Implementation of Tracking System for Human Detection based on Pyroelectric Infrared (PIR) Sensor

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ABSTRACT
In this paper, tracking of human has described. It has a great importance for detection security and robotics, beside that it can be used for sensing the abnormal behavior of patients in hospital. The aim of this work is to design and implementation of the human detection and tracking system. The design of tracking system has the ability to rotate a camera toward any position in a horizontal axis in both clockwise and anticlockwise directions. The experimental work shows that the direction of rotation can be obtained by determining which one of the four pyroelectric infrared sensor (PIR) is interrupted by the objective. Also the stepper motor controlled the AVR microcontroller based Arduino board which makes the camera track the objective movement. High performance of the proposed system under practice test. To reduce the power consumption of the tracking system a power control unit has been designed, to switch the power off when there is no human detected and switched the power on when a human is detected by a PIR sensor.

General Terms
Tracking system, human detection, power consumption, power control unit.

Keywords
PIR sensor, stepper motor, AVR microcontroller, webcam.

1. INTRODUCTION
Due to expanding number of burglary and crimes, the need to security framework is exceptionally crucial. Throughout the time the area is monitored by the security system, the responds successfully to the danger when needed. In the market we have lots of security systems for both outdoor and indoor applications such as microwave detectors, ultrasonic detectors, infrared detectors, photoelectric detectors etc. [1]. However one or the other systems have the restrictions of being costly, more memory space utilization of the recording system and complex circuitry, more electrical power consumption, etc. A solution to overcome these issues could be by utilizing a low cost sensor which has the ability to detect the intruders as they come within the range of sensors detection and generates an output. This yield utilizing further processing of signal or activating other devices like recording system, lighting system, alarm system and similar devices. This could be any event saves some power utilizations as some components get compelled just when there are intruders in the range of sensors detection. Pyroelectric Infrared (PIR) Sensor is a low power, inexpensive and reliable sensors used for these purposes [2]. When the PIR sensor of the power control unit detects the human, it will switch ON the system (microcontroller unit, PIR sensors unit and camera) and lamp. The output from the sensors unit will be connected to the microcontroller unit in order to track the human position by rotating the stepper motor (the camera) according to the position of the interrupted sensor.

The power control unit has been used in order to reduce the power consumption of the system to switch OFF the power of the system when the human is out. All simulations have been done by using the Proteus (7.6 SP4) Professional simulation program. Figure 1 shows the system block diagram.

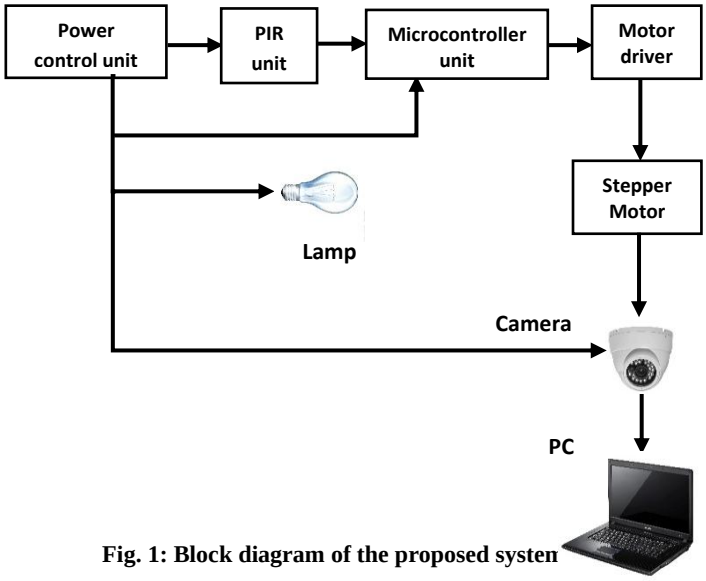

Fig. 1: Block diagram of the proposed systen

2. DESIGN OF THE PROPOSED SYSTEM
The proposed system consists of four units (PIR sensors unit, Power control, µC, Sensor unit) and they will be illustrated according to their sequence in the system.

