Web Navigation Tool for Motor Impaired Users

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Abstract

This paper focuses on a particular kind of disabled user, the motor impaired. Using evolutionary prototyping in conjunction with SSM a system has been developed in an iterative way in line with users' feedback.
The results showed that by focusing on dynamic processes of interaction, and placing the power in the interface itself all motor impaired users could use one system, something that is not possible in mainstream browsers. Using an onscreen keyboard and virtual click the number of clicks required to write a word were reduced to zero.
This paper demonstrated the issue of point and click for the motor impaired and the artefact proved that this could be overcome. By empowering users with freedom and flexibility complexities were broken down as were accessibility barriers.

Keywords - Browser, Motor Impairment, Disability, Accessibility, Changeable Interfaces, Human Computer Interaction

Introduction

The traditional communications media such as telephone, music, film, and television have been redefined by the Internet, by services such as Newspaper, book, blogging and web feeds. The Internet has enabled interactions through social networking sites.
There are 650 million persons with disability worldwide with 577,000 persons in the UK alone. By expanding the World Wide Web to millions of disabled persons, exclusion is reduced and organisations are able to offer their online services to a larger audience.
This paper focuses on the motor impaired users who often feel excluded from the information society as it can be difficult or impossible to use today's software applications. Common browsers for example are immutable as opposed to adaptable for disabled users. The complexity lies in the variations of ability and impairment of the individual, a one system fits all approach makes the target audience larger allowing a greater chance of success.
Gajos, *et. al*, state that it is estimated that only about 60% of the users who need assistive technologies actually use them. Currently a low cost interface for motor impaired users is scarcely available, largely because the target audience is a low percent of the population and the complexity of the systems is high, with classes of motor impaired persons differing on impairment and level of need. This paper sets out to answer one question:

How can the internet be made more accessible to the motor impaired?

Research was conducted into adaptable interfaces currently available, with the hope of improving current frameworks and mechanisms, and finally building a prototype for a system that showcases a new improved mechanism for enhancing accessibility of information online. The idea was to begin by researching the work of academics and reviewing the current systems available to gain understanding of what current systems are capable of and what needs to be improved. This fed into the requirements and gave an understanding based on sound analysis of what needed to be included to reach the desired outcome. In the remainder of this paper, a brief overview of systems investigated is presented, along with some background and overview of what similar systems do well and what needed to be improved. Finally the methods used for implementation design and testing are shown which is followed by a discussion of the results and conclusions.

Related Work Background and Overview

A number of specialised software applications have been developed for motor impaired users each focusing on adaptability as a key factor to success. For example (Magee & Betke 2010, p. 139) states that typically, users are required to adapt to the interfaces that they wish to use. We propose interfaces that change and adapt to the users abilities. While (Gajos, *et. Al.,* 2010, p. 1) states that SUPPLE, adapts to users‘ capabilities indirectly by first using the ARNAULD preference elicitation engine to model a User‘s preferences regarding how he or she likes the interface to be created. The second system, SUPPLE++, models a user‘s motor abilities directly from a set of one-time motor performance tests. Adaptability is the key in each approach.
HAIL is a framework which is used for adapting software applications that individuals use with mouse substitution interfaces. Magee & Betke state that our target audience generally has difficulty with precise control of a mouse pointer. This makes tasks such as clicking on small buttons or web links difficult. Wobbrock & Weld 2010 state that motor impaired users can perform well with conventional input devices (e.g., mice or trackballs) if provided with interfaces that accommodate their unique motor capabilities, this is in stark contrast to (Magee, & Betke 2010, p. 139) which assumes that their target audience cannot use standard devices such as a mouse.
Krzysztof Z. Gajos, Jacob O. Wobbrock and Daniel S. Weld are the designers of both the SUPPLE ++ and SUPPLE interfaces. HAIL and SUPPLE ++ use very different approaches. While the HAIL framework is able to be changed over time by the user whose ability may deteriorate or improve with their condition, or as they become more proficient in using the tool, SUPPLE ++ performs a onetime test using it’s built in ability modeler. The interface is generated based on the results of this test.
What is apparent is that both interfaces are driven by external factors, originating from the user or the users environment respectively. SUPPLE feeds preference statements into the ARNAULD engine, and according to (Gajos, et. *al* 2010, p. 2) these could typically consist of device specific constraints, such as screen size and a list of available interactors along with a usage trace. The system has a cost function and will produce an interface with the least cost.

