INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 11, Issue - 08, August - 2025

DOIs:10.2015/IJIRMF/202508038 --:-- Research Paper / Article / Review

Intelligent Signal System and Vehicle Navigation Using RFID Technology

Ms. Vidya D.
Dept. of Electrical and Electronics, Karnataka (Govt.) Polytechnic, Mangalore, India
Email: vdyktn@gmail.com

Abstract: *The signaling system is one of the most critical parts of traffic management as well as road safety. Developing an advanced kind of signaling system is necessary using IoT for the drivers. To ensuring safety on the road, this method makes use of cutting-edge technology. To solve a technical issue that arises in the traditional approach, this paper provides a technological solution employing wireless sensors, a communication network, and a GUI application. It also discusses some technical issues that drivers experience. A system was created to automate the signaling system in all weather conditions in accordance with road safety standards. Through a smart device, the signposts and signals can be read without any need for a smart solution or internet connection.*

Keywords: *Robotics, Internet of Things, Signal system, signpost, road safety, traffic management, All weather.*

1. INTRODUCTION

The Internet of Things (IoT) is already being used by different systems to monitor and the traffic management and signaling systems and primarily IoT enables the Internet to be used to link devices like detectors and provide feedback to the drivers on the signals and signposts in all weather conditions for safe travel. Given the current conditions across the globe on the non-availability of smart phones, network, cost of the technology, google maps, or adverse weather conditions there is need to develop an independent system which is cost effective yet solve the issues as mentioned above.

Adverse Weather Conditions such as Fog, heavy rain, snow, and extreme weather conditions can significantly impair a driver's ability to see road signs clearly. Braking Distances is also a concern visibility is compromised; braking distances may exceed the distance the driver can see ahead. This makes driving at the posted legal speed unsafe. Other Specific Challenges such as Dense fog reduces visibility to a few meters, making it challenging to identify road signs even at close distances. Heavy Raindrops on windshields can obscure sign visibility, especially during heavy downpours. Accumulated snow can cover signs, making them difficult to read. Nighttime: Lack of proper illumination can make signposts hard to spot at night. Non-Availability of Maps or Reliance on Maps: Drivers often rely on maps (either physical or digital) for navigation and signpost information. Unfamiliar Routes and Without maps, drivers may struggle to find their way on unfamiliar roads. During emergencies or detours, lack of maps can lead to confusion.

2. PROBLEM STATEMENT

Developing countries such as India and other countries, the road network is huge and some of the places there are not proper network coverage too, also given the technological reach to the people is also limited. Technology such as smart phone, internet connectivity or use of GPS technology is only limited to urban areas majorly. Due to this there is a need for a more affordable and simple solution which can be used for effective signaling systems in these areas, also during adverse weather conditions. The system what is being proposed will be both audio and Visual system which is independent of the internet and make improves road safely, better traffic management along with reduced accidents.

Fig 1: Signpost hidden by trees

Fig 2: Reduced visibility - weather.

Fig 3: Reduced visibility- rain

Fig 4: Obstruction from vehicles

3. PROPOSED METHODOLOGY

Investigation into the road signaling systems revealed that integrating smart systems to automate the sing reading will significantly boost safety and ease in drivability for the drivers and passengers. Furthermore, the drivers we spoke to show a keen interest in a variety of demands that can only be satisfied by these applications. For instance, several bike riders have suggested that they should be able to only be able to hear the audio while biking in their helmets or if the bike cluster itself can have image of the sign read on the display with Bluetooth connectivity for them to hear in helmet. Also, there is a suggestion from one of the traffic managements that they can use this for ad hoc signposts or barricades **too.**

