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(REVIEW ARTICLE)

Automated road watch sentinel

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Abstract

This study explores strategies for reducing road accidents at curve edges while enhancing wildlife safety during road crossings. It emphasizes the implementation of design modifications, such as sharper signage, enhanced lighting, and physical barriers, which can significantly decrease the incidence of vehicle collisions. Additionally, the incorporation of animal crossings, such as overpasses and underpasses, is evaluated for its effectiveness in facilitating safe animal movement. By integrating these approaches, the research aims to create safer road environments for both motorists and wildlife, ultimately promoting a harmonious coexistence and reducing the ecological impact of roadways. The findings suggest that a multi-faceted strategy combining engineering improvements with wildlife protection measures can lead to a notable decrease in accidents and foster biodiversity.

Keywords: NFC Transceiver; Blind Curve Detection System; Animal Detection System; Microcontroller; PIR Sensors

1. Introduction

Road safety is a critical concern, particularly in areas with sharp curves where visibility and control can be compromised. The incidence of accidents in these regions often results from drivers' inability to navigate the terrain effectively, leading to hazardous situations. To address this issue, and prevent accidents on road and animal collision innovative measures can be implemented to enhance safety, such as improved signage, road design modifications, and the introduction of technology-driven solutions.

In parallel, wildlife crossing roads presents another significant challenge. Animals are frequently at risk as they attempt to navigate human-dominated landscapes, leading to both fatalities and increased road hazards. By creating dedicated animal crossing zones, utilizing wildlife corridors, and implementing awareness campaigns, we can significantly mitigate these risks. This dual approach not only aims to reduce road accidents but also fosters a safer environment for both drivers and wildlife which prevent animals, ultimately contributing to a more harmonious coexistence between nature and urban development.

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Figure 1 Invisibility of the vehicles on blind curves

2. Literature review

In[1] Prajwal VR. The "Vehicle Detection and Collision Avoidance System in Hair Pin Curves" their main aims to detect and classify vehicles, avoid collisions and accidents using traffic signals, and manage traffic effectively in hilly areas. A logic-based signaling system, consisting of cameras, sign boards, and ultrasonic sensors, is planned for future development to prevent overtaking and traffic congestion in hairpin curve.

In[2] Harish S et al. The growing issue of human-wild creature conflict in forests and farming fields is causing significant loss of assets and potential human life risks. A proposed framework uses PIR sensors to identify movement of creatures, send images of interruptions to handling sensors, and classify them as animals or humans using content-based image classification. The solution addresses the ongoing issue globally, including an animal repellent framework.

In[3] Anand Balaji P et al . Accidents are a major cause of death in developing countries, particularly on mountain hilly areas and curve roads. These roads often have tight curves /edgy curve and narrow roads, making it difficult for drivers to see vehicles coming from the opposite side. To address this issue, a piezoelectric sensor is placed before the curve and an LED light is placed after it. This system alerts drivers to the presence of the opposite side of the curve, reducing accidents and potentially saving lives.

In[4] S.Sharma Et.al. The paper presents a low-cost automatic animal detection system on highways and roadways, trained using computer vision and real-world distance estimation. With an accuracy of 82.5%, it reduces collisions between animals and vehicles, and can be extended for other animals after proper training.

In[5] Saad, W.,and Alsayyari, et al Smart detection systems for loose animals crossing highways are crucial to reduce animal-vehicle accidents worldwide, which can be fatal. In Saudi Arabia, loose camels are the main cause of such accidents, causing lifelong injuries and serious damages . These accidents often occur at night and in foggy or dusty weather. Mitigation of these accidents has become a hot and important research topic, leading to the development of various detection systems and various technique. This paper presents a survey of animal-vehicle approaches techniques , comparing popular ones and presenting their advantages and disadvantages. It also discusses the challenges of designing a reliable animal detection system and proposes a framework for an efficient and effective camel-vehicle collision avoidance system.

