IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 9, September. 2019, ||Series -I || PP 11-17

Investigation of Infrared Sensors for Robot Navigation

S. B. A. Kumara[1]
[1]*(Department of Engineering Technology, University of Sri Jayewardenepura, Sri Lanka)*
Corresponding Author: S. B. A. Kumara
Received 17 August 2019; Accepted 03 September 2019

Abstract: This paper presents a study that was conducted on the use of IR sensors for robot navigation. Two types of IR sensors, a passive IR (PIR) sensor and a proximity IR sensor were studied. These sensors were used to detect relative motion of IR emitting bodies and to measure distance respectively. The results showed sensitivity of the proximity IR sensor depends on texture of a surface and the optimum configurations of the sensors were determined. The PIR sensor can be used to detect a human body, heated object and also suitable for fire (flame) detection. It senses within 15feet of the detection area. The proximity IR sensor can be used to measure distance and it is very accurate for short distances of about 10cm to 35cm. However, it is not suitable for detecting mirrored and or glass surfaces.
Keywords: Passive IR (PIR), Proximity IR, IR emitting bodies

I. INTRODUCTION

The main objective of the work was to investigate the types of sensors, suitable for the use of robot navigation in home environment. D203B passive IR (PIR) sensor (also called as pyroelectric IR sensor [1]), and Sharp GP2D12 IR proximity sensor [2] were tested for different relative motion of IR emitting objects/bodies and measure distance respectively.

Especially, PIR sensor can be used for motion detection [3]. A Fresnel lens is mounted with the PIR sensor for the high effectiveness of the sensor response. Proximity IR sensor can be used for measuring the distance between the mobile robot and obstacles [4, 5]. The Sharp GP2D12 IR sensor was selected because it has high accuracy when measuring short distances from 10cm to 80cm. Then the optimum configurations of the sensors were determined for the robot navigations.

1.1 PIR (D203B) Sensor

The experiment was conducted for relative motion detection of IR emitting bodies including flames. The Human bodies, heated objects, objects in the room temperature, and flames were concerned.

1.2 Proximity IR Sensor (GP2D12)

Experiments were carried out to identify the surface dependency, accuracy and limitations of the sensor. The results were processed using statistical analysis and the important sensor parameters for robotic applications were identified.

1.3 Mobile Robot

The Microchip's microcontroller PIC16F877A [6] was used for data processing and controlling the mobile robot. The inbuilt 10- bit analog to digital convertor (ADC) of the PIC microcontroller was used to convert the analog output of the sensors to a digital signal. The free moving ability is considered to be the major characteristic of the developed mobile robot, which means that the robot can be moved to detect objects and it does not collide with these obstacles. While the robot is moving, it can detect a human body or a heated object and fire (flame).

1.4 Sensing and Self Intelligence

The robot receives raw sensor data from its sensors. It has to map those measurements into an internal representation to formalize this data [7]. This is rather a complex process since in general the output signals of sensors are noisy and the environment is partially observable, unpredictable, and often dynamic. The Mobile robot has moving, turning, stopping and reversing actions. These actions can be done according to the formalized data of the sensors by using a programmed microcontroller. This action is called self-intelligence of a mobile robot.

1.5 Mobility and Navigation

Mechanical parts such as motor, bearings, and wheel systems should be mounted accurately for the navigation of the robot [8]. A stable and permanent power supply is needed for the successful completion of the task.

II. DATA COLLECTION METHODOLOGY

Data has been collected from PIR D203B sensor and Sharp GP2D12 sensor under the research.

2.1 PIR D203B Sensor Data Collection

The sensor analog data was converted to a digital signal by the inbuilt ADC of the microcontroller and collected data sent to a computer serially for further processing. A graphical user interface (GUI) was developed for reading the data of the microcontroller. The processed data was plotted using a software tool which was developed using the .net framework. The plotted graph (ADC value - 10 bit A/D converter result vs data number) signifies the variation of data in relation to time.

Two methods of data collection were used for the PIR sensor.

1. Human body moving to PIR sensor.
2. PIR sensor moving to object (as robot moving to object).

2.1.1 Human body moving to PIR sensor

The data was collected when the human body was moving towards the PIR sensor according to the following two methods.

- Perpendicular movement of the human body cross the detecting area of PIR sensor as shown in figure 1 [9].
- Human body moves parallel to the detecting area of the PIR sensor as shown in figure 2 [9].

