Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2017, 4 (6): 466-470

Research Article **ISSN: 2394 - 658X**

Implementation of Infra-Red Search and Track System

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ABSTRACT

Tracking is a process of determining current and past locations of a unique item or property. It is used to detect and locate targets when they moved and report new position. Another approach is to report the arrival or departure of the object and record the identification of the object, the location where observed, the time, and the status. This approach leaves the task to verify the reports regarding consistency and completeness. It is used in many fields whether it was industrial, martial, environmental studies, etc. In this paper the concept of Infra-Red Tracking System (IRST) is addressed. The system is analysed, simulated using Proteus, and then it has been implemented using appropriate components.

Keywords: Infra-Red Tracking System (IRST), Field of View (FOV), Objects Tracking, Infrared Homing, Reflectance, Emissivity

INTRODUCTION

Tracking the path of moving objects is an activity of a long history. People in ancient societies used to track moving prey to hunt and feed their children, invented ways to track the motion of stars for navigation purposes, and to predict seasonal changes in their environments. Object tracking has been an essential technology for human survival and has significantly contributed to human progress [1]. Object/target tracking refers to the problem of using sensor measurements to determine the location, path and characteristics of objects of interest. A sensor be any measuring device, such as radar, sonar, laser, camera, infrared sensor, microphone, ultrasound, or any other sensor that can be used to collect information about objects in the environment. The typical objectives of object tracking are the determination of the number of objectives, their identical, and their states; such as positions, velocities and in some case their features. A typical example of object /target tracking is the radar tracking of aircraft. The object tracking problem in this context attempts to determine the number of aircrafts in a region of surveillance, their types; such as military, commercial, or recreational, their identities, and their speeds and positions, all based on measurements obtained from radar [2]. There are a number of sources of uncertainly in the object tracking problem that render it a highly non-trivial task. For example, object motion is often subject to random disturbances, objects can go undetected by sensors and the number of objects in the field of view of a sensor can change randomly. The sensor measurements are subject to random noises and the number of measurements received by a sensor from one look to the next can vary and be unpredictable. Object may be close to each other and the measurements received might not distinguish between these objects. At times, sensors provide data when no object exists in the field of view [1]. The typical object tracking problem is essentially a state estimation problem where the object states to be estimated from noisy corrupted and false measurement are kinematic states like position, velocity, and acceleration, as shown in Fig. 1. The tracking system consists of: [2] An object or objects to be tracked, a sensor which measures some aspect of the object, a signal processor and an information processor.

Infrared Research and Tracking System (IRST) is widely used in modern defence, where infrared small moving target detection technology plays a crucial role [3]. Infrared search and track systems are wide field of view surveillance systems are wide field of view surveillance systems, designed for autonomous search, detection, tracking, classification and prioritization of potential targets. IRST system are becoming more and more important in air defence applications because radar do not meet the requirement of surveillance, suffer from jamming, and are vulnerable to anti-radiation missiles. Other reason for preference of IRST systems over radars is dramatic increase in IR sensor performance, resulting in long-range detection capability. On other hand, however, target is become less observable and the requirement of the user are becoming more stringent; e.g. larger Field of View (FOV), detection against dense and complex background target entering from all directions with high speeds, detection of point target at very long rangers, etc. In addition, IRST should be able to provide landing and flying-aid capability during night and bad weather conditions [4]. An IRST system, is a method for detecting and tracking objects which give off or reflect infrared radiation. IRST is generalized case of Reflected infrared (RFLIR), i.e. from forward-looking to all-round situation awareness. Such system is active (infrared radiation and detection), meaning they give out radiation from their own infrared radiation, like radar [5]. The typical objectives of object tracking are the determination of the number of objectives, their identical, and their states; such as positions, velocities and in some case their features. IRST systems are wide field of view surveillance systems, designed for autonomous search, detection, tracking, classification and prioritization of potential targets [6].

Infra-red (IR) is invisible radiant energy, electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of visible spectrum at 700 nanometres (frequency 430 THz) to 1 mm (30 GHz). Most of the thermal radiation emitted b objects near room temperature is infrared. Infrared is usually measured using a thermal detector such as thermopile, which measures temperature change due to absorbed energy. While these thermal detectors have a very flat spectral responsively, they suffer from temperature sensitivity, and usually must be artificially cooled. Another strategy employed by thermal detectors is by modulating incident light with a chopper. This allows the detector to measure deferentially between the dark (zero) and light states. Quantum type detectors are often used in the near infrared, especially below 1100 nm. Specialized detectors such as alternatively Indium Gallium Arsenide (InGaAs) offer excellent responsively from 850 to 1700 typical silicon photodiodes are not sensitive above 1100nm, as in Fig. 2 [7].

