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A SMART APPROACH FOR SECURE CONTROL OF RAILWAY TRANSPORTATION SYSTEMS

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Abstract: A novel method for secure transportation of railway systems has been proposed in this project. In existing methods, most of the methods are manual resulting in a lot of human errors. This project proposes a system which can be controlled automatically without any outside help. This project has a model concerning two train sections and a gate section. The railway sections are used to show the movement of trains and a gate section is used to show the happenings in the railway crossings. The scope of this project is to monitor the train sections to prevent collisions between two trains or between humans and trains and to avoid accidents in the railway crossings. Also an additional approach towards effective power utilization has been discussed. Five topics are discussed in this project : 1) Detection of obstacles in front of the train;2) Detection of cracks and movements in the tracks;3) Detection of human presence inside the train and controlling the electrical devices accordingly 4) Updating the location of train and sharing it with other trains automatically 5) Controlling the gate section during railway crossing. This project can be used to avoid accidents in the railway tracks.
Keywords: PIR Sensor, UART, Ultrasonic Sensor , SMAC Protocol, SCU.

I.INTRODUCTION

Railway train control systems are used to protect and manage the operation of trains over the railway infrastructure, including wayside signaling systems and train onboard controllers with components that communicate with each other. Train control systems are typical safety critical systems since they prevent collisions between trains and ensure the safety of train operations in general.

Here we implement a train collision avoidance system in which at the first level choose SMAC protocol for communication which has more coverage distance than Zigbee and is sufficient for two or more trains to communicate with each other.

Hence here we design a system which can be used by both trains to communicate with each other. We design automated switching section in trains which can be used for choosing tracks in multi track lines. Also automated road cross safety system is also implemented.

As the train approaches the railway crossing area the gate section closes automatically displaying a red light to warn passersby. Vibration sensor is used to predict the cracks
As the train approaches the railway crossing area the gate section closes automatically displaying a red light to warn passersby . Vibration sensor is used to predict the cracks and movements in the tracks. Ultrasonic sensors are used to detect the presence of obstacles in front of the train, causing the train to stop when it comes near the obstacles. PIR sensor is used to detect the presence of humans inside the train and turns off the electrical devices when there is no humans present utilizing power effectively.

II.RELATED METHODS

Haifeng Wang *et al.* [1] proposed an innovative topology based model for modelling railway control systems. The method addresses the problems of having to rely too much on designers' experience and of incurring excessive cost of validation and verification in the development of railway train control systems. Four topics are discussed in the paper: 1) the definition of basic topological units for modelling railway networks, based on the essential characteristics of these units; 2) the concept of a train movement authority topological space; 3) the interpretation of the train control logic as a topological space construct; and 4) topological space theorems for train control system verification. Advantages of this paper include higher levels of integrity in the design and implementation of such systems. The proposed model is less complex than the traditional approach and is more precise in terms of train control computation theorems.

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However moving block train control systems have not been discussed in this paper. Also there is no method to test this practically.

Thierry Lecomte *et al. [2]* present some recent applications of the B formal method to thedevelopment of safety critical systems, namely platform screen door controllers. These SIL3/SIL41 compliant systems have their functional specification based on a formal model. This model has been proved, guaranteeing a correct by construction behaviour of the system in absence of failure of its components. The constructive process used during system specification and design leads to a high quality system. The methodology we have developed appears to be efficient and well suited to address projects requiring high level of safety and short development time. The B formal method was not initially considered by RATP, but is now well accepted. The writing of some extra documents were required to help RATP engineers to fully understand, verify and qualify our deliverables. Reuse of existing models for similar projects proved to be efficient Advantages of this paper include efficiency and well suited to address projects requiring high level of safety and short development time. However manual translation from B models to the target language is error prone and requires specific verification process. Also functional and dysfunctional models are disjoint and also error prone.

