# Gesture control system in machine interfacing

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The way humans interact with machines is constantly evolving into being more hassle-free. We have moved from using mechanical buttons and dials to using touch panels to interact with machines, for example, mobile phones, washing machine control panels, and car instrument panels. The next step forward in machine interfacing would be to use gestures to interact with machines, making interactions even more intuitive. Gesture control has been around for a while now, available even in commercial appliances in form of motion gesture sensing. Motion gestures have been used in gaming consoles and mobile phones. Though such gestures require the user to be in physical contact with the sensors. An alternate form of gesture recognition has been visual/optical recognition. This project is faintly inspired by theremin, an electronic musical instrument that senses non haptic feedback from the movement of fingers in its electromagnetic field, to detect gestures. The goal of this gesture recognition system is then to be used as a machine interface, in this case, home automation.

*Introduction:* A significant step forward for modern consumer electronics today would be to design methods to interact with a system that are convenient, intuitive, and enjoyable.

Gesture recognition is the mathematical interpretation of a human motion by a computing device. Modern research of the control of computers changes from standard peripheral devices to remotely commanding computers through speech, emotions, and body gestures [7].

There have been a large variety of gesture recognition methods and prototype projects developed in the past couple decades[2][6]. Some of which were widely used in consumer electronics. Gaming consoles have been using motion gaming, where either a handheld remote is used to sense gestures, or optical sensors, such as cameras are used. Lidar is another upcoming optical solution, but its high price makes its use only possible in luxury electronics, such as self-driving cars. Smartphones are packed with numerous sensors and hence have a lot of room and opportunity for gesture sensing. Gestures such as twisting, shaking smartphones to activate pre-programmed applications is common practice in smartphones[3]. The two general limitations of the gesture recognition of today are:

1.They are haptic in nature, that requires direct contact with the sensors, which is in the case of motion gaming, and smartphones. This contact or need to hold on to a device makes them less intuitive and natural.

2. Non-haptic gesture recognition, such as optical methods often require complex set up and expensive infrastructure.

These limitations are some of the main reasons why gesture control is not commonplace in consumer electronics yet, even after being around for such a long time.

This project is primarily inspired by the Theremin. Theremin is a non-haptic electronic musical instrument which senses the movements of the player's hands in the electromagnetic field of the device.[4] Theremin consists of two antennas and two pairs of oscillator circuits. One of the oscillators in a pair resonates at a fixed frequency and the other resonates at frequency adjusted by varying capacitance induced by the antenna and the hand of the player.[5]

The general idea of the project is to establish an inexpensive gesture-controlled system that can be used as an interface to interact with a machine. Unlike some projects developed earlier[1] which uses expensive hardware the aim is to make the system inexpensive. The project relies on ultrasonic sensors to retrieve input data, Arduino UNO to process and recognize gestures, and a wireless server-client set up to interface the system with any device. This project set up uses inexpensive and light set up to achieve a similar goal.

*Project Setup:* Project development was split into three stages of prototyping to decide the sensors to be used and check the feasibility and proof of the algorithm for the final design. Project consists of a pair of sensors which are used to input data to the microcontroller. The data from sensors is used to determine the distance and direction of movement of the user's hand.

To identify the gesture, an algorithm is designed, and the gesture recognition system is calibrated according to the noise picked up by the sensors. The calibration is done by constant testing of several prototype stages. The whole mechanism is aimed to provide a cost-effective and simplistic circuit.

The algorithm used in this project is based on the principles of coordinate geometry. The area where the gestures are to be performed as an input is essentially a 2-dimensional plane bounded by coordinates, resting perpendicular to ground. Trend of the movements are determined through slope and lines.

*Prototype 1:* The project started off with an IR sensor connected to an Arduino to sense motion and distinguish it from random noise. pulse In () is used to distinguish a deliberate trigger from random noise depending upon the duration of the signal received. Fig. 1 capture the setup of prototype 1 with an IR sensor used with Arduino.

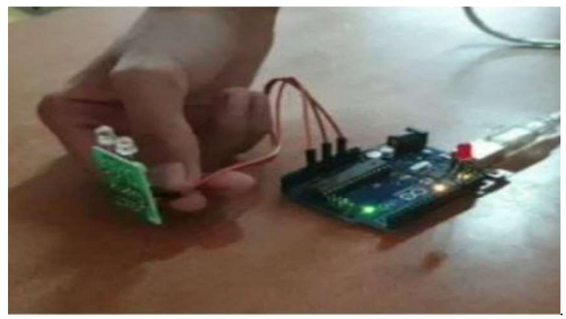

**Fig. 1** *Prototype 1 represented with an IR sensor connected to an Arduino*

*Prototype 1.5:* Using an IR sensor introduces a lot of noise in the system in the form of infrared reflected off certain surfaces and other sources of Infrared in modern electronics present all around us. Highly deviant reading of IR in different environments prompted that ultrasonic sensors were a better choice for our purpose.

