedures outlined in a manual, even if the former course takes much longer and is less effective.

So, people prefer to learn through doing. GUI and direct manipulation interface are good environments for supporting this kind of learning by supporting exploratory interaction and importantly allowing users to ‘undo’ their actions, i.e., return to a previous state if they make a mistake by clicking on the wrong option.

Carroll has also suggested that another way of helping learners is by using a ‘training wheels’ approach. This involves restricting the possible functions that can be carried out by a novice to the basics and then extending these as the novice becomes more experienced. The underlying rationale is to make initial learning more tractable, helping the learner focus on simple operations before moving on to more complex ones.

There have also been numerous attempts to harness the capabilities of different technologies, such as web-based, multimedia, and virtual reality, is that they provide alternative ways of representing and interacting with information that are not possible with traditional technologies. In so doing, they have the potential of offering learners the ability to explore ideas and concepts different ways.

People often have problems learning the difficult stuff---by this we mean mathematical formulae, notations, laws of physics, and other abstract concepts. One of the main reasons is that they find it difficult to relate their concrete experiences of the physical world with these higher-level abstractions. Research has shown, however, that it is possible to facilitate this kind of learning through the use of interactive multimedia.
Dynalinking
The process of linking and manipulating multimedia representations at the interface is called dynalinking. It is helpful in learning. An example where dynalinking have been found beneficial is in helping children and students learn ecological concepts. During experiment a simple ecosystem of a pond was built using multimedia. The concrete simulation showed various organisms swimming and moving around and occasionally an event where one would eat another. When an organism was clicked on, it would say what it was and what it ate.

The simulation was dynalinked with other abstract representations of the pond ecosystem. One of these was a food web diagram. People were encouraged to interact with the interlinked diagrams in various ways and to observe what happened in the concrete simulation when something was changed in the diagram and vice versa. Dynalinking is a powerful form of interaction and can be used in a range of domains to explicitly show relationships among multiple dimensions, especially when the information to be understood or learned is complex.

10.2 Reading, Speaking and Listening
These three forms of language processing have both similar and different properties. One similarity is that the meaning of sentences or phrases is the same regardless of the mode in which it is conveyed. For example, the sentence “Computer are a wonderful invention” essentially has the same meaning whether one reads it, speaks it, or hears it. However, the ease with which people can read, listen, or speak differs depending on the person, task, and context. For example, many people find listening much easier than reading. Specific differences between the three modes include:

- Written language is permanent while listening is transient. It is possible to reread information if not understood the first time round. This is not possible with spoken information that is being broadcast.
- Reading can be quicker than speaking or listening, as written text can be rapidly scanned in ways not possible when listening to serially presented spoken works.
- Listening require less cognitive effort than reading or speaking. Children, especially, often prefer to listen to narratives provided in multimedia or web-based learning material than to read the equivalent text online.
- Written language tends to be grammatical while spoken language is often ungrammatical. For example, people often start and stop in mid-sentence, letting someone also start speaking.
- There are marked differences between people in their ability to use language. Some people prefer reading to listening, while others prefer listening. Likewise, some people prefer speaking to writing and vice versa.
- Dyslexics have difficulties understanding and recognizing written words, making it hard for them to write grammatical sentences and spell correctly.
- People who are hard of hearing or hard of seeing are also restricted in the way they can process language.
Incorporating Language processing in applications
Many applications have been developed either to capitalize on people’s reading writing and listening skills, or to support or replace them where they lack or have difficulty with them. These include:

- Interactive books and web-based material that help people to read or learning foreign languages.
- Speech-recognition systems that allow users to provide instructions via spoken commands.
- Speech-output systems that use artificially generated speech
- Natural-language systems that enable users to type in questions and give text-based responses.
- Cognitive aids that help people who find it difficult to read, write, and speak. A number of special interfaces have been developed for people who have problems with reading, writing, and speaking.
- Various input and output devices that allow people with various disabilities to have access to the web and use word processors and other software packages.

Design Implications
- Keep the length of speech-based menus and instructions to a minimum. Research has shown that people find it hard to follow spoken menu with more than three or four options. Likewise, they are bad at remembering sets of instructions and directions that have more than a few parts.
- Accentuate the intonation of artificially generated speech voices, as they are harder to understand than human voices.
- Provide opportunities for making text large on a screen, without affecting the formatting, for people who find it hard to read small text.

10.3 Problem Solving, Planning, Reasoning and Decision-making
Problem solving, planning, reasoning and decision-making are all cognitive processes involving reflective cognition. They include thinking about what to do, what the options are, and what the consequences might be of carrying out a given action. They often involve conscious processing (being aware of what one is thinking about), discussion with others, and the use of various kinds of artifacts, (e.g., maps, books, and pen and paper). For example, when planning the best route to get somewhere, say a foreign city, we may ask others use a map, get instructions from the web, or a combination of these.
Reasoning also involves working through different scenarios and deciding which is the best option or solution to a given problem. In the route-planning activity we may be aware of alternative routes and reason through the advantages and disadvantages of each route before deciding on the best one. Many family arguments have come about because one member thinks he or she knows the best route while another thinks otherwise.
Comparing different sources of information is also common practice when seeking information on the web. For example, just as people will phone around for a range of quotes, so too, will they use different search engines to find sites that give the best deal or best information. If people have knowledge of the pros and cons of different search engines, they may also select different ones for different kinds of queries. For example, a student may use a more academically oriented one when looking for information for writing an essay, and a more commercially based one when trying to find out what’s happening in town.

The extent to which people engage in the various forms of reflective cognition depends on their level of experience with a domain; applications about what to do using other knowledge about similar situations. They tend to act by trial and error, exploring and experimenting with ways of doing things. As a result they may start off being slow, making errors and generally being inefficient. They may also act irrationally, following their superstitions and not thinking ahead to the consequences of their actions. In contrast experts have much more knowledge and experience and are able to select optimal strategies for carrying out their tasks. They are likely to able to think ahead more, considering what the consequences might be of opting for a particular move or solution.

**Reasoning**

Reasoning is the process by which we use the knowledge we have to draw conclusions or infer something new about the domain of interest. There are a number of different types of reasoning:

- Deductive reasoning
- Inductive reasoning
- Abductive reasoning

**Deductive reasoning**

Deductive reasoning derives the logically necessary conclusion from the given premises. For example,

- It is Friday then she will go to work
- It is Friday
- Therefore she will go to work

It is important to note that this is the logical conclusion from the premises; it does not necessarily have to correspond to our notion of truth. So, for example,

- If it is raining then the ground is dry
- It is raining
- Therefore the ground is dry.

Is a perfectly valid deduction, even though it conflicts with our knowledge of what is true in the world?

**Inductive reasoning**

Induction is generalizing from cases we have seen to infer information about cases we have not seen. For example, if every elephant we have ever seen has a trunk, we infer that all elephants have trunks. Of course, this inference is unreliable and cannot be proved to be true; it can only be proved to be false. We can disprove the inference simply by producing an elephant without a trunk. However, we can never prove it true
because, no matter how many elephants with trunks we have seen or are known to exist, the next one we see may be trunkless. The best that we can do is gather evidence to support our inductive inference. In spite of its unreliability, induction is a useful process, which we use constantly in learning about our environment. We can never see all the elephants that have ever lived or will ever live, but we have certain knowledge about elephants, which we are prepared to trust for all practical purposes, which has largely been inferred by induction. Even if we saw an elephant without a trunk, we would be unlikely to move from our position that ‘All elephants have trunk’, since we are better at using positive than negative evidence.

**Abductive reasoning**

The third type of reasoning is abduction. Abduction reasons from a fact to the action or state that caused it. This is the method we use to derive explanations for the events we observe. For example, suppose we know that Sam always drives too fast when she has been drinking. If we see Sam driving too fast we may infer that she has been drinking. Of course, this too is unreliable since there may be another reason why she is driving fast: she may have been called to an emergency, for example.

In spite of its unreliability, it is clear that people do infer explanations in this way and hold onto them until they have evidence to support an alternative theory or explanation. This can lead to problems in using interactive systems. If an event always follows an action, the user will infer that the event is caused by the action unless evidence to the contrary is made available. If, in fact, the event and the action are unrelated, confusion and even error often result.

**Problem solving**

If reasoning is a means of inferring new information from what is already known, problem solving is the process of finding a solution to an unfamiliar task, using the knowledge we have. Human problem solving is characterized by the ability to adapt the information we have to deal with new situations. However, often solutions seen to be original and creative. There are a number of different views of how people solve problems. The earliest, dating back to the first half of the twentieth century, is the Gestalt view that problem solving involves both reuse of knowledge and insight. This has been largely superseded but the questions it was trying to address remain and its influence can be seen in later research. A second major theory, proposed in the 1970s by Newell and Simon, was the problem space theory, which takes the view that the mind is a limited information processor. Later variations on this drew on the earlier theory and attempted to reinterpret Gestalt theory in terms of information-processing theories.

Let us look at these theories.

**Gestalt theory**

Gestalt psychologists were answering the claim, made by behaviorists, that problem solving is a matter of reproducing known responses or trial and error. This explanation was considered by the Gestalt school to be insufficient to account for human problem-solving behavior. Instead, they claimed, problem solving is both productive and reproductive. Reproductive problem solving draws on previous experience as the behaviorist claimed, but productive problem solving involves
insight and restructuring of the problem. Indeed, reproductive problem solving could be hindrance to finding a solution, since a person may ‘fixate’ on the known aspects of the problem and so be unable to see novel interpretations that might lead to a solution.

Although Gestalt theory is attractive in terms of its description of human problem solving, it does not provide sufficient evidence or structure to support its theories. It does not explain when restructuring occurs or what insight is, for example.

**Problem space theory**

Newell and Simon proposed that problem solving centers on the problem space. The problem space comprises problem states, and problem solving involves generating these states using legal state transition operators. The problem has an initial state and a goal state and people use the operator to move from the former to the latter. Such problem spaces may be huge, and so heuristics are employed to select appropriate operators to reach the goal. One such heuristic is means-ends analysis. In means-ends analysis the initial state is compared with the goal state and an operator chosen to reduce the difference between the two. For example, imagine you are recognizing your office and you want to move your desk from the north wall of the room to the window. Your initial state is that the desk is at the north wall. The goal state is that the desk is by the window. The main difference between these two is the location of your desk. You have a number of operators, which you can apply to moving things: you can carry them or push them or drag them, etc. however, you know that to carry something it must be light and that your desk is heavy. You therefore have a new sub-goal: to make the desk light. Your operators for this may involve removing drawers, and so on.