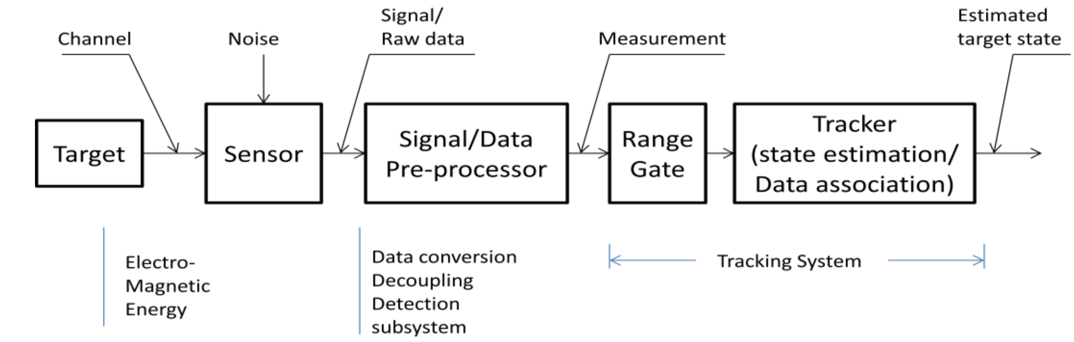

Fig. 1 Typical object tracking system

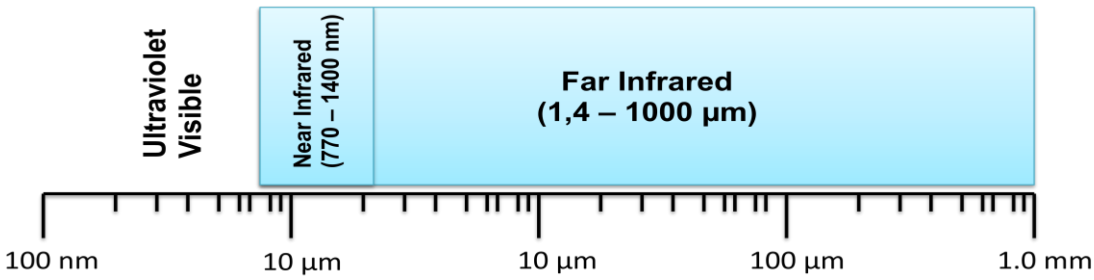

Fig. 2 The Infra-Red spectrum

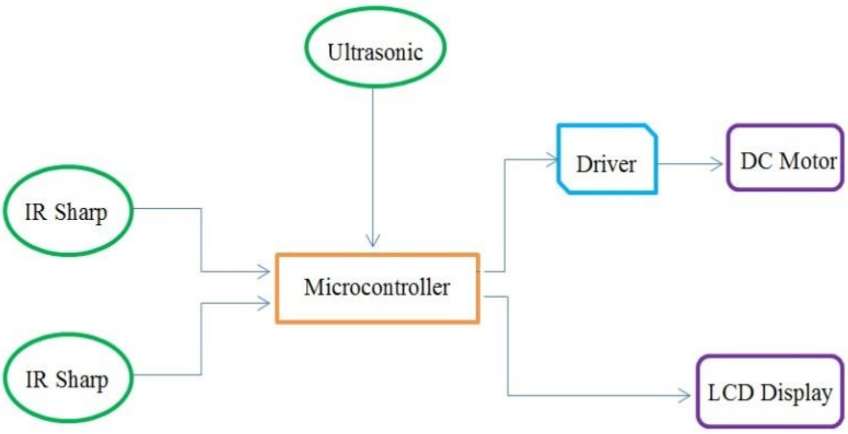

Fig. 3 System block Diagram

SYSTEM HARDWARE CONSIDERATIONS

The system of this study was built with two sensors; each one contained the IR transmitter and IR receiver. The main idea was that when an object enters the range of any one of the sensors, the motor turns right or left as micro-controller commands. The module is shown in Fig. 3.

8-Bit AVR Microcontroller

The AVR core combine a rich instruction set with 32 general purposes working registers, all the 32 registers are directly connected to the ALU allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional microcontroller.

