Universal Access in the work-place: A case study

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Abstract

Universal Access belongs not only in the research laboratory, but also in an industrial environment. Many countries have set out specific legal requirements for companies to meet in terms of proportions of staff with disabilities and meeting those requirements is a new experience for many employers. More enlightened companies wish to take their commitment beyond meeting the letter of the law and to provide a genuinely inclusive work-place. However, implementing such an approach is complex.

The principal aim of this paper is to describe the steps being taken by The Post Office (TPO), with the assistance of the University of Cambridge, to offer a more inclusive work-place to support a wider range of employee physical capabilities. Computer access, including interface and input system design issues, features very prominently in research at Cambridge. An approach taken to assess the potential for universal access within the TPO environment is described and the relative merits of adaptive and proactive design methods discussed. Although the case study presented is very specific and still in its preliminary stages, the generic usability issues are applicable to a wider range of computer applications.

INTRODUCTION

In the United Kingdom, all companies with over 25 employees are expected to meet the requirements of the 1996 Disability Discrimination Act [DDA 96]. This stipulates a minimum proportion of employees with physical impairments and that the work-place must not present unnecessary obstacles to employment opportunities. This includes both buildings access and access to work opportunities. It is the latter target, access to employment opportunities through the appropriate provision of universally accessible equipment, that this paper focuses on. by including the specification of equipment used. Similar acts exists in many other countries, most noticeably the 1990 Americans with Disabilities Act [ADA 90].

However, providing an inclusive work-place is not simply a matter of meeting legislated requirements. There are strong economic arguments why employers should wish to remove unnecessary barriers to employment. For example, the ageing population is growing inexorably. By 2020, almost half the adult population in the UK will be over 50, with the over 80's being the most rapidly growing sector [Coleman 93] and with age comes an increasing divergence of physical capability [Fozard 90]. It will become increasingly important for employers to ensure that they do not arbitrarily curtail an employees working life simply because of an inaccessible work-place.

Technological solutions to inclusive work-places

Computers continue to play an increasing role in the typical office and ensuring *universal access* to them is a key goal. If designed correctly, they have the potential to enable employers to retain the services of experienced employees who might otherwise have to retire

through ill health. In addition they may enable recruitment of those with physical impairments.

Other approaches to making the work-place more inclusive include the development of assistive robotic devices [Buhler 98]. If designed appropriately, they can help provide vocation opportunities to those with the mental faculty to perform useful tasks, but whose physical impairments would otherwise prohibit their employment. Examples include the AFMASTER office workstation [Gelin 99] and the IRVIS robot [Dowland 98].

A more fundamental change in philosophy is to encourage working at home. The technology required to support this is now readily available and removes the need for operators with limited mobility to commute on a daily basis. The principal advantage of working at home is that it should enable employees to work in an environment that has been specifically tailored to meet *their* individual needs. Perhaps it could be thought of as the ultimate inclusive work-place.

Other perceived advantages of working at home include offering a degree of insulation from work-place stresses. For example, it avoids negative reinforcement of the motion-impaired operator's abilities when sitting next to an able-bodied operator who is possibly working at a higher rate of productivity.

However, there are also disadvantages to working at home, particularly a sense of isolation and a lack of communication with colleagues. Unless specific support measures are included to assist with a sense of being part of a team, then motivational issues may become preeminent as there is a risk that the operator may feel left out. This may be overcome by using the same technology that enables the remote access to work to provide access to social structures, such as virtual communities [Pieper99].

UNIVERSAL ACCESS AND THE POST OFFICE

The Post Office (TPO) is one of the UK's largest employers, directly employing some 190,000 people. It consists of four core businesses - Royal Mail, Parcelforce Worldwide, Post Office Counters and Subscription Services Limited. Of particular interest in this paper is the Royal Mail, which is responsible for the delivery of the overwhelming majority of letters and small parcels within the UK. The usual sequence of delivery involves the posting of a letter at a postbox or over the counter in a post office, collection by van and transportation to a centralised sorting office for automatic sorting. From there the letters are despatched to the appropriate local delivery office for distribution by postmen and women.

