Interacting with the Big Screen: Pointers to Ponder

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ABSTRACT

In large screen projection environments, inexpensive wireless input devices can not match the performance of standard desktop interactive devices. We added buttons and a radio transmitter to a standard laser pointer to match the functionality of a standard mouse. User testing revealed that the device performed as well as a standard mouse and significantly better than standard presentation input devices. Devices that used visible laser light performed significantly better than those with invisible near-infrared lasers.

Keywords

laser pointer, large screen display , pointing devices

INTRODUCTION

As large, wall-sized, multi screen display systems become more ubiquitous, there is a need for better and simpler interaction tools. While there are non-tethered systems on the market (such as Gyration's Gyromouse & Interlink's RemotePoint), their focus tends to be on simple presentation support, rather than on providing precise input for direct object manipulation. Design and data exploration tasks in a multi screen environment require an input device that is both easy to use and highly accurate.

While laser pointers can provide excellent positional information, they have generally been implemented in a way that accentuates their limitations. Many of the limitations described by others [4] stem from their choice of using off-the-shelf laser pointers, which lack any buttons other than an on/off switch. While this is an understandable design decision, this has forced them to develop elaborate systems to overcome the inherent limitations via software: Olson and Nielsen [3] use dwell times to represent input events; Chen and Davis [2] use gesture recognition. We have chosen a hardware solution: our system adds buttons to the laser pointer using a radio transmitter, allowing the user to interact with a WIMP interface in the standard manner.

Our system is quite similar to the one described by Olsen and Nielsen [3]. It is implemented as an inexpensive addition to an existing three screen, front projected theatre. A low cost (<$75 US) black and white CMOS camera is mounted on top of each projector, directly above the projector lens. All three cameras are processed by a single Linux workstation with three commodity video capture boards. Points are detected and sent via UDP to the display computer. A simple calibration routine is implemented: the tracked position is within 1 pixel of the observed laser position (the projected image had a resolution of 1024x768.) Latencies of less than 40 milliseconds are achieved, which is the limit of the capture card/camera combination.

Two buttons are added to the laser pointer. Click events are sent via radio frequencies to a receiver, which translates the events into a standard PS/2 mouse output.

DEVICE COMPARISON TEST

Standard Fitts and Tunnel tests [1] were conducted to test the efficacy of the laser pointer. We compared a standard mouse, an Interlink RemotePoint RF (a pressure sensitive input device often bundled with video projectors) and the laser pointer system.

In all of our tests, users were asked to stand a standard distance (1.5m) away from the screen. The screen is 2m X 3m and the working area is 1.5m X 2m.

Methodology

A within-subjects factorial design with repeated measures was used. Four subjects participated in this experiment. Independent variables were Test (Fitts and tunnel), Device (mouse, RF remote pointer, and VR laser pointer), Difficulty, (ID = 10, 15, 20, and 30) and Time (1st, 2nd, 3rd, and 4th measurement). The dependant variable was response time recorded in milliseconds.

Results

A repeated measure ANOVA was performed to evaluate the effects of the within-subjects variables. The sphericity assumption was met for all effects so no correction was applied. The results revealed a significant interaction between Test and Difficulty, $F(3,9) = 20.690$, $p < .0001$, and Test and Device, $F(2,6) = 8.080$, $p < .020$ (see Figure 1). Main effects for Test, $F(1,3) = 134.548$, $p < .001$; Device, F(2,6) = 46.093, $p < .0001$; and Difficulty, F(3,9) = 28.776, $p < .0001$ were also found.

