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The application of computing technology to interpersonal communication at the University of Dundee's Department of Applied Computing

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ABSTRACT

This paper gives an overview of the major areas of research within the Department of Applied Computing at the University of Dundee. This research focuses on the areas of Interactive Communication Systems, Telecommunications and Remote Learning, Computer based Interviewing and Knowledge Elicitation, Health Informatics, Software Engineering, and Digital Signal Processing. A major strand throughout these areas is a focus on Human Computing Interaction issues, and the use of computing technology to facilitate interpersonal communication, particularly for people with disabilities. The research has produced many new insights in these areas and a number of commercial products have been licensed as a result. The Department's unique approach is based on placing the user at the centre of the design process and people with disabilities make a major contribution to appropriate research projects, both as participants in the research and also as researchers.

KEYWORDS

Disability, communication aids, HCI, usability, AAC, multimodal, telecommunications, predictive systems, prediction, computer-based interviewing.

INTRODUCTION

Founded in 1980, the Department of Applied Computing at the University of Dundee {previously known as the MicroCentre} (Newell et al., 1993) contains one of the largest academic groups in the world researching into communication systems for disabled people. It also has strong international and national reputations in other aspects of human computer interaction research. The quality of the group's research was recently recognised in the 1996 United Kingdom Research Assessment Exercise through the award of a top grade of 5a, the only Applied Computing research group to be so rated. The Department has an engineering bias and brings together a unique blend of disciplines including computer scientists and engineers, psychologists, speech therapists, a special education teacher, and staff who have benefited from interdisciplinary careers. In all its work it is committed to the principles of usability engineering with a focus on developing academic and practical insights, and producing software which can be commercialised. Research is funded from a wide portfolio of funding agencies which includes European Union grants as well as British Government funding and a significant sum from charitable sources: the total research grants awarded in the years 1996/1997 exceeded $2 million. The Department has licensed many software products to commercial companies in the USA and Europe, and collaborates in its research with commercial, academic and service organisations world-wide. {Further details can be obtained from the Department's web site at www.computing.dundee.ac.uk}.

The Department offers undergraduate and postgraduate Degrees in Applied Computing in a unique programme where the learning of HCI and usability engineering techniques is integral

throughout the courses. This slant on the teaching of Applied Computing reflects the research interests and approaches of the Department and has been offered as a model for integrating the teaching of human factors and usability within a computing curriculum (Gregor et al., 1998a).

With the Department's research portfolio there are two main major groups investigating the application of computing technology to interpersonal communication. These are the *Interactive Communication Systems for Disabled People* group and the *Telecommunications and remote learning* group. Running through all the research in the Department, however, is an underpinning belief in the need to adopt a pragmatic, user-centred approach to the design and development of systems. The practical implementation of such a philosophy is facilitated by the multi-disciplinary nature of the group, and their firm grounding in the real worlds of users, whether they be children at school, adults with dyslexia or people with mild or severe communication difficulties. The work of the group is also underpinned by the concept, which it developed within the HCI community, that extra-ordinary (*disabled)* people operating in ordinary environments, pose similar problems to able-bodied (*ordinary*) people operating in extra-ordinary (*high work load, environmentally unfriendly)* situations (Newell, 1993,1995, Newell et al., 1993). In a practical example which demonstrates the verity of this principle, they have shown how simultaneous generic system comprising multi-modal input, combined with user monitoring and plan recognition, can enhance the reliability of human-system interaction for pilots, air traffic controllers and people with disabilities (Peddie et al., 1990)

INTERACTIVE COMMUNICATION SYSTEMS FOR DISABLED PEOPLE

The Interactive Communication Systems for Disabled People group is focused on the development of communication systems which allow non-speaking people to communicate more naturally in face to face situations. Augmentative and Alternative communication (AAC) systems have traditionally focused on providing fast access to needs-based communication. Conversation, however, does not exist for the sole purpose of making our physical needs known, it also enables individuals to interact socially (Newell, 1992, Newell and Alm, 1994). Our research recognised the prime importance of this latter function of conversation and has focussed on developing computer based AAC which facilitated this type of human-human interaction.

