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Identification of Approaching Vehicle using Arduino

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Abstract: ***Many safety-critical Advanced Driver Assistance Systems (ADAS) applications, including automatic emergency braking, pedestrian detection, surround view parking assistance, driver drowsiness detection, and gaze detection, are dedicated to helping drivers prevent car accidents and safeguard lives. In situations where numerous vehicles share the road simultaneously, having precise data on the relative speed and distance between these vehicles is of paramount importance. To calculate both long-range and short-range information, specialized sensors are utilized to estimate vehicle speed and range.The central objective of this project is to effectively detect approaching vehicles. This goal is achieved by using a Doppler radar module to sense vehicle movements, and an Arduino board is employed to process the radar signals, providing the necessary data. The system has been put into action and thoroughly tested in a real- world environment, with the results indicating its precise ability to identify and track vehicles as they approach. In essence, this project serves as a compelling showcase of the viability of employing budget-friendly hardware and open-source software to construct a straightforward yet highly efficient system for recognizing approaching vehicles. The project requires hardware components including the Grove Doppler Radar (BGT24LTR11) for vehicle detection, the Grove Shield for Seeeduino XIAO to interface with the Seeed Studio XIAO SAMD21 microcontroller, and a 2-channel Relay Module (JQC-3FF-S-Z) for motor control. The Arduino IDE is used for software development, enabling the creation of control algorithms and logic to process radar data and operate the system effectively.***
Keywords: Doppler Radar, Signal Processing, Arduino, Blindspots,

I. INTRODUCTION

The ongoing technological evolution has paved the way for inventive solutions across multiple sectors, including transportation and safety. A notable illustration of this is the utilization of arduino microcontrollers paired with radar sensors to identify oncoming vehicles. This amalgamation of electronics, programming expertise, and sensor technology offers an intriguing project that not only highlights the potential of contemporary tools but also contributes to the enhancement of road safety. At its core, the central objective of this project is to fashion a system capable of recognizing and categorizing vehicles as they approach a specified area. The synergy of an arduino microcontroller with a radar sensor facilitates the acquisition of real-time data, its subsequent processing, and the swift execution of responses. As vehicles traverse within the radar's operational range, their presence is promptly detected and subjected to thorough analysis. The insights drawn from this analysis can then be harnessed to trigger a spectrum of actions, including the activation of warning signals, the dispatch of notifications, or even the accumulation of data for more extensive scrutiny in the future.

II. LITERATURE REVIEW

A. Md. Shriful Islam

Detecting Objects Using Ultrasonic Sensor System Radar.Published year: 2019

This RADAR system is composed of essential elements: an ultrasonic sensor, a servo motor, and an Arduino UNO board. It is controlled through the Processing IDE software. Ultrasonic radar, also known as an ultrasonic distance sensor system, is a widely used and practical technology for gauging the closeness of objects. These systems rely on ultrasonic waves to ascertain the distance between the sensor and an obstructing object.

B. Mr. Aditya Gudipudi

Detection and velocity of a fast moving objectPublished year: 2017

Recent years have seen technology profoundly reshape our lives, impacting sports and daily activities. Coaches now possess powerful tools for real-time athlete feedback. Wearable sensors and tracking devices monitor vital performance data, aiding coaches in improving training programs.

Continuous research and development in sports equipment focuses on enhancing performance, ensuring fairness in competition, and athlete safety. Technology has seamlessly become an integral part of the sporting experience, enriching it with data-driven advancements.

C. May Zin Tun | Kay Thwe Zin

Implementation of Doppler Radar Based Vehicle Speed Detection SystemPublished year: 2019

In today's times, there is a concerning surge in vehicular accidents, with a significant portion attributed to speeding. This thesis details the development of a vehicle speed detection system using Arduino and Doppler radar technology. The primary aim of this system is to create a speed detector that leverages Doppler radar to reduce accidents caused by speeding. It employs continuous wave (CW) Doppler radar as a sensor, and a microcontroller processes the data to calculate the vehicle's speed. An amplifier is used to enhance the microvolt-level sensor output, and an LCD display is integrated for speed indication. Doppler radar detects frequency shifts in electromagnetic waves due to object movement towards or away from the radar, with a negative frequency indicating retreat and a positive frequency indicating approach.