Input Devices in Relation to Supple and Supple++

Hail was specifically written to work with the camera mouse, which is a device designed to convert head movements into mouse pointer movements, (Magee & Betke 2010, p. 141) states that camera mouse movements are more akin to keyboard movements such as up, down, left, right. For this reason it works well with linear lists and grids. The camera mouse issues a click when an item is hovered over for a certain amount of time.
SUPPLE and SUPPLE++ however have been tested mainly with the mouse or trackball

and there are no findings supporting any testing of the interface with the camera mouse or mouth joystick. The trackball can be used with various parts of the body, for example the chin, backs of the fingers, bottom of the wrist or bottom of the fist. This is in contrast to the camera mouse used by the HAIL browsers audience which can only be used by the head.

Analysis Central Issues and Critique

Each systems focus is on adaptability, however when all things are considered, there still is not a truly adaptable system available. For example the HAIL interface has been designed specifically for users of the camera mouse, and the only other device mentioned is a mouth joystick, this inherently assumes the user has control of the head. A person who is classed as being Hemiplegic, for example someone who has had a stroke or suffers from cerebral palsy, may want to use the hand on the working side of the body, and so chose a trackball. While the trackball may work, it is likely to be less effective than the camera mouse, the device the interface was designed to work with. Trackball users may be able to perform diagonal movement which isn't catered for with a camera mouse. With HAIL, links can be navigated through in turn, with the obvious draw back whereby if a user needs to get from link 1 to link 10, they have to click 10 times. This could be frustrating and cause fatigue.
There's no evidence to suggest that SUPPLE can or can't work well with a camera mouse, however assuming it can, there may be frustration where functionality exists for example, for diagonal movements and camera mouse users aren't able to have the features.

User Interface Design and the User Model

(Tihomir, et. *al* 2006, p. 86) suggest that "Point and click" interactions are one of the key features of operating systems based on graphical user interfaces (GUIs). While (MacKenzie, 2003, P.27) states that the movement of body and limbs is inescapable in human-computer interaction (HCI). The term input device tends to suggest inputting information; however interaction is more akin to meaning dynamic process of interaction. Disabled users have issues with using conventional point and click devices, with the movement of limbs so both authors have highlighted the major issue faced by the motor impaired, which are that they do not have precise control of limbs to enable the use of traditional point and click devices, and today's GUI interfaces are point and click centered. Based on this, the research must focus more on dynamic processes of interaction than on input devices, and any adaptable user interface for motor disabled persons must be driven by the movement a user can perform. All aspects are interconnected and contribute to the user experience. (Findlater, et. *al* 2010, p.1) inform that challenges are mostly due to fine pointing corrections at the final stages of target acquisition. Two differing methods are presented to overcome this:

- Click and cross
- Visual Motor Magnifier

The method of using click and cross is to move the circular area of the cursor over the area where the target resides, it is activated with a click, to make the selection the user needs to cross the cursor through the area selected for the small target. With the visual motor magnifier the user must move the cursor to the desired area and click once.

Analysis Central Issues and Critique

Today's interfaces are very much point and click centered and devices seem to assume a click can actually be issued by the user. This is the case for both the motor magnifier and the click and cross system. This wouldn't work for a tetraplegic person, however the camera mouse discovered in earlier chapters, issues a click automatically when an item is hovered over for a certain length of time. Tetraplegics do have the use of the head so this would work for them, although the constant use of the head could cause fatigue. The conclusion that this leads to is again back to adaptability.

