IST-Africa 2010 Conference Proceedings
Paul Cunningham and Miriam Cunningham (Eds)
IIMC International Information Management Corporation, 2010
ISBN: 978-1-905824-15-1

An Alternative Multi-User Interaction Screen: Initial Ergonomic Test Results

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Abstract: We investigate a potentially low-cost multi-user computer pointing interface. Given a choice of four targets arranged on the screen, we looked at what the user's preference is in visiting the targets with a hand-held light source. Our study reveals that our sample group has a preferred starting point when initiating the interaction sequence. In addition, we report how some users contorted their bodies during the study.

Keywords: Light pointer interaction, sequence preference, children, camera-based interaction.

1. Introduction

Multiple user interaction screens are becoming affordable for schools in developed countries. However, in Africa such luxury remains mostly unaffordable. A novel interaction system is discussed in this paper and we report on specific tests conducted to determine some of its ergonomic properties.

Specifically, we are interested in determining how well a hand-held light source could be used to control on-screen interactions on a large display. To date, little empirical research has been done on how people interact with public displays [1].

Our installation differs from others in the way the pointing is determined. It is usual to either detect the reflected dots on a screen using a video camera, or use a number of cameras to locate the position of the pointing device and somehow also determine the light source's orientation. Using this data, the direction being pointed in can be calculated.

Our approach differs from others in that the light is directed directly at the camera and translated horizontally and vertically over the camera's detector by the participant's direct arm and wrist movements. Elsewhere in the paper we report on the disadvantages of using this method. Although we have not yet analysed the collected data in detail, we have already observed interesting statistics.

The main contribution of this paper is the sequence in which the participants voluntarily followed in executing a given task. In this paper we also briefly report on the participants' physical motions when interacting with our system.

We hope that the results of this paper will help inform the design of interactive systems when a light pointer is considered as a low cost interaction device.

Section 2 describes the test configuration. The research method followed is given in Section 3, and Section 4 highlights our observations. Results are considered in Section 5, while Section 6 summarises two related prior works. Section 7 concludes and gives pointers to future work.

2. Configuration

Our installation was set up in a dance rehearsal hall, with all walls and ceiling painted black. Two tables were centrally placed and rows of chairs on either side accommodated participants and spectators (Figure 1). The projected image was mirrored horizontally. This allowed a one-to-one correspondence between the movement of the light source and the

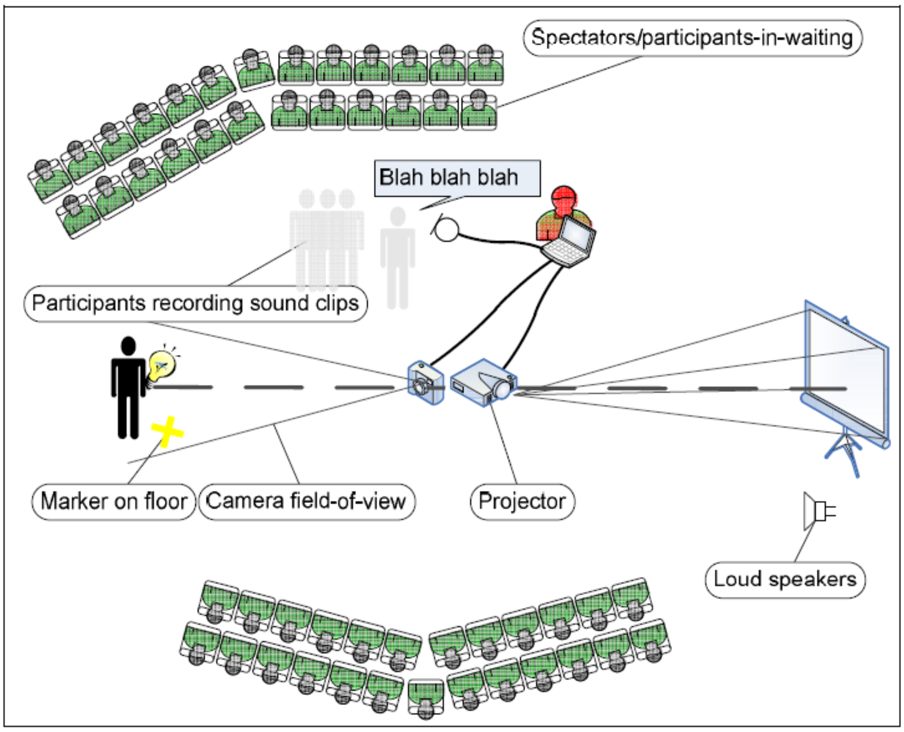

Figure 1: Plan View of General Test Venue Configuration.

projected movements on the screen. A web camera was installed in line with the user and projection screen.

