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Automatic Train Protection (ATP) and Signaling with Accident Avoidance System for Indian Railways

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Abstract- Automatic Train Protection (ATP) and signaling with accident avoidance system for Indian Railways is proposed in this paper which aims to develop p a prototype of a safety system for unmanned level crossing areas and to avoid train accidents due to collisions and obstacles. The system consists of two Arduino Uno boards, two IR Sensors, two traffic lights on both sides of the track, servomotor controlled gate and an ultrasonic sensor to stop the train in case of any obstacle in front of running train .According to the INDIAN RAILWAYS ANNUAL REPORT AND ACCOUNTS 2014-15 [1] the main cause of accidents were carelessness on unmanned level crossings and the number of injured and killed were maximum due to this reason mentioned in [1]. The proposed system has automatic traffic light signaling on both sides of the track which indicates the traffic to stop while the train is moving and the gates on both sides of the track will automatically close to stop the transport and open after train crosses the other end. The proposed system will also provide safety for train collisions. This logic was applied in Embedded C and programmed to the Arduino Uno.

Keywords *: **Arduino, Unmanned level crossing, IR Sensor, Microcontroller, Ultrasonic Sensor, Servomotor***

I. INTRODUCTION

Railway is the cheapest and easiest mode of transport for a common person but as the population increases it also becomes the most inconvenient and unsafe source. Due to the huge burden on railway industry results many problems which includes technical errors and human mistakes at level crossings. The area of crossings is a high accidental place due to the cross-section of railway track and road intersect each other .Most of the studies came in to existence to analyze the parameters responsible for mishaps in railways. In which one of the current studies deals the data of last 16 years that is year 2000-2016 revealed that the major accident type was train derailment followed by level crossing accidents. The accident type occurred in Indian Railways over the years followed the trend Derailment >Accidents at level crossings> Collisions >
Fire in trains > Miscellaneous accidents [3]. It has been proven in many studies that level crossing accidents and collisions are the biggest factors of accidents in railways.

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Therefore a consistent system is required in order to operate level crossings automatically. The aim of this paper is to introduce a economical automatic signaling arrangement for unmanned level crossings that give traffic signal to avoid accidents and the system also have the provision to stop the train if any obstacle or chances of collision is detected.

II. EXISTING SYSTEM

Over the years many researchers have tried to produce a system that can automatically handle level crossings. Vinit P. Kharkar in [2] presented a system which uses infrared sensors to senses the movement of train and to control the functions Raspberry Pi module is used .The closing and opening of gate is controlled by servo motors.

Xiaomin Zhu and Junyang Li gave a WLAN based CBTC(Communication Based Train Control system)for train protection. This paper gives the studies of general structure and modeling of ATP system and establish a model of brake curve for ATP system which helps in optimal design of ATP system[4].

Many mechanical systems have been developed to overcome these problems .Authors in [5] gave a microcontroller based system for unmanned level crossings that control the level crossing gate by instructing the micro-controller. Whenever train approaches at the sensor, warning is activated for the general population at entryway and the gate will be shut. Once the train arrived, this system will lifts the gate. DC adapted engines are utilized for the mechanical operation of gate. They used an installed microcontroller worked on 8051 family for control. The microcontroller will follow the instructions to shut or lift the gate. This logic was implemented in Embedded C and uploaded to the Raspberry PI.

Authors in [6] proposed a WSN network model for the railway functions which have control centers connected to the wire lined connection and different wireless sensor nodes through the rail track. In [7] authors gave a RF tag system for unmanned level crossings .The proposed system can also prevent the problem of collisions of trains on common track by using IR transmitter and receiver system at each station. Much research is being done around the world to address the issue of level crossing. An article in this context, proposed in [8], illustrates the use of Ultra wide band technology to Level crossing security and proposes a solution related to the combination of UWB connection and optical fibers that continuously integrates all signal processing processes signal to one remote central unit [8].

