Chapter 1. Interactive Systems

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"I think there is a world market for maybe five computers." - Thomas Watson, chairman of IBM, 1943

"There is no reason anyone would want a computer in their home." - Ken Olson, president, chairman and founder of DEC

Context

This unit introduces the specialist computing area known as Human Computer Interaction (or HCI for short). One aim of the unit is to give you a clear understanding of what practitioners and researchers in this field know and do. Importantly, too, the unit will try to motivate you to see that HCI is a vital component of successful systems development by giving success stories where the user was considered in the design and failures where the users were overlooked. The unit will also outline the other units in the course and give full details of the assessment scheme used.

Objectives

At the end of this unit you will be able to:

- Understand the nature of an interactive computer system
- Distinguish between design and evaluation processes in an interactive computer system
- Place the specialist area of HCI within the broader area of Computing and systems development.
- Argue the importance of HCI practices within interactive systems development.
- Know what is required to complete the course – the knowledge, skills and assessments involved.

Interactive Systems

The Past

This module is about the design and evaluation of a class of systems that were not even envisaged until relatively recently.

Until the 1980s almost all commercial computer systems were non-interactive. Computer operators would set-up the machines to read in large volumes of data – say customers bank details and transactions – and the computer would then process each input and generate appropriate output.

The Present

There are still lots of these systems in place but the world is also now full of interactive computer systems. These are systems that involve users in a direct way.

In interactive systems the user and computer exchange information frequently and dynamically. Norman's evaluation/execution model is a useful way of understanding the nature of interaction:

1. User has a goal (something to achieve)
2. User looks at system and attempts to work out how he would execute a series of tasks to achieve the goal.
3. User carries out some actions (providing input to the system by pressing buttons, touching a screen, speaking words etc)
4. System responds to the actions and presents results to the user. System can use text, graphics, sounds, speech etc.
5. User looks at the results of his action and attempts to evaluate whether or not the goals have been achieved.

A good interactive system is one where:

- User can easily work out how to operate the system in an attempt to achieve his goals.
- User can easily evaluate the results of his action on the system.

Note

This course is about methods, tools and techniques that can be used to ensure that the user and computer can interact effectively. We will be looking, then, at the Human-Computer Interaction (or HCI) elements of systems design.

What interactive systems do you use in your day-to-day life? Your first response might be to identify the Personal Computer and all its applications. However, the term ‘interactive system’ can be applied to a much broader range of devices, for example:

- Mobile telephones
- Cash dispensing machines
- The World Wide Web
- Car navigation systems
- Video recorders
- Machines driven call centres (e.g. for telephone banking).
- Workflow system to co-ordinate a teams work-efforts.

Activity 1 - A diary

Over the next week, keep a log of all the times you use an interactive computer system. For each encounter record:

- The goal you were trying to achieve.
- How easy the interactive system was to use as you attempted to complete your tasks.
- Any problems or frustrations you had with the system.
- Any improvements you would suggest to the system.

A discussion of this activity can be found at the end of the chapter.

The Future

In his book, ‘The Invisible Computer’Don Norman argues the case for ‘information appliances’. He suggests that the PC is too cumbersome and unwieldy a tool. It has too many applications and features to be useful. He sees the future as being one where we use specific ‘appliances’ for specific jobs.

Norman envisions a world full of information appliances, a world populated by interactive computer systems:

- The home medical advisor: sensors in the home will enable blood pressure, temperature, weight, body fluids and so on to be automatically monitored. A computer could use these readings to assist with medical advice or to contact a human doctor.
- Digital picture frames: give this frame to a friend or relative. When you have taken a new picture you want them to share, simply ‘email’ the picture direct to the frame. The frame will be connected to the net wirelessly.
- The weather and traffic display: at the moment, when we want the time we simply look at a clock. Soon, perhaps, when we want to know the weather or traffic conditions we will look at a similar device.
- Embedded systems within our clothes: ‘consider the value of eyeglass appliances. Many of us already wear eye glasses … why not supplant them with more power? Add a small electronic display to the glasses … and we could have all sorts of valuable information with us at all times’ [Norman 99, pg 271-272]

Many people believe we will soon enter an age of ubiquitous computing – we will be as used to interacting with computing systems as we are with other people. This dream will only be fulfilled if

the businesses that produce these systems and services clearly understand the needs of users so that the systems can be useful and usable.