1) PIR Sensor: The PIR sensor is the core part of the system. The system basically function based on infrared radiation, which is emitted from human body. PIR sensor is widely used in security system to detect the motion of human [3]. Infrared (IR) light is electromagnetic radiation with a wavelength between 0.7 and 300 micrometer.

Human beings are the source of infrared radiation. It was found that the normal human body temperature radiate IR at wavelengths of 10 micrometer to 12 micrometer [4] [5]. PIR sensors are passive electronic devices which detect motion by sensing infrared fluctuations [6]. It has three pins (gate, drain and source). After it has detected IR radiation difference, a high is sent to the signal pin. PIR sensor is made up of crystalline material that generates a surface electric charge when exposed to heat in the form of IR [4]. This change in radiation striking the crystalline surface gives to change in charge. The sensor elements are sensitive to radiation of wide range but due to the use of filter window that limits the sensitiveness to the range 8 to 14 micrometer which is most suitable to human body radiation [4]. Figure 2 shows the infrared radiation of human body. Figure 3 shows the PIR sensor output waveform.

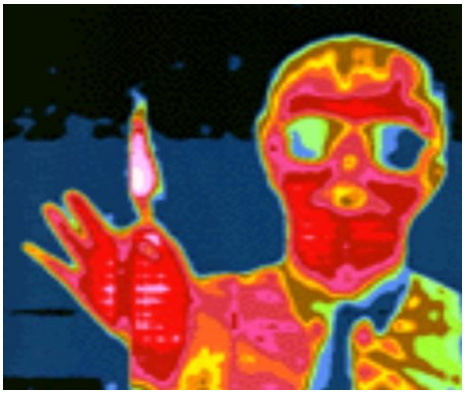

Fig. 2: Infrared radiation of human body [1]

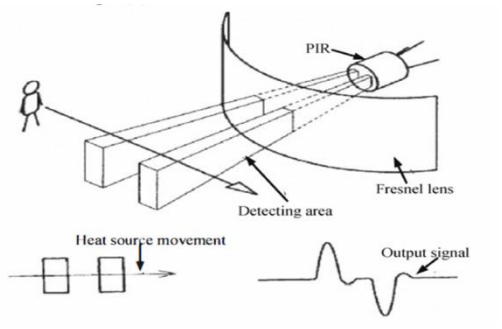

Fig.3: PIR sensor output waveform [7]

2) Power Control Unit:
This circuit has been added to reduce the power consumption of the system by switching the power off the system when there is no intruder to the room so the camera, sensors unit, lamp, and stepper motor will be inactive so that the power will be saved. Figure 4 shows the power control unit block diagram. The PIR sensor has been installed at the upper corner of the room wall to cover all the room area. When a human enters the room the PIR sensor will be switch on the system and a lamp.

3) Microcontroller Unit:
The AVR (ATMEGA328P) is used to control the whole system and it's responsible for the following:

1. Receiving the signals from sensors unit and determining **2**. Sending control signals to the stepper motor driving unit.

3. Controlling the rotation of the stepper motor according to the position of the sensor that has been interrupted by the human.

Figure 5 shows the simulation design of the microcontroller unit connected to the stepper motor driver and four switches (represents the four PIR sensors).