A system to control railway gate using mechanical and electrical components has also been published .They uses infrared detectors which detects the arrival of train and drives the signal to controller. A timer receives the signal and displays the remaining time for shutting and opening the gate according to the situation.

A motor is used to move an L- shaped cylinder which is connected from beginning to end to the pinion- rack arrangement. The motion of rack opens or closes the gate without human interference [9].

One another work is proposed by authors in [10] in which railway track occupancy status is detected using XBEE module and HC-SR04 (ultrasonic sensor). The sensed output of the system gives the Time Difference of Arrival which is used to identify the existence of target. The detect status is given to the receiver which is placed at level crossing and it activates the alert mechanism [10].

Although the system is designed with low cost components. But the system proposed in this paper is more cost effective and having more features than any other proposed systems. Table I shows the year wise train accidents occur due to different reasons.

TABLE I-OCCURRENCE OF TRAIN ACCIDENTS IN INDIAN RAILWAY FROM YEAR (2000-2016) [11]

Year	Collisions by trains	Derailments	Accidents at level crossing	Fire in trains	Miscellaneous	Total
2000-01	20	350	84	17	2	473
2001-02	30	280	88	9	8	415
2002-03	16	218	96	14	7	351
2003-04	9	202	95	14	5	325
2004-05	13	138	70	10	3	234
2005-06	9	131	75	15	4	234
2006-07	8	96	79	4	8	195
2007-08	8	100	77	5	4	194
2008-09	13	85	69	3	7	177
2009-10	9	80	70	2	4	165
2010-11	5	80	53	2	1	141
2011-12	9	55	61	4	2	131
2012-13	6	49	58	8	0	121
2013-14	4	53	59	7	3	117
2014-15	5	63	56	6	5	135
2015-16	3	65	35	0	4	107
Total	167	2045	1125	120	67	3515
Mean	10	128	70	8	4	220
SD (±)	6.9	89.3	16.4	5.2	2.4	112.9

Authors in [12] investigated an innovative localization algorithm that centralizes tachometers and inertial measurement units. In present days, the assessment is done by an odometry algorithm that formulates on the sensors of wheel angular speed. The motive of the system was to rise the accuracy of the odometric assessment, in serious conditions, for which sensor fusion techniques is used which is based on Kalman filter theory[12].

Author in [13] designed an alert system that provide alert to the train operator regarding the traffic at level crossing. The model has a vehicle locator that detect whether there is an obstacle stuck at the level crossing.

Authors in [14] designed a system which uses an upgraded communication between Internet of Things and Embedded Systems. The system gives a real-time caution in advance for unmanned level crossings. The developed system provides an audio and visual warning to the traveler that warns about an approach of train.

In [15] author developed an infrared arrangement for ATP. This ATP is the intermittent train protection system which is divided into two parts one is onboard and the other is trackside equipment. The equipment also has the receiver of infrared which detects and process the train speed, alarm and brake. The trackside equipment consists of infrared transmitter that works the transducer.

A. Limitations of Existing System

1. These systems do not have the provision to stop the train in case of collision or any obstacle.
2. Existing system does not have the automatic control on both sides traffic.

III. PROPOSEDSYSTEM

The proposed system is a microcontroller ATmega328P based system with very low cost. This microcontroller is the brain of the system and it is incorporated in a board which is equipped with some I/O pins which can easily interface with other circuits. The proposed system has two Arduino boards, one ultrasonic sensor, and one relay, two servo motors on both side of the track to close or open the gates of track. System also has an automatic traffic light signaling system on both sides in order to control the traffic .If any obstacle or train comes in front of running train the system will stop the train itself using relay to avoid collision. The methodology flow chart of the developed system is given in figure1.