Review Questions 1

How does an interactive system differ from a non interactive system? Give examples of types of both systems.

Answer to this question can be found at the end of the chapter.

Review Questions 2

What does the term ‘ubiquitous computing’ mean?

Answer to this question can be found at the end of the chapter.

Usefulness and Usability

Back Story

DotDash Bank PLC has launched a new telephone-based banking service. Customers will be able to check balances, order chequebooks and statements and transfer money all at the press of a button. Users are presented with lists of choices and they select an option by pressing the appropriate touch-tone key on their handset. The system development team is certain that the system is technically very good – the speech synthesis used to speak out instructions/ options is the state-of-the-art and the database access times are very fast.

The new banking system described is clearly a success from a system point of view: the designers have thought about the technical demands of the system to achieve, for example, high through-put of database queries.

How, though, do users feel about the system?

Note

The bank’s customers have responded badly to the new system. Firstly, users want to know why the system does not let them allow them to hear details of their most recent transactions, pay bills and do other common functions. Worse still, they find the large number of key-presses needed to find out a piece of information tedious and irritating. Often, users get lost in the list of choices, not sure of where they are in the system and what to do next.

From a human perspective the system is a real failure. It fails because it is not as useful as it might be and has very serious HCI problems – it fails because the designers have not fully considered what would be useful and usable from the customers’ point of view.

Usefulness

For an interactive system to be useful it should be goal centred. When a person uses a computer they will have one or more goals in mind – e.g., ‘work out my expenses for this month’; ‘buy a book on motor mechanics’. A useful interactive system is one that empowers users to achieve their goals. When you build an interactive system you should make sure you use a range of design and evaluation methods to discover the goals and associated system functionality that will make your system useful.

Usability

A cork-screw is a tool for opening bottles sealed with a cork. They are useful tools. However if you are a left-handed person most cork-screws are difficult to use. This is because they are designed for right-handed people. So, for a left-handed person the cork-screw has low usability (despite being useful).

Usability is about building a system that takes account of the users' capabilities and limitations. A system that has good usability is likely to have the following qualities:

- Flexible. Users should be able to interact with a system in ways that best suit their needs. The system should be flexible enough to permit a range of preferences.
- Robust. A system is robust if a user is given the means to achieve their goals, to assess their progress and to recover from any errors made.

In a later unit we will look at each of these aspects and consider ways in which they can be achieved.

Review Question 3

What qualities does a usable system have?

Answer to this question can be found at the end of the chapter.

Why is HCI important?

Note

'Interfaces are something we do at the end of software development. We want to make the system look nice for the end user'

Unfortunately many analysts and programmers might agree with the above statement. They cannot see the point in spending time and money on seriously considering and involving the users in design. Instead they consider they know what is best for the user and can build effective interfaces without using extensive user-centred methods.

However experience has shown that badly designed interfaces can lead to serious implications. If you build poor interfaces you might find:

- Your company loses money as its workforce is less productive than it could be
- The quality of life of the users who use your system is reduced
- Disastrous and possibly fatal errors happen in systems that are safety-critical

Productivity

There has been a lot of interest in the past into a phenomenon known as the productivity paradox. People have wondered why when so much money has been spent in recent years on computer systems has there been such a limited improvement in organisation and country productivity. The common belief is that computers can make a business more efficient and effective but there has been little economic data to back this up.

Tom Landauer, in his book The Trouble with Computers, suggests that one of the key reasons why computers are not living up to our expectations is that they are difficult to use. Employees waste time with difficult systems, become frustrated and slowed down and are thwarted from achieving their employer's goals.

