Study of Weight in Motion Sensor for Railroad Crossing Warning System Using Artificial Neural Network

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Abstract. The risk of accidents in the railway, especially on unmanned railroad crossing, are still high. A train arrival on railroad crossing warning system is indispensable. The warning system will detect train arrival on the railroad crossing and issue a warning to the crossers. A sensor based on optical fiber Weight in Motion (WIM) is proposed. This paper presents a design of a railroad crossing warning system based on WIM sensor. The sensor placed under the railroad tracks and detects vibrations footprints transmitted along those rails. Artificial Neural Network (ANN) is used to process the signal pattern of the WIM system output. By using ANN, the vibration footprint pattern was classified and used as on-sensor train detection. As the train detected, the arrival time of the train on the railroad crossing was estimated. The result is a warning system which can detect train arrival on the railroad crossing and issue a warning signal.

1. Introduction

Accident in railroad crossing are considered more dangerous than other transportation accidents in term of death rate dan casualties. Thus risk of accidents are increase, especially on unmanned railroad crossing. Therefore, a warning system in railroad crossing is needed to detect train arrival and issue warnings to the crossers.

In a railroad crossing warning system, train detection are main components. Information from detector device are used by the warning system to initiate warning for crossers. In automatic level crossing control systems, the warning are interrelated to train signalling system, but triggered by the train movements, especially on wheel detection technology for synergistic effect [1]. Wheel detector function by detecting the travelling direction and presence of the train wheels at the strike in point [2]. Wheel detection can be used on detection point, tract location, direction of traffic and train speed [1].

Fiber optic sensors have the advantage of high sensitivity, anto-electromagnetic interference, high temperature and corrosion resistance compared with traditional sensors [3]. Weight-in-Motion (WIM) system measure the vehicle weight by detects the the shift light intensity output of optical fiber when the vehicles passing through on fiber sensor [4].

Pattern recognition is perhaps the most common use for neural networks. the neural networks the attempts to determine if the input data matches a pattern that the neural network has memorized [5]. This paper proposed a design of warning system which uses a sensor based on optical fiber Weight-in-Motion (WIM) and Artificial Neural Network (ANN).
2. Experimental
There are many scenarios and designs for train detection on railroad crossing. Such as, using sensor network [6] [7] [8], RFID [9] [10], IR [11][12][13][14], Ultrasonic [15], Accelerometer sensor [16], Android and GSM [17] [18].

The vibrations generated by the railway wheel will be detected by the WIM sensor placed under the railway bearing. Data from WIM sensors will be sent via Arduino UNO. The signal obtained from the WIM sensor will be processed first so it can be displayed in graphical form. The design of the railroad crossing warning system is shown on Figure 1.

![Figure 1](image1.png)

**Figure 1.** Design of Railroad Crossing Warning System.

The graph data then processed by Neural Network (NN). Neural Network will determine whether the signal being processed is indicating a train or not. If Neural Network detects that the signal is a train arrival signal, the Neural Network will calculate the time it takes for the train to arrive at the intersection. Based on the time calculation, the warning device will issue a warning signal for the arrival of the train.

The sensor will continue to read vibrations from the railway to the rail and send a signal to the Neural Network. If Neural Network detects the signal generated by the WIM sensor indicating that the train is running away from the WIM sensor, then the warning device will be turned off. The train detection processes is shown by Figure 2.

![Figure 2](image2.png)

**Figure 2.** Train detection processes.
3. Results and Discussion
The Neural Network consists of 256 nodes in the input layer, 64 neurons in the hidden layer, and 2 neurons in the output layer. The activation function of each neuron is a binary sigmoid, momentum constant is 0.6, the learning rate is 0.5, and the target error is 0.001. The number of learning and testing data of vibration patterns for train and non-train are shown in Table 1. The identification result of WIM pattern by NN in the testing phase is shown in Table 2. It shows that the NN can distinguish between the train and the non-train with the rate of 100%.

| Condition | Data Learning | Data Testing |
|-----------|---------------|--------------|
| Train     | 5             | 3            |
| Not Train | 10            | 3            |
| **Total** | **15**        | **6**        |

| Target | Testing | MSE | MSE |
|--------|---------|-----|-----|
| Train detected | 1 | Train | Train | 0.01 | 0.001 |
|           | 2 | Train | Train |     |     |
|           | 3 | Train | Train |     |     |
|           | 4 | Train | Train |     |     |
|           | 5 | Train | Train |     |     |
| Train Not Detected | 1 | Not Train | Not Train |     |     |
|           | 2 | Not Train | Not Train |     |     |
|           | 3 | Not Train | Not Train |     |     |
|           | 4 | Not Train | Not Train |     |     |
|           | 5 | Not Train | Not Train |     |     |
| **Percentage** | **100** | **100** |     |     |

4. Conclusion
This study has been focused to study the feasibility of using Weight In Motion (WIM) sensor to detect the arrival of train in a rail road crossing. The result will be used to design a warning system for a train arrival on railroad crossing. A Neural Network is used to determine whether the signal being processed is indicating a train or not. The result of the experiment shows that the Neural Network can recognize the signal from WIM sensor and determine whether the signal indicating a train or not with success rate 100%.

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