An Error Detection Strategy for Improving Web Accessibility for Older Adults

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***Abstract*— The ability to use the Internet can provide an important contribution to an older adult's quality of life. Communication via email with family, friends and service providers have become critical factors for improving ones ability to cope with modern society as individual's age. The problem is that as users age, natural physical and cognitive impairments make it more difficult for them to use the required technology. Setting user preferences in browsers has been suggested as a means of dealing with these limitations. However, questions exist as to the effectiveness of older adult's ability to use self-assessment as a means of setting preferences. The present study investigates the use of error detection as a means of improving web access amongst older adults. Specifically, an error detection strategy has been developed and compared to self assessment, written tests, and observation as a means of identifying the impairments of older Internet users**.

Keywords-web usability, error detection, older adults

I. Introduction

The normal aging process can trigger decreases in acuity of vision and cognition as well as physical impairments, which impact Web usability, particularly if Web designs are not user-friendly [8,9]. Web design issues related to fonts, colors, graphics, background images, navigation, and search mechanisms might prevent older adult users from taking full advantage of online health resources. Web designs may also present reading comprehension barriers for the older adult, due to limitations in visual acuity, cognitive abilities, and education levels, all of which may have a consequence on Web usage [6]. Savago, Sloan, and Blat [24] see cognition problems as the largest barrier to computer use by older adults. Cognitive issues place older adults at greater risk for falling for Internet scams [7].

The implication of better health care for older adults is a longer life [12]. It is crucial for them to be able to keep abreast of new developments in health care that can enhance their life [2]. Older adults who have access to the Internet have access to a large number of ways to find information to help them achieve this goal. It also provides an excellent means of interacting with family members, which also has implications for positive health outcomes. Xie [33] has noted that the use of the Internet has changed the relationship between older adults and their health providers. Many older adults have problems performing daily tasks because of restricted mobility, lack of transportation, inconvenience, and fear of crime [4]. Home computers with an Internet connection can provide access to information and services, and can also be used to manage banking and Internet shopping tasks. This can be of critical importance. Sum et al. [27] have found that Internet usage is an important factor in older adult's ability to deal with loneliness. Kwon and Noh [14] have also noted that using the Internet can help reduce boredom. Hogeboom et al. [10] have shown that Internet usage is important in strengthening older adults' social networking. Madden [16] notes "Social networking among Internet users ages 50 and older almost doubled -- from 22% to 42% during the 2009-2010 period". Uphold [30] found that older adults are the most likely to seek information on the Web.

Sloan et al. [26] and Mazur et al. [17] have noted that the full impact of how older adults use Internet tools is still an open question. Salces et al. [22] provide a detailed discussion of the effect of aging. Interestingly, studies [13,15,16,31] have found that the average age of computer users has continued to increase. Berry [3] suggests that the variation in the older users should be taken into account as methods for older adults are considered.

Xie and Bugg [32] have found that good training for older adults in public libraries can improve effective computer usage. However, training does not help with the user's limitations. One means of dealing with these issues is for website designers and Human Computer Interaction (HCI) professionals to provide services for better interfaces and Websites in order for older adults to effectively use computers and obtain information resources on-line [12]. While such an approach is viable, it restricts use of the Internet to sites that have been designed with such limitations in mind.

To provide a more general solution to the problem, it requires taking the limitations of the users into consideration. Hanson and Crayne [8] make use of user preferences. However, older adults are not as successful as younger users in making use of the preference options provided by the browser [8, 9]. To bridge this gap, we propose the use of an error detection strategy to determine the level of impairment of user. The proposed error detection strategy is compared against self assessment, written test, and one on one observation

The information on the user's level of expected performance is stored in a user profile and then is used by the server to modify the Web page the user is working with. The use of user profiles is not new, but it has proved to be a useful construct in our tests. Jacko et al. [11] used visual profiles in their work. We ultimately see a user profile as containing information such as font size, cognitive level (reasoning, speed of processing and locus of control), and mobility/motor measures. The present work looks at the development of profile types based on self assessment, written tests, and observation and our error detection strategy and focuses on vision and motor skill issues.

The key question addressed in this research is "Does error detection produce a profile of the older adults' accessibility performance that is comparable to profiles based on self assessment, written tests, or observation?" To test these questions, we constructed a server based software platform that makes use of a user profile to modify Web pages. The platform was used in a user study of 25 older adults to examine our research question.

The next section briefly looks at some related work. Section III looks at the software platform used in the study and Section IV describes the experiment design. Section V presents the results of our study and Section VI provides a discussion of the results. Section VII provides concluding remarks and thoughts about future work.

II. RELATED WORK

Several approaches have been proposed to assist older adults. A number of special purpose devices have been developed to aid users with motor and vision issues [18]. Mice and specialized keyboards are available to aid older adults [4,5] with declining motor skills. Special viewers to magnify the symbols on the screen are available as well. While such devices are very useful, they tend to increase the cost of computer systems and restrict where older adults can access the Internet. Moreover, older adults are less likely to be aware of special hardware [8]. Hanson et al. [9] have looked at voice browsing as a compromise. Pervasive computing [21] has somewhat similar goals, but does not focus on the user's limitations. Sato et al. [23] have built on voice augmentation techniques to help older adults.

The IBM research group at Watson proposed a Web solution approach to Web accessibility for older adults [9]. They employed a server to reformat Web pages based upon user preference and capability. This Gateway software was built on WebSphere Transcoding Publisher. IBM WebSphere® Transcoding Publisher Version 4.0 for Multi-platforms is server-based software that dynamically translates Web content and applications into multiple markup languages and optimizes it for delivery to mobile devices, such as mobile phones and handheld computers. The software adapts, reformats, and filters content, tailoring it for display on pervasive devices, giving companies better access to mobile employees, business partners and customers.

Another group of IBM's researchers, Nagao et al. [20] continued research in the area of content adaptation through transcoding for accessibility for users with specific needs. Content adaptation is a type of transcoding that considers a user's environment devices, network bandwidth, profiles, and so on [20]. In their implementation, an annotation server annotated and changed the document contents in accordance with profiles.

More recently, Hanson and Crayne [8] have started to stress the use of user defined preferences at the browser level. However, older adults are not as successful as younger users in making use of the preference options provided by the browser [8]. Mobasher et al. [19] explored mining usage data for Web personalization. The rules are used to adapt the content served to a particular user. Collaborative filtering systems, such as Firefly [25], typically take explicit information in the form of user ratings or preferences, and through a correlation engine, return information that is predicted to closely match the users' preferences.

The next section looks at the software platform used in the experiment.

III. SOFTWARE PLATFORM

We start by briefly overviewing the design of the Error Detection System software used to support our study. The purpose of the Error Detection System is to measure efficiency in an unobtrusive and dynamic Internet browsing environment capable of evaluating user performance and providing dynamic modification of Web pages according to individual user profiles.

A. Overview of Platform

The Error Detection System's platform provides the mechanism to collect relevant information (errors) to gain insight into some of the problems that older adults encounter while browsing the Internet. The

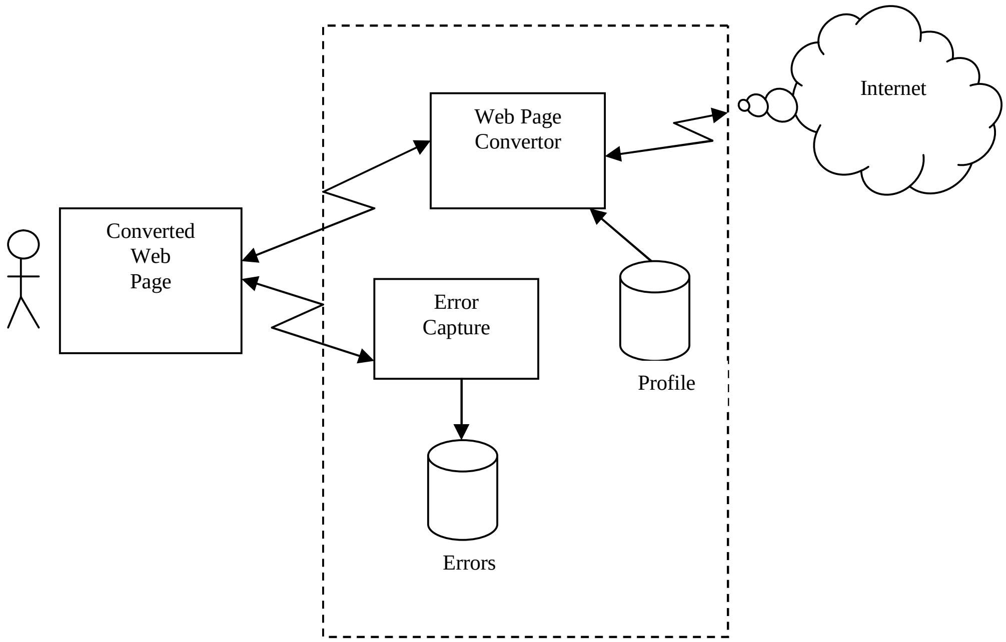


Figure 1. Block diagram of the software platform used by participants.

software uses a user profile for each individual to assist participants surfing the Internet, while tracking their error rates. The result is that users are able to get page modification without having to make manual adjustment with their browser.

