A Survey on Human Computer Interaction via Wearable Devices

Dawa Sangmoo Tamang, T. S. Chingtham

Sikkim Manipal University
Sikkim Manipal Institute of Technology
Dept of Computer Science and Engineering

sangmoo201011032@gmail.com, chingtham@gmail.com

***Abstract*— The use of computer have always come up with the question of interfacing. The methods of interaction between humans and computers have seen much progress since the beginning of its development. New designs of technologies come up more and more everyday and the research in this field have been increasing exponentially since the last few decades. Wearable device is a new technology in which many researchers and developers are working, keeping in mind the motive of improving the interaction between the humans and computers. This paper seeks to give description on various wearable devices which have been designed and developed which users can wear to perform interaction with the computers.**

***Keywords*— Human Computer Interaction, wearable devices, interface, interaction.**

I. INTRODUCTION

The role of computers has grown very fast in our society. Most of our day to day jobs are governed by the use of computers. Computers have become an integral part of human life. Therefore, development of a proper interface for interaction between humans and computers has become an important topic to be looked upon. Human Computer Interaction (HCI) is an area of research and practice that emerged in the 1980's with the motive of improving the ways in which humans use their computer[1]. The methods of interaction between humans and computers have seen much progress since the beginning of its development. Various researches and development have been done in improving the interaction between humans and computers. Designing and development of wearable devices is one of a technique which is gaining more and more importance. Wearable devices are devices which are worn by the user on one of its body parts while having interaction with the computer or any other machine. The main idea behind designing wearable devices is to make the communication between the user and computer more natural. Development of wearable devices for human computer interaction is a very new and fresh topic and progress is being done in this field in a rapid speed. This paper tries to give an elaborated discussion on various wearable devices already being developed for human computer interaction.

II. RELATED WORK

One of the first work on wearable device [2] which can be worn like a glove was designed as an input device for human computer interaction called as wired glove or a data glove. Various sensor technologies were used to capture physical data such as bending of the fingers and motion trackers such as magnetic tracking device or inertial tracking device were used to capture the position or rotation data of the data glove. A software would follow the data glove which would interpret the movement of the data glove.

A wireless computer pointing device [3] was designed with accelerometer based movement control to control the computer mouse pointer. The accelerometer sensor is placed on the glove which is worn by the user. Accelerometer sensor is used to sense the magnitude of tilt of the hand so the cursor speed is based on the measure of the tilt. For the mouse click operations finger contact pads were designed which is also placed on the glove. The glove senses the user actions via two types of sensors: accelerometer sensors and finger contact pads. This wireless glove consists of two main parts one is the glove and another is the base station. The working of this wireless glove is, after the microcontroller mounted on the glove unit processes the input data, it forwards the message to a transceiver mounted on the glove unit. The transceiver then forwards the message wireless to the transceiver on the base station, then the message is transmitted to the computer.

As, a standard mouse is the basic interface between a user and the computer, many researchers in Human Computer Interaction (HCI) have tried to incorporate vision technology to control the mouse, like using video devices. An approach was made for controlling mouse movement using a real-time camera by Hojoon Park [4].

By applying vision technology one can control the mouse by natural hand gestures. The approach used a video device and was able to perform mouse tasks like left click, right click, double clicking and scrolling. The working was, first the camera mounted on the computer gets an image which is then converted from color space RGB to YCbCr. Then, a range of color is defined as skin color and those pixels are converted to white and all other pixels are converted to black. Then, the centroid of the dorsal region of the hand is computed. After the identification of the hand, a circle that best fits the hand region is found and the radius of the circle is multiplied by some value to compute the non-finger region. From the binary image of the hand, we get the vertices of the convex hull of each finger. From the vertex and centre distance, the position of the active fingers is obtained and the by extending any one vertex, the movement of the mouse is controlled. The mouse cursor control operation is controlled by absolute index finger mapping. It means that the index finger on a camera screen, position maps to a desktop screen position. When the degree of the index finger and thumb is 70 to 90 degree then the gesture is recognized as left clicking. The double-clicking occurs when the thumb moves 0 to 90 degree and back two times fast. For right click operation, the gesture for left click is kept static for atleast 3 seconds. Other researchers have also done work on controlling the mouse using digital image processing. In paper [5] Erdem et al have used a camera and computer vision technology, such as image segmentation and gesture recognition to control mouse tasks. Another approach was made by Chu-Feng Lein [6] where the method of Motion History Images (MHI) to detect hand motion is used to control the mouse cursor. The finger tips of the hand were used to control the mouse cursor and perform click operations. The user had to hold the cursor for specific amount of time at a particular position where wants to perform the click operation. Kamran Niyazi[7] et al used Web camera to detect color tapes for cursor movement. The clicking actions were performed by calculating the distance between two colored tapes in the fingers. If we compare their work, then we can say that almost everybody had used similar technique to control the mouse cursor but they have used different methods to perform clicking operations.

