Inclusivity in the Digital Connected Home

Optimising the Accessibility of Digital Connected Home Technology for Disabled Users

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Abstract. This paper introduces a Proof of Concept to demonstrate the feasibility and benefit of exploiting existing home management devices for disabled users. The model we present exploits an integrated platform exposing an API which can be utilized by a variety of User Interface approaches, including accessible Smartphones/tablets or more specialised hardware/software combinations. Future research will investigate the extent to which provision of suitable control technology can enhance feelings of wellbeing in disabled users, increase their independence, and enhance a sense of control over their living environment.

1 Introduction

In a report [1] commissioned by the UK government in 2008, the New Economics Forum (NEF) listed the following “5 Ways to Wellbeing”:

- Connect
- Be Active
- Take Notice
- Keep Learning
- Give

For the purposes of this paper, we propose the addition of a 6th “way to wellbeing”, namely Control, specifically control of the environment in which we live, or shared control where more than one person inhabits the same environment.

Control (or lack of) can be particularly experienced by elderly people [2] who may already be experiencing a sense of social isolation: Friends move away or die, financial constraints restrict travel and increasing habitual inertia adds further barriers to leaving the home. Self-confidence can be further eroded if, due to age-related disabilities any requirement for a change to room temperature, lighting etc has to be requested for action by another person. Enhanced independence can be expected where technology is employed to return control of these functions to the user, and to

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enable control of other aspects of the environment, such as security, power management, etc.

In terms of a business proposition, the fact that there is an ageing population globally makes the offer of "control" services for a Smart Home compelling – it is after all a growing market [3]. And for users the proposition is also compelling – it can enhance their quality of life, and can offer reassurance for their families.

2 Opportunities and Limitations of Technology for Disabled Users

A key component of recent developments in digital technology is the extent to which it is capable of being interconnected. Network technology in the home has supported the proliferation of devices for the management of features such as security, energy management, access to media devices, and communication. However, the proliferation of networked digital devices has the potential for negative as well as positive implications for disabled users. Analogue controls, for example, such as physical dials, buttons, switches, levers and valves were conventionally addressable by more than one of the 5 senses. In many cases they could be touched, seen, and heard. For instance, turning a dial might indicate progress by a visual and tactile arrow, and might emit clicks to indicate a change of state. The state of a real (as opposed to a metaphorical) radio button, could be felt, and seen, and a change in state of a group of these buttons could be heard.

Reducing the number of moving parts of this type both reduces the cost and increases the flexibility of the user interface, since extra functionality can be introduced without the requirement for additional physical controls. However, it also has the effect that interactions rely for the most part on a single sense, primarily visual output from the device. Where the relevant sense is impaired, backup strategies such as the ability to ascertain the state of a physical button by touch, are no longer available.

The more positive effect of this trend can be seen in the potential for customisation of digital technology. Although the graphical user interface is becoming increasingly ubiquitous in devices such as domestic kitchen equipment, energy and environmental control etc, the underlying technology can be designed to allow access options of many types to interact with the services they implement. Thus, in spite of possible disadvantages, it can be seen that this technology, while increasingly popular among the general population, has the potential to be truly life-enhancing for some groups of disabled users.

3 Smart Home Context

Technology to control appliances and environment in the home has been developing rapidly in the past years, encouraged by enhanced connectivity which has the effect of reducing the cost of control interfaces. Examples include Air Conditioning, Moisture detectors (for alarms triggered by leaking freezers or pipes), sensors to test whether doors and windows are open/closed, thermostats etc.

Currently, many of these have incompatible, proprietary interfacing strategies for operation via dedicated apps on smart phones and tablets. The potential benefits for disabled people of this new technology are obvious, but for many, the promise remains unfulfilled due to the incompatibility of the user interface, with assistive technology appropriate to a specific disability. The approach demonstrated by our Proof of Concept (outlined below) provides a user interface with flexibility to facilitate access by users with a variety of disabilities, primarily those with a visual impairment.

Fig. 1. Smartphone handset featuring Smart Home application used in the Proof of Concept

4 Proof of Concept

User Requirements

Our Proof of Concept (POC) user interface (see figure 1.) was based on the requirements of users with a severe visual impairment, though the model could be extended to incorporate the requirements of other disability groups, such as those with manual dexterity issues. The requirements of visually impaired users are of particular interest in this context since these users are currently excluded from the use of much of the current generation of Smart Home and media technology due to the almost total reliance placed on visual feedback employed by the associated user interfaces. Control of heating is an area with particular issues, since the user needs to be able to read the current temperature, the target temperature, the state of the heating system (on, off), the various programmes determining when the state will change, etc. This function was included in our Proof Of Concept (POC) together with sensors to indicate whether doors were open/closed. It also had the capability to control devices such as lamps.