An important feature of Newell and Simon’s model is that it operates within the constraints of the human processing system, and so searching the problem space is limited by capacity of short-term memory, and the speed at which information can be retrieved. Within the problem space framework, experience allows us to solve problems more easily since we can structure the problem space appropriately and choose operators efficiently.

**Analogy in problem solving**

A third element of problem solving is the use of analogy. Here we are interested in how people solve novel problems. One suggestion is that this is done by mapping knowledge relating to a similar known domain to the new problem-called analogical mapping. Similarities between the known domain and the new one are noted and operators from the known domain are transferred to the new one.

This process has been investigated using analogous stories. Gick and Holyoak gave subjects the following problem:

A doctor is treating a malignant tumor. In order to destroy it he needs to blast it with high-intensity rays. However, these will also destroy the healthy tissue, surrounding tumor. If he lessens the ray’s intensity the tumor will remain. How does he destroy the tumor?

The solution to this problem is to fire low-intensity rays from different directions converging on the tumor. That way, the healthy tissue receives harmless low-intensity rays while the tumor receives the rays combined, making a high-intensity does. The investigators found that only 10% of subjects reached this solution without help.
However, this rose to 80% when they were given this analogous story and told that it may help them:
A general is attacking a fortress. He can’t send all his men in together as the roads are mined to explode if large numbers of men cross them. He therefore splits his men into small groups and sends them in on separate roads.
In spite of this, it seems that people often miss analogous information, unless it is semantically close to the problem domain.

Skill acquisition
All of the problem solving that we have considered so far has concentrated on handling unfamiliar problems. However, for much of the time, the problems that we face are not completely new. Instead, we gradually acquire skill in a particular domain area. But how is such skill acquired and what difference does it make to our problem-solving performance? We can gain insight into how skilled behavior works, and how skills are acquired, by considering the difference between novice and expert behavior in given domains.
A commonly studied domain is chess playing. It is particularly suitable since it lends itself easily to representation in terms of problem space theory. The initial state is the opening board position; the goal state is one player checkmating the other; operators to move states are legal moves of chess. It is therefore possible to examine skilled behavior within the context of the problem space theory of problem solving.
In all experiments the behavior of chess masters was compared with less experienced chess players. The first observation was that players did not consider large number of moves in choosing their move, nor did they look ahead more than six moves. Masters considered no more alternatives than the less experienced, but they took less time to make decision and produced better moves.
It appears that chess masters remember board configurations and good moves associated with them. When given actual board positions to remember, masters are much better at reconstructing the board than the less experienced. However, when given random configurations, the groups of players were equally bad at reconstructing the positions. It seems therefore that expert players ‘chunk’ the board configuration in order to hold it in short-term memory. Expert player use larger chunks than the less experienced and can therefore remember more detail.
Another observed difference between skilled and less skilled problem solving is in the way that different problems are grouped. Novices tend to group problems according to superficial characteristics such as the objects or features common to both. Experts, on the other hand, demonstrate a deeper understanding of the problems and group them according to underlying conceptual similarities, which may not be at all obvious from the problem descriptions.
Lecture 11. The Psychology of Actions

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand mental models
- Understand psychology of actions
- Discuss errors.

11.1 Mental model
The concept of mental model has manifested itself in psychology theorizing and HCI research in a multitude of ways. It is difficult to provide a definitive description, because different assumption and constraints are brought to bear on the different phenomena it has been used to explain. A well-known definition, in the context of HCI, is provided by Donald Norman: ‘the model people have of themselves, others, the environment, and the things with which they interact. People form mental models through experience, training and instruction’.

It should be noted that in fact the term mental model was first developed in the early 1640s by Kenneth Craik. He proposed that thinking ‘…models, or parallels reality’: ‘If the organism carries a “small-scale model” of external reality and of its own possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilize the knowledge of past events in dealing with the present and future, and in every way to react in a much fuller, safer, and more competent manner to emergencies which face it.’

Just as an engineer will build scale models of a bridge, in order to test out certain stresses prior to building the real thing, so, too, do we build mental models of the world in order to make predictions about an external event before carrying out an action? Although our construction and use of mental models may not be as extensive or as complete as Craik’s hypothesis suggests, it is likely that most of us can probably recall using a form of mental simulation at some time or other. An important observation of these types of mental models is that they are invariably incomplete, unstable, and easily confusable and are often based on superstition rather than scientific fact.

Within cognitive psychology the term mental model has since been explicated by Johnson-Laird (1983, 1988) with respect to its structure and function in human reasoning and language understanding. In terms of structure of mental models, he argues that mental models are either analogical representations or a combination of analogical and prepositional representations. They are distinct from, but related to images. A mental model represents the relative position of a set of objects in an
analogical manner that parallels the structure of the state of objects in the world. An image also does this, but more specifically in terms of view of a particular model. An important difference between images and mental models is in terms of their function. Mental models are usually constructed when we are required to make an inference or a prediction about a particular state of affairs. In constructing the mental model a conscious mental simulation may be ‘run’ from which conclusions about the predicted state of affairs can be deduced. An image, on the other hand, is considered to be a one-off representation. A simplified analogy is to consider an image to be like a frame in a movie while a mental model is more like a short snippet of a movie. So, after this discussion we can say that while learning and using a system, people develop knowledge of how to use the system and, to a lesser extent, how the system works. These two kinds of knowledge are often referred to as a user’s mental model.

Having developed a mental model of an interactive product, it is assumed that people will use it to make inferences about how to carry out tasks when using the interactive product. Mental models are also used to fathom what to do when something unexpected happens with a system and when encountering unfamiliar systems. The more someone learns about a system and how it functions, the more their mental model develops. For example, TV engineers have a deep mental model of how TVs work that allows them to work out how to fix them. In contrast, an average citizen is likely to have a reasonably good mental model of how to operate a TV but a shallow mental model of how it worked.

To illustrate how we use mental models in our everyday reasoning, imagine the following scenario:

- You arrive home from a holiday on a cold winter’s night to a cold house. You have small baby and you need to get the house warm as quickly as possible. Your house is centrally heated. Do you set the thermostat as high as possible or turn it to the desired temperature (e.g., 70F)?

Most people when asked the questions imagine the scenario in terms of what they would do in their own house they choose the first option. When asked why, a typical explanation that is given is that setting the temperature to be as high as possible increases the rate at which the room warms up. While many people may believe this, it is incorrect.

There are two commonly held folk theories about thermostats: the timer theory and the valve theory. The timer theory proposes that the thermostat simply controls the relative proportion of time that the device stays on. Set the thermostat midway, and the device is on about half the time; set it all the way up and the device is on all the time; hence, to heat or cool something most quickly, set the thermostat so that the device is on all the time. The valve theory proposes that the thermostat controls how much heat comes out of the device. Turn the thermostat all the way up, and you get maximum heating or cooling.

Thermostats work by switching on the heat and keeping it going at a constant speed until the desired temperature set is reached, at which point they cut out. They cannot control the rate at which heat is given out from a heating system. Left a given setting, thermostats will turn the heat on or off as necessary to maintain the desired temperature. It treats the heater, oven, and air conditioner as all-or-nothing devices that can be either fully on or fully off, with no in-between states. The thermostat turns the heater, oven, or air conditioner completely on—at full power—until the temperature setting on the thermostat is reached. Then it turns the unit completely off.
Setting the thermostat at one extreme cannot affect how long it takes to reach the desired temperature.
The real point of the example is not that some people have erroneous theories; it is that everyone forms theories (mental models) to explain what they have observed. In the case of the thermostat the design gives absolutely no hint as to the correct answer. In the absence of external information, people are free to let their imaginations run free as long as the mental models they develop account for the facts as they perceive them.

**Why do people use erroneous mental models?**

It seems that in the above scenario, they are running a mental model based on general valve theory of the way something works. This assumes the underlying principle of “more is more”: the more you turn or push something, the more it causes the desired effect. This principle holds for a range of physical devices, such as taps and radio controls, where the more you turn them, the more water or volume is given. However, it does not hold for thermostats, which instead function based on the principle of an on-off switch. What seems to happen is that in everyday life people develop a core set of abstractions about how things work, and apply these to a range of devices, irrespective of whether they are appropriate.

Using incorrect mental models to guide behavior is surprisingly common. Just watch people at a pedestrian crossing or waiting for an elevator (lift). How many times do they press the button? A lot of people will press it at least twice. When asked why, a common reason given is that they think it will make it lights change faster or ensure the elevator arrives. This seems to do another example of following the “more is more” philosophy: it is believed that the more times you press the button, the more likely it is to result in the desired effect.

Another common example of an erroneous mental model is what people do when the cursor freeze on their computer screen. Most people will bash away at all manner of keys in the vain hope that this will make it work again. However, ask them how this will help and their explanations are rather vague. The same is true when the TV starts acting up: a typical response is to hit the top of the box repeatedly with a bare hand or a rolled-up newspaper. Again, as people why and their reasoning about how this behavior will help solve the problem is rather lacking.

Indeed, research has shown that people’s mental models of the way interactive devices work is poor, often being incomplete, easily confusable, based on inappropriate analogies, and superstition. Not having appropriate mental models available to guide their behavior is what caused people to become very frustrated—often resulting in stereotypical “venting” behavior like those described above.

On the other hand, if people could develop better mental models of interactive systems, they would be in a better position to know how to carry out their tasks efficiently and what to do if the system started acting up. Ideally, they should be able to develop a mental model that matches the conceptual; modal developed by the designer. But how can you help users to accomplish this? One suggestion is to educate them better, however, many people are resistant to spending much time learning about how things work, especially if it involves reading manuals and other documentation. An alternative proposal is to design systems to be more transparent, so that they are easier to understand.

People do tend to find causes for events, and just what they assign as the cause varies. In part people tend to assign a causal relation whenever two things occur in
succession. If I do some action A just prior to some result R, then I conclude that A must have caused R, even if, there really was no relationship between the two.

**Self-blaming**

Suppose I try to use an everyday thing, but I can’t: where is the fault, in my action or in the thing? We are apt to blame ourselves. If we believe that others are able to use the device and if we believe that it is not very complex, then we conclude that any difficulties must be our own fault. Suppose the fault really lies in the device, so that lots of people have the same problems. Because everyone perceives the fault to be his or own, nobody wants to admit to having trouble. This creates a conspiracy of silence, maintaining the feeling of guilt and helplessness among users.