In[6] Fan, T., Sadeghian, R., and Aram, S. et al . Animal-vehicle collisions are a significant issue, causing 1.5 million car accidents and collision on the road and hilly areas, $1 billion in damage, and 175-200 fatalities annually occure. Current anti-collision technology fails to prevent these collisions which is major concern. This research aims to reduce these collisions by developing a modern machine learning algorithm based on Deep Neural Networks. The algorithm can distinguish deer from different types of vehicles and objects. Using traditional machine learning models like Support Vector Machine, Random Forest, and Convolutional Neural Network, the 16-layer CNN model achieved high accuracy of 95.42% on testing data and 97.90% on validation data.

In[7] Rakhimov, M. A. K., Ibragimov, A., Lee, J.-D., and Oh, R.-D. Et.al. Collisions between vehicles and animals remain a significant issue very major issue which is to be solved for traffic safety. Advanced technology, such as LDM (Local Dynamic Map) and machine learning SVM (Support Vector Machine) models, can help reduce collisions and accidents. This research aims to decrease collisions between wildlife mainly animals and vehicles by performing machine learning predictions in an LDM-based database environment. Big data analysis helps to understand problems and implement algorithms. Future work will involve real experiments using virtual data to improve forecasting accuracy.

In[8] Mammeri, A., Zhou, D., and Boukerche, A. This paper research the use of vision-based solutions for detecting large as well as small animals on roadways using automated roadwatch systems. The researchers and investigators compare and analyzed three detectors: Haar-AdaBoost, histogram of oriented gradient (HOG)-AdaBoost, and local binary pattern (LBP)-AdaBoost, initially developed and designed to detect humans and their faces. They design a two-stage architecture that outperforms these detectors in terms of various parameters such as accuracy and processing time and many other. The proposed architecture detects candidate regions of interest using LBP-AdaBoost in the first stage, offering robustness to false positives in real-time conditions.

[9]-[12] articles explains various other hardware based systems for the collision avoidance in hilly and forest areas.

3. System requirements

This system consists of mainly two parts named as: Hardware and software.

Hardware design consists of microcontroller like 89C51, RF transmitter, RF receiver, HT12E encoder, HT12D decoder for encoding and decoding the signal and sensors like PIR (Passive infrared sensor) sensor, and LED and many more.

3.1. HARDWARE

3.1.1. MICROCONTROLLER (89C51)

The 89C51 microcontroller belongs to the family of 8051 microcontroller.

The 8051 microcontrollers may seem primitive, but its straightforward architecture and features can make it a perfect fit for "Automated Road Watch Sentinel" project, especially if the project's requirements align with its capabilities. Here are some reasons and special features of the 8051 that might justify its use in such a project:

- **Cost-Effectiveness**: The 8051 is a low-cost solution compared to modern microcontrollers, making it ideal for budget-conscious projects.
- **Simple Design**: Its basic, well-documented architecture makes development, debugging, and troubleshooting simpler—an advantage in projects like automated systems.
- **Multiple I/O Ports**: The 8051 offers four 8-bit ports for interfacing sensors, actuators, or other devices involved in your "road watch" automation.
- **Timers for Event Monitoring**: The 16-bit timers are helpful for tasks like monitoring time-based road activity or controlling periodic actions in the sentinel system.
- **Interrupt Handling**: The microcontroller supports up to five interrupt sources. This feature can be utilized for priority handling of real-time events on the road.
- **UART for Communication**: Its built-in serial communication interface allows efficient data exchange, enabling integration with external systems or communication modules.
- **Reliable in Static Applications**: If your automated sentinel isn't overly dynamic or processing-intensive, the 8051's reliability becomes a significant advantage.

Using the 8051 ensures simplicity and stability, especially in systems that perform repetitive tasks like traffic monitoring, detecting obstacles, or sending alerts. Its capabilities perfectly align with the functional needs of this application.

So the additional special features of 89C51 microcontoller are as follows

- **Bit Architecture**: It has an 8-bit CPU and an 8-bit arithmetic logic unit (ALU), making it suitable for basic computational tasks
- **Flash Memory**: It includes 4 KB of on-chip reprogrammable flash memory, allowing for easy program updates.
- **RAM**: It has 128 bytes of on-chip RAM for data storage.