IR Sensor

The sensor that is used in this study is active sensor; active infrared sensors consist of two elements: infrared source and infrared detector. Infrared source includes an LED or infrared laser diode. Infrared detectors include photodiodes or phototransistors. The energy emitted by the infrared source is reflected by an object and falls on the infrared detector as shown in Fig. 4. Infrared transmitter is a Light Emitting Diode (LED) which emits infrared radiations. Hence, they are called IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye. Infrared receivers are also called infrared sensors as they detect the radiation from an IR transmitter. IR revivers come in the form of photo diodes and phototransistors. Infrared photodiode is different from normal photo diodes as they detect only infrared radiation. The principle of IR sensor working as an object detection sensor can be explained in Fig. 4. An IR sensor consists of an IR LED and IR photodiode; together they are called Photo-Coupler. When transmitter emits radiation it reaches the object and some of the radiation reflect back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined [8].

Ultrasonic Ranger

Ultrasonic sensors (also known as transceivers when they both send and receive, but more generally called transducers) work on a principle similar to radar or sonar, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. The ultrasonic sensor measures the distance of the object at some particular angle if its distance is less than 30cm (motor 1 stops), and then sends that particular angle to the motor 2, having antenna at its top which will align to the direction of detected object and then communicate with that object. Thus, the functionality of the entire system has been tested thoroughly and presented in this paper [9]. Active ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echoes to determine the distance of an object. While, passive ultrasonic sensors are basically microphone that detects ultrasonic noise that is present under certain conditions, the ranger of the target is determined by the time lagging between transmitted pulse and the received echo. So microwave and ultrasonic frequencies are used in radars as shown in Fig. 5 [10].

SYSTEM IMPLEMENTATION AND TESTING

The proposed system was implemented as shown in Fig. 6. The system uses two sensors to determine the location of the object. Infra-red sensors detect the electromagnetic radiations of the transmitter reflected from the object. As shown in Fig. 7, two IR sensors were located at the top of the motor, then the motor turn left and right as the object moves. Results are shown on LCD display.

SYSTEM SOFTWARE CONSIDERATIONS

The system is programmed by Beginner's All-purpose Symbolic Instruction Code (BASIC) language, which it is a family of general-purpose, high-level programming languages where its design emphasizes ease of use. The code for this system is organized as a number of functions that are defined within the modules which they are related to. The flow chart of the code is shown in Fig. 8.