Methods

Research was conducted into methodologies and tools and it was decided that evolutionary prototyping would be used as requirements were not well defined up front and feedback can be fed back into the prototype. Disabled persons have no straightforward 'problems' or easy 'solutions as the classes of user differ, and so SSM is a suitable approach that will help to produce a system that is socially aware.

Analysis, Design and Implementation

Based on the issues and objectives outlined in previous chapters this section aims to further explore the user's needs using SSM and a series of models in conjunction with evolutionary prototyping, which will help to structure the project in an iterative way. Firstly the users input is gathered from real user stories, then a rich picture is developed and root definitions defined, this leads onto the building of conceptual models. In turn this will be fed into implementation and design. A series of prototypes will be built, tested and then the results evaluated, the rich picture will be redefined to gain better understanding of the social situation.

Root Definition

A system to demonstrate how the World Wide Web can be made accessible to motor impaired users, by delivering interfaces based on the movement a user can perform in relation to their disability in order to eliminate exclusion and overcome barriers, contributing to an ongoing project to make the Web accessible to all motor impaired persons.

Catwoe

- Customers – Motor impaired persons, Day care centers, Health organisations, and Voluntary sector organisations: May have different interests.
- Actors – Developers, Testers: Time constraints.
- Transformation – Movement is dynamically transformed into mouse pointer movement on-screen, information is outputted to screen. Movement is transformed into keystrokes, words are outputted to screen: Output is information and interaction based interfaces.

- World View – Motor impaired users overcoming barriers and exclusion, seeking every aspect of World Wide Web available to able bodied persons. Organisations who are seeking to reach millions of disabled persons, currently excluded from aspects of the World Wide Web.
- Owner – Developer, Motor impaired persons or organisations using the system: Will fail if it does not meet their needs.
- Environmental Constraints – Web standards not always met by web developers, health and safety issues, and Accessibility issues I.E. no access to assistive technology or computers, financial.

Root Definitions

A system owned by developers to demonstrate how the World Wide Web can be made more accessible to the motor impaired in organisations or at home, by transforming movement into mouse pointer movement and text to screen, creating dynamic interfaces, in order to overcome barriers and exclusion, allowing motor impaired persons the same access to information as able bodied uses.

Analysis and Design Prototype 1

The original rich picture which can be viewed in the appendix (Figure 1) helped to gain an overall understanding of the complexities and social aspects surrounding motor impaired persons in relation to browsing the World Wide Web. However this needed to be further refined to gain a better understanding of what is required for the initial prototype which will need to contain the bare bones of the system. The rich picture shows a high level understanding of what is needed and what level of functionality will not be accomplished at this stage. The basic uses of the artefact are demonstrated, including; simplified navigation with quick links which are used to aid navigation and book marking. The facility to hover and issue a click is not yet available nor is the virtual keyboard. The rich picture demonstrates that severely impaired persons are still excluded based on this.

Testing Evaluation and Feedback

Participants included four persons without motor impairments (age: 20-55) and two persons with mild impairments aged 60+. Three were female and two were male. The participants were family members. The abilities of users spanned a broad range with some users having mild impairments such as arthritis which limited keyboard skills and others having no disability at all. All relied on a computer for some aspect of their lives.

Apparatus

All users were given the choice of input devices but chose a standard mouse. The software was tested on a Windows 7 Dell Vostro PC with an Intel i5 CPU 750 @ 2.67GHz with 4GB of installed RAM.

Testing

Testing was split into some key areas including usability and bug testing which were split further into categories such as list selection, pointing, typing and general navigation.

The system generated the interface dynamically depending on the user's impairment. Navigation was simplified by the mobile version of the web page being returned for example where a user was severely impaired.

