Controlling Railway Gates Using Automata Based Intelligent Controller

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Abstract **- In recent days, it is observed that the rates of accidents are rapidly increasing at Railways crossings. Due to poor maintenance and casual manual handling, the rate of accidents is increasing, signifying an urgent need of an automatic system. The demand of Railway Gate Control System (RGCS) is rising, providing a scope of improvement. This paper deals with Deterministic Finite Automata (DFA) and Unified Modelling Language (UML), explained through sequential flowcharts. Vienna Development Method Real Time (VDMRT) is used for mathematical purposes. VDMRT has a high level of abstraction than other general-purpose languages. The operations of the railway gate are controlled by UART 8051 microcontroller, explained via sequential diagram. This paper is an easier approach to make the RGCS automatic and independent of any human control.**

Index Terms **- Railway Gate Control System (RGCS), DFA, UML, UART-8051 microcontroller, GPS, VDM-RT.**

I.INTRODUCTION

Accidents due to railways are a leading cause of death all over the world. According to the survey [1], held in between 2001-2017, about 1078 accidents had taken place at railway crossings. In between 2010-2017, a total 781 railway accident cases were reported, out of which 359 (around 45.97%) accidents were held at level crossing. Operations of railway gate at level crossing by manual labour currently controlled by Railway Gate Control System (RGCS), is not reliable now a days. The bystanders have to wait for a huge amount of time before and after the train's arrival lot of time is wasted in this procedure as a gatekeeper has to manually operate the gate. So, an automata-based control system is needed, which is more reliable and reduces the chance of accident.

For a better understanding of the behaviour, modelling of system is required. Deterministic Finite Automata (DFA) is a powerful tool, used for the better understanding of perceptible flows of state transactions. DFA applications include security analysis, natural language processing, and speech recognition. We have proposed a system named Automata Based Intelligent Controller (ABIC) that includes DFA. Due to natural calamities high chances are there for the systems failure in RGCS. Hence in order to prevent this in our ABIC calculation of error free design level testing is provided by the UML. One of the major drawbacks of DFA is that it is unable to recognize simple languages including any problem which requires more than one constant. DFA converts to Vienna Development Method Real Time (VDMRT) that takes the various functions in our proposed system. Major drawbacks of UML include more emphasis on design and more time consumption.

II. RELATED WORKS

In [2], the authors have designed a Programmable Logical Control (PLC) based automated system which also includes DC motors, Light Emitting Diode (LED) signal light, reflective type photo-electric sensors. The sensors and PLC are used to design automatic railway level crossing gate control and DC power source is provided to control the main board and other components to detect the train. But in PLC it is difficult to connect the wires and sometimes it is also difficult to find errors. The system provided by S. Shrirao et al. in [3] is based on a study of railway gate control system which includes X-bee sensors that is used to avoid railway accidents and the signal is sent to the motor driver IC L293D which drives DC motor, by the microcontroller to close and open the gate. The X-bee sensors include short range, low complexity and low network stability which are not enough to control the railway gates at level crossing. The authors in [4] propose a system of railway gate control, based on

automata system, that detects the train by ultrasonic sensors and analyse the reflected waves which results of producing alarms, lights and controlling of gate. The limited testing distance and inflexible scanning methods can give inaccurate readings for the ultrasonic sensors. In [5], the authors propose a system based on Peripheral Interface Controller (PIC) microcontroller, ultrasonic IR sensor and Global System for Mobile Communication (GSM) Module.

They have implemented a modern communication system which decreases the manpower and at the same time to avoid maximum number of accidents. However, the used GSM technology can make trouble that is due to the same bandwidth used by multiple users. The authors in [6] implements an Arduino based anti-collision system for automatic gate control of railroad switch which uses GPS, Arduino, Infrared (IR) sensor, Ultra-violet (UV) sensor and Radio Frequency Identification Device (RFID). They provide an anti-collision system using Arduino which will be used to detect hindrance present on the railway track and later on will alert the train driver to avoid accidents.