Interestingly enough, the common tendency to blame ourselves for failures with everyday objects goes against the normal attributions people make. In general, it has been found that normal attribute their own problems to the environment, those of other people to their personalities.

It seems natural for people to blame their own misfortunes on the environment. It seems equally natural to blame other people’s misfortunes on their personalities. Just the opposite attribution, by the way, is made when things go well. When things go right, people credit their own forceful personalities and intelligence. The onlookers do the reverse. When they see things go well for someone else, they credit the environment.

In all cases, whether a person is inappropriately accepting blame for the inability to work simple objects or attributing behavior to environment or personality, a faulty mental model is at work.

**Reason for self-blaming**

**Learned helplessness**

The phenomenon called learned helplessness might help explain the self-blame. It refers to the situation in which people experience failure at a task, often numerous times. As a result, they decide that the task cannot be done, at least not by them: they are helpless. They stop trying. If this feeling covers a group of tasks, the result can be severe difficulties coping with life. In the extreme case, such learned helplessness leads to depression and to a belief that the person cannot cope with everyday life at all. Some times all that it takes to get such a feeling of helplessness is a few experiences that accidentally turn out bad. The phenomenon has been most frequently studied as a precursor to the clinical problem of depression, but it might easily arise with a few bad experiences with everyday life.

**Taught helplessness**

Do the common technology and mathematics phobias results from a kind of learned helplessness? Could a few instances of failure in what appear to be straightforward situations generalize to every technological object, every mathematics problem? Perhaps. In fact, the design of everyday things seems almost guaranteed to cause this. We could call this phenomenon taught helplessness.

With badly designed objects—constructed so as to lead to misunderstanding—faulty mental models, and poor feedback, no wonder people feel guilty when they have trouble using objects, especially when they perceive that nobody else is having the
same problems. The problem is that once failure starts, it soon generalizes by self-blame to all technology. The vicious cycle starts: if you fail at something, you think it is your fault. Therefore you think you can’t do that task. As a result, next time you have to do the task, you believe you can’t so you don’t even try. The result is that you can’t, just as you thought. You are trapped in a self-fulfilling prophecy.

The nature of human thought and explanation
It isn’t always easy to tell just where the blame for problem should be placed. A number of dramatic accidents have come about, in part, from the false assessment of blame in a situation. Highly skilled, well-trained people are using complex equipment when suddenly something goes wrong. They have to figure out what the problem is. Most industrial equipment is pretty reliable. When the instruments indicate that something is wrong, one has to consider the possibility that the instruments themselves are wrong. Often this is the correct assessment. When operators mistakenly blame the instruments for an actual equipment failure, the situation is ripe for a major accident.

It is spectacularly easy to find examples of false assessment in industrial accidents. Analysts come in well after the fact, knowing what actually did happen; with hindsight, it is almost impossible to understand how the people involved could have made the mistake. But from the point of view of the person making decisions at time, the sequence of events is quite natural.

Three Mile Island Nuclear Power Plant
At the Three Mile Island nuclear power plant, operators pushed a button to close a valve; the valve had been opened (properly) to allow excess water to escape from the nuclear core. In fact, the valve was deficient, so it didn’t close. But a light on the control panel indicated that the valve position was closed. The light actually didn’t monitor the valve, only the electrical signal to the valve, a fact known by the operators. Still, why suspect a problem? The operators did look at the temperature in the pipe leading from the valve: it was high, indicating that fluid was still flowing through the closed valve. Ah, but the operators knew that the valve had been leaky, so the leak would explain the high temperature; but the leak was known to be small, and operators assumed that it wouldn’t affect the main operation. They were wrong, and the water that was able to escape from the core added significantly to the problems of that nuclear disaster. Norman says that the operators’ assessment was perfectly reasonable: the fault was in the design of the lights and in the equipment that gave false evidence of a closed valve.

Lockheed L-1011
Similarly many airline accidents happened just due to misinterpretations. Consider flight crew of the Lockheed L-1011 flying from Miami, Florida, to Nassau, Bahamas. The plane was over the Atlantic Ocean, about 110 miles from Miami, when the low oil pressure light for one of the three engines went on. The crew turned off the engine and turned around to go back to Miami. Eight minutes later, the low-pressure lights for the remaining two engines also went on, and the instruments showed zero oil pressure and quantity in all three engines. What did the crew do now? They didn’t believe it! After all, the pilot correctly said later, the likelihood of simultaneous oil exhaustion in all three engines was “one in millions I would think.” At the time, sitting in the airplane, simultaneous failure did seem most unlikely. Even the National
Transportation Safety Board declared, “The analysis of the situation by the flight crew was logical, and was what most pilots probably would have done if confronted by the same situation.”

What happened? The second and third engines were indeed out of oil, and they failed. So there were no operating engines: one had been turned off when its gauge registered low, the other two had failed. The pilots prepared the plane for an emergency landing on the water. The pilots were too busy to instruct the flight crew properly, so the passengers were not prepared. There was semi-hysteria in the passenger cabin. At the last minute, just as the plane was about to ditch in the ocean, the pilots managed to restart the first engine and land safely to Miami. Then that engine failed at the end of the runway.

Why did all three engine fail? Three missing O-rings, one missing from each of three oil plugs, allowed all the oil to seep out. The O-rings were put in by two different people who worked on the three engines (one for the two plugs on the wings, the other of the plug on the tail). How did both workers make the same mistake? Because the normal method by which they got the oil plugs had been changed that day. The whole tale is very instructive, for there were four major failures of different sorts, from the omission of the O-rings, to the inadequacy of the maintenance procedures, to the false assessment of the problem, to the poor handling of the passengers. Fortunately nobody was injured. The analysts of the National Transportation Safety Board got to write a fascinating report.

Find an explanation, and we are happy. But our explanations are based on analogy with past experience, experience that may not apply in the current situation. In the Three Mile Island incident, past experience with the leaky valve explained away the discrepant temperature reading; on the flight from Miami to Nassau, the pilots’ lack of experience with simultaneous oil pressure failure triggered their belief that the instruments must be faulty. Once we have an explanation—correct or incorrect—for otherwise discrepant or puzzling events, there is no more puzzle, no more discrepancy. As a result, we are complacent, at least for a while.

**How people do things**

To get something done, you have to start with some notion of what is wanted—the goal that is to be achieved. Then, you have to do some thing to the world, that is, take action to move yourself or manipulate someone or something. Finally, you check to see that your goal was made. So there are four different things to consider: the goal, what is done to the world, the world itself, and the check of the world. The action itself has two major aspects: doing something and checking. Call these execution and evaluation. Goals do not state precisely what to do—where and how to move, what to pick up. To lead to actions goals must be transformed into specific statements of what is to be done, statements that are called intentions. A goal is some thing to be achieved, often vaguely stated. An intention is specific action taken to get to the goal. Yet even intentions are not specific enough to control actions.

Suppose I am sitting in my armchair, reading a book. It is dust, and the light has gotten dimmer and dimmer. I decide to need more light (that is the goal: get more light). My goal has to be translated into the intention that states the appropriate action in the world: push the switch button on the lamp. There’s more: I need to specify how to move my body, how to stretch to reach the light switch, how to extend my finger to push the button (without knocking over the lamp). The goal has to be translated into an intention, which in turn has to make into a specific action sequence, one that can
control my muscles. Note that I could satisfy my goal with other action sequences, other intentions. If some one walked into the room and passed by the lamp, I might alter my intention from pushing the switch button to asking the other person to do it for me. The goal hasn’t changed, but the intention and resulting action sequence have.

**Action Cycle**

Human action has two aspects, execution and evaluation. Execution involves doing something. Evaluation is the comparison of what happened in the world with what we wanted to happen.

**Stages of Execution**

Start at the top with the goal, the state that is to be achieved. The goal is translated into an intention to do some action. The intention must be translated into a set of internal commands, an action sequence that can be performed to satisfy the intention. The action sequence is still a mental event: nothing happens until it is executed, performed upon the world.

**Stages of Evaluation**

Evaluation starts with our perception of the world. This perception must then be interpreted according to our expectations and then compared with respect to both our intentions and our goals.

**Seven stages of action**

The stages of execution (intentions, action sequence, and execution) are coupled with the stages of evaluation (perception, interpretation, and evaluation), with goals common to both stages.

**11.2 Errors**

Human capability for interpreting and manipulating information is quite impressive. However, we do make mistakes. Whenever we try to learn a new skill, be it skiing, typing, cooking or playing chess, we are bound to make mistakes. Some are trivial, resulting in no more than temporary inconvenience or annoyance. Other may be more serious, requiring substantial effort to correct. In most situations it is not such a bad thing because the feedback from making errors can help us to learn and understand an activity. When learning to use a computer system, however, learners are often frightened of making errors because, as
well as making them feel stupid, they think it can result in catastrophe. Hence, the anticipation of making an error and its consequences can hinder a user’s interaction with a system.

Why do we make mistakes and can we avoid them? In order to answer the latter part of the question we must first look at what is going on when we make an error. There are several different types of errors. Some errors result from changes in the context of skilled behavior. If a pattern of behavior has become automatic and we change some aspect of it, the more familiar pattern may break through and cause an error. A familiar example of this is where we intend to stop at the shop on the way home from work but in fact drive past. Here, the activity of driving home is the more familiar and overrides the less familiar intention.

Other errors result from an incorrect understanding, or model, of a situation or system. People build their own theories to understand the casual behavior of systems. These have been termed mental models. They have a number of characteristics. Mental models are often partial: the person does not have a full understanding of the working of the whole system. They are unstable and are subject to change. They can be internally inconsistent, since the person may not have worked through the logical consequences of their beliefs. They are often unscientific and may be based on superstition rather than evidence. Often they are based on an incorrect interpretation of the evidence.

A classification of errors
There are various types of errors. Norman has categorized them into two main types, slips and mistakes:

Mistakes
Mistakes occur through conscious deliberation. An incorrect action is taken based on an incorrect decision. For example, trying to throw the icon of the hard disk into the wastebasket, in the desktop metaphor, as a way of removing all existing files from the disk is a mistake. A menu option to erase the disk is appropriate action.