The data was collected in the two methods given above under three different speed of a human body; they were categorized as Normal, Slow, and High speed. Normal speed moving of the human body refers to the normal walk of a human.

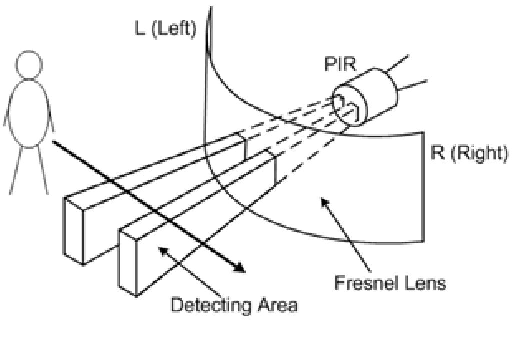

Figure 1: Perpendicularly cross the detecting area

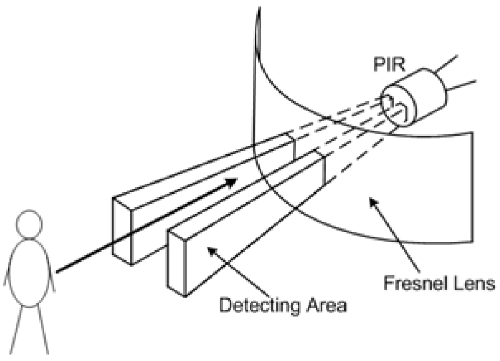

Figure 2: In parallel move to detecting area

2.1.2 PIR sensor moving to object (as robot moving to object)

Here the PIR sensor was mounted on a remote car and data was collected using a serial communication. The remote car was moved to different types of objects and these are categorized according to the nature of the temperature such as room temperature (Wall, Piece of Wood, Plastic, Metal), Hot water (about 50 ºC), High temperature-Fixed (Soldering Iron, Iron), and High temperature – Varying (Oil lamp, Candle).

2.2 Sharp GP2D12 Proximity Sensor Data Collection

The sensor output voltage was recorded while varying the distance between the object and the sensor. Using the recorded data output voltage vs distance was plotted. This procedure was repeated for different types of surfaces such as white color paper, red color paper, black color paper, glass (transparent), and a mirror (reflection). This sensor output depends on the surface color and texture of the surfaces. Here, the distances were calculated according to the variation of the output voltage of the Sharp IR sensor. The error expectation is also calculated using a statistical method. Several data measures from GP2D12 IR sensor were obtained for a predetermined distance from a consider surface. Then the distance (30cm, 40cm, 50cm, 60cm and 70cm) from that surface was and stored data was measured for each of the positions as above. Then this procedure was repeated for all the surfaces. Collected data was used to calculate the error expectation of the distance caused by the sensor.

III. RESULTS

3.1 Reading of PIR D203B Sensor

A serial interface between the microcontroller and the PC was established (43 data per second). Generally, the PIR sensor output voltage (without amplifying) was 556mV and amplified signal was varying around 2.38V – 2.26V at the normal condition owing to the ambient IR variation. The resolution of the internal 10 bit A/D converter of the PIC 16F877A Microcontroller was 4.88mV. Effective maximum distance to sense the IR variation of PIR sensor was about 20 feet (when the Fresnel lens is mounted). The effective maximum distance without the Fresnel lens of the PIR sensor was 1.0 feet.

Figures 3(a) and 3(b) illustrate the variations of PIR sensor output when a person moved perpendicularly across the detecting area from left to right and right to left respectively under three speed conditions (high, normal, and slow). Further, these figures shows there is no distinguishable difference in the data obtained from PIR sensor, whether it is related to human body moving speed (high, normal, slow) or direction (left to right or vice versa).

