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Archetype Infrared Detection and Ranging System

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ABSTRACT
In The industry has always focused to devise engineering methodologies for establishment and modification of relatively easier methods for any exhaustive process. A number of different technologies have been developed suitable for the detection of the motion or presence of a target at shorter or longer distances. Most of them make use of a small portion of the electromagnetic spectrum, usually ranging from visible light over infrared radiation to radio waves. Specifically for detecting the direction and speed of an unidentified object, Radar detectors using the microwave region produce good results [1],[2]. However the major problem with the microwave Radar systems is that they can be easily detected [3].

Infrared (IR) detectors fall into both the active and passive categories. The paper presents a comparison of the said categories for IR-based ranging and detection. This paper demonstrates the design of detection and ranging unit capable of performing scans of a target at short range. The prototype system uses a PC GUI interface. The model is experimentally tested using the PC-based system and some interesting results were found in the process and in the comparison of various technologies.

General Terms
Ranging system, RADAR

Keywords
Active RADAR, Passive RADAR, IR based system, object detection.

1. INTRODUCTION
RADAR is a system that uses radio waves to detect, determine the direction and distance and/or speed of objects such as aircraft, ships, terrain or rain and map them. A transmitter emits radio waves, which are reflected by the target, and detected by a receiver, typically in the same location as the transmitter. Although the radio signal returned is usually very weak, radio signals can easily be amplified. Radar is used in many contexts, including meteorological detection of precipitation, air traffic control, police detection of speeding traffic, and by the military [4]. Our paper uses IR ranging to detect objects rather than the radio waves. This change in ranging method will not result in a change of features or principle[5]; hence it can be classified as a Radar demonstrator. In this paper we used IR rather than radio waves it can be called a archetype Infra-Red Detection and Ranging System (AIRDARS). The only limitation or downside of using IR instead of radio ranging is the limited range offered by the IR, but as the intention of this paper is merely to simulate the working principles of the radar we are not interested in a huge radar coverage area, it will not affect our idea. An AIRDARS has wide ranging applications and uses in industrial and educational. The AIRDARS is cheaper and much smaller to implement than the RADAR A more advanced passive version of the AIRDARS known as IRST (Infra-Red Search and Tracking) is used by military aircraft to detect enemy aircraft under heavy electronic warfare environments were conventional radars can’t operate because of electronic jamming. The IRST is found on most 4.5 generation fighters and can detect targets by the infra-red emissions in the air caused by aircraft engine exhaust. A laser range finder is then directed towards the target to determine its exact range. IRST has a maximum range of 15km and at short ranges it is more accurate and more feasible to implement than conventional radars, so it is also used as a seeker on most short range (visual range) missile guidance systems.

2. OBJECTIVE
The purpose of the work is to explore the diversity of ranging and detection systems over the various ranges of the electromagnetic spectrum. We channelize our main focus for the need and development of the Radar systems using the Infra-red range. The main objectives are as follows:

- The prototype model is especially suited to radar applications were the ranging area is small.
- The AIRDAR is used as a means of guidance for research and industrial robots.
- An increasing number of industrial systems use this process as a means of proximity detection and alignment assistance.
- In educational institutes the AIRDARS can be used to train people on working principles of conventional Radar while avoiding the hurdles of costs and maintenance associated with it.

3. SYSTEM DESIGN
This section discusses the prototype system design and the workflow required by the different blocks used in order to make the system tested. The main challenge during the manufacturing was the trial and error calibration of the IR transceiver (Tx/Rx) modules as well as devising a method to implement the processes. We had to put a lot of effort in determining which type of techniques we would use to implement our tasks. The range of alternatives or options in order to perform each task was numerous and we had to carefully analyze them. The Schmitt trigger, stepper motor drive and interrupt systems were each selected after consideration of availability of parts and our ability to actually implement them. The model consists of a containing the circuitry, stepper motor mechanism and the transducers. A

