Architectural Presentation with Laser Pointers on a Projection Screen

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Abstract. *In a conventional group meeting environment with digital content presented on screen, the discussion may be dominated by a presenter who has the control of the computer. Being widely used in meetings, laser pointer is a potential tool that can tackle this problem. This paper describes a novel use of laser pointers in architectural presentations. A laser pointing system designed for a projector-and-screen environment was developed. The performance and usability of the system were tested. A controlled user experiment was carried out to compare the laser pointer with other interacting devices, including a mouse, a stylus, a trackpoint and a TabletPC. The usability was tested by using the system in a real application. Details of the laser pointing system, the experiments and the results are reported in this paper.*

Keywords. *Laser pointing system, group meeting environment, laser pointer*

Introduction

Projectors and screens have become standard settings for most educational and commercial presentations. Projection on a large screen provides a shared platform on which all participants can see the information under discussion. The screen projection settings are used mainly for one-way information dissemination presentations where the flow of presentation is usually controlled by the presenters. The discussion may be dominated by the presenter who has the control of the computer. This type of settings may not be able to meet the high demand of interaction between all participants in architectural presentations, especially in design critiques.

With the widespread use of laser pointing devices, we have a potential tool to tackle this problem. A number of attempts in using laser pointers in human computer interaction have been made (Matveyev and Göbel, 2003; Oh and Stuerzlinger, 2002). The technical issues of implementing laser pointing systems are thoroughly discussed. Nevertheless, the benefits and problems of using laser pointers in group discussions have not been reported.

This paper describes a novel use of laser pointers for architectural presentations. A laser pointing system, designed for a projector-and-screen environment was developed. With this system, each participant with a laser pointer has an equal chance to take control of the presentation content.

It is envisaged that the laser pointing system is able to enhance the engagement of participants in architectural presentation and discussion. In order to test the performance and usability of the laser pointing system, two experiments were carried out. Details of the system and the experiment results are reported in this paper.

Related work

Eckert and Moore (2000) used laser pointers in a large classroom to increase interactivity between instructor and students. The position of a bright laser spot on the projection screen is taken as the location of the mouse cursor. Different mouse events are mimicked by pointing the laser spot to certain positions on the screen. Neither the weaknesses of the laser pointing system nor the users' feedback is reported by Eckert and Moore.

Olsen and Nielsen (2001) developed an interaction interface using laser pointer on XWeb systems. They asserted that simple mapping of Mouse Up/Down to Laser On/Off does not work. A laser spot movement is interpreted by its dwell and off events together with icons on the screen. By comparing the efficiency of the laser pointing system and mouse-based interaction, Olsen and Nielsen found that mouse-based interaction is twice faster than the laser pointing system.

Jeng and Lee (2002) used a laser pointer to control the viewpoint of a digital 3D model in design reviews and critiques. Laser pointer and hand gesture recognition were used together in their iCube project, but details of the experiment were not reported. Myers, et. al. (2002) revealed that due to hand jitter and difficulties in turning the beam on or off at the right position, conventional interaction techniques designed for a mouse or a stylus are doomed to fail when used with a laser pointer. Nevertheless they still asserted that point to things across a room using a laser pointer is natural and convenient.

Some researchers further attempted to extend the pointing systems to support multiple pointers. Oh and Stuerzlinger (2002) elaborated the technical issues of implementing a multi-pointer system. In spite of this, the interaction of the concurrent multiple pointers were not explained. Vogt, et. al. (2004) show that using multiple laser pointers is useful in a specifically designed problem-solving task.

These literatures demonstrate the possibility of using laser pointers as computer interaction devices. They also reveal some physical limitations in manipulating with laser pointers. However no attempt of using laser pointers in group discussion has been made.

A laser pointing system

The aim of this research is to develop an interaction tool which is suitable for interactive discussion in architectural presentations. A Laser Pointing System (LPS) is thus proposed and developed. It is a flexible tool suitable for various applications and usable in a variety of situations with a variety of projectors and cameras. No specific application is assumed during development.

The system, composed of two major parts, is implemented in a client-server architecture (see Figure 1) which allows the transparent integration of different devices independent of platform. A LPS server running on a computer, connected to a camera, is responsible for detecting laser spots and sending the laser ON/OFF signals and the coordinates of the laser spot to the client. A client of the system, executed in a participant's computer, is responsible for receiving spot coordinates from the servers, interpreting the movement of laser spots into interaction commands, and sending the events to the operating system. A client can be connected through a local area network (LAN) to as many as two LPS servers. Therefore the system is able to handle a tiled screen projection.