Storytelling

One approach we have adopted to improving augmented communication is to enable non-speaking individuals to create and narrate their own stories (Waller, 1998). Stories consist of anecdotes, jokes and experiences, and are used to promote social acceptance, social closeness and personality projection. The research group has identified three areas of investigation: the creation of story texts; the easy retrieval of pre-stored story texts; and the pragmatics of story telling. We believe that stories allow the storyteller to take control of a conversation, and investigations are currently under way in which teachers and therapists can facilitate the development and use of story-based communication systems by children with severe communication disorders (Waller et al., 1998a). Two software packages have been developed for story telling: Talk:About, (Waller et

al., 1996) (1). and TalksBac, is a sentence-based communication system designed for adults with non-fluent aphasia (Waller et al., 1998b).

Word prediction

Other research by the group, which pioneered research into predictive and adaptive word-processing (8), and its use to aid those with dyslexia and spelling dysfunctions (Newell, 1989, Newell et al., 1992, Booth & Gregor, 1994) includes: (i) the development of BlissWord, a predictive retrieval system for Blissymbolics which allows users to retrieve any symbol from the entire Blissymbol dictionary for use in a word processor (Andreasen et al., 1998b); (ii) PredictAbility (9), a multi-lingual orthographic predictive aid for children and adults with language dysfunction (Ricketts et al., 1997, Claypool et al., 1998, Palazuelos et al., 1998); and (iii) SeeWord (10), which enables dyslexic users to configure their word processor interface for optimum legibility when working with text (Gregor at al., 1998b, Andreasen et al., 1998a). Prediction was used within the above mentioned joint project which developed a generic human-machine interaction system for pilots, air traffic controllers and people with disabilities (Peddie et al., 1990). The use of predictive and signal processing techniques is also being investigated to assist with the maintenance and support of elderly people within the community.

Conversational modelling

A group has for some time been investigating the possibilities of conversation modelling and speech act prediction to improve augmentative and alternative communication systems for non-speaking people (Alm et al., 1989a). Prototypes have been developed which embody a number

of features of conversation patterning, and some of these have now reached the marketplace as internationally distributed systems (1,2,3). The development method in most cases has been multi-disciplinary, involving the direct participation in the process of potential users, speech and language therapists, and colleagues from Dundee University's Psychology Department. The important conversational events of opening, closing, and giving feedback were implemented in a prototype which showed the effectiveness of being able to perform these actions quickly (Alm et al., 1992b), and the use of a text database within a conversation aid demonstrated the need to store conversational material with respect to its pragmatics as well as its semantics (Alm et al., 1989b). Research based on simultating the natural flow of topics in a conversation, has allowed users to produce conversations which match or better naturally produced conversations in terms of their flow and how interesting they were (Todman et al., 1995a, Alm et al., 1993a). Fuzzy information retrieval has produced some promising results in modelling the linkage between conversational utterances (Negoita et al., 1976, Alm et al., 1993b) and the application of a script structure to conversational interaction has resulted in the development of a system based on scripts with a novel pictorial interface (Dye et al., 1998).

A number of commercial products have resulted from this work. The openings, closings, and feedback features have been incorporated into the previously mentioned Talk:About (1). TALK Boards (2), another internationally distributed product, was developed by Todman et al (1995b) in collaboration with the Department of Applied Computing, This is based on research into topic flow, as well as the previous work on opening and closing conversations, and giving feedback remarks. These facilities also appear in a new product, Quick Phrases (3). The research project

on scripts has resulted in ScripTalker, a system which is currently commercially available in English, German, and Dutch versions (4,5,6).

Emotion in speech synthesis

Inclusion of pragmatic speech effects, such as emotion, has been difficult, partly due to the nature of the speech synthesis strategies used, but also due to a lack of fundamental understanding about the nature of emotion and how it transfers into speech. It is apparent, however, that emotion is conveyed by changes in pitch, timing and voice quality, which occur in different combinations for different emotions. Using current knowledge of emotions in human speech (Murray & Arnott, 1995), some prototype synthetic speech-with-emotion systems, including HAMLET, have been developed using existing synthesisers based on formant (Murray and Arnott, 1993, Cahn, 1990, Lewis & Tatham, 1995, Carlson, 1992) and concatenative technology (Murray and Edgington, 1998) . A review of progress and future possibilities in this area is given in (Murray et al., 1996).