Tx/Rx mount unit emerges out of the main housing's top; this mount unit is capable of free rotation with the help of attached resistance eliminating ball bearings. The mount is driven by a belt attached to suitably powered stepper motor. All the ICs are CMOS and operate at 5V DV. An attached power supply unit provides the required 5V DC after step down and regulation from 220V AC. An LCD module and a serial interface slot are attached to the main housing for output. On power up, the first thing the device does is to reset the IR Tx/Rx mount unit's position to 0deg. Once at reset position the Tx/Rx mount unit begins to sweep for targets, its motion is between 0 deg to 270 deg, the cycle is repeated back and forth. This motion is controlled by the microcontroller via stepper motor driver IC. The IR Tx module emits mid-range infra-red emissions which are received by an IR Rx module. The IR Rx module emits a voltage output whose strength varies according to the strength of the signal received which is determined by the distance of any target reflecting the IR signal from the transmitter. Once a target is detected an interrupt is sent to the microcontroller through a Schmitt trigger circuit. The microcontroller quickly locks the stepper motor on to the target and calculates the angle of the target. The microcontroller also receives a digitized signal from the analog to digital converter indicating the distance of the object. Both the information regarding angle and distance are then displayed onto the LCD module as well as relayed to the PC via serial port. Once the target is removed out of ranging distance the microcontroller unlocks the stepper motor and continues the sweep for locating another target in its vicinity.

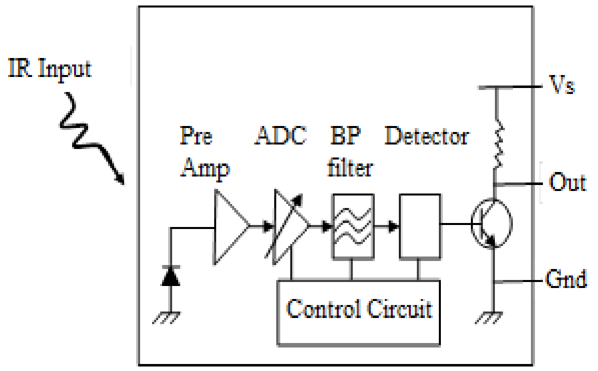


Fig 1: Architecture of the proposed algorithm

4. DESCRIPTION OF FUNCTIONAL BLOCKS

To best illustrate the performance and working of the model, the different functional blocks are distinguished. These blocks operate in conjunction with one another to make the model work properly. The separated functional blocks of the proposed model in form of a basic block diagram is illustrated here in Figure 2, which is reflecting the actual working progress of the detection and ranging system, the function being performed by each block is mentioned below.

4.1 Infra-Red (IR) Transmitter

The oscillator will be used to generate a square wave at a predetermined frequency. The wave is fed into a transistor that drives an infrared LED on and off very rapidly. Because the emissions are infrared and very fast, neither is visible to the human eye.. If used for object detection, the signal needs to travel the distance to the object, bounce off the object, and then travel the distance back to the receiver. So, distance becomes a factor.

4.2 IR Receivers

Although it's possible to decode IR control signal with nothing more than a photodiode or phototransistor, to work well these devices required significant ancillary circuitry, rather than reinvent the mousetrap we will use an inexpensive IR receiver module. Because infrared receivers amplify the signal to improve detection, electrical noise generated from the oscillator can leak into the receiver and trigger a false detection. Therefore, transmitter and receiver circuits must be carefully designed and positioned apart to be useful. Inexpensive infrared receiver chips are available at 36 kHz, 38 kHz, and 40 kHz. The receivers are sensitive to oscillations several kilohertz to either side, although reception distance improves with a better signal to start with.