The architecture was designed to capture errors related to vision and motor skills. In this study, user performances were compared based on profiles created by self-assessment, written tests, observation, and our error detection software. Details on the design and generation of the four types of profiles are given in Section IV. Here it is sufficient to note that the user profile variables (font size, motor skills) represent the perceived limitations of the owner of the profile.

User Name
Date
Time
Profile Level
Font Size
Motor Skills Score

Figure 2. Profile parameters.

A block diagram of the basic software platform used in the experiment is shown in Figure 1. URL's for the Web pages requested by the user are sent to the *Web Page Convertor* module. The module downloads the requested Web page and modifies it based on the contents of the user's profile (Figure 2). The strategy in converting webpages is to increase the font size to the value given in the user profile, if necessary. The motor skills and mobility scores are used to enlarge the area of interactive screen features, like buttons and text boxes, using JavaScript. We used the phrase *sensitive area* to represent this enlarged area. When the user clicks inside the sensitive area, the feature is activated (e.g., button is clicked).

When a web page is requested, the page is retrieved and loaded onto the server. The web page is then parsed for font parameters, tags, size and area. If the values are the same or larger than required by the profile the fonts or button size are not changed. Each converted Web page is supplemented with code (JavaScript) to support error detection and collection. The errors made by the user are captured on the webpage and sent to the server level and stored to support analysis. An example of an error would be a user clicking near the sensitive area of a button but not close enough to activate the button.

B. Profiles

Four approaches to constructing the user profile have been used in this work [1,28]. Each profile has the same composition and structure. They only differed in the way values in the fields were generated. More details on the four profiles are given in Section IV. Here we provide a brief overview.

1) Self Assessment Profile: Participants were asked to make a self-evaluation of their preferences

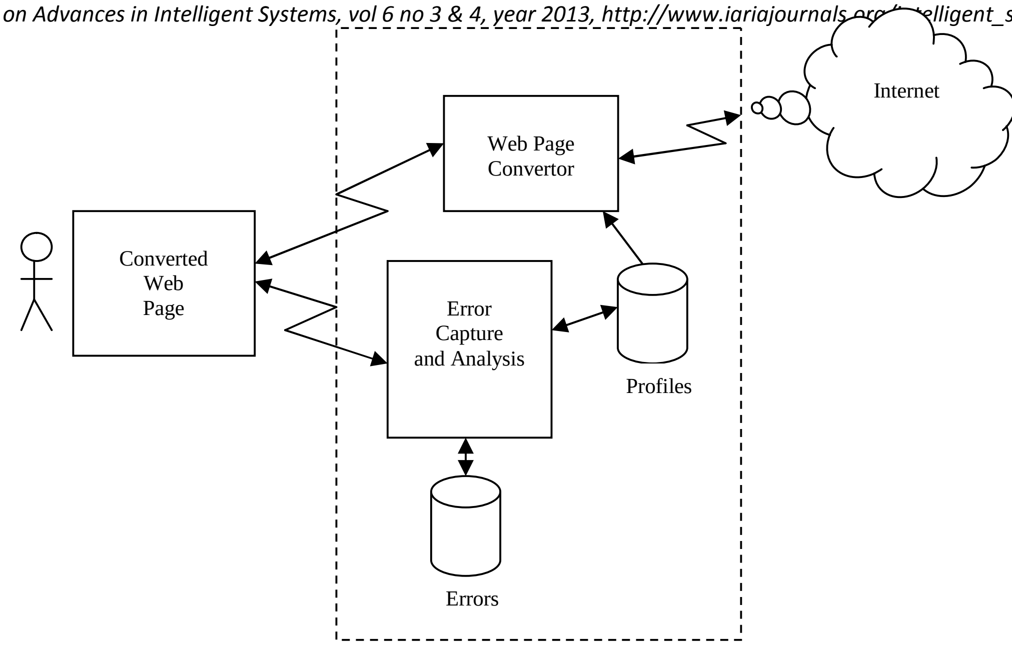


Figure 3. Block diagram of the system platform for supporting development and use of an error based user profile.

for font size and rating their motor skills. The self-evaluation was the participants' perspective of their own ability and their assessment of what they thought was the optimal settings for them to perform effectively. The self-assessment was used to generate a user profile for each user. In the remainder of the manuscript we use the phrase *self profile* to represent this profile.

2) *Written Test Profile:* Each participant was given a written test to check their limitations with respect to vision and motor skills. The exam results were recorded and used to create a user profile. This profile is called the *test profile* in the rest of the manuscript.

3) *Observation Profile:* Participants were observed while they were completing a task set. To ensure consistency, an observation evaluation form was developed with the help of a psychologist (Jennifer Margrett). Moreover, all observations were conducted by the same reviewer to reduce any observer biases. The phrase *observation profile* is used to represent the use of this profile in the rest of the manuscript.

4) *Error Detection Profile:* The errors generated by a user as he/she worked their way through a set of tasks were captured and used to generate a user profile. Figure 3 shows the block diagram of the modified platform. During the tasks, the errors that are captured are analyzed and used to modify the participant's current profile when the number of errors is above a preset threshold. The process continues until the system sees no additional change in the performance of the user. The number of clicks around a button or link is counted to determine the motor skill score. The font size is set in part based on the user's performance based on giving the users different font sizes to work with. The strategy behind error detection was to provide a transparent tool to measure errors and change the current profile to reduce the user errors. We use the phrase *error profile* in the remainder of the manuscript when referring to the use of this profile.

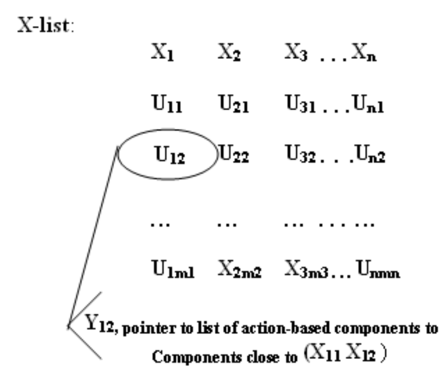


Figure 4. Basic index structure used for Error Detection.

C. *Determining Errors*

A key aspect of the software instrument is the successful determination of when an error has occurred and how to assign the error type. In the