TELECOMMUNICATIONS AND REMOTE LEARNING

The telecommunications and remote learning group is investigating how the facilities provided by data communication networks can be used improve the quality of life for disabled and elderly people. Telecommunications networks offer a wide range of new possibilities to people with disabilities and special needs. They can enable access to multimedia information and services to be provided in the home, workplace or mobile setting. They can also support inter-personal communication, with text and video-phone facilities, between multiple participants, using studio or desktop systems. Such facilities could be of major benefit to people with disabilities in the

pursuit of enhanced quality of life and give them better access to education and other important amenities. Users with disabilities inevitably encounter problems in attempting to use modern telecommunication services, however, and research is being conducted to develop methods of anticipating and recording such problems (Hine et al., 1997b), and to identify the special adaptations and services that users will require from telecommunications networks. The group has also developed special services relating to interpersonal communication and have demonstrated the advantages of novel graphical forms of communication as an enhancement to live video. This activity has been supported by research in multimedia services and HCI, and is linked with more recent research into the use of video and other support services for disabled and non-disabled students. Most of the research is collaborative, usually with European partners. A number of specific areas of research are described below.

Augmentative and Alternative Communication in Broadband Networks

Broad-band telecommunications allow for simultaneous transmission of textual data services and audio-visual services and these can enable a non-speaking AAC (Augmentative and Alternative Communication) user to send text messages to a remote communication partner accompanied by graphical information and video signals (McKinley et al., 1995). Using this technology, AAC users can converse in text messages while maintaining video contact with each other, for gesture and visual recognition, whilst also being able to access information or discussion material (e.g. a World Wide Web page) from a third site. Text messaging over a network between remote AAC partners has been shown to be a valuable communication medium for non-speaking people, and AAC systems used in this situation can capitalise on the bi-directional information flow (e.g.

adaptive prediction systems - see above - can acquire new information from both sides of a dialogue in order to enhance their prediction performance). Communicating with graphical icons can also be as efficient across a broadband data link as in a face-to-face situation, but more research is required to properly support remote interaction involving emotional content (McKinley et al., 1995).

Wireless Networks and Mobile Systems

Telecommunications networks give mobile connectivity, with computer users able to access a network or server using wireless technology for information or inter-personal communication. The current generation of mobile computers (e.g. compact or "hand-held" PC), however, may not have sufficient computing power to run advanced assistive applications such as the AAC systems based on conversation or language models described above. Handheld versions of such systems, however, could request a more powerful remote machine (server) to run such an application and download its results to the user's hand-held system (client). This, however, raises issues of quality of service for the user which may be impaired by restricted data rate or unreliability of the wireless connection. An example of this problem was demonstrated in a pilot experiment (Beattie et al., 1997) where word predictions from a server-based word predictor were delivered to a subject at a data rate which might be experienced when predictions are transmitted over a cellular telephone. The subject observed a significant delay in delivery of the word predictions when data rates of 1200 and 2400 baud (the lowest data rates simulated) were used, and the subject's keying efficiency was seen to deteriorate. It was evident that subject

performance was adversely affected by these lower data rates on the simulated wireless link, and the subject did not like using the remote process at these rates. Other server-based applications which a user might need to access could require much larger amounts of information (e.g. graphics or video information from a multimedia application) to be transferred over a wireless connection. Wireless networks does offer significant potential benefits for mobile users, however, and further developments in wireless networks the mobile AAC systems with wireless connectivity are very likely to emerge (Hine et al., 1998b). Given that the transfer of a relatively small quantity of data (a short list of predicted words) could create a significant usability problem, as the pilot experiment showed, it is evident that there are serious technical and usability issues to be addressed if multimedia applications for special needs are to be made available in a wireless environment.