A tape marker was stuck at a fixed spot in front of the camera, also in line with the main axis of the configuration (left-to-right dashed line in Figure 1).

Custom light sources were assembled, consisting of three ultra-bright white LED's powered using a 9V battery. Three LED's facilitated the adjustment of the radiated light pattern during the sessions, if required.

Interactions were captured using video and still images. Real-time pointing motions were automatically captured by the application and saved to a text file for later analysis.

We developed the application using the Processing programming language [2]. This language is well suited for experimental development, requiring little learning when accessing powerful functionality. We made extensive use of its image capturing and graphic libraries. The development environment and libraries are available as open source. When executing, the application projects four target areas on the screen with the centre of the display area serving as a neutral position (Figure 2).

2.1 Research Mode

The participants were instructed to start from the centre and move the projected pointer to any one of the four targets, and then back to the centre (See example in Figure 8, top left). The process was repeated until all four target areas have been visited.
When a target has been reached, the sound clip assigned to that target is played. Once all four targets had been visited, the application changed to the gaming mode. We restarted the application for each participant in the group until all participants have had a turn. An

exception was for the last participant. In this case the application would be left running in the game mode. At this point everybody in the group could participate in the game mode as described later.

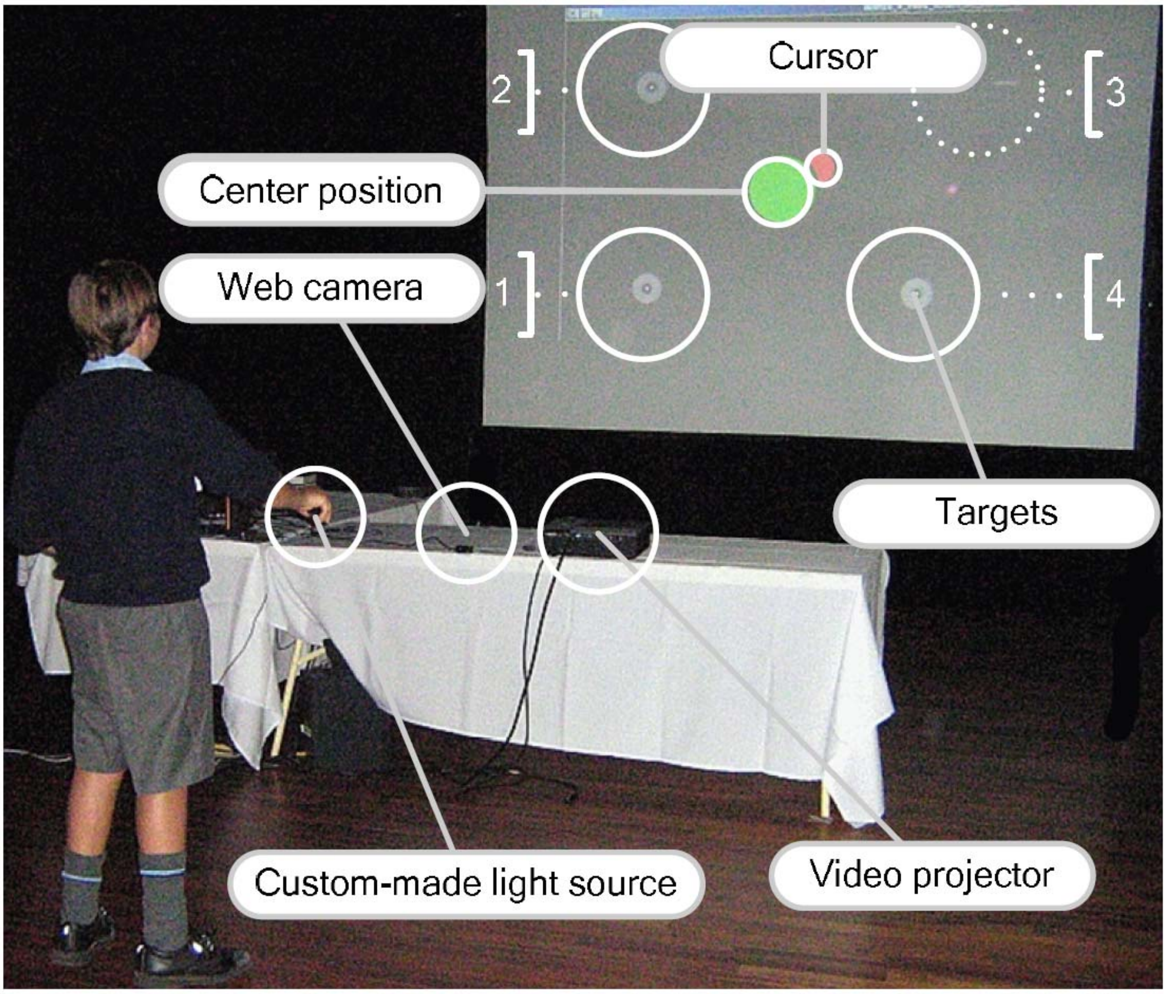

Figure 2. A participant interacts with the system by moving the light source in front of the camera. One target has already been reached (dashed position) and the cursor is being guided to the centre position. (The white circles and other markings on the screen were not part of the experiment.)

At no point did we make any mention of time restrictions when posing the challenge to the participants. No visual time measurements were either made or communicated. However, time measurements were automatically made by the software application and recorded for later analysis. Once the test session was initiated, the application would save a position sample every 100 milliseconds, being the default processing rate.

2.2 Game Mode

The game mode served as reward to the participants for their participation. We are of the opinion that it also served as an attraction for spectators to offer their participation. We encouraged elaborate body motions to interact with the open-ended application. This part of the session was limited to a few minutes at the most, so as not to bore the spectators who themselves would rather want to have a turn.

3. Methodology

The workshops were held in the Eastern Cape Province, the most neglected province of South Africa. Workshops were held as part of an annual science week where a combination of workshops, exhibitions and talks with the aim of attracting young children to the research domains of engineering, science and technology. Workshop bookings required a small upfront payment. This was to ensure that would-be participants attend the workshops. As past experience has shown that there was little commitment when no booking fee was required.

