Design and Development of Gesture Recognition System using Raspberry Pi

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Abstract— Gesture recognition has gained lot of popularity and become the new generation user interface. Developing an interactive user interface is the trend and gesture recognition provides a very good platform to build it. Gestures have been an important part of our life from a very long time, used to convey message or communicate without the need of language. To use these interactive system based on gestures, one does not require any prerequisite knowledge as in the case of touchscreens, keyboard etc. The aim is to develop a plug and play gesture recognition system (GRS) which can be scalable to any kind of application like playing a game or displaying an interactive advertisement. To build a complete plug and play device so that it is portable and easy to carry. This device provides a natural user experience at an economical price and opens a wide platform for future enhancement. To obtain a small device we have used Raspberry Pi along with the gesture recognition sensor which communicates with Raspberry Pi over I2C bus protocol.

Key words: Gesture Recognition System, Raspberry Pi

I. INTRODUCTION

A gesture recognition system (GRS) is comprised of a gesture, device (sensor) which detects gesture and classification algorithm. In personal computing, gestures are most often used in the form of input commands. It makes computers more accessible for physically disabled people by recognizing gesture as input commands. It is also used in gaming and virtual reality environment by providing more natural experience. For a long time, Human-computer interaction (HCI) has been limited to Graphical User Interface (GUI) [1]. Interaction with the help of hand gestures provides successful replacement to traditional key board and mouse. It makes the communication feel very easy and natural along with the advantage of overcoming language barriers. In today's digital world we can use human hand as input command to control any device directly.

Hand gesture is the most powerful and frequently used gesture in daily life. In linguistics, it is a prominent component of body language. Some of the applications of hand gesture recognition are tele robotics, gaming, and controlling television set remotely, teleconferencing, enabling hand as a 3D mouse, interpretation and learning of sign languages and so on. Hand gesture can also lead to complex problems since gesture varies across countries, religion and individual and same gesture can mean in different context. In this paper we are developing a plug and play GRS using IR sensors which detect the meaningful movement of hand as gesture. To make this GRS portable and scalable we are using Raspberry Pi as the processor.

II. RELATED WORK

Sigal Berman Et al. [2] did a comprehensive analysis of the integration of sensors into GRSs and they found that their impact on system performance is lacking in the professional literature. Determination of the sensor stimulus, context of use, and sensor platform are major preliminary design issues in GRSs. Hence, these three components form the basic structure of their taxonomy. They considered sensors that are capable of capturing dynamic and static arm and hand gestures. Various types of sensors were discussed here. Electronic sensors are present that gear users with wiring or other implements in order to track the user's hand or body movements. Based on technology sensors can be classified as following:

A. Optical Sensor

An optical sensor is a sensor which converts light rays into electronic signals. It measures the physical quantity of light and then coverts into a readable form. Most of the times it is connected to an electrical trigger. When a change in the signal within the light sensor occurs, the trigger gets activated and it initiates the camera to capture video or image. Once the image is captured, it is processed to trace extreme curvature values that are the peaks and valleys to detect the gesture.

B. Depth Sensor

It is a monochrome CMOS (complimentary metal-oxide semiconductor) sensor and an infrared projector working together to view the room in 3-D irrespective of the lighting conditions. The depth sensor image appears to be a 3D image. After applying background subtraction and other image processing algorithm, body parts can be easily mapped and plotted.

C. Accelometer and EMG Sensor

EMG sensors along with accelometer are also used for GRS [3]. The EMG sensors are placed at finger muscles and wrist (as shown in the figure below) so that any movement of hand can be easily captured by this sensor. By analyzing the intensity of the EMG signal, we can detect the start and end points of a meaningful gesture. To get the final result decision tree and multistream hidden Markov models are applied to get the final results.

D. Infrared Sensors (IR)

This sensor consists of a LED which emits light wavelength in the infra-Red spectrum. Then the light sensor detects the reflected IR light. By measuring the intensity of the received light it performs the decision making task using threshold values. For example when an object is present close to the sensor and LED emits the IR radiation, the light bounces off the object and reflects into the light sensor. This results a

large increment in the intensity value which can be detected using a threshold.

