Magnification for Distance Pointing

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ABSTRACT
We see currently the trend of having larger and larger displays in our living rooms and that more and more computer oriented applications which are usually controlled by a mouse are displayed by them. Examples for the latter are web browsing, picture browsing, chatting and email. This leads to two problems. Firstly, most applications and web pages are not designed for situations in which the user is sitting in a relative large distance from the display. The user is therefore often not able to read the text, to interact easily with buttons or to click on hyperlinks. Secondly, it is not appropriate to use the mouse as the input device as flat surfaces are typically not in reach when sitting on the sofa in the living room. This paper investigates firstly whether direct pointing would be a suitable interaction concept and secondly whether the usage of magnifiers helps the user when interacting from a distance. The paper reports a study comparing three different magnification techniques for direct pointing interaction with remote screens. The results provide clear evidence for the advantages of such interactions, especially when combined with linear and Fish Eye magnifications.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Input devices and strategies; Prototyping.*

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Pointing, remote pointing, remote interaction.

1. INTRODUCTION
We see nowadays the trend of having larger and larger high resolution TV screens in our living rooms. Those devices are more and more used for PC applications such as web browsers, media players and file managers.

Many hardware vendors have offered so-called media Set-Top-Boxes such as Apple TV and Acer Set-top-Box, which enable people, not only to watch TV and DVDs, but also to browse the Internet and use computer applications on their TVs. Furthermore, many vendors also try to integrate conventional home entertainment devices such as TV and radio receiver into PCs and even provide them with software (e.g. Windows Media Center) that makes them similar to home entertainment systems.

The currently available remote controls are not suitable when considering interactions with web pages and media players that have many more and different user interface elements when compared with a standard TV user interface.

The main obstacle of adopting mouse and keyboard to a home entertainment system is that those input devices are designed to be used in a working environment which is deployed on a desk, where a keyboard and mouse can be used properly. In the contrary, people watch TV in their living room from a TV viewing distance, and most likely, while they sit on their sofa. Lorenz et al. study proved already that without a desktop like environment, using a mouse and keyboard in the setting is not suitable [1].

The second problem is that text and buttons of PC and web applications appear too small when considering that the user is sitting relatively far away from the TV in the living room. Users have problems to recognize the displayed content (e.g. Web page) and make mistakes because they can't see the labels or links clearly when interacting from a distance.

This work focuses firstly on pointing tasks in this context and assumes that remote pointing is a promising solution for this case since TV users are used to point at their TV with their remote controls anyway. Direct pointing has also certain advantages over indirect pointing techniques such as touch pad, track ball and mouse because it maps directly the hand or arm direction to the location on the screen.

The paper focuses secondly on the usage of magnifiers that magnify where to user points to in order to help her to read and interact with displayed information. Three different magnifiers were implemented and evaluated in a comparative study.

The paper is structured in the following way. Firstly we relate our work when compared with others. Following this, we discuss the three different magnifiers used within our study. The next section discusses our study design which is followed then by a report of the study results. Finally we analyze our findings and discuss future work.

2. RELATED WORK
There has been a lot of research regarding pointing from a distance. Olsen and Nielsen introduced the idea of using a laser pointer for interactions with a remote display whereby a camera was used to track the position of the laser pointer [2]. Myers et al. conducted research that was aimed to inform the design of laser pointers used for distance interactions [3]. They analyzed the impact of the delay which is caused by the time the system needs to track the pointer, studied the jitter caused by hand unsteadiness and compared different laser pointers. The best laser pointer in their study was the heaviest one as this one had the least jitter due to unintended hand movements.

MacKenzie and Jusoh evaluated two input devices for remote pointing with a standard mouse as the baseline condition [4]. Their research shows clearly the advantages of the standard mouse when compared with direct pointing interactions.

Our research assumes that the usage of a standard mouse in a living room is an unrealistic assumption as there is often no flat surface close to a chair or sofa available.

