User-Oriented Finger-Gesture Glove Controller with Hand Movement Virtualization Using Flex Sensors and a Digital Accelerometer

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***Abstract*—A low-cost wireless glove controller that detects finger gestures was developed using makeshift flex sensors and a digital accelerometer. The performance of the makeshift flex sensors was compared to that of commercially available ones. A system using Arduino, Bluetooth, and Processing was developed to allow the user to specify desired finger gestures for controlling a variety of robotic devices. A simple mobile robot (mobot) was used to demonstrate the capabilities of the glove in controlling devices. A 3D virtual environment was also created for the virtualization of the user's hand movements detected by the glove controller. Inside this virtual environment, the user-defined finger gestures also allowed the user to control elements inside the virtual environment which can branch out to various applications including rehabilitation and body-oriented gaming.**

***Keywords*—flex sensor, digital accelerometer, Blender, Python, Processing, Arduino**

I. INTRODUCTION

Flex sensors are sensors that change resistance when bent. This change in resistance can either be increasing or decreasing depending on the type of flex sensors used. This concept shows that if flex sensors are placed at the joints of fingers, they can be used to determine if fingers are bent or not. Given five fingers with two states each, one for bent and one for relaxed, finger gestures could easily be given a numeric code which be used as command signals for device control and virtual simulation.

With this concept, flex sensors along with a digital accelerometer, which can be used to detect the hand tilting movements, can be placed in a glove allowing hand movements to be captured and be used as commands for device control and virtual simulation.

Thus, it was aimed to create a low-cost wireless glove controller through the use of flex sensors and a digital accelerometer which allows the user to define specific finger gestures to be used to control robotic devices and to be simulated in a 3D visual environment.

Through the creation of a glove controller that uses flex sensors and a digital accelerometer that allows the user to define gestures for device control commands wirelessly, various technological applications based on alternative ways for device control can be implemented.

II. IMPLEMENTION

The implementation of this thesis was divided into five parts: (1) the creation of the glove controller; (2) the process of how finger gestures are to be interpreted; (3) the programming of the Arduino microcontroller for processing flex-sensor and digital-accelerometer data; (4) the development of a program for the user-definition of gestures and device control; and (5) the creation of a 3D environment for virtual simulation of hand movements and device control.

A. Glove Controller

The glove controller was created using flex sensors and a digital accelerometer connected to a gizDuino microcontroller and a Bluetooth shield for wireless implementation. Two kinds of glove controller was created, one using commercial flex sensors and one using makeshift flex sensors.

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Commercial flex sensors can be readily bought in the market and cost around Php600.00 each. In order to reduce the cost for the creation of the glove controller, commercial flex sensors were recreated using low-cost materials. Fig. 1 shows the steps taken for the creation of the makeshift flex sensors.

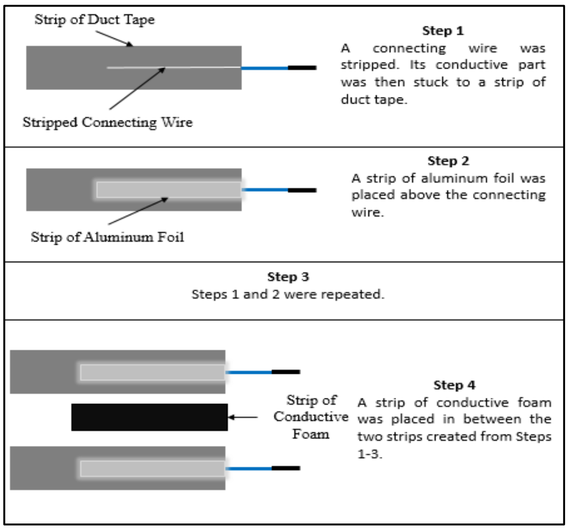

Fig.1. Creation of Makeshift Flex Sensors

Through the creation of the makeshift flex sensors, the cost of the glove controller was reduced to around 90% of the cost if commercial flex sensors were to be used.

B. Finger Binary System

The concept of the Finger Binary System was used for the detection of finger gestures. Since there are two states of the fingers, flexed and relaxed, each state was given a bit value, 0 for relaxed and 1 for flexed. Thus, with the thumb being the most significant bit and the digital accelerometer being the least significant bit, the Binary Coded Decimal (BCD) equivalent can be used to refer to each gesture.

C. Arduino IDE and Microcontroller

Through the use of a gizDuino microcontroller programmed via Arduino IDE, the data from the flex sensors and the digital accelerometer were read and interpreted. These data were then sent to the user-definition program and the virtual environment.

