Determinants of User Interface Design for the Visually Impaired

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Abstract: ***This study focuses on different trends on user interface designs geared towards meeting the special needs requirements, that is, the visually impaired. The study analyzed various user interface designs in place for aiding the visually impaired in interaction with mushrooming technical devices, such as computers, mobile phones, home appliances and other computerized devices. It was observed that, much effort has been made towards making the interaction of visually impaired people with computers, to be more efficient so that they can easily collect, create, manipulate, understand or use any information from device interface designs. The study reviewed different user interface design trends that have tried to meet the needs of the visually impaired. The study found that making allowances for magnification of texts, use of contrast keys, color contrast, font size adjustment, the use of keyboard shortcuts to navigate, use of audio and haptic devices have been explored. Descriptive research design method was used with frequency counts, percentages, means and inferential statistics using SPSS. Age of persons correlated significantly to gender with a mean of 13.71 for males and 14.86 for females.***

Keywords: Human User interface design; audio devices; color blindness; visually impaired computing

1. Introduction

The advancement in information technology such as computers, mobile phones and other devices has been growing every year but with limited information for the visually impaired. Many studies have been conducted with a view to understanding how the visually impaired people interact with the technologies. Any objective of a good user interface design, is to make the user's interaction as simple and efficient as possible and this may not be the case for the visually impaired.

By description, a user interface design is the design of user interfaces for machines and software like computers, home appliances, mobile devices focusing on maximizing usability and the user experience (Norman, D. A, 2002). A good user interface design facilitates finishing of the task at hand without drawing unnecessary attention to itself. A good user interface design requires a good understanding of the user's needs. For the visually impaired, a good user interface should enable them to perceive, understand, navigate, interact, contribute and access computing efficiently.

Visual impairments greatly affect human interaction with technology. People rely on vision in order to operate a computer system. The visual impairment encompass a wide range of vision problems related to acuity, accommodation (ability to focus on objects at different distances from the eyes), illumination adaption, perception of depth, and color vision. Minor visual impairments can usually be addressed by magnifying the size of interactive elements, increasing color contrast, or selecting appropriate color combinations for color-blinded users. Take an example of a website, a webpage is composed of tools, and applications that are practically unusable for people with visual impairments. There are few tools that aid the visually impaired people when most user interfaces are not large enough for the visually impaired. Design engineers ought to design user interfaces with tools and features that should aid the visually impaired in very task.

2. Problem Statement

User interface engineers continue to design fancy user interfaces on digital devices, but there is still very little to show on user interfaces design considerations for the visually impaired people. There are very few user interfaces that can fully cater and encompass visually impaired needs. There are various reasons why this imbalance exists with some quarters alluding to the fact that, there is a low number of visually impaired people, less cash, less tools and resources and lack of efficient ICT infrastructure as some of the reasons why there is very little effort in meeting visually impaired user's needs.

3. Purpose of the Study

The study aims at analyzing literature with empirical data validation on trends towards identification of user interface design considerations for the visually impaired people at the design stage by user interface designers.

Study Questions

- Identify some of the user interface design considerations and features for user interface designs that cab aid the visually impaired.
- Is there an impact of user interface designs for visually impaired, to increase the human-computer interactions?

4. Scope of the Study

The study was undertaken at Rongo area in Migori County, Kenya. It involved interviews with visually impaired individuals. A population sample of 200 visually impaired persons were sampled to assess their knowledge and experience in user interface designs.

5. Literature Review

A good user interface is designed to help in proper interactions, creating tasks, navigation, contribution and access to the necessary task to improve human computer interactions. A good user interface also helps to increase productivity and profitability. for instance, a visually impaired sensitive company will have a corporate image which is important to the company. Nondiscrimination of disability intentions will boost the organization image. The visually impaired face many challenges when there are no corresponding tactile feedbacks from the interfaces they use. According to a study Rodriguez-Sanchez et al., accessible and assistive technologies for the visually impaired still continue to face challenges due to the fact that, existing accessibility features are not enough in meeting their needs and expectations. People with this disability suffer from lower probability in success with touchscreens like in mobile phones, than the full sighted people.

