Wireless Personal Communications (2023) 128:1133–1152
https://doi.org/10.1007/s11277-022-09992-5

Sensor Based Smart Railway Accident Detection and Prevention System for Smart Cities Using Real Time Mobile Communication

Ali Mustafa[1] · Ozain Rasheed[1] · Shahzad Rehman[1] · Farman Ullah[1] · Salman Ahmed[2]

Accepted: 29 August 2022 / Published online: 13 September 2022

Abstract
Recent advances in various technologies have introduced effective new systems that can be successfully deployed in various future rail operations and applications, including smart city security functions. Rail accidents are a major problem in the transportation industry in many countries around the world. There is an urgent need to install protective elements to prevent accidents. This research describes the design and implementation of the rail safety system for smart cities using real-time mobile communication. The proposed prototype system has two basic functions to operate, namely accident detection and accident prevention. The proposed system consists of several sensors, LTE module, micro-controller, motorized gate and various displays for traffic control. The detection of the train is tracked via round trip time of the ultrasonic sensor and a micro-controller is used together with a GPS module and an LTE module to detect accidents. Hence there is two-way communication between the train and the control room. The proposed system is implemented by controlling the automated doors according to the reading of the sensors. When the sensors detect the movement of the rail, they can indicate this in real time through a buzzer and the message, which will eventually close the doors installed at the level crossing. In addition, the coordinates of the rail are transmitted via the GPS module, the GPS module continuously monitors the location, speed and time of the car. Therefore, the stated goal is achieved through real-time two-way communication between the control room and the rail via LTE and GPS modules. In this research, a prototype is designed and tested in real time for various scenarios to demonstrate the effectiveness of the proposed system. In the end, this research provides the simulation results to substantiate our claim to the reliability and importance of the proposed system for the implementation in the smart cities.

Keywords Smart city infrastructure · Railway network control · Adaptive sensor network · Intelligent transportation systems · IoT and 5G

✉ Ali Mustafa
ali.mustafa@ciit-attock.edu.pk

[1] Department of Electrical and Computer Engineering, COMSATS University Islamabad, Attock, Pakistan

[2] Department of Computer Systems Engineering, UET, Peshawar, Pakistan

1 Introduction

Railway is one of the famous worldwide transportation system and approximately 3900 Billion people uses train around the world. At the same time, it experiences multiple accidents on a larger scale which results in a loss of many precious lives. The various causes for such accidents in a world is well described in Fig. 1 [1]. It is well obvious from the Fig. 1 that the main reason of the 50% railway accidents is the trespassing [2, 3] so motivated by such problems in the existing railway setups we are proposing a smart sensor based intelligent railway transportation system for smart cities. Specifically, only in Pakistan there exists an about more than 2000 unmanned level crossings around the country. So, it is much needed to take certain steps to control the accidents of railway by implanting the smart standards to minimise the risk of human loss. It is worth mentioning here, that in the first three years of the present government in Pakistan there is no such work in the top priorities related to railway accident prevention system [4, 5]. According to a latest survey nearly 595 accidents tool place in the country which cost many lives [6, 7].

Motivated by the problems described in the literature, we are proposing such a system in which we can make our cities safe and provide our country with economic growth. One of the major problems around the world is increasing ratio of accidents [8]. A great challenge to overcome this situation, so a solution is proposed which consists of two phases.First phase is accident prevention with the help of LTE module, ultrasonic sensors and traffic indicators. In second phase accident detection is carried out when train is crashed there is a sudden change in it's speed which is continuously monitored through GPS module on train and sent to control room [9].

Due to increasing development in automation there is a risk factor present,so there should be a system to make the fast moving tracks safe.This paper proposes a system comprised of multi-sensors. Two levels are used; a high level and a low level. In high level tracks safety is determined while in low level there is emission and detection process with the help of us (ultrasonic) sensor [10, 11]. Due to over speeding road accidents are increasing over the time, which cost life of many people so a system is proposed in this research. Which comprises of a LTE module to keep track of train location, speed and time. Which is very helpful in tracing the accident location and sending required information to alert control centre to reach at accident site [12, 13]. To make railway transportation system safe and reliable, we need to design a system that responds to certain events in a very short period

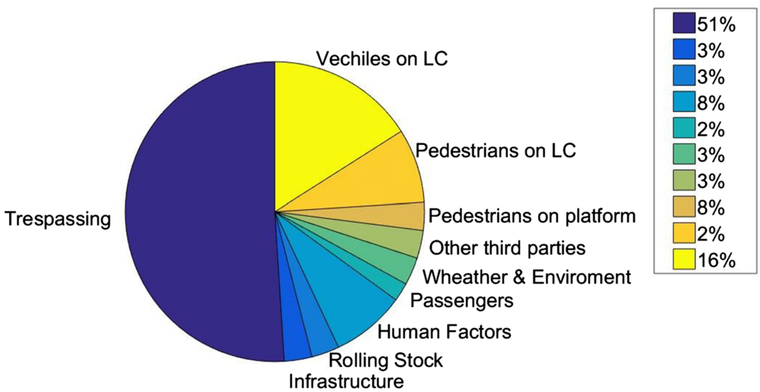


Fig. 1 Global accident ratio

of time using IOT. Through different sensors installed at different positions and locations, all data is gathered and is send to cloud for further actions [14, 15]. On the basis of the data received, we can timely make decisions. Through this method their is possibility that human interference not only can be minimized but can be removed from the level crossings and all system can be visualized through a single setup [16, 17]. Proposed mode of communication is very important in aspects of safety and it can be easily be implemented [18, 19]. Proposed model acquire the data using sensors for detection of train and provide the desired information to the control room for the further processing [20].

Furthermore, the proposed research is presented as follows. Section 2 provides the Literature review. Proposed model is presented in Sect. 3. We present simulation results in Sect. 4 and conclusion is provided in the end of the paper in Sect. 5 of the paper.

2 Literature Review

The modern world is advancing very rapidly in terms of technology and communication [21]. In today's era, we are very much near in the introduction of the autonomous vehicle systems, industrial revolution and concepts like virtual reality, e-health, and machine learning [17]. To catch up with these up to date versions of automation we need to have a fast and wireless communication system [19]. Different modulation techniques are implemented at the transmitter end with the technological enhancement such as 256 QAM [22]. 5G provides the connectivity to everyone, everything and everywhere. There is another advancing concept called 3GPP (third generation partnership project) which can be considered as the key feature of 5G [11]. The world is very much near in implementing the 7G communication system but in our country, we are looking towards 5G which has a very high data rate and more users can be accommodated in the available bandwidth [13]. In 5G we have a new term called MM (massive MIMO) means we have a large number of transmitters and receivers and this means that the mode of communication is very much advanced and is growing very rapidly. The concept of small cells or femtocells is really the 5G because in this way more users can be benefitted [23]. 5G operates in different bands depending upon the availability [7]. With the technological advancement, we are having advanced versions of batteries and processors [3]. Along with the hardware advancement, we have link enhancement which includes smart antennas having nanotechnology, modulation, adaptivity, bandwidth and digital signal processing [15]. Then we have network enhancement which includes efficient resource allocation and after that, there is an enhancement in the application which includes soft and adaptive quality of service [24].