Implementation

Motor impaired persons will struggle with general navigation due to limitied mobility, therefore quick links are provided.. When display hyperlinks is clicked all links on the current web page are shown and are clickable. This reduces movement required to navigate around a web page and aids usability. All links are picked up that are defined on the web page using the <a> tag along with the href attribute.
The Zoom feature has been added to allow the text to be increased on web pages, this is dependent on the body tag and the font-size attribute being present, this further enhances target acquisition by allowing the user more clickable space. Likewise decrease font works in the same way but makes text smaller.

Feedback

Users were very positive about prototype 1 but the users with more sever impairments had struggled because of the lack of a virtual click. There were some bugs uncovered such as clicking on favourites before the web page had fully loaded gave an object not set to an instance of an object error. Switching to the mobile version of the web page set it for the entire session and even on closing the web browser it couldn't be subsequently set back to the standard version for mildly impaired users. Quick Links become un-clickable once enlarged or decreased using ZOOM

Summary

In summary prototype 1 met its targets; it was required to include the bare bones of the system which will be built upon in subsequent artefacts. There are some bugs to be addressed but this is to be expected for an initial prototype and the iterative nature of SSM and evolutionary prototyping allow for this to be corrected at later stages. There is lots of positive feedback as well as some good input on improving general usability of the system which will now be incorporated into prototype 2.

Analysis and Design Prototype 2

The rich picture within the appendix (Figure 2) shows that in prototype 2 barriers are being overcome, users can now issue a virtual click which means severely impaired users are no longer excluded. Adaptability is achieved by ensuring all users can access all features but not all features are available by default, thus driving the interface by movement and disability. Complexities have been overcome using the one system fits all approach. The rich picture also shows that there is still some exclusion for the severely impaired as they are unable to enter the URL, a key component in navigating a web page.

Implementation

If the mildly impaired form was selected and the mobile version launches as opposed to the standard version of a web page, the user can now click refresh. This will force the web page to reload from the server and will resend the header information as the client user agent string. NB – Choosing set mobile version from the view menu will overwrite this functionality as it set for the entire browsing session. To return to the standard version the user then needs to close all open forms, re-launch and click refresh. Users can now issue a virtual click on any item but the functionality is adaptable and can be switched on or off.

The user can now hover over the green go button and the text in the address bar is navigated to, likewise links are displayed when Display Hyperlinks is hovered, and back and forward can be hovered over to step back or forward a page. All items within the main menu including favourites set mobile version for example have their functionality launched on hover so users no longer need to click.

Users will click zoom and then hover over increase to enlarge links, the links now remain clickable thus addressing an earlier bug.

Testing

The same users and apparatus were used as in previous prototypes for consistency and the areas of testing remained the same.

Feedback

There was a bug uncovered on first page load where an exception is thrown due to the favourites not being present, the XML is dynamically created and is there for all future page loads. To get around this, the XML file will be supplied with the install and the user guide will detail where to place it. Users were happy with this. Users had asked for a tool tip on the quick links which has not been added and this is because it is deemed not necessary to the success of the project. The main feedback was that a virtual keyboard is paramount for severely impaired persons.

Analysis and Design Prototype 3

Figure 13 within the appendix shows that prototype 3 is breaking down barriers to accessibility. Users are overcoming their impairments with the addition of an on-screen keyboard that requires no click to type. All users can now enter the URL and the system is adaptable in that the keyboard is optionally used. This should be the final artefact that achieves the goal of demonstrating how the internet can be made accessible to the motor impaired.

The virtual keyboard is launched, users can hover or click an item and the selection is appended to the text box always to the right. Hovering over delete will remove the last letter in the textbox and clicking or hovering enter closes the keyboard and inserts the URL into the main form that the user navigated from.

The URL is entered as the top item in the combo box as and the user can hover or click on the green go button to be taken to the selected web page, please refer to the appendix section for images.

