Accessibility: a Case of "Us and Them"?

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Abstract — **Why bother researching into enabling better access for disabled people to computer systems, especially the increasingly important area of virtual worlds? What benefits could this research possibly give to wider society? This paper presents an overview of our past and ongoing research in the areas of accessibility and usability, in an effort to explain how such work *can* benefit us all. It then discusses game and virtual world accessibility in more depth and brings the other strands of our work into this context.**

I. Introduction

Why bother researching into enabling better access for disabled people to computer systems, especially the increasingly important area of virtual worlds? What benefits could this research possibly give to wider society? Can we learn anything from carrying out this work that could be applicable in other areas of research or development?

Often when people outside of these issues consider accessibility, they develop an "us and them" attitude—*they're* not disabled, they might not know any disabled people, their service, content or software isn't meant for people who can't use computers—and what would those people want with the software anyway? They don't understand the nature and the needs of people living with disability, which causes barriers to disabled users and can make them and their non-disabled customers miss out[2].

This paper presents an overview of our research which, though focused on improving the quality-of-life of people with disabilities, is also showing the potential to benefit wider society—and answer the questions posed above.

The topics covered begin with the general motivations behind the work and move through the different projects the authors have been and are involved in, before discussing the relevance of thees projects to the issue at hand—virtual world accessibility.

A. Virtual World Accessibility Challenges

One reason—from the research point-of-view—to cover virtual world accessibility is that it provides a convenient collection of highly-related challenges. As well as the fact that modern games are based on theories developed (and emerging) in areas such as HCI, machine learning & AI, graphics and sound technology, they also pose a number of accessibility challenges. These challenges are briefly described below.

Structure & Serialisation: Games are one of many sources of structured (and often time-sensitive) information. Techniques are needed for prioritising this information and conveying the structure of an environment effectively.

Navigation: The structures presented must be navigable, both locally and globally.

Documentation: The trend of distributing large manuals with most software is diminishing as people become more familiar with computers and the technology becomes able to present helpful information on-the-fly, as the desire to not read manuals remains. This presents opportunities to make the documentation accessible in new ways and is discussed later on.

Alternative Visualisations: Techniques for developing the most effective signals for users to both understand and *enjoy* their experience.

Education & Inclusion: Games and game-like technologies are being used in educational settings [8] and must be kept inclusive. Not only could games be used as part of an effective strategy for social and educational integration of disabled people, but the techniques developed may very well benefit non-disabled people as well [10].

Many traditional computing applications are now being influenced by hardware and software techniques originally designed for gaming uses (e.g. the 3D desktop, edutainment packages). This may well be due to the fact that gaming (and, subsequently, general virtual worlds) predominantly developed out of a need for computer-based entertainment. This makes games unique in that the developers consequently have almost total freedom over product and interface design. Ideas developed for the gaming arena are now being adopted in many others, providing yet more incentive for making these novel interface

[1]Thanks to The Grundy Educational Trust and Loughborough University for jointly funding much of the research described here.

[2]This is because the techniques developed to make life easier for disabled people may often be of use to those ho do not consider themselves disabled—this is discussed throughout the rest of the paper.

technologies accessible—or, better yet, *designing* them to be accessible.

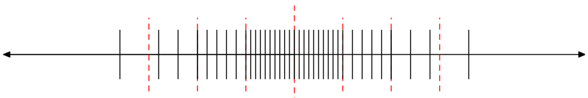

Figure 1: The spectrum of users is continuous and varied–and not everyone is near the targetted "average user".

II. We're all Disabled

There is no such thing as the "average user" that so many systems are apparently designed for; the result of this is that many people find it difficult to use computer systems (amongst other common products and services) [15, 10].

We can imagine an entire spectrum of possible users for a given system; figure 1 is a simple 1-dimensional (and very symmetric) illustration of that concept. Though most users may be clustered around the average point, a significant number can be found further away. This may be due to disabilities, or maybe the different devices that are used to access computer systems. A mobile device may well have limited visual rendering capability–and a vision-impaired person has limited ability to receive information in the visual channel. (The mobile device may also have means of interaction that a desktop computer does not, such as location sensing, and this should be taken into consideration, too.)