A technique called image recognition technology is used in Taiwan for enhancing emergency management. Image recognition and location-based services are used to improve the safety system. Railway is a very efficient mode of transportation but still, a lot of accidents occur around the country [25]. To overcome this problem vision based object detection algorithm is used, in this method different cameras are installed at different positions on the railway platform. After that the data from these cameras is checked through data fusion technique. Three-way cameras are used to determine any object placed on the track and also checking the arrival, departure, stop or in motion status of the train [26].

An algorithm called augmented reality (AR) is used now a day's across different parts of the world. We can define AR as, "Enlarged the truth is an intelligent encounter of a true situation where the items that dwell in reality are improved by PC produced perceptual data, now and then over numerous tactile modalities, including visual, sound-related, haptic, somatosensory and olfactory". This system uses GPS and a camera for the complete monitoring of the train [27]. After obtaining the desired results the whole communication is made through a client–server architecture. Client architecture includes the AR module, network control, data access module, and google maps. In server architecture, we have web service, image retrieval engine, and data access layer [28].

For the passenger's safety, we studied a system namely vision-based object detection for passengers safety. This system proposes the work on three dimension position information algorithm, which trains from different angles using a stereo vision system and also the obstacle in the path of the track can also be detected. This process is so efficient that it can differentiate between the human beings and non-living things, this is the thing that makes it efficient and unique from other processes [29]. For condition monitoring of train as well as the track we can use different topologies, some of which are discussed here. One of them is a wireless sensor network which includes relay nodes, sensor nodes and GSM for communication regarding the condition of the train. We can define relay nodes as, "A relay node" is short type of network which provides a communication between two devices [5]. In such a system the source and goal can't impart to one another straightforwardly because the separation between the source and goal is more prominent than the transmission scope of the two. Wireless communication and ad hoc networking are used to relate sensors to one another to completely transmit the information. In this way, we can easily find the status regarding the train onboard condition and railway track [30].

It's a very important factor in terms of safety-related to railway that we know the train position either the train is coming from east, west, north or south. And also there's no need of external supply or fuel to run the train. A load coil is installed on the train and a source coil is installed on the track. Through this way train will work on electricity and there's no need of fuel for it. And also FPID blocks are installed to detect the position of train [31]. In particular, Pakistan railways is not at its best. Many factors are responsible for making Pakistan railways one of the unsafe transportation system for the country men. The work that is in top priority of government is to expand length of the tracks and to increase number of engines. The whole communication of the country is made by one main data center which is setup at headquarter office, Lahore. This office plays a vital role in timely decision making. It includes CISCO core switches, firewall and edge switches [32]. Different substations are linked up with the main station through wide area network (WAN) sharing databases and applications [33]. Thus we can also tell that what needs to be done to sustain over railway transportation. Furthermore, various researches [34–43] have proposed various solutions for such systems (Table 1).

3 Proposed System Model

In this section, a method is proposed which comprises of a control room and location tracker system and presented in Fig. 2. The communication between the control room and the tracker is by means of LTE [14, 18]. Control room in the proposed model consists of a micro-controller, ultrasonic sensors for the detection of train [20], LTE module for bidirectional communication [45], LCD for display of data related to train information like speed, direction and distance, traffic lights at level crossing, a buzzer that will sound when train is detected and an automatic motorized gates are also installed [16]. The complete system of control room is installed on the level crossing to make it human free system. On the other hand, tracking module is mounted on train to keep track of it's data like train speed and location. Whereas, tracker module consists of a micro-controller, a GPS module and a LTE module for communication with control room [46] to share the run time information of the train.

Table 1 Experimental analysis between existing methods

No.	Refs.	Hardware and software	Findings
1	[26]	GPS, Image recognition technique and location based services. T-express app and kiosks	Comprise of disaster warning system and train operation management
2	[29]	Fusion unit (data fusion and situation analysis) with the help of Image processing technique. Stereo Vision based monitoring system	Vision based object detection algorithm. It uses three dimension position information
3	[28]	Using accelerometer, GPS and camera. Using web app and web services for image retrieval to data access layer	Monitoring system is to rely on radio communication. The system is developed on client–server architecture
4	[30]	Sensor network topology is being used. Relay nodes, sensor nodes and GSM are used for communication purpose	Wireless communication and mobile ad hoc networking coupled
5	[31]	3D FEM simulation model used along with the components require are; motor, motor controller, load coil, regulator and rectifier	Train position information using a source coil. The system is ferrite position identification
6	[18]	Mobile communication systems for railways like GSM, LTE, 5G	Communication of railway in current situation with GSM and discussion of future technology and it's implementation in railways
7	[44]	Train detection, magnetic field sensing, magneto resistive sensors, high-speed railway	Train is detected by using magneto resistive sensors at railway track

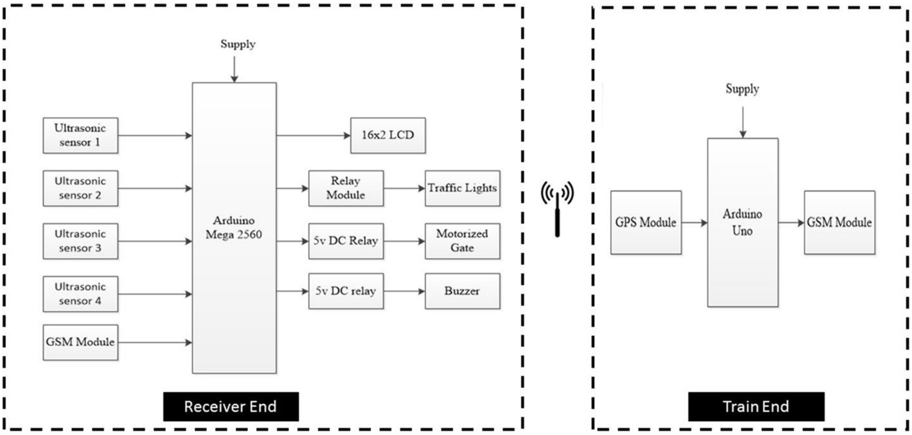


Fig. 2 Proposed block diagram

Figure 3 presents a smart city concept in which every thing is inter-related and communicates with each other all the time and proposed model well fit in the domain of smart transportation system. The design of the proposed model contains a number of innovative new features. Regarding the state of the environment in Pakistan. There are over two thousand instances of trespassing without gates, which leads to a hundred or more accidents every year. Few of the novelties of the proposed system are IoT-based service for round the globe availability of information, cloud for file storage and sharing, remote assistance and monitoring of railway activities, minimum Human dependency and utilization of WSN for the achievement of the United Nations' (UN) sustainability goal of smart cities. In the era of smart technologies, every component of the