Hardware and Software Approaches

The device chosen as the platform for the User Interface was a fifth generation Apple iPod Touch, as the VoiceOver screen reader which comes as standard with this device offers comprehensive Text To Speech conversion enabling voiced feedback. Encouraging results were also achieved using an iPhone 4, and a selection of Android devices.

An early decision in the development of our POC was the use of a web application, as this approach is particularly suited to portability across browsers and devices. The "web app" was built using HTML, CSS and JavaScript. It also makes use of the jQuery 1.X and jQuery Mobile libraries, which were chosen due to their cross-platform compatibility.

A core attribute of the design of the Web App was the W3C Access Initiative, Accessible Rich Internet Applications suite (WAI-ARIA) [4]. The ARIA suite was chosen as it assists the developer to ensure that information relating to the type and purpose of an object is correctly exposed to assistive Technologies so that it can be rendered to a disabled user in a meaningful way. By defining facilities that help Assistive Technologies to present rich content, WAI-ARIA provides a powerful set of tools that help developers make their web content truly accessible. Specifically, ARIA roles, states and properties are the semantic means by which information is conveyed to the User Agent and associated assistive technologies. Role attributes are assigned to elements to inform User Agents of the purpose, or role, of a particular element, its relationship to other elements, and subsequently how to handle each element.

Various browsers were used to validate the design of the "Web App" including Google Chrome, Internet Explorer 9 and Mozilla Firefox, the last of which was also used for its excellent debugging abilities via Firebug and its element inspector.

The ZWave protocol, designed to automate devices around the home, was used to enable the Wi-Fi element of the POC.

User Interface Options

Accessibility/Inclusivity is most likely to be achieved where the user interface can be optimised for the requirements of the user. These include, voice and gesture recognition and single-switch control for severely disabled users.

A secondary application was coded on top of the Z-Wave infrastructure to experiment with different kinds of interfaces – in this case the LEAP motion controller and aural interfaces, specifically clapping to extend the functionality for those experiencing difficulties with speech, for example.

Feedback can be provided via screens with configurable characteristics such as font size and contrast or using Speech Synthesis, and even Braille.

Prototype Testing

The POC web app was evaluated by a totally blind user, who in a mocked-up "home environment" tested the app via specific tasks such as detecting the state of doors and windows, setting and testing room temperature, and activating and de-activating devices plugged into the power switch using amended gestures and spoken feedback native to the iPod test platform.

For this POC, the user experience was continually developed and optimised via iterative requirements capture sessions conducted throughout the development period. Informal validation of this POC was considered sufficient ahead of a formal trial proposed for later in 2014, and the results gained from it will be used to inform the development of the trial version.

5 Conclusion

The initial evaluation demonstrated the validity of the concept sufficiently to conduct a trial with a small number of participants who will be able to use the basic functionality provided by the prototype in the participants' home environment. The trial's objective will be to evaluate the extent to which our accessibility model can help to increase the control of the home environment, and by extension to enhance the well-being of the user. By understanding in-home use, and by specifying specific functions (such as those covered in the initial prototype testing) we can, over a period of time, ascertain whether or not the application indeed offers enhanced control and less reliance on others, to enhance independence among the participant group.

In order to fulfil our research objectives of demonstrating the scope of technology to enhance independence and reduce social isolation, this Proof Of Concept should be considered to be a part of the overall Accessible Smart Home, which would include enhanced communications, and the option for remote monitoring by carers and health professionals. This holistic approach is intended to have multiple benefits for many user groups, going beyond the "user", including their entire community. Any future business case for development of such services will need to consider this holistic view.

References

1. Five Ways to Well-being: The Evidence, New Economics Forum. Report commissioned by UK Government Foresight project on Mental Capital and Wellbeing: `http://www.neweconomics.org/publications/entry/five-ways-to-well-being-the-evidence`
2. Older People, Technology and Community, Independent Age. Report, commissioned by the Calouste Gulbenkian Foundation (UK Branch), `http://www.independentage.org/publications/research-reports/`
3. `http://www.inclusivedesigntoolkit.com/betterdesign2/why/why.html#./images/rsz_agevartop__260.gif`
4. `http://www.w3.org/WAI/intro/aria`