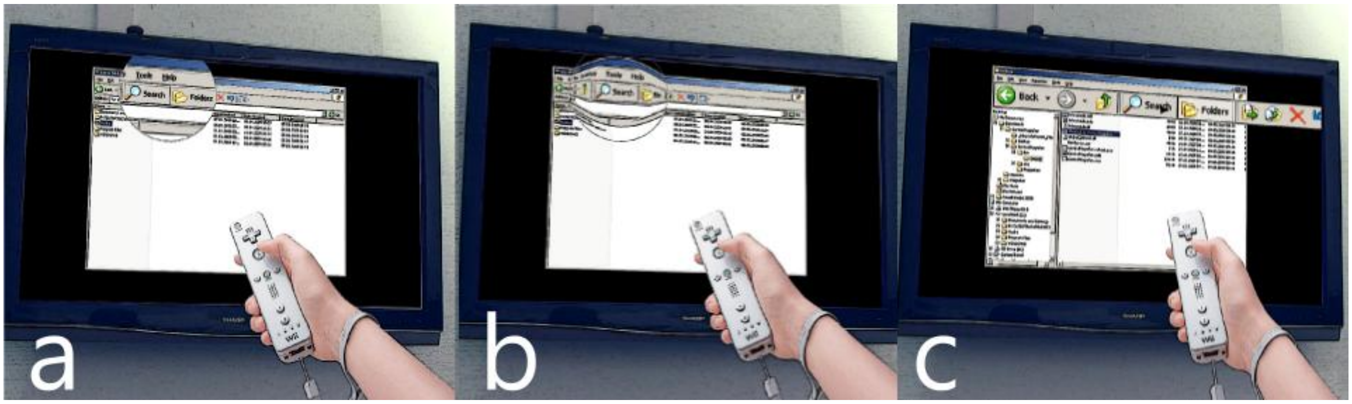

Figure 1. (a) linear magnification (b) hybrid fisheye magnification and (c) widget magnifier.

This argument is also supported by Lorenz et al. who performed a user study about remote interactions with home media applications [1]. They used a similar environment setting as used in this work and compared interactions for internet browsing using a wireless mouse & keyboard, PDA stylus & virtual keyboard and PDA joystick & physical PDA keyboard. As the setting was on a chair without a desk, the user had to use the wireless keyboard and the mouse without a flat surface. The results showed that mouse & keyboard were not suitable for this setting.

Research conducted by Freeman and Weissman proposed a television controlled by hands gestures [5]. Their system used image processing for detecting hand gestures. The disadvantage of his system is that the user interface needs to have large widgets to accommodate the hand size and is therefore not suitable for complex user interfaces or interactions with web browsers or media players.

Many direct pointing devices available and become more and more popular. Examples for this are the Nintendo Wii Controller (*Wiimote*), GyroPoint and RemotePoint. Pointing with a laser pointer has the problem that the pointer moves unstable due to unintended hand jitter. The Nintendo Wii overcomes this problem by using large UI elements. However, large widgets cannot be contained in a small space and therefore don't provide a solution for existing UIs.

3. MAGNIFACTION FOR REMOTE INTERACTION

The research presented in this paper addresses two problems. The first one is the issue of not being able to use a conventional desktop mouse for pointing interaction with a remote screen. The second is the issue that web pages and PC application rendered on a remote screen are difficult to read and interact with. The reason for that latter is that there were designed for desktop use and not for interaction at a distance in a living room.

This work introduces magnifiers for direct remote interaction to overcome both problems. Three magnifiers were implemented and evaluated in a comparative study. The first and second one magnify the area around the mouse pointer with a linear (Figure 1a) and a hybrid fisheye transformation (Figure 1b) respectively. The third one magnifies the widget beneath the mouse pointer, as depicted in Figure 1c.

The linear magnifier gives very good detail information of the location the remote control points at. On the other hand it breaks the relationship between the magnified and the neighboring area through which the user loses orientation when moving the attention from the focus to the global context.

The advantage of the fisheye magnification is that it enhances the localized detail while preserving the continuity of transition to the global context. On the other hand, a continuous distortion over the image misleads the orientation of the focus. Thus, hybrid fisheye tries to combine the advantages of linear magnification and fisheye by transforming the surrounding area of the focus gradually and linearly magnifies the focus area. The advantage of this approach is that the users still get the continuity of the relationship between the magnified dimension and the non-magnified dimension while the focus area is not distorted.

The third approach magnifies the UI widgets such as buttons and toolbars with which the user interacts with. The advantage of this approach is that the magnified dimension does not move following the cursor so that the users have a more steady magnified area.

4. IMPLEMENTATION

The Nintendo Wii game controller (Wiimote) was used as the direct pointing device for remote interactions with a TV screen (42inch, 1024x768 pixel). The Wiimotelib library was used to determine the mouse pointer location on the screen. Using Wiimotelib, we could access the values of the IR camera of the Wiimote that was used to determine the mouse pointer location on the screen. The IR camera sends the location of the captured IR lights of the sensor bar attached to the TV. As a user points at the screen using Wiimote, the position of the mouse pointer is calculated based on the Wiimote's camera values.

To visualize the magnifier, the algorithm calculates a clipping area as big as the magnifier size on the surrounding area of the pointer. Then, it copies the pixels and interpolates these pixels based on the magnifier type. A more detail explanation of these interpolation algorithms can be found in [6].

To overcome hand's noise movement, we introduced a filter function. The filter function uses a dynamic averaging that works by measuring the pointer location's changes. If the changes are small, it averages a number of previous locations. If the changes are big then the user moves the pointer rapidly. Therefore it averages only a few previous locations. If the changes are very small the pointer should not be moved because this is normally unintended movement.