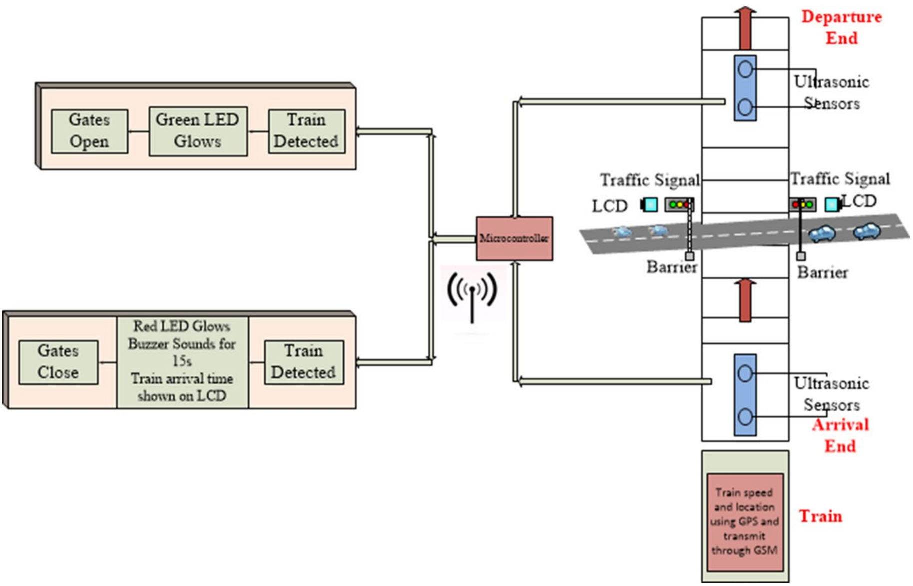


Fig. 3 Proposed system model

society needs to be hasty and well connected to meet the requirements of the smart cities, so the proposed model of the system for smart cities is presented as under:

The proposed model, works in such a way that when a train is detected at arrival end sensor-1 and sensor-2 need to be true at the same time only to set the condition true. Microcontroller sends a signal to different relays that further operate the different elements including traffic light indicators in which red LED will be turned on. In the same way, relay allows the buzzer to sound and further relay operates the motorized gate in such a way that it will be closed for the incoming traffic at the level crossing. At the same time, the other micro-controller works in a different fashion it continuously takes data from the GPS module which includes train speed, location and direction and then transmit it without any delay through LTE module. After that, the data received will be transmitted through a LCD and displayed. So that the traffic at the level crossing have an idea about the trains speed and in how much time it will reach the level crossing.

Similarly, when the train reaches the departure end sensor-3 and sensor-4 get active at that time only then the condition is met. Micro-controller sends a signal to different installed relays that further operate the different elements. Including traffic light indicators in which green LED will be turned on and the red LED will be turned off, in the same way, the relay causes the buzzer to turn off and further the relay operates the motorized gate in such a way that it will be opened for the incoming traffic at a level crossing. On the same time, the other micro-controller works differently it continuously takes data from the GPS module which includes train speed, location and direction and through LTE module and send it to the another LTE module. After that, the data received will be transmitted through a LCD and displayed so that the traffic at the level crossing has an idea about the train's speed. Figure 4 describes the complete system implemented on the level crossing including ultrasonic sensors. Along with different

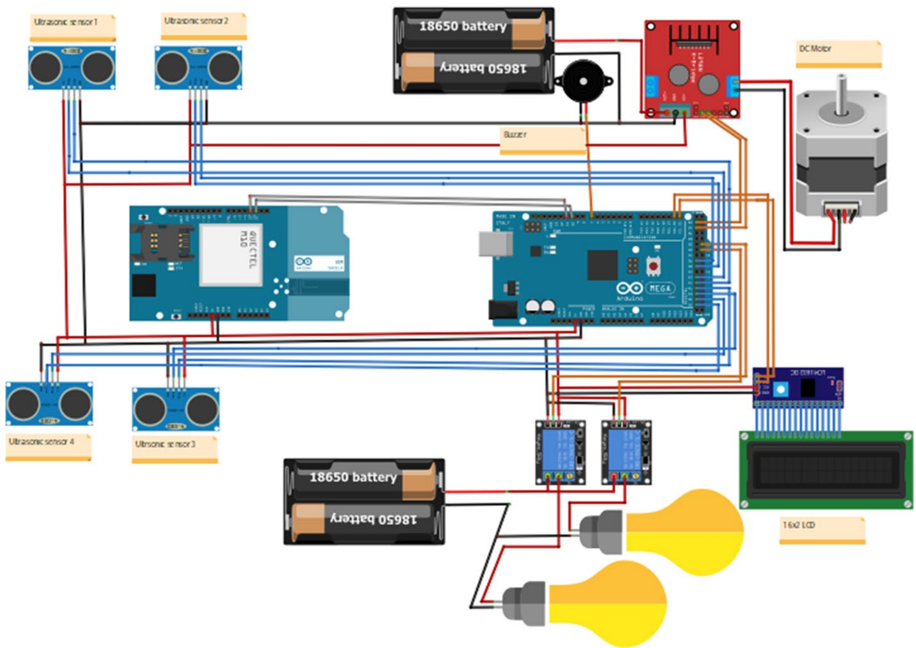


Fig. 4 Circuit installed at level crossing

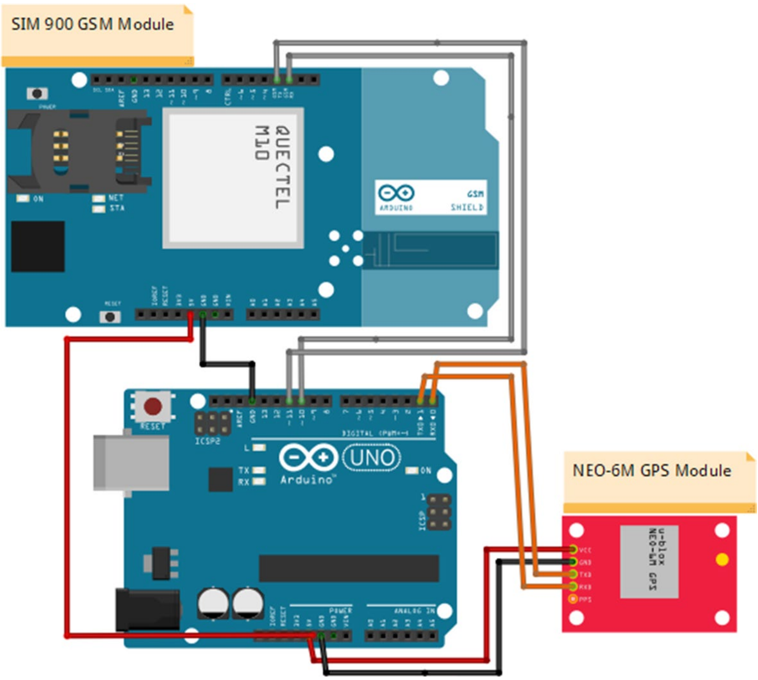


Fig. 5 Circuit installed on train

output devices mainly LED, LCD, buzzer and a motor. Similarly, Fig. 5 shows the circuit installed on the train. This system continuously takes the coordinates and speed of train and send it to the control room.

As this studies, proposes a system based on wireless sensor network, so we have considered the constraints that are imposed by wireless sensor networks in real time implementation. We have referred to a solution while keeping in mind the limitations of WSN. We have designed a unique protective box specifically for the weather, and it is capable of performing admirably in adverse environmental conditions such as (heats, cold, rain and in fire). Moreover, in the event that a node should fail, we have redundant nodes in place. They work in a redundant fashion, so if the primary node fails to function properly, the secondary node will immediately become operational and begin exchanging information with the control end. Furthermore, it has been proposed in a system that in the not-too-distant future, 5G technology will be used for reliability and to avoid communication failure in the event of a communication link failure. It is also suggested that satellite communication be used for the real-time implementation in order to avoid any communication link failures and thereby avoid any accident situations. It's an expensive solution, but it has the potential to work well for the vast railway network that spans the country with no chance of disconnected areas.

