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COMPUTER SCIENCE
CASE STUDY: COMPUTERS AND DISABILITY

For use in May 2008, November 2008, May 2009 and November 2009

INSTRUCTIONS TO CANDIDATES

- Case study booklet required for higher level paper 2 and standard level paper 2 computer science examinations.

Special Note

Following advice from various people working in the community we note that different terminology is used by different authors and that some people may take offence at some of the terminology used here.

In particular there appears to be a vigorous debate around the use of the terms "people with disabilities" or "disabled person(s)". In some sections of the community the first is thought to be preferable, since it correctly puts the people or person first. Others see this as an indication that it is the people who have the disability (in some sense the implication is that it is "their fault") rather than the ignorance or indifference of society as a whole that causes difficulties for them. Thus, some people prefer the second term.

We have chosen to use the term disabled person(s), not because we feel that we are in a position to make a judgement on this issue, but more because a decision has to be made.

It is not the IB's intention to cause offence to any sector of the world community and all reasonable steps have been taken to ensure the quality and accuracy of the material included in this case study.

The IB would also like readers who are not students or teachers of the IB Computer Science course to note that this is not an attempt to make an exhaustive study of this topic, although it does seem to be an excellent opportunity to raise awareness.

Students and teachers of the subject should note that they are not being asked to follow up every single web or text-based reference in the case study and examine it in great detail, but to use the study to illustrate and exemplify issues found in the Computer Science syllabus.

Contents:

Computers and Disability

Introduction

"The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect[1]*."*

This case study highlights a range of issues associated with the use of computer systems by disabled people. This case study limits itself to a range of physical disabilities while acknowledging that other forms of disability exist which can seriously affect the ability of people to use computer systems effectively.

The use of computers and related communications devices has become so widespread that it is difficult to imagine life without them.

As potential creators of future systems involving hardware and software you are asked to think carefully about designing systems that are accessible to the greatest possible range of potential users.

This case study contains sections on the most common devices and software systems that have been designed for use by disabled people. The sections at the end refer to further resources that teachers and students can use with this case study in their teaching and learning.

There is a further section that connects the Subject Guide to the case study, indicating the kinds of question that are likely to be asked in the examination.

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[1] Tim Berners-Lee, W3C Director and inventor of the Web

Types of disability

There are five senses: hearing, sight, touch, taste and smell. Using a computer (usually) does not involve taste or smell although there are Human Computer Interaction (HCI) projects which are experimenting with these[2]. See, for example, Human Computer Interaction[3], for a full description of input and output peripheral devices that could be used in a computer system.

The design of most current computer systems relies on users having good visual abilities; hearing is not always a requirement, except for multimedia applications; most output from computer systems is visual.

Touch and dexterity (the ability to control movements with accuracy) are often assumed by application designers when data is required to be input to the system. Keyboards and mice that are in common use with computer systems at the moment are generally not well designed for users who may experience difficulty in this area.

Where designers make these assumptions about a "normal" user or just design for the majority of users then it follows that people experiencing issues with these abilities will have some degree of difficulty in using computers. This then disadvantages them because the computer and similar devices are a major means of communicating information for learning, work and leisure.

We can illustrate some of the more obvious difficulties that people experiencing issues in each of these areas will be likely to have:

Issue	Input devices	Output devices
Touch/dexterity	Hard to use keyboard, mouse and similar devices.	Not commonly used.
Sound/hearing	People with hearing problems usually find it difficult to control their own sound output – creates difficulties for voice input devices.	Cannot hear speech output systems (*e.g.* from screen readers).
Vision/sight	Many devices depend on having visual feedback (*e.g.* mouse pointer).	Cannot see the screen or read conventional printer output.

This quick survey leads naturally to a discussion of the types of device that can be used to give access to computer technology for disabled people.

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[2] But, see appendix III.

[3] Human Computer Interaction, Dix A, Finlay J, G Abowd, and Beale, R. 2003, Prentice Hall - http://www.hcibook.com/e3/editions/.

Hardware and disability

Touch/dexterity

Disabled people may have conditions that make it difficult to use standard input devices such as the mouse and keyboard. For example they may have little or no functional use of digits or limbs.

A range of hardware solutions to these problems have been surveyed by Philip Henderson (see box).

For output, as long as people with dexterity impairment can use their sight and hearing then they are able to access the standard forms of output – print, monitor display and sound alerts. Output to improve dexterity functions is uncommon but not unknown:

"Biometric control devices can be used to detect nervous impulses and take specified action in response to certain patterns. Often impulses can be detected even when the limb or organ to which they are directed no longer functions. In such cases the impulses can be used to control prosthetic sensing or control devices[4]."

