Research Article

AUTONOMOUS MISSILE DEFENSE SYSTEM: INTEGRATING ADVANCED SONAR-BASED TRACKING FOR PRECISE DETECTION

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ABSTRACT

The objective of this project is to develop and build an automated system for detecting and neutralizing missiles. This system is specifically engineered to identify and track the target (missile) while it maneuvers in various directions. The automated target destruction system tracks the missile's trajectory and engages it by precisely aligning and firing onto the target. This system comprises an advanced sonar-based object tracking system that continuously monitors the target. Once the target is detected, it transmits the precise location of the target to a Central Control System. The Central Control System initiates the movement of the firing mechanism towards the target (missile). After correcting the orientation, it transmits the control command to the firing system in order to launch an attack on the target. This project utilizes an ultrasonic radar system and a DC geared motor-powered firing device that is connected to a Microcontroller based control unit. We choose the use of ultrasonic sensors due to their ability to cover a greater detecting distance and detect targets under various illumination circumstances, including both day and night. Microcontroller programming is accomplished using the Embedded 'C' language. This article has undergone processing in order to minimize human labor and fully automate the missile system. This results in reduced human error and more precision in system processing. This survey outlines the many approaches to automating the missile guidance system using maneuverable actuators. The diverse concepts pertaining to the automation system and the design modules will facilitate the exploration of multiple approaches in relation to the automation system.

Keywords: *Arduino controller, missile tracking, ultrasonic sensor, laser beam, DC motor.*

1. INTRODUCTION

In an era characterized by evolving geopolitical landscapes and technological advancements, the need for robust defense systems has become paramount [1]. One critical aspect of modern defense infrastructure is the development of automated systems capable of detecting and neutralizing potential threats. This project focuses on the creation of an advanced Autonomous Missile Defense System, designed to autonomously identify, track, and neutralize incoming missiles with a high degree of precision. The primary objective of this project is to engineer a system that can operate seamlessly in dynamic and unpredictable scenarios, where the trajectory of incoming missiles may vary significantly. By combining cutting-edge technologies, such as advanced sonar-based object tracking, ultrasonic radar sensors [2], and a Microcontroller-based control unit, we aim to achieve a level of automation that minimizes human intervention, reduces errors, and enhances the overall efficiency of the missile defense process. The significance of this project lies in its potential to address the increasing complexities and challenges associated with missile threats [3]. Traditional defense mechanisms often rely heavily on manual intervention, which introduces the risk of human error and may not provide the speed and precision required to counter rapidly maneuvering missiles. By leveraging automation, we aim to create a system that can respond swiftly and accurately to incoming threats, thereby enhancing the overall security and effectiveness of defense infrastructure [4].

Advancements in Tracking Technology: The foundation of our Autonomous Missile Defense System lies in the integration of an advanced sonar-based object tracking system. Sonar, known for its effectiveness in underwater applications, has been adapted to create a sophisticated tracking mechanism for airborne targets. This system continuously monitors the trajectory of incoming missiles, providing real-time data on their position and movement. The utilization of sonar technology adds a layer of versatility, allowing the system to operate effectively in various environmental conditions, including adverse weather and low-visibility situations.

Ultrasonic Radar Sensors for Enhanced Detection: The system incorporates ultrasonic radar sensors, a choice motivated by their ability to cover substantial detecting distances while remaining effective in both day and night scenarios. These sensors play a pivotal role in the initial detection phase, working in tandem with the sonar-based tracking system. Their capacity to operate in diverse lighting conditions ensures the system's reliability in a range of environments, contributing to the system's adaptability and effectiveness.

Microcontroller-based Control Unit: The heart of the Autonomous Missile Defense System lies in the Microcontroller-based control unit. Programming in Embedded 'C' language, this control unit acts as the brain orchestrating the entire defense mechanism. Upon receiving data from the tracking system, the control unit processes the information, calculates the optimal response, and issues precise commands to the firing mechanism. This level of automation not only accelerates the response time but also ensures a coordinated and accurate engagement with the incoming threat.

Minimizing Human Labor and Error: One of the fundamental goals of this project is to minimize human involvement in the missile defense process. The automation introduced through the integration of advanced technologies significantly reduces the reliance on manual intervention, decreasing the likelihood of errors and enhancing overall system efficiency. By mitigating the impact of human-related factors, the Autonomous Missile Defense System aims to provide a more reliable and consistent defense against missile threats.