The widget magnifier works differently than the previous magnifiers (Figure 1c). It magnifies the widget that is currently under the mouse pointer by copying the whole area of the widget. Then it interpolates the copied area, uses it as a background of a transparent window, and then places this window on top of the original widget. When the user performs any mouse event, it is rerouted onto the original widget. When the pointer moves to another widget, the previous magnifier window is destroyed, and the whole process of visualizing a magnifier is repeated. The drawback of this method is if the user moves rapidly and crossing several widgets, then the all of these widgets would be magnified one by one.

5. EXPERIMENT

The purpose of evaluation was to test these following hypotheses:

- H1: The usage of magnifiers will reduce the error rate for selecting small targets in a home entertainment setting.
- H2: The usage of magnification will reduce the task completion time for practical tasks such as web browsing or interactions with media players.
- H3: Magnification leads to a higher selection time since targets seem to be moving faster in the magnified area. Therefore the user has to readjust her movement speed.

The experiment was conducted in a living room like setting where a sofa was placed 3.5 meter away from a 42inch TV which is mounted on the wall (Figure 2). The study used a within-subject design with 12 right-handed participants whose ages ranged from 17 to 29 with a mean age of 25 years. The participants had different professional backgrounds.

Figure 2. Room used for experiment, shows used TV and sofa on which the participants sat.

The participants performed two different tasks. First a Fitts's law tapping task and then a practical task. In the tapping task, four widths of icon width (16, 32, 48, and 64 pixels) and three distances (100, 300, and 704 pixels) were used. The comparison of the sizes and distances is depicted in Figure 3. The tapping task followed ISO9241-9 standard for evaluating multidirectional tapping. ISO9241-9 describes the ergonomic requirements for office work with visual display terminals. Each participant hit 13 targets for every possible combination of magnifier (*without magnifier, hybrid magnifier, linear magnifier* and *widget magnifier*), width and distance. The sequence of interaction technique, width and distance was counterbalanced using a balanced Latin square algorithm in order to avoid any learning and exhaustion affects.

The practical task was conducted directly after the tapping task. The participants had to check their emails on Gmail and had to find particular news items on the BBC webpage. Furthermore they had to create a playlist and to play a particular song using the Windows Media Player. Both tasks were performed using the four different interaction techniques (*without magnifier, hybrid magnifier, linear magnifier* and *widget magnifier*) and completion times were recorded. Different tasks and counterbalanced sequences were used to avoid any training effects.

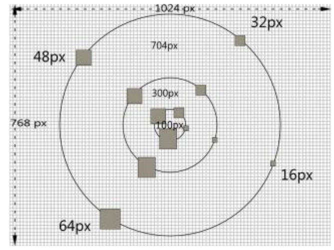

Figure 3. Comparison of targets and distances and the screen size for Fitts's law tapping task.

6. RESULTS

The results of a 3-way ANOVA for the Fitts's law tapping task indicated that the selection times and error rates were significantly affected by magnifiers, widths, and distances.

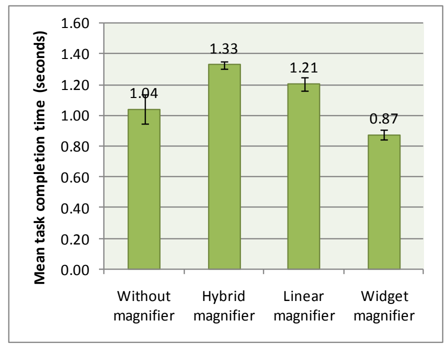

Figure 4. Mean selection times.

As depicted in Figure 4, *widget magnifier* had the shortest selection time (M=0.88, SE=0.05), followed by *without magnifier* (M=1.04, SE=0.04), *linear magnifier* (M=1.21, SE=0.02), and hybrid magnifier (M=1.33, SE=0.05).

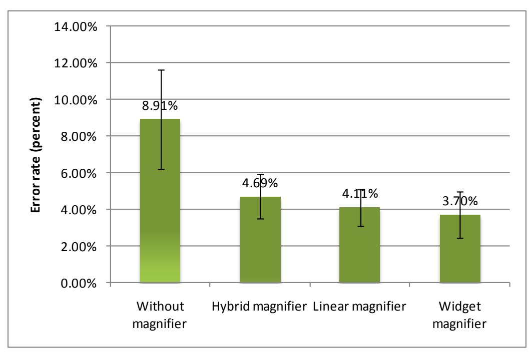

Figure 5. Mean error rates.

Figure 5 shows that *hybrid*, *linear* and *widget magnifier* had a significantly less error rate when compared with *without magnifiers*. The *without magnifier* interaction technique had especially very high error rates when considering small targets.*Without magnification* had on average a 123% higher error rate than the other interaction techniques when considering an icon size of 16 pixel. There was no significant difference of error rates among the different magnifiers.