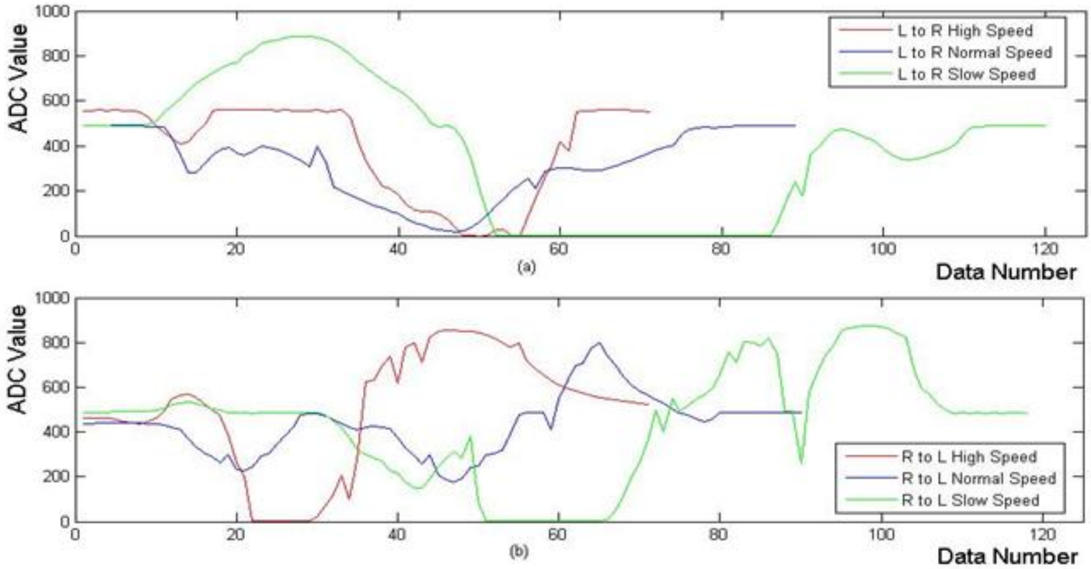

Figure 3: Perpendicularly cross the detecting area from Left to Right and Right to Left

Figure 4 shows the data variations of the PIR sensor while the human body moves in a parallel direction to the sensor detection area with respect to three different speeds. There is no clear difference in PIR sensor output between high and normal speeds. But there is a significant variation in very slow speed data of the PIR output relative to other speeds. The PIR sensor was moved towards a wall, a piece of wood, a plastic object, and metallic object and sensor output variations were analyzed (see figure 5). Later results do not have large variations when compared to the human body moving data. Detecting distance of PIR sensor for the above objects is low. It is about 1.5 feet (when Fresnel lens is mounted on PIR sensor).

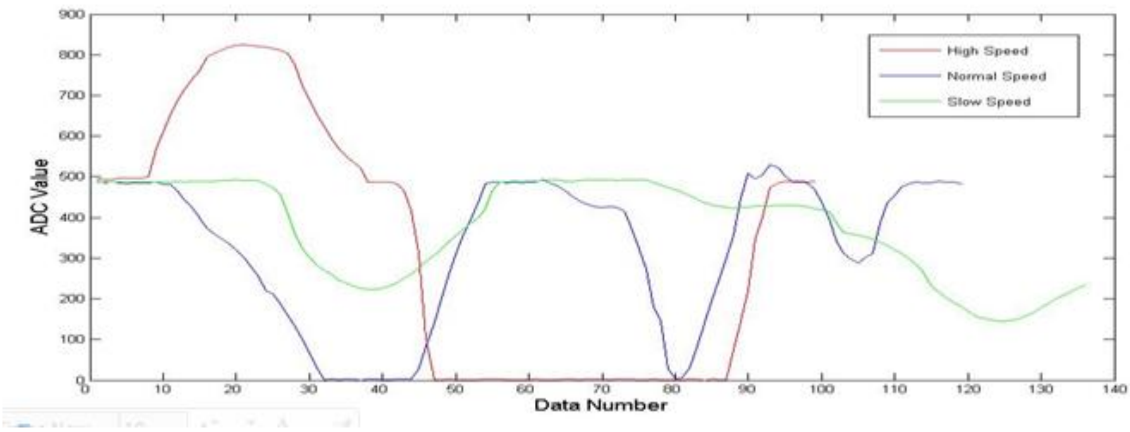

Figure 4: Human body moves in parallel direction towards the sensor detecting area