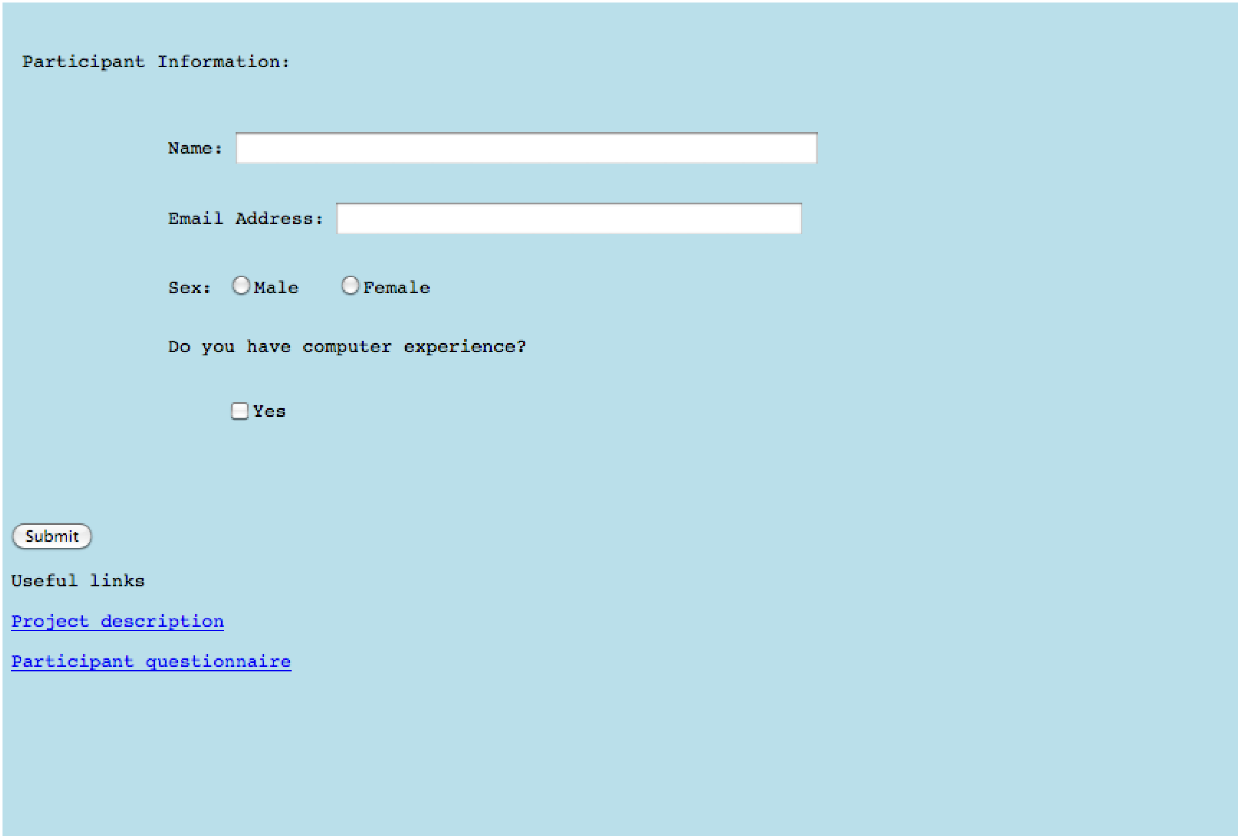


Figure 5. Simple webpage example.

X-list	8	71	163	168	177	209	240	255	538
Y-lists	385	385	195	92	289	491	144	195	92
	409	409	210	113	305	506	164	210	113
	457		289				195		144
	475		305				210		164
	491		457						
	506		475						

Figure 6. Idealized version of the index for the simple webpage from Figure 5.

present work, we have used two error types, namely, motor skills errors and vision errors.

To detect errors, we see the screen real estate as being broken into two disjoint regions, namely, a

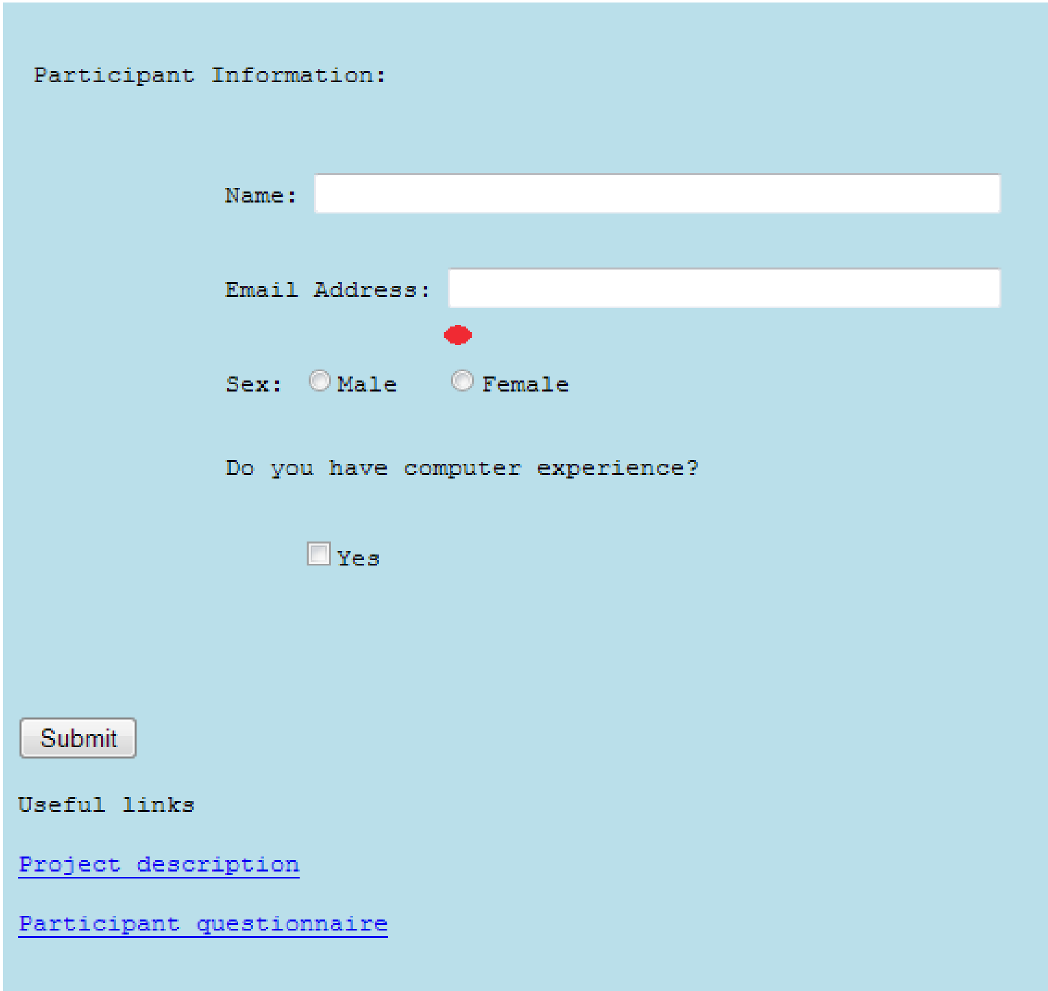


Figure 7. Mouse clicks shown as oval.

sensitive region and a non-sensitive region. The *sensitive region* of the screen is defined as the portion of the screen where an action is initiated whenever a mouse click occurs within its boundary. For example, if a user clicks on the sensitive area around a web link, the browser action is to transfer the user to the web page indicated by the web link. Similarly, the browser takes actions when a user clicks on a button, a textbox, radio button or any other action-based HTML component.

The *non-sensitive region* of the screen is the region of the screen where a mouse click does not cause an action to occur. The non-sensitive portion of the screen can be made up of empty space or screen components that do not generate actions (such as labels, images or text that are not defined by HTML as web links).

D. Index

To support the detection of mouse click errors, we developed a screen real estate index designed to index the active components on a web page [29]. The structure of the index (shown in Figure 4) makes use of an x-list (the x-values of the set of points on the web page that define the location of the action-based components). For each x_i entry we have a list of u objects, where each u object consists of a y value and a pointer to the list of action-based components that are within a threshold t distance from the (x, y) point indicated by the u entry. Consider the simple webpage shown in Figure 5. An idealized version of the index for the simple webpage from Figure 5 is shown in Figure 6.

To detect errors the index described in the previous subsection is used whenever the user clicks