Quality of Life

Note

'I booked a ticket to fly to Athens for an Easter holiday using an online e-commerce site. I was impressed by the cheapness of the ticket and that I could do all the booking without leaving my computer.

> The time for the holiday came and I drove to Gatwick airport in London. I parked my car and went straight to the check-in. Everything went well until the airline representative said, “You do know that you are flying back from Athens into London Heathrow, don’t you?”.
>
> We had a good holiday but when we returned we landed in Heathrow and then had to spend 4 hrs trying to get to Gatwick airport (some distance away).
>
> I felt let down by the Web site I had booked the tickets at.

A poor user interface had led to stress and tension for the holiday maker. A well designed interface might have meant that the problems never arose.

Activity 2 - Redesigning the Online Flight Booking System

Below is an extract that appears in the discussion on usability and quality of life:

Note

> ‘I booked a ticket to fly to Athens for an Easter holiday using an online e-commerce site. I was impressed by the cheapness of the ticket and that I could do all the booking without leaving my computer.
>
> The time for the holiday came and I drove to Gatwick airport in London. I parked my car and went straight to the check-in. Everything went well until the airline representative said, “You do know that you are flying back from Athens into London Heathrow, don’t you?”.
>
> We had a good holiday but when we returned we landed in Heathrow and then had to spend 4 hrs trying to get to Gatwick airport (some distance away).
>
> I felt let down by the Web site I had booked the tickets at.

How would you redesign the online booking Web site interactions to avoid such problems?

A discussion of this activity can be found at the end of the chapter.

Safety-critical systems and disasters

Sometimes poor HCI design can lead to very serious implications. There are many systems that are safety-critical. A safety-critical system must work under all conditions without failure or error. Some examples are:

- Aeroplane control systems
- Nuclear power control systems
- Computer controlled medical equipment.

A Near Miss

Note

> A new type of aeroplane had all its documentation online. Pilots could browse through the material in the cockpit as if they were browsing the Web.
>
> On one particular flight the pilots encountered a potential serious engine problem. The captain tried to use the interactive documentation system to get help. Unfortunately he became lost in the maze of inter-linked documents.
>
> By chance the co-pilot had printed out the appropriate part of the manual the night before (he was revising for an examination) and the captain quickly found what he needed to know by flicking through the notes.

Bad interfaces can lead to disasters and even fatalities.

In unit 2 of this course we will think in more detail about the importance of HCI. You will explore arguments that you could use to convince your company to take interactive system design seriously.

Review Question 4

Imagine you are the technical director of an electronic company that makes a wide range of product including home entertainment systems, safety-critical systems and business productivity tools. You wish to persuade the board of directors that they should employ a number of Human Factors people. Write some outline notes of the presentation you would make to the next board meeting.

Answer to this question can be found at the end of the chapter.

Designing and Evaluating usefulness and usability

This course is about the design and evaluation of interactive computer systems in order to improve usefulness and usability. What does design and evaluation mean and why are these activities important?

Design

When a child builds a house out of bricks there is very little design. It is unlikely that the child has analysed requirements, drawn up plans (with alternatives) and selected tools and techniques to carry out the task.

Unfortunately, sometimes when an interactive system is built, designers fail to consider an essential aspect of the system – the human users. For successful interactions, there has to be explicit and well-thought out consideration of this human factor – usability needs to be designed into the device or system.

To achieve this, as we will see later in the course, there are a range of models, techniques and tools that can be used to construct the system. All of these methods attempt to centre the design on the user group (this is why the methods are collectively known as User-Centred Design or UCD).

Interactive system designers must understand their users. A design developed for one type of users might not be the best for another group. For example, think about a cash-dispensing machine. What would be a good interactive design for this sort of system? Unless you know something about the user group you will not be able to give a workable answer to this question.

