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RFID-Based Vehicle Noise and Air Pollution and Overspeed Monitoring and Enforcement System

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Abstract: *These days, mass-produced vehicles benefit from research on Intelligent Transportation System (ITS). One prime example of ITS is vehicle Cruise Control (CC), which allows it to maintain a pre-defined reference speed, to economize on fuel or energy consumption, to avoid speeding fines, or to focus all of the driver's attention on the steering of the vehicle. However, achieving efficient Cruise Control is not easy in roads or urban streets where sudden changes of the speed limit can happen, due to the presence of unexpected obstacles or maintenance work, causing, in inattentive drivers, traffic accidents. In this communication we present a new Infrastructure to Vehicles (I2V) communication and control system for intelligent speed control, which is based upon Radio Frequency Identification (RFID) technology for identification of traffic signals on the road, and high accuracy vehicle speed measurement with a Hall effect-based sensor. A fuzzy logic controller, based on sensor fusion of the information provided by the I2V infrastructure, allows the efficient adaptation of the speed of the vehicle to the circumstances of the road. The performance of the system is checked empirically, with promising results.*

Noise and air pollution violation is one of the factors that contribute to car crashes in India. In this project, a vehicle noise and air pollution monitoring and enforcement system which using RFID technology is proposed in order to reduce the noise and air pollution ing violation. In India, AES cameras are installed at fixed locations to capture the vehicles which violating noise and air pollution limits. After certain time, the drivers will come in mind the locations of the AES cameras. This may lead to a very dangerous situation. For example, when the drivers approaching the enforcement zone, they will suddenly decelerate the vehicle noise and air pollution and only to accelerate again after passed through the enforcement zone. RFID reader which uses ultra-high frequency (UHF) can easily to scan the tag for maximum 100 meter.

Therefore, the RFID reader can install far away from the roadside and make the drivers hard to aware the enforcement zone. This is the reason why preferring RFID technology over others after discussed and studied. In this project, method on how to collect data from the RFID reader every time the vehicle pass through the RFID reader will be shown. The time count will start when the vehicle pass through the start RFID reader and stop when the vehicle pass through the stop RFID reader. The noise and air pollution of the vehicle will calculate based on the time difference. If the calculated noise and air pollution exceeds the noise and air pollution limit, a buzzer will sound up and a message will send to the driver.

Keywords: Intelligent Transportation System

I. INTRODUCTION

Road fatalities are a major concern in the developed world. Recent studies show that a third of the number of fatal or serious accidents are associated with excessive or inappropriate speed, as well as changes in the roadway (like the presence of road-work or unexpected obstacles). Reduction of the number of accidents and mitigation of their consequences are a big concern for traffic authorities, the automotive industry and transport research groups. One important line of action consists in the use of advanced driver assistance systems (ADAS), which are acoustic, haptic or visual signals produced by the vehicle itself to communicate to the driver the possibility of a collision. These systems are somewhat available in commercial vehicles today, and future trends indicate that higher safety will be achieved by automatic driving controls and a growing number of sensors both on the road infrastructure and the vehicle itself. A

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prime example of driver assistance systems is cruise control (CC), which has the capability of maintaining a constant user-preset speed, and its evolution, the adaptive cruise control (ACC), which adds to CC the capability of keeping a safe distance from the preceding vehicle. A drawback of these systems is that they are not independently capable of distinguishing between straight and curved parts of the road, where the speed has to be lowered to avoid accidents.

However, curve warning systems (CWS) have been recently developed that use a combination of global positioning systems (GPS) and digital maps obtained from a Geographical Information System (GIS), to assess threat levels for a driver approaching a curve too quickly; likewise, intelligent speed assistance (ISA) systems warn the driver when the vehicle's velocity is inappropriate, using GPS in combination with a digital road map containing information about the speed limits. However useful, these systems are inoperative in case of unexpected road circumstances (like roadwork, road diversions, accidents, etc.), which would need the use of dynamically-generated digital maps. The key idea offered by this paper is to use Radio Frequency Identification (RFID) technology to tag the warning signals placed in the dangerous portions of the road. While artificial vision-based recognition of traffic signals might fail if visibility is poor (insufficient light, difficult weather conditions or blocking of the line of sight by preceding vehicles), RF signals might still be transmitted reliably.

