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Mobile Object Sensing Technologies using Arduino Microcontroller

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Abstract**:** ***Motion detectors are sensors that record movement in a certain area. This study proposes the evaluation of three motion detectors, using the Arduino microcontroller to execute orders to the sensors infrared, PIR (passive infrared sensor) and ultrasonic, to determine the obstacle detection behavior against different objects. According to the tests carried out and the theory presented for each sensor, we have found that the most efficient sensor for object detection is the PIR, due to its scope and viewing angle, which represents being feasible and more reliable to implement; for example, in security systems.***

Keywords: Motion detection, obstacles, sensors.

I. INTRODUCTION

With the development of technology in different fields, a great variety of technological devices has been incorporated in the working world. This impact of technology allows us to provide engineering solutions to different problems and automatize diverse processes. In addition, by adding intelligence to the systems of these devices, they can automatically alert their users.

To evaluate the applicability of the infrared, PIR, and ultrasonic sensors, we have used an Arduino Uno board to execute the instructions of each one of them. The objective is to assess these sensors and determine which one of them is the best in different scenarios, taking into account the distance and vision angle.

II. LITERATURE REVIEW

Electronic motion detectors contain a motion sensor that transforms the detected motion into an electrical signal. Therefore, motion sensors are electronic devices used for motion detection. They allow to integrate or connect other devices, which help to alert the users of an obstacle presence within the visual field of the mentioned sensor, which has become a vital component of comprehensive security systems for businesses and homes [1].

In the study of [2], they make use of the infrared sensor to determine the distance of an object, controlling the system from an Arduino board to evaluate the sensor facing different colors at different distances. While in [3], they use the same type of sensor for controlling a robot; nonetheless, its brain is still controlled by an Arduino board, where all instructions are executed. As a result, when the robot finds an obstacle it deflects and find the free route.

In the same way, according to [4] infrared sensors are also used for controlling car traffic at traffic lights. These sensors are placed on the side of the road or street, adding a dynamic control system based on the density of queued cars. The previous sensors are activated when vehicles pass nearby them; in this way enhancing the traffic in the place, they are located.

In the same context, but using another type of motion detection sensor, in the University of Kufa [5], they implement a system for tracking and detecting suspicious events with PIR sensors, incorporating cameras for real-time monitoring, through a computer, tablet or mobile device. PIR sensors can also be used for automatic control of lights in a building [6] in order to reduce the electricity waste; however, they mention that if alarms are used instead of lights, the system will be good enough to function as a security system.

The research of [7] is based on a comparison of measurement techniques implementing ultrasonic and infrared sensors for obstacles detection made of different types of materials. These sensors are used in a car, which touring and detects different objects, in order to choose the best sensor or in some cases using both to have greater efficiency in the detection of obstacles.

III. MOTION SENSOR

The sensors are electronic components, which allow a piece of electronics to interact with the world, for example: the electrical pulses that are sent between the neurons of our brain [8].

According to [9] a sensor is an input device that provides a manipulability output of the measured physical variable. The sensor acts as an intermediary between the physical variable and the measurement system, allowing it to be implemented with other electronic devices.

With the advances in computer science and electronics, new low-cost detection devices have emerged that allow a space or place to be monitored. Next, we detail the functionality of three motion sensors used today, each with similar applications, but in practice, the detection methods are different.

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A. Infrared Sensor

Infrared sensors are an electronic component consisting of an infrared LED and a phototransistor placed next to each other (Fig 1), so that the led acts as a transmitter and the phototransistor as a receiver. The infrared led emits infrared light, higher wavelength or minor frequency, invisible to the human eye. If this light hits a white surface it will be reflected and will reach the phototransistor; otherwise, if it hits a black surface, the material will absorb most of the light and will not reach the photoreceptor [10].

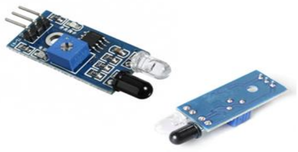

Fig. 1.Infrared sensor.

According to [11] these types of sensors detect presence over short distances, typically between 5 to 20mm (Fig 2). In addition, the infrared light received depends on the color, material, shape and position of the obstacle, that is to say, they are inefficient in providing an estimate of the distance to the object.

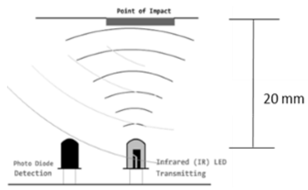

Fig. 2.Infrared sensor focus.

B. Passive Infrared Sensor

A passive infrared motion sensor uses pyroelectric sensors to detect temperature changes through the electrical reaction of certain crystals. The temperature change comes from infrared radiation. This type of sensor uses multiple pyroelectric sensors to identify movement by detecting changes in infrared radiation [12].