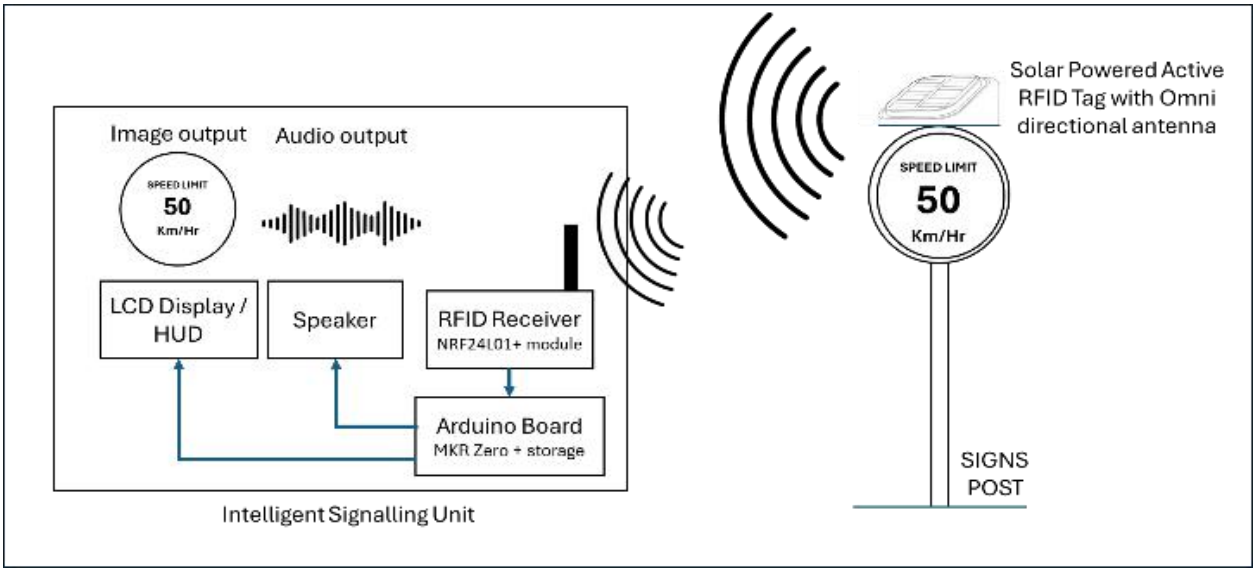

Figure 1: Representation of the system's design process and architecture.

The primary hurdles faced by vehicle drivers include the reduced visibility, Slippery Roads, Limited Road Signs, obstruction of signposts from other vehicles, climatic conditions, lack of GPS or internet, non-availability of smart devices, adverse weather conditions and unfamiliar routes increase the likelihood of accidents.
To address these challenges, drivers should exercise caution, maintain safe speeds, and consider alternative routes

when faced with adverse weather and limited navigation resources. A device which addresses all these issues and reduces accidents which is affordable and effective is highly desirable. Additionally, since driving/riding is highly safety oriented, where accuracy is essential, automation and the use of sensors would tremendously assist the vehicle drivers. This article focuses on employing an interactive interface application that is loaded on a simple device to automatically read the signpost and give the audio and visual signal with intelligent suggestion system has been constructed to aid the user in better understanding the road conditions ahead and take precautions and decision for safe and effective driving.

Using an application loaded on to the Auridon board, a user sees the real time signpost reading while travelling with more confidence and higher awareness of the road ahead. This ensures more confidence for the drivers and without any smart IOT technology. This can also be used by bike riders with only audio as the final output.

- **Installation of RFID Tags:** the active RF tags (BLE 2.45GHz Rugged Long range Active RFID Tag) will be matched with the appropriate signposts marking which will be powered by a solar panel along with a battery for night power requirements.
- **Data Gathering and Analysis:** Data gathered from IoT sensors may be saved in the SD card storage for analysis. There, it can be used to monitor driving behaviors and can identify and address any problems.
- **Remote Monitoring and Control:** Using a smartphone or other device, an IoT-enabled on the system may be remotely monitored and managed. Drivers may be able to check on the system from any location, get notifications when problems develop, and modify the system as necessary thanks to this.
- **Predictive Analytics:** The system's data may be utilized to create predictive analytics models that can foresee systemic changes and allow preventative action to be done in future.

4. INCREASED DRIVABILITY AND SAFETY FOR THE BELOW CONDITIONS:

- **Reduced Visibility**: RFID tags can be read from a distance, even in low visibility conditions. Drivers can receive critical information without needing direct line-of-sight to the signpost.
- **Slippery Roads:** RFID provides rapid data capture. Drivers can quickly access road information without stopping or risking skidding on slippery surfaces.
- **Limited Road Signs:** RFID tags are versatile and can be embedded into signs. It helps even if physical signs are obstructed, RFID-enabled vehicles can still receive relevant data.
- **Obstruction of Signposts from Other Vehicles:** RFID tags are not affected by visual obstructions. Vehicles can read signposts regardless of other vehicles blocking the view.
- **Climatic Conditions:** RFID technology is robust. It works reliably in various weather conditions, ensuring consistent communication.
- **Lack of GPS or Internet:** RFID does not rely on external networks. Vehicles can navigate using RFID data even when GPS or internet is unavailable.
- **Non-Availability of Smart Devices:** RFID is independent of personal devices. Drivers do not need smartphones or other gadgets to access road information.
- **Adverse Weather Conditions:** RFID tags are durable. They can withstand rain, snow, and extreme temperatures, ensuring continuous functionality.
- **Unfamiliar Routes:** RFID assists in navigation. Even on unfamiliar roads, drivers receive real-time guidance from RFID-enabled signs. To maximize output and satisfy customer demand, IoT-enabled system may be combined with other systems, such as weather forecasting systems and market demand systems.
- **Scalability:** An IoT-enabled signal system allows for the expansion of in traffic management with the addition of more sensors it can also be used as a tracking device for insurance companies to see the safe riding parameters of the drivers by adding GPS module. This may contribute to the sustainability and economic viability.