Hardware setting

In this project, inexpensive cameras, cost about US$40 each, were used to monitor a front projection screen. The camera captures the screen at 800x600 pixel resolution at a rate up to 30 frames per second. The camera was connected to a computer through a high-speed USB2 cable. As the camera resolution is often lower than the resolutions of most projection display, the camera must be placed at a location close to the screen so as to utilize the capture area. Since the brightness of a laser spot is so high that the camera sensor is always made saturated at a normal setting, it is necessary to reduce the exposure time of the image. This can increase the accuracy of the laser spot detection.

Detecting the laser spot

Detection of the laser spot is handled by the server which scans through each individual frame to check if there is any instance of pixel brighter than a certain threshold. If more than one bright pixel are detected, the mid-point of these bright pixels is computed. This is based on an underlying assumption that only one laser pointer is on at one time. This assumption is made because there is no easy way to solve the possible conflicts which may arise when multiple users attempt to control a computer at the same time. Due to the same reason, no general-purpose computer supports multiple mice. Multiple pointers can only be made for some specifically designed interactions.

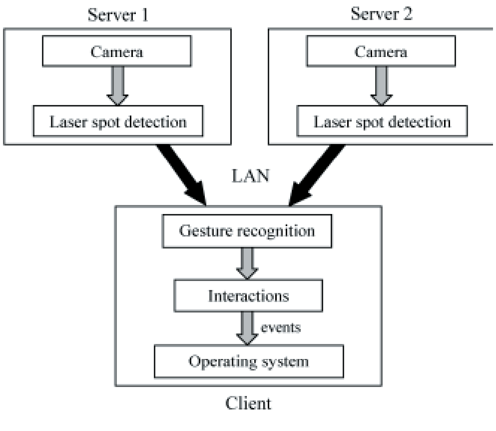

Figure 1. System architecture.

Calibrating the camera

Since the resolution of the display produced by projectors is often higher than the resolution of a camera and it is extremely difficult to match the projection area with the capture area perfectly, a mapping function is needed to convert a captured display area to its corresponding area on the projection screen. A calibration step is thus necessary when the LPS server initializes. Eckert and Moore (2000) assumed that the captured projection area is trapezoidal and did a linear mapping from a trapezoidal area to a rectangular area. This assumption only holds for few expensive cameras. The non-linear pincushioning effect of most cameras and the keystoning effect of projectors (Olsen and Nielsen, 2001) make the linear mapping approach infeasible. As a result, a non-linear mapping approach is employed in our system.

In the initialization step, a user target the laser pointer to a series of nine points on the screen whose corresponding coordinates on the projection display are known. With these nine pairs of points, the coefficients (ri and si) of the following polynomials can be found:

$$x' = r_0 + r_1 x + r_2 y + r_3 x^2 + r_4 y^2 + r_5 x^y + r_6 x^2 y + r_7 x y^2 + r_8 x^2 y^2 \quad (1)$$

$$y' = s_0 + s_1 x + s_2 y + s_3 x^2 + s_4 y^2 + s_5 x y + s_6 x^2 y + s_7 x y^2 + s_8 x^2 y^2 \quad (2)$$

where r_i and s_i are coefficient constants determined in the initialization.

These learned polynomials are then used to compute the actual location of the laser spot on the projected area. They produce an accurate mapping between the coordinates on the captured image and the coordinates on the projection display. These mapped coordinates are sent to the LPS client through a LAN using a stream of UDP packets.

Interaction

Since the determination of the laser ON/OFF and the computation of the spot coordinates are done by the server, a LPS client is free to change its function to perform different interactive actions according to different needs. For instance, the interaction of a game and that of a presentation can be different. We can modify the behavior of the client easily to suit different needs.

In this project, two client programs were implemented. One simply mimics the movement of the mouse cursor and invokes a mouse click when the laser spot goes OFF. The other provides a set of interactive behaviors, including mouse click, double mouse click, right click, drag and drop, up cursor key and down cursor key, for the general use of a computer. These complicated interactions were made possible by a stroke recognition function. The locus of a laser beam is first interpreted as a command. Subsequent interaction will happen only when the system can recognize a predefined stroke.