- **I/O Ports**: The microcontroller provides four 8-bit bidirectional input/output ports, offering 32 programmable lines for interfacing.
- **Timers**: It has two 16-bit timers/counters for timing operations and event counting.
- **Interrupts**: The 89C51 supports six interrupt sources, enhancing its ability to handle real-time events.
- **Serial Communication**: It includes a UART for serial communication, enabling efficient data exchange.
- **Power-Saving Modes**: It offers power-saving features, making it suitable for energy-efficient applications.
- **Clock Frequency**: It can execute up to 1 million instructions per second with a clock frequency of 12 MHz.

These features make the 89C51 microcontroller a reliable and perfect choice for our project

3.2. PIR SENSOR

A PIR (Passive Infrared) sensor is an electronic device used to detect motion by measuring infrared radiation which is emitted by objects in its field of view. It operates on the principle that all objects with a temperature above absolute zero emit the infrared radiation. The PIR sensor consists of a pyroelectric material that generates an electrical signal when exposed to changes in infrared levels.

Typically, a PIR sensor has a Fresnel lens to focus the infrared radiation onto the sensor element, enhancing its sensitivity and range. These sensors are widely used in motion detection systems, such as security alarms, automatic lighting, and energy-saving devices. They are cost-effective, low-power, and easy to integrate into various applications. PIR sensors usually have three pins: VCC (power supply), GND (ground), and OUT (output signal). When motion is detected, then output pin sends a high signal, which can trigger the connected devices. Their detection range and sensitivity can often be adjusted or can be fixed, making them versatile for different environments and use cases.

3.3. RF TRASMITTER AND RF RECEIVER:

An RF (Radio Frequency) transmitter and receiver are essential components in wireless communication systems, enabling the transmission and reception of data over radio waves. The RF transmitter converts digital or analog signals into radio waves by modulating a carrier frequency, typically using techniques like Amplitude Shift Keying (ASK) or Frequency Shift Keying (FSK). It consists of components such as an oscillator, modulator, and antenna, and operates within a specific frequency range, commonly 433 MHz for many applications. The transmitter sends the modulated signal wirelessly through its antenna to the receiver.

The RF receiver, on the other hand, captures the transmitted radio waves using its antenna and demodulates the signal to retrieve the original data. It includes components like a tuner, demodulator, and amplifier to ensure accurate signal processing. The receiver's sensitivity and selectivity are crucial for isolating the desired signal from noise and interference. RF modules are widely used in applications such as remote controls, wireless security systems, home automation, and sensor networks due to their low power consumption, cost-effectiveness, and ease of integration. Together, the RFtransmitted receiver form a reliable communication link, enabling seamless data exchange in various wireless systems.

3.4. HT12E AND HT12D

The HT12E and HT12D are complementary ICs designed for remote control systems, enabling efficient wireless communication. The HT12E is an encoder IC that converts 12-bit parallel data into serial format for transmission. It features 8 address bits and 4 data bits, allowing secure communication by matching the address bits with the decoder. Operating within a voltage range of 2.4V to 12V, it includes a built-in oscillator that requires minimal external components. The HT12E is commonly paired with an RF transmitter module to send data wirelessly.

The HT12D, on the other hand, is a decoder IC that receives the serial data transmitted by the HT12E and converts it back into parallel format. It also operates within a voltage range of 2.4V to 12V and features 8 address bits and 4 data bits. The HT12D ensures secure communication by verifying the address bits before decoding the data. It includes a valid transmission (VT) pin that indicates successful data reception. The HT12D is typically paired with an RF receiver module to complete the communication link.

Together, the HT12E and HT12D form a reliable encoder-decoder pair widely used in applications like remote controls, home automation, and security systems. Their simplicity, low power consumption, and ease of integration make them ideal for various wireless communication projects.

3.5. Software

3.5.1. Ride software

RIDE (Robot Integrated Development Environment) is a GUI tool designed for creating, managing, and executing test cases within the Robot Framework, which is widely used for automation testing. It provides a user-friendly interface that allows testers to write, edit, and organize test cases in both graphical and text formats. RIDE supports features like adding libraries, variables, and resources to enhance test scripts and has a "Run" tab for executing test cases with options like start, stop, and pause.