Activity 3 - Design for Diversity

Interactive system designers need to know their users if they are to build effective systems. User-centred design, then, involves really understanding the capabilities, limitations, needs and wishes of your user group.

Standard cash machines (ATMs) are designed for ‘standard’ users with no physical or mental impairments.

Imagine you are designing an ATM for Sue. Sue is 75 years old.

- List out the possible physical and mental characteristics that Sue might have and that are relevant to the design of an ATM.
- How would you design an ATM to better suit Sue?

Now look at the World Wide Web Consortium's advice [http://www.w3c.org] designing Web sites for universal access.

A discussion of this activity can be found at the end of the chapter.

Evaluation

Note

imagine a parachute designer has designed what he feels is the ultimate parachute: lightweight, can carry heavy loads, and very safe. He is so convinced that it will work that he does not test his product until it is has been built. Then, one day, he takes a plane to a high altitude and, putting his faith in the chute, jumps…

A good designer will not simply trust that his skill and experience will always produce designs that are highly effective. Evaluation is about testing to see if the interactive system has good usability and usefulness. There are two types:

- Formative evaluation: it is not good enough just to test your system once it is completely built. Evaluations should be carried out all the way through the design and development cycle. The results of these evaluations should be used to guide the design.
- Summative evaluation: once a system has been built then an overall assessment of its usability is needed. These tests should be done to validate aspects of the design (e.g., is the system as learnable as we specified?) and to test the acceptance of the system by the end-users (i.e., do the users like the system, find it easy to use etc?). If a company is buying an off-the-shelf system, it might carry out summative evaluations of all the products to see which is best.

In this course you will look at several evaluation methods and learn when and how they can be used appropriately.

Activity 4 - Looking at bad designs

Spend half-an-hour looking at examples of bad human factors design on Michael Darnell's Web site [http://www.baddesigns.com/].

- Before reading why the design is bad, spend some time carrying out your own summative evaluation to spot the problems.
- Choose 3 items examples that you found the most interesting and post your thoughts on the course bulletin board.

A discussion of this activity can be found at the end of the chapter.

Review Question 5

What is the difference between summative and formative evaluation? Why are both needed in the development of interactive computer systems?

Answer to this question can be found at the end of the chapter.

The HCI Discipline

History

The study of Human-Computer Interaction has developed into a discipline in its own right over the last ten years or so.

Long before HCI people were studying how humans and systems (machines, processes and so on) worked together. In the Second World War, for example, weapons developers were interested in making their products more effective (!).

There has been a lot of work into the ergonomics of the machines, environments and systems that humans are involved in. The Ergonomics Society in the UK recently celebrated its 50th birthday (it was founded in 1949).

Ergonomics (which is sometimes also known as Human Factors) is mainly concerned with making sure that the physical aspects of a system fit well with a human's capabilities and limitation:

- Car design: are the cars controls – steering wheel, dashboard, pedals etc – well placed for the drivers?
- Product design : is this tool easy to handle?
- Workplace: is the lighting good; is the desk and seat adjustable to suit the users?

As more and more computer systems were introduced, people began to get involved in thinking about the way in which humans relate and interact with these new environments. Initially this new area of work was called man-machine interaction; it is now much more aptly named human-computer interaction.

Who does HCI

Researchers

Many universities and technology companies (e.g. Xerox [http://www.xerox.com], Apple [http://www.apple.com], and Microsoft [http://www.microsoft.com]) have research labs that are dedicated to improving interaction by amongst other things -

- Finding out key aspects that affect the quality of interaction.
- Developing new technologies (e.g. handwriting recognition) for interaction.
- Developing models and tools which system builders can use to build better interfaces.
- Evaluating the impact of alternative interaction approaches on usability.