M. Cacciola *et al.[3]* proposed a Finite Element Method based approach for modelling a fast and accurate evaluation of the defect in railways tracks. They exploit the measure of normal component, with respect to the scanned surface, of magnetic field. Whilst the scientific literature proposes a lot of solutions for detecting sub superficial defects, an open problem is related to the geometrical complexity of the structure and the relevant difficulty of crack detection. The proposed model is able to recognize deep and surface cracks even if their orientations are vertical to the longitudinal direction of the sensor. The modelled system is strongly versatile and the choice of electrical parameters affects the design of new probes for this kind of inspection. The modelled system is strongly versatile and the choice of electrical parameters affects the design of new probes for this kind of inspection. In particular, they propose a solution exploiting a rotating electromagnetic field with very encouraging results. The proposed model is able to recognize deep and surface cracks even if their orientations are vertical to the longitudinal direction of the sensor.

Advantages of this paper include providing a good overall accuracy in discriminating defect presence. The same approach should find useful applications like: Detection of third-layer cracks, above all concerning rivets within the framework of aging aircrafts' inspection, or micro-crack and micro-voids detection in welding process. However it can only detect the cracks after it has reached a certain magnitude giving very less time.

Satoshi Takahashi *et al.[4]* researched a paper for tracking people's locations in workplaces as part of a ubiquitous network system for providing context-aware services in daily activities using sensor network. Since the installation of such a sensor is desired any place within its target domain with few limitations, it must operate by battery for a relatively long time, e.g., one month. To satisfy this requirement, they designed a battery operated sensor node based on ZigBee technology and extended its operation period by developing a flexible sleep control protocol and a high-accuracy time synchronization mechanism between sensor nodes to reduce power consumption. Advantages of this paper include sending data to and fro between trains. The power consumption is very less when compared with the MEMS sensor. However The range of operation is limited by its operating conditions, suitable for in-door monitoring. ZigBee provides routing functions, in a cost of data loss during streaming.

III.PROPOSED METHOD

A model-based development and verification approach for railway train control systems and demonstrated a framework for constructing and verifying route-based tramway control systems. Ultrasonic sensor is used to detect the obstacles. PIR sensor is used to detect human presence in the train and controls electrical devices accordingly. Vibration sensor is used to detect the cracks and movements in the tracks. Efficient communication takes place between trains through SMAC protocol. IR sensor is used to detect the presence of humans near the railway crossings. RF transceiver is used to send the location of trains to the gate section and the gate, LED's are controlled accordingly.

This project is divided into 3 sections - 2 train sections and a gate section. Both train sections can also be fit in the same train. The train 1 section consists of ultrasonic sensor and PIR sensor. The train 2 section consists of vibration sensor, buzzer and RF transmitter. The gate section consists of IR sensor and RF receiver. All the sections consist of a power supply, LCD display and a 5x1 switch.

A. TRAIN 1 SECTION

The Train 1 section consists of a Microcontroller, Ultrasonic sensor, PIR sensor, 5x1 switch, LCD display, UART, SMAC protocol, SCU and buzzer. The Ultrasonic sensor is used to detect any obstacles in front of the train. It alerts the Loco pilot and stops the train if the train comes near the obstacle. The PIR sensor is used to detect h\the presence of humans inside the train and control the electrical devices accordingly. By placing these sensors in appropriate places, power can be supplied in areas where humans are present and not waste energy in unpopulated areas. The switches are used to control the sensors and power supply. The LCD display shows the output from Ultrasonic sensor and PIR sensor. The UART and SMAC protocol is used to share data with other trains.Fig.1. Shows the block diagram of Train 1 Section.