As pointed out by a University of Washington article on the web[5], some existing features of common word processors can be used:

"The AutoCorrect™ feature of Word allows sentences or blocks of text, such as an address, to be represented by unique and brief letter sequences. For example, entering "myaddr" could be set to automatically display one's address in proper format. Long words can be abbreviated and entered into the AutoCorrect settings to increase typing speed and accuracy."

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4 Virtual Reality Technologies for People with Special Needs, Philip Smythe, Stephen Furner and Marco Mercinelli, In Patric R.W.Roe (eds.) Telecommunications for all. ECSC-EC-EAEC, Brussels*Luxembourg 1995, http://www.stakes.fi/include/ch_5_05.doc

5 http://www.washington.edu/doit/Brochures/Technology/wtmob.html

The following is from a paper by Henderson, P. (2002) ‘Physical Disability and Technology’ in Phipps, L., Sutherland, A., and Seale, J, ‘Access All Areas’, ALT, JISC and TechDis and is reproduced with permission.

Please see the Resources Section for details of the TechDis website

Input devices

Generally, specialist keyboards perform the identical function to a standard model but are designed to fulfil a specific requirement, for example they may be much smaller reducing the range needed to select all the keys. Most keyboards, whether large or small, use individual keys providing tactile, and in many cases, audible feedback. Others have a smooth membrane surface, either with a fixed key layout or an overlay system where the arrangement and design can be changed in seconds by swapping a flexible sheet on the front of the keyboard. Layout of keys may be different to the commonly used ‘Qwerty’ arrangement, usually to reduce the effort of moving around the keyboard while typing. This is often referred to as ‘frequency of use’, where commonly used keys are grouped together, with the lesser-used keys at the edges of the keyboard. Some keyboards feature the ability to control the mouse cursor on screen giving the user reasonably good access. This method is not able to reproduce the fluid movement that other more traditional pointing devices allow.

Pointing devices

The mouse remains the primary method of moving a cursor around the screen. Current incarnations afford much more in the way of ergonomics, additional buttons and wheels. They are no doubt more comfortable to use and increase efficiency, especially when used with applications that take advantage of these features. Optical mice provide a maintenance free device, very useful where the user lacks the dexterity to remove the mouse ball and clean it. Cordless models also have their place, removing the problem of cables getting caught on other desk-based objects causing resistance to movement. Students who are unable to control a mouse sufficiently may use a joystick, tracker ball or touch pad. Leading mouse manufacturers produce a wide range of tracker balls, aimed mainly at the mainstream market for those wishing to prevent or reduce the effects of repetitive strain injury (RSI), and these are often useful for users with other physical disabilities. Touch pads seem to be the norm on the current generation of laptop computers and external models are available for use with desktop PCs. These require little physical effort to move the cursor and are frequently recommended for students who lack strength and have limited range of movement. Joysticks are usually used by students with poorer dexterity. Many pointing devices have additional buttons. These can enable functions such as a drag, double click and in some cases are programmable. Some devices have a speed control giving a wider range of cursor movement speed than available through the operating system control panel.

Alternative input methods

Where a student is unable to operate even a specialist keyboard and pointing device there are a number of options available; some are listed below.

Switches: These come in all shapes and sizes and are generally used when other input methods are not viable. They can be operated by any part of the body and positioning is often critical. Due to the fact that switch software requires scanning of some sort it is inherently slow. Although there are many software packages specifically created for switch users, full independence is only available from the use of a keyboard emulator.

Head mice: These systems enable the cursor to be controlled by movement of the head with software allowing the user access to all common mouse functions. By using a keyboard emulator a user can work independently as long as they have fine head control.

Voice recognition: Since the mid 90s the development of voice recognition systems has opened up new possibilities to some disabled users. The newer continuous speech systems have a particular application for dyslexic users, whereas the original discrete system, where the user has to say each word separately, includes good mouse control and is often more appropriate for severely physically disabled people. These systems require a large input of time from both the student in terms of training the voice and a trainer to ensure the system is set up for optimum performance. Remember voice recognition may be the only method of input for a physically disabled user. Many people see voice recognition as a ‘solution’ to lots of problems presented by physically disabled students where they have good verbal skills. This is not always the case. The additional cognitive load put on the student in terms of understanding the system, visual perceptual skills, problem solving and correcting text, all in addition to their course work places a burden too great for some individuals.