Participants were from diverse backgrounds. We had no a-priori participant information, being a mix of mostly Caucasian and African children. The children received home schooling, public schooling, or private tuition. The majority attended public schools. These data sets were not collected. However, we did take note of participant age and height.

Workshop attendees were both spectators and participants. The workshops each lasted approximately 60 minutes. We took care to give all attendees the opportunity to participate. The groups attending were always accompanied by at least one adult. In advertising the workshops in the program we made it clear that data would be collected for research purposes. Written informed consent was obtained from the accompanying adult responsible for the participant/s. This did not pose a problem.

Groups consisting of between four and six children participated at a time. Each child would be encouraged to record a one-second sound clip. The visual display was a tremendous help in making quick sound clip recordings. Each recording was projected onto the large screen in real-time. This was done to show the children what their recording 'looked' like to the computer, but more importantly, it served as a technical aid to quickly inspect the signal visually for amplitude clipping. Clipping occurred often because of the children's excitement. In some instances the recording volume was too low and the recording had to be repeated. Participants were very keen to record their own sound clip and the activity would invariably result in general laughter when played back.

We captured statistical information on the 297 participants, including age and height. Our original intension was to determine if there is a correlation between age, height and time taken to complete the sequence. It transpired that we did not make this comparison but instead analysed the order in which the sequences were executed.

Our workshop was designed to both collect research data and to be fun. Each group participated in the research and fun activities. The fun activity followed immediately after the research activity. The two activities are now explained in more detail.

3.1 Research Activity

In essence our pointing system is a closed feedback control system with the user in the feedback loop to control the position of the projected pointer on the screen.
According to Reeves' classification of interfaces [3], this part of the session can be classified as having Revealed Effects in response to Revealed Manipulations.

Our light source (Figure 3) was designed to provide a wide angle of illumination; more than what would be achieved using an off-the-shelf torch (flashlight). It has the added benefit of a quickly-adjustable radiant angle. This can be done by simply bending the LED legs.

3.2 Fun Activity

The second part consisted of semi-structured play, providing the children with an opportunity to explore the novel interface. We suggested some modes of interaction, but the children were free to explore others. The 3-LED torches were made available and some children made use of them. Some groups would only use the torches, even though the other objects were readily at hand. Because the system responded to any source of light, a range of light sources was explored. White table cloths (Figure 4) and children's own clothing were subjected to experimentation. All group members were encouraged to 'find' their own sound recording by moving their cursor across the screen.