Slips
Slips are unintentional. They happen by accident, such as making typos by pressing the wrong key or selecting wrong menu item by overshooting. The most frequent errors are slips, especially in well-learned behavior.
Lecture 12. Design Principles

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Understand conceptual models
- Discuss design principles

Conceptual Model
“The most important thing to design is the user’s conceptual model. Every thing else should be subordinated to making that model clear, obvious, and substantial. That is almost exactly the opposite of how most software is designed.” (David Liddle)

By a conceptual model is meant:
A description of the proposed system in terms of a set of integrated ideas and concepts about what it should do, behave and look like, that will be understandable by the users in the manner intended.

To develop a conceptual model involves envisioning the proposed product, based on the user’s needs and other requirements identified. To ensure that it is designed to be understandable in the manner intended requires doing iterative testing of the product as it is developed.

A key aspect of this design process is initially to decide what the user will be doing when carrying out their tasks. For example, will they be primarily searching for information, creating documents, communicating with other users, recording events, or some other activity? At this stage, the interaction mode that would best support this need to be considered. For example, would allowing the users to browse be appropriate, or would allowing them to ask questions directly to the system in their native language be more affective? Decision about which kind of interaction style use (e.g., whether to use a menu-based system, speech inputs, commands) should be made in relation to the interaction mode. Thus, decision about which mode of interaction to support differ from those made about which style of interaction to have; the former being at a higher level of abstraction. The former are also concerned with determining the nature of the users’ activities to support, while the later are concerned with the selection of specific kinds of interface.

Once a set of possible ways of interacting with interactive system has been identified, the design of the conceptual modal then needs to be thought through in term of actual concrete solution. This entail working out the behavior of the inter face, the particular interaction style that will be used, and the “look and feel” of the interface. At this stage of “fleshing out,” it is always a good idea to explore a number of possible designs and to assess the merits and problems of each one.
Another way of designing an appropriate conceptual model is to interface metaphor. This can provide a basic structure for the conceptual model that is couched in knowledge users are familiar with. Examples of well-known interface metaphors are the desktop and search engines.

Software has a behavioral face it shows to the world that is created by the programmer or designer. This representation is not necessarily an accurate description of what is really going on inside the computer, although unfortunately, it frequently is. This ability to represent the computer functioning independent of its true actions is far more pronounced in software than in any other medium. It allows a clever designer to hide some of the more unsavory facts of how the software is really getting the job done. This disconnection between what is implemented and what it offered as explanation gives rise to a third model in the digital world, the designer’s represented model—the way the designer chooses to represent a program’s functioning to the user. Donald Norman refers to this simply as the designer’s model.

In the world of software, a program’s represented model can be quite different from the actual processing structure of the program. For example, an operating system can make a network file server look as though it were a local disk. The model does not represent the fact that the physical disk drive may be miles away. This concept of the represented model has no widespread counterpart in the mechanical world. The representation between the three models is shown in Figure.

The closer the represented model comes to the user’s mental model, the easier he will find the program to use and to understand. Generally, offering a represented model that follows the implementation model too closely significantly reduces the user’s ability to learn and use the program, assuming that the user’s mental model of his tasks differs from the implementation model of the software.

We tend to form mental models that are simpler than reality; so if we create represented models that are simpler than the actual implementation model, we help the user achieve a better understanding. Pressing the brake pedal in your car, for example, may conjure a mental image of pushing a lever that rubs against the wheels to slow you down. The actual mechanism includes hydraulic cylinders, tubing, and metal pads that squeeze on a perforated disk, but we simplify all that out of our minds, creating a more effective, albeit less accurate, mental model. In software, we imagine that a spreadsheet scrolls now cells into view when we click on the scrollbar. Nothing of the sort actually happens. There is no sheet of cells out there, but a tightly packed data structure of values, with various pointers between them, from which the program synthesizes a new image to display in real-time.
Another important thing is that there are several gulfs that separate mental states from physical ones. Each gulf reflects one aspect of the distance between the mental representation of the person and the physical components and states of the environment. And these gulfs present major problems for users.

The Gulf of Execution
Does the system provide actions that correspond to the intentions of the person? The difference between the intentions and allowable actions is the gulf of execution. One measure of this gulf is how well the system allows the person to do the intended actions directly, without extra effort: do the action provided by the system match those intended by the person?

The Gulf of Evaluation
Does the system provide a physical representation that can be directly perceived and that is directly interpretable in terms of the intentions and expectations of the person? The Gulf of evaluation reflects the amount of effort that the person must exert to interpret the physical state of the system and to determine how well the expectations and intentions have been met. The gulf is small when the system provides information about its state in a form that is easy to get, is easy to interpret, and matches the way the person thinks of the system.

The Seven Stages of Action as Design aids
The seven-stage structure can be a valuable design aid, for it provides a basic checklist of questions to ask to ensure that the Gulfs of evaluation and execution are bridged. In general each stage of action requires its own special design strategies and, in turn, provides its own opportunity for disaster. It would be fun were it not also so frustrating, to look over the world and gleefully analyze each deficiency. On the whole, as you can see in figure the questions for each stage are relatively simple. And these, in turn, boil down to the principles of good design. Principles of good design are discussed bellow.

12.1 Design Principles
A number of design principles have been promoted. The best known are concerned with how to determine what users should see and do when carrying out their tasks using an interactive product. Here we briefly describe the most common ones

- Visibility
- Affordance
- Constraints
• Mapping
• Consistency
• Feedback

Visibility
The more visible functions are, the more likely users will be able to know what to do next. In contrast, when functions are “out of sight,” it makes them more difficult to find and knows how to use. Norman describes the controls of a car to emphasize this point. The controls for different operations are clearly visible (e.g., indicator, headlights, horn, hazard warning lights), indicating what can be done. The relationship between the way the controls have been positioned in the car and what they do makes it easy for the deriver to find the appropriate control for the task at hand. For example, one problem that I often encounter, in word processing software I often needed to set the properties of a word document. For this logically option of properties should be in the File menu, and I have often seen it there. But once, I opened the file menu I could not find it there, I was confused. Look at the figure.

In confusion, I looked through all the menus but in vain. At last, surprisingly I was again looking at the file menu when I noticed the arrow at the bottom of the menu, when I clicked on that I was able to see that option again on the menu. Look at the figure bellow.
Affordance

Affordance is a term used to refer to an attribute of an object that allows people to know how to use it. For example, a mouse button invites pushing by the way it is physically constrained in its plastic shell. At a very simple level, to afford means “to give a clue.” When the affordances of a physical object are perceptually obvious it is easy to know how to interact with it. For example, a door handle affords pulling, a cup handle affords grasping, and a mouse button affords pushing. Norman introduced this concept in the late 80s in his discussion of the design of everyday objects. Since then, it has been much popularized, being what can be done to them. For example, graphical elements like button, icon, links, and scroll bars are talked about with respect to how to make it appear obvious how they should be used: icons should be designed to afford clicking, scroll bars to afford moving up and down, buttons to afford pushing.

There are two kinds of affordance:

- Perceived
- Real

Real

Physical objects are said to have real affordances, like grasping, that are perceptually obvious and do not have to be learned.
Perceived
User interfaces that are screen-based are virtual and do not make sense to try to design for real affordances at the interface—except when designing physical devices, like control consoles, where affordance like pulling and pressing are helpful in guiding the user to know what to do. Alternatively screen based interfaces are better conceptualized as perceived affordances, which are essentially learned conventions.

Constraints
The design concept of constraining refers to determining ways of restricting the kind of user interaction that can take place at a given moment. There are various ways this can be achieved. A common design practice in graphical user interfaces is to deactivate certain menu options by shading them, thereby restricting the user to only actions permissible at that stage of the activity. One of the advantages of this form of constraining is it prevents the user from selecting incorrect options and thereby refuses the chances of making a mistake. The use of different kinds of graphical representations can also constrain a person’s interpretation of a problem or information space. For example flow chart diagram show which objects are related to which thereby constraining the way the information can be perceived.

Norman classified constraints into three categories: physical, logical, and cultural.

Physical constraints
Physical constraints refer to the way physical objects restrict the movement of things. For example, the way a external disk can be placed into a disk drive is physically constrained by its shape and size, so that it can be inserted in only one way. Likewise, keys on a pad can usually be pressed in only one way.

Logical constraints
Logical constraints rely on people’s understanding of the way the world works. They rely on people’s common-sense reasoning about actions and their consequences. Picking up a physical marble and placing it in another location on the phone would be expected by most people to trigger something else to happen. Making actions and their effects obvious enables people to logically deduce what further actions are required. Disabling menu options when not appropriate for the task in hand provides logical constraining. It allows users to reason why (or why not) they have been designed this way and what options are available.

Culture constraints
Culture constraints rely on learned conventions, like the use of red for warning, the use of certain kinds of signals for danger, and the use of the smiley face to represent happy emotions. Most cultural constraints are arbitrary in the sense that their relationship with what is being represented is abstract, and could have equally evolved to be represented in another form (e.g., the use of yellow instead of red for warning). Accordingly, they have to be learned. Once learned and accepted by a cultural group, they become universally accepted conventions. Two universally accepted interface conventions are the use of windowing for displaying information and the use icons on the desktop to represent operations and documents.
Mapping

This refers to the relationship between controls and their effects in the world. Nearly all artifacts need some kind of mapping between controls and effects, whether it is a flashlight, car, power plant, or cockpit. An example of a good mapping between controls are effect is the up and down arrows used to represent the up and down movement of the cursor, respectively, on a computer keyboard. The mapping of the relative position of controls and their effects is also important. Consider the various musical playing devices. How are the controls of playing rewinding, and fast forward mapped onto the desired effects? They usually follow a common convention of providing a sequence of buttons, with the play button in the middle, the rewind button on the left and the fast-forward on the right. This configuration maps directly onto the directionality of the actions.

Imagine how difficult it would be if the mapping in figure (a) were used.
Consistency
This refers to designing interfaces to have similar operations and use similar elements for achieving similar tasks. In particular, a consistent interface is one that follows rules, such as using the same operation to select all objects. For example, a consistent operation is using the same input action to highlight any graphical object at the interfaces, such as always clicking the left mouse button. Inconsistent interfaces, on the other hand, allow exceptions to a rule. An example of this is where certain graphical objects (e.g., email messages presented in a table) can be highlighted using the right mouse button, while all other operations are highlighted using the left button. A problem with this kind of inconsistency is that is quite arbitrary, making it difficult for users to remember and making the users more prone to mistakes.

