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RT Based Railway Gates Automation Using NI myRIO

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Abstract — Railway safety at level crossings remains a paramount concern due to the recurring incidence of train accidents. This study proposes an innovative solution to enhance safety by introducing an automatic gate system at unmanned crossings, replacing manual operation. The system utilizes strategically positioned proximity detectors to detect approaching trains, automating gate management. This reduces gate closure duration compared to manual operation, minimizing disruptions to road traffic. Additionally, the system reduces reliance on human labor, offering a more efficient and reliable solution. It is particularly suitable for unmanned crossings prone to higher accident probabilities, where dependable operation is crucial. By integrating infrared sensors and servo motors, the system ensures prompt gate closure upon train detection, reducing potential accidents caused by negligence. This study enhances prior research by utilizing two infrared sensors on each side of the track, improving train position tracking accuracy. The sensors are programmed using the LabVIEW platform, facilitating integration with myRIO controllers. Overall, this study presents a comprehensive approach to enhancing railway safety through innovative automation technology at unmanned level crossings.

Keywords— NI myRIO, IR sensors, Servomotor, Labview.

I INTRODUCTION

Railways are often hailed as the most cost-effective means of transportation, offering efficient mobility for both passengers and freight. Within railway infrastructure, level crossings serve as critical points where railway tracks intersect with roads, presenting inherent safety challenges. These crossings are broadly categorized into two types: manned and unmanned. In the early days of railway transportation, manned crossings relied on flagmen stationed nearby to manually signal approaching trains, typically using red flags or lamps to halt road traffic and ensure safe passage for trains. However, as railway networks expanded, particularly in regions like Asia boasting extensive railway infrastructure, the prevalence of accidents at level crossings grew, posing significant risks to public safety.

The increase in accidents at railway crossings is often attributed to various factors, including impatience among road users waiting for trains to pass and the disregard for closed gates. Putting a railway over a bridge is straightforward to do and the price is attractive compared to previous alternative methods [1]. Balog et al. [2] gave the chance of mistreatment of RFID technology by railway transport observance. The major part of the article describes the application of RFID technology in the railway industry of Slovakia. It alsodescribes

the principles of the RFID technology and its implementation in railways. Sankaraiah et al. [3] discussed the commonest types of RFID tags and readers, and the principles of RFID technology.

The system leverages advanced technology, particularly infrared sensors, to detect the presence of trains and trigger timely responses to regulate gate operations. By utilizing data acquired from these sensors [4-7], the system can accurately determine the train's location and promptly alert nearby road users, thereby reducing the likelihood of accidents.

The implementation of automatic control systems represents a significant advancement in railway safety technology, offering a range of benefits beyond accident prevention. These systems eliminate the potential for human error associated with manual gate operation, conserve energy through optimized gate management, and contribute to overall operational efficiency.

II METHODOLOGY

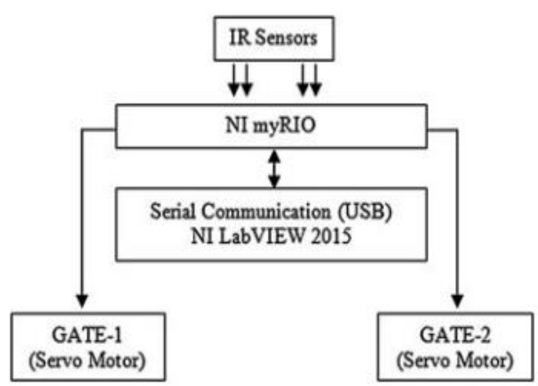

Fig.1: Block Diagram

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The IR emitter continuously emits infrared radiation. When an object enters the sensor's field of view, the receiver detects changes in the received radiation intensity.

The NI myRIO reads the analog voltage output from the IR receiver, which varies depending on object presence. LabVIEW programs the myRIO to interpret this signal, setting a threshold. If the signal surpasses this threshold, indicating an object's presence, LabVIEW generates a digital signal to control the servomotor. It sends a specific pulse width modulation (PWM) signal to the servomotor, determining the gate's position.

This design consists of four major components:

(1) NI myRIO (2) IR Sensors (3) Servomotor (4) LabVIEW

1) NI myRIO:

Fig. 2: NI myRIO

NI myRIO emerges as a powerful engine for automated railway gate control systems, bolstering railway safety. This compact and versatile embedded platform goes beyond traditional control systems by offering a unique combination of processing power, real-time data acquisition, and user friendliness. It's onboard processing muscle, featuring an FPGA and a RIO co-processor, tackles complex control algorithms and processes sensor data in real-time. It seamlessly interfaces with the real world through its analog and digital I/O ports. When NI myRIO integrates with LabVIEW, a graphical programming environment is created. LabVIEW's intuitive interface allows engineers to program NI myRIO's behavior without complex coding, simplifying development.