Summary

In summary the additions added for prototype 3 overcame the final barriers and made the system usable to all of our motor impaired persons by allowing virtual typing of the URL, there is still future work that has been identified but it is not paramount to the success of the project, as the prototype only needs to demonstrate how the web can be made more accessible to the motor impaired to meet its goals which has already been demonstrated.

Results & Discussion

Returning to the critical success factors, in order to be a success the artefact needed to enable the motor impaired to navigate around the World Wide Web with minimum movement required and to substantially increase accessibility of information in this way. The system accomplishes this by providing quick links for any web page, this vastly reduces how much movement a user needs to make in order to get to a link, and movement is also reduced by allowing users to use the mobile version of a web page which is more linear and only requires up, down, left and right movement.
All navigation on the form for the severely impaired and head users had the virtual click implemented, measured against existing browsers such as IE the improvement is vast, based on the fact that in standard browsers motor impaired users would simply be excluded because they can't click or move the pointer in the usual way.
By focusing on dynamic processes of interaction the system was able to accommodate many users with differing impairments, simply by empowering the users with freedom and flexibility and placing the power within the interface and not within the input device.
The virtual keyboard reduced the number of clicks to zero as each key typed on hover. The main issue here is that the virtual keyboard is tied to the URL and is simply used for improved navigation and to ensure a severely impaired user is not excluded from navigating to any site, the main goal of the system.
The system had to be able to adapt to different users and this is seen by the differences in the use cases for the severely impaired and mildly impaired. The system can adapt to its users, for example by using different paths and forms a severely impaired person is taken down a different route to a mildly impaired person. A mildly impaired person may be someone with arthritis and this person would get the standard version of a web page by default, but this is adaptable and the user can switch the mobile version on or off. The keyboard feature is on a hover menu item and does not have to be used to enter the URL. So users do have choice. Every user gets every feature and so adaptability is achieved and exclusion eliminated to a degree. Currently the virtual click cannot be turned on or off and this is something that should be improved in future, thus making the system truly adaptable and further empowering users. The idea is that the user makes the system fit them, and they have the choice.

Future Work

One of the major barriers was that today's GUI's are point and click centred which is a major issue for the motor impaired. This was overcome by allowing users to issue a virtual click on hover. While the system met this objective there were some issues, for example it was very easy for a user to inadvertently issue a click. Motor impaired persons may not have reliable control of the limb they are using and cannot be expected to accurately get the mouse pointer over the correct item first time, this could be frustrating. Future work would be to implement an adjustable timer on the hover to combat this, giving the user breathing space to get the mouse where needed.
While this success factor is met to reduce the number of clicks required to write a word

there is room for vast improvement, in future it would be better if the keyboard could be predictive as well as typing on hover. This would allow motor impaired users to branch into social networking, emailing and further eliminate exclusion. The implementation of the timer on hover would also be needed here as the frustration would become too much.
It is the hope that this work will contribute to the ongoing field of study and to the development of dynamic processes of interaction design for motor impaired users, with the goal of making information accessible to all, in a culture where exclusion is eliminated.

Conclusion

In conclusion this paper answered the question set, how can the internet be made more accessible to the motor impaired and demonstrated this with a new artefact for a web navigation tool. All critical and non critical success factors were met. The paper has shown how existing systems can be improved by focusing on dynamic interaction and movement as opposed to designing with a specific impairment or input device in mind. This contributes to the work of others in the field and hopefully working together will eventually result in information on line being accessible to all with no barriers or exclusion. This paper demonstrated the issue of point and click for the motor impaired and the artefact proved that this could be overcome. By empowering users with freedom and flexibility complexities were broken down along with the barriers they bring. By critically evaluating the work of others and uncovering a gap in what exists now, this moves the larger research area forward. The addition the paper brings is new understanding, using dynamic processes of interaction and a one system fits all approach the internet can be made truly accessible to the motor impaired rather than focusing attention on external factors such as an input device we get to the heart of the issue which ultimately is caused by a motor impaired persons limited movement, it is this that the paper at its heart addresses.