3.5.2. ORCAD software

OrCAD is a powerful electronic design automation (EDA) software suite developed by Cadence Design Systems, primarily used for designing and simulating electronic circuits and printed circuit boards (PCBs). It offers tools for schematic capture, circuit simulation, and PCB layout, making it a comprehensive solution for electronic design engineers. OrCAD's features include an intuitive interface, real-time design rule checks, and integration with PSpice for mixed-signal simulation, enabling users to optimize circuit performance and reliability.

3.5.3. Flashmagic software

Flash Magic is a versatile PC-based software tool designed for programming flash-based microcontrollers, particularly those from NXP Semiconductors. It supports and can handle a variety of interfaces, including serial, Ethernet, and CAN bus, it allowing users to program microcontrollers directly in their target hardware. Flash Magic simplifies and easily make the process of erasing, programming, and verifying flash memory, and it includes features like checksum verification, blank checking, and security bit programming and many other features to ensure reliable effective and secure firmware updates.

3.6. Working of the system

The image displays a flowchart outlining a system that reacts to signals potentially indicating the presence of vehicles or animals. Also find below

- **Start:** The system begins its operation.
- **RF receiver initialization:** An RF receiver is initialized.
- **If signal = 1?:** The system checks if a signal is received at the microcontroller pin P0 (pin no 0) of P1 (port1) (signal = 1)
    - **No:** If no signal is received, the system goes back to continuously check for a signal.
    - **Yes (Vehicle / Animals):** If a signal is received, it proceeds to the next step, indicating and showing a potential detection of a vehicle or animal
- **If data = 1?:** The system then checks the received data (data = 1) the that data will be received at microcontroller Pin P1 (pin no 1) of P1 (port 1) to confirm if it corresponds to a vehicle or animal.
- **No:** If the data does not confirm a vehicle or animal, the system sets the following outputs:
    - Buzzer = 0 (Buzzer off)
    - Red / Yellow lamp = 0 (Red/Yellow lamp off)
    - Green lamp = 1 (Green lamp on) After setting these outputs, the system loops back to continuously check for a new signal.
- **Yes (Vehicle / Animal):** If the data confirms the presence of a vehicle or animal, the system sets the following outputs:
    - Buzzer = 1 (Buzzer on)
    - Red / Yellow lamp = 1 (Red/Yellow lamp on)
    - Green lamp = 0 (Green lamp off) After setting these outputs, the system loops back to continuously check for a new signal.

In essence, the flowchart describes a detection system that uses an RF receiver. Upon receiving a signal, it verifies the data. If the data confirms a vehicle or animal, it activates a buzzer and a red/yellow lamp while turning off a green lamp. If the data does not confirm a vehicle or animal, it keeps the buzzer and red/yellow lamp off and turns on the green lamp. The system continuously monitors for new signals.