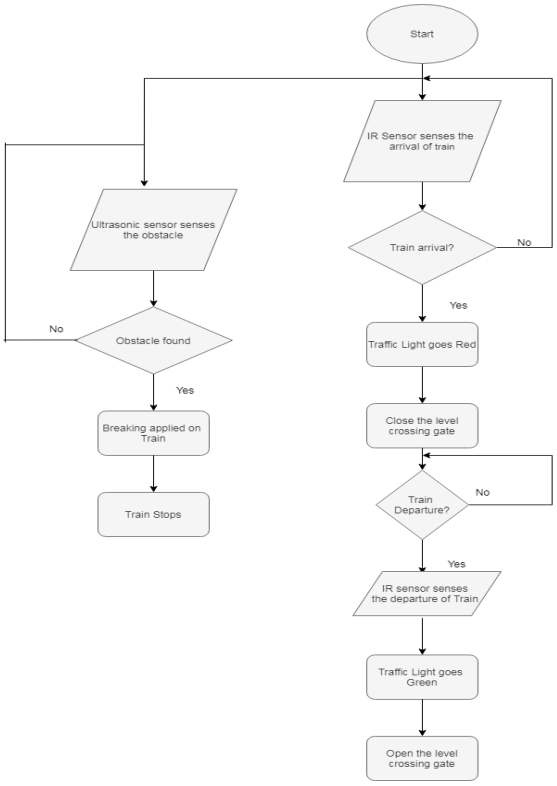

Fig. 1.Flow chart of the proposed system

A. Circuit Diagram of Proposed System

The circuit diagram of the whole system is given in figure 2 and figure 3. The figure 2 shows the connection diagram of the arrangement that will stop the train in case of any obstacle and figure 3 show the illustration of the system that automatically controls the level crossing gates.

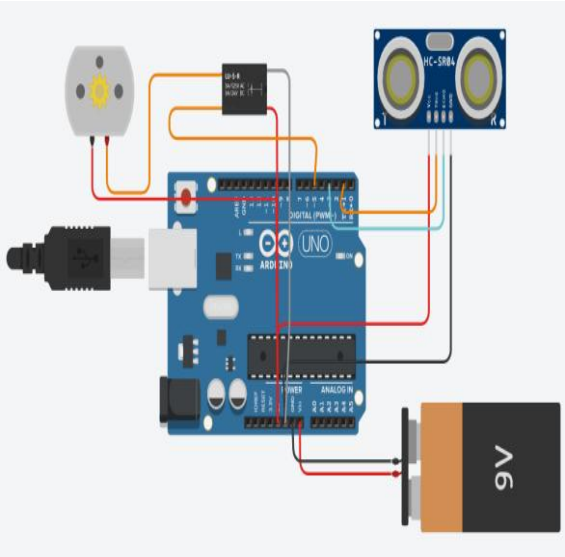

Fig. 2.Connection diagram of train control

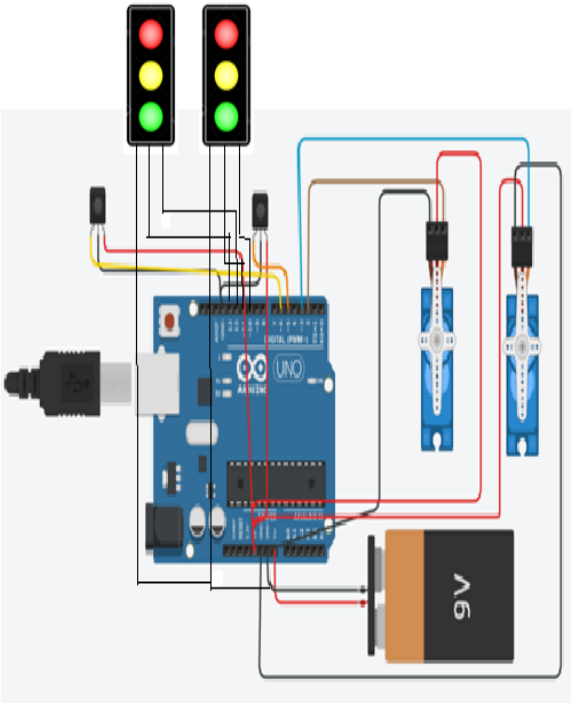

Fig. 3.Circuit diagram to control level crossing gates and traffic lights.