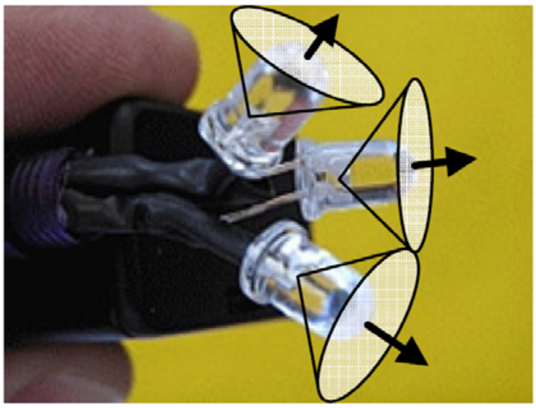

Figure 3. Custom-designed hand-held light source with adjustable LED's. Arrows indicate the direction in which the LED's are pointing, and the cones give an indication of the overlap between the light emanating from the LED's. Figure 4. Free-play is a great reward for participation. All reflective objects result in sounds being generated.

As can be expected, the free-play was a great source of excitement and the accompanying "mess" of sounds that can only be classified as noise. According to Reeves' classification of interfaces [3], this part of the session can be classified as having Amplified Effects in response to Revealed Manipulations.

4. Observations

A significant number of participants experienced great difficulty in reaching all four targets. Some participants were unable to move their cursor beyond a certain point, almost as if an invisible barrier had been reached. This could be explained by the contortions their bodies had been subjected to.

The following elaborates on the problems some participant experienced: The participant would move the pointer sideways and away from the body without realizing that a simple horizontal and vertical movement (while keeping the light directed at the camera) would solve their challenge. Simultaneously, the light would be directed away from the camera (Figure 5 B,C). Eventually the light no longer reached the camera and the cursor disappeared from the screen. The participant would then bring the arm closer to their body and retry. This would again be unsuccessful, eventually requiring intervention by the test supervisors.

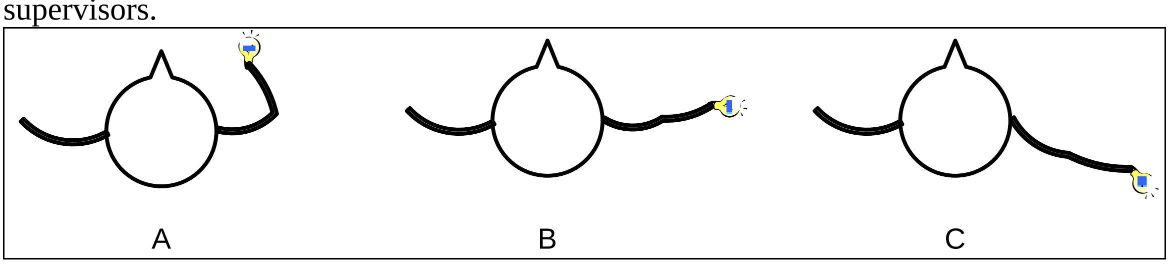

Figure 5: Plan-view of three dominant observed motions. Relaxed and in control (A), Contorted and out of control (B and C).

5. Results

The average age of the 297 participants was 12.4 years with a standard deviation of 6.2. The light pattern of the custom-made torches behaved well in most cases. In a few cases the emitted light was not omni-directional and did not reach the camera's sensor. Adjusting the

LED's relative orientations often solved this problem. Some participants had to be prompted repeatedly to keep the torch pointed at the camera.

It was obvious during the execution of the experimental part of the session that the majority of participants constantly repositioned parts of their bodies to reach the four targets on the screen. This was done by extending the arms.

Some participants had good control over the pointing and motions of their arms, indicating good spatial awareness and integration with their visual perception. For them, the wrist and arm would be rotated and translated in such a way as to keep the light source pointed at the camera. At the same time the light source would be moved across the camera's field-of-view in such a way that the various targets on the screen were reached. The motions were kept comfortably close to the body and it was obvious that the user had good control over the motions and was comfortable in completing the task at hand (Figure 5 A).

Some other motions observed are: excessive forward extension of the arm, the backward extension of the arm, and side extension of the arm (Figure 5 B,C).