In the last years, RFID technology has been gradually incorporated to commercial transportation systems. A well known example is the RFID-based highway toll collection systems which are now routinely employed in many countries, like the Telepass system in Italy or the Autopass system in Norway. Other uses include monitoring systems to avoid vehicle theft, access control to car parking or private areas, and embedding of RFID tags in license plates with specially coded IDs for automatic vehicle detection and identification. Placement of RFID tags on the road lanes has been proposed in order to provide accurate vehicle localization in tunnels or downtown areas where GPS positioning might be unreliable. In the work by Seo et al, RFID tagging of cars is offered as an alternative to traffic data collection by inductive loops placed under the road surface. The information about the traffic collected by a network of RF readers is then used to regulate traffic at intersection or critical points in the city. The work by Sato et al. describes an ADAS, where passive RFID tags are arranged in the road close to the position of real traffic signals. An antenna placed in the rear part of the car and close to the floor (since the maximum transmitting range of the ags is about 40 cm) permits reading of the information stored in the tag memory and conveys a visual or auditive message to the driver.

Initial tests at low driving speeds (20 km/h) show good results. The work described in this paper is a collaboration between AUTOPIA (Autonomous Vehicles Group) and LOPSI (Localization and Exploration for Intelligent Systems), both belonging to the Center for Automation and Robotics (CAR, UPM-CISC). The aim of the research is to build a sensor system for infrastructure to vehicle (I2V) communication, which can transmit the information provided by active signals placed on the road to adapt the vehicle's speed and prevent collisions. By active signals we mean ordinary traffic signals that incorporate long-range active RFID tags with information stored into them. This information is collected in real time by RFID sensors placed onboard of the vehicle (an electric Citroën Berlingo), which we have modified to automatically change its speed to adapt to the circumstances of the road.

In particular, we have implemented a fuzzy logic control algorithm acting on the longitudinal speed of the vehicle, with actuators which control the vehicle's throttle and brake to reach and maintain a given target speed. This paper in organized as follows. A description of the sensors installed in vehicle and infrastructure is provided in Section 2. This includes the RFID traffic identification tags and the placement of the detector readers in the vehicle; the differential Hall Effect sensor installed in the vehicle's wheels for better longitudinal speed control and the DGPS (Differential GPS). Section 3 discusses the system architecture, covering sensor data fusion, decision and control stages, followed by an explanation of the Cruise Control (CC) algorithm based in fuzzy logic in Section 4. Experimental demonstrations of the system in a test circuit in our institute's grounds are described in Section 5. The paper ends with a discussion of the results

1.1 Problem Statement and Motivation

Road plays an important role in the transportation field in India. At the same time, the field of transportation has an irreplaceable role in coordinating all countries ' development plan. In fact, the increase in human activities indirectly increases the need of human beings for various kinds of vehicles. Simultaneously, the demand for various kinds of

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vehicles caused the number of vehicles on the road increased. The rise in the number of vehicles in India directly led to various kinds of traffic issues especially in road crashes. Excessive noise and air pollution when driving on the road is one of the factors that led to a car accident.

In India, AES system is implemented in order to capture the picture of vehicles which violating the noise and air pollution limits. These AES cameras are usually installed on the roadside so the daily user of these roads can easily to aware them. After certain time, the drivers will come in mind the locations of the AES cameras. This may lead to a very dangerous traffic situation. For example, when the drivers approaching the enforcement zone, they will suddenly decelerate the vehicle noise and air pollution and only to accelerate again after passed through the enforcement zone and the problem remains as it is. Besides, the drivers that aware the locations of the fixed cameras may use the other roads in order to prevent the cameras, which may lead to traffic accident on the other roads.

In this project, radio frequency identification (RFID) technology is proposed to solve the noise and air polluting violations issue. The main reason for choosing the RFID technology is because RFID technology is more difficult to aware by the drivers and this will cause the drivers to reduce the vehicle noise and air pollution in order to avoid being fined.

1.2 Project Scope

This project develops a system that could monitor the noise and air pollution s of vehicles through the use of RFID technology and able to inform who exceeds the noise and air pollution limit by sending a message to the owner of the vehicle. The monitoring system station consists of two RFID readers and a Central Control Unit, which is Arduino Uno. Each car has its RFID tag. Two RFID readers are connected to the Central Control Unit, which is collecting data from them. The RFID reader will scan all the vehicles which are passing through it even the vehicle noise and air pollution is lower than the noise and air pollution limit. The time count will start when the vehicle pass through the start RFID reader and stop when the vehicle pass through the stop RFID reader. The time difference for a vehicle to pass through two consecutive readers are calculated. With the calculated time difference and pre stored constant distance the noise and air pollution of the vehicle is calculated. A buzzer will sound up to alert the driver and a text message will send to the driver if the vehicle exceeds the noise and air pollution limit

II. LITERATURE REVIEW

2.1 Introduction

RFID-Based Vehicle Noise, Air Pollution, and Overspeed Monitoring and Enforcement System* is designed to address urban environmental challenges by monitoring and controlling vehicle emissions, noise levels, and speed violations. Using RFID (Radio Frequency Identification) technology, the system identifies vehicles as they pass through designated checkpoints. Integrated sensors measure each vehicle's noise and pollution levels, as well as its speed. If a vehicle exceeds the permissible thresholds, the system logs the data and can issue alerts or fines automatically. This technology aims to enhance regulatory enforcement, reduce pollution and noise pollution, and promote safer driving in urban areas.