Stroke recognition

The stroke recognition function was implemented in one of the LPS clients using the neural network approach. After receiving a series of spot coordinates, the client feeds the coordinates sequence into the recognition function. When a predefined stroke is detected, the behavior of the following laser point interaction is changed accordingly. If an unknown stroke is detected, the sequence of spot locations is simply discarded. A set of predefined strokes in the client is listed in Table 1.

Experiment 1: Laser pointer performance

It has been shown that hand-held laser pointers possess some physical limitations (Myers, et. al., 2002). In order to compare the actual performance of the LPS with other interacting devices, an experiment was carried out to measure the efficiency of point-and-select interaction on a projection screen. A modified version of the Fitts' experiment was used in this experiment. Figure 2 shows a snapshot of the experiment program. Partici-

Stroke	Actions
↑	Send an UP cursor key event
↓	Send a DOWN cursor key event
C	Point laser spot to the right position and switch OFF to invoke a mouse left-click
R	Point laser spot to the right position and switch OFF to invoke a mouse right-click
D	Point laser spot to the right position and switch OFF to invoke 2 mouse left-clicks
M (move)	1. Point laser spot to the right position and switch OFF to select an object 2. Move the spot to another place (drag) and switch OFF to the object (drop)
P	Ignore following laser pointer actions (for simple pointing purpose)
←	(at the bottom of the screen) Restore stroke detection

Table 1. Command strokes

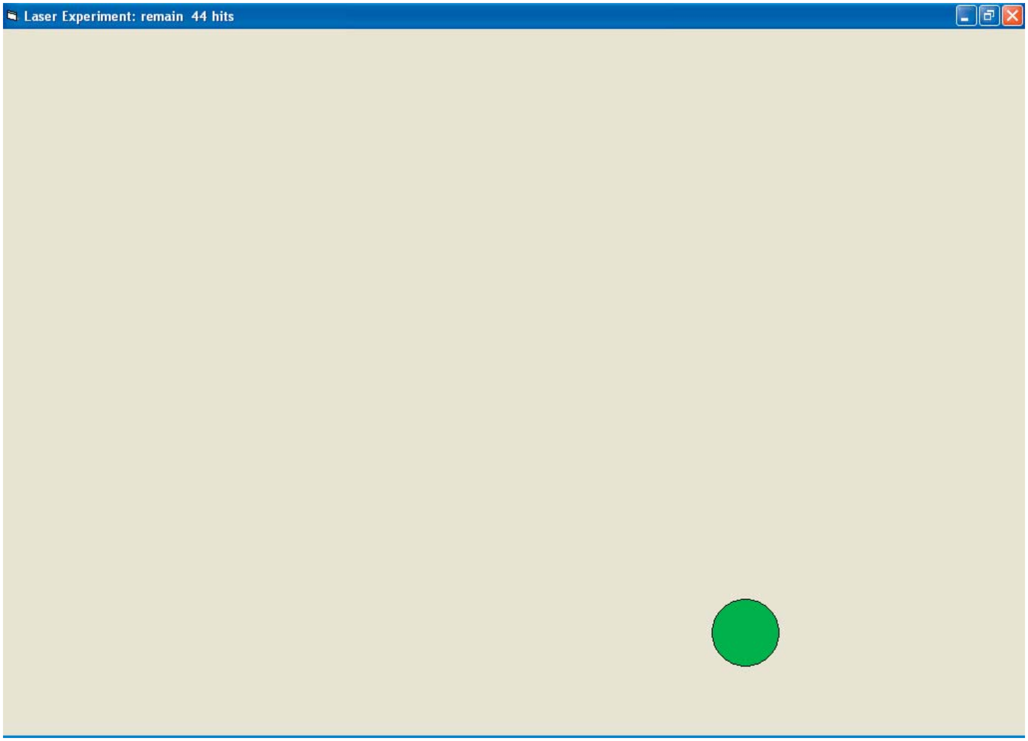

Figure 2. Snapshot of the experiment.

pants were asked to click on the circles appearing at random positions and in random sizes. “Parked” circles and “random” circles appear in alternation. A parked circle, of a fixed size of 30 pixels in diameter, is located at the center point of the window. And the size of a random circle ranges from 20 pixels to 100 pixels in diameters. It is guaranteed that the edges of any two consecutive circles are at 20 pixels apart.