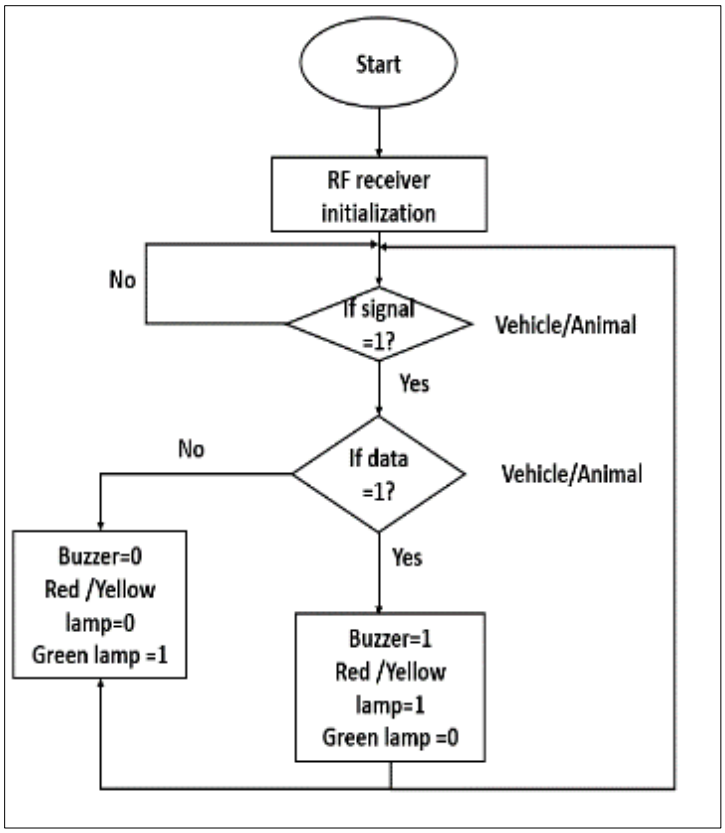

Figure 2 Logic Flow diagram

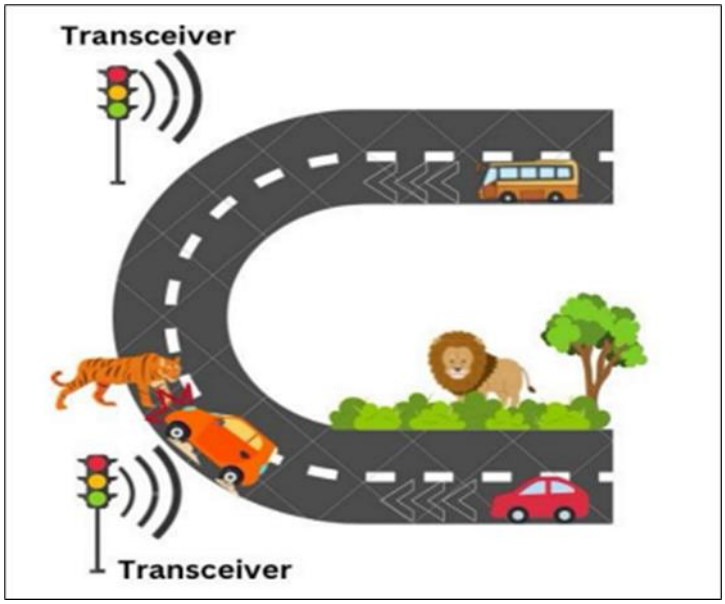

Figure 3 Road watch sentinel system

4. Objectives and scope of work

Intelligent highway safety prevention and driver assistance systems are very helpful to reduce the number of accidents and collisions that are happening due to vehicle-animal collisions and crossing which is the major concern nowadays and it needs to be resolved. On Indian roads, two types of animals – the cow and the dog are found more often than other animals like tiger, lion,and many other on the road.

The primary focus of the proposed work is for detection of animals on roads or while crossing the road in mainly hilly area or blind curve when animals are come on the road in search of food or water which can have the potential application of preventing an animal-vehicle collision or accidents on highways and hilly areas where drivers cannot see that the vehicle is coming from the opposite side and also for preventing vehicle accidents on the road which is the major safety concern nowadays in blind curve or on the hilly areas where high chances on accident occurs . Specific objectives of the research work are as follows:

To develop and design a low-cost, effective automatic animal detection system in context to Indian roads and hilly areas. Finding the approximate distance of animal from the vehicle and sending the signals.

To develop an alert system once the animal gets detected on the road which may help the driver in applying brakes and slowdown the speed of the vehicle or taking other necessary action for avoiding collision between vehicle and animal which ultimately prevent the accidents on the roads.

To develop Vehicle accident prevention systems to enhance and prevent the road safety by reducing the likelihood of accidents collisions and minimizing their impact. These systems often integrate and adds many other advanced technologies such as sensors, buzzer, lamps, and display to monitor driving conditions and detect potential hazards and prevent the road accidents.

To develop low-cost vehicle detection system to prevent road accidents.

4.1. Evidences of an animal-vehicle collision

Recent reports indicate that animal-vehicle collisions are a growing concern in India. Here are some key findings

Stray Animals and Road Accidents: A report published in August 2022 revealed that stray animals are the second biggest reason for road accidents in six major Indian cities. Dogs accounted for 58% of these accidents, followed by cattle at 25.4%2. The report highlighted that these accidents are preventable with proper measures.