In mobile computing for example, researchers have paid attention to the human computer interaction (HCI) technology of the touchscreen gestures for the visually impaired people, such as gesture performance and preferences, the usability differences between one handed gesture and two handed gestures, and the development of new interactive gestures. Another study by Kane et al., found that visually impaired people preferred audio based multi-touch over button based touch, even though their level of accuracy with the audio based methods were low.
Rodriguez-Sanchez, then developed a smartphone with a wayfinding system for the visually impaired people to enhance auditory and tactile feedback.

According to WHO 2010, it is estimated that there are 285 million people wo are visually impaired and 39 million which are fully blind. There are two major causes of visual impairment are uncorrected refractive errors at 42% and cataract at 33%. Figure 1 below shows how visual capability is affected by the two conditions.

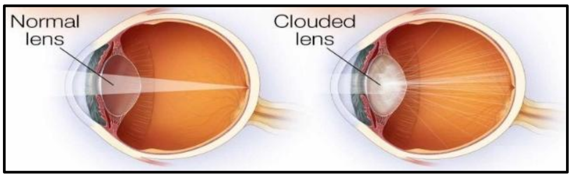

Figure 1: Cataract infected lens. Source: https://eyehospitalsinpakistan.weebly.com/blog/laser-cataract-surgery-new-hope-for-visually-impaired-people-in-pakistan

*Normal lens***:** clear images produced by focused light. *Visually impaired:* light is scattered or blocked by the cloudiness of the lens to produce blurred vision of foggy images.

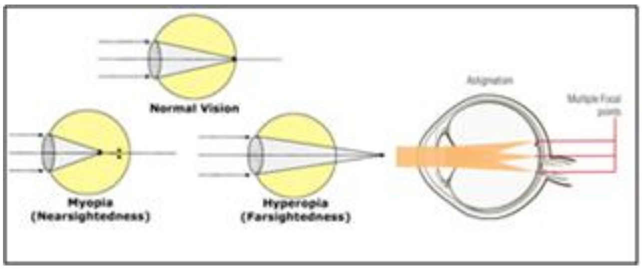

Figure 2: refractive errors infected lens. Source: https://www.torgaoptical.co.za/astigmatism

Myopia is a condition of short sightedness wherelight focus does not reach the retina, but just in front of it. This causes blurred vision far objects but normal for near objects. *Hyperopia* is the opposite of myopia. The long sightedness where the focus goes past the retina. *Astigmatism*on the other side causes an imperfection where light rays do not focus on the retina but are refracted with multiple focus points.

Trends to improve usability for users with visual impairments

Use of keyboard shortcuts for navigation
Use of keyboard shortcuts to navigate has been found to influence visually impaired people day by day interactions with user interfaces. Ravi McAllister (2008), in a review of the literature on difficulties experienced by visually impaired internet users, conducted a study involving 30 blind and partially sighted computer users and found that, the navigation strategies like use of keyboard shortcuts reduced navigation constraints on the users. The keyboard shortcuts enable visually impaired users to navigate much easier. The use of keyboard commands enables people with low vision to navigate a site with the use of arrow keys and a few quick strokes without having to follow a mouse cursor across the screen. This has help to reduce the eye strain and frustration on the users.

Allowances for text enlargement
Text enlargement maybe all that a visually impaired user requires, stylesheets with large font sizes and layout that do not break when text-only zoom is enabled according to a study done by Kelli Shaver (2011) on site accessibility to the visually impaired. Many visually impaired users will want to zoom in on the text without changing the scale of the entire site layout, which can lead to difficulties in scrolling and tracking text over long lines. Depending on the site's target market, the default font could be a few points larger.

Contrast in keys
A study done by Kelli Shaver on a sample of 100, showed that partial impaired people were affected by screen contrast as reported in Prevent Blindness America. Eye diseases like glaucoma, retinitis pigmentosa (common eye disorders) all lead to a significant decrease in contrast sensitivity, that is, the eye's ability to differentiate between similar shades and levels of brightness. New user interface design layouts all have detailed oriented, often utilizing subtle gradients and slight shifts in value to create clean, modern, unobtrusive interfaces. The use of bold text for added readability on low-contrast items and avoid very thin fonts.