In this study, we propose an Automata Based Intelligent Controller with combination of DFA and UML. For calculating the distance between the train and the railway crossing DFA is implemented by us. During any disasters such as earthquakes or heavy storms the system might fail to function. So, in order to prevent this, we propose UML to act in the system. The UML checks whether the calculation made by DFA to calculate the distance is error free or not. If not, the UML corrects it by the structural characteristics of the system. Meantime GPS located the next destination. DFA is then mapped into VDMRT that is a programming language similar to JAVA, C++ etc. We have implemented this as it contains various tools and performs different functions like whether syntax is correct or not, line checking, the type of variables used etc. For example, when the sensor sends signal to controller it checks whether the values in the program is stored in proper manner and values are not repeated. Then we have implemented UART 8051 Microcontroller that transfers the received signal from the GPS modem after calculation of exact distance which is calculated by our proposed system along with UART. After this the signal is send to the signal indicator that has the red and green lights which results in the opening and closing of the gate.

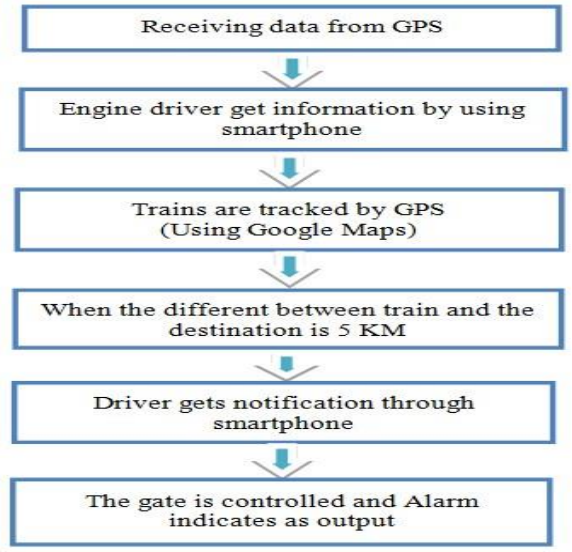

Fig.1 Block diagram of existing system

III. EXISTING SYSTEM

The existing automatic system, uses smart phone to control the railway gate, is based on the concept Internet of Things (IOT). IOT deals with machine to machine (two or more) communication. Previously, the devices that communicated with each other were, smart phones and signal indicators. The Global Positioning System (GPS) embedded smart phone was controlled by the engine driver. The Google map tracks the position of the train in real time. Earlier human monitoring was needed as the engine driver

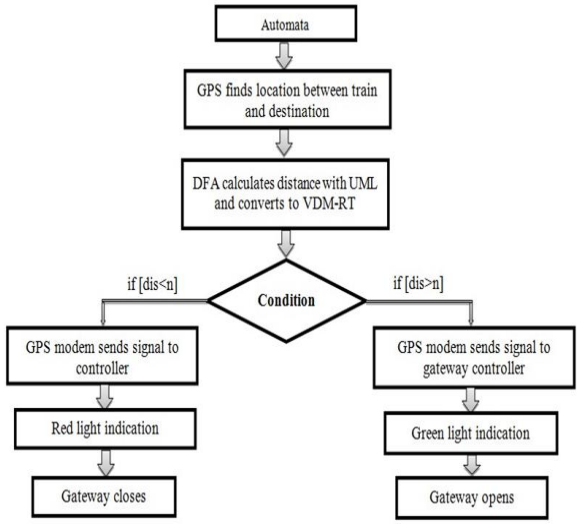

Fig .2 Activity diagram of our proposed system

himself controlled the railway gates via smart phone. Green signal used to get generated in the smart phone, when the train closed to the 5 km near the railway gate. Hence the engine driver could efficiently control (open or close) the gates at appropriate distance. An alarm used to get generated, when the driver pressed the button [7]. This process used to get continued at every railway gate. Fig. 1 shows the diagram of the previous system.

A. Railway Gate Control System

Railway Gate Control System (RGCS) is a crucial topic in railway system. It acquires major recognition because it helps to lower the rate of accidents. Many past studies show that different models are proposed and many techniques have been applied in railway crossing. Generally, gatekeepers are responsible for opening and closing railway gates. But many times due to the inconvenience of the railway staffs utmost accidents occur. To avoid this human intervention, the need of automated railway gate control system arrives. The automatic RGCS automatically sense the approach of the train and make the gate pull up and pull down. The present existing RGCS shows that at a certain distance when any train is about to approach at railway crossing, the sensors detect that and accordingly the operation of the gate happens.

