The Implementation of a Glove-Based User Interface

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Abstract

As multi-touch user interfaces are gaining in usage, this project aims to remove the touch screen restriction of such interfaces and implement a glove-based user interface using gesture recognition to simplify tasks and commands. The goal is to explore the usability of a glove interface by comparing its speed, accuracy, efficiency, and task simplifcation with other user interfaces. A glove-based interface should prove to be a better option to conventional user interfaces depending on the task being completed.

1 Purpose

The purpose of this research project is to explore the usability and effectiveness of a glove-based user interface, an interface which takes place in 3D space and provides the utility of a multi-touch screen without the need for touch screen hardware. Along with speed and accuracy optimization, a focus on task completion is necessary in order to evaluate the effectiveness of such an interface. To investigate how it enhances the user experience, it must be able to manipulate various applications such as software relating to geospatial imaging, 3D modeling, information visualization, and presentations.

2 Scope

Sophisticated machine vision and gesture recognition techniques have already been employed using real-time video feed and requires the user to

use no other hardware in order to interact with the computer. However, this project focuses on the development of a gesture-based interface with a focus on accuracy, efficiency, and usability compared to a mouse-based or multi-touch interface. Therefore, a glove-based interface is implemented in order to bypass the difficulties of implementing machine vision techniques on a user in everyday conditions. This allows for a focus on the development of the user interface experience rather than development of the machine vision algorithms. The findings from this project can still be utilized in more sophisticated gesture-recognition projects in order to improve the human-computer interaction experience.

3 Background

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, and have grown in usage both independently and commercially over the past few years as a result of improved accessibility to the required technology. And though the idea of a glove-based user interface dates back to the beginnings of virtual reality, proven applications in IR LED sensing such as with the Nintendo Wii have provided the glove-based interface the potential to enter wider usage.

4 Procedure

4.1 Hardware Implementation

A webcam modified to received only infrared light will be used. Each glove will contain three IR LEDs located on the tips of the thumb, pointer finger, and middle finger. The gloves will be wireless and battery-powered.

4.2 Language and Structure

This research project will be written in Java using the Java Media Framework in an effort to make the software more accessible and more efficient. A modular architectural framework will be utilized in order to add recognizable

gestures more easily. This also allows for the possibility for user-defined gestures and customization based on given control statements.

4.3 Software Implementation

The software being implemented needs to accomplish four tasks: LED detection, LED tracking, gesture recognition, and command execution. It is expected that the steps of LED detection and gesture recognition will take up the most processing time, and therefore most of the software optimization will focus on these steps.

5 Testing

The testing of an actual user experience cannot be easily translated into numerical data. A complication with testing this project is the possibility of bias reaching into the data. The key to testing this project will be to develop a methodology of testing that is fair. Since the focus of this project is usability, the areas to test are speed and accuracy.

There are two categories of gestures that need to be tested: static gestures and dynamic gestures. Static gestures are gestures that (1) do not depend on the absolute location of the LEDs, and (2) are recognized and executed once for each time the gesture is performed. Dynamic gestures are gestures that (1) do depend on the absolute location of the LEDs, and (2) are recognized and executed continuously as long as the gesture is being performed.

5.1 Static Gestures

Static gestures can be tested by comparing the number of times a gesture is attempted to the number of times the gesture is recognized. However, since the program cannot determine when a gesture is not recognized, it is up to the user to report this data.

5.2 Dynamic Gestures

Dynamic gestures can be tested by tracking the time and physical distance traveled while completing a certain task. This will show how often the mouse

pointer (or equivalent) "overshoots" its target.

5.3 Measuring Overall Efficiency

An overall gauge of the program's efficiency can be created from the length of time required for each processing step. This in combination with data reported from the usage of static and dynamic gestures will give a fair estimate of the glove interface's usability.

6 Applications

It is expected that the glove-based interface will be competitive to multi-touch interfaces, depending on the task being completed. Gesture-based interfaces have advantages in simplifying tasks since input takes place in 3D space. On the other hand, multi-touch interfaces have an advantage in mouse accuracy. Since the user is touching the screen directly where they want the mouse to register, there's little concern about "overshooting" a target. This is a problem with a mouse interface and it is suspected to also be a larger problem with a glove interface since there are six degrees of freedom in which an error can be made.

6.1 Visual Applications

A glove-based interface should have its strengths in visual applications. A visual database with multiple folders, files, and other objects to organize would be easier to control through gestures rather than multiple buttons. 3D rendering on a 2D screen requires a constant change of viewpoint. A glove interface would provide a more fluid 3D connection to the viewpoint than through button controls. Glove interfaces would also have an advantage is in video editing software. This application requires the user to rewind, fast forward, skip, and select pieces of video. Viewing, scaling, rotating, and sharing photos can be improved through glove gestures as well. When the user can control all of these tasks through gestures instead of clicking buttons, the user can use the application more effectively and efficiently.

6.2 Presentations

The glove-based interface also has its advantages during presentations. During a presentation, the user resorts to a one-handed wireless device with limited control over the computer, since the presenter can't be at the computer during the presentation. With a glove interface, the proximity restrictions between the presenter and the computer are improved. Though the hardware required to detect gestures from farther away requires brighter LEDs and a higher resolution camera, the findings of this project should still provide useful information towards improving presentations.

6.3 Further Applications

The applications of a glove-based interface are not limited to these examples and through this research project, more applications could be discovered.

7 Conclusion

Every user interface has advantages and disadvantages based on hardware and software; the key focus lies with the tasks the user needs to complete. This research project will aim to develop a glove-based user interface and explore its advantages and disadvantages in speed, accuracy, efficiency, and usability in a number of tasks in order to make a fair comparison to existing user interfaces.