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USABILITY COMPARISON OF LARGE TOUCHSCREEN SYSTEMS VERSUS DESKTOP-SIZE AND MOBILE-SIZE SCREEN SYSTEMS

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Abstract

In computer graphics, proposing efficient and usable human-computer interaction design solutions is a challenging task. Well defined guidelines and principles are very useful for designers to design new solutions for systems. To create these guidelines and principles, firstly differences among systems should be identified. In this study, we focused on comparing large screen systems and mobile-size/desktop-size screen systems by observing users while they interact with all three different size screens. We noticed that there are physical differences between these systems such as viewing distance, pixel count and weight. We also noticed that there are different applications for different usage areas. According to this, eight types of differences are defined and usability differences are categorized into these difference types. As a result, we conclude that large touchscreen systems need separate interaction design guidelines and principles.

Keywords*: Large Screen Systems, Large Screen Usability Differences, Human Computer Interaction, User Interfaces, Collaborative UI.*

1. INTRODUCTION

Human computer interaction is a discipline that primarily concerns with the design and implementation of human-centric interactive information systems. Introduction of large screen interaction goes back in early 90s.Large screens can be described as screens that allow multiple collaborating users standing in front and interacting with comfort. Collaborative usage is a situation where two or more people use the same user interface together. User friendly design and better human-computer interaction solutions for large screen systems according to the collaborative usage are popular topics in the field. Large screen systems have different usage purposes and our interest is on serious games. Serious games are designed for a specific goal other than pure entertainment.

We have set up a prototype system to run a military simulation considered as a serious game to observe the users for usage details. As the result of these observations, usability differences among large screen systems, desktop-size systems and mobile-size systems are defined.

The foremost usability differences which are identified during the study are; interaction style differences, user skill level differences, task and goal differences, navigation thru interface differences, display organization differences, UI element differences, data entry differences and feedback differences. These groupings and differentiations are inspired and created by investigating of previous studies[1, 2]about human computer interactions and UI design.

This document is organized as follows: Section II describes the related work about large screens and usability of systems. Section III provides insight about detected usability differences of large screen-size systems and other screen-size systems. Lastly, Section IV concludes the study.

2. RELATED WORK

There are various studies covering usability of systems. Nielsen has

detailed studies and provides valuable information in his book about usability [2]. He defines what usability is and provides some ideas for better human-computer interaction. To define whether a UI design is good or bad, Nielsen and Mack provided the heuristics for usability testing [3]. Their claim was that heuristic evaluation is comparable to user testing, yet require fewer test subjects. Others started working on large size screens and large screens started to be built because of the needs and capabilities of developing business world. A design by Elrod et. al. [4] demonstrates Live board, a technology to support large screen group meetings was proposed to solve such problems. Usability studies have emerged for large screen systems in the following years. Somervell et. al. [5] have studied usability heuristics for large screen information exhibits. Later it is understood that collaborative usage of such systems is necessary. Then researchers focused on how to use systems collaboratively. Kim et. al. [6] talks about this kind of interaction in their study. They mainly focus on asynchronous interaction on large screens. Other studies such as the one by Jagodic [7] started to focus on using large screens collaboratively and how to organize the display according to this interaction method. All these studies suggest that, further investments to large screen systems will be done and a serious of principles and guidelines for creating such systems are still missing.

3. IDENTIFIED USABILITY DIFFERENCES OF LARGE SCREEN SYSTEMS

Large screens have different dynamics and ergonomics than regular desktop-size screen systems and mobile-size screen systems according to the usability of human computer interaction. There are several reasons that cause design differences among different screen size systems. Shneiderman and Plaisant's book of "Designing the User Interface" [1], is a basis for identifying usability differences of large screen-size systems. General information about the differences among large screen systems and other two systems are given as a summary in Table I. These differences are discussed separately in the following subsections of this work.

Table 1. Differences of Large Screens and Other Screens

	Desktop-Size Screens	**Mobile-Size Screens**
Interaction Style	Mouse, keyboard and other interaction devices are used Mass data entry processes are completed Cursor is easy to locate on screen There is physical location to put mouse and keyboard	Touch count is limited Optimized for single user
User Skill Level	Mostlythere exists experienced and expert users for different applications Users do not have deep knowledge on every aspect of user interface	There exists intermediate experience level users, they are familiar with similar applications Users are technically novice, they are experienced on human computer interaction
Task and Goal	There are almost infinite range of applications and functionalities The applications are designed for data entry, retrieval and management Applications are processor-intensive	Physical mobility is targeted There are wide range of applications and functionality Repetitive usage is present
Navigation thru Interface	There exists several navigations among apps in a short time interval Simultaneous application usage is present	Applications are generally full screen Fast navigation among applications is possible Only one app is active at a time
Display Organizati on	UI elements can be located arbitrarily on screen Each part of the screen is in the field of view and items are located accordingly Every part on screen is easily reachable with mouse	UI elements are located according to the single handed handheld usage ergonomics UI elements are located with even intervals There are small number of UI elements on screen Paging principle is applied since too small screen Every part on screen is easily reachable
UI Element	There are specialized UI elements such as scrollable controls There are smaller size and high resolution UI elements There is not any right click functionality on UI elements	UI elements are large enough for finger to fit UI elements are much more detailed and high resolution UI elements are located with even intervals on screen
Data Entry	There is dense data input and there are suitable applications for dense data input Data input is generally handled by mouse and keyboard Audio, visual and other types of data are entered	On screen keyboard and auto complete are used There is less area to use while interacting with direct manipulation Audio, visual and other types of data are entered
Feedback	Visual feedback is located arbitrarily on screen Sound feedback is used Haptic feedback exists by mouse and keyboard	Full screen feedback is used Sound feedback is used