Overall, the Autonomous Missile Defense System presented in this project represents a significant leap forward in the realm of missile defense technology. By amalgamating advanced tracking technologies, ultrasonic radar sensors, and precise control mechanisms, this system aims to create a defense infrastructure capable of autonomously detecting and neutralizing incoming threats. The ongoing research and development in this field not only contribute to the enhancement of defense capabilities but also pave the way for future innovations in autonomous security systems.

2. LITERATURE SURVEY

"The Idea" Army, Navy and the Air Force make use of this technology. The use of such technology has been seen recently in the self-parking car systems launched by AUDI, FORD etc. And even the upcoming driverless cars by Google like Prius and Lexus. This setup can be used in any systems the customer may want to use like in a car, a bicycle or anything else. The use of Arduino in this provides even more flexibility of usage of the above-said module according to the requirements. The idea of making an ULTRASONIC RADAR came as a part of a study carried out on the working and mechanism of "mini radar". Hence this time we were able to get a hold of one of the Arduino boards, Arduino UNO. So knowing about the power and vast processing capabilities of the Arduino, we thought of making it big and a day to day application specific module that can be used and configured easily at any place and by anyone. Moreover, in this fast moving world there is an immense need for the tools that can be used for the betterment of the mankind rather than devastating their lives. Hence, from the idea of the self-driving cars came the idea of selfparking cars. The main problem of the people in the world is safety while driving. So, this gave up a solution to that by making use of this project to continuously scan the area for traffic, population etc.

After going through some of the papers regarding RADAR implementation using ultrasonic sensor we found that this concept is quite sought everywhere and is a popular concept which is still in progress. These papers had some really innovative ideas for prevention from accidents and driving safer. The techniques that were illustrated were par excellence and can bring about a major change in the field of automobiles. The technologies used were not only efficient and reliable but also economically feasible. This paper deals this deals the major causes of accidents and the simple ways in which they can be prevented. The existing system uses microcontroller and LCD display, we have used Arduino UNO and MATLAB for respective purposes. Our major aim is display the obstacle position as accurately as possible. and as well as protection of the vehicles at the same time to prevent accidents or minor scratches to the vehicles.

3. PROPOSED SYSTEM

Arduino is an open-source project that created microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices. The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog input/output (I/O) pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C. The projected system uses an ultrasonic module interface to microcontroller of ARDUINO family. An ultrasonic transducer encompasses a transmitter, and the receiver is worn. The transmitted waves had been meditated from the object and acquired by way of the transducer again. the overall time taken for sending the waves to receive it become calculated by way of taking into apprehension the rate of sound. Then the distance is calculated via the program going for walks at the microcontroller and displayed on a liquid crystal displayed (liquid crystal display) display screen interfaced to the microcontroller.

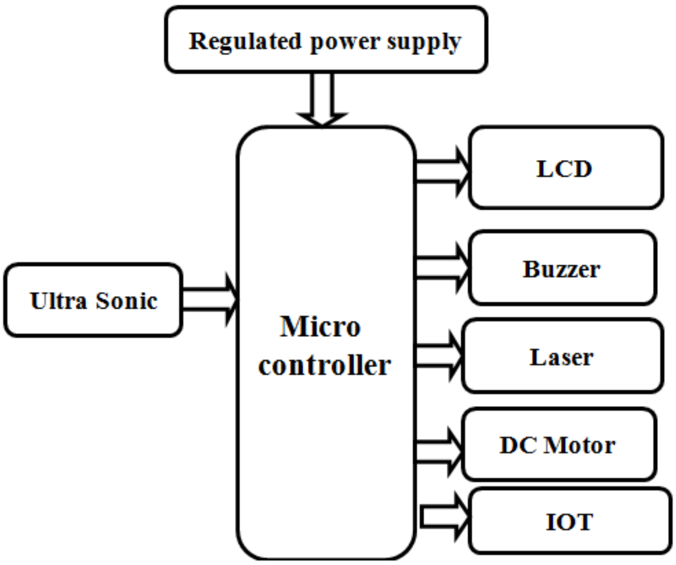

Fig. 1: Block diagram

ARDUINO

The Arduino Uno R3 is a open source microcontroller board based on the ATmega328 chip. This Board has 14 digital input/output pins, 6 analog input pins, Onboard 16 MHz ceramic resonator, Port for USB connection, Onboard DC power jack, An ICSP header and a microcontroller reset button. It contains everything needed to support the microcontroller. Using the board is also very easy, simply connect it to a computer with a USB cable or power it with DC adapter or battery to get started. The recommended range is 5v to 12v for Arduino Uno.

