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Hand Gesture Recognition System in Smart Environment

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Abstract: ***The smart environment allows users to interact effortlessly with their immediate surroundings using embedded sensors, displays, and computing devices. This system will not only be useful for ordinary people with no disabilities but also for people with disabilities like vision disability, cognitive, psychological and etc. Hand Gesture Recognition opens up a lot of possibilities for IoT based projects. At the end of the project, the goal is to design a cost-effective and highly interactive system through which a user can control the electric home appliances through hand gestures. This is a wireless device that is used to manipulate various devices using finger movement. The proposed device incorporates a transmitter connected to the MEMS accelerometer which detects movement warnings and transmits signals wirelessly using the radio frequency radio module (Zig Bee).***

The gesture alert which is input to the system is transmitted and obtained wirelessly using a wi-fi radio frequency module (ZigBee). The instrument contains a triaxial accelerometer, a microprocessor, and a ZigBee wi-fi transmission module. Acceleration warnings measured by the triaxial accelerometer are sent to a receiver via the ZigBee Wi-Fi module.

Keywords* : *MEMs, hand gesture, glove based technology, wireless technology.

I. INTRODUCTION

The smart environment allows users to interact effortlessly with their immediate surroundings using embedded sensors, displays and computing devices. The historical background of manual gesture recognition for IT devices began with creation of glove based management interfaces. Analysts imagined that communication through gestures would offer direct commands for a computer interface. This step forward has progressed and has therefore contributed to the production of accelerometers, infrared cameras, and even fiber optic fiber sensors. Many of these innovations in glove based systems have finally provided the flexibility to understand sensor-based artificial vision recognition attached to the gloves. These are the coloured gloves that give unmistakable tones to the finger tracking capability in recognizing movement generally based on PC vision[6]. Over the past 25 years, this evolution has led to numerous winning products that provide complete wireless reference with minimized user resistance. The project plan is to style a cheap and extremely interactive system through which a user will manage the electrical appliances through hand gestures. This system will not solely be helpful for traditional individuals however additionally for individuals with disabilities like vision incapacity, cognitive, psychological, movement and etc. This system is predicated on the MEMS-based system through that the user will manage devices like fans, tube-light, projector and etc. This is a wireless system that is used to control varied devices through the motion or gestures of their fingers. The planned system contains a transmitter that's mounted on the operator's hand along with sensors on the joints. MEMS accelerometer senses displacement signals and transmits through Zigbee bee modules to the receiver. The signals are transmitted and received wirelessly by Wireless Radio Frequency Module (Zigbee).[9][10]

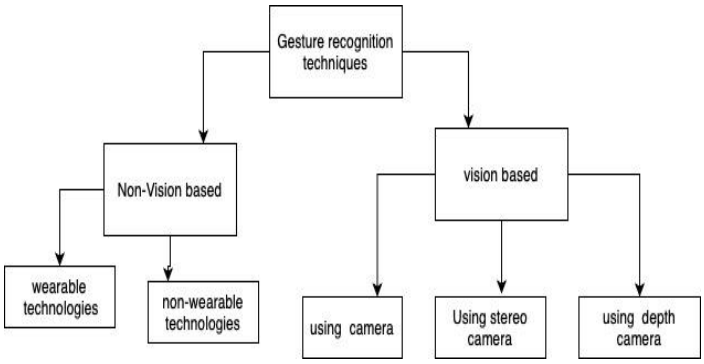

Figure 1

There are two main gesture recognition technique: Vision based and non-vision-based.

In the non-vision based generally the gestures are captured using the sensors like mems accelerometers and gyroscope. While in the vision based technologies, the camera are used to capture the points to capture the gestures.

There can also be hybrid techniques in which both visual and non-visual techniques are used in order to achieve the required results.

In the project, wearable technology is used to capture the hand gestures. MEMS accelerometers are mounted on a glove which capture the direction and position and save the data in database.

