The Implementation of a Glove-Based User Interface
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ABSTRACT

As the advantages of multi-touch interfaces are being utilized in numerous applications to improve the user experience, this research project aims to explore a user interface that goes a step further. A glove-based interface provides the utility of a multi-touch interface without the proximity restriction of physically touching the screen. It provides a more natural human-computer interaction which in certain applications also improves efficiency in the performance of complicated tasks.

CURRENT DEVELOPMENTS

As the technologies and tools for building alternative user interfaces have become more readily available, alternatives to button and mouse interfaces have emerged. Multi-touch interfaces have been implemented as early as the mid 1980s [1], and have grown in usage over the past few years. And though the idea of a glove-based user interface dates back to the beginnings of virtual reality [2], the glove-based interface can reach wider usage IR LED sensing.

OBJECTIVES

The goal of this project is to implement a glove-based user interface that is responsive, accurate, and efficient. Only when the interface meets these goals can a fair comparison be made to other user interfaces. A focus on task completion is necessary to evaluate the effectiveness of such an interface [3], and it must be able to manipulate various applications such as software for geo-spatial imaging, 3D modeling, information visualization, and presentations.

IMPLEMENTATION

This research project is written in Java using the Java Media Framework.

A modified Logitech USB webcam is used to provide a live video feed of infrared light. Its filters were modified to block visible-light and let infrared light pass.

Each glove contains three 950nm infrared LEDs. The LEDs are located on tips of the thumb, pointer finger, and middle finger. The gloves are wireless and are powered by two 3V button cell batteries.

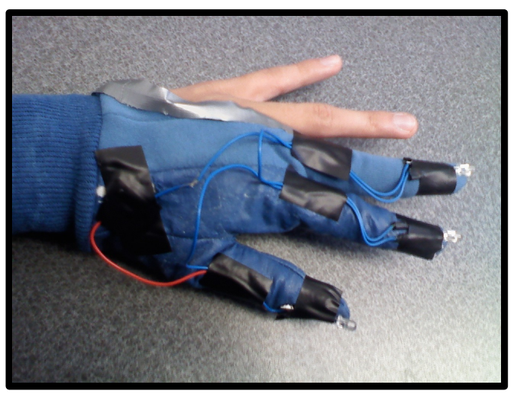

Fig 1. IR LED Glove Prototype

PROCEDURE

LED DETECTION AND TRACKING

Each captured video frame is evaluated through binary rasterization by automatically determining a threshold value for which each pixel's brightness value is either above or below. The optimal threshold value is determined by creating a histogram of pixel brightness values and selecting a value past the peak brightness [4].

An LED object class keeps track of previous positions in order to calculate its velocity and predict its next position.

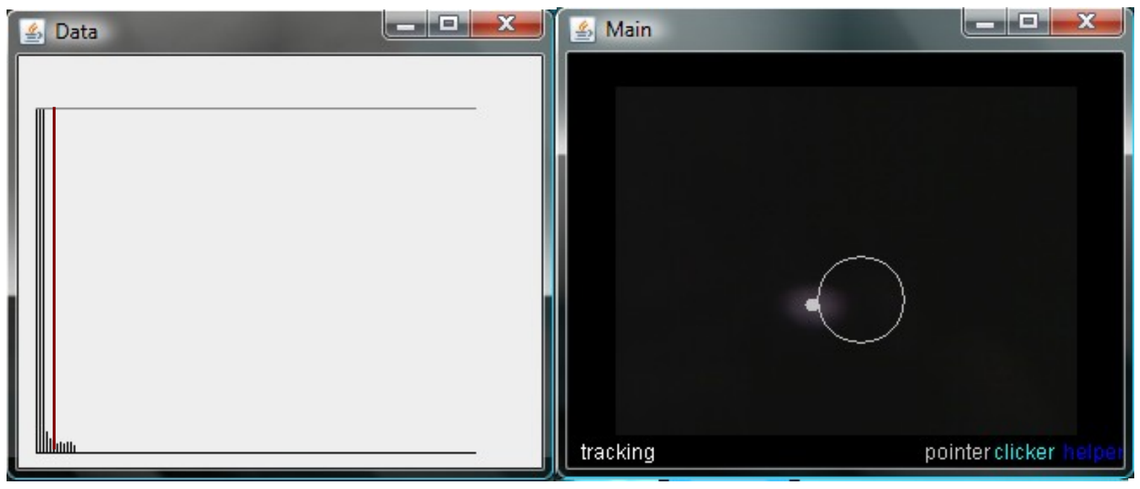

Fig 2. The left frame shows histogram of all pixel brightness levels. The red line indicates the calculated threshold value.

Fig 3. The right frame shows a capture video frame. The white dot shows the LED's detected position. The white circle shows its next predicted location.

GESTURE RECOGNITION AND COMMAND EXECUTION

Gestures are separated into two categories: static and dynamic.

Static gestures do not depend on absolute location. The minimize command is recognized when three LEDs are brought together.

Dynamic gestures do depend on absolute location. This project currently recognizes two dynamic gestures. When no other gestures are active, an LED is identified as the pointing LED which controls mouse movement. The drag and drop gesture is executed with a pinch and release action using two LEDs.

RESULTS

Currently, this interface reaches an average frame rate of 21 fps, slower than the 24 fps required to fool the human eye. Gesture recognition is also poor due to poor LED detection which is attributed to the low levels of IR LED brightness.

CONCLUSION

This glove-based user interface has several obstacles yet to overcome before it's ready for full testing and application usage. LED brightness must be improved in order to ensure gesture recognition accuracy. This project has proven the potential for a glove-based interface, but has yet to fully implement it for evaluation.

[1] Lee, SK, William Buxton, and K. C. Smith. "A Multi-Touch Three Dimensional Touch-Sensitive Tablet." *Conference on Human Factors in Computing Systems*. San Francisco, pp. 21-25, 1985.

[2] Sturman, David J., and David Zeltzer. “A Survey of Glove-based Input.” *Computer Graphics and Applications IEEE.,* pp. 30-39, 1994.

[3] Molina, Jose P., et al. “The Development of Glove-Based Interfaces with the TRES-D Methodology.” *Virtual Reality Software and Technology* pp. 216-219, 2006.

[4] Baek, SeongHo, et al. “IRED Gun: Infrared LED Tracking System for Game Interface.” *Lecture Notes in Computer Science 3768/2005 . pp* 688-699, 2005.