Lightglove: Wrist-Worn Virtual Typing and Pointing

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Abstract

We are presenting the "Lightglove", a watch-size wireless virtual typing device worn underneath the wrist(s), with light beams sensing fingertips and motion sensors tracking hand movement. A miniature keyboard image is superimposed over the user's application on the host system display, and active keys corresponding to each finger are highlighted and pan around the key-map as the hand moves. Typing and pointing actions are similar to those with conventional keyboard and mouse, as though a physical device were underneath the hand. When the cursor moves out of the keyboard display area the Lightglove acts as a pointer (mouse). Applications include computer/PDA input, gaming control, TV remote control, and musical applications.

1. Introduction

Keyboards and pointing methods exist now essentially as they did during their initial introduction. Incremental ergonomic improvements fail to address the challenges of modern pervasive input and control needs. Miniature keyboards and pen input devices are slow and cumbersome. Fixed-position desktop or notebook physical devices constrain posture and position during active use, which exacerbates repetitive motion stresses on the user.

The Lightglove offers a practical, wrist-worn virtual control mimicking the operation of the entrenched keyboard/mouse.

2. Theory of Operation

Optical reflectance comprises a patented [1] active low-resolution imaging method. In the example illustrated in Figures 1 and 2, the model consists of a 5-pixel LED scanner/receive sensor array generating key closures and a 2-dimensional micro-machined accelerometer for motion tracking. Previous work in this field has utilized cameras and image recognition software to capture hand gestures [2]. The Lightglove employs inexpensive electro-optical components (LED's and PIN photo-diodes), and requires little processor time. Optical beam-interruption devices are well known, including keyboards [3], [4], and the "laser harp". These devices surround the user's hand with electro-optical devices. With the Lightglove worn under the wrist as illustrated in Figure 1, virtual keys are constructed with no obstructions in the hand area.

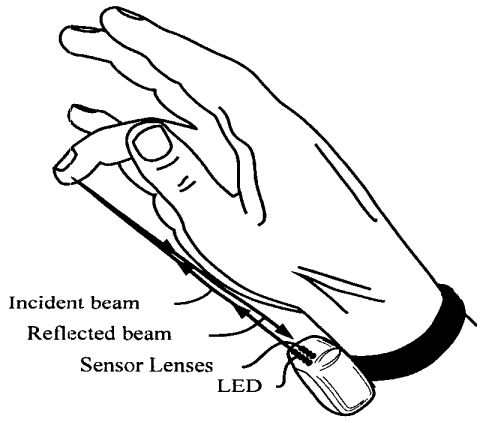

Figure 1. Single Row Optical Path

The Lightglove issues beams of light in a fan shape projecting from the wrist, which sequentially illuminate columns corresponding to the user's fingers, as depicted in Figure 2. Descending a finger into the light beam generates a key closure. The beam fanout angle is user adjustable to accommodate different hand sizes. Visual feedback is provided by the host system, and an aural indication (beeps or voice key-character indications) may be enabled to verify key closures. On-demand access for each Lightglove allows convenient multiplexing of other hand tasks such as sorting through papers or enjoying a cup of coffee, with host system input.

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Accelerometers provide free-space motion acceleration vectors for calculation of motion vectors. Acceleration vectors are processed to yield average hand motion in order to map out undesired hand vibration and accelerometer noise. Prior art in the field with sensors attached to the hands such as the "Acceleration Sensing Glove" [5], or commercially available Virtual Reality gloves. Other contributions include the "Gyro-Mouse" [7], a hand-held free-space pointer. These devices all physically occupy the hand, whereas the Lightglove samples the hand remotely from the wrist.

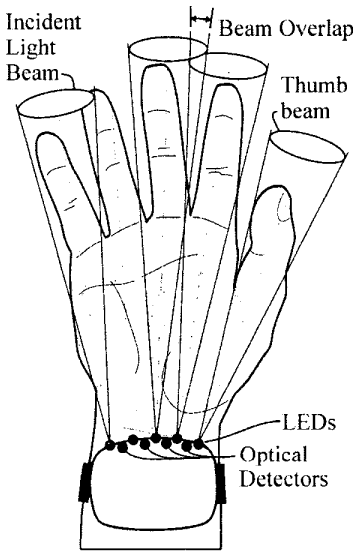

Figure 2. Optical Configuration

Lightglove systems include one or two wrist-worn devices, a base station and a host system. Radio communications allow user mobility and freedom of orientation. The Lightglove supports uploading from the host to the Lightglove(s) for adjustment of key capture variables and motion coefficients as well as mode of operation.

Ergonomic design is intended to mitigate the effects of repetitive motion stress. Hands are free from fixed-position operation. Light beams (or invisible infrared beams) fan out from the wrist in the shape of the hand and finger bones to provide an ergonomic typing "surface" adjusted for the hand. The Lightglove allows optimization of posture and orientation while supporting rapid switching from keyboard input to/from pointing operation. Other hand operations may be conveniently engaged while maintaining computer control.

3. Applications

The Lightglove is a platform from which a wide variety of applications spawn. As a generic electronic input and control apparatus it simply represents an active imaging and motion-sensing node.

A variety of applications lend themselves to the benefits of the Lightglove, including the computer input application described herein, PDA input, gaming controller, "aware building" socket, or for physically impaired users.

4. Prototype

Prototype Lightgloves were constructed and exercised with a notebook computer host test bed. All the mechanisms worked, and the "light buttons" had excellent sensitivity, even in harsh ambient lighting environments. Infrared communications from the Lightglove to the base station provided an inexpensive solution, but constrained the user's hand position by requiring the Lightglove be directed toward the base station for proper communications. This limited the range of pointing motion available, and made the pointing motion tricky to control. Future prototypes are under construction utilizing an inexpensive embedded 915 MHz radio transceiver.

5. Conclusion

The Lightglove virtual typing and pointing system offers an inexpensive solution for virtual electronic input and control. This platform supports numerous compelling applications and exploits a more natural and convenient hand input model.

References

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