3.1 Flow Chart

In Fig. 6, flow chart of the proposed study is projected. It consists of two parts, labeled as (a) and (b). Part (a) represents a complete flow of the system at level crossing, it is shown that initially ultrasonic sensors to go high, after this check certain tasks at output would be performed including on/off of the LED's, buzzer and open closing of gate. Similarly we look

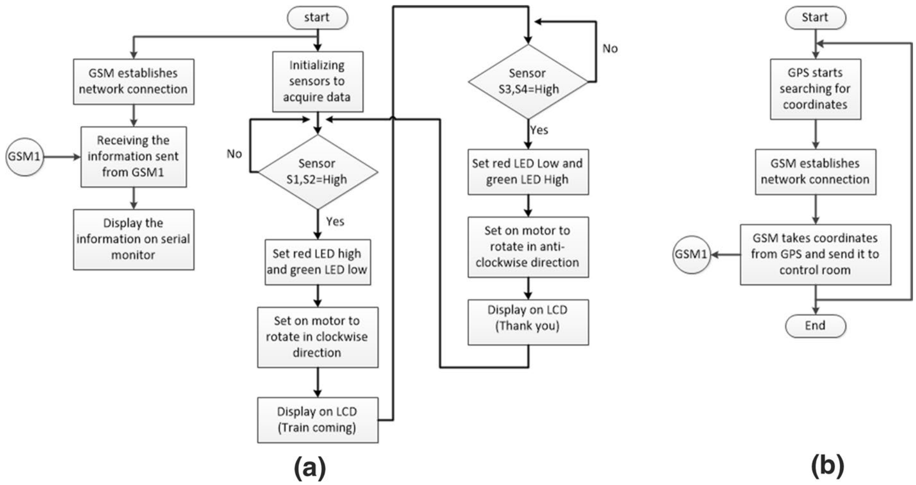


Fig. 6 **a** Represents flow of control room and **b** Represents flow of tracker circuit

for the sensors S-3 and S-4. In parallel it is also communicating with LTE module installed at control room. Part (b) represents a GPS module that establishes it's connection with the satellite. After that the coordinates of train are send to LTE installed at level crossing.

3.2 Proposed Algorithm

The proposed algorithm applied in this studies is presented step by step for the better understanding of the readers.

```
Input: Values from sensor s-1,s-2 and s-3,s-4
Output: Display of train speed and coordinates, display of traffic indicator lights with opening closing of gate
Data: This section includes US sensors, LED, LCD and a motor. Alongside with LTE and GPS module.
/* Now this is an if...else conditional loop                                                   */
if sensors s-1 and s-2 are high then
|  Provide warning at the level crossing with red LED in on status.
|  Display "train approaching the crossing".
|  Buzzer sounds to warn the incoming traffic.
|  Closing of gates at level crossing.
|  Fetching data from the microcontroller installed at train through means of LTE and GPS module.
|  Display of data at level crossing which includes train speed, location and direction and also the time in
|    which the train reaches the crossing.
end
else if sensors s-3, s-4 are high then
|  Provide indication at level crossing with green LED in on status.
|  Display "Thank you for your cooperation".
|  Opening of gates at level crossing.
end
else
|  Do nothing
end
/* Now this is a While loop                                                                    */
while true do
|  Again check the status of sensors s-1,s-2 and s-3,s-4
end
```

Algorithm 1: Complete process algorithm

4 Simulation Results

4.1 Mathematical Modeling

An ultrasonic sensor is used in our proposed prototype that operates in such a way that it gives the high-level time at its output pin so, we need to modify and convert this time into the distance in such away that it can easily be used as per our requirements. Following mathematical steps are involved to convert high-level time into distance.

$$d = \frac{(t * v)}{2} \tag{1}$$

where time is duration in which echo pin receives a high pulse and then waits for it to again go to low. Speed of sound = v = 340 m/s; distance fomula; s = v*t

$$t = \frac{t}{2} \tag{2}$$

Due to pulses ongoing and then coming back to sensor
V = 340 m/s and 1 m = 100 cm
V = 340*100 cm/us = 0.0340 cm/us

$$distance\ (\text{cm}) = \frac{duration * 0.0340}{2} \tag{3}$$

Similarly; 1 cm = 0.393 inches

$$V = \frac{0.0340}{0.393} \tag{4}$$

V = 0.01330 inches/us

$$distance\ (\text{inches}) = \frac{duration * 0.01330}{2} \tag{5}$$

So, we will use following formula for the calculation of distance;

$$distance = \frac{duartion * inches}{2} \tag{6}$$

4.2 Proposed Simulation Setup

The complete process is simulated via Proteus and the coding for micro-controller is done in Arduino IDE. In first phase, implementation of the control room is processed which includes an Arduino mega, ultrasonic sensors for train detection, then for the safety and awareness an automatic motor sliding gate along with is installed. Also, a traffic lights signal and a LCD display is mounted to show the received information of train like its speed, location and direction. Moreover, a sounding facility which includes an alarm to aware the citizens crossing the train track. Received information regarding its current status is also communicated with the control room through real time communication for centralize control. The second phase, includes installation of Arduino UNO with GPS module and LTE module on train. GPS module provides the exact co-ordinates of train along with speed and direction, whereas this information is shared with the control room for intimation.

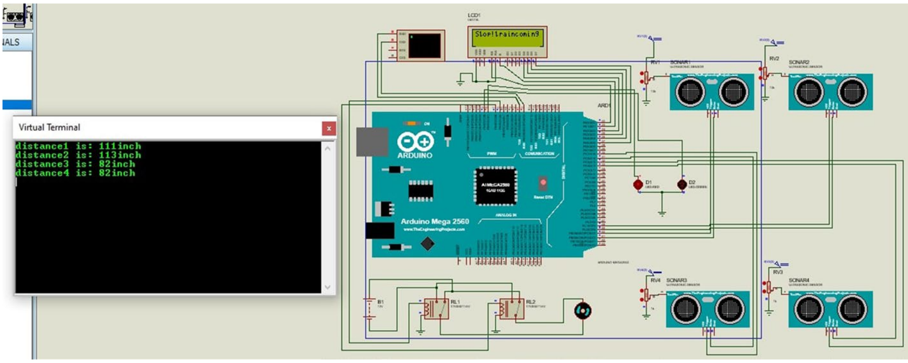


Fig. 7 Detection of train at arrival end

In Fig. 7, a circuit placement for the detection of train at arrival end is presented, which comprises of multiple sensors, micro-controller, LCD and the multiple components. Similarly, in Fig. 8 complete process after the detection of train at departure end is well presented. It is made up of the same building blocks as described in Fig. 7. The position of the departure and the arrival end circuitry can be better understandable if we refer Fig. 3. When train reaches within the sensing range of the ultrasonic sensor, it sends a message to the micro-controller which activates the signal and the received information will be displayed on a LCD installed at the level crossing. It is important to mention here that the same step of processes will be executed for both arrival and departure end. Furthermore, RTT (round trip time) of the sensors using serial monitor is shown in Fig. 9.