Figure 6 shows that in the internet browsing task, *hybrid* and *linear magnifier* were 73.09s (26%) and 71.40s (26%) faster than *without magnifier*. In contrast, *widget magnifier* was 17.80s (6%) slower. The result of the media player task indicated that *hybrid* and *linear magnifier* were 78.13s (26%) and 50.33s (26%) faster than without magnifier. In the contrary, *widget magnifier* was 35.42s (13%) slower.

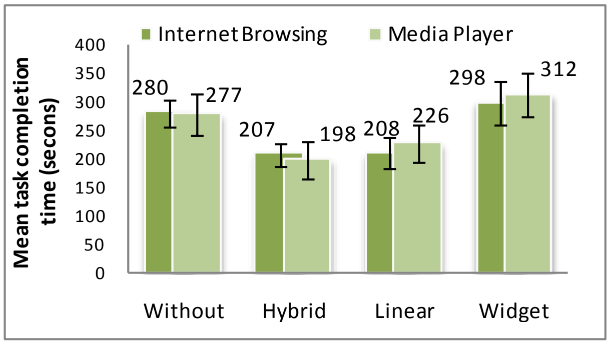

Figure 6. Mean task completion times for practical task.

The user acceptance was measured by questionnaires that were taken from IBM computer usability satisfaction questionnaires [7]. As showed in Figure 7 thought most participants that *linear* and *hybrid fisheye magnifier* are very enjoyable, quick, effective and satisfying interaction techniques. The *widget magnifier* on the other hand received constantly the worst ratings. *Without magnifier* received negative ratings regarding enjoyability, efficiency, quickness, effectiveness and user satisfaction. On the other hand received this interaction technique rather positive ratings when considering intuitiveness, comfortableness and simplicity.

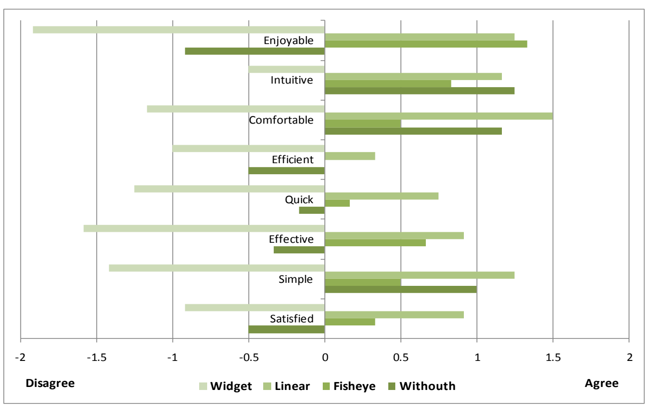

Figure 7. Feedback of participants.

At the end of the experiment participants were asked to state their interaction technique order of preference. 50% of the participants saw *linear magnifier* and 42% saw *widget magnifier* as their first choice. 67% saw *hybrid fisheye magnifier* as their second choice. One can conclude from that, that the users would prefer the usage of magnifiers in general but have different preferences when it comes to the question which magnifier to use.

7. DISCUSSION

Magnifier had a very positive effect on error rate particularly for the selection of small targets. When the target size was 16 pixels, the error rate of *without magnification* was more than 20%. In contrast to that lead the usage of magnifiers to significantly lower error rates. This finding is consistent with H1.

In the practical task, the results showed that the completion time *without magnifier* was significantly higher when compared with *hybrid fisheye* and *linear magnifier*. The authors believe that when the participants performed the task without any magnifier, they had problems to see and point on the small hyperlinks and buttons. Moreover, the authors assume that this is due to the fact that text and buttons sizes of web browsers and media players are designed having a desktop usage scenario in mind. Because of that they are not suitable for the TV viewing distance. Therefore, magnifiers improve the usability in this context by making the user interface more visible to the user. This finding supports H2.

The result of the tapping task showed that *hybrid fisheye* had the highest task completion time, followed by *linear magnifier*. This might be caused by the magnified motion effect as the objects in a magnified dimension seem to be moving faster than the actual movement of the pointer. Hence, the users would have to hit moving targets, which is harder and more time consuming than hitting static objects. This argument is supported by the positive task completion time of the *widget magnifier* in the tapping task, which was better that any other magnification types. This finding is consistent with H3.

8. CONLUSION

The presented research shows clear evidence for the advantages of using magnifiers for pointing interactions with remote screens. Those magnifiers help the user to read and interact with small buttons and hyperlinks displayed on remote TVs. This is proven through the significantly reduced error rates in the Fitts's law tapping task, the task completion times of the practical task, the user feedback and user preferences. As previously discussed provides each of the used magnifiers certain advantages and disadvantages which were also proven by the study results. The conclusion is to offer several magnifiers to the user and to let them decide which one to use.

9. ACKNOWLEDGEMENT

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