Here is a literature survey on RFID-based vehicle noise, air pollution, and overspeed monitoring and enforcement systems, including authors, publication years, and summaries of each study:

1. Kavya J., Sowmya P., Smart IoT-Based System for Vehicle Noise and Pollution Monitoring, International Journal of Electronics and Informatics, 2017

By integrating IoT and RFID, this system monitors vehicle noise and emissions through sensors measuring sound, CO, and particulate matter. Designed for busy city areas, it aims to help city planners tackle air and noise pollution by collecting extensive data on high-traffic regions.

2. Tan Kai Wei, Lee Kwan Gee, RFID-Based Vehicle Speed Monitoring and Enforcement System, UTAR, 2018

This study focuses on RFID-based tracking of vehicle speeds, where RFID tags are deployed to capture and record vehicle speed data. The system helps law enforcement by identifying speeding vehicles in real time, which contributes to enhanced safety in accident-prone areas through reliable monitoring and efficient regulatory enforcement.

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3. Lakshmi Boppana, Shivangni Rani, Ravi Kishore Kodali, RFID-Based Vehicle Emission Monitoring and Notification System, IEEE TENCON, 2019

This paper presents a real-time system to monitor and manage vehicle emissions using RFID technology. Equipped with sensors for pollutants such as CO and methane, the system gathers emission data, relaying it through RFID modules for processing and notifications. The model offers effective urban pollution management by identifying and notifying high-emission vehicles, enabling authorities to take corrective action swiftly.

4. Tarek et al., RFID-Based Intelligent Vehicle Speed Controller, IEEE, 2020

This system uses RFID and GPS to automatically control vehicle speed, particularly in areas with speed-sensitive restrictions. By monitoring vehicles in designated zones, the system ensures compliance with speed regulations, reducing accident risks and improving road safety.

5. Rahi, Choudhury, Ramesh, A Cloud-Integrated RFID-Based System for Vehicular Pollution Monitoring, ResearchGate, 2020

In this research, an RFID and cloud-based system is developed for monitoring vehicle emissions, with sensors to measure pollutants like CO2 and methane. The integration with cloud computing enables large-scale data storage and analysis, ideal for city authorities aiming to monitor pollution levels continuously and make data-driven environmental decisions.

6. Varsha K, Raghavendra S, Kiran Kumar T, Detection of Vehicle Emissions Through Green IoT for Pollution Control, Springer, 2021

This paper introduces a low-power system that uses RFID and IoT to monitor vehicle emissions continuously. The system, designed for urban environments, provides authorities with emission data to help address pollution hotspots, leveraging IoT for efficient data relay and timely response to excessive pollution events.

7. A. Rauniyar, M. Bhattarai, A. Prasad, IoT-Based Vehicle Emission Monitoring System, IEEE, 2022

This study leverages IoT and RFID to track vehicle emissions for smart cities, using a Raspberry Pi-based system to process pollutant data in real time. The low-cost and scalable design focuses on providing city administrators with immediate access to pollution data, aiming to improve air quality management in urban areas.

Each of these studies employs RFID in innovative ways to address vehicular issues such as emissions, speed monitoring, and noise pollution, making significant contributions toward safer and more sustainable urban environments.

III. SYSTEM DESIGN

3.1 System Architecture

System architecture is a conceptual model that defines a system. It allows the reader to understand and clear of how the system actually works. Based on figure 3-1-F1, the Arduino Uno will be the heart of the system which will be controlling the two RFID readers, LCD, buzzer and GSM modem. The two RFID readers will scan the tag and the Arduino Uno will collect the data from RFID readers. The time count will start when the vehicle pass through the start RFID reader and stop when the vehicle pass through the stop RFID reader.

The time difference for a vehicle to pass through two consecutive readers are calculated. With the calculated time difference and pre stored constant distance the noise and air pollution of the vehicle is calculated. Then, the calculated noise and air pollution will compare with the pre stored noise and air pollution and the result will display on the LCD and serial monitor. A buzzer will sound up to alert the driver and a text message will send to the driver if the vehicle exceeds the noise and air pollution limit.