E. Electric Field Sensor

E-field sensor is made up of 3D sensor technology that utilizes an electric field (E-field) for proximity sensing [4]. With the help of transmitter an electric field is generated and is spread three-dimensionally around the surface carrying the electrical charge. By analyzing the variation in E-field when a person swipes his or her hand over it, gesture is detected with the help of threshold values. In this paper we present a GRS system using APDS 9960 sensor based on IR technology. APDS 9960 is a proximity and light sensor which consists for and infrared (IR) emitter and 4 directional photodiodes. The IR emitter emits the light beams in infrared spectrum and these four directional photodiodes sense the reflected IR energy. This energy is captured by the sensor and converted into digital value. Its range is up to 10 to 20cm. It consists of a gesture engine, proximity engine, ambient light subtraction, dual 8 bit data converters, 32 bit FIFO and cross talk cancellation. The sensor communicates using I2C communication protocol and hence consists of interrupt driven I2C bus. The gestures which are supported by this device are simple hand swipe like up, down, right, left, far and near. By adjusting the IR emitter timings noise and power consumption is reduced.

III. PROPOSED SYSTEM

Figure 1 represents the proposed architecture. The gesture sensor used here is APDS 9960 sensor. The APDS 9960 sensor used to recognize gesture is connected to the as shown in the block diagram below. The components in the below block diagram have to be powered by a battery with good life time. To obtain a wireless system we are using a Bluetooth module HC-05. HC-05 is a Bluetooth module based on Serial Port Protocol (SPP) used to establish a wireless connection for serial communication. We are using a Arduino Uno board to receive the data from APDS 9960 and send it wirelessly to the Raspberry Pi using Bluetooth module. Arduino Uno is a microcontroller break out board constructed using ATmega328P. We have used a Raspberry Pi 3 model B processor here. The Raspberry Pi is loaded with Raspbian operating system with 1 GB RAM and four USB ports. It has Ethernet cable which helps us provide internet connectivity to our GRS easily. The Raspberry Pi 3 has inbuilt Bluetooth. The final display shown in the below block diagram can be chosen based on the requirement specification. For example, when this GRS is used for advertisement the display can be a huge high quality screen whereas if used in bank, the display can be fitted in the form of kiosk where a person can stand in front and operate in privacy.

The raspberry Pi used has to be loaded with supporting operating system and Bluetooth enabled. This GRS works on the basis of serial data received by the raspberry pi. Consider the user is standing front of the device (here device means the APDS 9960 sensor). Let us assume the user is watching a presentation on the display and is interested to see the next slide. The user acts a gesture that is right swipe in range of 10cm from the surface of the sensor. If the gesture is successfully detected by the sensor, the Arduino board processes the data and sends "R" (this data can be changed in the programing code depending on the requirements) via Bluetooth module HC-05 to the raspberry pi serially. The data received by raspberry pi is processed and executes the corresponding function. In this case since right swipe was made, the "RIGHT" key press from the keyboard is emulated in window displayed on the screen. Resulting in successful navigation to next slide of presentation. The application is independent of what is being displayed on the screen. Therefore, instead of power point presentation we can run a gaming application or open web console etc. The working principle can be explained by the flow chart shown below. Initially, the user has to stand in front of the GRS within the range that is 10-20 cm.

