International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Smart Wildlife Monitoring System for Railway Corridor Safety

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A B S T R A C T

Each year, railway accidents lead to significant resource loss and endanger both human and wildlife populations. To tackle this challenge, we propose a comprehensive monitoring system for railroad tracks capable of detecting the presence of humans and animals.

Our system integrates multiple sensors to ensure thorough surveillance. Initially, a Passive Infrared (PIR) sensor detects motion, enabling identification of movement along the track. Additionally, a Micro Electro-Mechanical System (MEMS) sensor is employed to detect vibrations, signaling the approach of a train or other disturbances.

By harnessing the capabilities of data-driven Intelligent Transportation Systems (ITS) and leveraging emerging Internet of Things (IoT) technology, we aim to significantly enhance safety along railroad tracks. For example, our system facilitates real-time monitoring of railroad crossings, activates warning signals, and optimizes lighting systems to alert both trains and pedestrians.

Trains remain a popular and environmentally sustainable mode of transportation globally, particularly in major cities. However, ensuring safety and preventing accidents is crucial. Our project focuses on developing a sophisticated railway track monitoring system using a Microcontroller to integrate various sensors and data transmission capabilities.

The multi-sensor system continuously monitors the track's condition and relays data to an IoT cloud platform, such as ThingSpeak. This real-time information can be accessed by railway officials via email or mobile notifications, enabling swift action to prevent potential accidents.

Ultimately, our goal is to create a convenient, secure, and cost-effective solution that enhances railway safety while protecting wildlife and human life near railroad tracks. By leveraging IoT technologies and intelligent sensor networks, we can proactively mitigate risks and ensure the efficient operation of our railway systems. This initiative underscores our commitment to advancing transportation safety and sustainability through innovative technological solutions

Keywords:

Internet of Vehicles

Microcontroller

Intelligent Transportation Systems (ITS)

CDROM

Embedded systems

1. INTRODUCTION

Railways play a pivotal role in transportation, especially in countries like India with extensive railway networks. However, maintaining railway safety is critical to prevent accidents and safeguard lives. To address this, a sophisticated rail safety system has been proposed, particularly focusing on areas where wildlife often crosses tracks. This system incorporates cameras for continuous monitoring and object detection along the railway lines. Through advanced image processing techniques, these cameras can identify and recognize objects or creatures on the tracks. Upon detecting an object, a rapid comparison of sequential images confirms the presence of any obstruction. If confirmed, an immediate alert is generated and relayed to the train's loco-pilot as well as the nearby control room. By implementing such proactive measures, potential accidents due to wildlife or track obstructions can be swiftly averted, ensuring the safety of passengers and railway personnel while also preserving wildlife habitats. This initiative highlights the importance of leveraging technology to enhance railway safety and efficiency in managing vast railway networks

Nomenclature

Central Processing Unit (CPU)

Internet of Things (IOT)

1.1 WIRELESS TECHNOLOGY

The evolution of mobile communications has brought forth a plethora of innovative applications utilizing embedded systems. The mobile phone stands out as a remarkable marvel from the latter part of the 20th century, offering powerful voice communication capabilities on the go. Beyond basic communication, modern mobile devices like Personal Digital Assistants (PDAs) and palmtops now enable access to a wide range of multimedia services over the Internet. Behind the scenes, the infrastructure supporting mobile communications, including base station controllers and mobile switching centers, also operate as robust embedded systems. These systems facilitate seamless connectivity, efficient data transfer, and enable a myriad of functionalities that have transformed the way we communicate and access information in today's mobile-centric world. As mobile technology continues to evolve, the integration of embedded systems into our daily lives will undoubtedly fuel further innovation and enhance the capabilities of mobile devices and networks.

1.2 INDUSTRIAL AUTOMATION

In today's industrial landscape, embedded systems play a critical role in process control across various sectors including pharmaceuticals, cement production, sugar refining, oil exploration, nuclear energy, and electricity generation and transmission. These embedded systems are purpose-built to execute specific functions such as monitoring temperature, pressure, humidity, voltage, and current levels within industrial settings. Based on the data collected, these systems autonomously trigger appropriate actions to control devices or transmit vital information to centralized monitoring stations.

In hazardous industrial environments where human presence is restricted or unsafe, robots programmed with embedded systems are deployed to perform specific tasks. These advanced robots are capable of executing complex and intricate jobs, including hardware assembly, with precision and efficiency. The integration of embedded systems into industrial processes not only enhances operational efficiency but also improves safety by minimizing human exposure to hazardous conditions. As technology continues to advance, embedded systems will continue to drive innovation in industrial automation, enabling industries to operate more effectively and safely in challenging environments..