5. FIELD STUDY AND VALIDATION

Studies on the signposts on road and the drivability using these signs often entail monitoring and gathering information on the system's performance, including the quality if the signal received from the signpost to the driver of the vehicle. This may be achieved by installing active RFID Tag with solar power with battery installed on the signpost and RF receiver connected to an Arduino module with memory an output connected to the speaker for interpreting signpost signal as speech and a Heads-up display (HUD) or a LED display to show the images as shown in the signpost. Observations are also made by researchers to see the impact of the system functioning in all the conditions. The system is optimized to raise its effectiveness and reliability.

Active RFID Tag: BLE 2.45GHz Rugged Long range Active RFID Tag - This type of RFID tag comes with its

own power source, usually a battery, which enables it to transmit signals to RFID readers actively. This built-in power source allows for an extended read range and enhanced performance compared to passive RFID tags, which rely on the reader to provide power. Active RFID tags are particularly useful for applications where real-time tracking and long read ranges are necessary.

RFID Receivers: NRF24L01+ module is long-range RFID readers are devices designed to read RFID tags from a greater distance than standard readers, which is particularly useful in applications like tracking large or high-value assets over extensive areas.

Processor / CPU: The Arduino MKR Zero board is an excellent choice for this projects that require the storage and playback of music files. It features a micro-SD card slot with dedicated SPI interfaces, allowing you to store large media files, build advanced user interfaces for displays, or log data offline.

Output For Audio Visual Accessibility: For adding audio output to your Arduino MKR Zero project, you can use an 8 Ω speaker or headphones. However, you will need an external audio amplifier like the LM386 to connect a speaker to the board, as the MKR Zero cannot drive a speaker directly. The amplifier circuit will increase the volume of the speaker, and you can control the volume with a potentiometer. As for the display, you can use an LCD compatible with the Hitachi HD44780 driver. These LCDs are widely available and can be controlled using the Liquid Crystal library in Arduino. They typically come with a 16-pin interface and can be operated in 4-bit or 8-bit mode. For the MKR Zero, you'll need to adjust the pin connections accordingly, as it communicates with the display using SP.

6. HARDWARE SETUP:

Creating a program to link received RF signals to preloaded audio and images on an Arduino MKR Zero involves several steps. By using the NRF24L01+ RF receiver to capture the signals, then use the Arduino to decode the signals, play the corresponding audio, and display the image. below a high-level overview of the process:

Preload Audio and Image Data:

- Store the audio files on a microSD card that can be read by the Arduino MKR Zero.
- Convert the images into a format that can be rendered on an LCD display, such as a bitmap array, and store them on the microSD card as well.

Set Up the NRF24L01+ Module:

- Connect the NRF24L01+ module to the Arduino MKR Zero using the SPI interface.
- Use the RF24 library to initialize the module and set up the communication parameters.

Receive RF Signals:

- Writing a function to listen for incoming RF signals using the NRF24L01+ module.
- When a signal is received, decode it to determine which audio and image file to access.

Play Audio:

- By using the Audio Zero library to play audio files from the microSD card through a connected speaker.
- Match the decoded RF signal to the corresponding audio file and play it.

Display Image:

- By using an LCD library compatible with your specific LCD display to render images.
- Match the decoded RF signal to the corresponding image file and display it on the LCD.

7. RESULTS AND ANALYSIS

The purpose of this approach is to notify the driver through sound and LCD indicators when the vehicle approaches within 50 meters of a signpost. The system detects the signpost symbol using an RF Tag, which is connected to an Arduino Nano. The hardware setup for RF Tag-based turning point detection using Arduino.

The adoption of RFID-based devices has significantly improved driver performance and efficiency. Drivers can now navigate with greater confidence, enhancing road safety. Studies have shown that these simple RFID systems dramatically increase drivability and safety. According to an IEEE report, the fatality rates from traffic incidents in the United States are declining due to the application of new safety technologies. Additionally, the global road safety market is expected to grow by over 50 percent by 2025, driven by advancements in technology.

Furthermore, integrating RFID devices for signpost recognition and in-vehicle reading can lead to reduced fuel consumption, less engine and tire wear, and fewer accidents, contributing to a more environmentally friendly and sustainable solution.

However, challenges remain in terms of device integration. Unfamiliarity with the technology may pose a learning curve for drivers, and implementation costs can be significant. Ensuring the reliability and accuracy of RFID tags through regular testing and calibration is essential for consistent functionality.

8. CONCLUSION

The primary goal of this study is to deploy RFID technology in various environments where reduced visibility, Slippery Roads, Limited Road Signs, obstruction of signposts from other vehicles, climatic conditions, lack of GPS or internet, non-availability of smart devices, adverse weather conditions and unfamiliar routes increase the likelihood of accidents or reduce the number of accidents and to follow traffic rules. On successful implementation of this technology, the number of accidents can be drastically reduced, and thousands of lives can be saved on roads and improved drivability. Moreover, this proposed model of RFID for road implementation can be further enhanced in the building of a new device with integrated HUD with speaker and RF receiver which could be placed on any vehicle as an accessory.

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