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Appendix

Figure 1 – Rich Picture 1

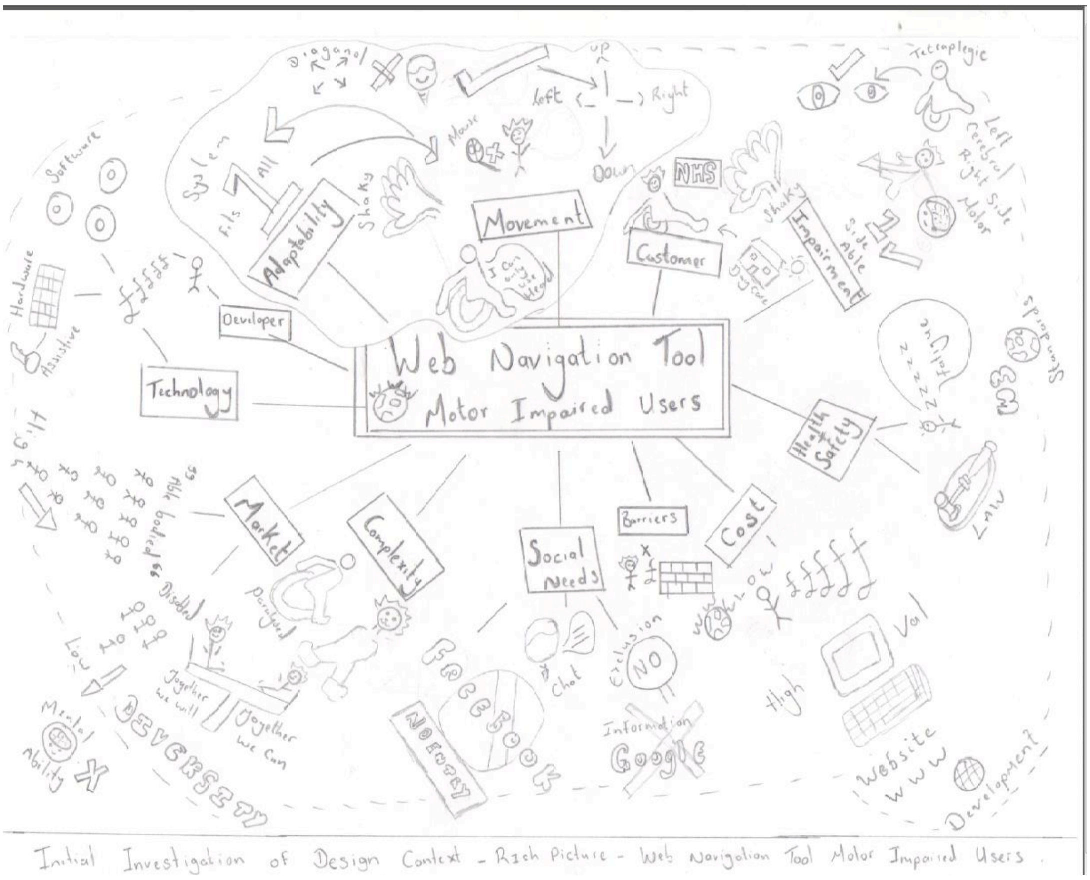