Similarly, a prototype circuit is designed and mounted on the train, it includes a GPS module, LTE module and a micro-controller. Designed circuit is used to continuously acquire the position and speed of the train at its track. Circuit implemented on a train is shown in Fig. 10 for tracking the real time location and the current speed of the train.

Figure 11 reflects the received information of geographical coordinates of the train location and its speed in the serial monitor, which is further forwarded to the control room end for activating the gates closure and for information display.

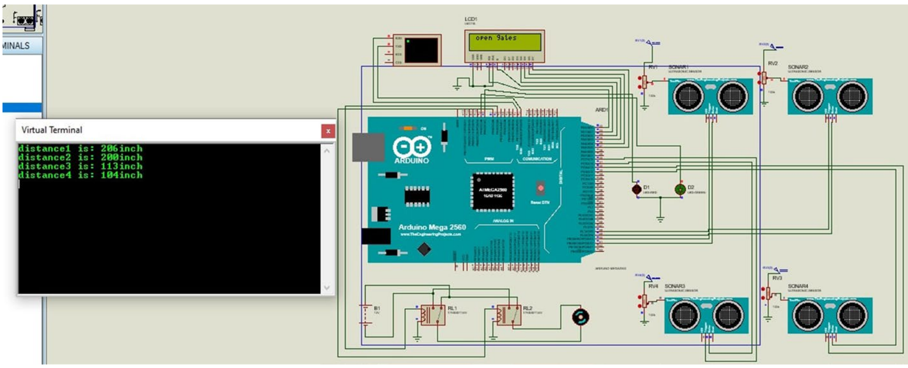


Fig. 8 Detection of train at departure end

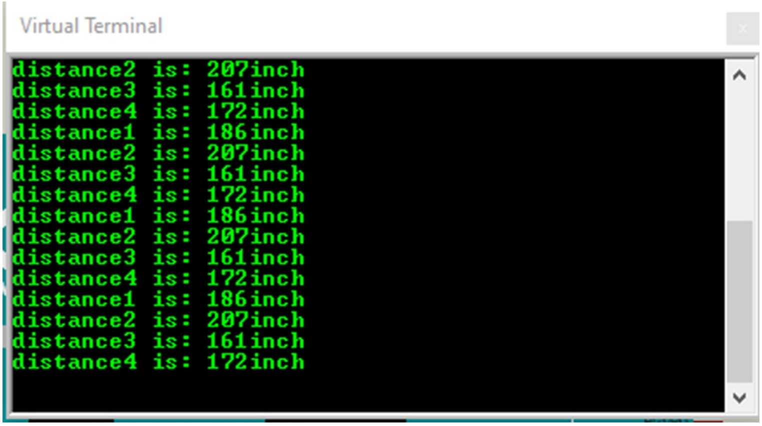


Fig. 9 RTT of sensors

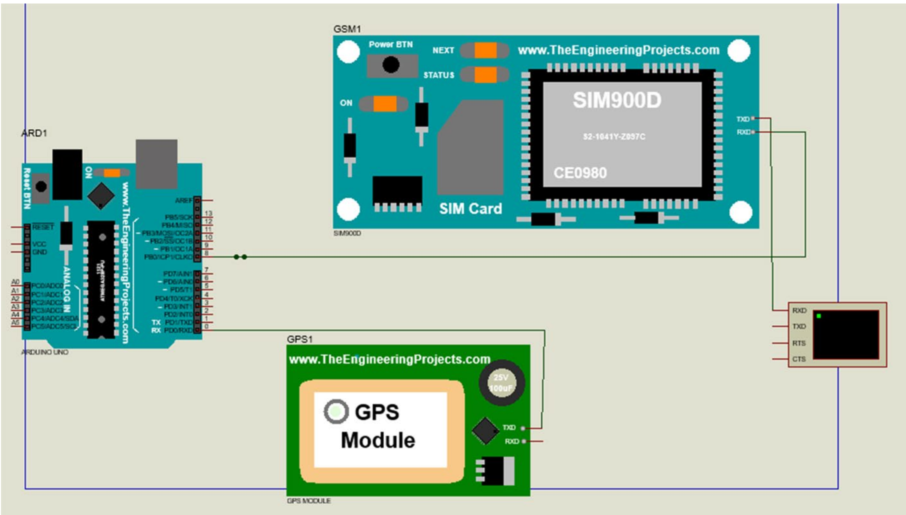


Fig. 10 Circuit installed on a train for location tracking

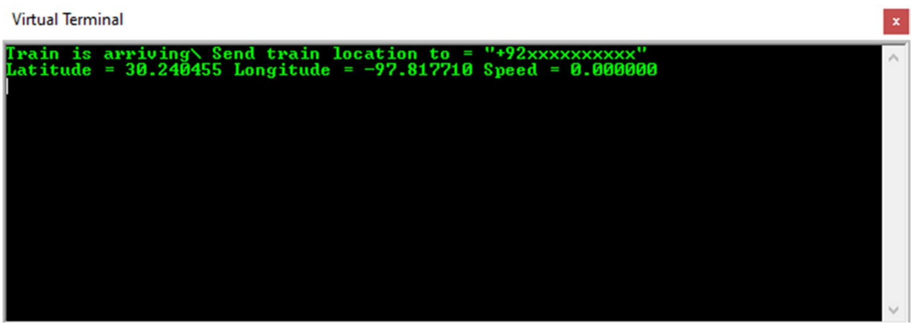


Fig. 11 Monitoring of the train speed and its geographical coordinates

4.3 Installment of a Hardware Setup

Figure 12 present the detail deployment of various components in the system setup for executing the proposed study. Figure 12a and b showing the placement of 2 ultrasonic sensors to minimise the error rate on each tower specially designed for departure and arrival ends, which is already discussed in detail in the section of proposed model. Figure 12c shows a complete setup placed at the level crossing, where the gate is connected with a motor which moves forward and backward depending upon the type of action required based on the information received. Traffic light indicators and a LCD is also mounted to display the action taken on the received data.

Figure 12d–f shows the train information at the arrival end and its synchronized process. As soon as a train is detected at the arrival end a signal is sent to control room which takes action and activates the traffic light and showing data on the LCD and then finally closing the gate at level crossing. Similarly Fig. 12g–i shows the demonstration of train arrival at the departure end. As, train is detected at the departure end a signal is immediately sent to control room automatically which results in lid the indication of the traffic lights and display data on the LCD for opening of the gates at level crossing.