Given that disability affects a significant proportion of people today—many of whom may not even realise they could benefit from some form of assistive technology—the need to provide more adaptive systems is highlighted.

III. We're all Going to be Disabled[3]

The argument for providing support for the disabled is made somewhat more urgent by the fact that, as our society continues to become more technological, it is also ageing. Though there are conflicting view on whether this is good or bad news for society as a whole [16, 13], it is widely agreed that it really is happening. In fact, in Europe, we see a faster rate of ageing than in many other areas[4]. This is a major problem because research has shown a trend towards *digital disengagement* as we get older [2]; this is largely due to the fact that technology is not well adapted to the needs of older people.

As people age, their abilities diminish—very often sight and hearing, sometimes physical dexterity and, in many cases, memory. There are many measures that can be taken in an attempt to mitigate these problems; in fact the techniques used are the same as those used in *access technology* (AT) for disabled people, because either the same, or very similar, conditions are present. These techniques include the use of screen magnification, text-to-speech and alternative input devices that may be easier to use than traditional keyboards or (tiny) mobile telephone and remote control keypads.

Granted, they may not have to be employed to the same extent in the first instance, but the techniques are still the same. Over time, as our abilities continue to change, technology should be responsible for monitoring these changes and adjusting the adaptation made (and their magnitude) accordingly.

III. Capabilities, not Disabilities[5]

There is a widely-held belief that the constraints imposed by disabilities may be very similar to those imposed by novel device types—this is typified by the current attitude to the mobile web and its relation to web accessibility [1]. Part of our work is involved in the development of a user modelling technique that embraces this view.

The technique is *modelling of users' capabilities* and it aims to express the properties of the interaction between human user and computer in a low-level and general manner. There are many purposes for doing this: to allow systems to be designed with better adaptation methods; to allow content to be adapted to users' needs at least semi-automatically and to better inform the software design and test process with the ability to make preliminary accessibility/usability assessments before going to the expense of bringing in users for testing. A summary of the technique is presented here.

A. Channels, Bandwidth and Maps

The user and computer must communicate with each other using a number of different *channels*. Each channel is a pairing of input/output device managed by the computer and sense/output from the user—the visual channel, for example, being a computer monitor paired with the user's eyes (multiple monitors would

[3]The topics discussed in this section are very much inspired by the work of the Loughborough University-led preparatory network in the New Dynamics of Ageing (NDA) research project, more information on which can be found at `http://newdynamics.group.shef.ac.uk/`.

[4]covered in the article "Depopulation and Ageing in Europe and Japan: The Hazardous Transition to a Labor Shortage Economy" by Paul S. Hewitt, published in International Politics and Society, January 2002—`http://www.globalaging.org/health/world/depopulationeuropejapan.htm`

[5]The work discussed in this section is a summary of material currently under review for publication.

mean multiple channels), or a set of speakers and the user's ears and auditory brain functions.

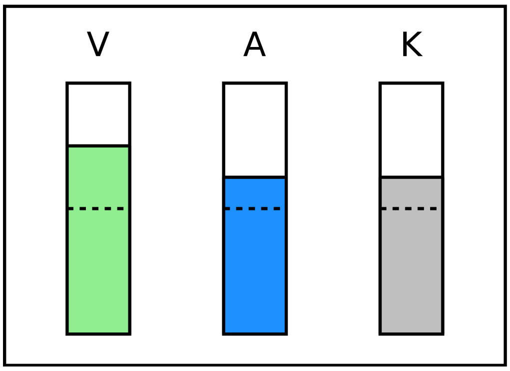

Figure 2: Example Capabilities for Channels—Sighted User.

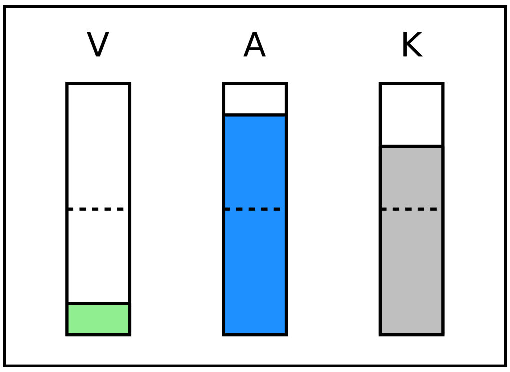

Figure 3: Example Capabilities for Channels—Blind User.

