# Tracking Multiple Laser Pointers for Large Screen Interaction

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## ABSTRACT

We describe a new technique for tracking and identifying multiple laser pointers simultaneously in a large screen collaborative environment. Our method is based on using a video camera to track and decode the laser pointers. We use an asynchronous serial bit stream created by blinking the laser light to encode the identity of each laser. Our goal is to use multiple laser tracking in large screen collaborative groupware applications so that people can work together easily in room-sized environments. Video capture and asynchronous identification provide a scalable and flexible implementation. Our approach contributes to the creation of a framework for supporting multiple input streams including laser pointers.

## 1. INTRODUCTION

In a large video projection environment, traditional desktop input devices such as computer mouse and QWERTY keyboard are not suitable for direct manipulation or control of on-screen objects. This limitation is particularly significant in groupware applications where multiple people can have concurrent inputs or controls. Since a laser point can provide the absolute position of a cursor, there is much research interest in creating a standard input device for large screen displays using laser pointer.

Many previous studies have investigated different interaction techniques to work within the limitations of an off-the-shelf laser pointer. [2] use gesture recognition to translate specific laser pointer movements to interactive commands. [5] use dwell times of laser pointers on the screen to represent input events.

Other work [6], [1], have investigated how one can physically customize laser pointers to work with the requirements of a WIMP interface, mainly by adding multiple buttons to match the performance of computer mice.

While most of these proposed solutions allow precise interaction with any on-screen object, most of the prototypes developed only provide support to use one laser pointer at one time. To cope with this drawback, we believe a standard way to support tracking and recognition of multiple lasers could allow previous interaction techniques to be used in large-display groupware applications. The value of multiple-laser-pointer (MLP) systems has also been investigated by [3, 4]. [3] proposed the use of MLPs to promote audience participation. Although their system tracks the positions of the laser pointers held by the audience, the exact identity of each pointer is not recognized. [4] built a wired, synchronized, MLP tracking system. In their proposed system, they use different patterns to blink the laser pointers, which are synchronized with the camera through a cabled connection. Their system provides a good way to identify different laser pointers, but the synchronization between camera and pointers requires expensive hardware support. For synchronized based identification, all laser pointers must be wired or have a bidirectional wireless link to a central control unit, limiting mobility or adding more complexity and accessibility of the system.

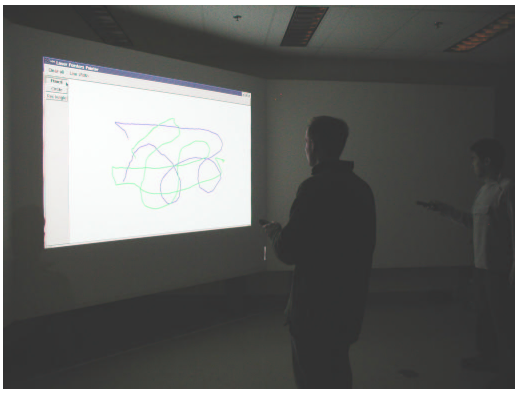

**Figure 1: A collaborative large-screen drawing application.**

In this work, we expand on the blinking solution found in [4] and successfully implement a wireless, *asynchronous* MLP tracking system. Instead of using a central control unit that synchronizes all laser pointers and the capture camera, we attach a microprocessor to each laser pointer to modulate its brightness. The camera, which works independently from the handheld laser units, captures images at a frequency that is twice of the laser blinking frequency. The images are processsed in software that detects, groups, and identifies the laser points. The resulting position and identity (ID) information is sent to applications so that each pointer's position may be updated.

## 2. LASER IDENTIFICATION

Asynchronous communication approaches have the advantage of not requiring a wired or wireless synchronization signal, reducing the complexity and enhancing scalability of the system. However, as with all asynchronous communication, a mechanism must be created to provide for the receiver to automatically synchronize with the incoming serial bit stream. In our case, the bit stream comes from the blinking of the laser pointers, and the decoding complexity is in the video processing of the receiver. Using video capture presents unique difficulties for sampling the multiple bit streams sent by the laser pointers simultaneously. Depending upon the phase between the blinking light and the video frame being captured, it is possible that a bit is missed. Using start bits is a normal technique to solve this problem, as standard protocols such as RS-232 use this technique. However, it is not possible to reset the video frame capture to match the baud rate, as is done with RS-232, since there are multiple streams coming simultaneously from the different laser pointers. Of note as well, video capture is not exactly like sampling a voltage level on a wire, rather, each pixel integrates the brightness over the duration of the exposure rate.

We have experimented with different techniques to mitigate the problem. We use 2X oversampling of the blinking rate as our first means to read the data stream correctly. However, it is still possible for the frame capture and blinking rate phase to be mismatched causing errors. The simplest solution that we found to be successful was to insert a small random delay at the beginning of each laser pattern. While not preventing the occasional missed ID when there is a frame mismatch, it prevents them from coming in long stretches at a time by distributing the likelihood of a frame capture mismatch. Erroneous IDs are discarded when there are errors. We also use error-correcting codes to mitigate some of the errors as well. Another technique we are investigating uses a sliding window identification pattern so that at any moment in time, a valid ID is available from the history of the capture blinks. While a sparse bit representation is required for this approach, it solves the synchronization problems.

## 3. SYSTEM OVERVIEW

To realize the utility of our approach, we built a system consisting of several handheld laser pointer units along with a software application projected onto a large screen video projection wall. Each handheld pointer unit consists of a laser diode whose brightness is modulated according to a set of uniquely predefined patterns. The points that are cast on the large display area are captured by a camera mounted on top of the video projector (running at 30fps). Using a video frame grabber, consecutive capture images are acquired and processed by a Linux workstation connected to the camera. The tracking process identifies multiple bright spots in a frame by grouping pixels whose intensities are higher than a threshold value. We use sub-pixel interpolation to get better spatial resolution. The corresponding identity of each bright spot is determined by decoding its blinking pattern over consecutive sequences of video frames. To facilitate the detection of moving blinking bright spots, predictive contour tracking techniques are applied as Kalman-filters. Once a laser point identity is determined, its coordinates are communicated to a designated groupware application running on another workstation using a UDP network connection.

Each handheld pointer also contains a set of buttons to support different modes of action such as object selection. In our prototype, button press events are sent via a wireless link to an addressable USB base unit connected to a workstation. A background process redirects these button events to the appropriate groupware application.

To demonstrate our tracking system with large-display groupware application, we have developed a collaborative drawing program that allows multiple people to simultaneously draw lines and shapes on a large display using their laser pointers. Each person paints in an unique color, which is dynamically determined by decoding their lasers' modulated patterns. Our system with the working application is shown in figure 1. We have two main target applications planned: a large-scale interactive Magnetic Resonance Image (MRI) annotation system for identifying abnormal brain regions and a collaborative decision making tool for forestry planning.

## 4. CONCLUSION

We built a working system for distinct MLP tracking. Our system is a building block suitable for collaborative workspaces and audience participation as well as two-handed interaction. The tracking algorithms we developed allows wireless heldheld laser units' pointers to be tracked and identified asynchronously using only a simple modulated laser beam.

Large display environments afford the interaction and collaboration of multiple people. Thus, in these environments it is important for applications to support multiple pointers so people can indicate their locus of attention to others. At this point, common window managers and operating systems do not support multiple pointers, however, we are creating applications that demonstrate their usefulness. We hope that our approach lays the necessary framework for creating laser pointers to drive the next generation of applications to support multiple pointers in general.

## 5. REFERENCES


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