In paper [8] a hand data glove was designed by Piyush et al which is worn by the user. This hand glove was designed as an interface between the user and the computer for the purpose of digital sketching and air writing system. The work of the hand glove is to sense various gestures done by the user using the hand. The hand glove is equipped with 5 bi-flex sensor, one on each finger to sense the gestures made by the hand. Flex sensors are sensors which change resistance when it bends. This value of change in resistance is used as the data. There are 3 degrees of integrated tracking with 3 axes, i.e., roll, pitch and yaw, measuring each movements of the hand. First, a code is written in C++ to collect the data and use it to train the system. Then KNN algorithm is used to cluster the data values for the various gestures defined. K- Nearest Neighbor is a method for classification of objects based on similar and closest features. The data value collected for right click operation is different from the left click operation as for right click, gesture of the bending of index finger or the thumb is used and for left click bending of the middle finger is used. These data values are collected and clustered. This data glove was specifically designed for 3D sketching and air writing system. The gestures are chosen in such a way that each gesture do not conflict with the other one.

In paper [9] Sheikh Rafik Manihar, had designed a human computer interface for controlling the mouse using head tilt and eye blink. The device uses 2D accelerometer for detecting the movement of the head and according to this the movement of the mouse cursor is controlled by the head. A photo sensor is used for detecting the blink of an eye. It detects the intentional long blink compared to the normal blink. A infrared transceiver which consists of a 935nm IR Transmitter and a phototransistor is mounted on the unit which detects a strong increase in the reflected signal upon intentional long blink compared to the normal eye blink. MMA7260Q accelerometer sensor is used to detect the movement of the head. The accelerometer consists of a G cell which does the work of sensing the acceleration and thus the tilt of the head. A microcontroller then receives the data from the accelerometer and the IR transceiver after getting processed through an A/D converter and then send suitable signals to the computer's serial port. The microcontroller used for this purpose is AT89S52 which has low power consumption and has high performance. It provides high flexibility and cost effective solution to many embedded control applications. RS-232 serial communication cable is used for communication between the computer and the microcontroller. A constant +5V power is supplied to the device using step down transformer, a bridge rectifier, filter capacitors C1 and 3 terminal regulator IC LM7805. This device was mainly designed for disabled or paralyzed person. Since the device can be controlled by head and eye blink, so it can be used by patients who are paralyzed from shoulder and downward.

In paper [10] Yogesh et al have designed a wearable wireless device where the user uses a handheld unit with sensors mounted on it. This device was designed to replace the mouse as an interface between the user and the computer. Two flex sensors were used to sense the

left click and right click. Accelerometer sensor (MMA7260) is used to sense the movement in the X-axis and Y-axis. Signals from the two flex sensors and accelerometer are given to the ADC pins of 1pc2138 processor. Two ZIGBEE modules (MAX 232 IC), one at the user side and another at the computer side are used for wireless transmission. The two flex sensors are mounted on the index finger and the middle finger respectively. When the index finger is bent for left click operation, then the flex sensor mounted on the finger is bent and the change in the resistance value of the sensor is sent to the ADC of the microcontroller which is sent wirelessly via ZIGBEE module. For the right click operation, the middle finger is bent and the flex sensor mounted on the middle finger is bent and change in resistance value causes the left click to happen. For the mouse pointer control, the hand is tilted towards the required direction and the accelerometer mounted on the glove also tilts and the change in the voltage is given to the microcontroller and sent using ZIGBEE module.

Jeff Rowberg's work called Keyglove [11] is a project based on open source wireless input device. The glove has 37 contact sensors placed strategically therefore it includes multiple sensor combinations which are ergonomically possible. The designer have implements the entire English alphabets using multiple sensor contacts. The glove is currently in prototype stage with no consumer ready units. We can say that the keyglove is a very flexible and powerful device. It has touch based full keyboard inputs and motion based mouse control. The keyglove gives the user vibration feedbacks. The keyglove is built around the well-known AT90USB programmable series of microcontrollers from Atmel. These are among the same chips used in Arduino devices, one of the pillars of the OSHW community. Not just charging and usage but also programming and configuration of the Keyglove can be accomplished through a standard USB connection. The main controller board is built to fit into a Mini PCI Express connector, which is an open standard and easily utilized by 3rd-party developers. The controller board design also includes a standard ISP header for in-system programming using free tools.