Sound/hearing

Sound input is a relatively common method today and speech synthesis is also frequently encountered – usually in menus on telephone enquiry systems.

Many people who are deaf or hard of hearing communicate either by sign-language (formal or informal) or by lip-reading – and often by both.

It comes as a surprise to many people that different countries have different sign languages and even finger-spelling alphabets – American Sign Language (ASL) is different from British Sign Language (BSL) for example.

A key problem with sign languages is that the syntax and/or sentence construction is often very different to their "text" equivalents and thus their translation is at least as difficult as that of spoken languages. As Dr Mike Wald writes:

> *"Although technologies are no substitute for the versatility of a skilled human interpreter, it is possible to provide automatic computer generated 3D animated Signed English from electronic text although satisfactory 'translation' to British Sign Language will be much more difficult to achieve. It is also technically possible to automatically 'translate' text to sign language using stored sign language video clips. This can be combined with speech recognition to first automatically transcribe the speaker's words into text and then automatically turn the speaker's words into sign language. However this would be 'word for word signing' rather than BSL, although there is research currently underway on how to translate text into BSL. There is no simple way to automatically translate sign language into written text, although it is technically possible to look up signs in a visual dictionary to find the text 'equivalent'[6]."*

Of course, the deaf and hard of hearing can also read information directly off screen or printout and this is a useful way to communicate too. For the deaf and hard of hearing who are unable to lip read or otherwise find it difficult to hold a conversation (for example, people who don't lip read will often turn their head away from the listener or may put a hand over their mouth during conversation) hardware devices can be used to assist:

> *"The hearing impaired hope to use [a voice-recognition system] as a portable communication aid to output the speech of others on a monitor."*

Such a device would also help a deaf or hard of hearing person to participate in group activities.

Many deaf people do not like to speak, even if they are able to, as they don't get the same degree of feedback via the ears and their speech can therefore seem "funny" to hearing people. Therefore voice input systems are not readily accessible to them. Again, there is no reason that a person with hearing difficulty cannot operate keyboards and mice normally.

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[6] Wald, M. (2002) 'Hearing Disability and Technology' in Phipps, L., Sutherland, A., and Seale, J, 'Access All Areas', ALT, JISC and TechDis.

Vision/sight

A typical computer system is set up based on the assumption that people can see what they are doing. Unless you are a touch typist, you need to look at the keyboard; the most common output devices are some form of screen and/or printer.

A range of hardware devices have been described by Neumann (see box).
Neumann, Z. (2002) 'Visual impairments and Technology' in Phipps, L., Sutherland, A., and Seale, J, 'Access All Areas', ALT, JISC and TechDis, reproduced with permission.

Please see the Resources Section for details of the TechDis website

4.2.1 Electronic Braille displays These are tactile devices that are placed under a conventional computer keyboard, which enables the user to read the contents of the computer screen, by touch in Braille. The displays are designed with buttons and/or bars to enable the user to roam around the screen, reading whichever part they wish. To gain full access to computer software it may also be necessary to use a screen reading programme. There are some purpose designed Notetakers on the market which have Braille displays and Braille keyboards and are designed as portable organizers with facilities for a diary, calculator, address book etc.

4.2.2 Electronic Reading Aids Electronic Reading Aids are used to scan and translate printed text into a computer readable file. This can then be read with synthetic speech, magnification software or a Braille display. The reading aid consists of two main components:

- a scanner that is used to scan the text to be processed,
- recognition software that can be in the form of a printed circuit board or software stored on a disc.

Stand-alone reading aids are integrated units with a scanner, Optical Character Recognition software and speech software. The document is scanned and then read all by the same machine. These machines tend to be portable. PC based reading aids may use mainstream or specialized software but the software may not necessarily be integrated to include speech feedback. While this can be a cheaper option, PC based reading aids are not portable.

4.2.3 Screen magnification Screen magnification software works by increasing the size of the image displayed on the screen. Therefore, only a portion of the original screen image can be seen at one time. Normally, the area around the cursor, mouse pointer or highlighted menu item is magnified. Some screen magnification programs now provide supportive speech output as well. Enlarging the text on the computer screen does restrict the amount of viewable area on the screen, but using a larger monitor in conjunction with screen magnification software can increase the viewing area on the screen. While there are specialized screen magnification software packages available, the Windows operating systems also include some screen enhancement features such as high contrast colour schemes, and larger font sizes.