1.3 POWER SUPPLY

The power supply section of electronic circuits is crucial for providing stable and regulated voltage to components like ICs and other devices. In many applications, such as providing a +5V supply, the IC LM7805 is commonly used for this purpose. The process typically begins with an AC voltage input, often around 220V AC, which is fed into a transformer. This transformer steps down the AC voltage to a lower level suitable for DC conversion. The transformer operates on the principle of electromagnetic induction, with the primary coil receiving the AC voltage and inducing a corresponding AC voltage in the secondary coil.

After the transformer, a diode rectifier circuit is employed to convert the AC voltage from the transformer's secondary coil into a pulsating DC voltage. The diode rectifier, commonly configured as a bridge rectifier using four diodes, ensures that both halves of the AC cycle are used to produce a more constant DC output compared to a half-wave rectifier. In a bridge rectifier, the AC input is applied to the diagonally opposite corners of the diode network, and the DC output is obtained from the remaining two corners. This configuration allows for full-wave rectification, providing a smoother DC output with less ripple.

Following rectification, the resultant DC voltage often exhibits some degree of ripple due to the nature of the rectification process. To stabilize and regulate this DC voltage, a regulator circuit is utilized. This circuit, typically incorporating a voltage regulator IC like the LM7805, ensures that the output voltage remains constant even when the input voltage from the transformer fluctuates or when the load connected to the output varies. The regulator IC effectively filters out the remaining ripple and maintains a steady +5V output required for powering electronic components reliably.

In summary, the power supply section of electronic circuits involves transforming high AC voltages to lower levels, rectifying the AC voltage to DC using diodes (commonly in a bridge rectifier configuration), and then regulating the DC output to provide stable and constant voltage for powering electronic devices. This process is essential for ensuring the proper functioning and longevity of various electronic systems and components.

1.4 VOLTAGE REGULATORS

Voltage regulators are integral components commonly used in electronic circuits, encapsulating various functionalities within a single IC. These IC units incorporate reference source circuitry, comparator amplifiers, control devices, and overload protection mechanisms. They are designed to regulate either fixed positive voltages, fixed negative voltages, or adjustable voltages based on specific requirements. Regulator ICs are available across a range of load currents, from hundreds of milliamperes to tens of amperes, and corresponding power ratings spanning from milliwatts to tens of watts.

A typical three-terminal voltage regulator features an unregulated DC input voltage (Vi) applied to one terminal, a regulated DC output voltage (Vo) from a second terminal, and the third terminal connected to ground. The popular series 78 regulators deliver fixed positive regulated voltages ranging from 5 to 24 volts, while the series 79 regulators provide fixed negative regulated voltages within the same voltage range. These ICs are also offered with fixed standard voltages such as 5V, 12V, and 15V, or with variable output voltages based on application needs.

Voltage regulator ICs are designed with built-in protections against excessive current (overload protection) and overheating (thermal protection), ensuring safe operation and reliability under varying conditions. Most fixed voltage regulator ICs feature a compact three-lead package resembling power transistors, like the 7805 +5V 1Amp regulator, which can be equipped with a heat sink for efficient heat dissipation if required. Overall, voltage regulator ICs play a critical role in stabilizing and delivering consistent voltages necessary for the proper functioning of electronic devices and systems.

1.5 MICROCONTROLLER

The Raspberry Pi Pico W is Raspberry Pi's wireless microcontroller board, designed to facilitate physical computing applications. It builds upon the success of the original Raspberry Pi Pico, incorporating wireless capabilities including Wi-Fi and Bluetooth. The board features the RP2040 ARM chip, developed by Raspberry Foundation, which is also used in the standard Pico model. The notable addition to the Pico W is the Infineon CYW43439 wireless chip, enabling IEEE 802.11 b/g/n wireless LAN and Bluetooth 5.2 connectivity.

Distinguishing the Raspberry Pi Pico W from its predecessor, the key difference lies in the integration of the Infineon CYW43439 chip responsible for Wi-Fi and Bluetooth functionalities. Additionally, the Pico W employs the RT6154A from Richtek as the power regulator, a departure from the RT6150B used in the original Pico design. The repositioning of the debug port closer to the System-on-Chip (SoC) accommodates space for the Wi-Fi antenna.