Increase in Fatalities: In Punjab, animal-vehicle crash deaths surged by 35% between 2020 and 2022. The study found that mid-block locations on highways and roads were the most dangerous, with the monsoon season and winter fog months being high-risk periods1.

Urban vs. Rural Areas: Urban areas in Punjab experienced a higher fatality rate from animal-vehicle collisions compared to rural areas.

4.2. Advantages

- Avoid and prevent accidents in curve roads, hilly areas mountains roads.
- Saves thousands of lives by preventing accidents on the roads.
- Easily implementable to the existing roads without any additional setup and conditions.
- Fully automated (No person is required to operate).
- Installation cost is very less.
- Vehicle and animal monitoring systems can be implemented easily and effectively.
- To provide a pleasant and peaceful hill travel and avoids any possibility of accidents in curves and in blind curves where high chances or possibility of accidents occur.
- The comfort and confidence to maneuver the vehicle in risky corners by the drivers is established.

4.3. Block diagram

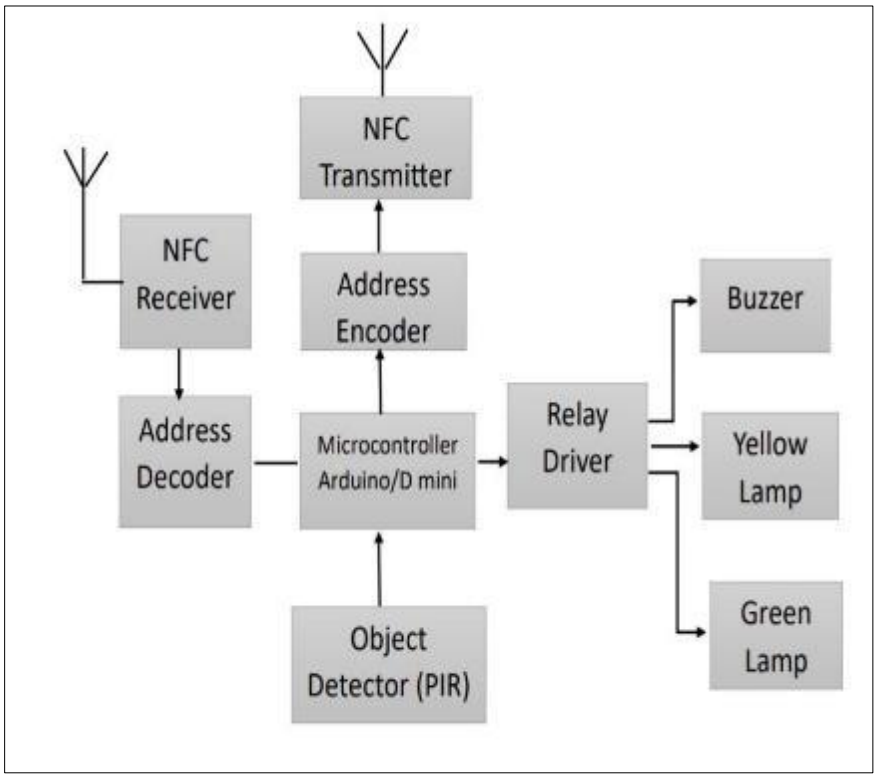

Figure 4 Block Diagram of transceiver module for Blind Curve

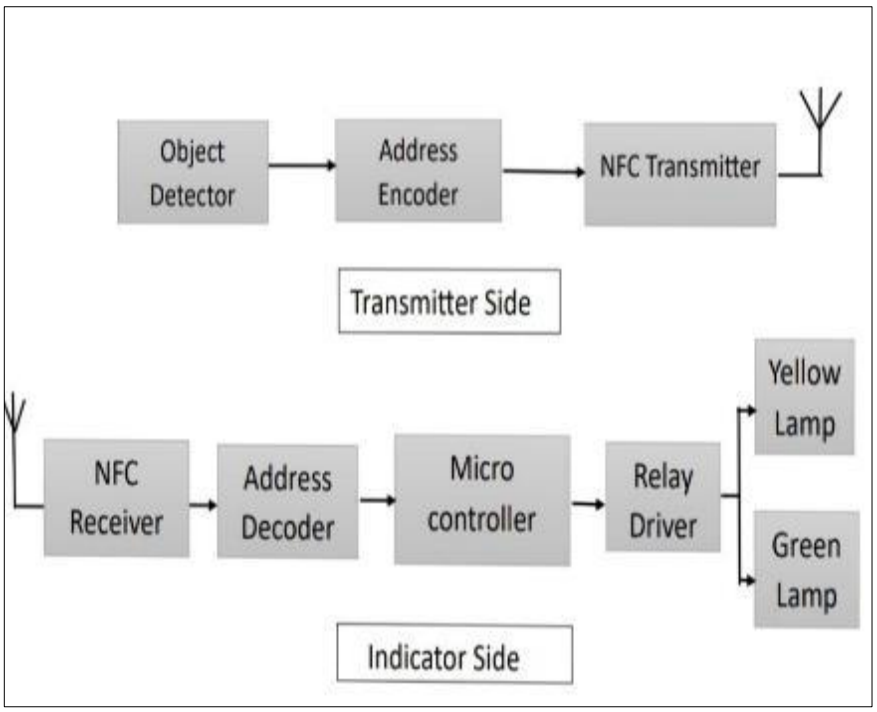

Figure 5 Block diagram of transceiver module for Animal Detection

5. Result