We measure the *capability* factor of a channel based on the nature of both the user's perception and any constraints on the computer's output (for example: the resolution of the monitor; impairments such as colour-blindness; the frequency reproduction limitations of speakers attached to a system or any limitations in the user's hearing). This overall value may be used when considering the amount of information that can be sent reliably over the channel (i.e. bandwidth). Some example user profiles are given; figure 2 shows such a profile for a sighted user in a system with three channels—visual (computer output), audio (computer output) and keyboard (computer input)—and figure 3 shows a profile belonging to a blind user for the same system.

Within each channel, further information may be needed in order to inform the computer how the users' capabilities vary—the *capability map*. In a 2-dimensional channel such as video, the map could indicate where the user's blind spots are (caused either by vision impairments or—likely in a multi-monitor situation—lack of visual attention from the user). These maps are used to indicate where and how content should be presented; the most important content must be displayed in areas the user can easily see.

Similarly, the idea of mapping may be applied to channels of other dimensionalities, such as audio.

B. Constraint Solution and Content Adaptation

The model contains information on what the user and machine, together, are capable of. The next step is the solution of the constraints posed by this combination of channels, maps and overall capabilities so that a series of adaptions can be applied to any content (such as a word-processed document, web page or game world) that is to be presented.

Methods for solving the constraints are out of the scope of this paper, as are the processes by which the data may be adapted, but it is important to mention that these steps need to take place for the modelling technique to be useful. The final step, of content adaption is, of course, domain-specific, but it is hoped that as much of the rest may be kept domain-agnostic —research and testing in this area is ongoing.

C. Wide Applicability

The main reason for promoting this technique is that it may be useful for providing improved usability or accessibility for many more people than are currently accounted for when mainstream systems are designed. We have seen how it maybe used to model situations involving disability, but it may also be used to model different devices and configurations.

One example is that of the mobile telephone or PDA; the screen is smaller, so the visual channel is far less capable. This could be expressed via the capability and map-based modelling technique. Also, a user with multiple monitors at their disposal will likely be paying more attention to one than the other, resulting in lower capability on one screen. As a result, lower priority or less dynamic information could be displayed there, perhaps in a visually clearer way.

Further testing is in progress to ascertain the extent to which the technique may be applied, in terms of user base and functional impairments and device characteristics.

IV. Information and Interaction Management (or, Treat Others as *They* Would Like to be Treated)

The process of rendering information in a suitable way for a given user has been discussed, but the adaptation of content is also very important, especially due to the problem of information overload [14]—a problem that really needs to be avoided in a game, where the primary focus is fun. Many approaches to this have been investigated; some using techniques retro-fitted onto existing standards [12, 18] and some promoting the development of new standards, such as *Essentiality & Proficiency* [9, 19].

A. The Right Information

This idea was later extended to make it applicable to general documents and to provide another dimension to the mark-up that takes into account the role, or interests, of the user. This, coupled with the capability-based rendering described above, is known as *Essentiality Tracks & Capability*. The technique has been described elsewhere [4].

B. What the User Wants

There are many situations in which the designers or developers of a product fail to capture the requirements of the users. One contemporary example is the "set-top media box". These often classify their services in terms of "Pictures", "Videos" and "Music", but the user is probably most interested in "our Holiday to Nempnett Thrubwell 2007". This creates barriers to users—perhaps only small barriers to the technically-minded (or at least of the same learning type), but often insurmountable difficulties for those who are not computer-literate[6].

There are many more examples of such mistakes on behalf of product design and development teams, all of which promote the need for more adaptive systems in future.

Of course, the problem of mapping the intent of developers to that of the users has a counterpart—enabling systems to understand the intentions/desires of users. This issue is more fully discussed elsewhere [17].

V. Accessible Gaming: Adaptations and Inclusion

Having systems in place that provide better personalisation and adaptation to different types of users, with varying needs is an important goal for any society that professes to value inclusion. One area that, until recently, was relatively under-researched was that of computer gaming and the social inclusion accessible computer gaming promotes.