On of the benefits of consistent interfaces, therefore, is that they are easier to learn and use. Users have to learn only a single mode of operation that is applicable to all objects. This principle worked well for simple interfaces with limited operations, like mini CD player with small number of operations mapped onto separate buttons. Here all the user has to do is learn what each button represents and select accordingly. However, it can be more problematic to apply the concept of consistency to more complex interfaces, especially when many different operations need to be designed for. For example, consider how to design an interface for an application that offers hundreds of operations. There is simply not enough space for a thousand buttons, each of which maps onto an individual operation. Even if there were, it would be extremely difficult and time consuming for the user to search through them all to find the desired operation.

A much more effective design solution is to create categories of commands that can be mapped into subsets of operations. For the word-processing application, the hundreds of operation available are categorized into subsets of different menus. All commands that are concerned with file operations are placed together in the same file menu.

Another problem with consistency is determining what aspect of an interface to make consistent with what else. There are often many choices, some of which can be inconsistent with other aspects of the interface or ways of carrying out actions. Consider the design problem of developing a mechanism to let users lock their files on a shared server. Should the designer try to design it to be consistent with the way people lock things in the outside world (called external consistency) or with the way they lock objects in the existing system (called internal consistency)? However, there are many different ways of locking objects in the physical world (e.g., placing in a safe, using a padlock, using a key, using a child safety lock), just as there are different ways of locking electronically. The problem facing designer is knowing which one to be consistent with.

Feedback
Related to the concept of visibility is feedback. This is best illustrated by an analogy to what everyday life would be like without it. Imagine trying to play a guitar, slice bread using knife, or write a pen if none of the actions produced any effect for several seconds. There would be an unbearable delay before the music was produced, the bread was cut, or the words appeared on the paper, making it almost impossible for the person to continue with the next strum, saw, or stroke.
Feedback is about sending back information about what action has been done and what has been accomplished, allowing the person to continue with the activity. Various kinds of feedback are available for interaction design—audio, tactile, verbal, visual, and combinations of these. Deciding which combinations are appropriate for different kinds of activities and interactivities is central. Using feedback in the right way can also provide the necessary visibility for user interaction.
Lecture 13. The Computer

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Describe the advantages and disadvantages of different input output devices keeping in view different aspects of HCI

In previous lectures our topics of discussion were covering the human aspects. From now we will pay some attention towards computers. We will study some computer aspects. You may have studied many of them before in any other course, but that are also part of our discussion, as at one side of our subject is human and at the other side computer lies.

Today will look at some input and output devices of computer. Let us fist look at input devices.

13.1 Input devices
Input is concerned with recording and entering data into computer system and issuing instruction to the computer. In order to interact with computer systems effectively, users must be able to communicate their interaction in such a way that the machine can interpret them. Therefore, input devices can be defined as: a device that, together with appropriate software, transforms information from the user into data that a computer application can process.

One of the key aims in selecting an input device and deciding how it will be used to control events in the system is to help users to carry out their work safely, effectively, efficiently and, if possible, to also make it enjoyable. The choice of input device should contribute as positively as possible to the usability of the system. In general, the most appropriate input device will be the one that:

- Matches the physiology and psychological characteristics of users, their training and their expertise. For example, older adults may be hampered by conditions such as arthritis and may be unable to type; inexperienced users may be unfamiliar with keyboard layout.
- Is appropriate for the tasks that are to be performed. For example, a drawing task from a list requires an input device that allows continuous movement; selecting an option from a list requires an input device that permits discrete movement.
- Is suitable for the intended work and environment. For example, speech input is useful where there is no surface on which to put a keyboard but is unsuitable
in noisy condition; automatic scanning is suitable if there is a large amount of
data to be generated.

Frequently the demands of the input device are conflicting, and no single optimal
device can be identified: trade-offs usually have to be made between desirable and
undesirable features in any given situation. Furthermore, many systems will use two
or more input devices together, such as a keyboard and a mouse, so the devices must
be complementary and well coordinated. This means that not only must an input
device be easy to use and the form of input be straightforward, there must also be
adequate and appropriate system feedback to guide, reassure, inform and if necessary,
correct user’s errors. This feedback can take various forms. It can be a visual display
screen: a piece of text appears, an icon expands into a window, a cursor moves across
the screen or a complete change of screen presentation occurs. It can be auditory: an
alarm warning, a spoken comment or some other audible clue such as the sound of
keys clicking when hit. It can be tactile: using a joystick. In many cases feedback
from input can be a combination of visual, auditory and tactile responses. For
example, when selecting an icon on a screen, the tactile feedback from the mouse
button or function keys will tell users that they instructed the system to activate the
icon. Simultaneously, visual feedback will show the icon changing shape on the
screen. This is coordinated with the sound of the button clicking or the feel of the key
resisting further pressure. Let us now discuss various types of devices in terms of their
common characteristics and the factors that need to be considered when selecting an
input device. We will discuss text entry devices first.

13.2 Text entry devices

There are many text entry devices as given below:

Keyboard

The most common method of entering information into the computer is through a
keyboard. Since you have probably used them a lot without perhaps thinking about
the related design issue, thinking about keyboards is a convenient starting point for
considering input design issue. Broadly defined, a keyboard is a group of on—off
push button, which are used either in combination or separately. Such a device is a
discrete entry device. These devices involve sensing essentially one of two or more
discrete positions (for example, keys on keyboards, touch-sensitive switches and
buttons), which are either on or off, whereas others (for example, pens with digitizing
tables, moving joysticks, roller balls and sliders) involve sensing in a continuous
range. Devices in this second category are therefore, known as continuous entry
devices.

When considering the design of keyboards, both individual keys and grouping
arrangements need to be considered. The physical design of keys is obviously
important. For example, of keys are too small this may cause difficulty in locating and
hitting chosen keys accurately. Some calculators seeking extreme miniaturization and
some modern telephones suffer from this. Some keyboards use electro mechanical
switches, while others use sealed, flat membrane keyboards. When pressing a key on
a membrane keyboard, unless appropriate feedback is given on screen, or using sound
it may be difficult to tell which key, if any, has been presses. On the other hand,
membrane keyboards can typically withstand grease, dirt and liquids that would soon
clog up typical electromechanical switches. This can be an important consideration in environments such as production floors, farm and public places.

Alterations in the arrangement of the keys can affect a user’s speed and accuracy. Various studies have shown that typing involves a great deal of analyses of trained typists suggest that typing is not a sequential act, with each key being sought out and pressed as the letters occur in the works to be typed. Rather, the typist looks ahead, processes text in chunks, and then types it in chunks. For alphabetic text these chunks are about two to three world long for numerical material they are three to four characters long. The effect is to increase the typing speed significantly.

**QWERTY keyboard**

Most people are quite familiar with the layout of the standard alphanumeric keyboard, often called the qwerty keyboard, the name being derived from the first letters in the upper most row from left to center. This design first became a commercial success when used for typewriters in the USA in 1874, after many different prototypes had been tested. The arrangement of keys was chosen in order to reduce the incidence of keys jamming in the manual typewriters of the time rather than because of any optimal arrangement for typing. For example, the letters ‘s’, ,t, and ‘h’ are far apart even though they are far apart even though they are frequently used together.

**Alphabetic keyboard**

One of the most obvious layouts to be produced is the alphabetic keyboard, in which the letters are arranged alphabetically across the keyboard. It might be expected that such a layout would make it quicker for untrained typists to use, but this is not the case. Studies have shown that this keyboard is not faster for properly trained typists, as we may expect, since there is no inherent advantage to this layout. And even for novice or occasional users, the alphabetic layout appears to make very little difference to the speed of typing. These keyboards are used in some pocket electronic personal organizers, perhaps because the layout looks simpler to use than the QWERTY one. Also, it dissuades people from attempting to use their touch-typing skills on a very small keyboard and hence avoids criticisms of difficulty of use.

**Dvorak Keyboard**

With the advent of electric and electronic keyboards and the elimination of levered hammers such considerations are no longer necessary. Attempts at designing alternative keyboards that are more efficient and quicker to use have produced, among others, the Dvorak and Alphabetic boards. The Dvorak board, first patented in 1932, was designed using the following principles:

- Layout is arranged on the basis of frequency of usage of letters and the frequency of letter pattern and sequences in the English language.
- All vowels and the most frequently used consonants are on the second or home row, so that something like 70% of common words are typed on this row alone.
- Faster operation is made possible by tapping with fingers on alternate hands (particularly the index fingers) rather than by repetitive tapping with one finger and having the majority of keying assigned to one hand, as in the QWERTY keyboard, which favors left-handers. Since the probability of vowels and consonants altering is very high, all vowels are typed with the left hand and frequent home row consonants with the right.
The improvements made by such as ergonomic design are a significant reduction in finger travel and consequent fatigue and a probable increase in accuracy. Dvorak also claimed that this arrangement reduces the between-row movement by 90% and allows 35% of all words normally used to be typed on the home row. Despite its significant benefits, the dvorak layout, shown in figure has never been commercially successful. The possible gain in input speed has to be weighed against the cost of replacing existing keyboards and retraining millions of people who have learned the QWERTY keyboard.

**Chord keyboards**

In chord keyboards several keys must be pressed at once in order to enter a single character. This is a bit like playing a flute, where several keys must be pressed to produce with a small number of keys, few keys are required, so chord keyboards can be very small, and many can be operated with just one hand. Training is required to learn the finger combination required to use a chord keyboard. They can be very useful where space is very limited, or where one hand is involved in some other task. Training is required to learn the finger combinations required to use a chord keyboard. They can be very useful where space is very limited, or where one hand is involved in some other task. Chord keyboards are also used for mail sorting and a form of keyboard is used for recording transcripts of proceeding in law courts.

**Special keyboards**

Some keyboards are even made of touch-sensitive buttons, which require a light touch and practically no travel; they often appear as a sheet of plastic with the buttons printed on them. Such keyboards are often found on shop till, though the keys are not QWERTY, but specific to the task. Being fully sealed, they have the advantage of being easily cleaned and resistant to dirty environment, but have little feel, and are not popular with trained touch-typists. Feedback is important even at this level of human-computer interaction! With the recent increase of repetitive strain injury (RSI) to
users’ finger, and the increased responsibilities of employers in these circumstances, it may be that such designs will enjoy resurgence in the near future. The tendons that control the movement of the fingers becoming inflamed owing to overuse cause RSI in fingers and making repeated unnatural movement.