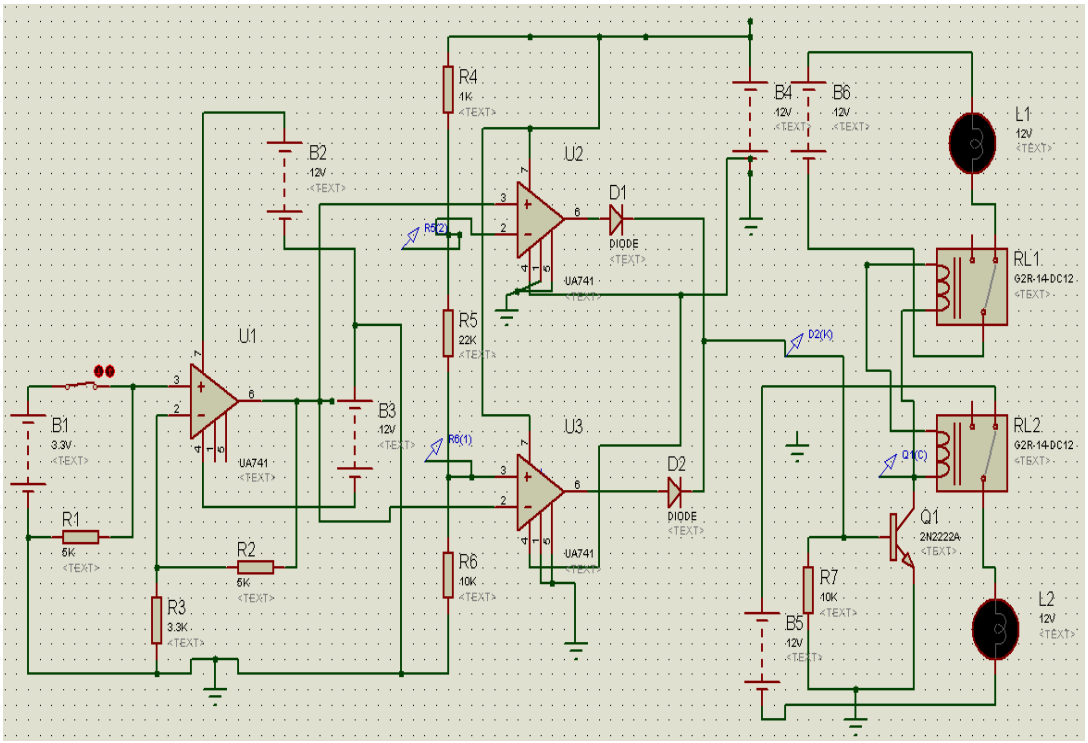

Fig. 4: Simulation design of the power control unit

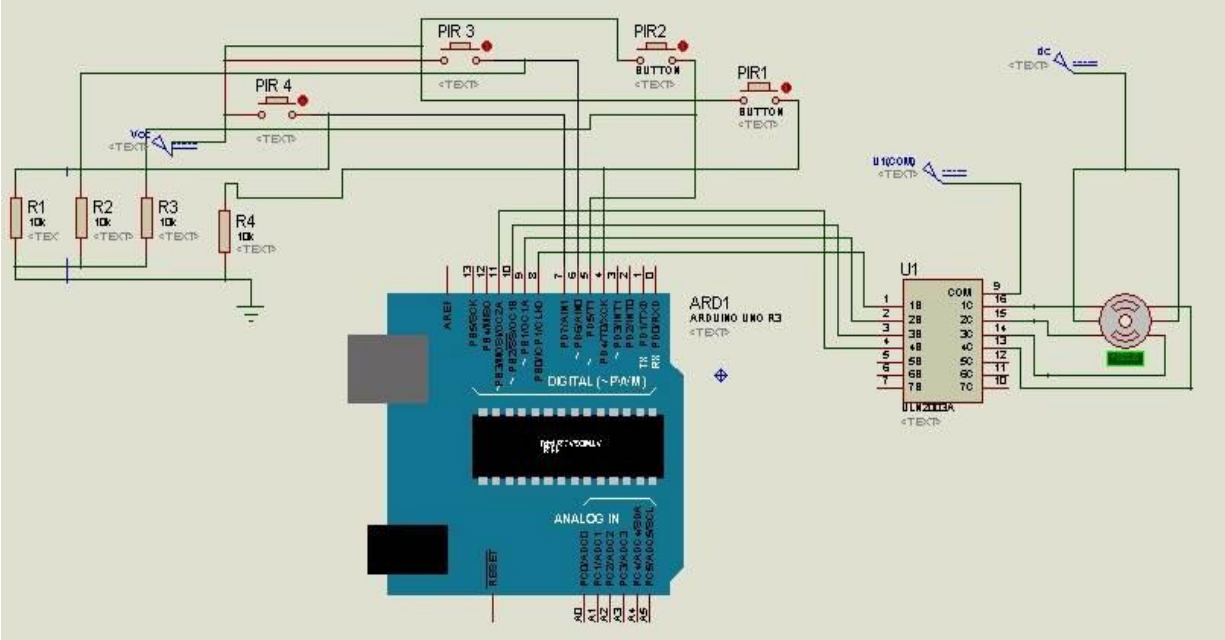

Fig. 5 Simulation of microcontroller unit

4) Sensor unit:

This unit is responsible for detecting the human position in the room and sending the signals to the microcontroller to rotate the stepper motor (the camera) toward the human. This unit consists of four PIR sensors that will detect the human by sensing the infrared wave radiated from the human body. In the simulation design the PIR sensors are represented by four switches. The practical implementation of the sensors unit is shown in Figure 6.These sensors are installed in wooden box, the front side of the box is inflected and divided to four divisions each division is 45°from the neighbor sensor.

Fig. 6: Practical implementation of the sensors unit

When sensor 1 (PIR1) detects the human body the Arduino microcontroller will drive the stepper motor to rotate 45 degrees (the position of sensor1), when the human reaches the sensor 2 (PIR2) area the Arduino microcontroller will drive the stepper motor to rotate an additional 45 degrees (the rotation will be 45+45 =90 degrees), when the human inters the region of sensor 3 (PIR3) the Arduino microcontroller will drive the stepper motor to rotate an additional 45 degrees (the rotation will be (45+45+45=135 degrees), finally when the human detected by is sensor 4 (PIR4) the Arduino microcontroller will drive the stepper motor to rotate an additional 45 degrees (the rotation will be 45+45+45+45=180 degrees) which is the complete area which faces the wall that the system is mounted on, and hence the human detecting and tracking will be achieved.

5) Stepper motor driving unit:

This unit is responsible for receiving the control signals from the microcontroller and providing adequate power to rotate the stepper motor that will rotate the camera in order to track the human who entered the room where the tracking system has been installed. The driver unit has been used is the ULN2003A IC which is an integrated circuit motor driver that can be used for simultaneous, bidirectional control of a stepper motor. Figure 7 shows that the drivers for steppers motors [8].

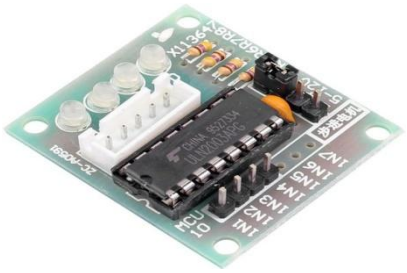

Fig. 7: The driver for stepper motor [8]

3. FLOW CHART AND PROGRAMING STEPS OF THE PROPOSED SYSTEM

Figure 8 shows the flowchart of the human detecting and tracking system. The stepper motor (camera) will track the human according to the sensor position.