Though many accessible computer games exist (by far the most common ones being for vision-impaired and blind gamers [3][7], but some exist for people with other disabilities, such as motor control problems[8]), they are just that: "accessible games" that are not for "normal" gamers. There have been many successful attempts at creating games that require the use of sound (though they may present graphics, these are not essential); they are known as audiogames [21]. However, these are not mainstream at the present time, even on mobile platforms where they would be ideal, and thus do not help with the segregation in the market caused by most mainstream games remaining inaccessible.

In the past five years, a number of projects have been attempting to remedy this situation, by adapting mainstream games to render them accessible to users with certain disabilities. Two examples are the AGRIP project[9] and Games[CC][10]—in fact, the latter has inspired Valve Software, a major games developer, to incorporate closed-captioning in their games. The work of the International Game Developers Association (IGDA) Game Accessibility SIG[11] includes awareness raising in these areas, as well as demonstrations of how effective truly multimodal games may be [22].

A. Stages of Game Accessibility

This section presents an overview of the aspects of games that need to be made accessible in order for people with disabilities to be able to play them. Some of these stages are currently only applicable to the AGRIP project.

Low-Level Game Accessibility: This stage concentrates on the relatively low-level requirements and techniques involved in adapting a game to use a primarily auditory interface. Techniques such as information prioritisation, filtering and serialisation are employed to promote local navigation (the ability to navigate about rooms, open doors, activate switches, pick up items and engage with enemies). In the AGRIP project, completion of this stage (Summer 2004) made it possible for blind gamers to play Quake, albeit in single-player mode and without the appreciation of the overall environment or game goals (such as the general shape of the current level and therefore direction to the exit).

Online Capability: Inclusion in Internet games was always a goal of the AGRIP project. Throughout 2005, after the basic work was completed, an Internet-optimised version of the game was developed. This allows blind people to play with/against each other and interact, individually or on teams, as sighted

[6]Noted during a study of elderly people and technology, recently carried out by Roger Stone, Thomas Gudzelak (Computer Science) and Mark Hepworth (Information Science) in the author's institution.

[7]Also, products such as: GMA Games, Shades of Doom, `http://www.gmagames.com/sod.html`, 2001; ESP Softworks, Monkey Business, 2001

[8]such as Barrie Ellis' "OneSwitch" project—`http://www.oneswitch.org.uk/`

[9]Accessible Gaming Rendering Independence Possible—`http://www.agrip.org.uk/`; 2003–Present

[10]`http://gamescc.rbkdesign.com/`

[11]`http://www.igda.org/accessibility/accessibility_members.htm`; last accessed 9th October 2007

gamers do (including the development of an accessible statistics-tracking web application). After future research, a “fair play” system will be implemented to allow blind and sighted players to compete more evenly (initial results show this to be possible).

Development Support: Many modern 3D games can be regarded as development environments for creating innovative 3D applications. Previously, the power and availability of these environments were irrelevant to blind people as they were inaccessible. We have carried out work to reverse this trend and enable blind (and, in the future, other groups of disabled) users to benefit from and build upon them.

Implicit Accessibility: This activity is where research into audio design and the use of modern sound technologies such as OpenAL[12] are incorporated into the game engine accordingly. These provide features such as 3D audio and effects. The goal is to provide more natural, realistic clues as to the player’s surroundings[13]. In the context of capability modelling, discussed above, this allows the available bandwidth between game and player to be more effectively used, whilst enabling them to get more enjoyment from the experience due to the more “realistic” and less symbol-like sounds.

Level Editing: Other research being undertaken in parallel aims to allow users to edit their own game levels. This represents the last major barrier to blind people being able to produce complete games for both themselves and the sighted. The work is being carried out with generalisation in mind and has the further objective of making viewing and editing other types of 3D structures accessible in the future. The beginnings of such a framework are proposed elsewhere [6].

Many accessible games implement most of these layers already. Level editing of mainstream games has not yet been achieved, but it is our hope to do so in our ongoing research. Accessible game development for a mainstream game was first achieved by the AGRIP project and taught through a series of workshops at the 2005 ICC[14]. Some tools have emerged since to promote the creation of audiogames by blind and vision-impaired people[15].