4.2.4 Notetakers There are four kinds of note-taking systems. Specialist electronic note-takers with Braille or Qwerty keyboard input, and speech and/or Braille output; small laptop computers running access software such as a screen reader; speech-based notetakers that are either tape-based (using cassette recorders) or digital (using Dictaphones or MiniDiscs) and Speech-based organizers, which are digital recorders with extra features such as diary and calculator.

4.2.5 Speech output systems Typically a speech output system will consist of a speech synthesizer and screen reading software. A speech synthesizer, with a built in speaker and headphone socket, produces speech output from text sent to it from the screen reading program installed on the computer. The speech synthesizer can be an external box, but it is usually a software application, which uses a sound card as an output device. A screen reading program sends screen text displayed on the screen to be spoken by a speech synthesizer. Common features include the ability to speak the full screen, a user defined area of the screen, a line, word, or individual letter.

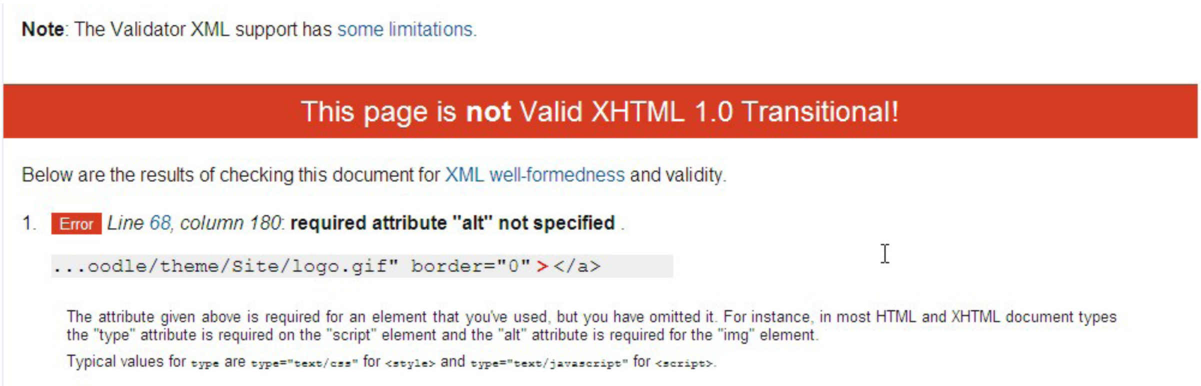
4.2.6 Video magnifiers Video magnifiers or CCTV act as a magnifying aid for people with some useful vision. Printed material and objects can be placed under a camera and the magnified image is displayed on a television screen or computer monitor. The majority of video magnifiers are intended for use on a desk or work surface. Most desktop magnifiers have a camera, which is in a fixed position some distance above the desktop, and a reading table or platform that rests on the desktop. The printed material is placed on the reading table, which can be moved left to right and backwards and forwards. A few desktop video magnifiers have a camera on an angle pose type stem, so there is some flexibility of position. Within all areas of education and employment, assessment and training are fundamentals of gaining successful access to technology. Before embarking on a decision to purchase a particular device or application, it is necessary to determine the user's needs within the learning environment and therefore the role of Disability Student Advisor is essential.

Usability issues on the World Wide Web

The World Wide Web developed from a need for researchers to share information and was built upon earlier technology designed for military communications. It has been something of a frontier area for many systems designers and there are still many issues surrounding authenticity, reliability and browser incompatibility.

In the context of this case study, the US and other governments have mandated that users with disabilities should have equal access to computer systems[7].

The World Wide Web Consortium also has extensive guidelines for promoting accessibility on it's Web Accessibility Initiative page[8]. This includes a validator[9] you can use to check if web pages are following the guidelines:



The WAI guidelines and the output of the checking tool are quite technical for the average user. There are many other checking tools on the market for example:

- The Wave
- A-Prompt
- Bobby
- The TechDis Web Accessibility Evaluation Tool.

It should be stressed that these tools only offer a partial solution. They all give an indication of where a website may fail to provide adequate accessibility but human judgment should always be applied over and above what any mechanical tool advises.

For example, the alt attribute for an image can be used to describe the image to visually impaired people who may be accessing the page via a screen reader. Jakob Nielsen provides useful information and example web pages illustrating the use of the alt tag and other features that are of help to people with usability issues[10].

However, blind application of as rule that alt tabs should never be left empty leads to situations where a person trying to access your page may be hearing "decorative margin image" and "coloured leafy background" which is both irritating and unnecessary. Thus a null entry in an alt tag may well be appropriate but the checking tools won't be able to tell you this.