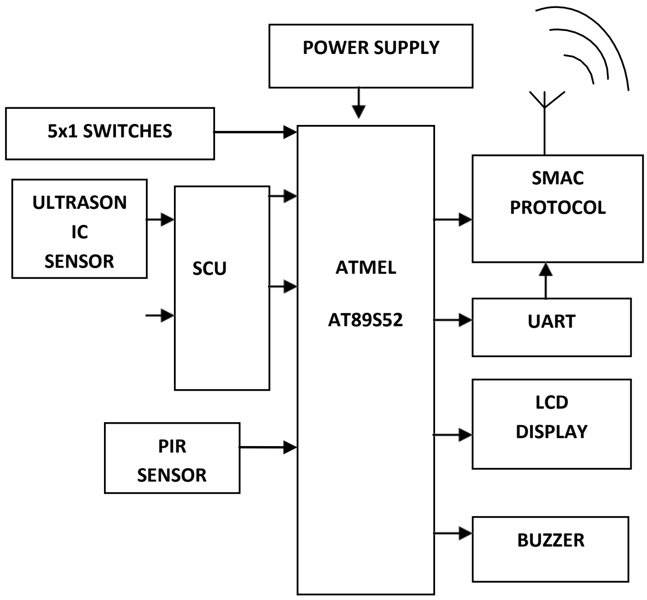

Fig.1. Block Diagram of Train 1 Section

B.TRAIN 2 SECTION

The Train 2 section consists of a Microcontroller, Vibration sensor, RF Transmitter, 5x1 switch, LCD display, UART, SMAC protocol, SCU and buzzer. The Vibration sensor is used to detect if there is any cracks or movements in the tracks and warns through the buzzer. The RF Transmitter is used to update the location of the train to the gate section. The rest of the devices are used just as they are used in Train 1 section. Fig.2. shows the block diagram of train 2 section.

B. GATE SECTION

The Gate section consists of a Microcontroller, 2 IR sensors, RF Receiver, LED's, Relay and a DC motor. The IR sensors are used to detect the presence of humans in front of the railway crossings. The RF Receiver is updated about the location of the trains. The LED's are used to display the red and green signal to the people. The DC motor is used to control the gate and the Relay is used to run the motor.Fig.3. Shows the block diagram of gate section.

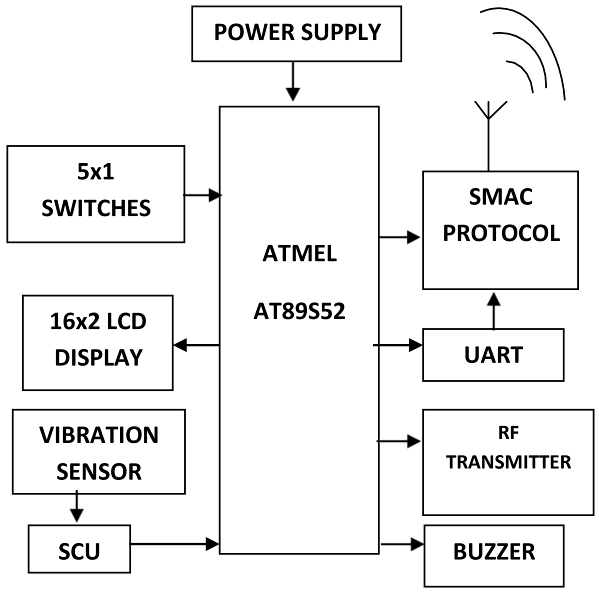

Fig.2. Block Diagram of Train 2Section

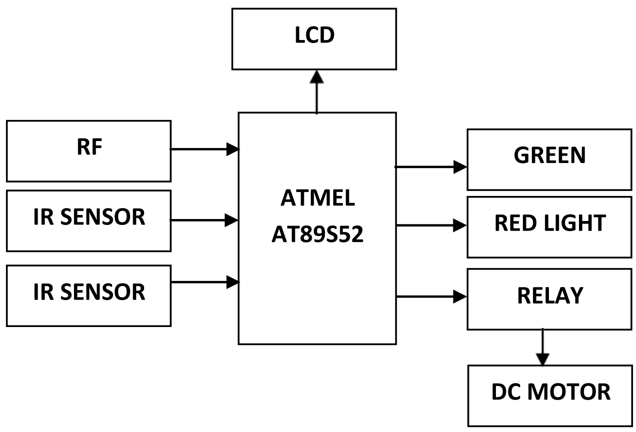

Fig.3. Block Diagram of Gate Section

IV. RESULTS AND DISCUSSION

A. TRAIN 1 SECTION

Fig.4. shows the circuit for train 1 section. It consists of an ultrasonic sensor, a PIR sensor, a power supply, a LCD display, a 5*1 switch and a relay. The ultrasonic sensor is used here to detect the presence of human and controls the motor accordingly. According to our observations, the motor starts when the distance is between 50 to 100 cm. Any other distance will not make the motor run.Fig.5. Shows the image of ultrasonic sensor.