Two ultrasonic sensors are placed perpendicular to each other such that the distance from corresponding sensors represents the x and y coordinate of an object in the plane created. Fig. 2 displays the physical setup of ultrasonic sensors. The distance is limited to a certain range so that noise signals are not picked up from unrelated motions that are out of bound. The x and y coordinates are obtained and stored to be processed via the Arduino program and its output, whose snippet can be referenced in Fig 3. and Fig 4. respectively.

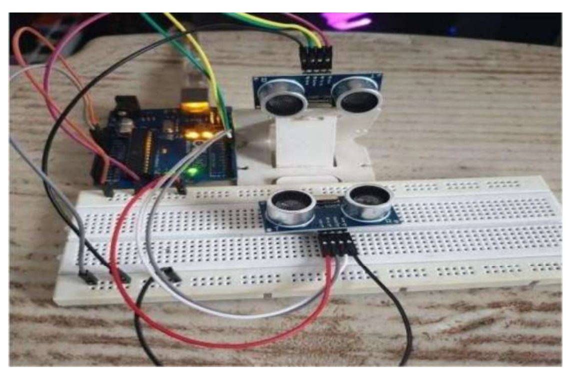

**Fig. 2** *Prototype 1.5 with two ultrasonic sensors placed perpendicular to each other connected to the Arduino*

```
const int echoPin = 4;
const int trigPin = 3;
const int echoPin = 5;
void setup() {
Serial.begin(9600);}
void loop()
{
long duration, inches, cm;
pinMode(trigPin, OUTPUT);
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
pinMode(echoPin, INPUT);
duration = pulseIn(echoPin, HIGH);
inches = microsecondsToInches(duration);
cm = microsecondsToCentimeters(duration);
Serial.print(inches);
Serial.print("in1, ");
Serial.print(cm);
Serial.print("cm1");
Serial.println();
delay(100);
Serial.print(inches);
Serial.print("in2, ");
Serial.print(cm);
Serial.print("cm2");
Serial.println();
delay(100);
}
long microsecondsToInches(long microseconds)
{return microseconds / 74 / 2;
}
long microsecondsToCentimeters(long microseconds)
{return microseconds / 29 / 2;}
```

**Fig. 3** *Prototype 1.5 code in Arduino*

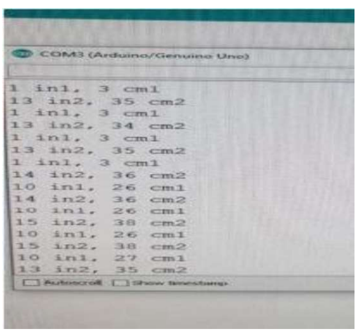


**Fig. 4** *Prototype 1.5 code output*

*Prototype 2:* We have successfully captured the coordinates of an object. Fig.5 shows the schematic diagram of the prototype. An algorithm is devised to process sensor input data and make sense of it to recognize gestures. A set of data is recorded and compared to a previous data set. This gives the change or delta of each coordinate. This is used to determine the trend of the movement. Buffer zones are added to reduce noise. Movement along the x-axis, perpendicular to y axis is tagged as the 'toggle' gesture which in this project is used to toggle between I/O pins of the microcontroller. Similarly, movement along the y axis is tagged as the 'intensity control' gesture which controls the duty cycle of the output voltage at the selected I/O pin from the toggle gesture. The registration of the respective gesture is printed on the serial monitor which can be referenced in Fig. 6. The algorithm keeps a count when a gesture is made on the x-axis and the count is programmed to switch between devices when it increases. It reverts to the first device if the count exceeds the number of connected devices.

Three Light Emitting Diodes (LED) are used as load to this circuit, which represents appliances such as LED bulbs, and electric fans. With the toggle gesture we can switch through the three LED controls. Intensity control gesture changes the brightness of the selected LED. The flowchart of the algorithm is represented in Fig. 7. Through this project set up a basic application of the novel gesture recognition is demonstrated in the form of appliance control board.