3.1. Interaction Style Differences

Large Screens vs. Desktop-Size Screens:

Human computer interaction is mostly handled by mouse and keyboard on desktop-size screen systems [8]. Generally, these systems are used for mass data entry. Word processing applications are possibly the most used applications on desktop computers [9]. This situation yields to high use rate of keyboard. However large screen systems are generally used for distribution of knowledge instead of collecting knowledge. Users, who are located near the screen, have difficulties using the mouse pointer. Thus instead of using mouse, touch screen interaction is preferred on large screens. Large screen systems aim to create enhanced virtual reality with high immersion using large viewing area but third party interaction devices reduces this immersive effect which is not desired for such systems [10]. Users of such systems are not using these devices for long hours thus the users do not have the time to get tired of using direct manipulation technique on these systems which enhances the virtual reality feeling [10].

Large Screens vs. Mobile-Size Screens:

Direct manipulation interaction is a good choice for mobile devices [11]. Same interaction technique is used on both large screens and mobile-size screens.

3.2. User Skill Level Differences

Large Screens vs. Desktop-Size Screens:

Desktop-size screen device users are more experienced with the applications they are using or get used to those programs. Word processing applications, spreadsheet applications and all similar desktop software require mouse and keyboard interaction for data input and manipulation.

Large Screens vs. Mobile-Size Screens:

Mobile-size screen device users are generally familiar with the general user interface principles because of their prior experience on similar applications. Even though they do not have high level technical knowledge,

they are experienced on similar devices and applications for content management. With a novice user interface skill level, users are able to use the applications with different functionalities.

3.3. Task and Goal Differences

Large Screens vs. Desktop-Size Screens:

Desktop devices, are developed and used for data entry, data retrieval and generally data management purposes and their functionalities and applications are processor-intensive [9].Desktop-size screen devices almost do not have a limitation in terms of functionality. On the other hand, large screen devices have a restricted usability area. As a result of this, the applications written for large screens are limited and task oriented. Since this is the situation, capabilities of these devices are much less than expected in practice even though they are much more in theory. The tasks on large screens are simpler and they are discrete and well defined.

Large Screens vs. Mobile-Size Screens:

Mobile devices are mostly developed and used for easy usage and specialized for using applications on different physical locations [12].Users of the large screen devices have much more limited functionality on the applications. Due to this, possible functionalities are limited with the provided applications such as users may not have the opportunity to open a website or surf on the internet. Mobile device users use their applications several times repetitively.

3.4. Navigation thru Interface Differences

Large Screens vs. Desktop-Size Screens:

Navigation among different applications and in-app navigation thru other parts of the app is important for desktop-size screens. Users of such devices frequently complete different tasks with these devices thus different applications and navigation among those applications should be easy and quick. This process is provided with task bars and application switch screens using keyboard and mouse.

Large Screens vs. Mobile-Size Screens:

Navigation among different applications and in-app navigation thru other parts of the app is important also for mobile-size screen. Home button on iOS and home button on Android are such examples of these dedicated buttons. With this buttons, navigation among applications is fast and easy. Only one application is full screen and active most of the time.

3.5. Display Organization Differences

Large Screens vs. Desktop-Size Screens:

Desktop-size screen devices have enough space on screen but mouse and similar interaction devices are used and this causes smaller UI elements to be used. On large screens, this cannot be used since there is not a precise pointing device to be used. Every part of the screen area on desktop-size screen devices is easily reachable because of the usage of pointing devices. Direct manipulation is proposed on large screens. However when direct manipulation is taken into account, it is sometimes difficult to reach every part of the screen easily.

Large Screens vs. Mobile-Size Screens:

Mobile devices are designed to let their users to use them with single hand [13]. These devices are physically small and the area on screen can contain a small number of elements. Every part of the screen area on mobile-size screen devices is easily reachable because the screen is too small and users can easily touch anywhere. UI elements on the screen should be large enough for a finger to fit on. There should be several UI elements on these devices and these UI elements should fit on the small screen. As a solution, designers have chosen to use paging principle on these devices; this yields the navigation among applications and in an application to be solved with this manner. On large screen devices on the other hand, there is enough space and users need to reach different parts of the screen arbitrarily.

