Acceleration Sensing Glove (ASG)

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Abstract

A glove with 2-axis accelerometers on the finger tips and back of the hand has been built using commercial-off-the-shelf components. Taking advantage of gravity induced acceleration offsets, we have been able to identify pseudo static gestures. We have also developed software that allows the glove to be used as a mouse pointing device for a Windows 95 or NT machine.

Keywords

Wearable input device, hand-gesture recognition, data glove, human computer interaction, mouse pointer, etc

Introduction

The goal of this project is to demonstrate that accelerometers can be used as sensors to detect and translate finger and hand motions into computer interpreted signals. To this end we have developed an acceleration sensing glove from commercial-off-the-shelf components. The glove contains 2-axis accelerometers on the fingers and back of the hand. Wires connect the accelerometers to a controller board that is affixed to the wrist of the user. An RF transceiver on the controller board makes it possible to transmit acceleration data wirelessly to a computer (Figure 1). Currently, we have written a simple program that allows the glove to be used as a mouse pointing device.

Hardware

The hardware consists of a wrist controller and six accelerometers, five on the fingertips and one on the back of the hand (Figure 2). Each accelerometer (1.3x1.4cm) is an Analog Devices ADXL202 with +/- 2g of range [1]. An Atmel AVR AT90LS8535 microcontroller on the forearm controller (4.4x6.6 cm) converts the analog signal from the accelerometer to a digital signal. The wrist controller is capable of transmitting the sensor data wirelessly at 916.5 MHz (RF Monolithics). Signal processing at the computer is then used to interpret commands based on hand gestures. The overall power consumption of the glove is 45mW at 3.3 Volts.

Software

Before the accelerometer data could be analyzed it had to be calibrated, normalized, and low pass filtered. We calibrated our system by orienting our glove in particular directions and normalizing with respect to gravity. The unbuffered ADXL202 produced noise with a standard deviation of 70 mg. At 220 Hz, signals were averaged to reduce white noise. A coordinate transformation was performed which converted the Cartesian data format to polar values ($\underline{R}_{acc}$, θ, see Figure 3).

Static Data Analysis

In static situations, the only force acting on the accelerometers is gravity (Figure 3). The resulting vector of the projection of the gravity vector, $\underline{G}$, into the plane defined by the 2 axis accelerometer is $\underline{R}_{acc}$. The orientation of the accelerometer relative to $\underline{G}$ is given as the angle, θ. The angle the acceleration plane is offset from the horizontal is given as ϕ.

By using this idea of gravity-induced accelerometer bias we were able to develop a pointing device. One 2-axis accelerometer was placed on the back of hand as a tilt motion detector for moving the pointer on the screen and three other 2-axis accelerometers were placed on the thumb, index finger, and middle finger to operate as mouse click buttons. By tilting the hand in the θ direction, the on-screen pointer will move in that direction at a rate proportional to ϕ. Curling an individual finger is

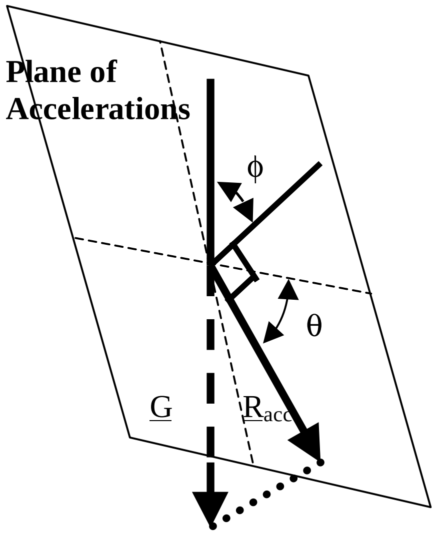

Figure 3. *Acceleration plane relative to gravity vector.*

equivalent to clicking a mouse button. The mouse pointer currently functions in standard Windows NT or Windows 98 desktops.

Additionally, simple hand gestures can be uniquely distinguished. In Figure 4, the hand is upright while the user moves his fingers into different positions. The differences in $\underline{R}_{acc}$ and θ can be seen as the fingers move up and down.

Future Potential

The finger acceleration glove is a large-scale device used to model the functionality of Smart Dust [2] on fingers. Smart Dust is a project whose 3-year goal is to integrate communications, intelligence, power, and sensors into a package that is no larger than 1 mm^3 (Figure 5). Integrating a single chip wireless solution with a MEMS accelerometer would yield an autonomous device small enough to apply to the fingernails. Because of their small size and weight, these Smart Dust devices would be less noticeable than one's own eyeglasses, providing no more discomfort than fingernail polish. People would have instantaneous input access to the digital world at all times, facilitating a paradigm shift in human-computer interaction.

Some potential applications for the Acceleration Sensing Glove are: a wireless wearable mouse pointing device, a wireless wearable keyboard, hand motion and gesture recognition tools, virtual musical instruments, computer sporting games, and work training in a simulated environment.