There are very verities of specially shaped keyboards to relieve the strain of typing or to allow people to type with some injury or disability. These may slope the keys towards the hands to improve the ergonomics position, be designed for single-handed use, or for no hands at all. Some use bespoke key layouts to reduce strain of finger movements. The keyboard illustrated is produced by PCD Maltron Ltd. for left-handed use.

**Phone pad and T9 entry**

With mobile phones being used for SMS text messaging and WAP, the phone keypad has become an important form of text input. Unfortunately a phone only has digits 0-9, not a full alphanumeric keyboard.

To overcome this for text input the numeric keys are usually pressed several times. Figure shows a typical mapping of digits to letters. For example, the 3 keys have ‘def’ on it. If you press the key once you get a ‘d’, if you press 3 twice you get an ‘e’, and if you press it three times you get an ‘f’. The main number-to-letter mapping is standard, but punctuation and accented letters differ between phones. Also there needs to be a way for the phone to distinguish, say, the ‘dd’ from ‘e’. on some phones you need to pause for short period between successive letters using the same key, for others you press an additional key (e.g. ‘#’).

Most phones have at least two modes for the numeric buttons: one where the keys mean the digits (for example when entering a phone number) and one where they mean letters (for example when typing an SMS message). Some have additional modes to make entering accented characters easier. Also a special mode or setting is needed for capital letters although many phones use rules to reduce this, for example automatically capitalizing the initial letter in a message and letters following full stops, question marks and exclamation marks.

This is all very laborious but you can see experienced mobile users make use of highly developed shorthand to reduce the number of keystrokes. If you watch a teenager or other experienced txt-er, you will see they often develop great typing speed holding the phone in one hand and using only their thumb. As these skills spread through society it may be that future devices use this as a means of small format text input. For those who never develop this physical dexterity some phones have tiny plug-in keyboards, or come with foldout keyboards.

Another technical solution to the problem is the T9 algorithm. This uses a large dictionary to disambiguate words by simply typing the relevant letters once. For example, ‘3926753’ becomes ‘example’ as there is only one word with letters that match (alternative like ‘ewbosld’ that also match are not real words). Where there are ambiguities such as ‘26’, which could be an ‘am’ or an ‘an’, the phone gives a series of option to choose from.

**Handwriting recognition**

Handwriting is a common and familiar activity, and is therefore attractive as a method of text entry. If we were able to write as we would when we use paper, but with the computer taking this form of input and converting it to text, we can see that it is an intuitive and simple way of interacting with the computer. However, there are a
The different nature of handwriting means that we may find it more useful in situation where a keyboard-based approach would have its own problems. Such situation will invariably result in completely new systems being designed around the handwriting recognizer as the predominant mode of textural input, and these may bear very little resemblance to the typical system. Pen-based systems that use handwriting recognition are actively marked in the mobile computing market, especially for smaller pocket organizers. Such machines are typically used for taking notes and jotting down and sketching ideas, as well as acting as a diary, address book and organizer. Using handwriting recognition has many advantages over using a keyboard. A pen-based system can be small and yet still accurate and easy to use, whereas small keys become very tiring, or even impossible, to use accurately. Also the pen-based approach does not have to be altered when we move from jotting down text to sketching diagrams; pen-based input is highly appropriate for this also. Some organizer designs have dispensed with a keyboard completely. With such systems one must consider all sorts of other ways to interact with the system that are not character based. For example, we may decide to use gesture recognition, rather than commands, to tell the system what to do, for example, drawing a line through a word in order to delete it. The important point is that a different input device that was initially considered simply as an alternative to the keyboard opens up a whole host of alternative designs and different possibilities for interaction.

Speech recognition

Speech recognition is a promising area of text entry, but it has been promising for a number of years and is still only used in very limited situations. However, speech input suggests a number of advantages over other input methods:

- Since speech is a natural form of communication, training new users is much easier than with other input devices.
- Since speech input does not require the use of hands or other limbs, it enables operators to carry out other actions and to move around more freely.
- Speech input offers disabled people such as the blind and those with severe motor impairment the opportunities to use new technology.

However, speech input suffers from a number of problems:

- Speech input has been applied only in very specialized and highly constrained tasks.
• Speech recognizers have severe limitations whereas a human would have a little problem distinguishing between similar sounding words or phrases; speech recognition systems are likely to make mistakes.
• Speech recognizers are also subject to interference from background noise, although the use of a telephone-style handset or a headset may overcome this.
• Even if the speech can be recognized, the natural form of language used by people is very difficult for a computer to interpret.

The development of speech input systems can be regarded as a continuum, with device that have a limited vocabulary and recognize only single words at one end of the spectrum and systems that attempt to understand natural speech at the other. Isolated word recognition systems typically require pauses between words to be longer than in natural speech and they also tend to be quite careful about how she speaks. Continuous speech recognition systems are capable, up to a point, of problems and system complexity. Although these systems still operate by recognizing a restricted number of words, the advantage is that they allow much faster data entry and are more natural to use.

One way of reducing the possible confusion between words is to reduce the number of people who use the system. This can overcome some of the problem caused by variations in accent and intonation. Speaker-dependent systems require each user to train a system to recognize her voice by repeating all the words in the desired vocabulary one or more times. However, individual variability in voice can be a problem, particularly when a user has a cold. It is not uncommon for such systems to confuse words like three and repeat. Speaker-independent systems, as the name suggests, do not have this training requirement; they attempt to accommodate a large range of speaking characteristics and vocabulary. However, the problem of individual variability means that these types of system are less reliable, or have a smaller vocabulary than speaker-dependent systems.

The perfect system would be one that would understand natural speech to such extent that it could not only distinguish differences in speech presentation but also have the intelligence to resolve any conflicts in meaning by interpreting speech in relation to the context of the conversation, as a human being does. This is a deep unsolved problem in Artificial Intelligence, and progress is likely to be slow.

13.3 Positioning, Pointing And Drawing

Pointing devices are input devices that can be used to specify a point or path in a one-, two- or three- dimensional space and, like keyboards, their characteristics have to be consider in relation to design needs. Pointing devices are as follow:

• Mouse
• Touch pad
• Track ball
• Joystick
• Touch screen
• Eye gaze
Mouse

The mouse has become a major component of the majority of desktop computer systems sold today, and is the little box with the tail connecting it to the machine in our basic computer system picture. It is a small, palm-sized box housing a weighted ball- as the box is moved on the tabletop, the ball is rolled by the table and so rotates inside the housing. This rotation is detected by small rollers that are in contact with the ball, and these adjust the values of potentiometers.

The mouse operates in a planar fashion, moving around the desktop, and is an indirect input device, since a transformation is required to map from the horizontal nature of desktop to the vertical alignment of the screen. Left-right motion is directly mapped, whilst up-down on the screen is achieved by moving the mouse away-towards the user.

Foot mouse

Although most mice are hand operated, not all are- there have been experiments with a device called the footmouse. As the name implies, it is foot-operated device, although more akin to an isometric joysticks than a mouse. The cursor is moved by foot pressure on one side or the other of pad. This allows one to dedicate hands to the keyboard. A rare device, the footmouse has not found common acceptance.

Touch pad

Touchpads are touch-sensitive tablets usually around 2-3 inches square. They were first used extensively in Apple Powerbook portable computers but are now used in many other notebook computers and can be obtained separately to replace the mouse on the desktop. They are operated by stroking a finger over their surface, rather like using a simulated trackball. The feel is very different from other input devices, but as with all devices users quickly get used to the action and become proficient.

Because they are small it may require several strokes to move the cursor across the screen. This can be improved by using acceleration settings in the software linking the trackpad movement to the screen movement. Rather than having a fixed ratio of pad distance to screen distance, this varies with the speed of movement. If the finger moves slowly over the pad then the pad movements map to small distances on the screen. If the finger is moving quickly the same distance on the touchpad moves the cursor a long distance.

Trackball and thumbwheel

Trackball is really just an upside-down mouse. A weighted ball faces upwards and is rotated inside a static housing, the motion being detected in the same way as for a mechanical mouse, and the relative motion of the ball moves the cursor. It is a very compact device, as it requires no additional space in which to operate. It is an indirect
device, and requires separate buttons for selection. It is fairly accurate, but is hard to draw with, as long movements are difficult. Trackballs now appear in a wide variety of sizes, the most usual being about the same as a golf ball, with a number of larger and smaller devices available.

Thumbwheels are different in that they have two orthogonal dials to control the cursor position. Such a device is very cheap, but slow, and it is difficult to manipulate the cursor in any way other than horizontally or vertically. This limitation can sometimes be a useful constraint in the right application.

Although two-axis thumbwheels are not heavily used in mainstream applications, single thumbwheels are often included on a standard mouse in order to offer an alternative means to scroll documents. Normally scrolling requires you to grab the scroll bar with the mouse cursor and drag it down. For large documents it is hard to be accurate and in addition the mouse dragging is done holding a finger down which adds to hand strain. In contrast the small scroll wheel allows comparatively intuitive and fast scrolling, simply rotating the wheel to move the page.

**Joystick and trackpoint**

The joystick is an indirect input device, taking up very little space. Consisting of a small palm-sized box with a stick or shaped grip sticking up from it, the joystick is a simple device with which movements of the stick cause a corresponding movement of the screen cursor. There are two types of joystick: the absolute and the isometric.

In absolute joystick, movement is the important characteristic, since the position of the joystick in the base corresponds to the position of the cursor on the screen.

In the isometric joystick, the pressure on the stick corresponds to the velocity of the cursor, and when released, the stick returns to its usual upright centered position.

Trackpoints are smaller devices but with the same basic characteristics is used on many laptop computers to control the cursor. Some older systems had a variant of this called the keymouse, which was a single key. More commonly a small rubber nipple projects in the center of the keyboard and acts as a tiny isometric joystick. It is usually difficult for novices to use, but this seems to be related to fine adjustment of the speed settings.

**Touch screens**

Touch displays allow the user to input information into the computer simply by touching an appropriate part of the screen or a touch-sensitive pad near to the screen. In this way the screen of the computer becomes a bi-directional instrument in that it both receives information from a user and displays output from a system. Using appropriate software different parts of a screen can represent different responses as different displays are presented to a user. For example, a system giving directions to visitors at a large exhibition may first present an overview of the exhibition layout in the form of a general map. A user may then be requested to touch the hall that he wishes to visit and the system will present a list of exhibits. Having selected the exhibit of his choice by touching it, the user may then be presented with a more detailed map of the chosen hall.