Thirteen participants, 9 male and 4 female, took part in this experiment. Each participant had to do 5 tests. In each test, a subject was asked to click on 100 circles in one test, including 50 parked circles and 50 random circles appearing in alternation. With a projection screen, each subject tested the following devices: laser pointer, track-point, mouse and a stylus. For a comparison purpose, the participants were also asked to a test with the LCD penal of a TabletPC. The order of the tests were randomly assigned to each participant. The sizes of each circle, distances between each pair of consecutive circles, and the time spent in each click were logged in a text file.

Results of Experiment 1

According to Fitts’ model (Fitts 1954), the time (MT) to move a pointer to select a target of width W at distance A is

$$MT = a + b \log_2(2A/W) \qquad (3)$$

where a and b are constants determined through linear regression. The log term is the index of difficulty (ID) and carries the unit “bits”. If MT is measured in “seconds”, then the unit for b is “seconds/bit”. The reciprocal of b is the index of performance (IP) in “bits/second” and measures the human rate of processing for the movement task under investigation. Although Fitts’ model is inherently one-dimensional and our experiment is two-dimensional, the model remains intact as our targets are circles (MacKenzie and Buxton, 1992). As a result, Fitts’ model is used to evaluate the performance of different interaction devices.

The coefficients in the Fitts’ model are not only affected by the properties of a device, but also affected by the response speed and the proficiency of the participants. For example, three participants who are experienced computer game players had better performance than other participants. Instead of mixing the data together to get an overall model, the data for each test of each participant were fit into the Fitts’ model separately. The coefficients a and b for each device were found and compared.

By comparing the constant coefficient (a) for all devices in Table 2, it is found that there is no significant difference among laser pointer, stylus, track-point and mouse. This shows that the overhead for these devices is about the same. The movement time (MT) depends mainly on the performance of the devices. From Table 3, we see that the efficiency of the laser pointer and a stylus has no significant difference. Furthermore, using a mouse with a projection screen has also no significant difference compared to pointing on a TabletPC which is the fastest in speed. From this experiment, we conclude that although the laser pointing system is not as efficient as a conventional mouse in point-and-select, its performance is still as good as, or even better than, other common input devices, such as stylus and track-point. Therefore a laser pointer has the potential to be a useful device in real applications.

Experiment 2: user studies

From Experiment 1, we see that a laser pointer has good performance in point-and-select interactions. In order to further test the usability of the LPS in group discussion, a group of First Year architectural students were invited to use the LPS in their interim critique. 7 students and 2 instructors participated in the critique. 4 students presented their projects whilst all others who were not presenting did participate in the discussion. The cri-

Device	Mean a (ms)	Mean b (ms/bit)	Average MT (ms)
Laser pointer	338.2	223.4	1102
Stylus	422.3	247.7	1264
Track-point	405.5	331.2	1555
Mouse	380.4	153.3	917
TabletPC*	275.2	158.3	822

* A projector is not used

Table 2. Statistics of the coefficients for different devices

	Stylus	Track-point	Mouse	TabletPC*
Laser pointer	0.2882	0.0104	< 0.0001	0.0004
Stylus		0.0483	0.0005	0.0006
Track-point			< 0.0001	< 0.0001
Mouse				0.5563

* A projector is not used

Table 3.A comparison of constants b for different devices (probability of paired 2-tail t-test)

tique lasted for 3 hours for 4 projects. Students were asked to present their design project using a computer running the LPS client.

Before the critique, all participants were given a brief of the use of the LPS for about 2 minutes. 5 laser pointers were used in this experiment. After the experiment, opinions of all participants were immediately collected in the form questionnaire. Some questions were in a 5-point Likert's scale: 1 being strongly disagree, 3 being neutral and 5 strongly agree. Subjects were also free to express their opinions in some open-ended questions. One of the authors also participated in the critique to observe the experiment in-situ.

Result and discussion of Experiment 2

Most subjects had neutral feeling towards the negative questions: "the LPS caused interruption to my presentation" (average rating of 3.2) and "the LPS distracted my presentation" (average rating of 2.8). It is because the participants were not familiar with the stroke recognition behavior of the LPS. It happened that some false strokes were recognized and some false interaction invoked. In spite of some usability problems, the presenters thought that the LPS allowed them to present their ideas more clearly (average rating of 3.5) and that the LPS allowed them to attract people's attention more easily (average rating of 3.8). This may be due to two reasons. First, without the limitation of computer wiring, presenters are free to move around in the room. This allows more direct interaction between the presenter and the audience. Second, the laser pointer also serves as a pointing device besides being used as an input device. The red bright spot helps to guide audience's attention to the right position on the projection screen.