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[7] The Americans With Disabilities Act, http://www.usdoj.gov/crt/ada/pubs/ada.txt
[8] http://www.w3.org/WAI/
[9] http://validator.w3.org/
[10] Designing Web Usability, Jakob Nielsen, New Riders, Indianapolis, USA, 2000.

A full list of initiatives around web usability can be found at the Trace Center of the University of Wisconsin[11].

You don't have to be blind to have difficulty using the web; it is not uncommon for males to have some form of colour blindness. Frank Dutton[12] (possibly with some information from Diana H. Heath, M.D – the website is not completely clear), states that:

> *Colour blindness (colour vision deficiency) is a condition in which certain colours cannot be distinguished, and is most commonly due to an inherited condition. Red/Green colour blindness is by far the most common form, about 99%, and causes problems in distinguishing reds and greens. Another colour deficiency Blue/Yellow also exists, but is rare and there is no commonly available test for it.*
> *Depending on just which figures you believe, colour blindness seems to occur in about 8% – 12% of males of European origin and about one-half of 1% of females. Total colour blindness (seeing in only shades of gray) is extremely rare.*

An interesting website[13] attempts to show what the world might look like to people with different types of colour blindness. Students will also find *"a collection of computer based artifacts that simulate aspects of disability"* on the TechDis website[14].

A related thread on the Webmaster World website[15] discusses the difficulties experienced by some colour blind users. For example:

> *"I say don't *depend* on colour; I don't say not to *use* colour. My graphic designer friend says that the thing to do is use colours, but make sure the grey levels are different. The quick way to check? Print it out on a black and white printer. If rendering it in black and white like this causes you to lose meaning, then you are certainly losing visitors on the web too.*
>
> *I would add that another method you could use is to take a screenshot of your page, then open it in Photoshop and set the colour saturation to zero. This won't be perfect, since the greyscale won't render exactly the same everywhere (depending on contrast etc), but it will give you a pretty good idea."*

While these issues may not seem important to most of us they are of great importance to those who may be socially and economically disadvantaged because of our inattention to such details.

As Tom (aka ergophobe) says in the thread already quoted above:

> *"if there is a colour difference but no greyscale difference, it becomes a monochromatic screen with no text. I sometimes ask my wife to check for me and often she can read the text where I see nothing but a blank, albeit coloured, screen. I can't find an example, but a surprising number of pages are completely inaccessible to me. I would describe the typical page that fits this as a page that tries to be "cool" or "hip". To me they are just web buildings without wheelchair ramps."*

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11 http://trace.wisc.edu/world/web/
12 http://www.toledo-bend.com/colourblind/aboutCB.html
13 http://www.vischeck.com/examples/
14 http://www.techdis.ac.uk/simdis/
15 http://www.webmasterworld.com/forum21/2354.htm

Jakob Nielsen[16] again:

> *"There are essentially two basic approaches to design: the artistic ideal of expressing yourself and the engineering ideal of solving a problem for a customer."*

Often, as web designers or computer programmers we simply assume that the whole world sees things as we do or just consider the best solution is the one that satisfies us.

In the colour example, the lesson is that using colour alone to convey meaning is putting some of our potential users at great disadvantage. Similar issues might be:

- selection of font faces and sizes
- use of sound alerts with no corresponding visual cue
- use of visual cues with no corresponding sound
- key combinations (such as for shortcuts) which can be difficult for some users
- features of the software accessible via keyboard (or mouse) users only.

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[16] Designing Web Usability, Jakob Nielsen, New Riders, Indianapolis, USA, 2000

Other Social Implications

"There is a growing digital divide between those who have access to the digital economy and those who don't, and that divide exists along the lines of education, income, region and race[17]*."*

"*Among adult computer users in the United States:*

- *1 in 4 has a vision difficulty*
- *1 in 4 has a dexterity difficulty*
- *1 in 5 has a hearing difficulty*[18]"

Richard Spinello in the book from which the above quote was taken states *"connection to the network is critically important to one's social and economic advancement"*.

If there is such a large digital divide between the socio-economic classes and between the world's nations, how much worse is this for those who have some form of physical disability. There must be many people in the world who are doubly disadvantaged.