The advantages of touch screens are that they are easy to learn, require no extra workplace, have no moving parts and are durable. They can provide a very direct interaction. Ease of learning makes them ideal for domains in which use by a particular user may occur only once or twice, and users cannot be expected to spend a time learning to use the system.
They suffer from a number of disadvantages, however. Using the finger to point is not always suitable, as it can leave greasy marks on screen, and, being a fairly blunt instrument, it is quite inaccurate. This means that the selection of small regions is very difficult, as is accurate drawing. Moreover, lifting the arm to point a vertical screen is very tiring, and also means that the screen has to be within about a meter of the user to enable to be reached, which can make it too close for comfort.

**Stylus and light pen**

For more accurate positioning, systems with touch-sensitive surface often employ a stylus. Instead of pointing at the screen directly, small pen-like plastic stick is used to point and draw on the screen. This is particularly popular in PDAs, but they are also being used in some laptop computers.

An old technology that is used in the same way is the light pen. The pen is connected to the screen by a cable and, in operation, is held to the screen and detects a burst of light from the screen phosphor during the display scan. The light pen can therefore address individual pixels and so is much more accurate than the touchscreen.

**Eyegaze**

Eyegaze systems allow you to control the computer by simply looking at it. Some systems require you to wear special glasses or a small head-mounted box, others are built into the screen or sit as a small box below the screen. A low-power laser is shone into the eye and is reflected off the retinal. The reflection changes as the angle of the eye alters, and by tracking the reflected beam the eyegaze system can determine the direction in which the eye is looking. The system needs to be calibrated, typically by staring at a series of dots on the screen, but thereafter can be used to move the screen cursor or for other more specialized uses. Eyegaze is a very fast and accurate device, but the more accurate versions can be expensive. It is fine for selection but not for drawing since the eye does not move in smooth lines. Also in real application it can be difficult to distinguish deliberately gazing at something and accidentally glancing it.

**Cursor keys**

Cursor keys are available on most keyboards. Four keys on the keyboard are used to control the cursor, one each for up, down, left and right. There is no standardized layout for the keys. Some layouts are shown in figure but the most common now is the inverted ‘T’. Cursor keys used to be more heavily used in character-based systems before windows and mice were the norm. However, when logging into remote machines such as web servers, the interface is often a virtual character-based terminal within a telnet window.
13.4 Display devices

Cathode ray tube
The cathode ray tube is the television-like computer screen still most common as we write this, but rapidly being displaced by flat LCD screens. It works in a similar way to a standard television screen. A stream of electrons is emitted from an electron gun, which is then focused and directed by magnetic fields. As the beam hits the phosphor-coated screen, the phosphor is excited by the electrons and glows. The electron beam is scanned from left to right, and then flicked back to rescan the next line, from top to bottom.

Black and white screens are able to display grayscale by varying the intensity of the electron beam; color is achieved using more complex means. Three electron guns are used, one each to hit red, green and blue phosphors. Combining these colors can produce many others, including white, when they are all fully on. These three phosphor dots are focused to make a single point using a shadow mask, which is imprecise and gives color screens a lower resolution than equivalent monochrome screens.

The CRT is a cheap display device and has fast enough response times for rapid animation coupled with a high color capability. Note that animation does not necessarily means little creatures and figures running about on the screen, but refers in a more general sense to the use of motion in displays: moving the cursor, opening windows, indicating processor-intensive calculations, or whatever. As screen resolution increased, however, the price rises. Because of the electron gun and focusing components behind the screen, CRTs are fairly bulky, though recent innovations have led to flatter displays in which the electron gun is not placed so that it fires directly at the screen, but fires parallel to the screen plane with the resulting beam bent through 90 degrees to his the screen.

Liquid Crystal Display
Liquid Crystal Displays are mostly used in personal organizer or laptop computers. It is a light, flat plastic screen. These displays utilize liquid crystal technology and are smaller, lighter and consume far less power than traditional CRTs. These are also commonly referred to as flat-panel displays. They have no radiation problems associated with them, and are matrix addressable, which means that individual pixels can be accessed without the need for scanning.

This different technology can be used to replace the standard screen on a desktop computer, and this is now common. However, the particular characteristics of compactness, lightweight, and low power consumption have meant that these screens have created a large niche in the computer market by monopolizing the notebook and portable computer systems side.
Digital paper
A new form of display that is still in its infancy is the various forms of digital papers. These are thin flexible materials that can be written to electronically, just like a computer screen, but which keep their contents even when removed from any electrical supply.

Physical controls and sensors

Sound output
Another mode of output that we should consider is that of auditory signals. Often designed to be used in conjunction with screen displays, auditory outputs are poorly understood: we do not yet know how to utilize sound in a sensible way to achieve maximum effect and information transfer. Sounds like beeps, bongs, clanks, whistles and whirrs are all used for varying effect. As well as conveying system output, sounds offer an important level of feedback in interactive systems. Keyboards can be set to emit a click each time a key is pressed, and this appears to speed up interactive performance. Telephone keypads often sound different tones when the keys are pressed; a noise occurring signifies that the key has been successfully pressed, whilst the actual tone provides some information about the particular key that was pressed.

13.5 Touch, feel and smell
Sense of touch and feel is also used for feedback; tactile feedback has its own importance and is being used in many interactive devices. We usually feel textures when we move our fingers over a surface. Technology for this is just beginning to become available.

13.6 Physical controls
A desktop computer has to serve many functions and do has generic keys and controls that can be used for a variety of purpose. In contrast, these dedicated controls panes have been designed for a particular device and for a single use. This is why they differ so much.

Usually microwave a flat plastic control panel. The reason is this, the microwave is used in the kitchen whilst cooking, with hands that may be greasy or have food on them. The smooth controls have no gaps where food can accumulate and clog buttons, so it can easily be kept clean and hygienic.

When using the washing machine you are handling dirty clothes, which may be grubby, but not to the same extent, so the smooth easy-clean panel is less important. It has several major settings and the large buttons act both as control and display.

13.7 Environment and bio sensing
Although we are not always conscious of them, there are many sensors in our environment—controlling automatic doors, energy saving lights, etc. and devices monitoring our behavior such as security tags in shops. The vision of ubiquitous computing suggests that our world will be filled with such devices.
Lecture 14

Lecture 14. Interaction

Learning Goals
As the aim of this lecture is to introduce you the study of Human Computer Interaction, so that after studying this you will be able to:

- Define interaction
- Discuss interaction styles keeping in view different aspects of HCI

In the previous lectures we have studied the detailed introduction of human side and computer side. These are two participant of our course Human Computer Interaction. As the name of the course reveals that both of these complex entities are not in isolation rather they come in contact with each other. Human communicate with computers.

There are a number of ways in which human can communicate with the system. If we look at the beginning, batch input system was used, in which the user provides all the information to the computer in form of batch. Now a day it is the age of virtual reality and ubiquitous computing. Here user constantly interacts with computers in his surroundings. Today there is richer interaction.

14.1 The terms of Interaction

Domain
A domain defines an area of expertise and knowledge in some real-world activity. Some examples of domains are graphic design, authoring and process control in a factory. A domain consists of concepts that highlight its important aspects. In a graphic design domain, some of the important concepts are geometric shapes, a drawing surface and a drawing utensil.

Task
Task are the operation to manipulate the concepts of a domain. A goal is the desired output from a performed task. For example, one task within the graphic design domain is the construction of a specific geometric shape with particular attributes on the drawing surface.

Goal
A related goal would be to produce a solid red triangle centered on the canvas. So, goal is ultimate result, which you want to achieve after performing some specific tasks.
14.2 Donald Norman’s Model

We have already studied Donald Norman’s Model of interaction. In which user chooses a goal, formulate a plan of action, which is then executed at the computer interface. When the plan, or part of the plan has been executed, the user observes the computer interface to evaluate the result of the execution plan, and to determine further actions.

The two major parts, execution and evaluation, of interactive cycle are further subdivided into seven stages, where each stage is an activity of the user. Seven stages of action are shown in figure. To understand these we see an example, which was also used by Norman.

Imagine you are sitting reading as evening falls. You decide you need more light; that is you establish the goal to get lighter. Form there you form an intention to switch on the desk lamp, and you specify the actions required to reach over and press the lamp switch. If some one else is closer, the intention may be different-you may ask them to switch on the light for you. Your goal is the same but the intention and actions are different. When you have executed the action you perceive the result, either the light is on or it isn’t and you interpret this, based on your knowledge of the world. For example, if the light does not come on you may interpret this as indicating he bulb has blown or the lamp is not plugged into the mains, you will formulate the new state according to the original goals – is there is now enough light? It so, the cycle is completed. It not, you may formulate a new intention to switch on the main ceiling light as well.

Gulf of execution and evaluation

Norman also describes the two gulfs, which represent the problems that are caused by some interfaces to their users.

Gulf of execution

Gulf of execution is the difference between the user’s formulation of the actions to reach the goal and the actions allowed by the system. If the action allowed by the system correspond to those intended by the user, the interaction will effective. The interface should therefore aim to reduce this gulf of execution.

Gulf of evaluation

The gulf of evaluation is the distance between the physical presentation of the system state and the expectation of the user. If the user can readily evaluate the presentation in terms of his goal, the gulf of evaluation is small. The more effort that is required on the part of the user to interpret the presentation, the less effective the interaction.
14.3 The interaction framework

The interaction framework breaks the system into four main components as shown in figure. The nodes represent the four major components in an interactive system – the System, the User, the Input and the Output. Each component has its own language. The system and user are each described by means of a language that can express concepts relevant in the domain of the application. The system’s language is referred as the core language and the user’s language is referred as the task language. The core language describes computational attributes of the domain relevant to the system state, whereas the task language describes psychological attributes of the domain relevant to the user state. There are also languages for both the input and output components. Input and output together form the interface.