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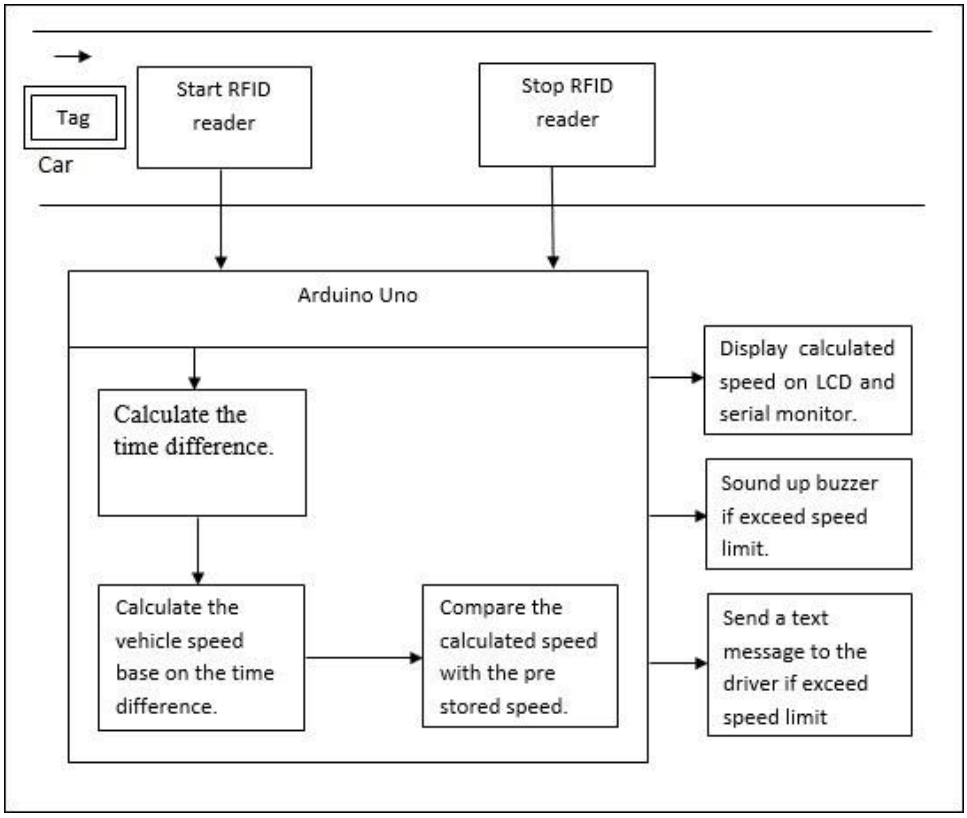

Figure 3.1.F1: System architecture

IV. METHODOLOGY AND TOOLS

4.1 Design Specification

In this section the methodologies adopted will be described, while there will be list of tools used for development of the project.

4.1.1 Methodologies

The prototype model refers to a working prototype of the system that should be built before the actual software development. A prototype is an analog implementation of the system and generally has limited functionality, lower reliability, and insufficient performance compared to actual software. Several shortcuts are often used to build prototypes. These shortcuts may include the use of inefficient, imprecise, and virtual functions. A prototype is usually a crude version of the actual system. The prototype model obtains user feedback by providing prototypes to the user so that the developed software can truly reflect the user's needs. By using this model, the client can get an “actual feel” of the system much earlier instead of they have to wait for the final system to be completed. This allow any misunderstanding of requirements, additional features and possible errors to be detected much earlier, before the actually system is finalized. This model is most suitable for projects whose requirements cannot be known in detail ahead of time.

In this project, prototype model was selected after discussed and studied. As this project is not a very large scale project, hence the prototype model is suitable. Besides, user can actually understand more on this system earlier instead of waiting for the final system to be complete by using this model. Furthermore, this model allows any changes or modification to made in order to reduce failure

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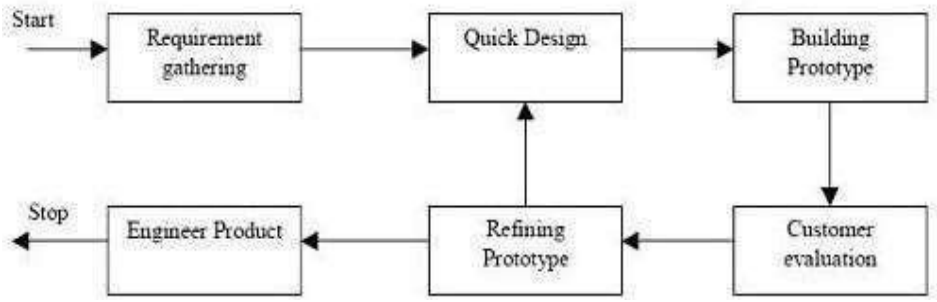