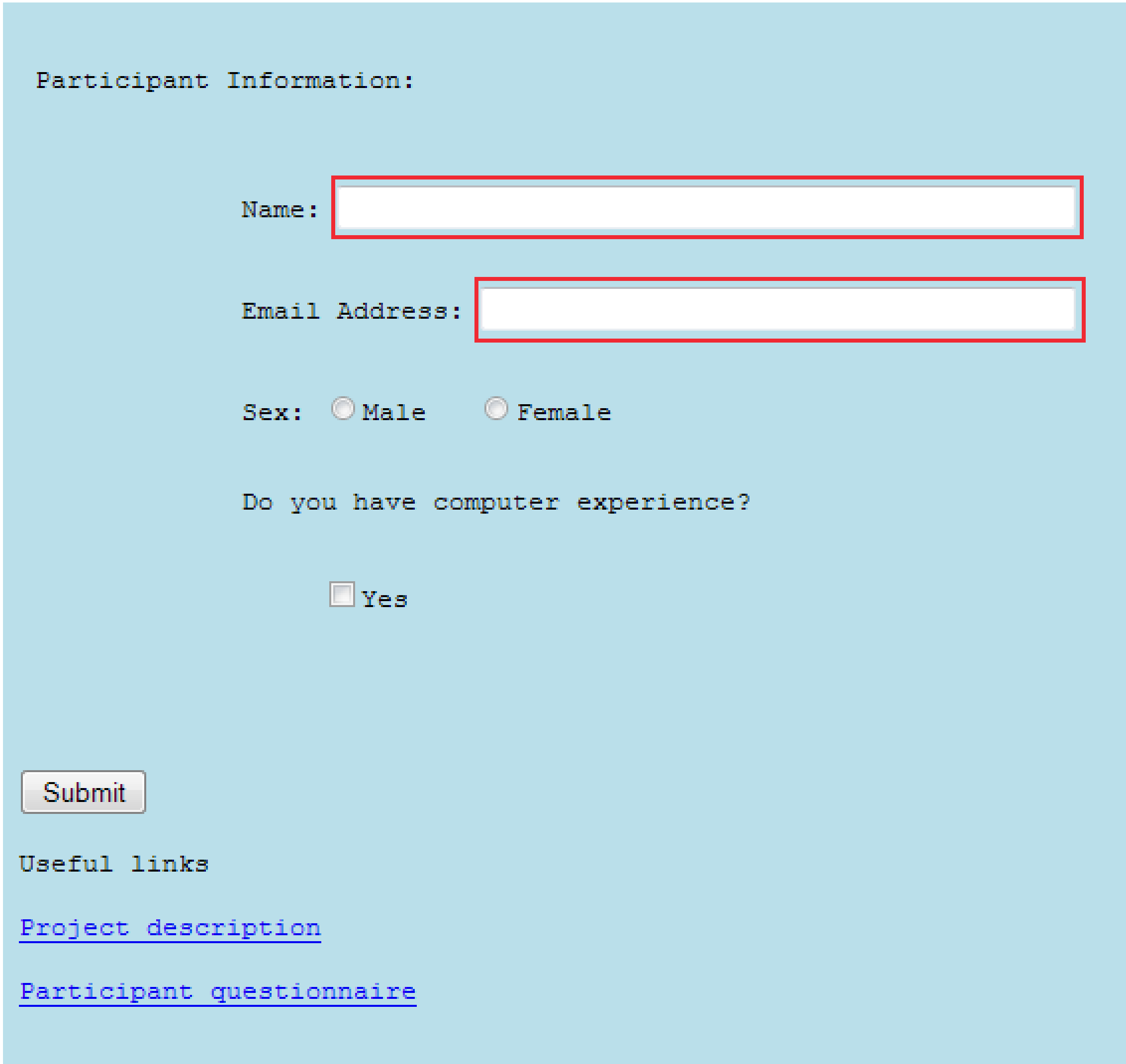


Figure 8. Expanded sensitive areas for textboxes.

in the non-sensitive region of the screen. Suppose a mouse click occurs at location (x^1, y^1) in the non-sensitive region. The x^1 value is used to search the x-list of the index to locate the two x values that bound x^1 (note that x^1 can not be in the x-list or it would not have occurred in the non-sensitive region). Once we have found the two x values (say x_1 and x_2) that bound x^1, we examine the u-lists for x_1 and x_2 to find the y values that bound y^1 in each list. We can then use the components that are linked to the u-list entries to determine if our mouse click at (x^1, y^1) is sufficiently close to one of the components to label it an error. We define *sufficiently close* to mean that (x^1, y^1) is within a distance t (a system defined threshold) from one or more action-based components. A simple example using the webpage from Figure 5 and the index from Figure 6 is given in Figure 7.

In Figure 7, the mouse click is represented by the red oval. The location of the mouse click is at (245, 179). The x-value (245) falls between 240 and 255 in the x-list of the index. The y-value (179) falls between 164 and 195 in the y-list for 240 and is less than 195 in the y-list for 255. For the points we have

Point	Components within t = 40
(240, 164) →	1) Email text box
	2) Female radio button
(240, 195) →	1) Email text box
	2) Female radio button

Testing the distance from the mouse clicks to the two components, we find that the mouse click is

Table I. Participant Demographics.

Male	11
Female	14
Age	M=77
Range	62-97

closer to the email text box. We assign the error type as a text box error. Since mouse click errors can either be motor skill or vision errors, we first look to extend the sensitive area around the components of the type found to be sufficiently close to the mouse click (incase of ties, the sensitive area around all tied component types are inspected). The sensitive areas are investigated to determine if they can be expanded without causing the sensitive areas of action-based components to overlap. If no overlap is found, the error is considered to be a motor skill error; otherwise, we label it as a vision error. The errors are logged. Figure 8 illustrates what we mean by expanding the sensitive area around a component type. The figure shows the expanded areas around the textboxes as a red rectangle. Since the expanded sensitive areas around the textboxes do not overlap, we assume that the error is a motor skills error and we log the error. Note at this point we are only interested in classifying the error and no actual expansion of the sensitive area during this action. Details on how the user profile will be modified are given in Section IV.

IV. EXPERIMENT DESIGN

To study the effectiveness of the error detection approach, we compared it to the traditional methods: Self-assessment, written test and observation.

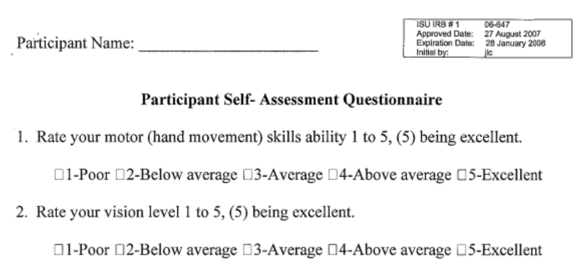
A. Participants

Twenty-five participants were recruited for the study. They were comparable in health, and received comparable treatment throughout the study. The background and characteristics of the participants who completed the study were similar to those reported in other studies of usability for older adults. No significant differences in demographic characteristics or baseline performance were observed between the participants who completed the study (N=25). The participants were scheduled individually for each step of the study.

The study was conducted at a retirement community, which provides services for independent living, assisted-living, and nursing care residents. The sample size was 25. There were 24 independent living and one assisted-living participant. The sample of 25 participants was randomly selected from a pool of volunteers. Table I shows the demographics of the participants. All of the participants met the preconditions of being over the age of 60 years and not having any severe physical impairment such as blindness or could not use the mouse and/or keyboard. They had to be willing to learn and have the ability to sit at a computer for a 30 to 60 minute session. The participants were not paid.

B. Basic Experiment Description

Participants were placed approximately 25 inches from a 20-inch viewable Dell monitor display screen. Screen resolution was set at 1024 × 768 pixels, with a 32 bit-color setting. The icon and the target folders sizes were 36.8 mm (diagonal distance) based on the findings from Jacko et al. [11]. To perform the experiment, each participant used an IBM Pentium computer. The operating system was Microsoft Windows XP Professional. The computer used a Digital Subscriber Line (DSL) for Internet access. The computer was housed on a computer desk with an accompanying chair in the retirement community.
Each participant was instructed to complete a list of tasks. At the initial meeting, each of the participants was given a letter of consent to read that explained the study. They were told that there would be four tests and their activity would be recorded. At the first meeting each user was asked to give a self-assessment of their limitations and their abilities. At the second, a pen and paper test of vision, motor skills and memory was administered and recorded, then their performance using the profile based on the pen and paper test was recorded. At the third meeting, there was an observational assessment of the participant's abilities based on his/her vision, and motor skills. Afterwards, the participants completed a set of tasks and their performance was captured via the server. Finally, the participant was evaluated using the Error Detection approach. We initially set the participant's profile settings according to the test profile settings for the Error Detection study. The


Participant Name: ____________________

ISU IRB # 1 06-647
Approved Date: 27 August 2007
Expiration Date: 28 January 2008
Initial by: jlc

Participant Self- Assessment Questionnaire

1. Rate your motor (hand movement) skills ability 1 to 5, (5) being excellent.

☐1-Poor ☐2-Below average ☐3-Average ☐4-Above average ☐5-Excellent

2. Rate your vision level 1 to 5, (5) being excellent.

☐1-Poor ☐2-Below average ☐3-Average ☐4-Above average ☐5-Excellent

Figure 9. Participant Self-Assessment Questionnaire fragment.