III. OBJECTIVE

The "Identification of Approaching Vehicles using Arduino and Radar" project has a number of key goals that highlight its importance for both education and real-world applications. These goals emphasise the project's importance for practical learning and improving road safety while offering a clear path forward for its development:

1) *Vehicle Detection and Identification:* The main goal is to put in place a reliable system that can recognise and differentiate between incoming vehicles. The system's goal is to distinguish between cars and other objects by interpreting radar data, providing real-time information about the presence and characteristics of vehicles.
2) *Real-time Data Processing:* The project's goal is to improve the capacity for real-time radar data processing. This entails showcasing effective algorithms for receiving data streams processing and quickly making decisions on automobiles that are detected.
3) *Implementation of Response Mechanism:* Creating and putting into place a response mechanism that initiates the proper activities when it detects an incoming vehicle is a key component of the project. These could include sounding the alarm, contacting the appropriate persons, or documenting the incident for further examination. Gaining a deeper understanding of radar technology, including signal transmission, reflection, and reception, is the goal ofthe research. It aims to investigate the possibility of using radar waves to collect environmental data.
4) *Arduino Programming Proficiency:* Using Arduino microcontrollers to improve programming abilities is a key component ofthe project. This entails writing code to process data, communicate with the radar sensor, and carry out the reaction mechanism efficiently.
5) *Enhanced Road Safety:* By possibly preventing accidents, the project's ultimate purpose is to improve road safety. Theproject's results are in line with the main goal of lowering the risks connected to vehicle movement.
6) *Data Logging:* At a later stage, the project may be extended to incorporate data logging. This would offer insightfulinformation about vehicle speeds, traffic patterns, and associated data.
7) *Alert System:* Depending on the project's use, designing an alert system that sounds an alarm or sends out a notification when approaching cars cross predetermined speed or distance thresholds may be necessary.
8) *Integration with Traffic Management:* In order to facilitate data analysis, smart traffic control, and decision-making, theproject's scope may include integration with more comprehensive traffic management systems.

In conclusion, the project seeks to develop an identification and detection system for automobiles by fusing radar technologywith Arduino-based control. This system may find use in safety systems, traffic monitoring, surveillance, and other areas. It is a useful illustration of the Internet of Things in action, gathering and processing real-world data with the help of sensors and microcontrollers.

IV. METHODOLOGY

The integration of advanced technologies like Doppler radar and microcontrollers has revolutionized the realm ofautomation and smart systems. This system aims to enable vehicle detection using Doppler radar and subsequently trigger actions through relay control.

1) *Initialize:* Set up the Arduino IDE with the Seeeduino XIAO Board and libraries for the Seeeduino XIAO.
2) *Library Integration:* Import the Seeeduino XIAO libraries, which may include the Grove Doppler Radar library.
3) *Pin Configuration:* Defined the pin connections between the components. Configure pins for radar module data input, relay control.

A. Loop Function

1) *Radar Data Processing:* Continuously read data from the radar module to detect any motion. The Doppler radar can sense moving objects, such as vehicles.
2) *Vehicle Detection:* Implement logic to determine if the detected motion corresponds to a vehicle. This can involve analyzing the frequency and strength of the Doppler radar signal to differentiate between vehicles and other objects.
3) *Relay Control:* If a vehicle is detected, activate the relay(s) to control motors to that of rover, such as turning on lights and control the rover.
4) *User Interface (M5 Stick, if used):* Display relevant information about detected vehicles on the M5 Stick's display(not applicable)

Real-world Testing will deploy the system in the intended environment to verify its performance under various conditions. Optimization is refining the code and configuration based on real-world feedback and performance observations.
Maintenance as follows regularly check for any issues, update the code as needed, and perform maintenance on the hardware components.

B. Hardware and Software Used

1) Software

a) ARDUINO IDE

Arduino IDE is a software development platform and the symbol is shown in figure 8, that allows you to program and control Arduino microcontrollers. The program written in C++ is designed to work with the Arduino IDE. Its main objectiveis to interface with the BGT24LTR11 Doppler radar module to detect approaching targets and control LEDs based on their motion. To begin with, the code initializes serial communication and configures the radar module to match the hardware setup. In the main loop function, the program reads and assesses the speed and status of the detected target, categorizing it asapproaching, departing, or not found. Based on the target's state, the program manipulates three LEDs and their associated pins to turn them on or off, providing a visual indication of the target's movement.