Several wearable technologies have been proposed to replace the basic mouse for interacting with the computer. Here are some of the approaches which people have come up with to replace the working of the old mouse. Mycestro is wearable 3D mouse which the user wears on its index finger. It has all the functionalities of a regular mouse and the cursor is controlled by your hand movement. Mycestro claims that due to its lightweight it will not interfere with your keyboarding. It has 3 buttons just like a regular mouse and if you want to scroll you just slide your thumb on a thumb pad. ThumbTrack is another wearable device which is also worn on your index finger and it has similar functions as Mycestro. We can click and scroll as we would in a traditional mouse. We can work with it for 15 hours straight before charging it. ThumbTrack can make presenting powerpoints easy and interactive compared to a mouse. Flying Fingers Mouse is glove shaped mouse that is said to give user a better experience than a traditional one. It uses the hand movement of the user to give orders just like a user would do with a regular computer mouse. It can help prevent a carpal tunnel syndrome which is great for people who spend a lot of time behind the computer. Using index finger and middle finger is all it takes to do all the basic commands like left and right click, going up, down and back. Maestro Gesture Glove puts electronic power in user's hands. This glove is used to control electronic devices and machines with hand and arm gestures. Users are able to use it in multiple ways. They provide a Maestro Gesture development software kit which allows the user to choose the controlling of any device like GoPro, gaming console, or laptop.

Mouse Glove 2010 [12] is an ongoing open source project conducted by Marco Ramill where he has designed a wearable device in the form of a hand glove which offers a natural way to control the mouse pointer, click and drag operations. Mouse Glove uses an ARDUINO duemilanove board (ATMEGA 328) to control two main signals, Left and Right Clicks, an accelerometer to capture the hand movements, and finally a glove to fit the sensors to the hand. A Java based dirver captures the hardware signals translating them into cursor movements. He has introduced a MouseGlove v0.1 which uses Arduino duemilanove which is basically a microcontroller board based on the ATmega328. Arduino has 14 digital input output pins, 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. A 3 axial accelerometer is used to grab the hand's movement which is connected directly to the Arduino sensor's three shield analog input. The left click and right click are sensed through 3 wires which are connected to the Arduino's digital inputs(Pin 3 and Pin 4) and to VCC. VCC is present on the thumb. Pin 3 (right click) is present on the index finger and Pin 4 (left click) is mounted on the middle finger. Both index and middle fingers close a circuit with the VCC when the intent to click operation is made by the user. The glove has a custom designed switch distributed on the three fingers. The code for managing the onboard analog and digital signals is written in C program. On the other hand a Java program is written to take the serial input

from the USB cable, decode it and calculate the mouse pointer's coordinates and scale the acquired parameters to fit in the monitor.

Two students from Cornell University, Adam Shih and Hyodong Lee had built a wireless computer pointing device [13] as a college project with accelerometer based movement control. Their implementation, allows the user to a set of hardware (a glove and connected armband) and control a cursor through different hand orientations and finger presses. Users can operate their computers with their hands in midair without the hassle of desks or wires. The user of the glove has two primary modes of input as well as one auxiliary mode. The primary modes of input are hand orientation for mouse movement control and buttons for mouse clicks. Hand orientation is sensed by 3 axes accelerometer in terms of hand tilts and outputs an analog voltage to the glove microcontroller unit. The MCU is connected to the Atmega1284's analog to digital converter. Button presses are sensed by contact pads placed on the side and glove's finger. The contact pads are also connected to the MCU ground. A 4 DIP switches are connected to the MCU to control mouse user preference features such as sensitivity, axial inversion and rapid fire clicking. The accelerometer used for the purpose of sensing the hand tilt is MMA7361. They have constructed copper contact pads for the mouse click operations using copper tape, copper wire, foam and electric tape. The wireless transceiver used for the purpose of transmission is Radiotronix WI.232FHSS-25-FCC-R.

III. CONCLUSION

The papers mentioned above and works done by various researchers can be very helpful to new researchers who want to contribute to the field of human computer interaction or design a wearable device. One can gain knowledge on wearable devices after reading these papers and studying the work done by various researchers in this field. It may be concluded that wearable devices is a new emerging technology in the field of human computer interaction and more works have been encouraged in this field.

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