3.6. UI Element Differences

Large Screens vs. Desktop-Size Screens:

UI elements can be too small on desktop-size screen devices since there are mouse pointers on these devices and these pointers are fairly accurate, small and do not block the vision of UI elements. On the other hand, it is not possible to use the same UI elements with same method on large screen devices.

Large Screens vs. Mobile-Size Screens:

UI elements on mobile-size screen devices are designed large enough for a finger to fit on because of the usability and ergonomics of touch screen interaction [14] this also avoids more than one UI element to be placed under the same finger. Large screen devices similarly have the same interaction style thus requires large enough UI elements. These devices have enough space on screen and have smaller number of pixels per inches thus this situation does not make a problem. However, matrix style locating of UI elements should be adapted on large screen devices.

3.7. Data Entry Differences

Large Screens vs. Desktop-Size Screens:

Data entry process is generally provided by mouse and keyboard on desktop-size screen devices. Besides text input, multiple choice and other similar input techniques are also used. But still user interfaces are designed according to the keyboard usage and applications provide data entry via keyboard functionalities. On large screens on the other hand, data entry is used to receiving data instead of providing data and their usage are restricted. There are also different interaction methods on desktop-size screens. For example, voice and visual input is provided to the system during video conference applications. Large screens are not used for same type of applications thus there is no need for voice and visual input for these devices.

Large Screens vs. Mobile-Size Screens:

Data entry process is difficult on mobile-size screen devices since there is not any third party input device such as mouse and keyboard. The lack of keyboard which is the easiest way of data input in form of text [15] is tried to be overcome with virtual keyboards and auto complete functionalities on these devices. On the other hand, on large screens, smaller size data is transferred into system instead of large text values when we consider the usage and needs of such systems. To provide such functionality, users choose from multiple choices or touch to select function instead of entering text. Apart from the text input, users use single touch instead of double click on both systems. Besides using direct manipulation on both systems, margins and limitations are much more effective on mobile-size screen devices because of physical available space. Large scale input is used on large screens when we consider collaborative usage of several users to avoid confusion. Audio, visual and other types of data are entered to the system.

3.8. Feedback Differences

Large Screens vs. Desktop-Size Screens:

Feedback is given as visual and haptic besides as text based and shape change on desktop-size screen devices. Users also feel the haptic feedback received from input device while using mouse and keyboard. For example, when a user attempts to clicks on a key on the keyboard, then the feeling also gives the feedback to the user like the key is pressed. Similarly user can get haptic feedback from scroll wheel on mouse. Apart from haptic feedback, audio feedback is also provided to the user whether the task is completed or not. On large screens on the other hand, both situations may not be available. There is no haptic feedback since there is not any mouse or keyboard like third party interaction device. Clicking on a UI element can be understood only by shape change of the clicked UI element. Similarly using audio feedback is difficult because these devices are used by several people and audio feedback is received by every single user.

Large Screens vs. Mobile-Size Screens:

On mobile-size screen devices, feedback is provided with windows on screen. UI element feedbacks are shown with shape changes and voices to create real manipulation effect on a real object. Since every part of the screen is within focus area of humans, asynchronized and immediate feedback can be shown as full screen or located anywhere on the screen. On large screens on the other hand, is should be shown within the focus area of the user if it is not expected by the user. If a random feedback is shown to the user, best approach is to define a feedback area and show all user feedback to the user within that area.

4. CONCLUSION

In this study, a number of studies in the literature have been reviewed to collect standards and regulations in the field. Besides, a prototype was built and users were monitored. As the result of these, we identified that large screen systems has different usability dynamics than desktop-size and mobile-size systems. We have seen that eight major difference types for large, desktop, and mobile size screens exists and according to various previous studies associated with UI. We have come into conclusion that large screen systems need to have different guidelines and principles for design process.

There are usability differences among mobile-size screen devices, desktop-size screen devices and large screen devices caused by the physical differences of these devices. Usability differences lead to design differences for different platforms. These design differences show that large screen systems need specific design for UI and interaction. Our study points out that, designers, should consider design issues that are specific to large screen setups while designing large screen systems. Majority of design differences are caused from physical differences of different size screens. On the other hand, a small amount is caused from the needs of applications designed specifically for multi user and large screen environments. All these differences lead to the necessity of different approaches adapted for large

screens in terms of user interfaces and human-computer interaction. Further studies will be specifically focused on how to design and build systems for large screen environments based on the current information that covers the differences among different size screen environments. Also supervision of new configured standards or existing ones is critical for future of the large screen usability issues.

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