Figure 2 – Rich Picture 2

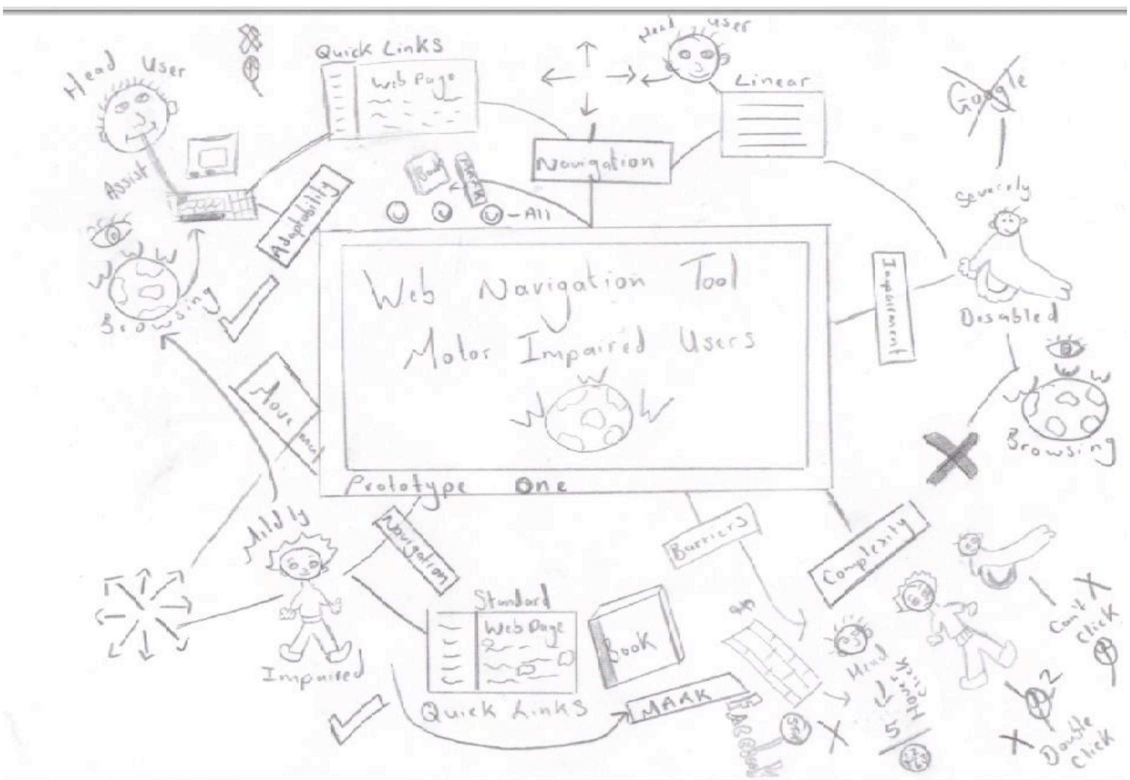


Figure 3 – Rich Picture 3

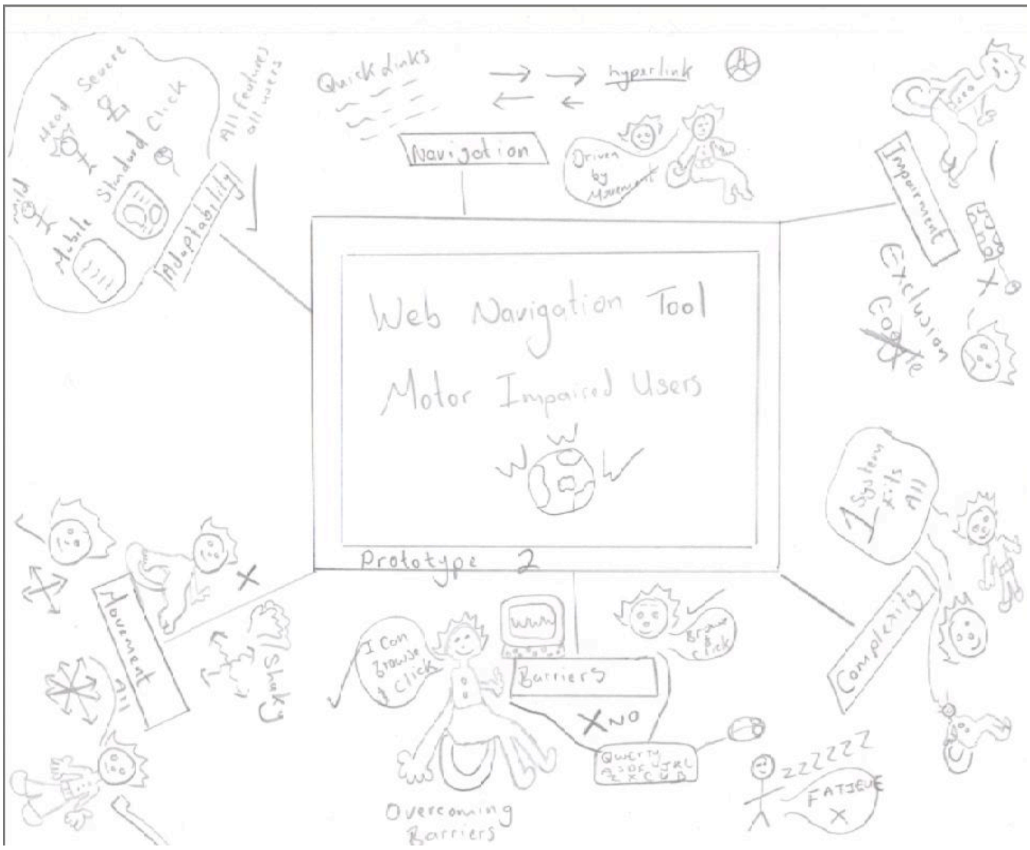