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While in the non-wearable technologies, radio frequencies are used to capture the gestures, for example Google's soli.[7]
Advantages of wearable technology:

- Fast response
- More precise
- Precise tracking

Disadvantages:

- Contact with human body
- A lot of cables

II. ABBREVIATIONS

- HMI – Human Machine Interface
- MEMS – Micro electro mechanical system
- ADC – Analog to digital convertor

III. LITERATURE SURVEY

Gesture recognition using hands gives a very natural and some modern ways of non-verbal communications. Some of the major applications of gesture recognition is in the HCI (Human Computer Interactions) and in the sign language. The major and most important purpose of this system is to detect some shapes. The gesture recognition by using hands has a camera attached to it which is generally used to detect the images of gesture the human is making and take these images as an input to the proposed and given algorithm. [1]
The most important component of HCI or the popularity of gestures is to recognize the gestures that are made on users. The main knowledge resides in such systems, which can be the use of accelerometers or the production based on gloves. Many documents are used to illustrate approaches to the popularity of these hand-based gestures. Some packages of this technology are also shown. [2]
In this article we focus primarily on effective gloves that can be used to understand and apply sign language. It is said that thanks to gloves we can better use sign language, which can be a gift. With the help of a glove, we can apply signal language even without sitting on the computer screen. We can talk to someone with hearing problems from sign language and we can also use glove-based strategies. We believe that this technology will be a better learning tool and will allow people to discover it even more. [3]
Here we are bringing out gesture-based recognitions the usage of Euler angles that are supplied via multiple sensors. This algorithm focuses on uncrewed air car over manned air crafts. After obtaining knowledge of and implementing quite a few arms based gesture popularity algorithms, we deal with a real-time technique, the use of seasoned precision motion tracker is-300 by inter sense. [4]
Since all human hands are similar, this document refers to a real-time system for the recognition of gestures through the use of the hands that detects some predefined shapes, such as the state of the finger, raised or bent thumb, fingers and their respective positions. The approach given is based exclusively on the input given to the system through the use of hands and gestures. It does not depend on the shape, the colors, and the size of the hand of the user who gives the voice. [5]

IV. BLOCK DIAGRAMS

The system comprises of two parts:

- Transmitter side
- Receiver side

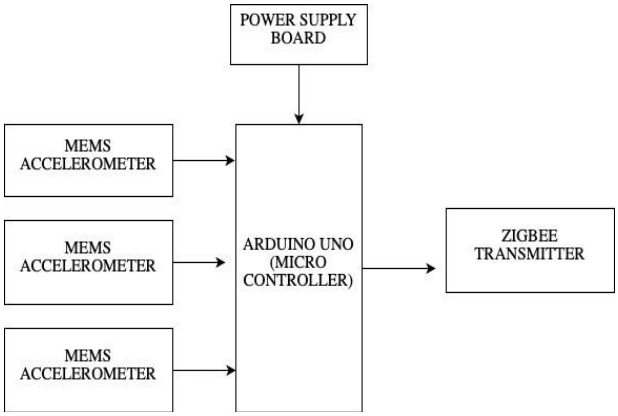


Figure 2. Transmitter

Figure 2 depicts the circuit diagram of transmitter side which is used to transmit the control signals to receiver side.

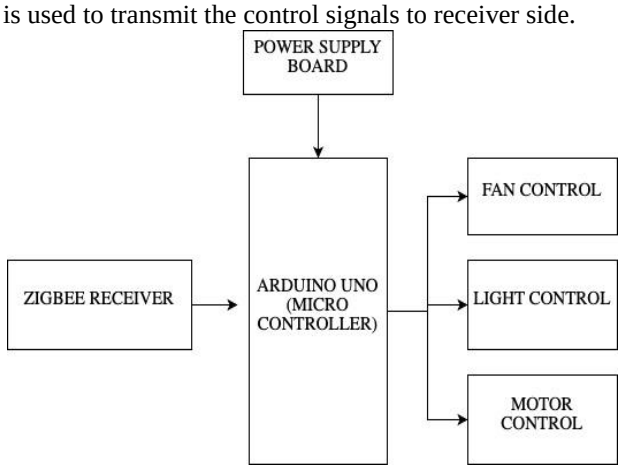
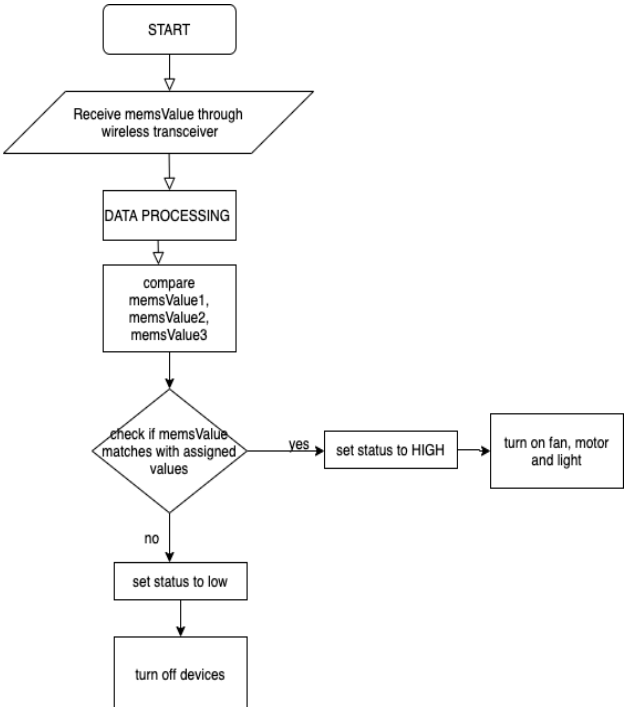