Fig. 2: Arduino

FEATURES:

Microcontroller: ATmega328P, Operating Voltage: 5V, Input Voltage: 7-12V, Digital I/O Pins: 14 (of which 6 provide PWM output), Analog Input Pins: 6, DC Current: 40mA, Flash Memory: 32 KB, SRAM: 2 KB, EEPROM: 1 KB, Clock Speed: 16 MHz

LCD MONITOR

Liquid Crystal Display used to display the parameters for status of the proposed system. This can display 32 characters having 2 columns. When each sensor is activated, corresponding massage will be displayed in 16*2 LCD modules. In this we use four data pins using these pins we transfer the data from micro preprocessor to LCD.

IOT- MODULE

Internet of things used for controlling any device or monitoring the device status through internet. This proposed system we use this IOT module for taking all parameters data and post into the cloud called server. ESP8266 modules as IOT module it can operate through Wi-Fi frequency concept.

BUZZER

Buzzer is the output module for alerting of any parameter changes. if any sensor increases the threshold value or if increases then microprocessor alert us by using this system.

SOFTWARE

Software is the important parameter to make the device automation. In proposed implementation we used embedded c programming language and compiler Arduino IDE we used. Here we used Arduino IDE software for programming write up and execution of entire system.

ULTRASONIC SENSOR

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo. As the distance to an object is determined by measuring the time of flight and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background interference. Virtually all materials which reflect sound can be detected, regardless of their color. Even transparent materials or thin foils represent no problem for an ultrasonic sensor. Micro sonic ultrasonic sensors are suitable for target distances from 30 mm to 10 m and as they measure the time of flight they can ascertain a measurement with pinpoint accuracy. Some of our sensors can even resolve the signal to an accuracy of less than 0.18 mm. Ultrasonic sensors can see through dust-laden air and ink mists. Even thin deposits on the sensor membrane do not impair its function. Sensors with a blind zone of just 30 mm and an extremely narrow beam spread are finding totally new applications these days: measuring levels in yoghurt pots and test tubes as well as scanning small bottles in the packaging sector - no trouble for our sensors. Even thin wires are reliably detected.

TARGET AIMING GUN: LASER

A laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on the stimulated emission of photons. The term "laser" originated as an acronym for Light Amplification by Stimulated Emission of Radiation. The emitted laser light is notable for its high degree of spatial and temporal coherence, unattainable using other technologies. Spatial coherence typically is expressed through the output being a narrow beam which is diffraction-limited, often a so-called "pencil beam." Laser beams can be focused to very tiny spots, achieving a very high irradiance. Or they can be launched into a beam of very low divergence in order to concentrate their power at a large distance. Temporal (or longitudinal) coherence implies a polarized wave at a single frequency whose phase is correlated over a relatively large distance (the coherence length) along the beam.[3] A beam produced by a thermal or other incoherent light source has an instantaneous amplitude and phase which vary randomly with respect to time and position, and thus a very short coherence length. Most so-called "single wavelength" lasers actually produce radiation in several modes having slightly different frequencies (wavelengths), often not in a single polarization. And although temporal coherence implies monochromatic, there are even lasers that emit a broad spectrum of light or emit different wavelengths of light simultaneously. There are some lasers which are not single spatial mode and consequently their light beams diverge more than required by the diffraction limit. However, all such devices are classified as "lasers" based on their method of producing that light: stimulated emission Lasers are employed in applications where light of the required spatial or temporal coherence could not be produced using simpler technologies.

DC MOTOR

A dc motor uses electrical energy to produce mechanical energy, very typically through the interaction of magnetic fields and current-carrying conductors. The reverse process, producing electrical energy from mechanical energy, is accomplished by an alternator, generator or dynamo. Many types of electric motors can be run as generators, and vice versa. The input of a DC motor is current/voltage, and its output is torque (speed). The DC motor has two basic parts: the rotating part that is called the *armature* and the stationary part that includes coils of wire called the *field coils.* The stationary part is also called the *stator.* Figure shows a picture of a typical DC motor, Figure shows a picture of a DC armature, and Fig shows a picture of a typical stator. From the picture you can see the armature is made of coils of wire wrapped around the core, and the core has an extended shaft that rotates on bearings. You should also notice that the ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the *commutator,* and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine.