On a more positive note computer technology has the potential to be a great help to disabled people:

"One of the results of the availability of computers technology for disabled people is that people who formerly could not work now can. Many disabled people have formed and run their own businesses[19]*."*

On the other hand, as Deborah Johnson[20] points out it *"may not be pursued to the extent that it could be"*. The amount of money spent on devices to help disabled people compared to other expenditure, such as the military, might be a social, ethical and moral issue to be debated.

However, it's worth noting that some devices in common use by disabled people were originally developed in different contexts, *e.g.* technology developed to help fighter pilots direct a computer-controlled attack without using their hands can be used to help disabled people.

The provision of assistive technologies for some sections of society can make the difference between access to computers being possible and being impossible. As stated at the beginning of the study, computer systems are now an integral part of the life of most people.

These technologies have the power, if not to actually "level the playing field" completely, at least to improve access. Some of the difficulties in providing assistive technologies may be technical, others financial or political.

These social implications, while extremely important, are more the topic of the Group 3 Information Technology in a Global Society course than of the Computer Science course. However, it is important that everyone involved in computing knows the basics of accessibility and tries to implement what is relevant in their own everyday activities.

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17 President Bill Clinton, as quoted in Case Studies in Information Technology Ethics, Richard A Spinello, Prentice Hall, New Jersey, 2nd edition, 2003.

18 Study Commissioned by Microsoft Corporation and Conducted by Forrester Research, Inc., in 2004 "http://www.microsoft.com/enable/guides/default.aspx.

19 A Gift of Fire, Sara Baase, Prentice Hall, New Jersey, 2nd edition, 2003.

20 Computer Ethics, Deborah G Johnson, Prentice Hall, New Jersey, 3rd edition, 2001.

The Voice-Activated Wheelchair

This section is included as an example of an application of technology that assists physically disabled people to gain some degree of mobility and independence.

Students at the Department of Mechanical Engineering at the State University Of New York At Stony Brook[21] describe a system which *"uses voice recognition technology for controlling wheelchair movements"*.

There are potential problems with this technology. There are situations in which the use of a voice-activated device could be dangerous – and some of these may not be immediately obvious. Words use to control a wheelchair, such as **left** can, of course, be used in normal conversation without meaning *"**turn left**"*.

So one issue might be how the program deals with ambiguous commands – whether it needs context or whether you need to add to the word list so the programme knows that:

- I have only fifty dollars left for this month
- I plan to turn left at the next intersection

are not commands that it needs to act on. One way of solving this issue might be to have a key word that indicates that the next word is a command – but then you have the same problem all over again in that the "command word" might also be used in normal conversation.

Various conditions of ambient noise may also affect the ability of the system to discriminate commands and even the person's own voice changes may affect the system – *e.g.* if they have a sore throat.

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21 John D. Antonakakis, Avren U. Azeloglu, and Theophilos Theophilou, Controlling a Power Wheelchair with Voice Recognition Technology, http://me.eng.sunysb.edu/senior-design/2001-2002/index.php

From John D. Antonakakis, Avren U. Azeloglu, and Theophilos Theophilou, Controlling a Power Wheelchair with Voice Recognition Technology, http://me.eng.sunysb.edu/senior-design/2001-2002/index.php and used with permission.

The speech recognition engine used in this investigation is Microsoft's Direct Text to Speech and Direct speech recognition. The Program is written in Visual Basic and enables the user to basically operate various functions on the computer by voice activation.

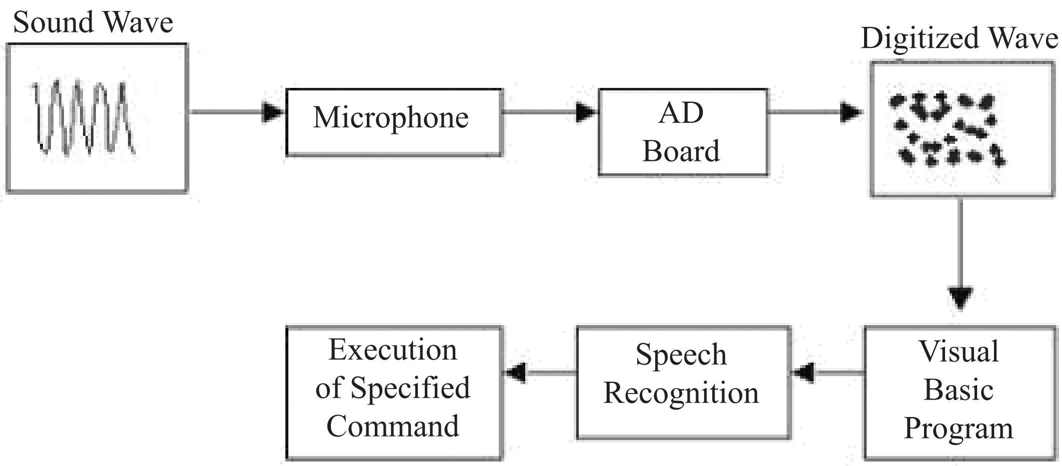

Figure 4: A schematic for the voice recognition system.