Color contrast

y done by Muller, Tylor (2001), on the use of color in icon design, the study specified on designing of icons, and concentrated on the use of color in an internet environment. The study recommended the use of color combinations that do not confuse a partially impaired user, who is color blind. The use of more colors on a user interface makes it more difficult for the visually impaired to quickly identify the primary actions and links, but for a color blind user, it becomes even more difficult. Colors such as red, green, blue and yellow play a key role in the user interface design and the use of these colors for combos for actions that require attention may confuse the users and should avoided.

Use of audio and haptic features

In a study carried out by Murphy and Emma Strain (2006) on a novel multimodal interface for improving visually impaired people's internet accessibility, found that in contrast to traditional used assistive tools, such as screen readers and magnifiers, the new users interface designs employ a combination of both audio and haptic features to provide spatial and navigational information to users. The haptic features are presented via a low-cost feedback mouse allowing the blind and visually impaired people to interact with the interface. The audio provides navigational and textual information through the use of non-speech sounds and synthesized speech. Interacting with multimodal interface offers a novel experience to target users who are visually impaired.

Use of screen readers

In a study carried out in the year 2016 by William, shows that user interface design trend for the visually impaired, found that users who are visually impaired, were able to browse and read from the screen through text to speech software. Rachel Vorm (2009), found out that a screen reader could translate webpages into plain text and reads it aloud per line in a linear fashion till end of the page.

6. Methodology

The methodology section details the study design, population and sampling approach, the data collection and analysis methods.

Study design

The study adopted Kothari 2004 procedure, that combined the relevance of the research purpose with economy in procedure. The research design was both descriptive and correlational with the analysis carried out using SPSS (Statistical Package for the Social Sciences) software.

Population of study

According to the census of Kenya 2009, it showed that 50,000 people were either blind or visually impaired in Migori county. A sample size of the sample population of 200 people was chosen because of time and transport constraints.

Data Collection

Face-to-face interview method was used to conduct the interviews directly. The data sought was ordinal and included determination of characteristics of the respondents and their views on user interface designs.

7. Results and Discussion

This chapter discusses the demographic characteristics of the study population including: age and gender. A total of 200 users participated in this study, out of which 52% were female and 48% were male. The mean age was 36 years while the median age was 39 years.

Table 1: Bootstrap Specifications

Bootstrap Specifications	
Sampling Method	Stratified
Number of Samples	200
Confidence Interval Level	95.0%
Confidence Interval Type	Percentile
Strata Variables	Gender

Table 2: Descriptive Statistics

Descriptive Statistics						
		Statistic	Bootstrap[a]			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
Gender	N	7	0	0	7	7
	Sum	96				
	Mean	13.71	.00	.00	13.71	13.71
Gender	N	7	0	0	7	7
	Sum	104				
	Mean	14.86	.00	.00	14.86	14.86
Valid N(listwise)	N	7	0	0	7	7

Table 3: Age distribution of the respondents

Age Group	Frequency	%
18-24	60	30
25-31	50	25
32-38	24	12
39-45	12	6
46-52	8	4
53-59	6	3
59 +	40	20
Total	200	100

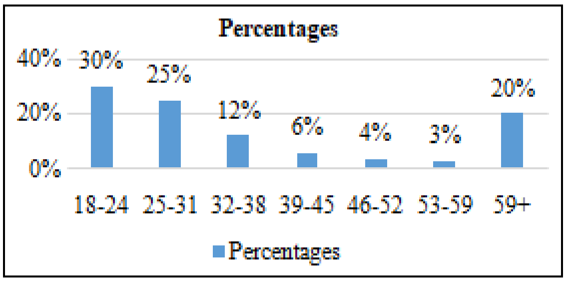

Figure 3: Gender distribution by respondents

Table 4: Age distribution by respondents

Age Group	Male	Female	Total Frequency	%
18-24	35	25	60	30
25-31	21	29	50	25
32-38	17	7	24	12
39-45	4	8	12	6
46-52	5	3	8	4
53-59	2	4	6	3
59 +	12	28	40	20
Total	200	100	200	100