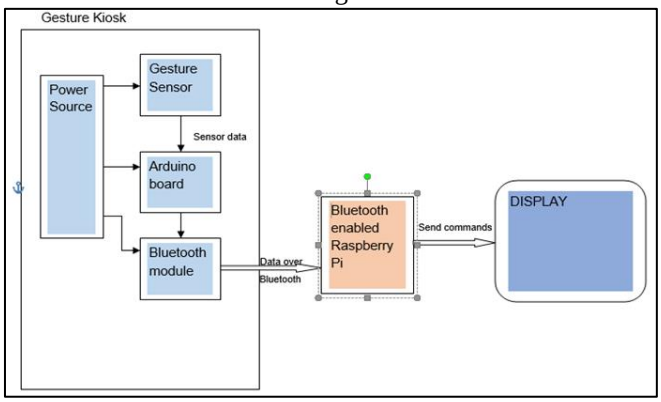

Fig. 1: Block Diagram of Proposed Architecture

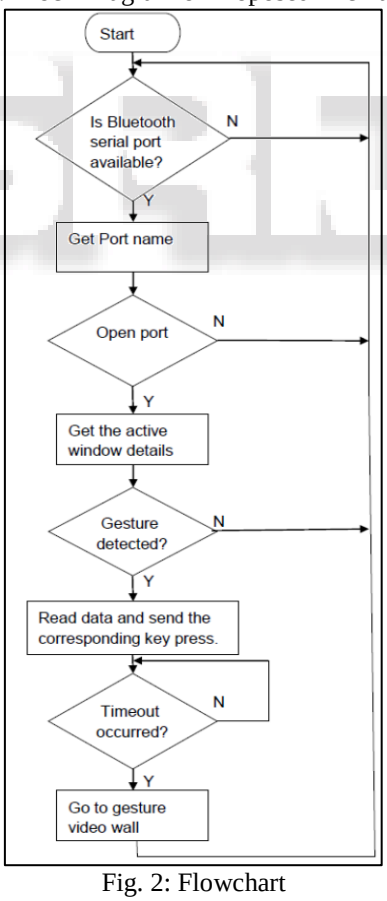

Fig. 2: Flowchart

IV. EXPERIMENTAL RESULTS

The performance of this GRS system largely depends on the success rate of the APDS 9960 sensor. The performance of sensor is influenced by three fundamental factors which are Environmental factors, IR LED emission and IR reception.

To check the performance and viability of our GRS we have to consider the following parameters for testing and analysis

A. Robustness

In real time, the visual image can be adulterated by noise, very rich and sometimes incomplete due to change in background, lightings etc. Image based systems should be dynamic in nature and independent of the user.

B. Scalability

The GRS system should be easily scalable when the application differs. For example, the interaction of the user with GRS should be same in the case of desktop environments, gamming environment and navigation also.

C. Computational Efficiency

The software and algorithms used should be fast and cost effective at the same time. It also should be adaptive to real time environment.

D. User's Tolerance

The application developed should be tolerable to the user's mistake. When a mistake is made by the user, instead of making wrong decisions it should assist and provide suitable messages to guide the user effectively.

The graph below depicts directional orientation for ideal response.

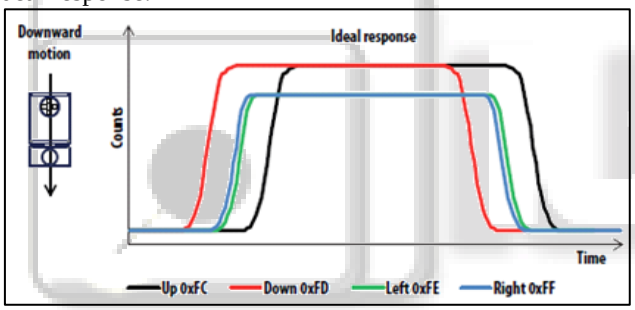

Fig. 2: Directional orientation of downward motion.

V. CONCLUSION

In today's world where technology has ruled over everything and everywhere, modes for providing inputs to an application has changed (to say enhanced) drastically. People always tend to get bored and want more entertaining methods every time. Traditional user interface like keyboard and mouse had been taken over by virtual keypads, touchscreen etc. The goal is to create user interactive environment and develop applications which can be controlled easily with smart input methods. Gesture user interface is an interesting and interactive user interface. It has gained lot of scope in home automation and advertisement scenario. One of the many advantages of using hand gesture recognition system is that the user can interact from a distance which was not possible in the case keyboard and mouse input methods. By installing a gesture kiosk, it increases the longevity as it need not be touched. This eliminates major drawbacks like seen in touch screen kiosks where the screen gets worn out in short time period and has to be replaced often.

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