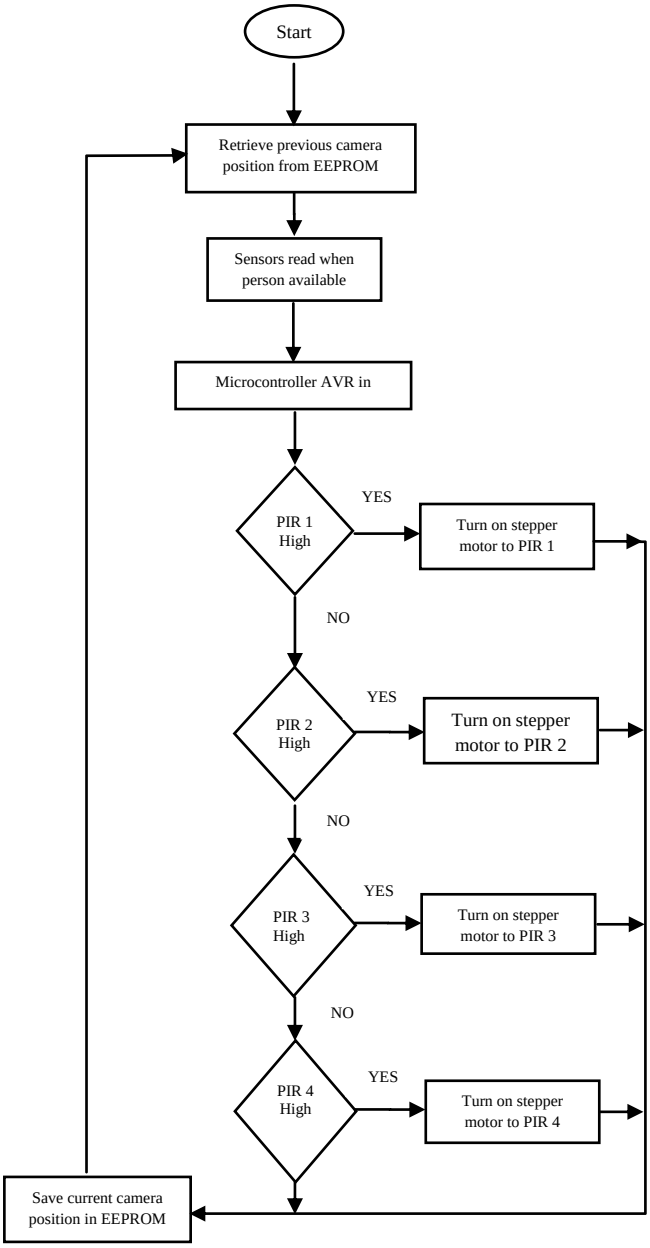

Fig. 8: Flowchart of the system

The software of the simulated system has been written in the following steps:

Step1: At the beginning of program, the variables must be declared using suitable function for each one.

Step2: Any program is written in Arduino language must use the necessary libraries which are related with used functions.

Step3: The pins (4, 5, 6 and 7) are used as digital inputs each one is connected with each PIR's. The function (pin mode) is used to introduce digital inputs.

Step4: The stepper motor that has been used is of (32) steps per internal revolution, but it has also a reduction gear box of 1:64 so it needs (32*64=2048) steps.

Step5: The function (myStepper.setspeed) is used to set the speed of stepper motor; in revolution per minute (r.p.m).

Step6: There is an infinite loop to complete the program.

Step7: Each PIR sensor which gives logic "1", its value will be saved in variable that is declared previously in step (1).

Step8: The variable above has saved the last value of any sensor which gives logic "1".

Step9: The angle in which the stepper motor's moving is according to the following instruction

(mystepper.step((p-pp)*256));

where :-

pp: The previous position which is saved from the last loop.

p: The current position which is read by the present loop.

Step10: The current position is pp=p is saved as the last position in EEPROM.

At the end: The program will be stayed in standby mode i.e. the system will check all the sensors at any time, and the angle of camera responds to the sensor which has active HIGH or logic "1.

4. PRACTICAL IMPLEMENTATION RESULTS

The practical results have been obtained using a camera that sweeps the angular displacement of the human when tracked from one PIR sensor region to the next PIR sensor region. The system has been tested in room with dimension of (7*7) m. Figure 9 shows the AutoCAD design of locations of the PIR sensors of the system.

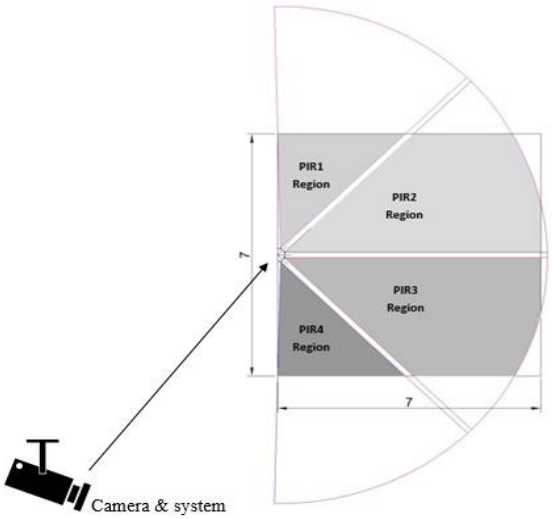

Fig. 9: Locations of the PIR sensors of the system

In the following the response of the practical implementation of the microcontroller unit and the stepper motor unit for each sensor will be shown.

This test has been done when the human moving at 4m distance from the sensors unit, and the human was tracked by each sensor. The following is the result of 4m case.

1. Human at PIR1

For the first sensor (PIR1), Figure 10 shows the output of the camera for the first sensor (PIR1).