Figure 4 is a schematic diagram of the speech recognition control system. The analog sound wave propagates through the microphone and is digitized by the AD board of the computer (sound card) the digitized information is stored in the computer and is processed by the visual basic program. The voice command is then recognized and the analogous directive to that command is executed.

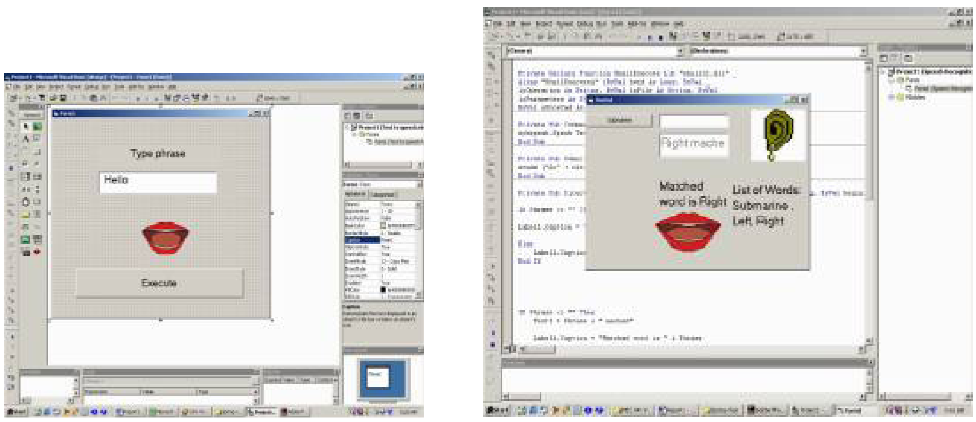

Figure 5: Graphical interface for the voice recognition system.

Figure 5 depicts the visual interface of the speech recognition program. Virtually almost all of computer functions could be accessed by the software. However it was noticed that sometimes phrases had to be repeated and that the user had to be close to the microphone when talking. The accuracy was drastically improved when the vocabulary was minimized. Archimedes was tested with a vocabulary up to 50 words and phrases and the resulted accuracy was 78%. However when the vocabulary was dropped to 10 words or phrases the accuracy improved significantly to an acceptable performance of 90%. Furthermore the accuracy increased even more when the selected words were phonetically very different to 95%. In the targeted application of Archimedes which the automation of a wheelchair the words that will need to be recognized are “forward”,” backward”, “left”, “right”, “stop”, “accelerate” and “decelerate”. The number of commands is well in the range of acceptable accuracy and they are phonetically dissimilar.

Appendix I Using the case study, an example worksheet

This case study deals with some of the issues around the use of computers and related technology in assisting people who have some kind of disability or impairment.

When a person without any form of impairment uses a computer they mostly use the senses of touch, sight and, perhaps less frequently, sound. They also use their hands a great deal.

As an exercise, you might like to try to identify the physical capabilities that could be associated with a range of input devices associated with computer use:

Device	**Sound**	**Touch/dexterity**	**Vision**
Keyboard	Would it be possible for each key to make a different sound like a touch-tone phone? Are there too many keys for people to remember so many tones?	If you are missing fingers or they have lost their use (*e.g.*, excessive shaking, stiffness, soreness) it can be a problem.	Those who cannot “touch type” need to see the keys.
Touch screen			Sight is needed. Could some special surface be used that has indentations, as in Braille devices?
Mouse			
Scanner			
Others?			

The Microsoft website (http://www.microsoft.com/enable/guides/default.aspx) will help you to research this issue. You need not restrict yourself to this website, of course, a list of resources is provided at the end of the case study.

Relation to the syllabus

Note that specific questions about these technologies and how they work will not be asked in the examination but you might be expected to be able to illustrate your answers with some features related to sight, dexterity and hearing of your own choosing.

For example:

"Explain how a person with poor vision could enter text reliably into a computer system."

would be a fair question, while

"Explain the operation of a screen enlarger."

would be an unfair question.

The following links should be considered examples only; the case study should be used to inform the teaching of the programme wherever it is appropriate to do so.