Figure 3. Receiver

Figure 3 depicts the circuit diagram of receiver side. On receiving the signal from transmitter, each electric device will respond accordingly based on preset value or template.

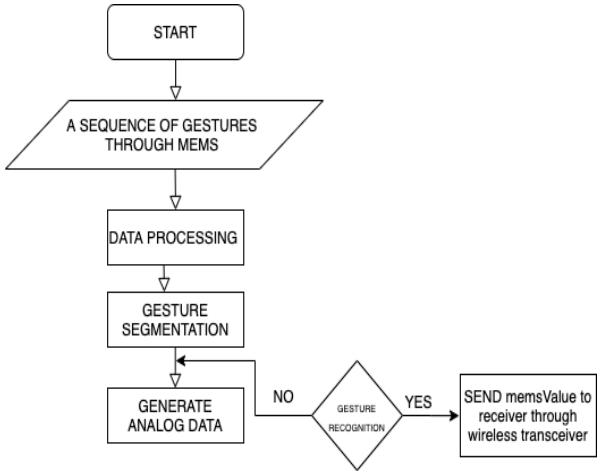
V. SYSTEM WORKFLOW



On the receiver side, mems values are received via the wireless transceiver and then the data for these mems values are processed. After processing, these values are compared with the default values that are already set in the program. So, we will check if the mems value is the same as the default value in the program and if the status is set to high, it will turn on the fan, the motor and the lights; otherwise, the status value will be set to low, which means that the devices are turned off.

Data acquisition It is used to collect the data value for the recognition of hand gestures. Mems devices must be kept horizontally throughout the process.

Data processing The data received through the sensors of the transmitter are processed on the receiver side.



On the transmitter side, a sequence of gestures is received as input through the mem sensors, then their data is processed, then segmentation of the gestures is performed and analog data is generated if the conditions are true; otherwise, gesture recognition takes place and mems values are received by the wireless transceiver.

Data processing

The data acquired by the sensors are processed on the transmitter side.

Gestural segmentation

Data preprocessing: first, the raw data received from the sensors are preprocessed and then segmentation occurs.

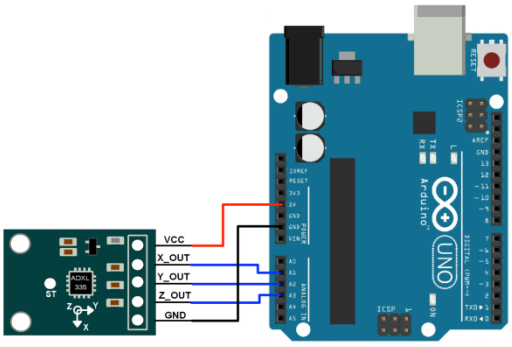
Segmentation: the segmentation algorithm finds the end points of each gesture in a series of data in the sequence of gestures. The algorithm checks various conditions of all data points and chooses the most probable records as gesture termination points.

Recognition of gestures

It is obtained by evaluating the value generated on the default value in the program.