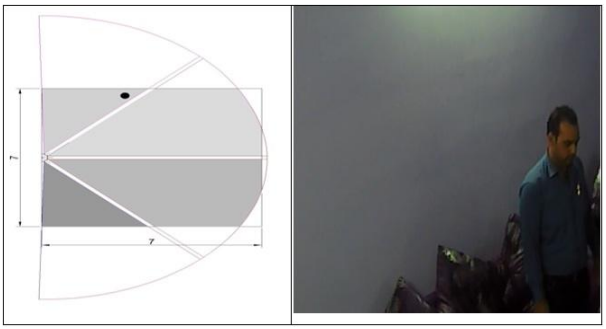

Fig.10: The output of the camera for the first sensor (PIR1).

2. Human at PIR2

For the second sensor (PIR2), Figure 11 shows the output of the camera for the second sensor (PIR2).

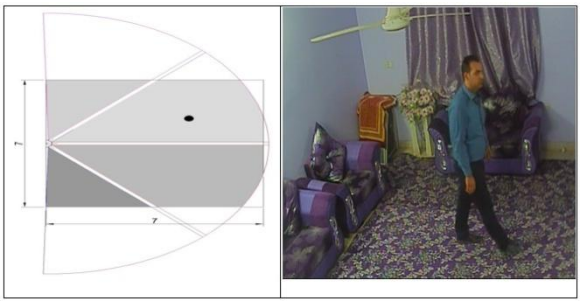

Fig. 11: The output of the camera for the second sensor (PIR2).

3. Human at PIR3

For the third sensor (PIR3), Figure 12 shows the output of the camera for the third sensor (PIR3).

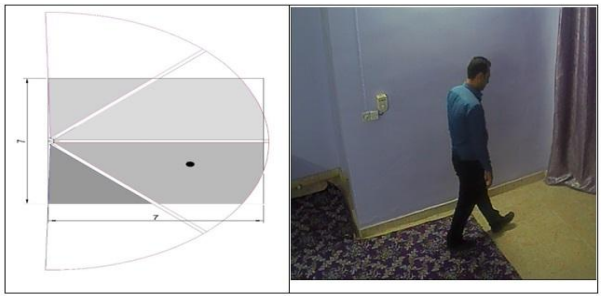

Fig. 12: The output of the camera for the third sensor (PIR3).

4. Human at PIR4

For the fourth sensor (PIR4), Figure 13 shows the output of the camera for the fourth sensor (PIR4).

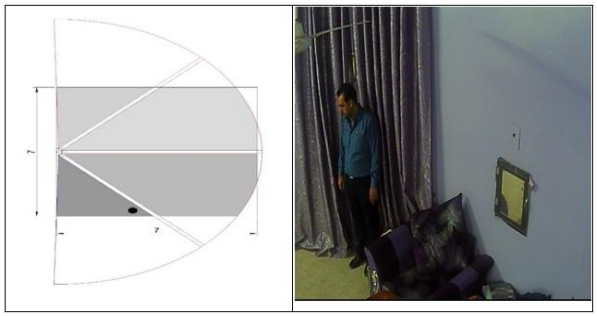

Fig. 13: The output of the camera for the fourth sensor (PIR4).

5. CONCLUSIONS

In this work, designing and implementation of a human detection and tracking system presented. This system is achieved by using four Pyroelectric Infrared (PIR) sensors, microcontroller and stepper motor. The proposed detection and tracking system is more efficient and accurate for human intruder detection .The system is able to track the human walking in complete round trip, as well as able to detect the human in a dark environment in the event of a change in the type of camera to night camera. The use of stepper motor in this system was very successful because its accurate rotation made the camera cover all of the room area. The Arduino microcontroller used in this system was very suitable because of its reliability in receiving signals from the PIR sensors, and controlling the stepper motor rotation in two directions. The power control unit played a remarkable role in reducing the power consumption of the overall system.

6. ACKNOWLEDGMENTS

Our thanks to University of Technology, especially, Department of Electrical Engineering for facilitating and supporting us with the requirements to fulfill the project.

7. REFERENCES

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