The compactness and user-friendliness make it ideal for diverse railway environments. NI myRIO facilitates customization through LabVIEW and the reconfigurable FPGA, allowing for tailoring to specific railway layouts, train speeds, or safety protocols. In essence, the processing power, real-time data acquisition, and seamless integration make it a cornerstone for robust and efficient automated railway gate control systems, ultimately enhancing railway safety.

2) IR Sensor:

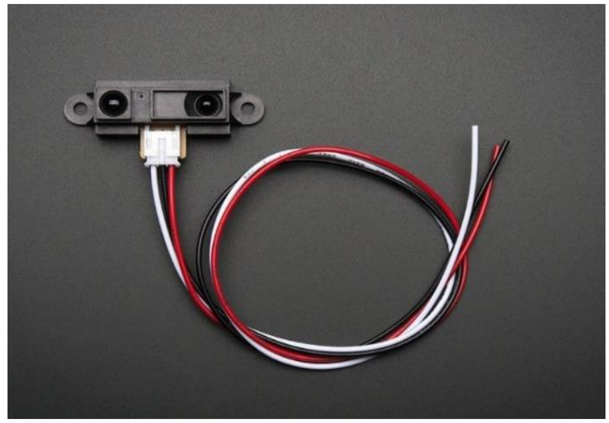

Fig.3: NI myRIO Mechatronics Kit rangefinderIR

Infrared (IR) sensors play a pivotal role in ensuring the timely activation of automated gate closure mechanisms. These sensors function by emitting and detecting infrared radiation, a form of electromagnetic energy invisible to the human eye. When a train approaches a railway crossing, it disrupts the continuous beam of infrared radiation emitted by the sensor. This interruption triggers a pre-programmed response in the system, leading to the swift closure of the gates. The inherent reliability of IR sensors in detecting approaching trains, coupled with their ability to initiate a timely response, significantly mitigates the risk of accidents at railway crossings. By seamlessly integrating into existing safety protocols, IR sensors contribute to improved traffic management and bolster the overall safety of railway operations.

3) Servomotor:

Fig.4: NI myRIO Mechatronics Kit GWS S03N STD Servo

In automatic railway gate systems, servo motors play a crucial role in physically operating the gates. These electromechanical devices translate control signals from the system's controller into precise mechanical movements. When triggered by sensors detecting an approaching train, the servo motor activates the gate mechanism with remarkable accuracy, ensuring timely closure.

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Compared to industrial motor counterparts, servo motors offer a compelling combination of power and control. Their ability to rotate to predetermined angular positions makes them ideal for precisely positioning railway gates, resulting in smooth gate operation. By automating gate movements and eliminating manual control, servo motors significantly reduce the risk of accidents at railway crossings, thus enhancing railway safety.

The role of servo motors in railway safety is undeniable, solidifying their position as an essential element within modern railway infrastructure.

4) Labview:

LabVIEW is a graphical programming environment created by National Instruments. It's renowned for its intuitive visual programming language, empowering engineers and scientists to swiftly develop intricate systems without the need for traditional coding skills. In railway safety systems, LabVIEW plays a crucial role by interfacing with sensors, managing real-time data, and controlling actuators, thus facilitating the implementation of automated gate systems at railway crossings. Its modular design and extensive library of functions make it adaptable for crafting advanced control solutions tailored to specific needs. Moreover, LabVIEW's seamless compatibility with hardware like NI myRIO enables smooth integration and deployment of control systems across various applications. Additionally, LabVIEW offers extensive documentation and community support, aiding developers in troubleshooting and optimizing their systems efficiently. LabVIEW's flexibility extends to its compatibility with third-party hardware and software modules, enhancing its versatility and interoperability in various engineering environments.