2) Hardware

a) Doppler Radar

At the core of our project is the Doppler radar system, a cutting-edge technology that leverages the Doppler effect to detect motion by analyzing the frequency shift of radar waves reflected off objects. This Doppler radar system functions as the "eyes" of our rover, empowering it to accurately and efficiently perceive moving objects in its proximity. Doppler radar, as aradar technology, relies on the Doppler effect to identify the motion of objects concerning the radar unit. This technology finds widespread use in meteorology, where it measures the velocity of precipitation particles, and it also has applications in diverse fields such as aviation, traffic monitoring, and military surveillance.

b) Dual Channel 5V Relay Module

The 2-Channel 5V Relay Module is an interface board compatible with microcontrollers like Arduino. It uses a 3.3-5VDC control signal to operate relays, serving as an automatic switch in control circuits for high-current applications. The relay module accepts a 0-5V signal input voltage range. It has separate power supplies, VCC for the system and JD-VCC for the relay, which can be shorted for convenience.

c) Grove Shield

The Grove shield provides an interface between the ESP32 and Arduino. It simplifies the connection of various sensors and modules, ensuring seamless communication between the two microcontrollers.

d) Rover, Motor, And Battery

Integrating a rover into the project involves controlling the motorized vehicle through a 2-channel relay module. This setup allows for precise and directional movement based on relay instructions. The microcontroller communicates with the relays to manage the rover's forward, backward, left, and right movements. This relay-based motor control introduces dynamism to the system, empowering the Arduino to govern the rover's actions through the relay module's switching mechanism, enhancing the project's versatility and functionality. The inclusion of a rover combined with the 2-channel relay module enriches the project by facilitating motor control capabilities, with the relay module serving as the intermediary between the microcontroller and the rover's motors, enabling the execution of specific movement commands.

V. RESULTS AND DISCUSSION

The results of vehicle identification using Arduino and Doppler radar technology are typically characterized by the system'sability to accurately detect and provide information about approaching vehicles.

A. Vehicle Speed

The system can effectively measure the speed of vehicles, providing real-time data on how fast they are moving.

B. Direction of Travel

It can determine whether the vehicle is moving towards or away from the radar sensor, which is crucial for situational awareness.

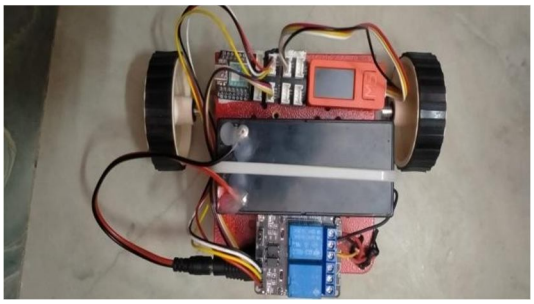

Fig.1. Circuit Diagram

1) *Speed Measurement:* The system can provide accurate speed measurements for approaching vehicles. This data is typically presented in real-time, enabling traffic authorities or system operators to monitor and enforce speed limits effectively.
2) *Real-Time Monitoring:* The system allows for continuous monitoring, enabling timely decision-making and enhancing operational efficiency.

```
target speed:0
target approach
target speed:52
target approach
target speed:52
target leave
target speed:52
target speed:0
target leave
target speed:0
target leave
target speed:316
target leave
target speed:263
target approach
target speed:52
target leave
target speed:105
target leave
target speed:105
target leave
target speed:0
target speed:52
target leave
target speed:0
target speed:158
target speed:52
target approach
target speed:105
```

Fig.2. Results

The results of vehicle identification using Arduino and Doppler radar technology offer valuable insights into vehicle behavior and can be applied in various fields, including traffic management, smart cities, and transportation safety. The quality of the results is closely tied to the system's design and its ability to function effectively under different conditions.

Overall, the successful implementation of Arduino and Doppler radar technology for vehicle identification can provide valuable data for traffic management, access control, and various other applications in the field of intelligent transportation systems.

VI. CONCLUSION

In summary, the fusion of Arduino and Doppler radar technology for identifying approaching vehicles offers a promising yet multifaceted solution, replete with advantages and considerations. The system's precision in detecting vehicle speed, direction, and even classification opens doors to a multitude of applications in traffic control, access management, and more. The real- time monitoring capabilities, enabled by the Arduino microcontroller, empower timely decision-making and elevate operational efficiency. Nonetheless, challenges such as vulnerability to environmental variables, intricate data processing requirements, and the potential for erroneous readings underscore the necessity for meticulous system design, calibration, and ongoing maintenance.

While this technology delivers cost-efficiency and adaptability, it necessitates technical expertise to ensure seamless integration and optimal performance. Addressing privacy concerns and adhering to regulatory prerequisites is of paramount importance. The amalgamation of Arduino and Doppler radar represents a significant stride in the realm of intelligent transportation systems. Its successful implementation hinges on a well-balanced approach that capitalizes on the technology's advantages while mitigating its limitations. As technology continues to advance and solutions continue to evolve, this integration is positioned to play a pivotal role in shaping the future of efficient, data-driven, and secure vehicular identification and management.