In the existing system many times problem occurs due to information transmission and train detection.

To comprise the problem and to lower rate of accidents, conventional research is required.

B. Unified Modelling Language (UML)

The visual analysis of the system is presented by modelling, and depicts the system view in multiple perspectives. To demonstrate a system UML is used as an object-oriented language. UML furnishes the unique graphical notations which represents the system at notional level. Systems structural and behavioural properties are captured by this.

IV. OUR PROPOSED SYSTEM: AUTOMATA BASED INTELLIGENT CONTROLLER

A. Procedure

Our proposed work deals with RGCS and automata. In this work communication between devices is in between automata and the signal indicator. The GPS based embedded automata is installed in the train. The GPS tracks the location of the train in real time. As the whole process is controlled by automata, the manpower is not needed.

The modelling ability for complex and critical systems is enhanced by the integration of DFA with formal methods. The risk of disaster and uncertain situations may increase for the systems incorrect functionality.

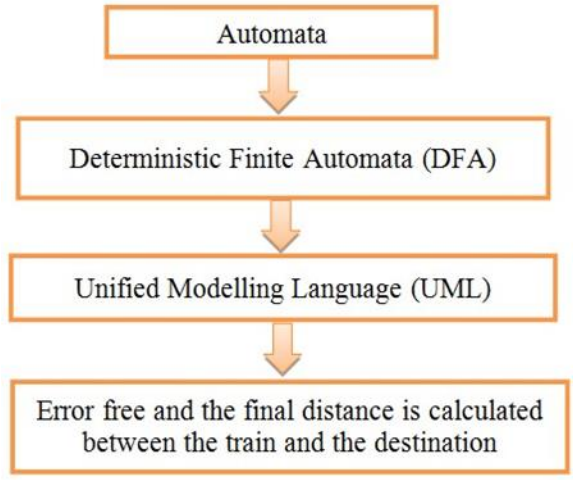

Fig .3 Block diagram of the working model of 'AUTOMATA"

The validation and correctness of the system is provided by formal methods that are mathematical statements providing designed level testing for which the occurrence of errors is reduced. Thus, the DFA converts to VDM-RT with help of UML that measures the dynamic behaviour of the system. With the help of VDMRT language, the system programs itself for accurate distance calculation. Then the GPS receiver receives the signal and the GPS transmitter transmits the signal serially to the gateway controller by UART 8051 microcontroller. Hence, the UART 8051 receives the signal and red light is generated, which results in closing the gate. After the train crosses 500m away from the railway gate, green light is indicated and the gate opens for the vehicles and people passing by. This method will be carried on after each train passes. Our proposed system can be further depicted by Fig. 2.

B. Description of Automata

Automata are a study of abstract machines where computational problems are solved. The word automata (the plural of automaton) come from the Greek word, which means "self-making".

Automata theory is closely related to formal language theory which includes mathematically based syntaxes that create the high-level model of the system. In short,

the automata take a word as input and decide whether to accept it or reject it [8]. Automata theory plays a significant role in computational theory due to its flexibility on representing finite length of symbols. The block diagram representing the working model of automata is illustrated in Fig. 3.

C. Sensor Calculation

DFA refers to Deterministic Finite Automata. If the machine reads one input string at a time than the finite automates it is called deterministic finite automata. Uniqueness of the automata is referred to as deterministic. In our proposed system, we are using DFA for calculating the exact location of the train. The automata-based sensor calculation algorithm is shown in Algorithm 1.

ALGORITHM 1

INPUT-

1. Take f_n as finite set of non-empty states that includes sens, cont, circ, dist, clos, open, buzz, ligh, dead i.e., sensor, controller, circuit, distance, close, open, buzzer, light and dead state.
2. Take $f_i$as finite set of alphabets that includes s, c, d, l, g, b, cl that means, sensor, check, distance, less, greater, buzzer, close
3. Take s as initial state, Trans as transition function that takes one alphabet and state as input, $a_0$as initial state of system.