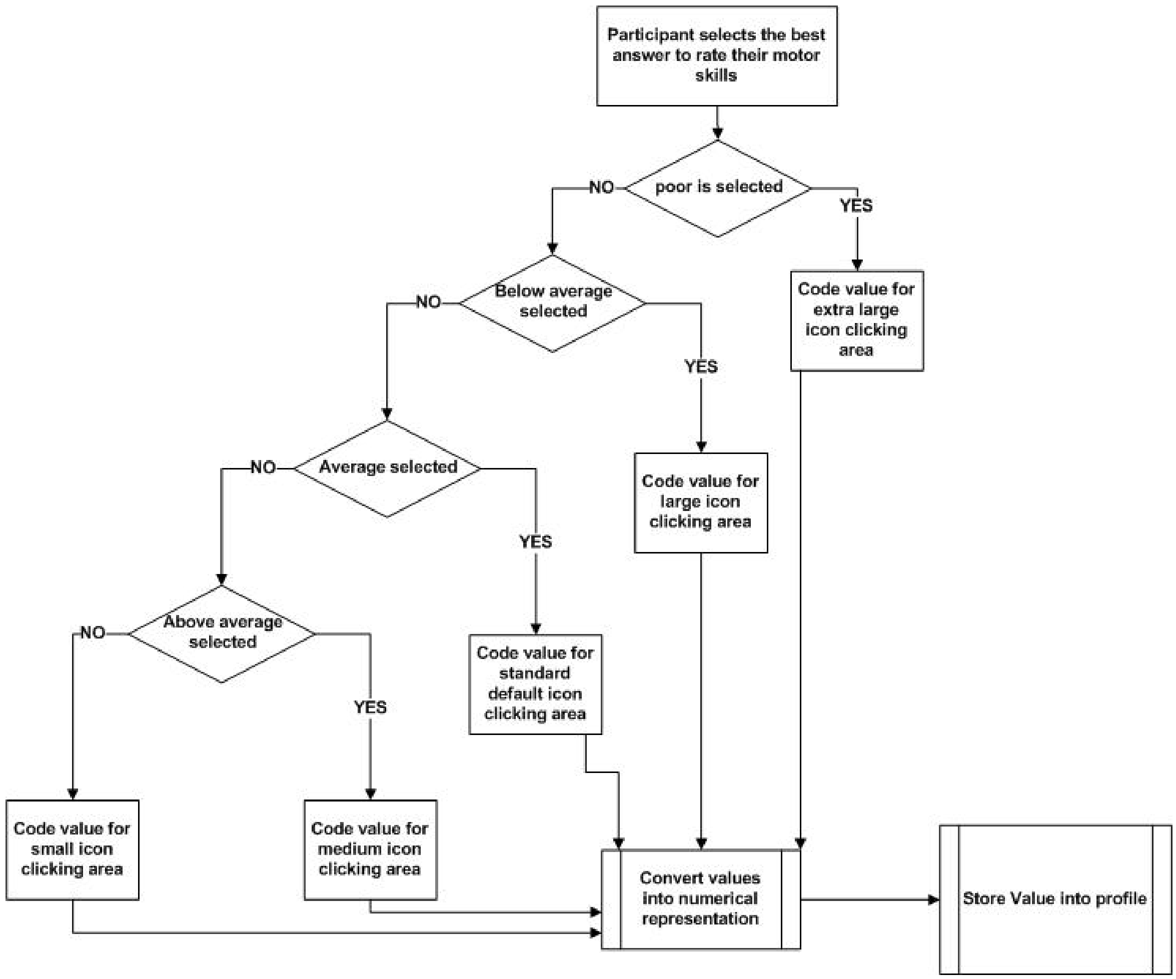


Figure 10. Self-assessment Profile Motor Skill Parameter Process flow.

four experiments were conducted within a twenty-one day period. Each experiment was scheduled for one hour. All of the participants completed the four experiments.

User profiles were created for each participant, based on the self-assessment, test assessment and observational test, respectively. Each participant executed an Internet usability task based upon the self, test and observation profiles. Finally, the participants utilized the Error Detection system to perform a similar task. The Internet usability task was used to capture how many errors the participants made. Each time they missed an icon/button because of low vision, mobility or motor skills it would be captured.

C. Profile Creation

1) *Self-Profile:* Each Participant completed a self-assessment, (Figure 9) of their limitations and computer skills. The responses from the self-assessment were used to define the parameters in the self-profile. The assessment asks the participant how they rated themselves in the context of using the Internet, their vision, motor skills, and their cognitive abilities.

The answers from the self-assessment questionnaire were the basis for the initial coding of the parameters for the self profile. Figure 10 illustrates the process flow for participant answers being translated into coded motor skills parameters for the profile. Figure 11 shows the process flow for creation of vision fonts.

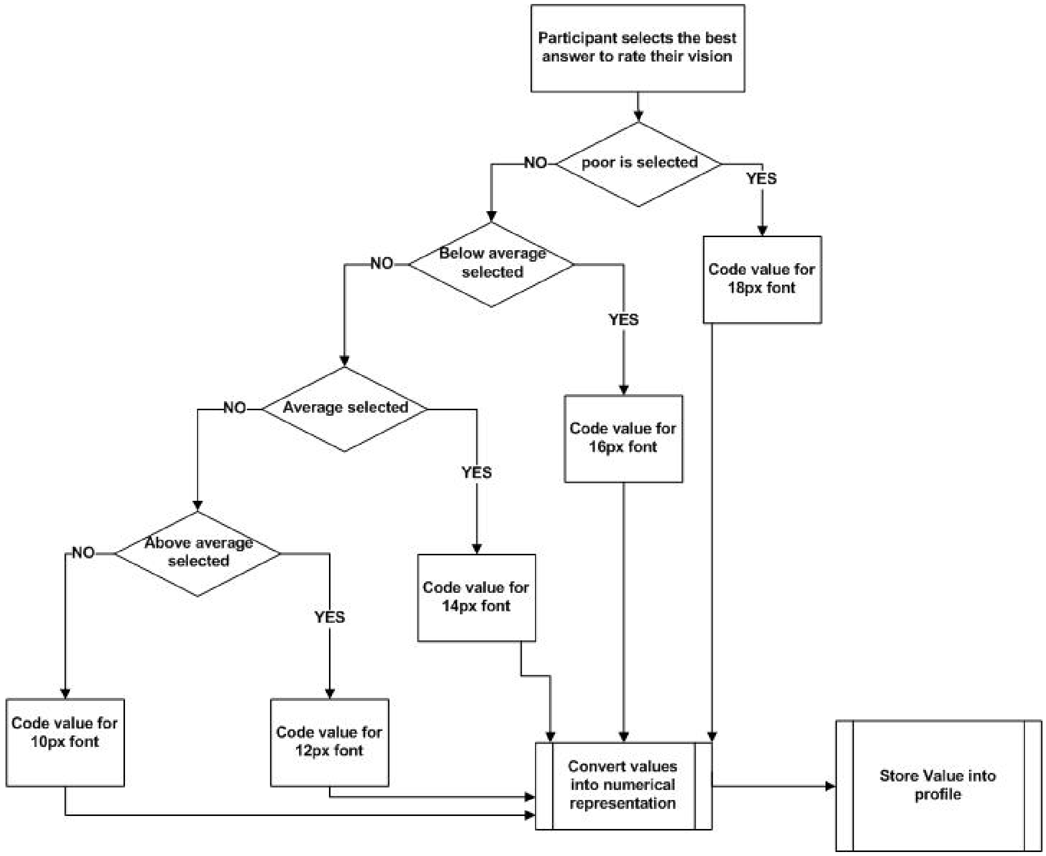


Figure 11. Self-assessment profile vision parameter process flow.

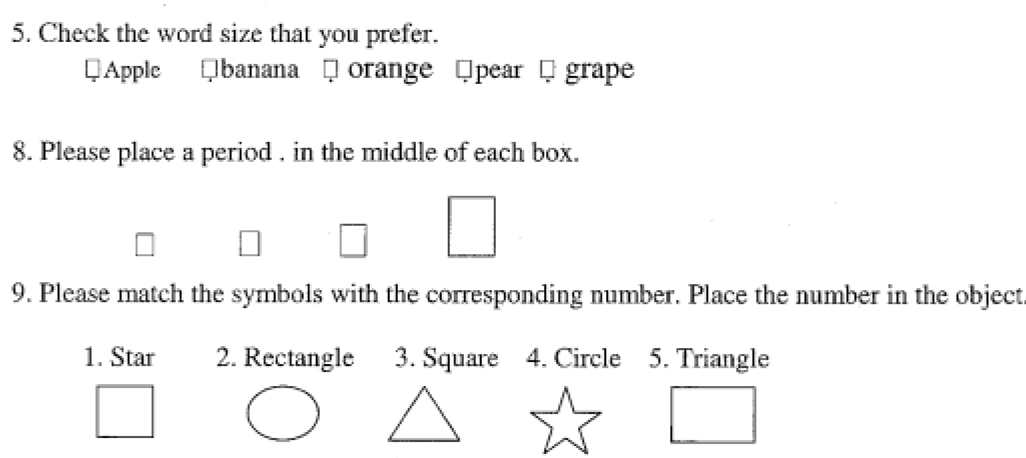


Figure 12. Test question fragment used to generate the test profile.

2) *Test Profile:* A paper-based test was used to test the participant's skills to show the capabilities of the participant through the execution of the tasks. Figure 12 shows a fragment of the test used. Figures 13 and 14 show the process flow used to convert the participant's responses into the test profile values for vision and motor skills, respectively.