III WORKING DESIGN

1) SERVOMOTOR INTERFACING

The interface circuit requires three connections to NI myRIO MXP Connector B:

1. Vcc (red) → B/+5V (pin 1)
2. Ground (black) → B/GND (pin 6)
3. Command signal (white) → B/PWM0 (pin 27)

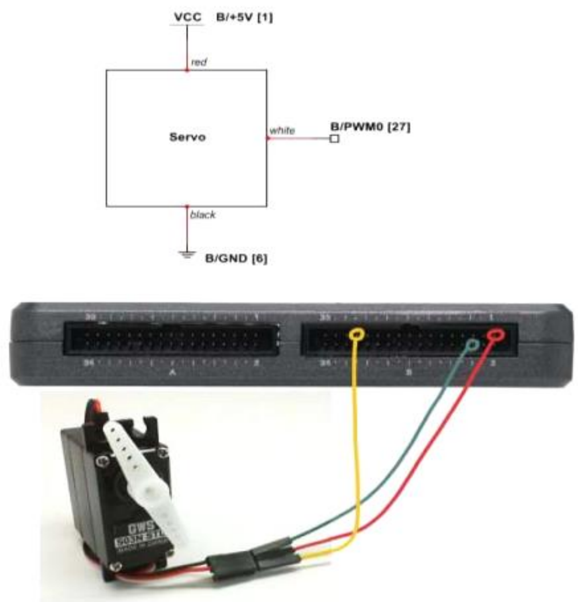

Fig.5: Demonstration setup for the GWS S03N STD servo connected to NI myRIO MXP Connector B

1.1 Physical Connections:

Ensure your myRIO is properly connected to your computer using the provided USB cable.

Verify that the servomotor is securely connected to the appropriate output port on the myRIO.

1.2 Configuring PWM Output for Servomotor Control

1.2.1 PWM Signal Generation:

In the LabVIEW Project window, create a new VI (virtual instrument) and locate the PWM function.

This virtual instrument generates a pulse width modulation (PWM) signal that is ideal for controlling servomotors. The duty cycle of the PWM signal determines the position of the servomotor shaft.

1.2.2 Frequency and Duty Cycle Settings:

The frequency of the PWM signal is 250 Hz, which is a common value for controlling servomotors.

1.3 Understanding Duty Cycle and Servomotor Movement

The duty cycle of a PWM signal represents the percentage of time the signal is on within a single cycle.

In the context of servomotors, a typical range for the duty cycle is between 5% and 10% for the minimum rotation angle (usually closing the gate) and 15% to 20% for the maximum rotation angle (opening the gate). The exact values might vary depending on your specific servomotor model.

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1.4 Determining Duty Cycle for Gate Movement

Run LabVIEW VI. Observe the servomotor's movement. If the gate doesn't start to close, gradually increase the duty cycle value using the front panel control. Continue adjusting the duty cycle until the gate begins to close. Upon observations,

Note down the value at which closing starts, likely around 0.37.

1.4.2 Full Gate Closure:

Increase the duty cycle value further. The gate should continue closing until it reaches its maximum closed position.

Record the duty cycle value at which the gate is fully closed (likely around 0.62 as observed).

Note: Make certain that you are using the correct servo (GWS S03N STD).

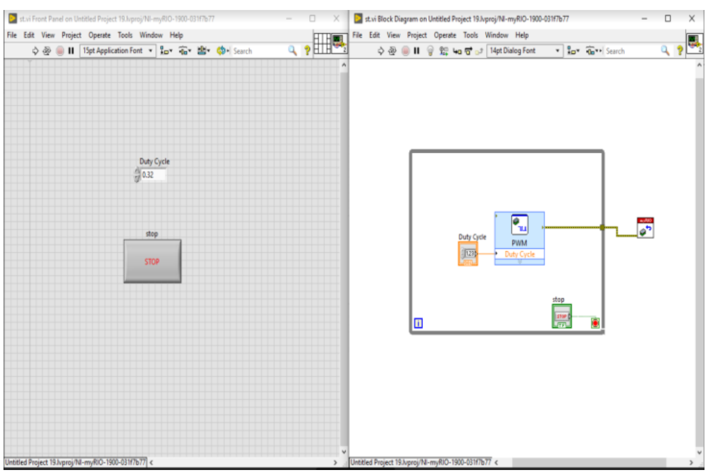

Fig.6: Front Panel and Block Diagram representation of Servomotor in labview

2) IR SENSOR INTERFACING

The interface circuit requires three connections to NI myRIO MXP Connector B:

1. 5-volt power supply → B/+5V (pin 1)

2. Ground → B/GND (pin 6)

3. Output signal → B/AI0 (pin 3)

2.1 Acquiring the analog input from the IR sensor

Connection: Connect the IR sensor's output pin to an analog input channel on myRIO.

2.2 Analog-to-Digital Conversion (ADC)

The myRIO's built-in ADC will convert the continuous analog voltage signal from the IR sensor into a digital representation.