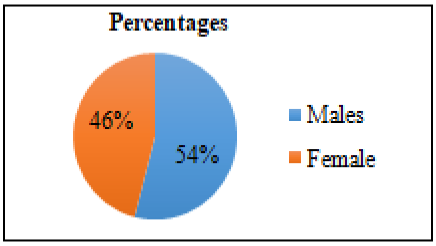

Figure 4: Age Distribution of the respondents

Table 5: Model summary

Model Summary		
Equation 1	Multiple R	.747
	R Square	.558
	Adjusted R Square	.411
	Std. Error of the Estimate	1.767

Table 6: Correlation Analysis for Gender (2-tailed)
Correlations

Correlations				
			Male	Female
Kendall's tau_b	Gender	Correlation Coefficient	1.000	.429
		Sig. (2-tailed)	.	.176
		N	7	7
	Gender	Correlation Coefficient	.429	1.000
		Sig. (2-tailed)	.176	.
		N	7	7
Spearman's rho	Gender	Correlation Coefficient	1.000	.607
		Sig. (2-tailed)	.	.148
		N	7	7
	Gender	Correlation Coefficient	.607	1.000
		Sig. (2-tailed)	.148	.
		N	7	7

Table 7: Correlation Analysis for Gender (1-tailed)

			M	F
Kendall's tau_b	Gender	Correlation Coefficient	1.000	.429
		Sig. (1-tailed)	.	.088
		N	7	7
	Gender	Correlation Coefficient	.429	1.000
		Sig. (1-tailed)	.088	.
		N	7	7
Spearman's rho	Gender	Correlation Coefficient	1.000	.607
		Sig. (1-tailed)	.	.074
		N	7	7
	Gender	Correlation Coefficient	.607	1.000
		Sig. (1-tailed)	.074	.
		N	7	7

Descriptive Statistics

Table 8: Descriptive Analysis of Gender in relation to age

Valid N (listwise)	Gender (Female)	Gender (Male)		
7	7	7	Statistic	N(Age groups)
	26	33	Statistic	Range
	3	2	Statistic	Minimum
	29	35	Statistic	Maximum
	104	96	Statistic	Sum
	14.86	13.71	Statistic	Mean
	4.48	4.439	Std. Error	Std. Deviation
	11.852	11.743	Statistic	Variance
	140.476	137.905	Statistic	Skewness
	0.335	0.991	Statistic	Kurtosis
	0.794	0.794	Std. Error	
	-2.56	0.532	Statistic	
	1.587	1.587	Std. Error	

Table 9: Anova for Gender

ANOVA					
Gender					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	827.429	6	137.905	.	.
Within Groups	.000	0	.		
Total	827.429	6			

8. Conclusion

The study observed that a lot of effort has been made towards making the visually impaired interaction with computers to be more efficient to enable them to easily collect, create, manipulate, understand or use any information from different any digital sources interfaces. However, not all interface designs have features that cater for the needs of visually impaired, therefore, there is still more effort needed to be put in place for most user interface designs for the visually impaired by the engineers. The study also found that the age of users correlated significantly to gender of the users.

The study has shown that, there is need to create user interface designs that have good features that can aid the visually impaired in their day to day activities such browsing the internet. This is because these features are helpful, thus the visually impaired are not left out with the onset of electronic or online business process revolution taking place in the world. Some of these features to help the visually impaired include but not limited to text enlargement, color contrast, contrast in key, key short cut navigation, screen readers, audio devices and haptic features. It is recommended that the user interface designers work hand in hand with the visually impaired through joint studies before designing any user interfaces.The above conditions therefore pose a challenge to computer interface designers by the fact that factors such as visual acuity (clarity), light, contrast and color vision needs to be carefully looked into.

We can conclusively say that visual acuity will affect (i) perception of text size, font, style, capitalization, and sizes of all elements. (ii) reading spacing such as letter spacing, word spacing, justification, margins, borders and spacing between elements (iii) elements identification such as element level customization, and proportional text increase.
Light and contrast sensitivity will affect brightness. Other environmental factors will be clarity of the devices such as dots-per-inch (dpi), brightness, lighting, glare, distance and angle and reading while in motion.

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