Eighty four percent (Figure 6) of the participants preferred to start their sequence at the two upper positions (indicated as '2' and '3' in Figure 7). A possible explanation for this phenomenon is our Western style of reading and writing, being from the top of a page, moving down. It is doubtful that the same reasoning holds for the horizontal movement preferences as there is only a slight preference (58%) evident for starting the sequence from the left as opposed from the right.

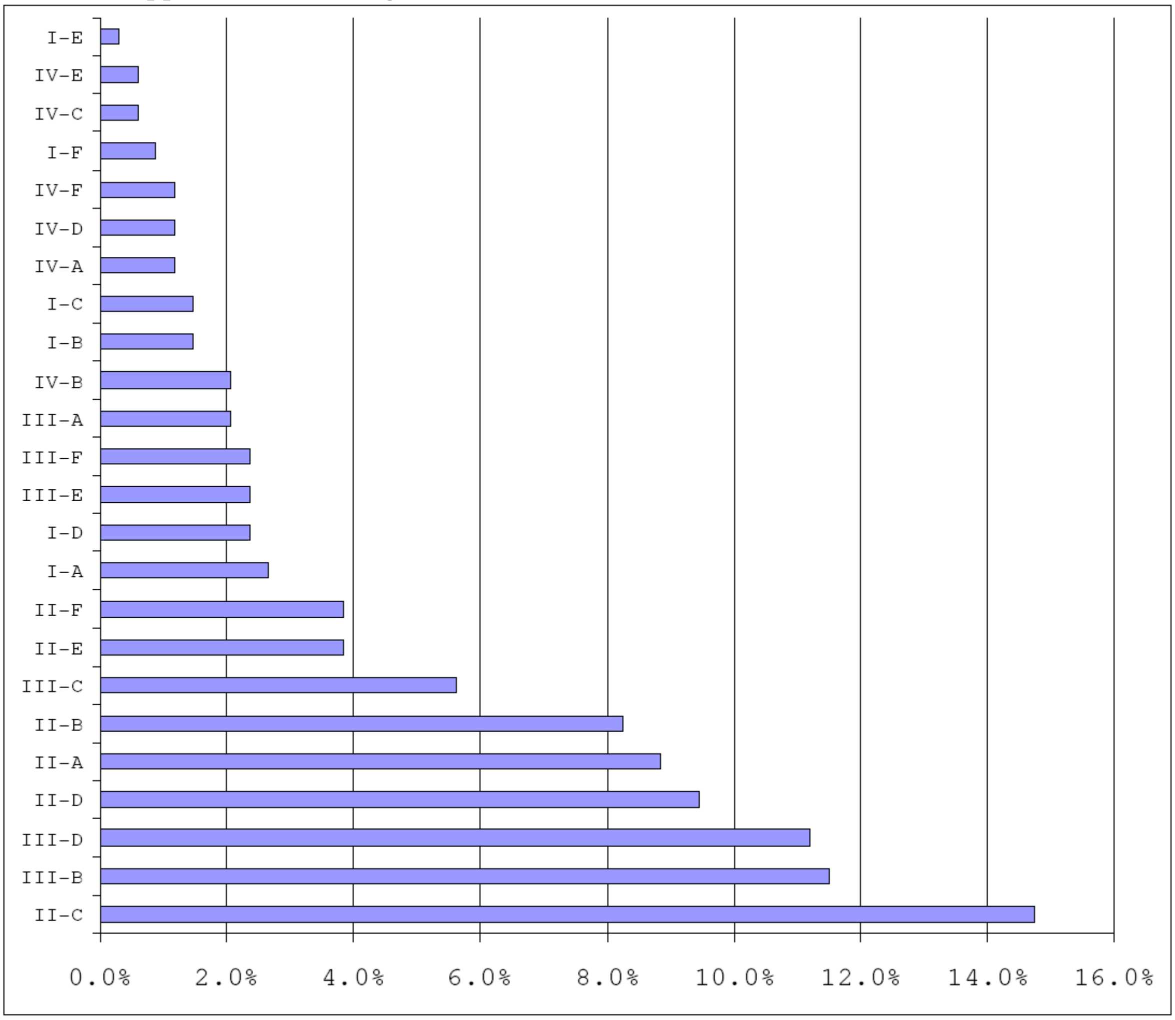

Figure 6. Probability of Each Sequence Given in Figure 7(n=339, std dev=4.2).