VI. METHODOLOGY

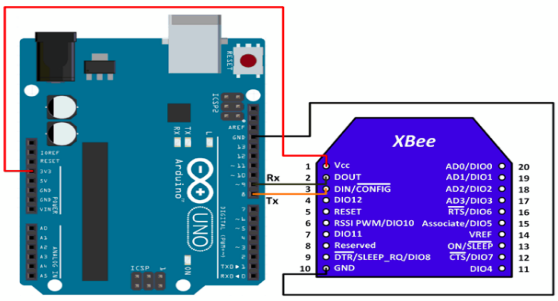
1. MEMS accelerometers are very precise, sensitive and low cost. It is used in embedded system to serve a lot of applications. When a capacitance change occurs, a signal is produced which is later amplified to produce a stable output(digital) of 4 to 20 milliampere. The main advantage of mems is, each sensor can fit into your palm. It is capable of handing different environmental conditions, as it can operate in temperature range of -40 to 85 degree celcius.
2. Refer below diagram, to connect Arduino UNO with MEM accelerometer.[8]



3. Now, we will have to get the values of pin A0, A1, A2 when we will make the angular motion of fingers. Note down these analog pin values and it will be used later.
4. Values of A0, A1, A2 can be known with respect to motion of fingers on which mem accelerometer is tied, by the following set of code.

```
void setup()
{
 pinMode(A0,INPUT);      //x-axis is connected to A0
 pinMode(A1,INPUT);      //y-axis is connected to A1
 pinMode(A2,INPUT);      //z-axis is connected to A2
Serial.begin(9600);       //To print data to Serial Monitor
}
void loop()
{
 Serial.print(" X= ");
 Serial.println(analogRead(A0));
 Serial.print(" Y= ");
 Serial.println(analogRead(A1));
 Serial.print(" Z= ");
 Serial.println(analogRead(A2));
 delay(1000);
}
```

5. For running these instructions, one can install Arduino IDE which is available for both mac and windows.
6. Zigbee is used for wireless communication to transmit the pin values from transmitter to receiver.
7.



XBee Coordinator

8. The transceiver and receiver pins of zigbee is connected with Arduino. The zigbee can transmit and receive values from another zigbee present in receiver module by following the instructions given by Arduino. That's how wireless communication works.
9. After connecting zigbee with Arduino, run the following set of code to start the communication through serial pins.

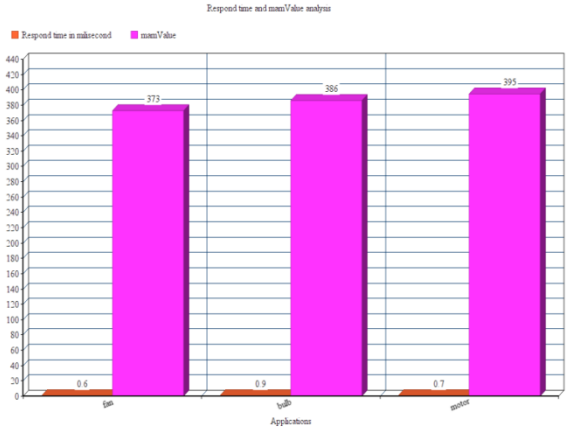
```
void setup()
{
Serial.begin(9600);
}
void loop()
{
while (Serial.available() ) {
Serial.write(Serial.read()); /
}
}
```

10. In the receiver module, data is received through the analog pins.
11. In receiver module all the electric devices are connected with relays to mechanically operate these devices on low power signal.
12. Transmitter continuously receives the memValue through zigbee from the transmitter side.
13. pinMode function configures the specified pin to behave either as an input or an output. The values from analog pin A0, A1, A2 are taken as input.
14. Now we can compare the values which were obtained from analog pins and were converted to integer values using analogRead function with 370 which is for fan , 380 which is for bulb and 390 which is for motor.
15. On exceeding these values, each electric device will respond accordingly based on preset value or template.

VII. REQUIREMENT/SPECIFICATION

1. ADXL330
   1.1. Operating voltage range: 2.0-3.6
   1.2. Temperature range: -25 - +70
2. Arduino Uno
   2.1. Input Voltage: 7-12V
   2.2. Temperature range: -40 - +85
3. Zigbee
   3.1. Range: 10-100m
   3.2. Data Rate: 20-250kbps
   3.3. Can only be used with mesh and device to device communication

VIII. TEST ANALYSIS



The above graph shows the respond time of each application which is 0.6 ms for fan, 0.9ms for bulb and 0.7ms for motor.