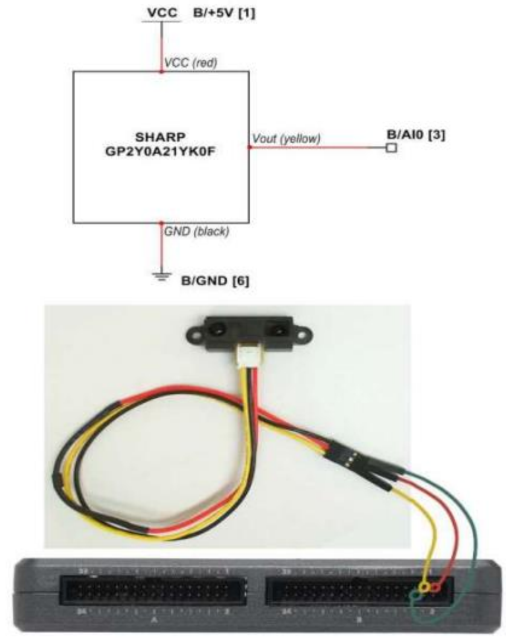

Fig.7: Demonstration setup for rangefinderIR connected to NImyRIOMXP Connector B

2.2.1 Converting ADC Value to Distance

Voltage Conversion: In some cases, the ADC output might be a raw digital value. If needed, you can convert this value back to a voltage value using the ADC's resolution and reference voltage.

2..2.2 Calibration: The relationship between the IR sensor's output voltage and the distance to an object is not always linear and can vary depending on the sensor model. Perform calibration to determine the constant of proportionality for a specific setup. This involves taking measurements of the sensor's output voltage at known distances and establishing a mathematical relationship between them.

2.2.3 Distance Calculation: Once we have the voltage value (either directly from the ADC or after conversion) and the calibration constant, you can use the following formula to calculate the distance:

Distance = [1 / (voltage)] * constant

We placed the IR sensors on opposite sides of the railway track, at a predetermined distance from the gate (e.g., 50 cm). This distance should be within the reliable detection range of your sensor.

Connect each IR sensor's output pin to separate analog input channels on the myRIO. Connect the servo motor to a PWM (pulse width modulation) output channel on the myRIO.

ADC Configuration: In your myRIO program, configure the analog

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input channels used for the IR sensors to read voltage values.

Implement a loop that continuously reads the voltage values from both IR sensors. Use the corrected formula distance = constant / voltage (along with the calibration constant) to calculate the distance for each sensor.

We defined a threshold distance (e.g., 20 cm) that signifies a train approaching the gate. Using a case structure in our program:

IF the distance calculated from either sensor is less than or equal to the threshold distance (20 cm) AND the distance calculated from the other sensor is also less than or equal to threshold distance.

Then send a control signal to the servo motor to close the gate.

ELSE (if neither sensor detects a train within the threshold distance)

Then send a control signal to the servo motor to open the gate.

Use the myRIO's PWM functionality to control the servo motor. By adjusting the pulse width of the signal, you can position the servo arm to open or close the gate.

Safety Considerations:

Include a safety buffer distance slightly larger than the threshold distance. This ensures the gate closes completely before the train reaches the sensor on the opposite side.

Consider adding additional sensors or redundancy measures for critical applications.

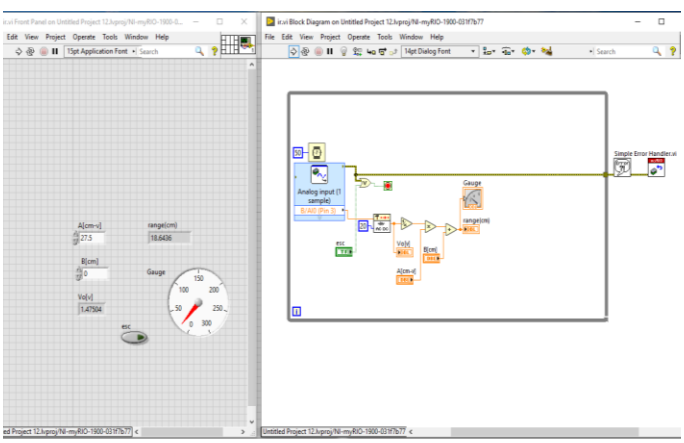

Fig.8: Front Panel and Block Diagram representation of IR Sensor in labview

IV RESULTS AND DISCUSSION

CASE 1:

In case of the train coming from the other end the after side IR sensors detects a signal and logic takes inputs and the gates are closed i.e., the move to 0°.As soon as the gate closes the delay is on and the gate remain closed until the train crosses the crossing.

Fig.9: Practical Output of CASE 1

CASE 2:

Whenever both IR sensors do not detect a train at threshold distance the servomotor will rotate to 90° (gate opened).