Our project mainly focuses on reducing road accidents at curve edges and enhancing wildlife safety during road crossings. It suggests design modifications like sharper signage, lighting, and physical barriers can reduce vehicle collisions. The research also evaluates the effectiveness of animal crossings, such as overpasses and underpasses, in facilitating safe animal movement. This approach promotes a harmonious coexistence between nature and urban environments, reducing ecological impact and reducing accidents. An efficient automatic animal detection system can also help reduce collisions.

Below is data related to the arrival of the vehicle and animal and at what timing the signal is detected.

Within a microsecond, system indicate whether the vehicle is coming from the opposite end or the animal is crossing the road. So that the driver can stop the vehicle or slowdown the speed of the vehicle. at the distance of 10meters away the system will detect the presence of animal / vehicle from the actual location of animal/vehicle.

Table 1 Sample results for Animal/Vehicle Detection and Notification

Sr. No.	Arrival of animal/vehicle	Detection of time/vehicle	Notification time	Distance of Notification(in mtrs)
1	6.00 AM	6.00 AM	0.1 µ Sec	10
2	7.00 AM	7.00 AM	0.1 µ Sec	10
3	1.55 PM	1.55 PM	0.1 µ Sec	10
4	2.30 PM	2.30 PM	0.1 µ Sec	10
5	3.45 PM	3.45 PM	0.1 µ Sec	10