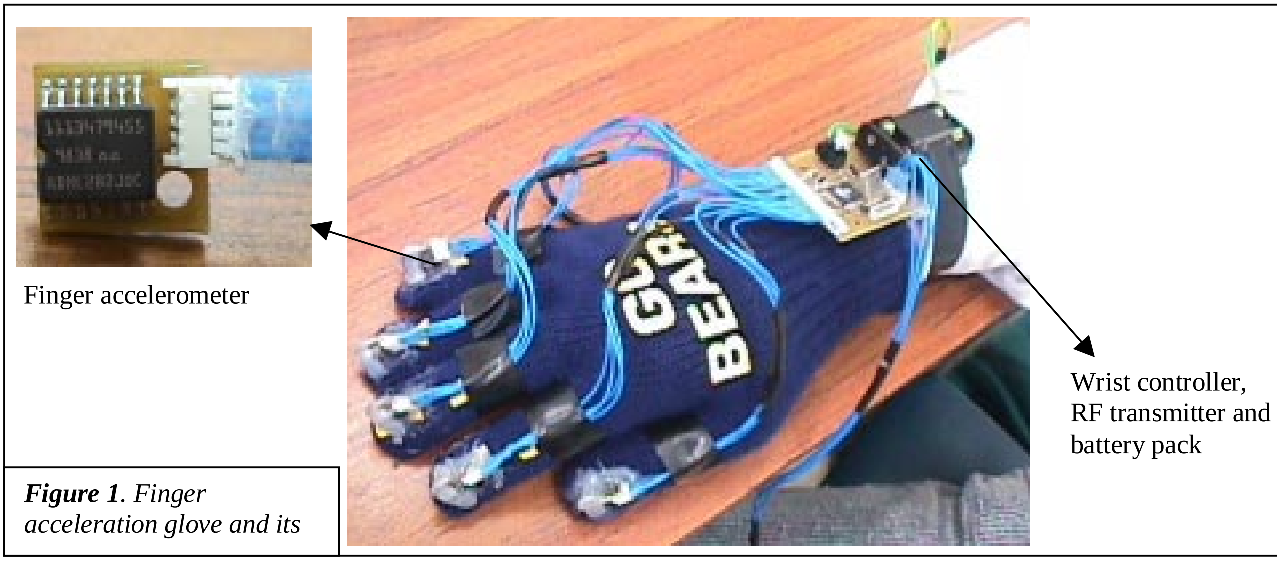

Figure 1. *Finger acceleration glove and its*

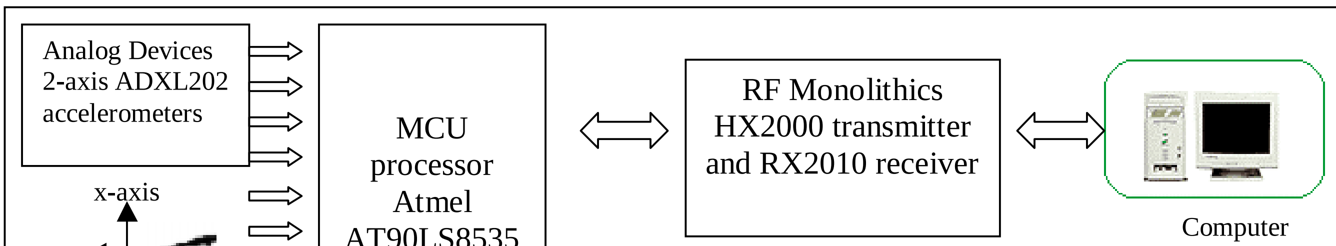

Figure 2. *Block diagram of finger*

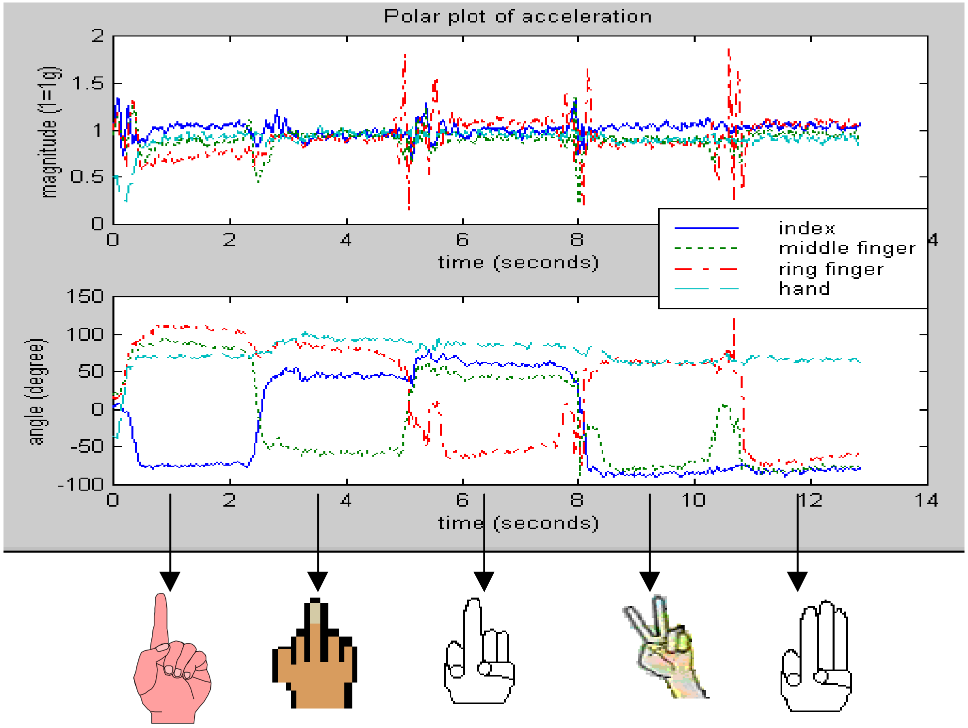

Figure 4. *Plot of R_{acc} and θ over time for various hand gestures.*

References

[1] Analog Devices, Norwood, MA, http://www.analog.com, September 1999.

[2] http://robotics.eecs.berkeley.edu/~pister/SmartDust, September 1999.

[3] Fukumoto, M and Tonomura, Y "Body Coupled FingeRing: Wireless Wearable Keyboard", CHI97 Conference Proceedings, pp147-154, Atlanta, March 1997.

Figure 5. *Future goal of Smart Dust on a finger*