Practitioners

Organisations that build interactive systems need HCI professionals to help them do a better job. Some examples of HCI in practice are:

- A HCI Lab in a consumer electronic manufacturer. Here, the HCI specialists are involved in the design and evaluation of a range of consumer products from mobile phones to video-recorders. They work with the software developers and industrial designers to explore the best designs for good interactivity.
- Usability consultants. Several organisations have recently emerged which offer a range of usability services to their clients.
- Software engineers with HCI training. Most computer science courses at universities throughout the world now include some instruction on HCI. The hope is that this education will bring awareness of the importance of good user-centred design and promote skills in people who are directly involved in building systems.

Activity 5 - Finding HCI research lab/ design specialists

Using the Web and a good search engine like Google find sites belong to the human factors/ HCI specialists in the following companies: IBM, Microsoft and Google. Spend sometime looking at each site.

- What types of work do they do?
- What kinds of people do they want to recruit?

Disciplines involved

HCI draws on a wide range of disciplines as we will see during this course. They include:

- Psychology
- Sociology
- Information systems
- Product design
- Computer science

Its natural ‘home’ though is computer science where it is a central concern.

Review Question 6

What contributions do you think that each of the following professional might bring to the field of HCI?

- Psychologists
- Sociologists
- Information systems experts
- Product designers
- Computer scientists

Answer to this question can be found at the end of the chapter.

The Rest of this Course

This unit has been an introduction to the course. In the next 9 units you will learn and think about much more:

- Motivations for studying this course. We will look in more detail at why HCI is important and what might happen if you get it wrong.
- The capabilities and limitations of human information processing. You need to know about how humans process information (from their senses): how does visual processing work? What other senses are used? How does human memory operate? These and other questions will be addressed and you will explore how this knowledge can be used to build better interfaces.
- Interaction technologies. You will learn about the range of devices and methods available for humans and computers to communicate.
- Tools and techniques for user-centred design. This is an Important part of the course. You will learn about and practice using a range of tools that can be used to make sure that users' concerns are at the hearts of the design process.

Online Resources

There are a range of Web based resources that you should use during the course. There are many excellent Web sites with superb coverage of HCI issues. Specific reference to sites will be made in the units following this one but three good starting points are

- ACM Sigchi resources [http://www.acm.org/sigchi]

- Jacob Nielsen’s usability site [http://www.useit.com]
- Bruce "Tog" Tognazzini usability site [http://www.asktog.com]

You also have access to the ACM’s digital library. In this resource there are online versions of a number of key conference proceedings and research journals on HCI. You should visit each of those sites NOW to see what is available.

- ACM Interactions - A bi-monthly magazine on applied human-computer interaction.
- ACM Bulletin - Official publication of ACM SIGCHI, featuring columns, reports, articles and news on the subject of Computer-Human Interaction.
- ACM TOCHI - Transactions on CHI. Research journal on human-computer interaction.
- ACM CHI conference proceedings – premier annual conference on HCI.

Activity 6 - Using the ACM Digital Library

The ACM digital library [http://www.acm.org/dl] has a huge range of HCI related resources. You can browse specific publications or search across the range of journals, conference proceedings and other forms of literature.

- Go to the library now.
- Download the current version of the HCI magazine Interactions.
- Read some articles in this magazine.
- Return to the library’s homepage.
- Search for ‘speech recognition’.
- Select an article that interests you and read it.
- Experiment with the digital library – find out the range of search types and browsing you can do.

Summary

This unit has introduced some of the key concepts and issues you will be working with over the next weeks. You have seen what HCI is about and why it is important. You have also been given an overview of the rest of the course and seen all the coursework requirements for this course.

Answers and Discussions

Discussion of Activity 1

During the week you might have encountered a whole range of systems (mobile phones, cash machines, ticket machines, word-processors, the web etc) as you attempted to achieve a diverse set of goals (travelling from home to work, completing an assignment, finishing off your home accounts etc).

Some systems would have been usable and useful whilst others left you confused and frustrated. Some of the systems you might have used for the first time – what was your experience with these novel situations?