Figure 4.1.1: Prototyping Model (ISTQB Exam Certification, 2018)

4.1.2 Tools to use

This project will be employing an Arduino Uno connected with two RFID readers which are MFRC522 in order to scan the vehicle. Each car has its own RFID tag. A LCD is implemented to display the calculated noise and air pollution and the pre stored noise and air pollution. A buzzer and a GSM modem are implemented to notify the drivers when they exceed the noise and air pollution limit. The software components include Arduino Software (IDE) and C++ language.

Hardware

Arduino Uno

The Arduino Uno is the heart of the entire system. It is capable to receive input from the RFID readers and produce result as output after process. Besides, it is reasonable in pricing and easy to get.

Figure 4.1.2.1.F1: Arduino Uno (Inventables, 2018)

Mifare RC522

Mifare RC522 is the high integrated RFID card reader which works on non-contact 13.56mhz communication, is designed by NXP as a low power consumption, low cost and compact size read and write chip, is the best choice in the development of this project.

` Figure 4.1.2.1.F2: Mifare RC522 RFID Card Reader (HAOYU electronics, 2018)

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ISO14443A smart IC cards

The MIFARE Classic® family is the most widely used contactless smart card ICs operating in the 13.56 MHz frequency range with read/write capability and ISO/IEC 14443A compliance.

Figure 4.1.2.1.F3: ISO14443A smart IC cards (HAOYU electronics, 2018)

Standard LCD 16x2 Display

A standard LCD 16x2 display is use to display the calculated noise and air pollution and the pre stored noise and air pollution for this project. This standard LCD 16x2 display is connected to the Arduino Uno by using jumper cable.

Figure 4.1.2.1.F4: Standard LCD 16x2 Display (thingbits, 2018)

Buzzer

A buzzer will sound up when the vehicle exceeds the noise and air pollution limit in order to alert the driver about the noise and air polluting violation.

Figure 4.1.2.1.F5: Buzzer (Banggood, 2018)

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GSM SIM900A Modem

GSM modem is a GSM phone without display, keypad and battery. It accepts a SIM card and operates over a subscription to a mobile operator just like a mobile phone. In this project, the GSM modem is controlled by the Arduino Uno to send a text message to the driver when the vehicle exceeds the noise and air pollution limit.

Figure 4.1.2.1.F6: GSM SIM900A Modem (Microsolution 2018)

Software

Arduino Software (IDE)

Figure 4.1.2.2: Arduino IDE (Arduino, 2018)

Arduino IDE is an open-source cross-platform application that make user easy to write code and upload the code to the Arduino board. This application is written in java language but the script that write to run this project is C++ language.

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C++ language

C++ is a middle-level language and is an extension of the C language. C++ language support multiple platform such as Windows, MAC OS and various versions of UNIX. In this project, a C++ script is created and uploaded to the Arduino Uno board through Arduino IDE.

Libraries Used

- There is a list of libraries that used in this project.
- RFID library allows the Arduino Uno to read data from tag by using the two RFID readers.
- SPI library allows the Arduino Uno to communicate with the SPI device, with the Arduino Uno as a master device.
- Liquid Crystal library allows the Arduino Uno board to control LCD.
- GSM library allows the Arduino Uno board to send message to the mobile phone.

VI. CONCLUSION

6.1 Conclusion

At the end of this project, a working full prototype system was developed. In this prototype system, the two RFID readers can scan the vehicle every time it pass through the RFID readers. The RFID readers can scan the vehicle only if the vehicle pass from the start RFID reader to the stop RFID reader. There is impossible for a vehicle to move in an opposite direction on the road. The full prototype system is able to calculate the time difference for the vehicle to pass through the two consecutive RFID readers and able to calculate the noise and air pollution based on the time difference. Finally, a buzzer will sound up to alert the driver and a text message will send to the driver if the vehicle exceeds the noise and air pollution limit to inform them about the noise and air polluting violation via GSM modem.

Although this project is proven to be difficult but the project objectives are able convert into deliverables such as calculate the vehicle noise and air pollution using RFID technology, which cause the driver hard to recognize the enforcement zone and the driver will reduce the vehicle noise and air pollution to avoid being fined.

Nevertheless, the evolution of IoT technologies is growing fast nowadays. The potential of this project is so helpful that it can reduce the noise and air polluting violations issue in India.

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