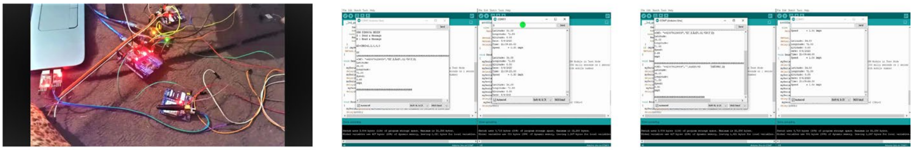
The complete circuit implemented on the train and synchronization with the control room is shown in Fig. 13. Figure 13a presents a complete circuitry used for tracking train position and speed. This circuit is installed on the train and works in such a way

(a) Sensor stands at arrival end (b) Sensor stands at departure end (c) Motorized gate with indicators

(d) Gates close (e) LCD showing closing status (f) Red traffic light on

(g) Opening gates (h) LCD showing opening status (i) Green traffic light on

Fig. 12 Sensor placement at both ends



(a) Circuit for sending and receiving of messages **(b)** Output shown on serial monitor **(c)** Sending and reception of messages on serial monitor

Fig. 13 System interfaced with control room

that it continuously takes coordinates and speed and whenever the driver or any other staff member presses the 'S' button on serial monitor the coordinates along with speed are sent to control room. Figure 13b shows output of the GPS module installed on the train. This module provides coordinates and speed of train with date and time. In the figure, two outputs are shown on COM11 and other on COM9. The output shown on COM11 is the output of GPS module along with LTE module. Where, COM9 shows the output of LTE module installed in control room. This module will receive any message send by the tracker circuit and will display it on serial monitor. Similarly, Fig. 13c shows that when we press button 'S' in the serial monitor of COM11 only then the data that is acquired continuously by GPS will send to the control room. And the message received is displayed on the COM9 of serial monitor. The output includes longitude, latitude, altitude, date, time and speed (kmh).

Figure 14 shows the complete circuitry installed on train. Its a tracker circuit that keeps control room informed about train speed and location. The GPS module takes about few seconds to establish it's connection with the 24 satellites present in the earth orbit but

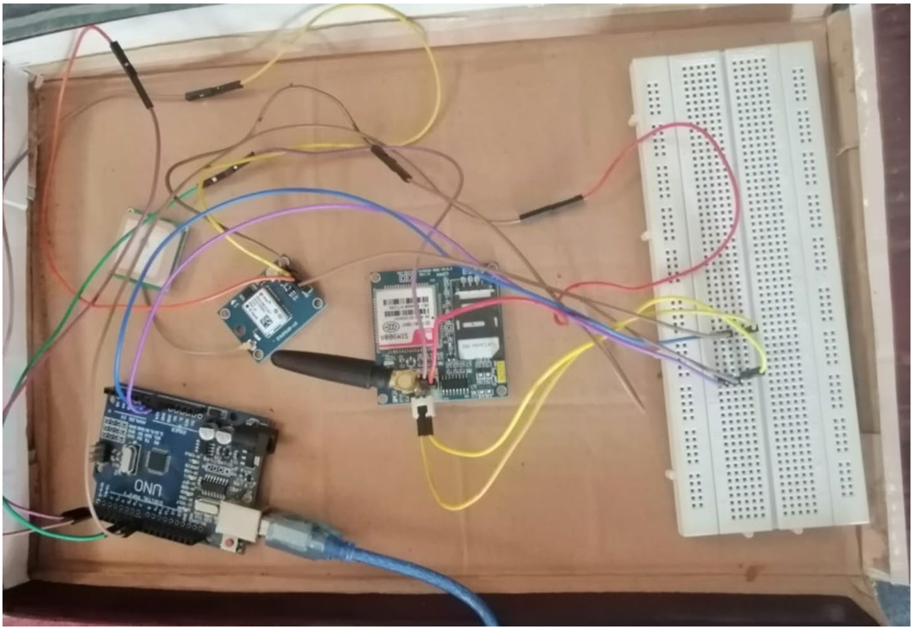


Fig. 14 Tracking system installed on a train

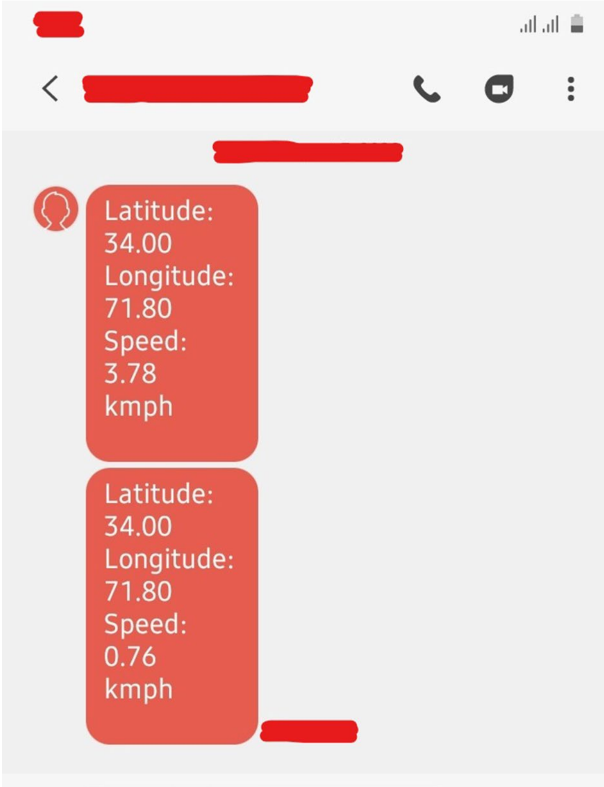


Fig. 15 Trains data received at remote end

requires only 4 of them to lock the location. Similarly, Fig. 15 presents the data received on a mobile node at control station which was sent by the train.

In Table 2, sensitivity of the round trip time of the ultrasonic sensors is provided. It is well seen in the the acquired data that the when the train is approaching towards the sensor, the RTT of the sensor is low and vice versa.

Table 2 Measurement of RTT actual and measured for ultrasonic sensors

Actual distance (inches)	Measured distance (inches)	High level time (ms)
1	0.65	0.15
4	3.5	0.5
7	6.7	1
10	10.3	1.5
13	12.7	1.8
16	15.5	2.2
19	18.4	2.7
22	21.7	3.2
25	24.7	3.6
28	26.5	4
31	30.1	4.4

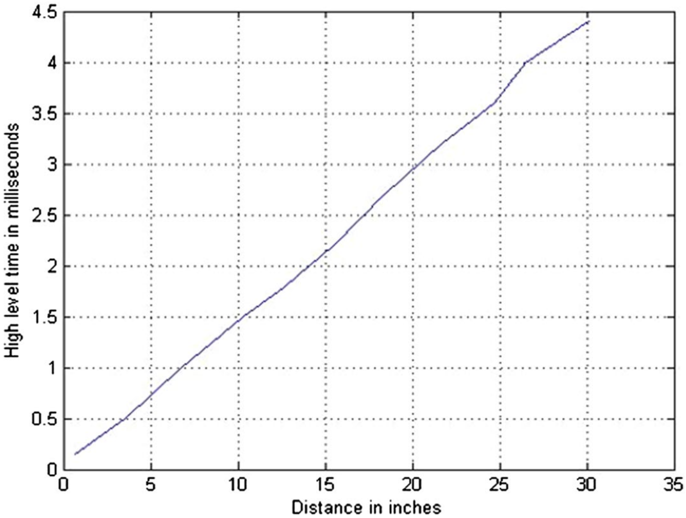


Fig. 16 Graph of ultrasonic sensor

Figure 16 shows the graph of distance (inches) versus high level time (milliseconds). This high level time is the one in which echo pin remains high and again goes to low. It can be seen from the graph that as distance between the ultrasonic sensor and obstacle increases the high level time also increases with it. In this graph high level time is dependent upon the distance.