Discussion of Activity 2

What would a human travel agent do if you tried to select an outward flight from one airport and a return flight to another?

They would probably draw your attention to the possible problems/ errors. So, the online system could bring up a warning message to highlight the possible unintentional booking you were about to make.

Discussion of Activity 3

Sue's characteristics might include:

Physical

- Frailty – inability to press down on ordinary 'hard' buttons.
- Wheelchair bound – ATM at wrong height.
- Poor eyesight – difficulty in reading screen and legends on keyboard.

Mental

- Memory problems – difficulties in remember PIN code and complicated sequences.

A redesigned ATM might include:

- Large screen with large fonts for readability.
- Large buttons with large legends. Easy to press.
- Use of eye-based/ fingerprint-based validation to avoid need for PIN code.
- One-to-two steps to get any transaction completed.
- Speech synthesis options?
- Speech recognition to avoid need for hand-based input? (what would the problems of using speech be?)

Answer to Review Question 4

Some favourites amongst previous students include:

- Trapped Between Doors [http://www.baddesigns.com/doors.html]
- Top-loading VCR [http://www.baddesigns.com/vcr.html]
- Where are the Stamps? [http://www.baddesigns.com/stamps.html]

Answer to Review Question 1

An interactive computer system is one which requires dynamic, frequent intervention by the user – online e-commerce sites, word-processors, ATM (cash machines) are all good examples.

Utility billing systems, bank cheque processing systems and direct mail letter printing systems are all examples of non-interactive system. These systems work repetitively through large amounts of data doing well defined and set tasks.

Answer to Review Question 2

'Ubiquitous computing' is a term that looks to the future when computing systems will be deployed extensively within the environments we live and work within. Many people believe that these systems will be all around us, sensing events in the locality and providing us with effective, focused information and services any time any where.

Answer to Review Question 3

A usable system is likely to be: learnable, flexible and robust. Users should be able to easily assess how they might use the system to achieve their goals and should be able to evaluate their progress as they use the system.

Answer to Review Question 4

Your aim is to convince the board that spending money on HCI makes good business sense. Ways of doing this would include showing how HCI might reduce costs or generate incomes.

Could argue that by using HCI methods that products would improve such that:

- Home users that bought the systems would be satisfied and feel good about their purchases. Their quality of life would be improved. This might lead to them buying further products in the future or recommending the company to their friends/ colleagues. Bad interfaces will lead to confusion which might mean that the company has to spend more on support (e.g. help lines or documentation).
- Business users might find that the company becomes more productive – look again at the notes on productivity and HCI. This will lead to potential further sales.
- If disasters/ fatalities occurred because of poor interfaces in the safety-critical systems, the company could be very seriously affected. It might be sued for high amounts of damage costs and its reputation would be greatly tarnished.

Answer to Review Question 5

Summative evaluations occur once a system has been completely developed. In contrast, formative evaluations occur during development. Summative evaluations are required in two cases:

- where a system has been developed in-house, a summative evaluation acts as a final check on usability and system acceptance. The system deployment should be delayed if problems are noted at this stage.
- an organisation may need to decide between several possible bought-in (off-the-shelf) solutions. Summative evaluations can produce comparative information from a user point of view (e.g. which one is easier to learn, fits best with employees working practice etc).

Formative evaluations should be used whenever a system is being developed – these evaluations should help produce improved designs as the system evolves.

Answer to Review Question 6

Psychologist – knowledge about the human capabilities and limitations in terms of information processing. How we perceive information (through our eyes, ears etc), focus our attention, use our memories, reason and problem solve.

Sociologist – knowledge about how people work and relate together. Particularly useful when designing the newer types of CSCW (computer support of collaborative work system).

Information system expert – various systems methodologies have been developed which attempt to involve users in the design process (e.g. Soft Systems Methodology).

Product designer – ergonomic aspects of the physical elements of the interactive system.

Computer scientist – knowledge about potential interaction technologies and methods; capabilities and limitations of the computer.