B. User Requirements and Opinions

The consultation of users plays a central role in all accessibility projects and accessible gaming is no exception. In the experience of AGRIP, our users have continuously informed the development of new accessibility techniques—both general and game-specific. Some examples of these are briefly discussed here; more information can be found elsewhere [5].

In the area of prioritising information, our initial reading and experience indicated that the fairest way to allow blind people to play would be to present a RADAR-like warning that indicated where enemy characters were positioned. It was believed that allowing the “RADAR” to scan through walls would level the playing field somewhat. This was not the case: in reality, this confused players, making them believe they could travel through walls. Taking out this supposed “helpful” feature made both the game-code simpler and the players more able to navigate successfully—and it did not harm their ability to defeat the enemies presented by the game.

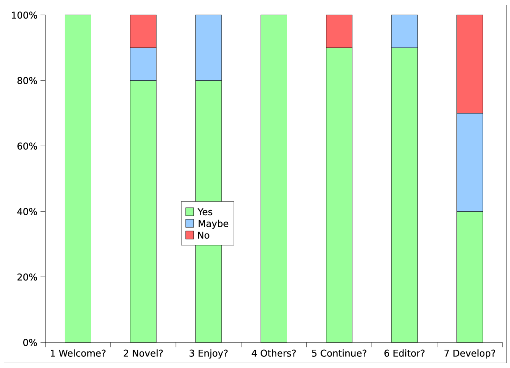

Figure 4: Chart depecting User Satisfaction Survery Results (see [6]).

From a survey carried out [7] (the results of which are repeated in figure 4 for convenience), we can see that (a) the techniques developed and used in AudioQuake have been well-received; (b) the ability to play over the Internet was also well-received; (c) many gamers wish to develop modifications for the game[16] and (d) almost everyone wishes to be able to make their own maps for the game.

C. Enabling Adaptations & Adaptations for Improvement

As discussed above, adaptations made to rendering can be useful to non-disabled users, especially those using non-standard devices such as PDAs. More details on the techniques used for rendering in the AGRIP project have been detailed [6]. The work also describes methods for providing a more structured method for activities such as level design and the benefits this may bring to those with disabilities (enablement—the ability to *do* level design) and those

[12]`http://www.openal.org/`

[13]e.g. through the use of echoes to indicate sizes of rooms, using more realistic sounds to represent enemies

[14]International Camp on Communications & Computers for vision-impaired people; `http://www.icc-camp.info/`

[15]`http://www.audiogamemaker.com/`, 2006–2007

[16]this has now happened: `http://www.tbrn.net/modgirl/`; accessed 12th October 2007

without (improvement—computerised validation and semi-automatic content generation).

D. Applications in Other Areas

The techniques presented above and in the current section for making general information systems and specifically games more accessible can be applied in many other areas. There are many public virtual worlds and communities[17] already being established and the infrastructure to provide new ones is constantly evolving[18]. Inclusion for disabled people in these new forms of interaction is essential—and may be more helpful to them in social terms than for more able people.

In addition, in education, a number of games and game-like metaphors are being used [11] and further integration of these is under investigation[19]. Research into providing programming tuition in an accessible way, such as that carried out by AGRIP and others [20] is important to ensuring that this emerging area is not rendered inaccessible.

VI. Conclusions

The types of adaptations made to the game Quake by the AGRIP project were general accessibility techniques, very similar to those used in Essentiality Tracks and Modelling of Users' Capabilities. They have been shown to be useful to a wide range of people—not just those who are disabled. These techniques can be classified into those used to provide local [5] and global [7] information in an accessible way.

The point of our work is to improve the situation for disabled people significantly by promoting a better platform for *all* of us to use. Though we may not yet be able to solve the problems of people with multiple or very severe disabilities, at least it may be easier to create specialised systems for them, based on a more solid and personalisation-aware mainstream framework.

It is hoped that the reader has gained some understanding of how research targeted originally at people with disabilities may also benefit wider society in a number of interesting and possibly unexpected ways.

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[17] e.g. the Virtual International Space Station, released in 2001 and based on the Unreal game engine and SecondLife —`http://secondlife.com/`

[18] e.g. through the provision of services such as Multiverse; `http://www.multiverse.net/`

[19] One such project is "FutureLab", sponsored by NESTA and EA—`http://www.futurelab.org.uk/`

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