5 Conclusion

The proposed study is directly associated with the safety and quality of railway's. The set objectives of the studies are successfully achieved in the prototype model and the train can be tracked through its coordinates and position using the GPS received information. Furthermore, ultrasonic sensors provide the timely detection of the rail on the track and automizing of the railway crossing gates are achieved based on the information received at control room end. In the future this research can be extended by introducing innovations on different sections like communication system improvement and implementing latest advance powerful micro-controllers in the real time railways track to achieve the full safety for the people.

Funding There is no funding sources for this research.

Data Availibility Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Code Availability The code developed during and/or analysed during the current study are available from the corresponding author on reasonable request.

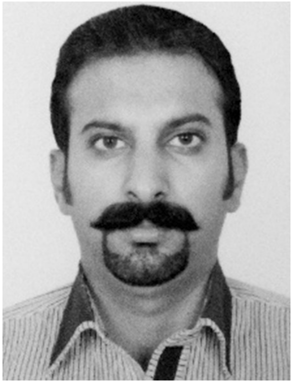
Declarations

Conflict of interest There is no conflict of interest between the authors for this research.

References

1. News. (2019). *Emedia* (vol. x, pp. 2–4). https://www.thenews.com.pk/print/514587-govt-taking-steps-to-upgrade-vulnerable-railway-level-crossings.
2. UIC. (2019). *Data from internet* (vol. x, pp. 2–4). https://uic.org/img/pdf/worldwide-rail-transport-regional-share2017.pdf.
3. Mowla, M. M., Ahmad, I., Habibi, D., & Phung, Q. V. (2017). A green communication model for 5G systems. *IEEE Transactions on Green Communications and Networking, 1,* 264–280.
4. Thenews. (2019). *Electronicmedia* (vol. x, pp. 1–3). https://www.thenews.com.pk/print/397393-pakistan-railways-in-100-days-10-new-trains-16-deaths.
5. Behnad, A., & Wang, X. (2017). Virtual small cells formation in 5G networks. *IEEE Communications Letters, 21,* 616–619.
6. Report. (2019). *Enews* (vol. x, pp. 2–5). https://uic.org/com/uic-e-news/623/article/international-union-of-railways-uic-issues-yearly-report-2018-on-railwaypage=modalenews.
7. Dzagbletey, P. A., & Jung, Y. (2018). Stacked microstrip linear array for millimeter-wave 5G baseband communication. *IEEE Antennas and Wireless Propagation Letters, 17,* 780–783.
8. Li, X., Alam, K. M., & Wang, S. (2018). Trend analysis of Pakistan railways based on industry life cycle theory. *Journal of Advanced Transportation, 2018,* 1–11.
9. Al Wadhahi, N. T. S., Hussain, S. M., Yosof, K. M., Hussain, S. A., & Singh, A. V. (2018). Accidents detection and prevention system to reduce traffic hazards using IR sensors. In *2018 7th International conference on reliability, Infocom technologies and optimization (trends and future directions) (ICRITO)* (pp. 737–741). IEEE.
10. García, J. J., Hernandez, A., Urena, J., & Garcia, E. (2016). Fpga-based architecture for a multisensory barrier to enhance railway safety. *IEEE Transactions on Instrumentation and Measurement, 65*(6), 1352–1363.
11. Morocho-Cayamcela, M. E., Lee, H., & Lim, W. (2019). Machine learning for 5G/B5G mobile and wireless communications: Potential, limitations, and future directions. *IEEE Access, 7,* 137184–137206.
12. Amin, M. S., Jalil, J., & Reaz. (2012). Accident detection and reporting system using GPS, GPRS and GSM technology. In *2012 International conference on informatics, electronics and vision (ICIEV)* (pp. 640–643). IEEE.
13. Chettri, L., & Bera, R. (2020). A comprehensive survey on internet of things (IoT) toward 5G wireless systems. *IEEE Internet of Things Journal, 7,* 16–32.
14. Ahmed, A., Noor, K. R., Imteaj, A., & Rahman, T. (2018). Unmanned multiple railway gates controlling and bi-directional train tracking with alarming system using principles of IoT. In *2018 International conference on innovations in science, engineering and technology (ICISET)* (pp. 486–491). IEEE.
15. Zhang, L., Zhao, H., Hou, S., Zhao, Z., Xu, H., Wu, X., et al. (2019). A survey on 5G millimeter wave communications for UAV-assisted wireless networks. *IEEE Access, 7,* 117460–117504.
16. Amarnatha, R. E., et al. (2017). A secure railway crossing system using IoT. 2017 *International conference of Electronics, Communication and Aerospace Technology (ICECA)*. (Vol. 2, pp. 196–199). IEEE
17. Ahmad, W. S. H. M. W., Radzi, N. A. M., Samidi, F. S., Ismail, A., Abdullah, F., Jamaludin, M. Z., & Zakaria, M. N. (2020). 5G technology: Towards dynamic spectrum sharing using cognitive radio networks. *IEEE Access, 8,* 14460–14488.
18. Chen, R., Long, W.-X., Mao, G., & Li, C. (2018). Development trends of mobile communication systems for railways. *IEEE Communications Surveys & Tutorials, 20*(4), 3131–3141.
19. Ghosh, A., Maeder, A., Baker, M., & Chandramouli, D. (2019). 5G evolution: A view on 5G cellular technology beyond 3GPP release 15. *IEEE Access, 7,* 127639–127651.
20. Oo, H. M., San Hlaing, N. N., & Oo, T. T. (2019). *Four IR sensor based automatic control of railway gate using microcontroller*. IEEE.
21. Wu, C., Wang, C., Sheng, J., & Wang, Y. (2019). Cooperative learning for spectrum management in railway cognitive radio network. *IEEE Transactions on Vehicular Technology, 68,* 5809–5819.
22. Liu, Y., Wang, C., Huang, J., Sun, J., & Zhang, W. (2019). Novel 3-D nonstationary mmwave massive MIMO channel models for 5G high-speed train wireless communications. *IEEE Transactions on Vehicular Technology, 68,* 2077–2086.
23. Liu, Y., Li, C., Xia, X., Quan, X., Liu, D., Xu, Q., et al. (2019). Multiband user equipment prototype hardware design for 5G communications in sub-6-GHz band. *IEEE Transactions on Microwave Theory and Techniques, 67,* 2916–2927.