Besides the opinions of the presenters, opinions of the audience were also collected. Since all subjects needed to attend others' presentation, they are all audience, including the instructors. Participants slightly agreed that the LPS allowed them to understand others' presentation better (average rating of 3.3). This may be caused by the fact that the use of laser pointer is very much promoted throughout the presentations. The use of a laser pointer can help the audience to follow the presentation more closely. The audience also agreed that the LPS allowed them to engage more actively in the discussion (average rating of 3.8). A possible reason of this experience is that, with the LPS, each participant in the discussion has an equal chance to take control of the content on the projection screen. They can scroll the slides up and down to search for their interested part for further discussion.

The overall opinions of the participants were also collected. Participants found that the LPS was easy to learn (average rating of 3.9). They just needed 2 minutes to learn the system and few minutes to get familiar with it. However, maybe due to some problems in the interaction design, the participants had a neutral feeling (average rating of 3.1) of the ease of use of the LPS. Some participants suggested that the stroke-based control interface was not intuitive. Since the camera captures the projection screen at about 25 frames per second, there is a small delay in the response of the system. Participants slightly disagreed that the response of the LPS was fast (average rating of 2.7).

In general, the participants felt that the interaction of the LPS was interesting and attractive (average rating of 4.1), and that the LPS is useful for architectural presentation (average rating of 3.9), teaching (average rating of 4) and other kinds of presentation (average rating of 4.1).

Discussion

In this research, a general-purpose laser pointing system for projection screens was developed. To compare the performance of a laser pointer with other input devices, a controlled user study was carried out to test the efficiency of different devices in point-and-selection interactions. Compared to

Olsen and Nielsen's (2001) experiment, the performance of our laser pointing system is improved. A mouse-based interaction is only 1.4 times, in terms of the IP in the fitts' model, faster than the LPS. The LPS is even more efficient than a track-point. This shows that a laser pointer has the potential to be a useful device in human computer interaction for remote pointing.

Another user study was carried out to test the usability and usefulness of the pointing system in architectural presentation where interactive discussion of the presentation content is needed. The study shows with the LPS, presenters can present their ideas more clearly and attract audience's attention more easily. The LPS also encourage active participation of the audience in the discussion.

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References

Eckert, R.R. and Moore, J.A.: 2000, The classroom of the 21st century: the interactive learning wall, SIGCHI Bulletin, 32(2), pp. 33-40.

Fitts, P.M.: 1954, The information capacity of the human motor system in controlling the amplitude of movement, Journal of Experimental Psychology, 47, pp. 381-391.

Jeng, T. and Lee, C.H.: 2002, iCube: ubiquitous media spaces for embodied interaction, Proceedings of the 10th CAAD Futures Conference, pp. 225-234.

MacKenzie, I.S. and Buxton, W.: 1992, Extending Fitts' law to two dimensional tasks, Proceedings of the SIGCHI conference on Human factors in computing systems, pp. 219-226, Monterey.

Matveyev, S. and Göbel, M.: 2003, The Optical Tweezers: Multiple-point Interaction Technique, Proceedings of the ACM Symposiumon Virtual Reality Software and Technology, pp. 184-188, Osaka.

Myers, B.A, Bhatnagar R., Nichols, J., Peck, C.H., Kong, D., Miller, R. and Long, A.C.: 2002, Interacting at a Distance: Measuring the Performance of Laser Pointers and Other Devices, Proceedings of the SIGCHI conference on Human factors in computing systems, pp. 33-40.

Oh, J.-Y. and Stuerzlinger, W.: 2002, Laser Pointers as Collaborative Pointing Devices, Proceedings of Graphics Interface 2002, pp. 141-149.

Olsen, D.R. and Nielsen, T.: 2001, Laser pointer interaction, Proceedings of SIGCHI'01 Conference, pp. 17-22.

Vogt, F., Wong J., Po, B.A., Argue, R., Fels, S.S. and Booth, K.S.: 2004, Exploring Collaboration with Group Pointer Interaction, Proceedings of Computer Graphics International 2004, pp. 636-639.