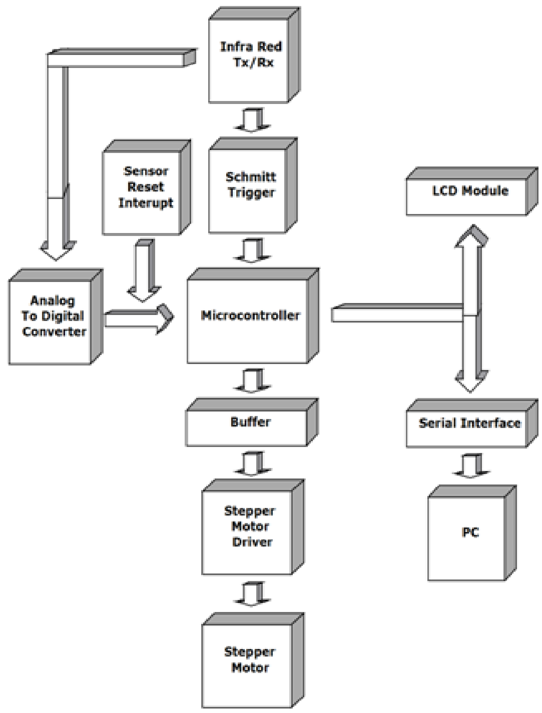


Fig 2: Architecture of the proposed algorithm

4.3 Schmitt Trigger

In order to generate an interrupt signal which the microcontroller can interpret, a Schmitt trigger circuit is used. Regardless of what type of input level the IR receiver gets the Schmitt trigger circuit generates a high signal whenever there is an input signal caused by the reflection off of a target. The high signal from the Schmitt trigger is sent to the P3.2 pin of the microcontroller, this alerts the microcontroller of an object in the vicinity and it locks the stepper motor and calculates range and angle. The reference voltages for the output of the Schmitt trigger are set by variable resistance In order to prevent the Schmitt trigger from any influence from negative input signal when there is no target a very high resistance (1M ohm) connects it to Vc.

4.4 Analog to Digital Converter

An ADC 0804 analog to digital converter IC is used to translate the analog signal from the IR Rx to the microcontroller in quantitative terms. The ADC 0804 is designed specifically to be used with microcontrollers and requires minimal circuitry for interfacing.

4.5 Microcontroller

We have chosen to use the Atmel 89C51 Microcontroller on our project. The microcontroller was very suited for our task and we had considerable experience using it in our regular course work. The microcontroller takes in three inputs, one is the interrupt for target found on P3.2, the second interrupt P3.3 is the switch which gives feedback on the reset position of the sensor module position and the third input P1.0-P1.7 is the digitized data from the analog to digital converter indicating the distance of target. Calculations are done using clever logic functions and the output is transmitted serially to a PC and displayed on an LCD via P0. The programming for the microcontroller was done using Assembly language and after compilation into machine language was transferred onto the microcontroller through a programmer.

4.6 LCD Module

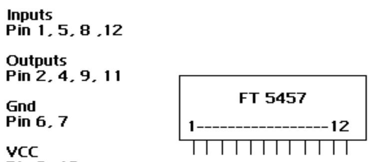
The output of the microcontroller is displayed on a Liquid Crystal Module (LCM). This module is of 2 line, 16 character type. The LCM offers ease of use as it contains internal driver for the LCD and all that is required for use is to interface data lines with microcontroller and initializing with assembly language.

4.7 Buffer

A Buffer IC is used to store the contents of the microcontroller for the stepper motor driver. The IC used for the purpose is the 74LS245 which is an Octal Bus Transceiver. Here the buffer will only be used as a transmitter.

4.8 Stepper Motor Driver and Mechanism

In order to rotate the Tx/Rx sensors we have made a stepper motor mechanism. The stepper motor is controlled by the microcontroller through a FT 5057 Stepper Motor Driver (SMD). The SMD is capable of providing the full 5A load current required by the stepper motor. There is a buffer IC interconnecting between the microcontroller and the SMD.



Stepper Motor Driver

The 5457 SMD IC was extremely difficult to find and in its internal architecture it contains 4 H-Bridge circuits, one for each data line. This allows the stepper motor to be powered by an external source other than the microcontroller.

The stepper motor is linked to the sensor module via belt drive mechanism. The stepper motor rotates at 1.9 steps per rotation. The sweep area of the sensor module is between 0deg to 270deg. Once a sweep is complete the motor starts rotating in opposite direction and then vice versa. This process continues until a target interrupt is sent to the microcontroller.