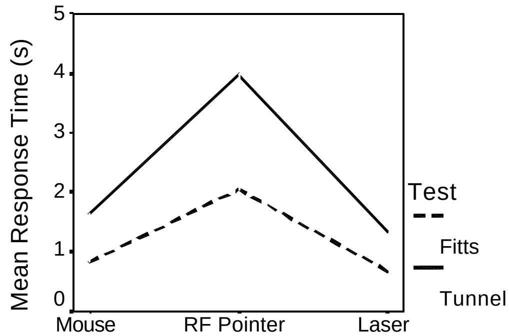

Figure 1: Test by Device Interaction

Discussion of Device Test Results

The laser pointer with added buttons outperformed the RF Pointer and matches the performance of the mouse in both Fitts and Tunnel tasks. While hand jitter was observed, it was not so much of a problem as is described in existing literature [3],[4]. We surmise that it did not have a significant effect in our test because users were not required to hold the laser steady for an extended time. Acquiring a target is relatively easy, while maintaining a static position is much more difficult.

VISIBLE VS. INFRARED LASER TEST

After our initial exploration of the device, it was apparent that it was impossible with current off-the-shelf technologies to achieve the latencies that users have come to expect from interactive devices. We hypothesized that if the laser point was made invisible, by using an infrared laser, the subjects would unconsciously compensate for the inherent system latencies, improving their performance and/or satisfaction level.

Therefore, we modified our device to include an infrared laser. In order to create lag similar to that described by Olsen [3], we added an artificial worst-case lag option to our processing software. We tested six subjects with both Fitts and Tunnel tasks.

Methodology

A within-subjects factorial design with repeated measures was used. Independent variables were Lag (lag, no lag), Laser (infrared, visible red), Difficulty, (ID = 10, 15, 20, and 30) and Time (1st, 2nd, 3rd, and 4th measurement). The dependant variable was response time, recorded in milliseconds.

Results

A repeated measures ANOVA was performed to evaluate the effects of the within-subjects variables. For the Fitts task, the sphericity assumption was met for all effects so no correction was applied. The results revealed a significant interaction between Lag and Laser: F(1,5) = 8.584, $p < .033$ (see Figure 2). Main effects for Lag, F(1,5) = 32.609, $p < .002$; Laser, F(1,5) = 7.718, $p < .039$; and Difficulty, F(3,15) = 43.795, $p < .000$ were also found.

For the Tunnel task, the sphericity assumption was met for all effects except those involving Difficulty. There, the Greenhouse-Geisser correction was applied. The results revealed a significant interaction between Laser and Difficulty, F(1.808,9.041) = 6.134, $p < .023$. Main effects for Lag, F(1,5) = 30.129, $p < .0001$; Laser, F(1,5) = 10.309, $p < .024$; Difficulty, F(1.062,5.308) = 20.195, $p < .005$; and Time, F(3,15) = 4.081, $p < .026$ were also found.

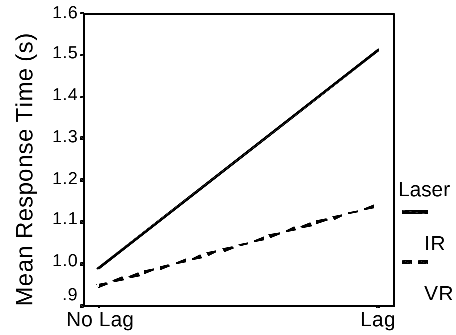

Figure 2: Lag by Laser Interaction (Fitts)

Discussion of Visible vs. Infrared Laser Results

Somewhat surprisingly, for both the Fitts and Tunnel tasks, the visible laser performed significantly better than the infrared under both our ideal and our artificially degraded latencies. One possible explanation for this might be that the subjects focused on the point of the laser, rather than on the cursor icon, given that the laser point has a much higher resolution and no latency. As a result, the feedback loop between the motor and perceptual systems is ideal. When users must rely on the system's interpreted location, they are always adjusting to positions 30+ milliseconds behind their current ones. We believe that if the latency and calibration were perfect, the visible would perform as well as the invisible laser.

CONCLUSIONS

By adding additional buttons to a standard laser pointer, a highly effective input device can be created quite inexpensively. Its effectiveness is similar to that of a desktop mouse, while still allowing the user to interact with large screens in a direct manner.

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