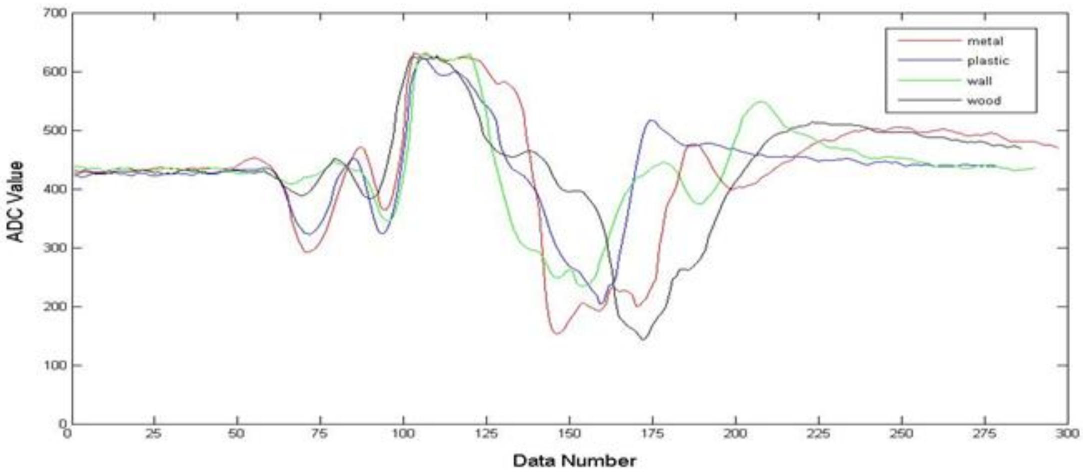

Figure 5: PIR sensor moves to room temperature objects

The IR emitting intensity of heated objects was greater than the room temperature objects. Temperature variation objects (Candle flame, Oil lamp) and temperature fixed objects (Soldering iron, Iron, Hot Water) are used for these data collections and Figure 6(a), (b), (c), (d) and (e) show data variations when the sensor moves towards hot water, iron, soldering iron, candle, oil lamp respectively. Soldering iron, iron, hot water sensor output data variations show similar characteristics as the data obtained when human body is moving to the sensor. Therefore, these objects and a human body cannot be identified separately using this device. Furthermore, the sensor can identify the flame because the output data variations appear as square pulses (see Figure 6(d), (e)).

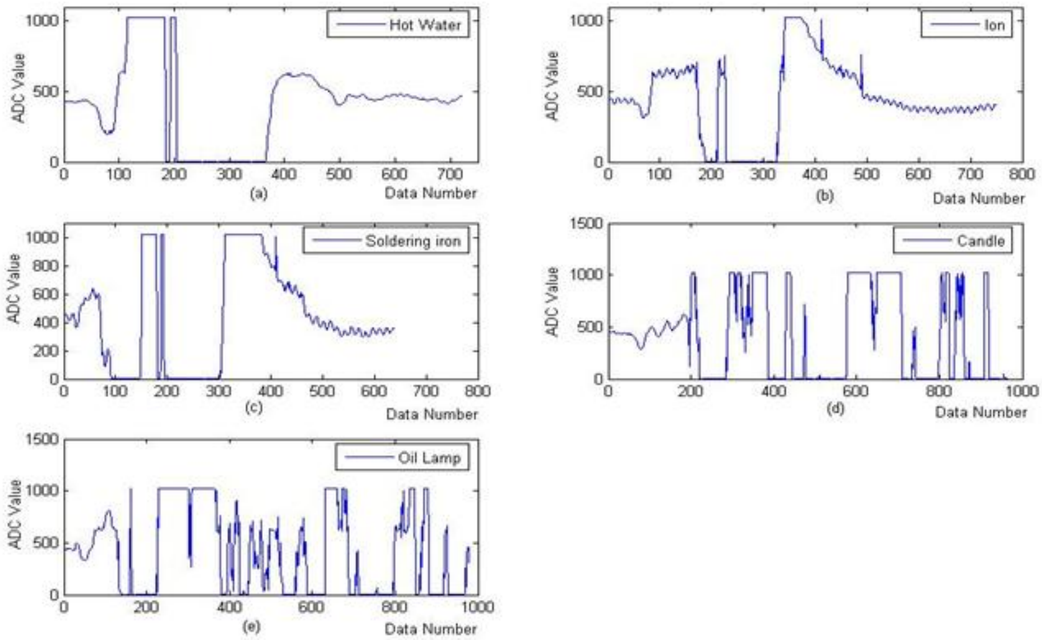

Figure 6: PIR sensor moves to heated objects

3.2 Reading of Proximity IR Sensor

Output voltage variations of the sensor vs distance between sensor and obstacle is shown in figure 7. When considering the red, white and black surfaces variation of the distance against the output voltage there is similarity. This variation shows exponential distribution. Even though there is a decrease in output voltage when the distance increases for mirror and glass surfaces, it is not a systematic decline but it can be used to get an idea about the distance measurement. These readings are not useable for slight motion of the glass or mirror obstacles because the glass and mirror surfaces have properties of high refraction and reflection respectively.