As the interface sits between the user and the system, there are four steps in the interactive cycle, each corresponding to a translation from one component to another, as shown by the labeled arcs in figure. The user begins the interactive cycle with the formulation of a goal and a task to achieve that goal. The only way the user can manipulate the machine is through the input, and so the task must be articulated within the input language, the input language is translated into the core language as operations to be performed by the system. The system then transforms itself as described by the operations; the execution phase of the cycle is complete and the evaluation phase now begins. The system is in a new state, which must now be communicated to the user. The current values of system attributes are rendered as concepts or features of the output. It is then up to the user to observe the output and assess the results of the interaction relative to the original goal, ending the evaluation phase and, hence, the interactive cycle. There are four main translations involved in the interaction: articulation, performance, presentation and observation. The user’s formulation of the desired task to achieve some goal needs to be articulated in the input language. The tasks are responses of the user and they need to be translated to stimuli for the input. As pointed out above, this articulation is judged in terms of the coverage from tasks to input and the relative ease with which the translation can be accomplished. The task is phrased in terms of certain psychological attributes that highlight the important features of the domain for the user. If these psychological attributes map clearly onto the input language, then articulation of the task will be made much simpler.

14.4 Frameworks and HCI
The ACM SIGCHI Curriculum Development Group presents a framework and uses it to place different areas that relate to HCI. As you can see in the figure, the field of ergonomics addresses issues on the user side of the interface, covering input and output, as well as the user’s immediate context. Dialog design and interface styles can be placed particularly along the input branch of the framework, addressing both articulation and performance. However, dialog is most usually associated with the computer and so is biased to that side of the framework. Presentation and screen design relates to the output branch of the framework. The entire framework can be placed within a social and organizational context that also affects the interaction. Each of these areas has important implications for the design of interactive systems and the performance of the user. Let us first take a brief look.

**Ergonomics**

Ergonomics (or human factors) is traditionally the study of the physical characteristic of the interaction: how the controls are designed, the physical environment in which the interaction takes place, and the layout and physical qualities of the screen. A primary focus is on user performance and how the interface enhances or detracts from this. In seeking to evaluate these aspects of the interaction, ergonomics will certainly also touch upon human psychology and system constraints. It is a large and established field, which is closely related to but distinct from HCI.

Physical aspects of Interface are as follow:

- Arrangement of controls and displays
- The physical environment
- Health issues
- Use of colors

**Arrangement of controls and displays**

We already have discussed in previous lectures the perceptual and cognitive issues that affect the way we present information on a screen and provide control mechanisms to the user. In addition to these cognitive aspects of design, physical aspects are also important. The user should group sets of controls and parts of the display logically to allow rapid access. This may not seem so important when we are considering a single user of a spreadsheet on a PC, but it becomes vital when we turn to
safety-critical applications such as plant control, aviation and air traffic control. In each of these contexts, users are under pressure and are faced with a huge range of displays and controls. Here it is crucial that the physical layout of these be appropriate. Indeed, returning to the less critical PC application, inappropriate placement of controls and displays can lead to inefficiency and frustration.

**Industrial Interface**

The interfaces to office systems have changed dramatically since the 1980s. However, some care is needed in transferring the idioms of office-based systems into the industrial domain. Office information is primarily textual and slow varying, whereas an industrial interfaces may require the rapid assimilation of multiple numeric displays; each of which is varying in response to the environment. Furthermore, the environment conditions may rule out certain interaction styles. Consequently, industrial interfaces raise some additional design issues rarely encountered in the office.

**Glass interfaces vs. dials and knobs**

The traditional machine interface consists of dials and knobs directly wired or piped to the equipment. Increasingly, some or all of the controls are replaced with a glass interface, a computer screen through which the equipment is monitored and controlled. Many of the issues are similar for the two kinds of interface, but glass interfaces do have some special advantages and problems. For a complex system, a glass interface can be both cheaper and more flexible, and it is easy to show the same information in multiple forms.

**Indirect manipulation**

The phrase ‘direct manipulation,’ dominates office system design as shown in figure (a). there are arguments about its meaning and appropriateness even there, but it is certainly dependent on the user being in primary control of the changes in the interface. The autonomous nature of industrial processes makes this an inappropriate model. In a direct manipulation system, the user interacts with an artificial would inside the computer.

In contrast, an industrial interface is merely an intermediary between the operator and the real world. One implication of this indirectness is that the interface must provide feedback at two levels as shown in figure (b). at one level, the user must receive immediate feedback, generated by the interface, that keystrokes and other actions have been received. In addition, the user’s action will have some effect on the equipment controlled by the interface and adequate monitoring must be provided for this.
The indirectness also causes problems with simple monitoring tasks. Delays due to periodic sampling, slow communication and digital processing often mean that the data displayed are somewhat out of date. If the operator is not aware of these delays, diagnoses of system state may be wrong. These problems are compounded if the interface produces summary information displays. If the data comprising such a display are of different timeliness the result may be misleading.

The physical environment of the interaction
As well as addressing physical issues in the layout and arrangement of the machine interface, ergonomics is concerned with the design of the work environment itself. Where will the system be used? By whom will it be used? Will users be sitting, standing or moving about? Again, this will depend largely on the domain and will be more critical in specific control and operational settings than in general computer use. However, the physical environment in which the system is used may influence how it is accepted and even the health and safety of its users. It should therefore be considered in all design.

Health issues
Perhaps we do not immediately think of computer use as a hazardous activity but we should bear in mind possible consequences of our designs on the health and safety of users. Leaving aside the obvious safety risks of poorly designed safety-critical systems. There are a number of factors in that may affect the use of more general computers. Again these are factors in the physical environment that directly affect the quality of the interaction and the user’s performance:

Physical position
As we discussed earlier users should be able to reach all controls comfortably and see all displays. Users should not be expected to stand for long periods and, if sitting, should be provided with back support.

Temperature
Although most users can adapt to slight changes in temperature without adverse effect, extremes of hot or cold will affect performance and, in excessive cases, health.

Lighting
The lighting level will again depend on the work environment. However, adequate lighting should be provided to allow users to see the computer screen without discomfort or eyestrain. The light source should also be positioned to avoid glare affecting the display.

Noise
Excessive noise can be harmful to health, causing the user pain, and in acute cases, loss of hearing. Noise level should be maintained at a comfortable level in the work environment.

Time
The time users spend using the system should also be controlled.
The use of color
Ergonomics has a close relationship to human psychology in that it is also concerned with the perceptual limitations of humans. For example, the use of color in displays is an ergonomics issue. The human visual system has some limitations with regard to color, including the number of colors that are distinguishable and the relatively low blue acuity. Color used in display should be as distinct as possible and the distinction should not be affected by changes in contrast. The colors used should also correspond to common conventions and user expectation. However, we should remember that color conventions are culturally determined.

14.5 Interaction styles
Interaction is communication between computer and human (user). For a successful enjoyable communication interface style has its own importance. There are a number of common interface styles including

- Command line interface
- Menus
- Natural language

Question/answer and query dialog

- Form fills and spreadsheets
- WIMP
- Point and click
- Three-dimensional interfaces

Command line interface
Command line interface was the first interactive dialog style to be commonly used and, in spite of the availability of menu-driven interface, it is still widely used. It provides a means of expressing instructions to the computer directly, using some function keys, single characters, abbreviations or whole-word commands. Command line interface are powerful in that they offer direct access to system functionality, and can be combined to apply a number of tools to the same data. They are also flexible: the command often has a number of options or parameters that will vary its behavior in some way, and it can be applied to many objects at once, making it useful for repetitive tasks.

Menu
In the menu-driven interface, the set of options available to the user is displayed on the screen and selected using the mouse, or numeric or alphabetic keys. Since the options are visible they are less demanding of the user, relying on recognition rather than recall. However, menu
options still need to be meaningful and logically grouped to aid recognition. Often menus are hierarchically ordered and the option required is not available at the top layer of the hierarchy. The grouping and naming of menu options then provides the only cue for the user to find the required option. Such systems either can be purely text based, with the menu options being presented as numbered choices, or may have a graphical component in which the menu appears within a rectangular box and choices are made, perhaps by typing the initial letter of the desired selection, or by entering the associated number, or by moving around the menu with the arrow keys. This is restricted form of a full WIMP system.

Natural Language
Perhaps the most attractive means of communicating with computers, at least at first glance, is by natural language. Users unable to remember a command or lost in a hierarchy of menus, may long for the computer that is able to understand instructions expressed in everyday words. Unfortunately, however, the ambiguity of natural language makes it very difficult for a machine to understand.

Question/answer and query dialog
Question and answer dialog is a simple mechanism for providing input to an application in

a specific domain. The user is asked a series of questions and so is led through the interaction step by step. An example would be the wizards as shown in figure. These interfaces are easy to learn and use, but are limited in functionality and power. As such, they are appropriate for restricted domains and for novice or casual users.

Query languages, on the other hand, are used to construct queries to retrieve information from a database. They use natural-language-style phrases, but in fact require specific syntax, as well as knowledge of database structure. Queries usually require the user to specify an attribute or attributes for which to search the database, as well as the attributes of interest to be displayed. This is straightforward where there is a single attribute, but becomes complex when multiple attributes are involved, particularly of the user is interested in attribute A or attribute B, or attribute A and not attribute B, or where values of attributes are to be compared. Most query language do not provide direct confirmation of what was requested, so that the only validation the user has is the result of the search. The effective use of query languages therefore requires some experience.

Form-fills and spreadsheets
Form-filling interfaces are used primarily for data entry but can be useful in data retrieval applications. The user is presented with a display resembling a paper form, with slots to fill in as shown in figure. Most form-filling interfaces allow easy movement around the form and allow some fields to be left blank. They also require correction facilities, as users may change their minds or make a mistake about the value that belongs in each field.

Spreadsheets are sophisticated variation of form filling. The spreadsheet comprises a grid of cells, each of which can contain a value or a formula. The formula can involve
the value of other cells. Now a days MS Excel is used widely. In past VISICALC and Lotus 123 had been used.

### The WIMP Interfaces

Currently many common environments for interactive computing are examples of the WIMP interface style, often simply called windowing systems. WIMP stands for windows, icons, menus, and pointers, and is default interface style for the majority of interactive computer systems in use today, especially in the PC and desktop workstation arena.

### Point and Click interface

In most multimedia systems and in web browsers, virtually all actions take only a single click of the mouse button. You may point at a city on a map and when you click a window opens, showing you tourist information about the city. You may point at a word in some text and when you click you see a definition of the word. You may point at a recognizable iconic button and when you click some action is performed.

### Three-dimensional interfaces

There is an increasing use of three-dimensional effects in user interfaces. The most obvious example is virtual reality, but VR is only part of a range of 3D techniques available to the interface designer. The simplest technique is where ordinary WIMP elements, buttons, scroll bars, etc., are given a 3D appearance using shading, giving the appearance of being sculpted out of stone.