As with all large UK companies, TPO is required under the 1996 DDA to have at least 3% of its workforce classified as disabled. This equates to approximately 6000 employees for whom gainful employment opportunities must be found. In addition, Royal Mail employees exhibit the usual prevalence of conditions and disabilities associated with ageing, such as strokes and other neurological conditions, but with a particular tendency towards developing arthritis. With a community of employees that is largely involved with travelling, there is also a higher than average rate of trauma through accidents. TPO currently has a medical retirement rate that costs the company over £100,000,000 last year. There is clearly a strong incentive to retain existing staff for as long as possible, both to reduce this cost and to extend the productive work-life of their employees.

The Royal Mail activities are predominantly physical in nature, from the letter collection to delivery. As such, they are not easily accessible by those with motion impairments or suitable for adaptation. Consequently, the TPO's approach has focused on areas providing support for the collection and delivery processes. Computers form a major part of such systems and computer support is seen as the means to creating a more inclusive working environment. TPO have already invested in the development of an in-house Disability Advice Centre, which recommends hardware accessibility options to those unable to use the traditional keyboard and mouse input arrangement.

The development of software interfaces and input systems that offer universal access is clearly an essential component in facilitating an inclusive work-place and the following case study highlights the many of the issues facing employers intent on creating such conditions.

CASE STUDY: UNIVERSAL ACCESS AND MAIL CODING

Video mail coding is an activity that supports the delivery process of the Royal Mail. It can be performed either on-line or off-line and is well suited to modification for universal access.

The need for video mail-coding

During automatic sorting for delivery, letters are fed past four digital cameras that take two images of each side of the envelope. These images are processed by an optical character recognition (OCR) suite that attempts to locate and read the postcode. If the OCR software fails to recognise the postcode to a predetermined level of confidence, then the images are fed to a Mail Coding Suite, where an operator manually enters the postcode. The typical postcode format is *letter-letter-number number-letter-letter*, where the numbers can have one or two digits. An example would be CB12 5ZF, where the area is defined by the CB12 and the street location by the 5ZF.

A 14 second delay is built into the letter sorting machine specifically to allow time for the images to be fed to the Mail Coding Suite and the postcode to be entered. After this, the mail is turned the right way up by recognising the position of the stamp and tagged either with a short four state bar code if the postcode is recognised, or a longer tag code if not. The letters are then sent onward for distribution or, if the postcodes are not identified during the 14 second delay, gathered and removed from the sorting machine. They are then stored until the postcodes have been processed. Between 20% and 70% of letters are successfully coded by the OCR system, the precise rate being affected by large business distributions and seasonal factors, such as Christmas.

The current mail coding process

The coders sit in a dedicated office, facing a terminal with a portrait orientated monochrome monitor. The keyboard is a standard layout, but the key tops have been customised for the coding process. Operators generally work 50 minutes in every hour although not for extensive periods of time. Their duties are intermixed with overseeing the activities of the sorting machines.

The monitor display is divided into three sections. The lower section displays the digitally captured images of the envelope. The centre strip displays the text entered by the coder along with prompts for action, and the top shows pop-up menus as required. The image of the

envelope is clear and easy on the eye. There is no attempt to assist the coders in locating the postcode. This has the advantage of not misleading the coder if the OCR has failed to locate the code correctly, but has the disadvantage that it would be cognitively faster for the coder to focus on a highlighted object.

The actions required from the coder are the same irrespective of whether the OCR has recognised most of the characters, or conversely failed to even locate the code. This has the advantage of minimising the cognitive effort required by the coder. However, it does lead to unnecessary key inputs if the OCR is only slightly wrong.

The maximum time that an operator has to enter the postcode on-line is theoretically 14 seconds from the scanning to the tagging of each letter in the sorting machine. Each postcode can be up to 8 characters long, giving 1.75 seconds per keystroke. If this time limit is not met then the letter has to be taken off-line to be coded later. On a busy day, with increased throughput and multiple letters that need to be coded entering the delay run, this time can be decreased to approximately 3 to 4 seconds per postcode. This corresponds to 500ms per keystroke.