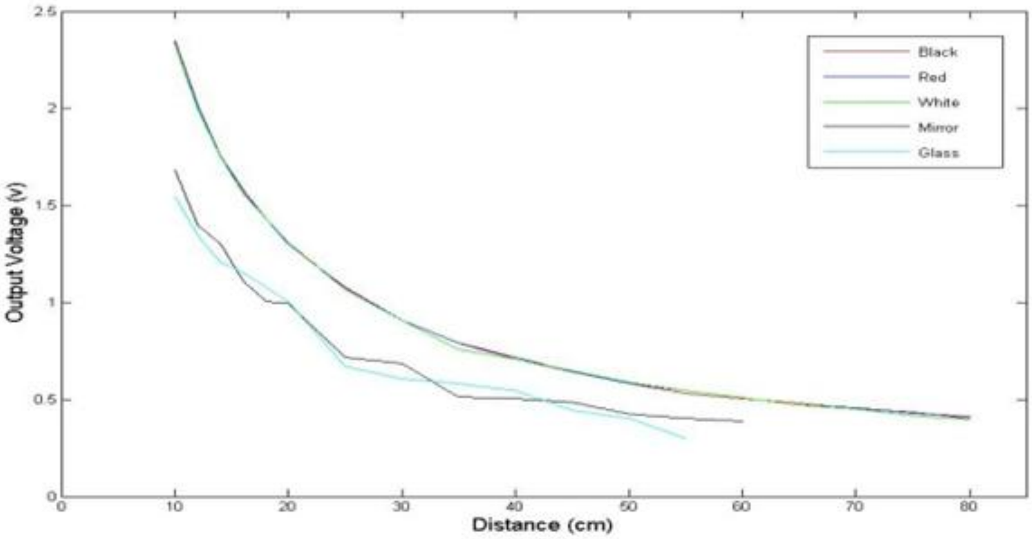

Figure 7: Distance measuring graph for surfaces

3.2.1 Expected Distance Tolerance of the Proximity IR Sensor

Table 1 lists the tolerance of the Proximity IR sensor output with respect to the distance measurements between sensor and obstacle. The expected distance tolerance was calculated within a range of a 95% confidence interval and those tolerance values are increased when the measuring distance is increased. Therefore distance measurement of the senor is not very accurate for long distance measurements such as 70 cm distances. The main advantage of the above calculations is, it can be given a tolerance and error range for the distance measured by using sensor.

Table 1: Distance Tolerance values for all color surfaces

	Tolerance (mm)		
Distance (cm)	**Red Surface**	**Black Surface**	**White Surface**
30	±2.00	±2.00	±2.58
40	±2.58	±3.16	±3.74
50	±4.32	±4.32	±3.74
60	±6.64	±5.48	±4.90
70	±6.64	±7.78	±6.64

3.3 Investigation of Sensors and Design of the Mobile Robot

Data collected using the PIR D203B and a Sharp GP2D12 sensor was used to investigate the optimal configuration for robot navigation. Using PIR sensor, it was possible to identify human body or heated object detection and Flame detection. It also helped to distinguish between these obstacles separately. Using the Sharp IR Sensor, it was possible to measure the distance including the error expectation.

The free moving ability is considered to be the major characteristic of the mobile robot. This means that the Robot can be moved to detect objects and it does not collide with obstacles. While the robot is moving, it can detect a human body or a heated object and detect fire. The functionality of the robot can improve to respond successfully in different conditions. The mobile Robot controlling circuit was designed using three sensors namely PIR D203B, Sharp GP2D12 IR sensor and a Photo detector. The block diagram of the mobile robot is shown in Figure 8.