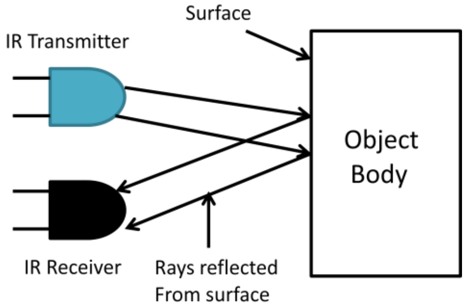

Fig. 4 Active IR sensor

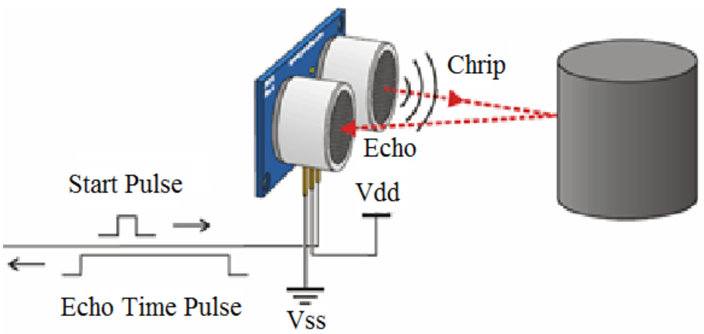

Fig. 5 Ultrasonic working principle

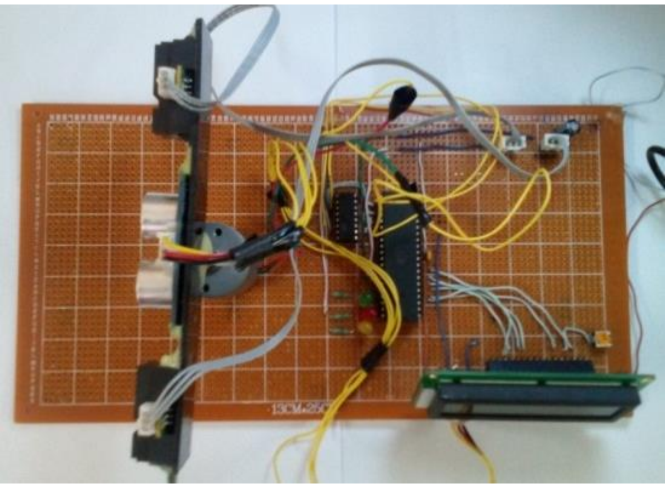

Fig. 6 System module

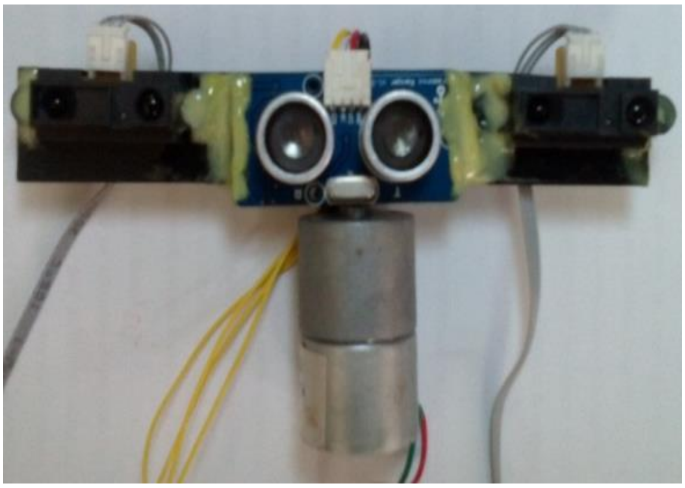

Fig. 7 Motor with IR sensors and ultrasound

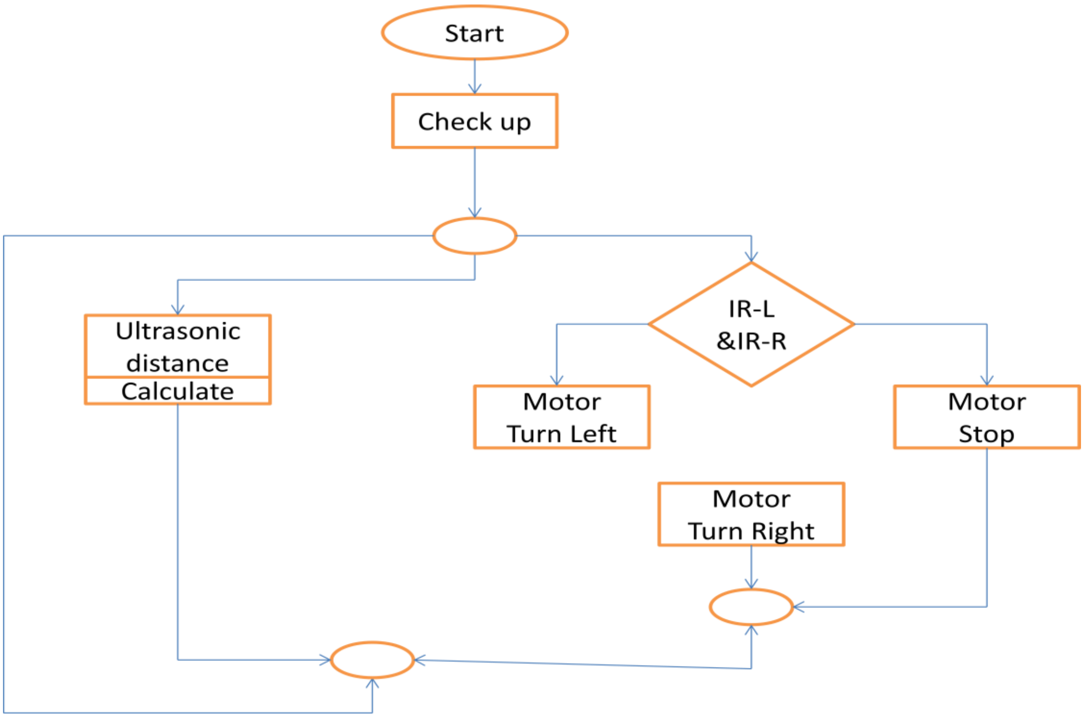

Fig. 8 System flow chart

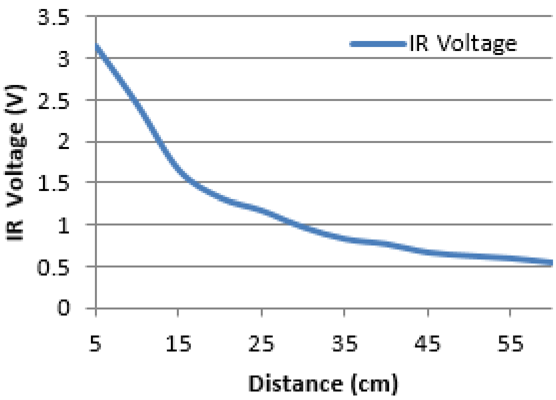

Fig. 9 IR-voltage versus distance

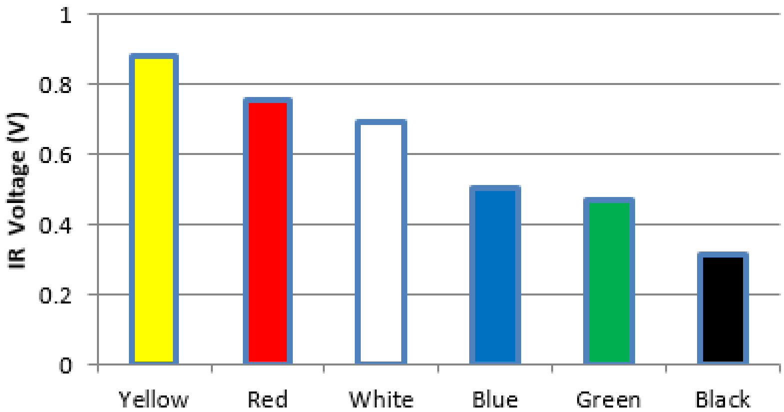

Fig. 10 Color effects on reflection

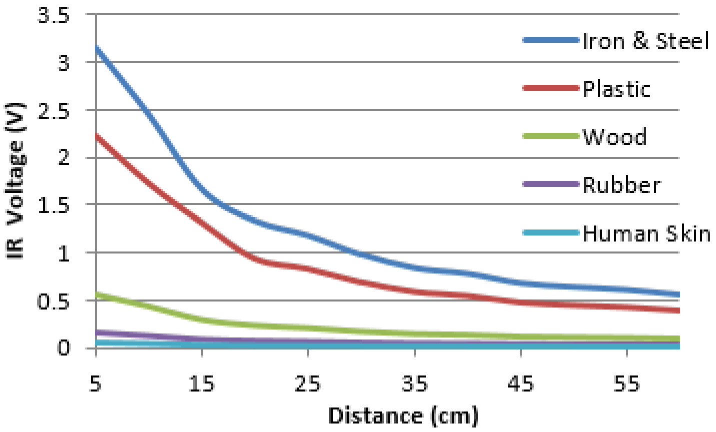

Fig. 11 IR-voltages for different material

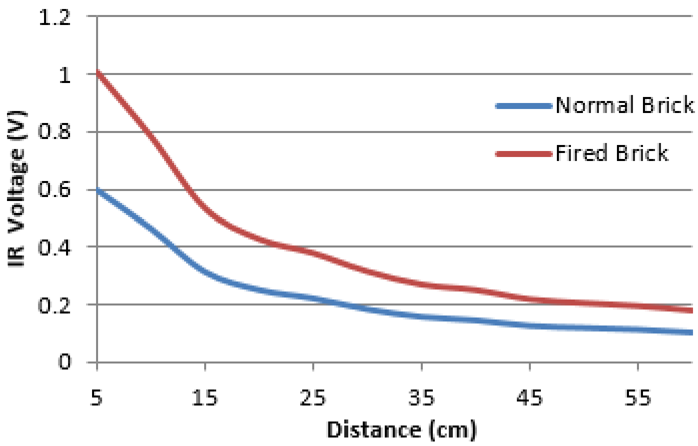

Fig. 12 IR voltages for normal and fired brick

EXPERIMENTAL RESULTS

A number of experiments were carried out. In each experiment the output voltages are measured corresponding to the distance (cm). The basic principle is that the output voltage of IR sensor is recorded for different object location.

Voltages Versus Distance

Fig. 9 shows the voltage of the sensor with different distance location of the object. The sensor voltage decreased as the object goes far from sensor.

Color Effects

Papers with different colors and same sizes were used to measure the effect of the object colors on IR reflecting. As shown in Fig. 10, the distance is fixed at 5cm and objects with different colors (white, black, green, dark blue, red, and yellow) were subjected to the system. the yellow color has the highest voltage and the black color has the lowest one.

Different Materials

Fig. 11 shows the IR sensor output voltage which is reflected from different material objects versus distances. Iron and steel material have high reflection compared with other materials. Fig. 12 shows differences between normal and fired two identical materials – brick.

CONCLUSION

In this paper the concept of Infra-Red Tracking System (IRST) has been designed and tested successfully. The system has been implemented by using appropriate hardware components used. It has been observed that the output voltages of IR sensor decreased when object moves away from the sensor, that is due to increase of voltage drop when distance increased. Also it was noticed that the fired brick reflects more IR than the normal brick due to emissivity of the fired brick was lower than the emissivity of the normal one.

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