D. User-Definition and Device Control via Processing IDE

A user-definition program was created using Processing IDE to allow the user to define his/her desired gestures for device control. The user was given the liberty to define his/her desired gestures for the actions to be performed by a device and/or the elements inside the virtual environment. Once was user was done in defining his/her desired gestures, the program created via Processing IDE will serve as an access point for device control. Through this, the user will now be able to use his defined gestures to control a device.

E. 3D Virtual Environment via Blender and Python

The open source 3D design software Blender has an integrated Python API which allowed the modification of the properties of the elements inside the modeling space. Properties such as the rotation, scale, and position can be modified using the Python scripts. The hand was first modeled using primitive shapes to mimic the basic anatomy of the hand and its movement. Data from the glove controller was obtained by accessing the serial port, to which the glove sends data via Bluetooth. The gradual change in the readings from the serial port was translated to the change in the rotation of the joints. The minimum and maximum rotation of the joints were set by observing the movement of an actual hand. The virtual environment was rendered by using the built-in Blender Game Engine.

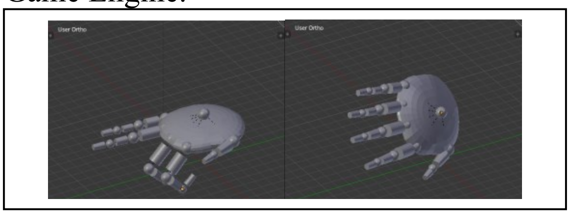

Fig. 2.

The control signals used for device control was also used inside the virtual environment. These were similarly used to let elements inside the virtual environment perform actions, such as the raising of a modeled robotic arm. The glove controller serves as the link for human interaction with the elements inside the virtual environment. This opens a lot of applications such as human motion capture for animations or simulations, and even an alternative means of input for human-software interaction.

III. Tests and Discussions

Since two glove controllers were created, the performance of the two in terms of how well they were able to control a device and the elements of the virtual environment were tested. As it turns out, the glove created using the commercial flex sensors were able to control the devices and the elements inside the virtual environment 100% of the time. Thus, data passed from the sensors and digital accelerometer were gathered and processed accurately. This also means that the flex sensors and the digital accelerometer where able to accurately detect the flexing and relaxing of the fingers, as well as, the tilting of the hand.

However, for the glove created using the makeshift flex sensors, the user has to emphasize the bending of the fingers in order to the gestures to be accurately detected. Fig. 2 shows the comparison of the data read by Arduino between the commercial flex sensors and the makeshift flex sensors where the reading began when the sensors were relaxed.

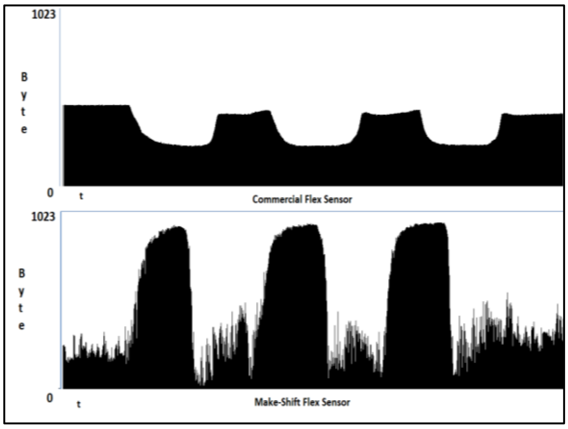

Fig. 3. Commercial Flex Sensors versus Makeshift Flex Sensors

Based on Fig. 2, the readings from the commercial flex sensors and the makeshift flex sensors are inversely related. This is because the commercial flex sensors used increase in resistance when bent while the makeshift flex sensors decrease in resistance when bent due to the material used. The graphs on Fig. 3 show the time vs. byte reading of the sensors as processed by Arduino. The graph of the commercial flex sensor decreases when flexed because a voltage divider circuit is created when the sensors, which serve as the variable resistor, are connected to the gizDuino microcontroller and the data read by the Arduino is the output voltage which is then outputted to is byte equivalent when outputted via Serial Monitor.

It is noticeable that the graph of the commercial flex sensors is smooth while that of the makeshift is noisy. This is the reason why the user has to emphasize the flexing of the fingers when makeshift flex sensors are used. The noise greatly affects the accuracy in detection of the gestures.

Other than what has been aforementioned, the glove created the makeshift flex sensors were able to wirelessly control a device and the elements in the virtual environment and can be used as a replacement for the commercial flex sensors, thus, reducing the price of the controller by 90%.

IV. Conclusion

Through this thesis, a low-cost glove controller which allows the user to define desired gestures for wireless device control and virtual environment simulation was developed, thus, paving way for various technological advances for alternative device control, medical rehabilitation, body-oriented gaming, and other applications that calls for wireless control.

V. References

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