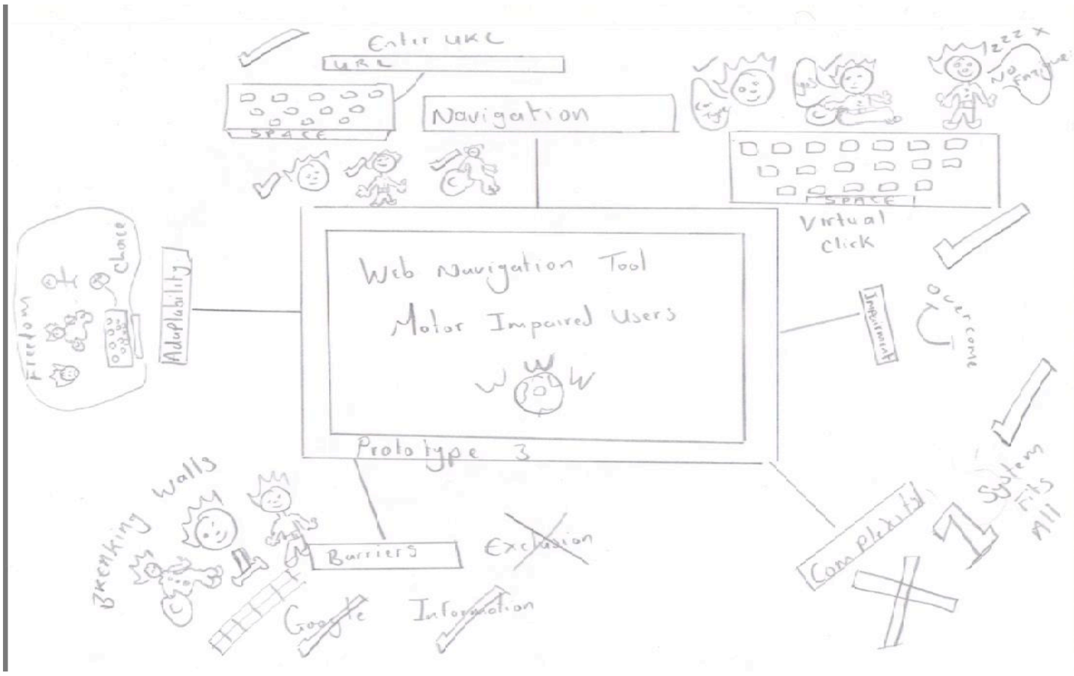


Figure 4 – Rich Picture 4



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