Take a_1, b as input where $b \in f_i$

OUTPUT-

By definition of transition function,

1. $\text{Trans}\,(a_1, b) = a_2$ (Output) where $a_1$is nearly equal to sign a_2.
2. T is the finite set of final state= {clos, open}
3. Trans outputs next state where, $\text{Trans}: f_n * f_i \rightarrow f_n$

In real system when DFA is mapped and the microcontroller receives signal from sensors at a particular distance the sensors are switched on always.

$\text{Trans: sens} * s \rightarrow \text{cont}$
$\text{Trans: cont} * c \rightarrow \text{dist}$
$\text{Trans: dist} * d \rightarrow \text{circ}$
$\text{Trans: circ} * g \rightarrow \text{open}$
$\text{Trans: circ} * l \rightarrow \text{ligh}$
$\text{Trans: ligh} * cl \rightarrow \text{clos}$
$\text{Trans: clos} * cl \rightarrow \text{clos}$

D. Vienna Development Method Real Time (VDM-RT)

A mathematical explanation of the desired behaviour of a software system, which is specified by abstract, terms what a system should do and not it is its documented specification. The necessity of formal specification languages, such as VDM-RT expects to specify object-oriented systems with parallel and real time behaviour. It is an object-oriented extension of the VDM++ language. In our proposed system the DFA model is transformed into VDM-RT. In this system VDM tool supports executable substance of VDM-RT that includes syntax checker, type checker, interpreter and code generation to JAVA and C++. It provides various sources of open-source tool built on eclipse platform (overture) and also provides new open source VDM tool set that enables more automation in measuring the distance between the train and the next location.

E. Global Positioning System

Global Positioning System (GPS) is an efficient tool in scientific uses, surveillance and tracking. It gathers information about time and location anywhere through satellite navigation technology. In our proposed system, we are using GPS to track the real time location of the train. It facilitates to control the railway gates at the appropriate time.

F. UART 8051

A small computer on a single Metal Oxide Semiconductor (MOS) integrated circuit (IC) chip is called a Microcontroller. In our proposed system we are using UART 8051 microcontroller. The data received from the GPS receiver is processed by the 8051 microcontrollers to take out its values in the form of longitude and latitude. The interfacing is shown below in Fig. 4. It consists of GPS modules, MAX 232, UART 8051 microcontroller, and an LCD display. Detailed diagram is shown in Fig. 4. The Transistor Logic Level (TLL) is converted to RS232 logic by an integrated circuit MAX232, through serial communication of Atmel's microcontroller. The controller works at TLL logic level 0-5V. The AT89C51 microcontroller is an 8-bit microcontroller belonging to the Atmel 8051 family. It can be programmed and erased several times. The main motive here is to find the observe location of the GPS receiver (longitude and latitude). The output data

given by the GPS module is in the RS232 logic level format. Line converter MAX232 is used to convert RS232 to TLL. It is attached between GPS module and AT89C51 microcontroller. The utility of the location is then displayed on an LCD which is interfaced to the microcontroller.