3) ***Observation Profile:*** The observation data was gathered while the participants were administered a set of tasks. The number of instances and actions

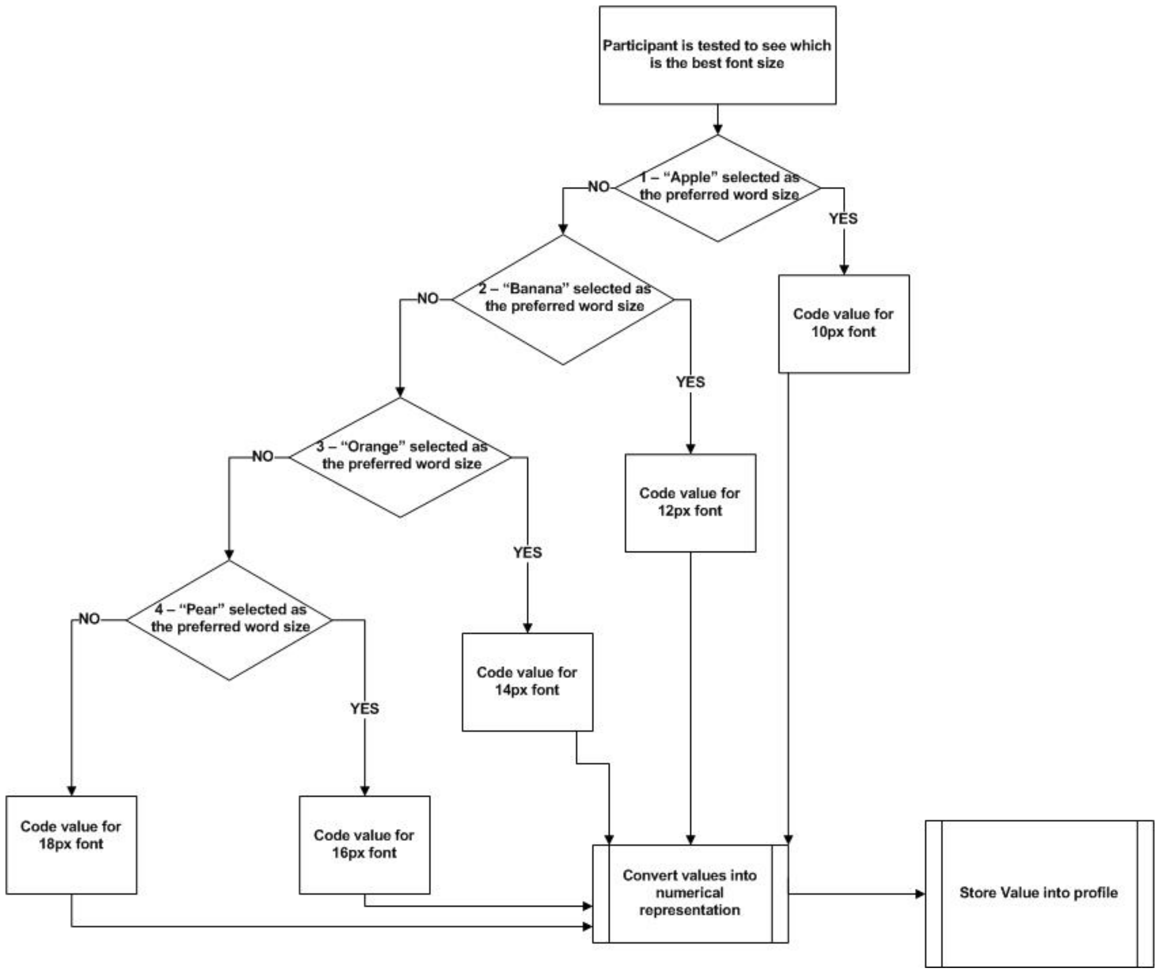


Figure 13. Test profile vision parameter process flow.

while the participants completed the usability task were recorded using an observation form. The results were converted into profile parameter values for font and motor skills. The process flow for converting the values are shown in Figures 15 and 16.

The main objective of the observation of the participant was to collect observable behavior of the participant surfing the web. The usability observation evaluation form was used to collect and record varied characteristics of the interaction of the participant, such as accuracy in moving and clicking the mouse, traversing through a web page, asking questions, talking out loud, and how efficiently they were accomplishing the tasks. The observational behavioral measures were used to evaluate and score specific behaviors that the participant displayed:

- *Screen response:* The ability to respond to prompt and icon presented on Webpage is the second item on the set measuring responsiveness and effect of the Webpage.
- *Type:* The item measures skills such as typing, vision and dexterity.
- *Visually Scanning:* This measure assesses participant's skill in application of material read and analyzes instructional skill. The ability to understand unfamiliar printed words.
- *Non-verbal:* This measure assesses the participant's facial kinesics to capture any computer anxiety or frustration that would be otherwise undetectable.
- *Body Language:* This measure, evaluates the participant's communication using body movements or gestures in the performance of task assigned.
- *Questions:* This measure assesses participant's skill and how well he or she performed the usability task with or without asking questions.
- *Talk aloud:* This measure, gauges the participant's cognitive processing and reasoning skills in applying analysis skills.

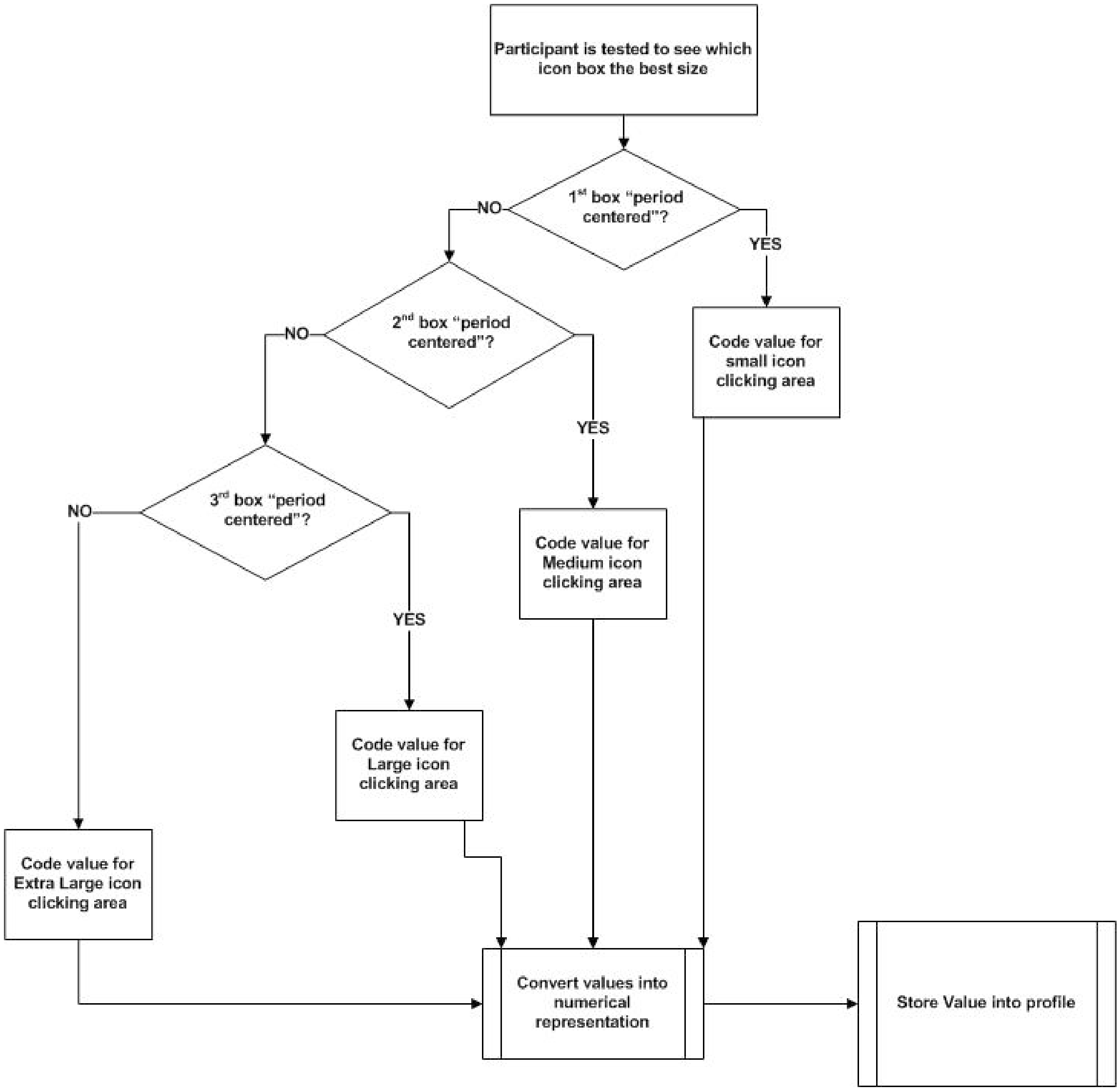


Figure 14. Test profile motor skills parameter process flow.

The results from the Usability Observation Evaluation Form were the basis for the initial coding of the parameters for the Observation profile. Figures 15 and 16 show the process of translating the observation into the font size and the motor skills parameters for the observation profile, respectively.

4) *Error Profile:* Participant data were collected through the system, when participants were working on a set of tasks. The system captured the (vision and motor skill) errors of the user and stored the information in a database maintained on a server. The errors were then used to develop a profile (collection of preferences) of usage for the participant.