A. *Future Scope*

1) *Integration with AI:* Implementing artificial intelligence techniques could enhance the system's accuracy in identifying vehicle types, predicting trajectories, and analyzing patterns of movement.
2) *Multi-Sensor Fusion:* Combining Doppler radar data with data from other sensors, such as cameras or Lidar, could provide a more comprehensive understanding of the environment and improve overall system reliability.
3) *Wireless Communication:* Implementing wireless communication between multiple sensor nodes and a central controller could enable a distributed network of sensors for broader coverage.
4) *Data Analytics:* Storing and analyzing historical data could lead to insights about traffic patterns, enabling better urban planning and infrastructure development.

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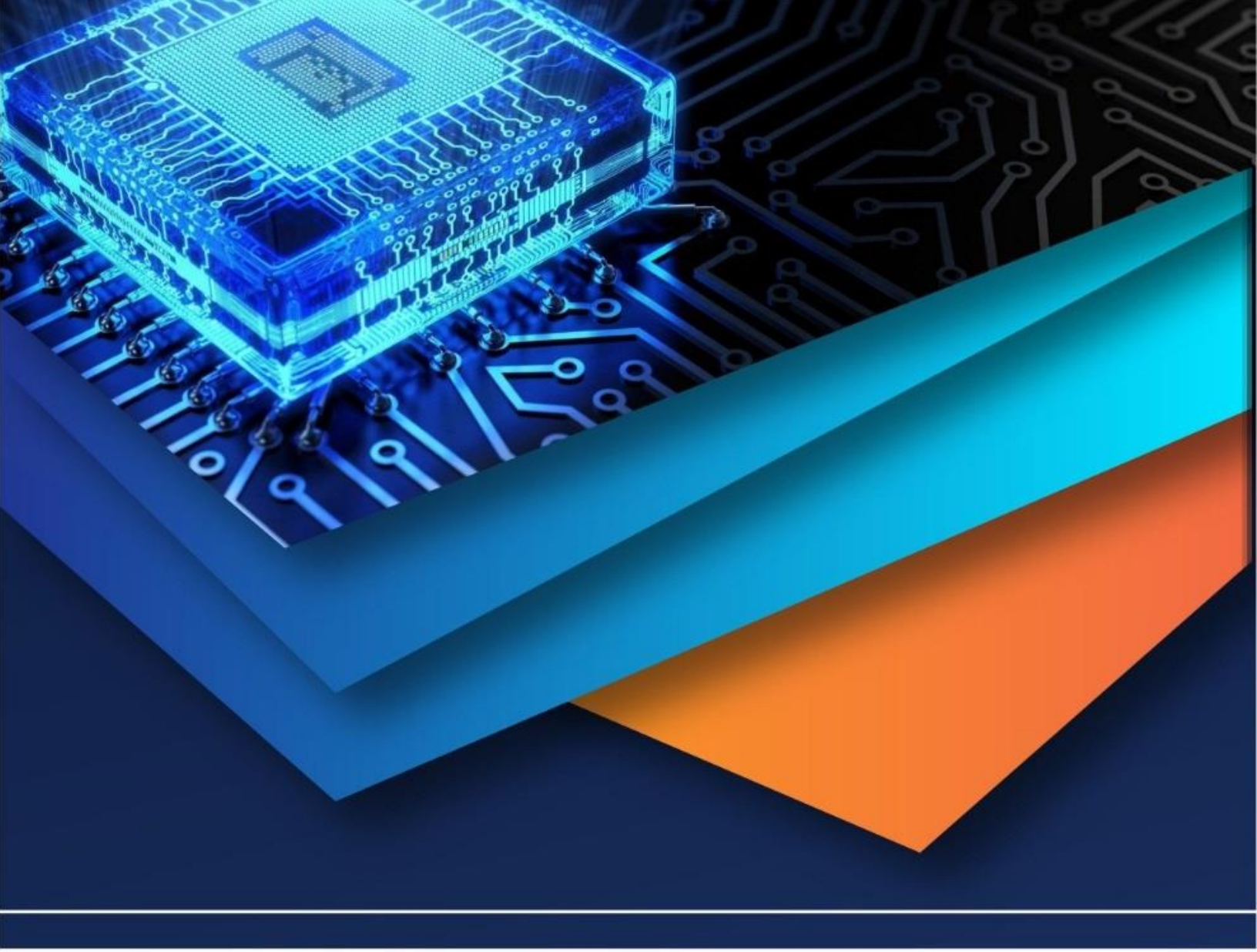

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