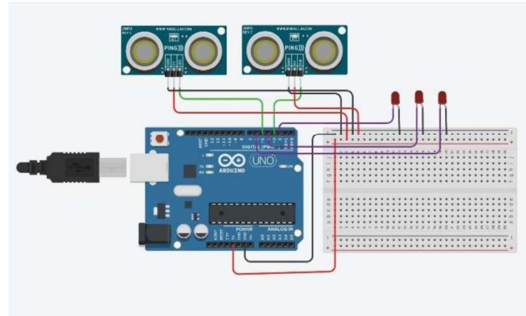


**Fig. 5** *Prototype 2 schematic diagram*

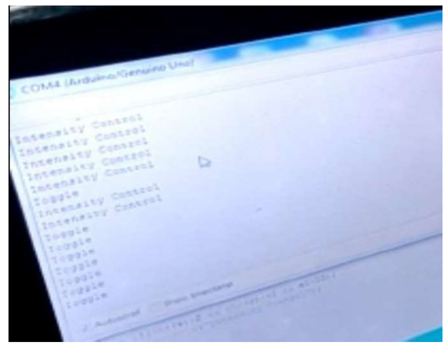


**Fig. 6** *Prototype 2 output showing gesture control*

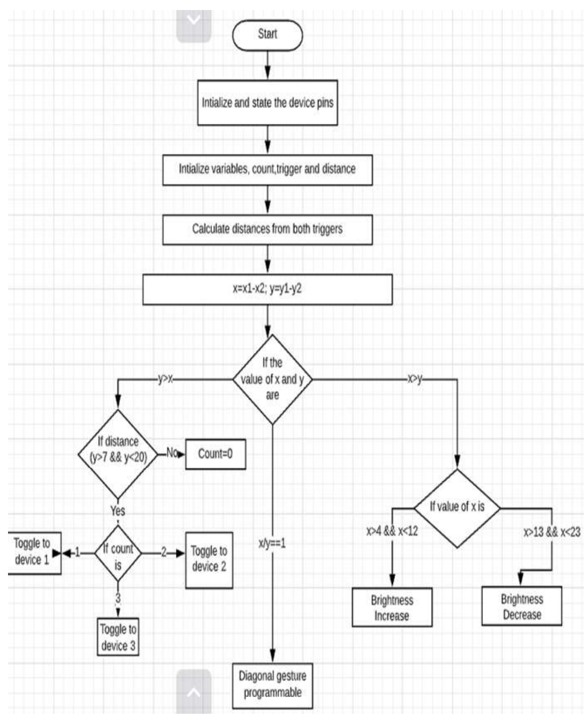


**Fig. 7** *Flowchart showing project's operation*

*Final Device:* After successfully programming the basic algorithm a skeleton of the prototype is ready.
To control the devices through the gestures we have established a wireless Client-Server simplex network based on the IEEE 802.11

protocol. The main setup of prototype 2 acts as a server and transfers commands wirelessly through server ESP266 to a client ESP8266 where the devices are connected as shown in Fig. 8.

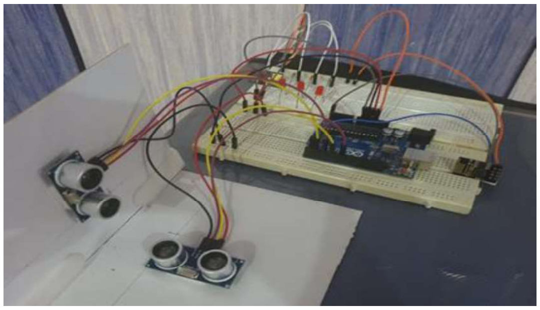

**Fig.8** *Final setup with wireless network through ESP8266*

*Conclusion:* An inexpensive network setup is suggested consisting of simple sensors and microcontrollers. This project successfully presents the proof of concept in a form of a general skeleton of a relatively simpler and versatile method of gesture recognition than its current contemporary that can be used as an interface between a user and the machine. The suggested method can be further improved and optimized through additional hardware filters and software optimization depending upon the precision required in the application it is being used for. Increased precision would result in more complex gesture recognition. Some application of such gesture recognition in consumer electronics has already been showcased by Google's project Soli, which too uses ultrasonic sensor to sense gestures. Though instead of one precise and expensive sensor with dedicated processing, two sensors can be used to increase the accuracy and reduce cost of processing hence giving hardware manufacturers a cheap alternative for receiving similar outputs. This project prototype can be used in inexpensive consumer electronics like wireless speakers, switchboard in smart home devices, and car device panels making control more intuitive for the driver and, hence requiring fewer conscious efforts.

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**References**

1. Tsung-Ching Liu, Shu-Hui Chang, Che-Yi Hsiao, 'A Modified Quad-Theremin For Interactive Computer', IEEE, 978-1-61284-774-0/11.
2. Christoph Endres, Svilen Dimitrov, 'Using a Theremin for Micro-Gesture Recognition in an Automotive Environment', AutomotiveUI'10, doi:11.11.10
3. Christian Geiger, Holger Reckter, David Paschke, Florian Schulz, 'Poster: Evolution of a Theremin-Based 3D-Interface for Music Synthesis', IEEE Symposium on 3D User Interfaces, 978-1-4244-2047-6/08, doi:08.03.2008
4. Jesús García-Guzmán, Daniel Salazar-Pérez, Gisell Celis-Ronzón, Jorge A. Vélez-Enríquez, 'Design and Experimental Prototype Testing of a Hybrid Digital Theremin System', (ICCE-Berlin), 978-1-5386-6095-9/18
5. William Buller, Brian Wilson, 'Measuring the Capacitance of Electrical Wiring and Humans for Proximity Sensing with Existing Electrical Infrastructure', IEEE, doi:15.06.05
6. Andreas Riener, Philipp Wintersberger, '3D Theremin: A Novel Approach for Convenient Point and Click- Interaction in Vehicles', Automotive UI'11, doi:29.11.11
7. Soeb Hussain and Rupal Saxena, 'Hand Gesture Recognition Using Deep Learning', IEEE, 978-1-5386-2285-8/17