The process of surfing and modifying the Web page of the participant was predicated on the reading a requested Web page and transforming the Web page for the participant based upon parameters that were captured within the error profile of default values. The system keeps track of the errors that are made as the participants worked their way through the task. The system automatically updated the profile based on the errors made. When the number of vision errors from regular screen operations and those obtained during the periods where the system changes font size increases above a preset system threshold, the font size parameter is increased. In a similar fashion, an increase in motor skill errors is used to raise the motor skill parameter value. The process for error profile creation is shown in Figure 17.

The next section looks at the discussion and the results of the study.

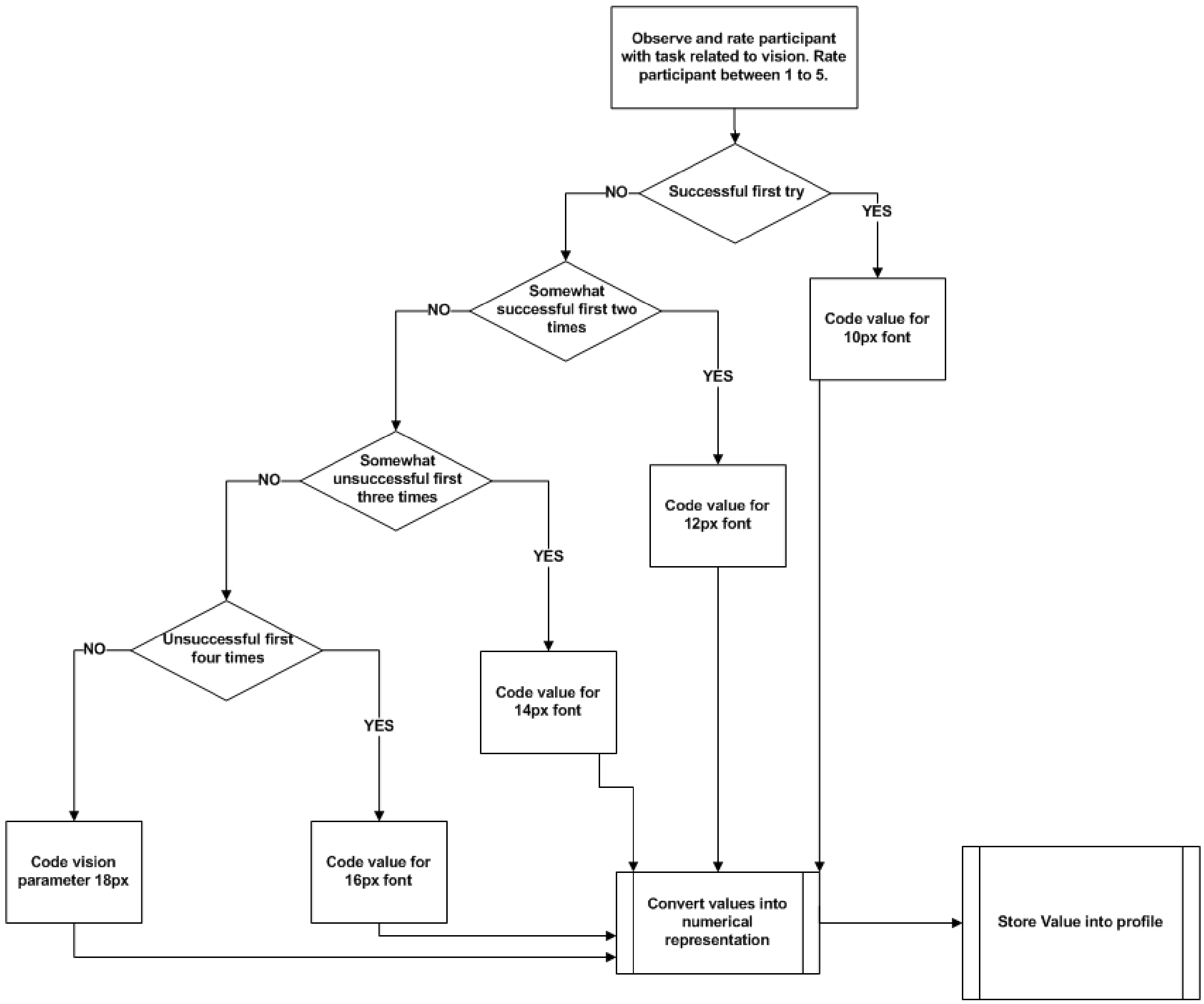


Figure 15. Observation Profile Vision Parameter Process.

V. RESULTS

Performance in the experiment was measured based on the number of errors that participants made while completing the task set. Errors were chosen over time due to our belief that the critical issue for the older adults was successful navigation rather than speed of performance. Table II shows the mean and standard deviation of the errors made for the cases where the Web pages were converted using a profile based on self assessment, written tests, observation, and on error detection.

To consider the key question, "Does error detection produce a profile of the older adults' accessibility performance that is comparable to profiles based on self assessment, written tests, or observation?", we looked at a series of four hypothesis and we used the paired samples t-test to test the individual hypothesis.

Hypothesis 1: Testing provides superior results (with respect to the number of errors a participant makes) to asking older adults for a self assessment of their limitations when using the Internet.

Hypothesis 2: One on one observation provides superior results (with respect to the number of errors a participant makes) to giving older adults written tests to determine their limitations when using the Internet.

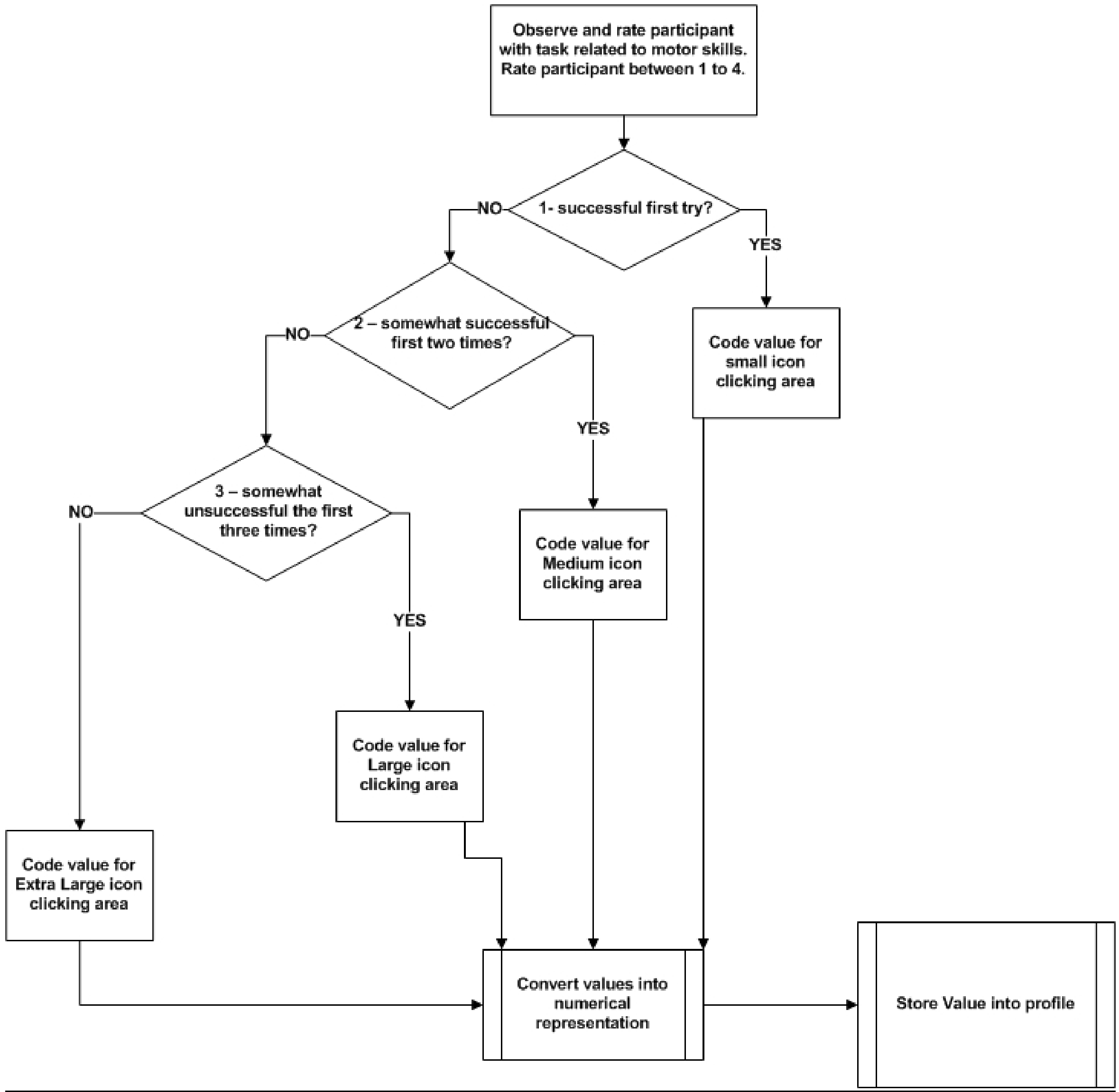


Figure 16. Observation profile motor skills parameter process flow.

