Early Warning System Prototype of Train Arrival Based on Internet of Things

D B Hertanto¹, R Asnawi² and F Surwi³
¹,²,³ Electrical Engineering Education Department, Universitas Negeri Yogyakarta
Colombo St, No.1, Depok, Sleman, Yogyakarta, Indonesia

Email: ¹denybudi@uny.ac.id; ²rustam@uny.ac.id; ³faranita@uny.ac.id

Abstract. This article discusses how to build a remote detection system prototype. An example of its application is for example to turn on a siren when it detects the arrival of a train at an unguarded rail crossing. The device to be produced is expected to be able to reduce and even prevent traffic accidents that often occur at unattended rail crossings. The specific objectives of the research are: (1) Producing a prototype design for the distance detection system at unattended rail crossings; and (2) Obtain good performance from the prototype design of the distance detection system at unattended rail crossings. Specific targets of research are prototypes of distance detection systems at unattended rail crossings that are performing well and well validated, nationally accredited journals, and IPR. The method of implementation uses development techniques (Research and Development) which refers to Pressman (2006: 409). This activity is carried out for 6 months, in outline the steps are: description and analysis of needs, design, making system prototypes, and system testing. The instruments used included checklists and questionnaires. The data obtained from the questionnaire were analyzed quantitatively to test whether the results met the predetermined indicators. The tool developed has special specifications, namely having a Lora-R02 transmitter and receiver module, a GPS module, a 900A SIM module which are all assembled as IOT using the Arduino Mega 2560. From the results of testing the prototype tool, all tool sensors can work well at a distance of less than 100 meters and only partial sensors work at distances greater than 100 meters. Meanwhile, the Lora module can begin to detect the arrival of objects at a distance of 300 meters.

1. Introduction
Train is one of the modes of land transportation that is of great interest to the public. Schedule accuracy, anti-traffic jam, and easy ticket purchase are the advantages of this mode of transportation. Apart from these various advantages, there are still many problems related to railways. The development of rail transportation modes in Indonesia still leaves many problems. The more rail lines built, the more negative impacts will be. The ease of purchasing tickets, the punctuality of travel, and the convenience of other land transportation modes makes it difficult to compete.

Another negative impact that arises is the increasing number of illegal railroad crossings. Illegal railroad crossings can often cause accidents that cause losses ranging from casualties to material losses of up to billions of rupiah, with an estimated average loss of over 100 billion per year [1].

Various methods have been done, ranging from counseling to the community, temporary guarding, to installing sirens. But accidents still happen. For example, a motorcyclist, Wahyu Rudiansyah (34), was killed by a train (KA) at a crossing without latches in the Village of Pesantren, Tambak District, Banyumas Regency, Central Java, Tuesday (18/6/2019) [2].

One solution to overcoming accidents at rail crossings is to install an Early Warning System (EWS). For example, the East Java Transportation Agency has installed 911 Early Warning Systems at railroad crossings [3]. However, the procurement of this equipment requires a lot of money. It costs tens of millions to purchase this tool. On this page it is also stated that the East Java Regional Government uses APBD funds for the procurement of these tools. In fact, the Ministry of Home Affairs prohibits the use of APBD funds for EWS procurement. This is a challenge that needs to be answered. Apart from the issue of funds for equipment procurement, the participation of the community, especially those in villages whose railroad crossings are not maintained, has also not been touched. As we know, the village has quite a lot of funds every year for development in the village.
To solve the above problems, as a first step, we are trying to develop a tool in the form of a cheap early warning system prototype for the arrival of trains using GSM signals. To make this happen, IoT is used in the application of the technology. So that this development activity has specific objectives, namely: (1) Producing a prototype design for the distance detection system at unattended rail crossings, and (2) Getting good performance from the design and construction of the distance detection system prototype at unattended rail crossings.

2. Research Method

The method used in this activity is research and development (Research and Development) which refers to Pressman (2012) [7]. Broadly speaking, the prototype development steps consist of: description and analysis of needs, design, manufacture or implementation, testing and validation, repair, fireplaces, testing of use or implementation, revision and finishing.

In the analysis of system requirements, this system prototype is expected to become a reference standard in the manufacture of early warning system prototypes in an effort to prevent accidents at train crossings without a guard, which refers to the prototype of an IOT-based remote control technology-based expert system. This system prototype is designed to be able to detect the train's arrival at a certain distance from the point of the tool, then turn on the direction of arrival lights and sirens to warn the surrounding community that a train is coming from a certain direction. Train arrival data is sent / broadcast from the train locomotive continuously as long as the train is running.