The sensor responds to infrared radiation centered around a wavelength of 10 µm (10 microns or 10,000 nm), it is the approximate body temperature of humans and animals. The word "passive" in the term "passive infrared" refers to the behavior of the detector, which receives passive infrared radiation. Proximity sensors must actively generate their own infrared radiation, which is interrupted or reflected by nearby objects. This sensor incorporates a Fresnel lens, which allows infrared radiation to pass in a range of 8 to 14 microns. This lens is used to activate the elements sequentially. When an infrared radiation source moves from one area to another, it energizes the elements alternately, creating an output [13].

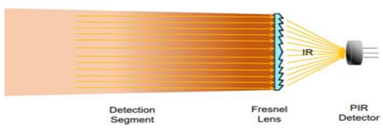

Fig. 3.PIR sensor detection segment.

According to [14] the PIR sensors of the HC-SR501 model are small and low cost, that incorporates recent technology on motion sensors. It uses two potentiometers and a jumper that allows to modify parameters and adapting them to the needs of the application such as detection sensitivity, activation time and response to repetitive detections.

According to [12], this type of sensors works just in the dark when there is not light, allowing them to be implemented in different scenarios, applying their use in office automation, smart homes, among other utilities.

C. Ultrasonic Sensor

Unlike the other two sensors, this one emits energy to space and uses the Doppler Effect detect movement. This effect describes the phenomenon we experience when a moving sound source pass [15].

Ultrasonic sensors work similar to radars and sonars. A piezoelectric transducer converts electrical energy into an ultrasonic wave usually between 40-50 kHz. This high frequency sound wave, which is beyond the capacity of the human ear, hits an object and it is reflected to another transducer that converts the sound wave back into electrical energy [16].

This sensor is a contactless distance-measuring device that uses a *t* variable, measured from the transmission of some type of pilot signals until a reflected signal is received from the object. The distance *L* to the object can be calculated with the following formula [1].

$$L = \frac{vt\cos\theta}{2}$$

Where, *v* is the speed of ultrasonic waves in the media (340 m/s), θ is the reflection angle; if the transmitter and the receiver are close to each other, then $\cos\theta \approx 1$.

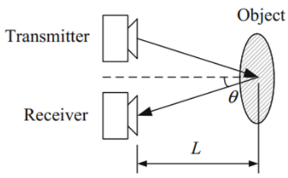

Fig. 4.Principle of ultrasonic sensor.

IV. RESULTS AND DISCUSSION

Before starting to make the connection or assemble of the circuit for each sensor, it is important to know the operating characteristics for each of them. Hence, it is necessary to present the following table:

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Table- I: Features of Motion Detection Sensors.

Sensor	Characteristics					
	Detection mode	**Detection range**	**Vision angle**	**Operating temperature**	**Operating voltage**	**Operating amperage**
Infrared	light	2-30 cm	35º	-25Cº to +85ºC	3.3 V	23 mA
PIR	wave	3-7 m	95º-110º	-15Cº to +70ºC	3.3 V	60 uA
Ultrasonic	sound	20 cm-2 m	15º	20ºC	5 V	2 mA

After knowing some features of these sensors, the connection, test codes, and outputs of the Arduino IDE serial monitor are presented for each them.

A. Infrared Sensor

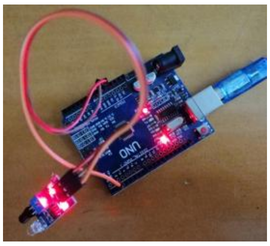

Fig. 5.Infrared and arduino sensor connection.

```
const int sensorPin = 2;
void setup()
{
Serial.begin(9600);
pinMode(sensorPin , INPUT);   Serial.print("\nCalibrating Sensor... ");
delay(2000);
Serial.print("\nSensor Activated!!! \n");
delay(1000);
}

void loop()
{
int pin_estado=LOW;
pin_estado=digitalRead(sensorPin);
if (pin_estado == LOW) {
Serial.println("Event Detected!!");
delay(2000);
}
if (pin_estado == HIGH)
{
Serial.println("No event!!");
delay (2000);
}
}
```

The particularity of this sensor compared to the other two, is that when it detects an object the status of the sensor puts it low (0), otherwise it will be high (1).

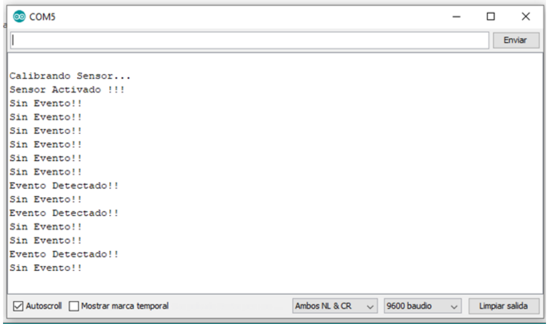

Fig. 6.Object message detected.