Powering the Raspberry Pi Pico W can be achieved through either the USB port (5V) or the VSYS pin (1.8V-5.5V). The USB port provides a straightforward method for powering the board and can also supply 5V to external components via the VBUS pin. Alternatively, the VSYS pin allows connection to a battery or similar power source, with the input voltage converted to a suitable 3.3V by an onboard voltage regulator.

Programming the Raspberry Pi Pico W is supported in C/C++ and MicroPython. Thonny IDE serves as a user-friendly environment for MicroPython programming. Additionally, the Pico W board can be programmed using the Arduino IDE, offering flexibility and ease of use for developers and makers exploring various applications with this wireless-enabled microcontroller platform

1.6 RASBERRY PI PICO W SPECIFICATIONS

The Raspberry Pi Pico W is a feature-rich wireless microcontroller board designed for versatile applications. It is powered by the RP2040 microcontroller chip, developed by Raspberry Pi, featuring a dual-core ARM Cortex M0+ processor capable of running at flexible clock speeds up to 133 MHz. This microcontroller board comes equipped with 264kB of SRAM and 2MB of onboard Flash memory, offering ample storage for programs and data.

One of the standout features of the Pico W is its integrated single-band 2.4GHz wireless interface, supporting 802.11n connectivity for wireless communication capabilities. The board's castellated module design allows for direct soldering onto carrier boards, providing flexibility for hardware integration.

In terms of connectivity, the Pico W supports USB 1.1 Host and Device functionalities, expanding its interfacing capabilities. It also features low-power sleep and dormant modes, enabling efficient power management, which is beneficial for battery-operated applications.

Programming the Raspberry Pi Pico W is simplified with drag & drop functionality using mass storage over USB, making it accessible for beginners and experienced developers alike. The board offers 26 multi-function GPIO pins and supports interfaces like SPI, I2C, and UART, as well as 12-bit ADC for analog input and 16 PWM channels for precise control of output signals.

Additionally, the Pico W features onboard accurate clock and timer functions, a temperature sensor for environmental monitoring, and accelerated floating-point libraries for enhanced computational capabilities. With 8 programmable PIO (Programmable I/O) state machines, the Pico W provides support for custom peripheral configurations, making it a versatile choice for various embedded and IoT projects.

2. RASPBERRY PI PICO W PINOUT

The Raspberry Pi Pico W is designed with a pinout that includes 40 pins, of which 26 are multipurpose GPIOs labeled GP0 to GP28. Notably, four of these GPIOs (GP23, GP24, GP25, GP29) are not exposed on the header, leaving 26 GPIO pins accessible for digital input and output operations. All GPIOs operate at a 3.3V logic level, ensuring compatibility with various electronics and components. In terms of power supply, the Pico W includes key pins such as VBUS (PIN 40), which connects to the micro-USB port and accepts a voltage range of 4.5V to 5.5V for powering the board. The VSYS (PIN 39) pin serves as the main system input voltage, accommodating a range of 1.8V to 5.5V. This voltage is used by the onboard SMPS (Switched Mode Power Supply) to generate a stable 3.3V supply required by the RP2040 microcontroller and GPIOs. Additionally, pins like 3V3_EN (PIN 37) enable the SMPS operation, while 3V3(OUT) (PIN 36) outputs the regulated 3.3V voltage suitable for external components, with a recommended maximum load current of 300mA. The presence of multiple GND pins ensures proper grounding for the Pico W and connected devices, contributing to stable and reliable operation. These power supply and GPIO pins provide essential connectivity and flexibility for a wide range of embedded and IoT applications using the Raspberry Pi Pico W

Table 1. RPi Pico W PWM Pinout

PWM Channel	GPIO
0A	GPIO 0, GPIO 16
0B	GPIO 1, GPIO 17
1A	GPIO 2, GPIO 18
1B	GPIO 3, GPIO 19
2A	GPIO 4, GPIO 20
2B	GPIO 5, GPIO 21
3A	GPIO 6, GPIO 22
3B	GPIO 7
4A	GPIO 8
4B	GPIO 9
5A	GPIO 10, GPIO 26
5B	GPIO 11, GPIO 27
6A	GPIO 12, GPIO 28
6B	GPIO 13
7A	GPIO 14
7B	GPIO 15

Table 2. Special Function Pins in RPi Pico

Pin	Function
GPIO23	Controls the on-board SMPS power save pin.
GPIO24	Senses voltage at VBUS pin – high if VBUS is present, else low.
GPIO25	Connected to onboard LED.
GPIO29	Used in ADC mode (ADC3) to measure VSYS/3.

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