Topic	Possible connection to the case study
1.1	Methods of data collection appropriate to disabled people; selection of suitable input/output devices; suitable test data for systems appropriate to disabled people.
1.2	Limitations of computer systems for disabled people. Some parts of the proposed system may not be appropriate.
1.3	Flow charts of relevant processes; data capture and relevant output methods; hardware components.
1.4	Social and economic implications for people with disabilities – the digital divide. How current trends might lead to more appropriate devices. Problems of usability.
1.6	User interfaces for different people with different skills; use of prototyping; suitable test data for appropriate systems. Colour blind users.
1.7	Different styles of documentation or tutorial help that might be appropriate.

Appendix II Bibliography

Resources on the web

http://www.allabilities.com/computers.html
http://www.cio.noaa.gov/hpcc/access/technews.htm
http://www.adcet.edu.au/ResourceList.aspx?catid=17
http://www.yousearched.com/
http://www.microsoft.com/enable/guides/default.aspx
http://www.lboro.ac.uk/departments/ss/Accessallareas.pdf
http://www.techdis.ac.uk/
http://www.disabilityexchange.org/
http://rehabengineer.homestead.com/
http://me.eng.sunysb.edu/senior-design/2001-2002/index.php
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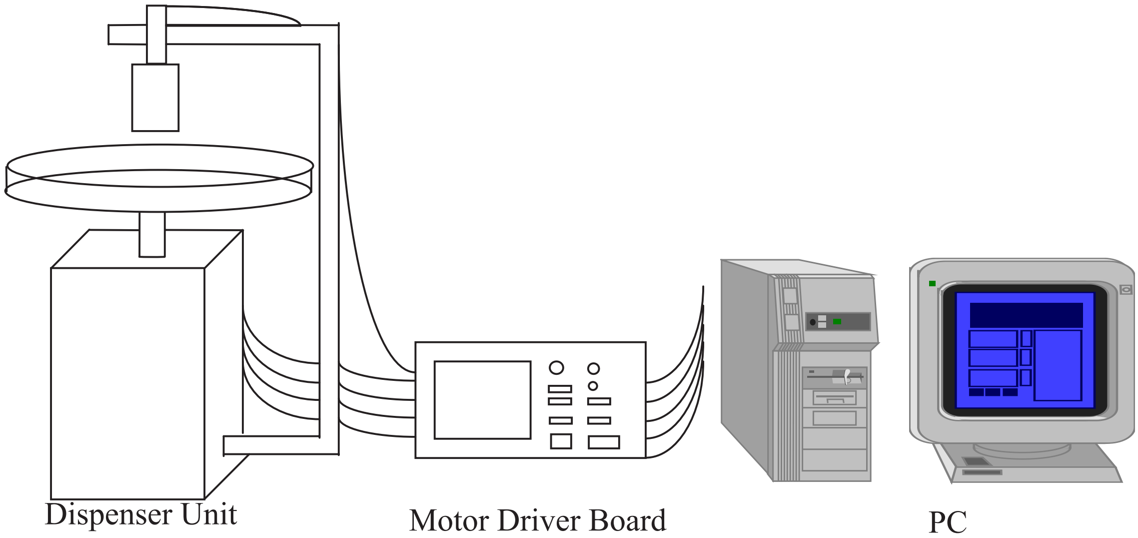
Appendix III Smells & tastes

In the case of smell, devices do exist and an encoding system has already been proposed[22]:

"Most devices available today are capable of emitting only 255 smells (256, if you consider "lack of smell" to be a smell itself). These devices are "8-bit smell" devices. New devices are beginning to emerge that support 16-bit smell, capable of outputting 65,535 smells. We settled on using 32-bit encoding scheme, since we expect that-much like colour monitors-the maximum bit depth will hit a ceiling at 32-bits."

In addition, some researchers are working on pc-controlled systems that will produce smells (or scents if you prefer)[23]:



(from E. C. Tan, C. H. Vun and A. Wahab, 1998 Remote-controlled scent system for virtual reality applications http://www.ee.cityu.edu.hk/~ISCE2000/022.doc)

So far, as far as we know, no devices have been created to simulate taste but somebody, somewhere is probably working on it. Presumably this device would activate nerve endings in the taste buds and may have to wait for someone willing to experiment upon their own tongue.

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22 Evan Coyne Maloney, 1997, Olfactory Transport Protocol (OTP) Content Encoding Schemes http://www.rru.com/webodor/rfc.html
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