Remote Learning for People with Disabilities

Students with disabilities may benefit from remote learning services, particularly when they live a long way away from appropriate educational establishments, and a remote learning system has been developed (Hine et al., 1997c, Mederly et al., 1997) which allows teaching activities and live lectures to be delivered over the Internet. This gives a convenient and cost-effective medium of higher education delivery for people who cannot attend the live events. This system was developed initially for use with any member of the population, but the technique is likely to be of particular benefit to people whose mobility is impaired for any reason. An Internet video-phone service is used to deliver live video and audio signals in both directions between lecturer and

student, so that bi-directional interaction between student and lecturer is possible during the lecture. The Dundee system, however, is designed to provide high quality audio/visual learning support material plus a lower quality moving image of the lecturers. The lecture material itself is delivered in the form of World Wide Web pages, i.e. HTML with supporting graphical files, which can be downloaded to the student's computer during, or prior to, delivery of the lecture. A student can therefore view the Web page lecture information, listen to the words of the lecturer and see a compact live image of the lecturer in operation in the lecture room. This facilitates a situation where the lecturer can give a lecture to students in the lecture room as well as delivering the lecture content over the Internet to several distant students, and thus enables students to participate in regular courses which otherwise they might not be able to attend. Responses from students with disabilities who participated in a trial of this system (Hine et al., 1998a) indicated that they found it useful and a valuable alternative to having to travel to their classes.

Picture Annotation to Augment Communication

Pictures and graphics can be used to help to convey complex ideas or highlight details during a conversation. Given that many people with communication impairments cannot type or encode text easily, it can be valuable to have pictures and graphics available in an AAC system to give the user something to point to or annotate as a way of conveying ideas. Picture annotation has been investigated (Hine et al., 1997a) in the context of remote AAC (i.e. augmented communication over a network connection). A communication task was set for subjects to complete using remote communication, with facilities included for displaying, pointing to (with cursor) or annotating

(with words or brief notes) a relevant picture. Some of the subjects exchanged information more quickly by displaying and annotating pictures, while others were faster using text messages, depending on the nature of their disabilities and the amount of movement involved in the annotation process compared to that in character selection. This research thus showed that picture annotation can be a valuable facility for some disabled users of remote communication.

OTHER RESEARCH

In addition to the two core areas of disability research described above, the department has significant research activity in other areas which feed into the overall research portfolio:

Computer based interviewing and knowledge elicitation

Models of the structures of human interviews have been used to develop general purpose software to conduct computer based and computer facilitated interviews (Gregor et al., 1994, Peiris et al., 1995). A commercial product based on this work *ChatterBox* (7) , has been evaluated in clinical use in a secure mental hospital, and within schools. Further research is focused on more flexible models of computer interviewing and on the potential of computer based interviewing techniques to assist in a variety of settings from engagement with psychosis sufferers to employment pre-interviewing. This research is leading to new insights concerning human computer interaction, and has particular relevance to knowledge elicitation from people with various types of communication dysfunction.

Health Informatics

In collaboration with medical and dental colleagues, this research group is investigating clinical decision support both in asthma treatment (McCowan et al., 1997) within general medical practice and molar extraction in general dental practice. They have taken part in major studies of child growth (White et al., 1995a), the clinical management of cystic fibrosis, and the linkage between asthma and poor growth (McCowan et al., 1998, White et al., 1995b). They have identified novel approaches to automating the visual inspection of both cervical smears (Ricketts, 1992)], breast (Stewart et al., 1992) and hand x-ray images (Manos et al., 1994).

Digital Signal Processing and Software Engineering

This recently formed research group focuses on Digital Signal Processing in its broadest sense including image processing and multi-dimensional signal processing. Particular interests cover remote sensing for environmental monitoring and signal processing on-board spacecraft. Research has covered data compression for synthetic aperture radar, work on a vision guided autonomous lunar lander, and space-based signal processing architectures. Experience in system development within the aerospace industry has provided the foundation for a research initiative in software engineering. Emphasis is on pragmatic software tools which utilise and build on HCI techniques developed within Applied Computing.

CONCLUSIONS

Research work within the Applied Computing Department at Dundee University has shown the value of interdiciplinary, but closely linked, research groups with common or overlapping research aims, and that a focus on human computer interaction, usability principles and the needs

of people with a wide range of abilities and disabilities can lead to important insights in the field and successful commercial exploitation.

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FOOTNOTES

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