- Make : Mini Angle Stepper
- Volt : max 6.5V
- Hz : 50 / 60
- Current : 0.75A
- Deg/Ste : 1.8deg

The stepper motor provides the following advantages:

1. The rotation angle of the motor is proportional to the input pulse.

2. The motor has full torque at standstill (if the windings are energized)

3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of

3 – 5% of a step and this error is non-cumulative from one step to the next.

4. Excellent response to starting/stopping/reversing.

5. Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependent on the life of the bearing.

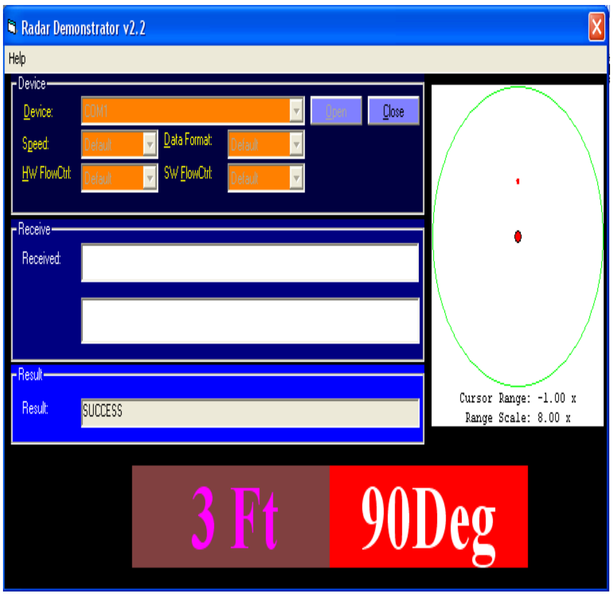
6. The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.

7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

5. SERIAL INTERFACE

This is a basic RS-232 transmit/receive circuit that is necessary for PIC microcontrollers to reliably communicate with a PC serial port. It is necessary because the RS-232 specification requires that the signal levels be Â±3-15 Volts and unfortunately the PIC microcontroller operates at TTL levels (0-5 Volts).



The MAX233 is an IC that allows you to convert microcontroller voltages to RS-232 compatible levels with no required external components. A MAX233 is used to convert the logic level signals of the PIC microcontroller to RS-232 compatible voltage levels. Technically the MAX233 is a RS-232 line driver/receiver, but an easier way to explain its operation is that it allows a PIC microcontroller to communicate at RS-232 voltage levels with a computer. The MAX233 should nominally be run at 5 volts input pulses.

6. GRAPHICAL USER INTERFACE

The program is based around the ActiveComport Serial Port Toolkit by ActiveXperts Software B.V. The toolkit provides all the necessary functions for serial interfacing and recognition of bits. The graph of the radar is made by using the radar.ocx component file. A self-installing package file is provided with the project and this software can be installed on any computer by simply running the setup file.

7. EXPERIMENTAL RESULTS

The testing model of the AIRDAR was created to simulate the operation of the proposed radar. The test model was experimented with numerous possible scenarios, varying from target positions with respect to range and direction, and also colour of the object to be detected and some very interesting results were found out. The performance of the proposed AIRDAR was found very satisfactory and the objects were detected precisely on every test run.

8. CONCLUSION

The paper discusses the effects and uses of IR in the ranging and detection domain. A prototype model was developed for ranging and detection system of objects at short range. Apart from the benefits discussed in the above section the other benefits and conclusion drawn from this paper can be that, as far as the system is concerned, the same system is suitable not only for simple and similar applications but also for application in many different areas like it can be used for monitoring in military, robotics or any other application where decision making is required on the basis of some sensor inputs, finding, detecting and ranging objects. This paper shows the use of the said system with the assist of the PC based interface, however for future purposes, if a impartial system with more enhanced features with smaller size and one which is also portable the design may include the infrared search and tracking system for military aircraft.

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