From the graph it can also be noted that, when memValue exceed 373, 386 and 395 turned on fan, bulb and motor respectively.

IX. CONCLUSION

The project has been properly implemented and a working prototype has been created successfully. The system comprises of three applications i.e fan, light and electric motor. On receiving memValue while change in position of MEM accelerometer sends input to the Arduino. Arduino checked whether the values exceeds given default values. On checking respective appliance starts working properly. If this prototype is implemented commercially, it will enable disabled people, visually impaired people, offices and homes to control their electrical appliances with their hand gestures.

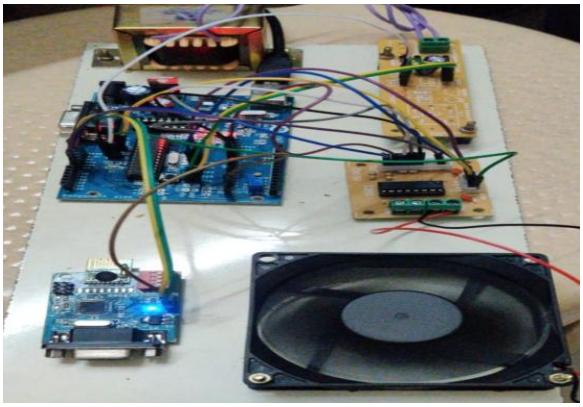


Table 1: Test cases with their obtained outcomes

TEST CASE ID	TEST CASE DESCRIPTION	STEP DETAILS	EXPECTED RESULT	ACTUAL RESULT	STATUS
001	Check if memsValue of MEME1 is greater than 370	Check if pin value MEMS_1 loads into memsValue_1	Value should be assigned	Value 379 passed	pass
002	Check if memsValue of MEME2 greater than 380	Check if pin value MEMS_2 loads into memsValue_2	Value should be assigned	Value 387 passed	pass
003	Check if memsValue of MEME3 is greater than 390	Check if pin value MEMS3 loads into memsValue_3	Value should be assigned	Value 396 passed	pass

004	Check if fan is working or not	Check whether fan starts working or not when MEMS_1>370	Fan should start working	Fan works correctly	Pass
005	Check if bulb is working or not	Check whether bulb starts working or not when MEMS_2>380	bulb should start working	bulb works correctly	pass
006	Check if motor is working or not	Check whether motor starts working or not when MEMS_3>390	motor should start working	motor works correctly	pass

X. FUTURE SCOPE

There is continuous growth of MEMS accelerometer and is widely gaining popularity in the market. Sensor market will grow up to two to three times in next 5 years. MEMS accelerometers can be from micrometers to millimeters in size and hence many sensors can be installed in a single device. For example a mobile phone, a number of sensors like temperature sensors, gyroscopes, accelerometer, proximity and etc. As these sensors are very cost effective and has very good compatibility with IOT, enabling students to innovate more and more out of it.

Recognition of hand gestures is moving at incredible speed for futuristic products and services and leading companies are developing technology compatible with the hand gesture system, including companies such as Microsoft, Samsung, Sony and devices such as computers. professional laptops, mobile devices, lights and LEDs.

Industries cover areas where gesture technology is and can be seen in the entertainment, artificial intelligence, education, medicine and automation sectors. And thanks to much research and development in the field of gesture recognition, the use and adoption will be more profitable and cheaper. This is an excellent feature that transforms data into functionality by combining technology and human wave.

Smartphones have achieved a surprising appearance and have seen gesture recognition technology and have worked on managing the smartphone in reading, navigation and this includes the so-called touch gestures. Google Glass was also in the same box. The technology has also been integrated with smart TVs that can be easily controlled and administered using voice and manual options.

In the field of medicine, you can also experience the gesture of the hand in the field of robotic care and treatment. Since technology changes and changes in the long term, it is silent and unpredictable, but we must ensure that the recognition of long-term gestures remains with more intense and moving experiences.

There are lot of technologies which are working for the advancement of mems sensors so it can fulfill IoT requirements. for example MEMs fabrication.

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