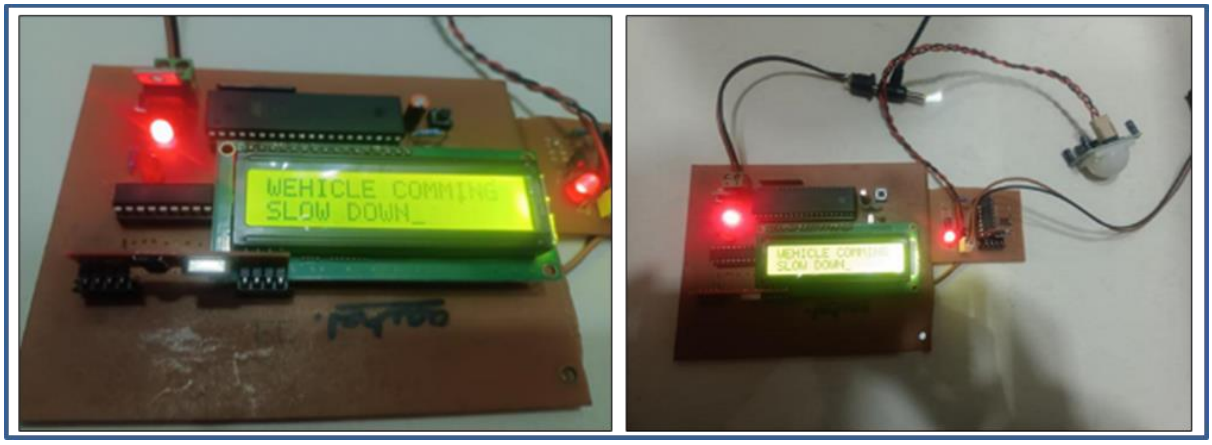

Figure 6 Vehicle detaction module

In Blind Curve When vehicle is coming from the opposite end the system will going to show that the vehicle is coming slowdown the speed , after sometime when vehicle is gone it will show go ahead.Same happens with the animal crossing the road when animal is crossing the road red lamp will go on which means that stop the vehicle and when yellow lamp is on which means slow down the speed.

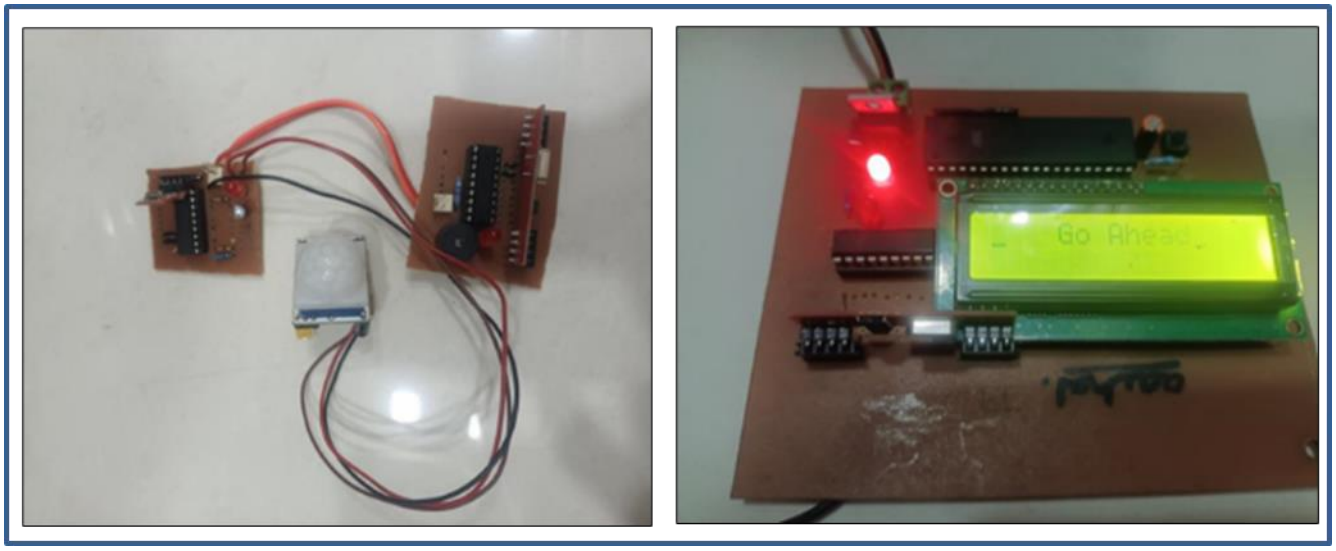

Figure 7 Module for animal crossing detection

6. Conclusion

In conclusion, implementing measures to reduce road accidents and avoiding collisions at curved edges and hilly areas while ensuring safe passage for animals as well as vehicles is essential and important for promoting road safety and wildlife conservation and prevention. By incorporating better signage, improved road design, and dedicated animal crossings for animals, we can significantly minimize and prevent the risks for both drivers and wildlife mainly animals These strategies not only enhance the safety of human travelers but also protect local ecosystems and prevent them from accidents, fostering a harmonious coexistence between nature and urban environments mainly humans and animals.

An efficient automatic animal detection and a warning / alerting system can help drivers in reducing the number of collisions occurring between the animal and the vehicle on roads and highways and hilly areas or blind curves mainly.

Ultimately, a proactive approach to road safety and wildlife protection can lead to a substantial decrease in accidents, benefiting both people and animals alike.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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