Fig.4. Image of Train 1 Section

Fig.5. Image of Ultrasonic Sensor

TABLE I

READINGS OF ULTRASONIC SENSOR

S.No	Distance from the sensor	Condition of the motor w.r.t distance from ultrasonic sensor
1	20	NOT RUNNING
2	40	NOT RUNNING
3	60	RUNNING
4	80	RUNNING
5	120	NOT RUNNING

Fig.6. Image of PIR Sensor

Fig.6. shows the image of PIR Sensor. PIR sensor is used here to detect the presence of human and displays whether the electrical devices are ON or OFF in the LCD display.

According to our observations, the PIR sensor immediately detects the presence of human as soon as the power supply is on and displays the ON in the LCD display. As most of the times a human is standing nearby, the PIR sensor shows ON for most of the time.

The ultrasonic sensor can detect the presence of obstacles at a distance between 50-100 cm. As it detects an obstacle the motor starts running. The PIR sensor detects the presence of humans and displays whether the light is ON in the LCD display.

The 5*1 switch is used to control the sensor. The power supply is used to run the motor.

B. TRAIN 2 SECTION

Fig.7. Image of Train 2 Section

Fig.7. shows the setup for Train 2 section. This section consists of a vibration sensor, a RF transmitter, a LCD display, a 5X1 switch, a relay, a buzzer.

Fig.8.Image of Vibration Sensor

Fig.8. shows the image of Vibration sensor. The vibration sensor is used to detect the cracks and movements in the railway tracks preventing any accidents which happen due to faulty tracks. According to our observations, a slight vibration caused manually around the surroundings of the sensor can be detected. As this vibration is detected the buzzer goes on indicating a slight movement.

The RF transmitter is used to send the data between the trains telling about its location to others. Here the train 1 sends the information to train 2 and if they are in the same track then the trains stop. The vibration sensor detects the cracks and movements in the tracks. It gives a warning via the buzzer if there is any pressure on it. The RF transmitter is used to send the location of a train to another train or gate. This avoids any collisions between trains if they move in the same track.

C. GATE SECTION

Fig.9. shows the output result of gate section. The gate section consists of a RF receiver, 2 IR sensors, a red and green light, a LCD display, and a relay. The RF receiver is used to receive the information sent by the trains containing their locations and it controls the gate accordingly. The IR sensor is used to detect the presence of humans near the gate and controls the light accordingly.Fig.10. shows the image of PIR sensor.

The RF receiver gets the location of the trains and if the train comes near the railway crossing the gate closes automatically. The IR sensor detects the presence of human near the gate and shows the red light warning the passersby.

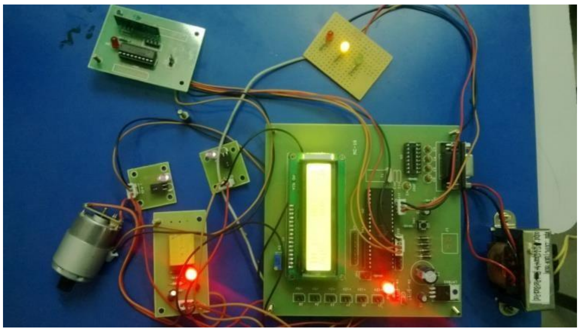

Fig.9. Image of Gate Section

Fig.10.Image of PIR sensor

For the reason of showing two trains we have fixed these sensors in two different trains. We can connect all these sensors in a single train. The UART and SMAC protocol is used to share the locations of the trains between them avoiding accidents if there are trains in the same track. The SCU is used to change the analog signals into digital signals. Mainly the Ultrasonic sensor produces analog signals which is converted to digital for further purposes.

V. CONCLUSION

The method proposed in this paper is a topology-based technique for the specification, development, and verification of safety critical train control systems. The application of this methodology will contribute to achieving ever higher levels of integrity in the design and implementation of such systems. This method will avoid all the human errors resulting in the decrease of accidents happening in the tracks. There is no need for a central hub due to direct communication between trains. Also there is no need of stationing manual help to constantly review the tracks. The loco-pilots can concentrate more on the driving aspect than constantly looking for dangers. Power is utilized effectively.

In the future, the number of devices used can be lowered so that less power is utilized. Also a much more effective wireless transceiver can be used to increase bandwidth.

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