Table II. Error means and standard deviations for the 4 approaches tested in the study.

	Self Assessment	Written Test	Observation	Error Detection
Mean	57.8	11.20	7.12	6.80
S.D.	13.952	4.003	3.621	4.010

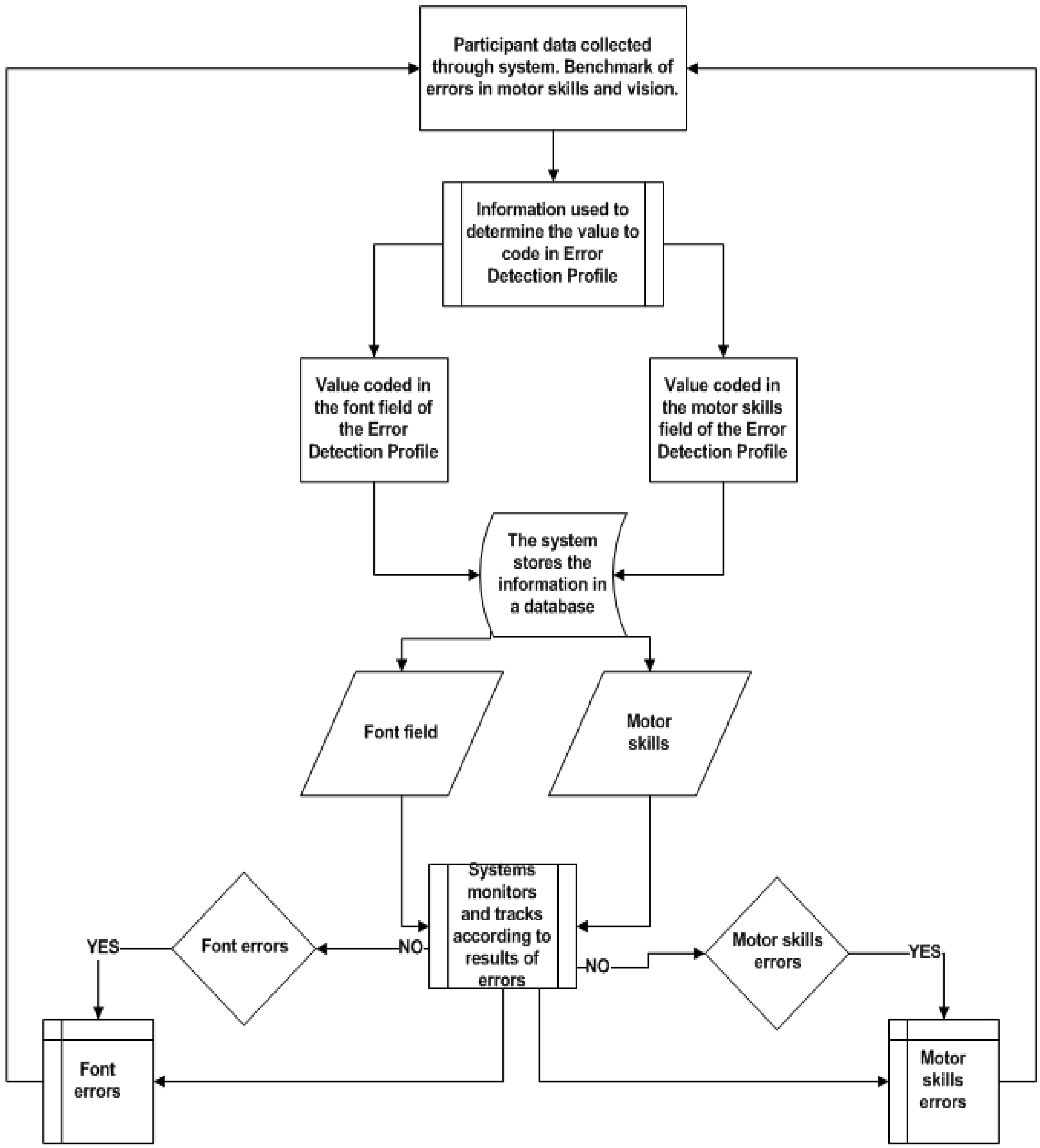


Figure 17. Error detection profile for font size and motor skills parameters process.

Hypothesis 3: One on one observation provides superior results (with respect to the number of errors a participant makes) to asking older adults for a self assessment of their limitations when using the Internet.

Hypothesis 4: Using the error detection strategy described in this paper provides comparable results (with respect to the number of errors a participant makes) with one on one observation when determining the limitations of older adults when using the Internet. The next section looks at the discussion of the study.

VI. DISCUSSION

Looking at Hypothesis 1, we see from Table III that there is a rather low correlation (0.469) between the error rates of the two methods. The first row in Table IV shows a t value of 18.551 with a significance of 0.0

Table III. Paired Samples Correlation.

	N	Correlation	Sig.
Errors made using the testing-based profile & a self-assessment-based profile	25	0.469	0.018
Errors made using the testing-based profile & a observation-based profile	25	0.627	0.001
Errors made using the observation-based profile & a self-assessment-based profile	25	0.385	0.057
Errors made using Observation profile & errors using Error detection	25	0.963	0.000

Table IV. Paired Samples t-test: self assessment, written tests, and observation error detection.

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	S. D.	Std. Error Mean			
Errors made using Self-assessment – Errors made using Testing	46.600	12.560	2.512	18.551	24	0.000
Errors made using Testing – Errors made using Observation	4.080	3.366	0.673	6.061	24	0.000
Errors made using Self Assessment – Errors made using Observation	50.680	12.996	2.599	19.498	24	0.000
Errors made using Observation profile – errors using Error detection	0.320	1.108	0.673	1.445	24	0.161

indicating that there is a significant difference between the two samples. From these results, we can see that written tests were far superior to self assessment in our study.

The second row of Table IV shows that for Hypothesis 2, we are able to say that observation provides a better estimate of an older adult than what we were able to get from written tests. The significance of the t value (6.061) is again 0.0 showing that there is a significant difference. Table III still shows a low level of correlation between the error rates of the two methods of creating profiles.

Hypothesis 3 compared the error rates of the observation against self assessment. As in the case of Hypothesis 1, self assessment performs very poorly when compared to observation. Again the significance of the t value (19.498) in row 3 of Table IV is 0.0, indicating that the there is a significant difference between the two samples. Table III indicates a very low correlation between the error rates of the two methods.

The results of the first three hypotheses indicate that one on one observation is statistically superior to either written exams or self assessment. The problem is that one on one observation is extremely expensive and does not lend itself to periodic retests of older adults.

Hypothesis 4 looks at the comparison of observation to the proposed error detection approach. Table III shows a high correlation (0.963) between the error rates of the two approaches. More important, the result shown in row four of Table IV indicates that the two tailed significance is greater than 0.05 and there was not a significant difference in our study between creating the user profile based on observation or on error detection. The importance of this result comes from the work required to create the profiles. Observation is very labor intensive and is difficult to use with very many users. The use of error detection, on the other hand, places the burden on the computer system. It can be applied to any number of users and is not site specific. Moreover, targeting the accessibility skills of an older adult is not a static target. The physical and cognitive limitations of older adults tend to increase as they age. The dynamic nature of using an error detection strategy allows the profile contents to dynamically change as the user changes.

VII. Conclusion

Performance in the experiment was measured based on a user study consisting of 25 older adults was developed and performed to compare the proposed error detection strategy to evaluation strategies based on self assessment, written tests, and one on one observation. A server based platform was developed for the user study. The platform used a user profile that contained a measurement of the user's impairments for motor skills and vision.

The server converted any Web page that the user requested based on the contents of the user profile. The results of the study were promising. Four hypotheses were tested. The first three compared self-assessment, written tests and one on one observation. The study results indicated that observation was superior with respect to the user error rates. The fourth hypothesis compared one on one observation against the proposed error detection strategy. The study indicated that there was no statistical difference between the means of the results of the observation-based profiles and the results of the error detection-based profiles. This is an interesting result in that doing in depth observations of the potential users is very labor intensive and error detection places the burden on the computer system. Currently, we are looking at the cognitive phase of our project.

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