Mail coding and the motion-impaired user

Mail-coding is inherently a process which a motion-impaired user should be able to do since the task is principally visual. In addition, the data is available in an electronic format and, with remote access technology, the user does not have to be located geographically close to the sorting machine. The volume of data to be transmitted, though, would be more suited to off-line coding.

For motion-impaired users to be able to contribute to the coding process, it is necessary to address the issue of the data entry rates for on-line coding. It is known that a typical response for a motion-impaired user to perform a keystroke in response to a simple stimulus is approximately 620ms [Keates 98]. This time does not allow for deciding which key to press or locating it on the keyboard. It is therefore unlikely that a motion-impaired user could match the 500ms data entry rates required to perform the coding on-line and certainly not for any extended period of time.

More mildly impaired users may be more able to meet these times, but this would have to be determined on a case-by-case basis. Reductions in the available time for postcode entry through increased letter-flow or a burst of poorly packaged circulars, would invariably mean that the gap between desired and actual productivity rates would widen. Even with radically different input hardware, it is unlikely that the necessary time constraints could be met whilst retaining the current data entry requirements.

Adapting the existing coding system

Discussions have shown that traditional HCI approaches are not the best way to achieving a universal access and that more specific studies are required to reach this goal [Stephanidis 97]. Two core themes from this work are *proactivity* - addressing the issue of accessibility at design time, and *adaptation* - the ability for the interface to be tailored to the user [Stary 97].

For the mail coding, as with all universal access software development, a choice has to be made between proactive and adaptive design measures to ensure accessibility. Possible adaptive input system modifications might include:

- Voice input – this removes a substantial portion of the impairment-related difficulties, but is unlikely to be effective. Even when ignoring the issues of motion-impaired operators who also have an associated voice impairment (not generally the case for arthritis, but certainly for cerebral palsy, post-stroke, and so on), this is a task that does not involve standard spoken English, but clusters of letters and numbers. Consequently, an unnatural, rather stilted way of speaking would be required that the users may tire of quickly.
- Specialist keyboards – the existing keyboard has been modified for this application and the modifications could be kept. However, the physical layout of the keys, spacing, size, could be modified for each user. Keyguards are an option, as are small keyboards.
- Keyboard emulators – for those who simply cannot use a keyboard, an on-screen keyboard emulator is the obvious choice, used in conjunction with an appropriate cursor device, or in scanning mode with a switch.

Alternative approaches for assisting motion-impaired users

Taking a more proactive approach to interface development, new coding systems could be developed with appropriate software interfaces and input systems to allow motion-impaired users to contribute productively to the video mail coding activities. If the premise that on-line coding of full postcodes by motion-impaired users will not meet the stipulated time constraints is accepted, then methods need to be found to either relax the time constraint or improve the effectiveness of the operators within the allowed time frame. If either, or both, of these goals could be achieved, then this should enable motion-impaired users to participate more actively in the coding process. In order to achieve this, it is necessary for the interface to be more active in assisting the coder.

Relaxing the time constraint - extending the physical length of the delay run in the sorting machine would proportionally increase the time allowed for data entry, but is not economically viable. A corollary to this, to help exploit the full availability of the time delay, would be to have more people working on the coding, which would decrease the number of letters per operator that required video coding. The final variant would be to dynamically allocate letters just entering the delay, rather already in it, to the motion-impaired operators to give them the full 14 seconds available.

Alternatively, off-line coding provides an opportunity to increase the time available for coding. A final, and obvious, option is to increase the OCR recognition rate and reduce the percentage of letters needing video coding. This has the equally obvious disadvantage of being more easily stated than implemented.

Improving the operator effectiveness - the existing able-bodied coders rely principally on their speed of data entry to perform the coding within the available time. Cognitive processing of the information presented to them is kept to an absolute minimum in an attempt to make the data entry as automatic as possible. In effect, they try reduce the task to one of muscle-memory and so any action by the interface that distracts from this basic goal may be viewed as an interference.