Making a prototype of this system requires several components. The components needed include: (i) Arduino devices at both receivers at the crossing point and at the locomotive, (ii) GSM module for two devices internet communication via cellular signal, (iii) prototype power supply system, (iv) Alarm lamp and OLED LCD, (v) Horn Siren, and (vi) 433MHz Lora Radio Module.

![Figure 1. Design of a prototype of the transmitter and receiver](image-url)

At the system prototype design stage, the tool container design, tool design, and system prototype interface design are carried out. The system prototype design is depicted in Figure 1. At the system implementation stage, system prototypes began to be built. Each design is assembled into a single system prototype which is interrelated with one another. The next step is to connect the device to the windows system prototype to run the prototype version of the program. The final step is testing the prototype. Tests are carried out to ensure that the prototype system being built can work properly according to the purpose of making the tool.

Data collection methods used in this study were tests and observations. The tests carried out include black box testing, which is to test the functioning of the prototype system for early warning of train arrivals at unguarded crossings. Observations were made when the railway expert validated the prototype system for Early Warning of Train Arrivals at Unattended Crossings. The instrument used in black box testing is a system prototype functional checklist. The instrument used in the railway expert validation is a checklist or validation format. The instruments used in the observation of the implementation trial of the prototype of the early warning system for train arrivals at unguarded crossings were questionnaires and checklists. As research subjects, there are several locomotives that are under maintenance at UPT Balai Yasa Yogyakarta. Samples were taken randomly. The data obtained by black box testing, railroad expert validation were analyzed descriptively.
3. Result

The way the device works is: (i) On the one hand, the motion sensor detects movement, (ii) When an incoming train is detected, the sensor will send data to Arduino, (iii) Arduino will send data to the GSM module, then the tool will send a signal, (iv) On the other hand, the train arrival signal will be received by the device, (v) The device will turn on the train arrival warning siren.

In the test, a point with Latitude -7.746076 and Longitude 110.372028 was chosen as a reference for installing the receiver and as a marker that the train will pass. The receiver will give a signal in the form of a buzzer for a few seconds and change the marker lamp from red to green. Changes in the marker lamp and buzzer on the receiver occurs when the simulated transmitter is inside the train entering the specified distance. In this test the specified distance is a radius of 100 meters from the receiver.

The starting point of the test starts with a transmitter at the coordinates of Latitude -7.743249 and Longitude 110.374271. The distance (S) between the receiver and the transmitter can be calculated using the following equation:

\[ S = \text{ACOS} \left( \text{COS} \left( \text{RAD} \left( 90 - L_1 \right) \right) \times \text{COS} \left( \text{RAD} \left( 90 - L_2 \right) \right) + \text{SIN} \left( \text{RAD} \left( 90 - L_1 \right) \right) \times \text{SIN} \left( \text{RAD} \left( 90 - L_1 \right) \right) \right) \]

The application of the tool can be seen in Figure 2. As a prototype, the tool is set up so that it can receive a signal at a distance of 300 meters and a warning will work when a distance of 100 meters. At the prototype testing stage, the receiver's position is at the coordinates Latitude -7.746076 and Longitude 110.372028. The transmitter will approach from a distance of about 1 km with an average speed of 60 km / hour.

The results of the tool testing can be seen in Figure 3. Based on observations in the functional testing checklist, the GPS module, Lora 433MHz module, LED, and Buzzer can work as desired. Figure 3 shows that at a distance of 305,358 meters, the Lora 433 MHz radio module starts working and sends telemetry data to the control computer as desired. At a distance of 98.2115 meters, the LED changes color from red to green, indicating the position of the transmitter has entered a distance of under 100 meters. At that distance the Buzzer also turns on a sound for a few seconds.

![Figure 2. Position of Transmitter and Receiver](image)

![Figure 3. Pieces of Tool Testing](image)
4. Conclusion and Suggestion

Based on the results and discussion, several things can be concluded as follows: (1) All the modules work 100%. Data transmitting is always on when the tool is working, (2) The system can always send telemetry data when GSM Module is active, (3) Receiver is responding when the Transmitter reach 300 meters distance. Receiver then will activate buzzer and the led when it reaches 100 meters distance, and (4) Distance detection system prototypes at unattended rail crossings was successfully developed with some limitations.

5. References

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