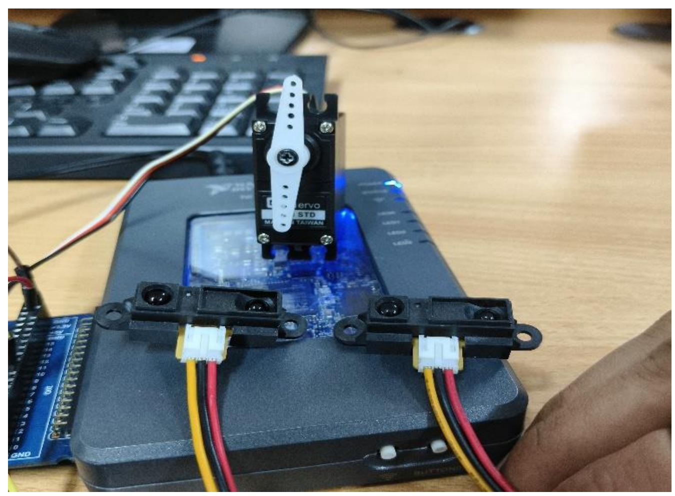

Fig.10: Practical Output of CASE 2

After complete integration of all components with NI myRIO and a personal computer. We have to run in stand-alone application.

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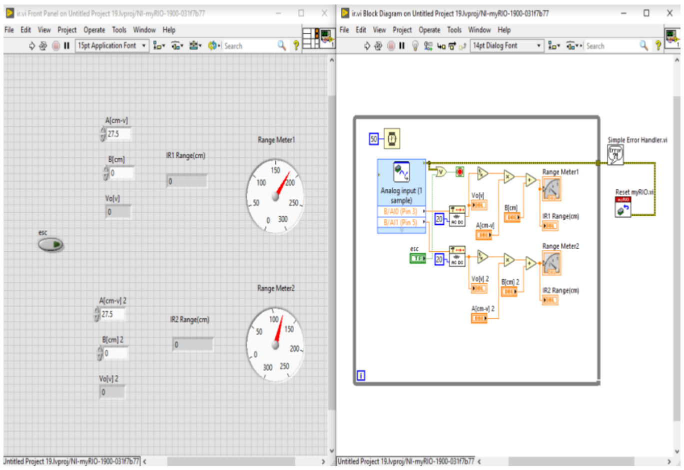

Fig.11: Front Panel and Block Diagram representation of Servo and IR Sensor in labview

RT (real time) Module:

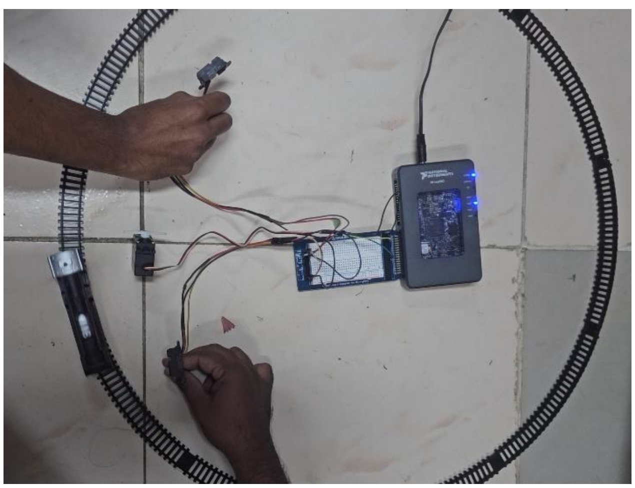

Fig.12: Demonstration of Real-Time Processing through stand-alone application

Creating a Standalone Application with LabVIEW:-

After developing your VI, generate a special type of executable file known as a "Real-Time Executable" using LabVIEW's build specifications. This executable is tailored to run in real-time on the myRIO's operating system (OS).

Transfer the built executable file to the memory of the myRIO device. This can be achieved through a USB connection between your development computer and the myRIO.

Once the executable is transferred to the myRIO, configure the device to automatically run the application upon power-on. This ensures autonomous operation without manual intervention.

Configure the myRIO device to automatically execute the deployed application upon powering on. This ensures seamless standalone operation without requiring manual initiation.

IV CONCLUSION

Proposing an automatic railway gate system to minimize human intervention in operating crossing gates, regulating the passage of cars and pedestrians across railway tracks. A key advantage lies in the placement of IR sensors at a minimum distance of 24 meters, enhancing detection accuracy. However, a limitation arises as once the gates close, they cannot reopen for vehicle crossings. Future endeavors aim to address this constraint by potentially incorporating load or proximity sensors and advancing the system for real-time implementation, resolving technological challenges for enhanced functionality.

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