4. RESULTS AND DISCUSSION

The project "Missile tracking and auto collision system" was designed such that the design and construct automatic missile detection and destroying system. This system is designed to detect the target (missile) moving in multiple directions. The target destroying system moves automatically in the direction of missile and fires it upon fixing the target. The projected system uses an ultrasonic module interface to microcontroller of ARDUINO family. An ultrasonic transducer encompasses a transmitter, and the receiver is worn. The transmitted waves had been meditated from the object and acquired by way of the transducer again. the overall time taken for sending the waves to receive it become calculated by way of taking into apprehension the rate of sound. Then the distance is calculated via the program going for walks at the microcontroller and displayed on an liquid crystal displayed (liquid crystal display) display screen interfaced to the microcontroller.

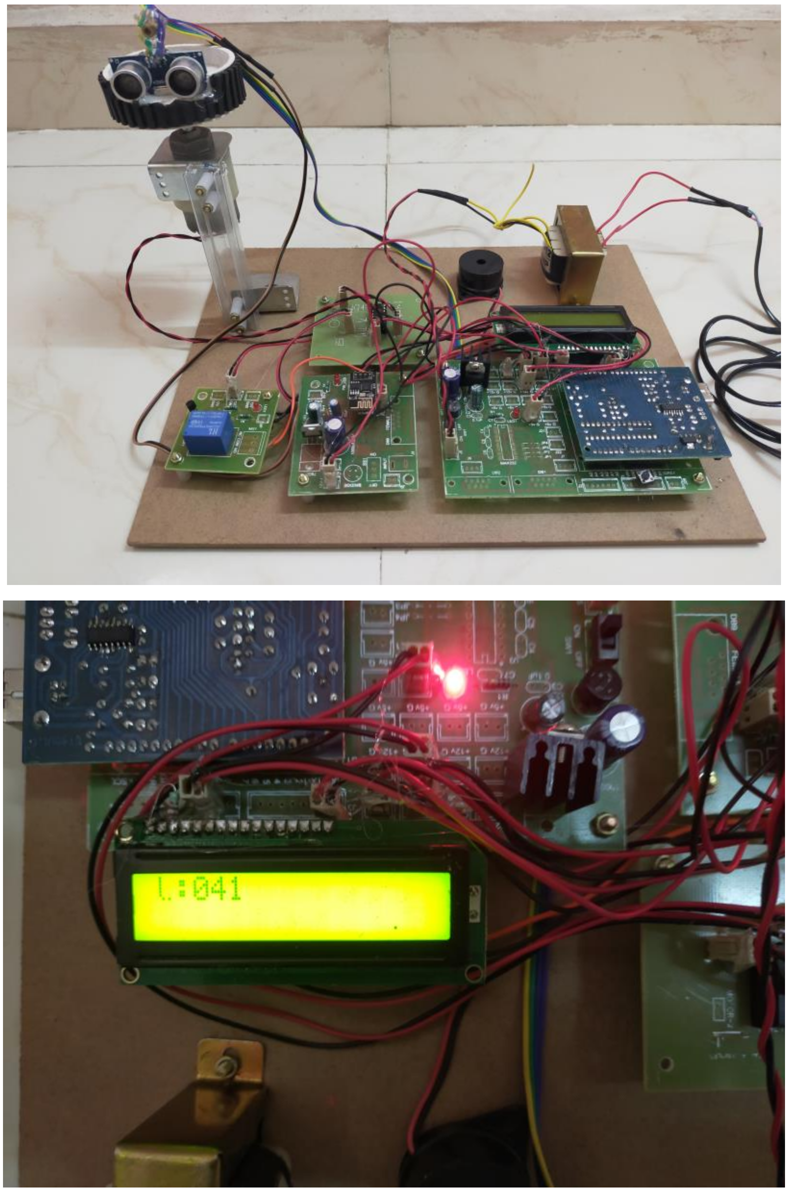

Fig. 3: Hardware experimental results.

5. CONCLUSION

In this paper we have attempted to use ultrasonic sensor for implementation of RADAR and got results that exceeds our presumed expectations. With some enhancements the system can be used for real time purposes.

The project “Missile tracking and auto collision system” is mainly intended to operate design and construct automatic missile detection and destroying system. The system is designed to detect the target (missile) moving in multiple directions. The target destroying system moves automatically in the direction of missile and fires it upon fixing the target. In future we can add GSM to this project is that the status of target properties is not known. This can eliminate by having a GSM module, which gives the status of target. We can also add Ultrasonic module, which is used for obstacle detection with GSM module which gives respective information. By connecting wireless camera to the system, then we can see the outer world from our personal computer only by using GPRS and GPS. We can use this system at so many fields and we can use to handle so many situations.

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