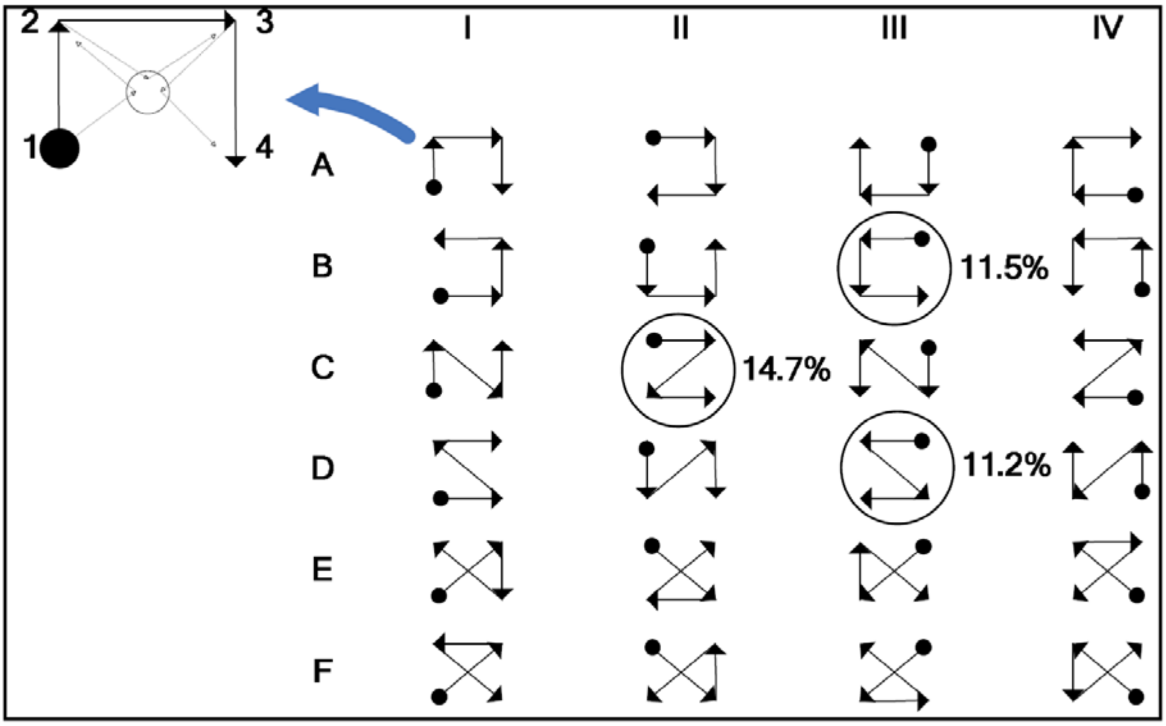

Figure 7. The 24 possible sequences for completing the task. Sequence I-A is top left, sequence IV-F is bottom right. It is implied that each motion, in each sequence, makes a detour through the centre of the display (example shown top left). The dots indicate the start positions. The three most frequent sequences are circled and their probability indicated alongside.

The game mode exposed at least two problems: (1) the software makes no distinction between the participants when they simultaneously interact with the system. Although the participants did get visual feedback, they did not always correlate their movements with the sounds; (2) the original application triggered a sound clip many times once a blob had been detected. The application was modified during the workshops so as to only trigger a single sound clip instance for every blob detected in a video frame, reducing the overwhelming "noise".

6. Prior Work

Hourcade [4] investigated the use of a computer mouse as a pointing device on a computer screen. He specifically looked at the differences between children and adults in how they used the computer mouse. This study encouraged us to conduct similar experiments using large displays with light pointing devices.

Other studies investigated the use of light sources when interacting with display systems. Two of these are: (1) Olsen [5] used a low-cost web camera to detect the location of a hand-held laser dot on a projected image. This technique requires that the camera be matched to the projector. (2) Maynes-Aminzade [6] tracked the position of reflected laser dots by using a camera pointed at the screen. The participants used handheld laser pointers to select areas on the screen. These positions were then tracked.

7. Conclusions and Future Work

In this paper we have reported on one observation and one statistical finding.

Analysis of the collected data revealed that our sample group exhibited a preference for a particular interaction sequence. A significant number of the participants found it difficult to control the cursor using the given configuration.

Additional analysis of the data is possible, such as the path taken to reach the targets, the time taken, and the correlation between participant height and duration.

Acknowledgments

This research was funded by the South African Department of Science and Technology.

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