However, reducing the amount of data that needs to be entered offers great potential for assisting motion-impaired users. Unlike the able-bodied coders, the time per physical keystroke for motion-impaired users is much higher than the cognitive time required to decide the input required. Consequently, minimising the amount of text entry for the motion-impaired coders is an essential goal. Methods for achieving this might include:

- Suggesting a code for the user to accept or decline when the OCR system is unsure of its interpretation of the postcode. This would be an interference for an able-bodied user, but not for a motion-impaired one. The success of this strategy would depend on the OCR system identifying the correct location for postcode and the threshold values for deciding whether to accept its own results.
- Presenting the user with a 'show me where the postcode is' request when the OCR system is confused about the location of the postcode. The operator could then highlight the postcode region on the envelope by a pointing device such as a mouse. This would be useful in the cases of a postcard or where there are multiple addresses on the envelope.
- Prompting the user with a 'tell me the missing letters/numbers only' request when the OCR has recognised some of the characters. Again this would probably be an interference for able-bodied users, but not for motion-impaired ones.

Other methods of improving the effectiveness of the motion-impaired coders could focus on increasing the speed of data entry. New input media, such as those described in the section on adaptive measures could be investigated.

Further work

To develop the interface beyond its current passive state, it is necessary to measure certain performance parameters for different user groups. Proposed areas of study include:

- an investigation of comparative rates of keystrokes for users with arthritis, neurological and congenital conditions;
- the quantification of the effects of re-distributioning the data entry from the high motor load/low cognitive effort of typing the whole postcode to a more active, low motor load/higher cognitive effort interface;
- the design and evaluation of new interfaces and input media;
- the development of a more complete model of human-computer interaction for users with disabilities.

CONCLUSIONS

Enabling inclusive work-places is not straightforward. Although legislation requires large corporations to employ people with physical impairments, only limited guidance is provided in how these targets should be met. Some organisations, such as The Post Office, view it not only as their legal, but also their ethical responsibility to meet the spirit, and not just the letter, of the law. However, until universal access becomes a de facto standard, to do so will require substantial investment in time and resources.

The case study described in this paper shows that retrospective adaptation of an interface is unlikely to be sufficient to provide universal access to the mail coding task and that a more comprehensive re-design of the entire interface is required. The challenge for research

establishments must surely be to find methods to make adopting universal access as effective and economically viable as possible and to communicate this knowledge to industry.

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REFERENCES

[ADA 90] *Americans with Disabilities Act of 1990*, US Public Law 101-336, 1990.

[Buhler 98] C. Buhler, Robotics for Rehabilitation - A European(?) Perspective. *Robotica*, 1998 **16**(5), pp 487-490.

[Coleman 93] R. Coleman, A demographic overview of the ageing of First World populations. *Applied Ergonomics*, 1993, **24**(1), pp 5-8.

[DDA 96] *The Disability Discrimination Act*, Dept. for Education and Employment, 1996.

[Dowland 98] R. Dowland, P.J. Clarkson, R. Cipolla, A prototyping strategy for use in interactive robotic system development. *Robotica*, 1998, **16**(5), pp 517-521.

[Fozard 90] J. Fozard, E. Metter, L. Brant, Next steps in describing ageing and disease in longitudinal studies. *Journal of Gerontology*, 1990, **45**(4).

[Gelin 99] R. Gelin, F. Coulon-Lauture, B. Lesigne, J-M le Blanc, M Busnel, AFMASTER: An industrial rehabilitation workstation. *Proceedings of ICORR 99*, Stanford University, USA, 1999, pp 149-155.

[Keates 98] S. Keates, P.J. Clarkson, P. Robinson, Developing a methodology for the design of accessible interfaces. *Proceedings of the 4th ERCIM Workshop*, Stockholm, Sweden, 1998.

[Pieper 99] M. Pieper, Information environments to overcome isolation, marginalization and stigmatization in an overaging information society. *Proceedings of HCI International '99*, Munich, Germany, 1999, pp 883-887.

[Stary 97] C. Stary, The role of design and evaluation principles for user interfaces for all. *Proceedings of HCI International '97*, San Francisco, USA, 1997, pp 477-480.

[Stephanidis 97] C. Stephanidis, Towards the next generation of UIST: Developing for all users. *Proceedings of HCI International '97*, San Francisco, USA, 1997, pp 473-476.