B. Schematic Figure of Developed System

Another figure 4 shows the schematic of the developed system. The picture clears the place of all connected components.

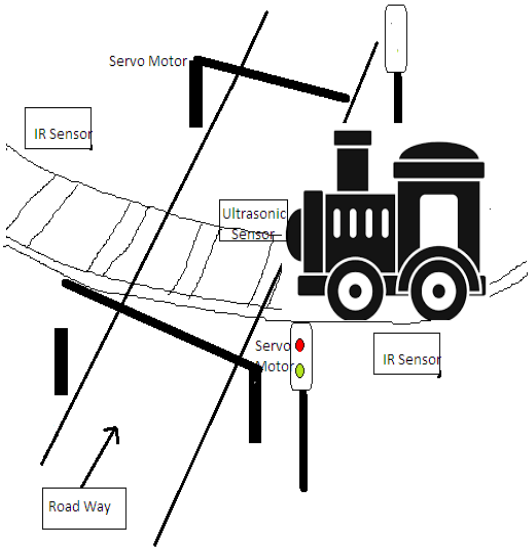

Fig. 4.Schematic of developed system.

C. Prototype of Developed System

Figure 5 & figure 6 show the images of the prototype of proposed system. Two Arduino Uno boards are used to develop the system one board is movable with train and another board will handle the proper working of traffic signaling and rotation of servo motors to control the level crossing gates .One ultrasonic sensor HC-SR04 is mounted in front of the train to sense the another coming train or any obstacle. In case of obstacle found one relay module of 10 A, 1 channel is connected to detach the supply of the train .Two IR sensors are located near the lane in which one is placed before the level crossing gate and other is placed after the level crossing gate to sense the arrival and departure of the train. Two servo motors SG90 are mounted to operate the functioning of level crossing gates.

Fig.5. Prototype of proposed system

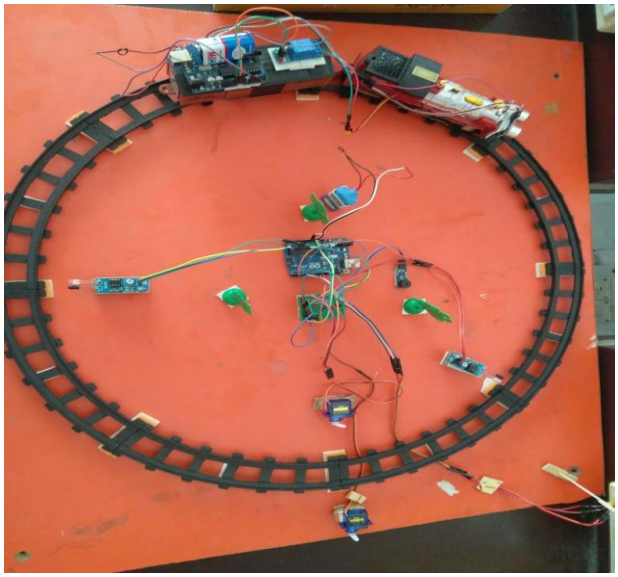

Fig.6. Prototype of proposed system

IV. COMPONENTS DISCRIPTION

A. Arduino Uno

Arduino is an open-source electronic hardware board which consists of hardware and software both which is handy use. It can read input light on a sensor, can operate servo motor and can control traffic light system according to the given instructions.

To program this Arduino board one software named Arduino Software (IDE) is used.

The Arduino is a µ-controller board which has ATmega328P µ-controller. It has 14 digital I/O pins in which 6 pins can be used as PWM output pins other 6 pins connected on other side of the board can be used as analog input pins, and the board also has 16 MHz frequency which is generated by a quartz crystal. Board also has a power jack, a USB point, a reset button to reset the microcontroller and an ICSP header. It consists of appropriate hardware to support the microcontroller and it simply can be connected to a computer through USB cable or it can be connected to AC –to-DC adapter or battery to get powered.