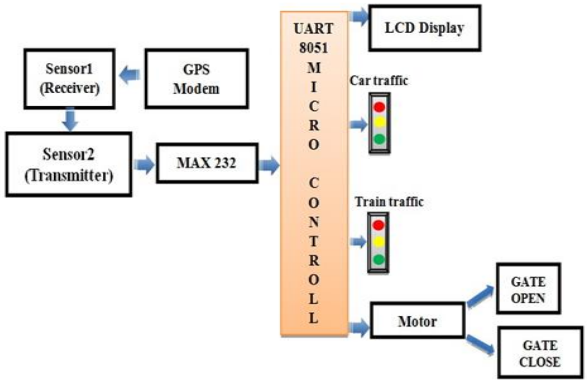

Fig .4 Working of Microcontroller

V. ADVANTAGES OF OUR PROPOSED MODEL

- Our Proposed system is deal upon Automata and different programming languages; thus, no manual control is needed and the system turns out in a complete automatic way. Also, more rapidly decisions can be taken as it is less time consuming.
- Our proposed system includes the major reduction of accidents, injuries and mishaps, so it is reliable much secure that provides safety to the road users.
- In previously mentioned model, the microcontroller used had a very narrow range (0-5volt). But in our proposed system, we have used microcontroller UART 8051. This provides a serial communication between UART and PC that works on RS232 standards having a wider range (-2.5V to 2.5V), which can be used in both Positive and negative ranges.
- In the existing system due to the usage of smart phones by the train driver there are high chances of accidents whereas our system is completely automated.
- The formal specification language VDM-RT, which is used in this paper, is the extension of VDM++ language. In technical works it helps to specify the object-oriented system with parallel and real time behaviour.
- VDM-RT systematically reports the desired behaviour of a system in abstract terms. This latest version of VDM supports executable subset of VDM++ that includes syntax checker, type checker, interpreter and code generation to JAVA and C++.
- VDM-RT is a model which has been expanded to be traced and to be written directly. It gives a feature to enable more automation in testing process.
- VDM-RT is a large language which helps to specify different high-level constructions, such as- sets, maps, and inferred functions, also without agonizing about the execution.

VI. CONCLUSIONS

Major accidents in railway level crossing are happening due to the negligence and inconvenience of the railway staffs and the drivers. This paper represents a model which will exclude manual intervention and will improve the safety standards. The new approach to improve the railway gate control system at level crossing is made after a comprehensive survey. Firstly, the system is designed by automata theory and based on Deterministic Finite Automata (DFA). Then it tends to Unified Modelling Language (UML) that provides unique graphical notations and capture systems structural and behavioural properties. Further the complete model is reformed into a formal specification language using VDM-RT which is an enormous language used in industrial and academic purposes. This paper provides a strong approach in automation of railway gate control system at level crossing.

REFERENCES

[1] G. H V Sai Simha, Shubhangini Bisht, “Accidents in Indian Railway System”, Journal of Transportation Safety & Security, pp. 1-12, Jan.2019. DOI:10.13140/RG.2.2.21497.93281

[2] R. Tasnim, Abu S. Shaikat, K. Sarkar, Md. I. Mahmud, M. Ali and Md. T. Islam, “Development of an Automated Railway Level Crossing Gate Control System using PLC”, Proc. of the Int. Conference on Industrial Engineering and Operations Management Bangkok, Thailand, pp. 3484-3493, March 5-7, 2019.

[3] Shubham Shrirao and Dinesh Rojatkar, "A study on Automatic Railway Gate Control System", Int. Journal of Advance Research and Innovation, vol. 5, issue 1, ISSN: 2347-3258, 2017.
[4] S. Mahmud, I. Reza Emon and Md. M. Billah, "Automated Railway Gate Controlling System", Int. Journal of Computer Trends and Technology (IJCTT), vol. 27, ISSN: 2231-2803, no. 1, sep. 2015.
[5] Dr. S. Anila, B. Saranya, G. Kiruthikamani, P. Devi, "Intelligent system for Automatic Railway Gate Controlling and obstacle detection", Int. Journal of Current Engineering and Scientific Research (IJCESR), vol. 4, issue. 8, ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697, 2017.
[6] Mahesh Kumar A S, Rajesh A S, Bhanu H S, "Implementation of Automatic Gate Control for Railroad Switch and Anti-Collision System using Arduino", Int. Journal of Recent Technology and Engineering (IJRTE), vol. 8, issue. 2S11, ISSN: 2277-3878, Sep. 2019.
[7] R. Velayutham, T. Sangeethavani, K. Sundaralakshmi, "Controlling Railway Gates Using Smart Phones by Tracking Trains with GPS", Proc. of the IEEE Int. Conf. on circuits Power and Computing Technologies (ICCPCT), 2017.
[8] A. Rehman, S. Latif, N. A. Zafar, "Automata Based Railway Gate Control System at Level Crossing", Proc. of the IEEE Int. Conf. on Communication Technologies (ComTech), pp. 30-35, March 2019.