B. Passive Infrared Sensor

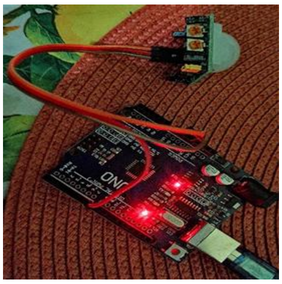

Fig. 7.PIR and arduino sensor connection.

```
void setup()
{
  pinMode(PIR, INPUT);
  Serial.begin(9600);
  Serial.print("\nCalibrating Sensor... ");
  delay(2000);
  Serial.print("\nSensor Activated !!! \n");
  delay(1000);
}

void loop() {
  pir_lectura = digitalRead(PIR);
  if (pir_lectura == HIGH)
  {
    Serial.println("Event Detected!!");
    delay(2000);
  }
 else{
    Serial.println("No event!!");
    delay(2000);
  }
}
```

The advantage of this sensor is the detection capacity in terms of scope and vision, since it is greater than the infrared and ultrasonic sensor.

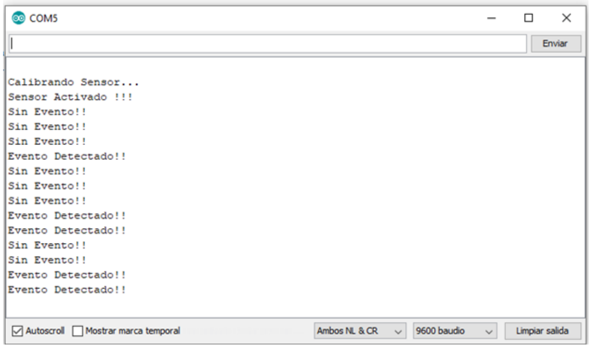

Fig. 8.Motion detection message.

C. Ultrasonic Sensor

Fig. 9.Ultrasonic and arduino sensor connection.

```
const int trigPin = 5;
const int echoPin = 6;
long duration;
int distance;

void setup()
{
 pinMode(trigPin, OUTPUT);
 pinMode(echoPin, INPUT);
 Serial.begin(9600);
}
void loop()
{
 digitalWrite(trigPin, LOW);
 delayMicroseconds(2);
 digitalWrite(trigPin, HIGH);
 delayMicroseconds(10);
 digitalWrite(trigPin, LOW);
 duration = pulseIn(echoPin, HIGH);
 distance= duration*0.034/2;
 Serial.print("Distance: ");
 Serial.println(distance);
 delay(1000);
}
```

This sensor has a transmitter and receiver, where the first emits the wave and the second receives it; therefore, when the said wave collides with an object the sensor measures the event distance.

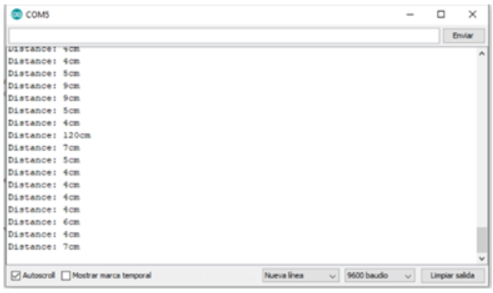

Fig. 10. Object message detection.

After knowing the functionality or working mode of each sensor and according to table I, a series of tests were carried out with different objects, to determine if these sensors are sensitive to the objects (table II).

Table- II: Evaluation of sensors with different objects.

Sensor	Test Object	Results
Infrared	Plastic (bottle)	Detected
	Human	Detected
	Animal (dog)	Detected
	Paper (white sheet)	Detected
PIR	Plastic (bottle)	Undetected
	Human	Detected
	Animal (dog)	Detected
	Paper (white sheet)	Undetected
Ultrasonic	Plastic (bottle)	Detected
	Human	Detected
	Animal (dog)	Detected
	Paper (white sheet)	Detected

V. CONCLUSION

In this study, the evaluation of three motion sensors has been carried out, using an Arduino one microcontroller. In the tests performed on each sensor, the operating voltage and amperage were taken into account, as well as the detection distance. The results showed that the infrared and ultrasonic sensors are sensitive to the different objects used for the evaluation, while the PIR sensor is only sensitive to humans; nevertheless, the PIR sensor has a greater range and vision compared to the ultrasonic sensor, which represents being feasible for the use; for example, on security systems.

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José Mela, Degree in Computer Engineering from the University of Panama. His research interest focuses on the areas of Networks, Operating Systems, Computer Architecture, Robotics, Electronics, Internet of things, cloud computing, blockchain, software engineering and artificial intelligence.

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