B. Ultrasonic Sensor

An ultrasonic sensor is also known as ultrasonic transducer. HC-SR04 ultrasonic sensor is also used in developed system. Sensor's transmitter transmits an ultrasonic wave and this wave travels in air and when it gets strikes to any other material it gets reflected like a radar/sonar.

Ultrasonic sensor measures the distance travelled by the ultrasonic wave between the emission and reception. It has 4 pins and a transmitter unit and receiver unit with a control circuit. Pin 1 is used to connect with power supply and pin 4 is used to connect the Ground as shown in figure3. Pin 2 is used as trigger pin and the received signal can be obtained on Pin 3. It can works at maximum of 5V DC supply. The circuit will draw current of 15 mA when the sensor is triggered. The sensor needed an initial 20µs trigger pulse.

C. IR (Infrared) Sensor

IR Infrared Obstacle Avoidance Sensor has two infrared LEDs which are used as a transmitting LED and receiving LED. When the transmitted waves are created ECHOs, then they will be received by the receiving LED. The processing circuitry for comparing does the processing and the indicator LED of green light will light up.

The module has 3 pins GND, VCC and an OUTPUT pin. It can work on 3.3 to 5V DC voltage. The output pin gives a low-level digital signal on reflection. The preset of this module is used to tune the operation. The range of the effective distance of the sensor is 2cm to 80cm.

D. Relay

A relay is a switch which is electrically operated. It has inputs terminals to control a single or multiple control signals, and the circuit will make or break depending upon the status of input signal. It has normally open (NO) and normally closed (NC) terminals in which the contacts will connected.

V. BLOCK DIAGRAM DESCRIPTION

1. The approach of train is detected by the sensor which is situated on both sides of the level crossing.
2. Once the train is approached and sensed, the sensed signal is input to the microcontroller of Arduino board.
3. According to sensed signal the traffic lights on both sides of level crossing indicates the road users to stop and the motor of level crossing gate start operating by closing the gate.
4. The departure of the train is spotted by the sensor which opens the level crossing gate.
5. In addition one ultrasonic sensor is also connected with the train which senses any obstacle or train collision further the sense signal is given to microcontroller to stop the train for which a relay is connected to make or break the connections of train.

VI. ADVANTAGES OF THE PROPOSED SYSTEM

1. Work on real time information processing
2. Automatically train sensing
3. Less sensitive to vibrations, shock and electromagnetic interference.
4. High accuracy in sensing
5. Less operating cost
6. Have the provision to automatically stop

VII. RESULT

The created system has ease of implementation and simple circuitry and the components used for implementation are also cheap. The system can avoid accidents due to train collisions and can handle the automatic signaling in crossing areas.

The signals generated by IR sensors instruct the microcontroller to open and close the gate in order to stop and release the traffic and the second advantage of the system is to avoid the collision by stopping the train in case of obstacle and for this ultrasonic sensor and relay is used to detect the obstacle and cut down the supply of train respectively.

VIII. CONCLUSION

There is a big challenge to avoid the accidents at the positions where there is no one to manage the opening and closing of crossing gates of railways. In the developed system we are using the servo motor to open and shut the crossing gates automatically. The movement of servo motor is restricted to 90 degrees and it can be rotated anticlockwise or clockwise direction. When the train approaches in a particular direction the transmitter of the mounted IR sensor senses and it will produces a suitable signal, then at the same time the receiver of the IR sensor receives the signal and generates an interrupt signal .This signal instruct the microcontroller to control the servo motor which is operating the motion of level crossing gates. The traffic light on both sides of the level crossing gates will stop the road traffic. When the train passes, both the gates will open automatically and traffic light will indicate to move on the traffic. Another important provision is added to the system to avoid collisions or accidents due to obstacles for which ultrasonic sensor is used which can detect the obstacle and a relay which will act as a switch will stop the train in case of obstacle is detected. By automating the level crossings in this way the number of accidents in the level crossings can be minimized. The system has all the provisions to stop any possibility of accident.

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