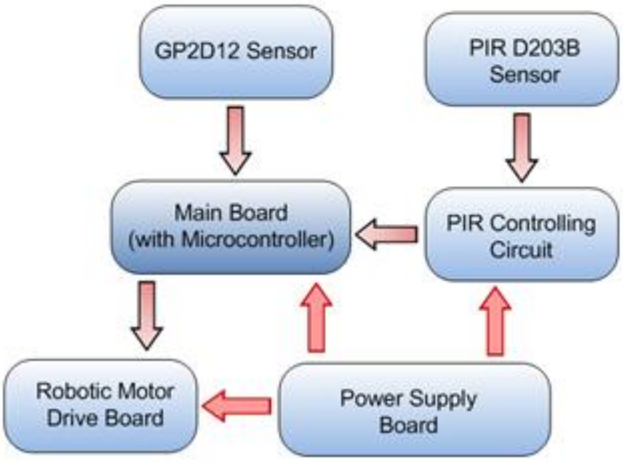

Figure 8: Block diagram of mobile robot

The IR sensor was mounted as it rotates according to the rotation direction of the rotate wheel. So, it can detect any obstacle, which it encounters in the direction of the robots rotation. When the robot reverses, it may collide with objects. The photo detector signal is used to stop the robot as soon as it collides and turns it to move in another direction.

IV. CONCLUSION AND DISCUSSION

The response of a PIR sensor (D203B) was studied when a human moves in front of the sensor response area, in different moving methods. A significant difference of the sensor response curves was observed when a human moved parallel to the detecting area very slowly. Results showed that the PIR sensor cannot be used to detect the speed of human and objects such as walls, plastic, wood and metals separately. The similar sensor response characteristics were obtained for a human body and heated objects. Therefore, PIR sensor cannot be used to identify a human body and heated objects separately. According to the results PIR sensor can be used to identify a human and flame (fire) separately.

Proximity IR sensor (GP2D12) were studied by keeping different objects in front of the sensor. A significant error was observed when positioning the mirror and glass surfaces with the orientation slightly varied (1˚or 2˚). Therefore data collection using this sensor should be done carefully. Normally, IR transmits through glasses and partially reflects. Therefore the sensor detects a glass by detecting that partially reflected beam. This sensor detects objects within the range of 10cm to 80cm. But for the glass surfaces the maximum detecting distance of the sensor is only about 45cm to 50cm. A main drawback of GP2D12 sensor is that, the output can be changed from the original reading of the sensor by sending an IR beam to the receiver of the sensor by using a separate IR source. This IR beam should be within the matching wave length of the sensor.

REFERENCES

[1]. Model: D203B Pyroelectric Infrared Radial Sensor manual, PIR sensor Co.LTD, www.micropik.com/ PDF/D203B-e.pdf

[2]. Sharp GP2D12 sensor, Optoelectronic Device, Sharp Corporation, http:// www.sharpsma.com/ webfm_send/1203 (2005)

[3]. Yucong Lu, Lingqi Zeng and Gary M. Bone, Multisensor system for safer human robot interaction, Robotics and Automation, 2005. ICRA 2005, Proceedings of the 2005 IEEE International Conference on. IEEE, 2005

[4]. G. Benet , F. Blanes, J.E. Simó, P. Pérez, Using infrared sensors for distance measurement in mobile robots, Robotics and Autonomous Systems, 40.4 (2002): 255-266

[5]. Tarek Mohammad, Using Ultrasonic and Infrared Sensors for Distance Measurement World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:3, No:3, 2009

[6]. Microchip Technology Inc. PIC 16F87XA Datasheet. http://ww1.microchip.com/ downloads/en/ DeviceDoc/39582b.pdf, (2003)

[7]. Qu Dongyue, Hu Yuanhang, and Zhang Yuting, The Investigation of the Obstacle Avoidance for Mobile Robot Based on the Multi Sensor Information Fusion technology, International Journal of Materials, Mechanics and Manufacturing, Vol.1, No. 4, November 2013

[8]. Gordon McComb, Robot builder's bonanza, 4th edition, McGraw-Hill, ISBN: 978-007-175035-6 (2003).
[9]. Adafruit.com website, How PIRs Work, https://learn.adafruit.com/pir-passive infrared proximity-motion-sensor/how-pirs work

IOSR Journal of Engineering (IOSRJEN) is UGC approved Journal with Sl. No. 3240, Journal no. 48995.

S. B. A. Kumara" Investigation of Infrared Sensors for Robot Navigation" IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 09, 2019, pp. 11-17.