24. Sim, G. H., Klos, S., Asadi, A., Klein, A., & Hollick, M. (2018). An online context-aware machine learning algorithm for 5G mmwave vehicular communications. *IEEE/ACM Transactions on Networking, 26,* 2487–2500.
25. Myint, S. H., Yu, K., & Sato, T. (2019). Modeling and analysis of error process in 5G wireless communication using two-state Markov chain. *IEEE Access, 7,* 26391–26401.
26. Jen, Y. Y., & Chang, S. K. J. (2016). Information and communication technologies for enhanced emergency management in Taiwan high speed rail. In *2016 IEEE international conference on intelligent rail transportation (ICIRT)* (pp. 67–74). IEEE.
27. Habibi, M. A., Nasimi, M., Han, B., & Schotten, H. D. (2019). A comprehensive survey of ran architectures toward 5G mobile communication system. *IEEE Access, 7,* 70371–70421.
28. Djanali, S., Huda, M., & Shiddiqi, A. M. (2014). Location finder using augmented reality for railways assistance. In *2014 2nd international conference on information and communication technology (ICoICT)* (pp. 487–492). IEEE.
29. Oh, S.-C., Kim, G.-D., Jeong, W.-T., & Park, Y.-T. (2008). Vision-based object detection for passenger's safety in railway platform. In *2008 International conference on control, automation and systems* (pp. 2134–2137). IEEE.
30. Hodge, V. J., O'Keefe, S., Weeks, M., & Moulds, A. (2014). Wireless sensor networks for condition monitoring in the railway industry: A survey. *IEEE Transactions on Intelligent Transportation Systems, 16*(3), 1088–1106.
31. Hwang, K., Cho, J., Park, J., Har, D., & Ahn, S. (2018). Ferrite position identification system operating with wireless power transfer for intelligent train position detection. *IEEE Transactions on Intelligent Transportation Systems, 20*(1), 374–382.
32. Pak. (2019). *Pakistan rail* (vol. x, pp. 2–3). *pakrail.gov.pk*.
33. Liyanage, C., Dias, N., Amaratunga, D., & Haigh, R. (2017). Current context of transport sector in south Asia: Recommendations towards a sustainable transportation system. *Built Environment Project and Asset Management, 7*(5), 490–505.
34. Goyal, S., Bedi, P., Kumar, J., et al. (2022). Realtime accident detection and alarm generation system over IoT. In *Multimedia technologies in the internet of things environment* (vol. 2, pp. 105–126). Springer.
35. Ramírez-Moreno, M. A., Keshtkar, S., Padilla-Reyes, D. A., Ramos-López, E., García-Martínez, M., Hernández-Luna, M. C., et al. (2021). Sensors for sustainable smart cities: A review. *Applied Sciences, 11*(17), 8198.
36. Telang, S., Chel, A., Nemade, A., & Kaushik, G. (2021). Intelligent transport system for a smart city. In *Security and privacy applications for smart city development* (pp. 171–187). Springer.
37. Iqbal, Z., Khan, M. I., Hussain, S., & Habib, A. (2021). An efficient traffic incident detection and classification framework by leveraging the efficacy of model stacking. *Complexity, 2021,* 1–17.
38. Gohar, A., & Nencioni, G. (2021). The role of 5G technologies in a smart city: The case for intelligent transportation system. *Sustainability, 13*(9), 5188.
39. Chehri, A., Sharma, T., Debaque, B., Duclos, N., & Fortier, P. (2022). Transport systems for smarter cities, a practical case applied to traffic management in the city of Montreal. In *Sustainability in energy and buildings 2021* (pp. 255–266). Springer.
40. Rao, P. M., & Deebak, B. (2022). Security and privacy issues in smart cities/industries: Technologies, applications, and challenges. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-022-03707-1.
41. Shankaran, R. S., & Rajendran, L. (2022). *Intelligent transport systems and traffic management in smart cities* (pp. 133–180). CRC Press.
42. Shikdar, T. A., Rashid, M. M., Ayub, F. B., & Faisal, S. (2022). Development of automated protection and monitoring system for poor railway infrastructure. In *Proceedings of third international conference on communication, computing and electronics systems* (pp. 527–546). Springer.
43. Bulgariu, C.-L. (2022). The attractiveness of the railway transport system-mobility and the correlation with safety and security. In *International conference "new technologies, development and applications"* (pp. 687–694). Springer.
44. Zhang, S., Lee, W.-K., & Pong, P. (2013). Train detection by magnetic field sensing. *Sensors and Materials, 25*(6), 423–436.
45. Prasad, R. J. C., Reddy, P. A., & Praneetha, Y. S. (2016). GSM based automatic railway gate control system with real-time monitoring. *International Journal of Science, Engineering and Technology Research (IJSETR), 5*(3), 740–745.
46. Bharath Kumar Reddy, G., Sharath Kumar Reddy, G., Ravinder Reddy, R., & Navya, G. (2018). Safeguard of railway crossing using IoT. *Journal of Telecommunications System & Management*. https://doi.org/10.4172/2167-0919.1000165.



Dr. Ali Mustafa is currently serving as an Assistant Professor in Electrical and Computer Engineering department in a COMSATS University Islamabad, Attock, Pakistan. He did his B.S. in Computer Engineering from Pakistan and completed his M.S. degree in Mobile Computing from the University of Bradford, United Kingdom. He received his Ph.D. degree in Electrical Engineering from Bahria University, Islamabad. His area of interest is in the field of wireless communications, Multi-agent Systems, Intelligent transportation Systems, AI/ML, M-Health and WSN.

Ozain Rasheed is graduated student in B.S. Electrical Engineering under the supervision of Dr. Ali Mustafa from the department of Electrical and Computer Engineering, COMSATS University Islamabad, Attock, Pakistan. His area of interest is in the field of wireless communications, intelligent transportation Systems and WSN.

Shahzad Rehman is graduated student in B.S. Electrical Engineering under the supervision of Dr. Ali Mustafa from the department of Electrical and Computer Engineering, COMSATS University Islamabad, Attock, Pakistan. His area of interest is in the field of wireless communications, intelligent transportation Systems and WSN.

Dr. Farman Ullah received his BSc degree in Computer Systems Engineering from the University of Engineering and Technology (UET) Peshawar in 2006. He joined Micronet & Nayatel (https://nayatel.com/) as a Network Support Engineering in 2006. He served as Telemetry Engineer at Advanced Engineering Research Organization from Feb-2007 to 2011. He did his M.S. in Computer Engineering from CASE, Islamabad in 2010. In August, 2011 he joined COMSATS Institute of Information Technology Attock Campus as a Lecturer. He did PhD from the Korea Aerospace University, South Korea by the fully funded scholarship program. During his Ph.D., he worked on different projects funded by Korea National Research Foundation, ETRI, Ministry of Knowledge Economy, KARI, and KEIT South Korea. During his PhD he contributed cum wrote two proposals titled as "Research on Algorithm and Protocol for the Control and the Predictive Cognition of Spatial-Temporal Aware Diffusion, Contagion in large-scale Heterogeneous Social Networks" and "Research on Trustworthiness based Social Networks Modeling and Privacy Control in Heterogeneous Social Network Environment" that are accepted by NRF Korea for research grant of 2.5 and 3 years each respectively. He aslo remained Research Assistant and Teaching Assistant at Korea Aerospace University from 2011–2016. From August, 2016 he is working as Assistant Professor at CIIT Attock. His area of interests include: Social Network Analysis, Graph Theory, Recommender Systems, IoT/WoT/WoO, N-Screen Communication, and Machine Learning.

Dr. Salman Ahmed is currently working as an Assistant Professor in the CSE Department. He is a graduate of UET Peshawar (Pakistan), Universiti Teknologi Petronas (Malaysia) and University of Alberta (Canada) in 2005, 2007, and 2013 respectively. He also worked for the Canadian oil and gas industries, where he worked as a Contractor/Research Scientist with Suncor Energy, and as a System Integration Consultant with Arc Resources, Cenvous, CNRL, Veresen Inc, Riotinto and Pengrowth. He also worked with the Malaysian Ministry of Science, Teknologi and Innovation as a Research Officer. His research areas include multi-rate digital signal processing, optimal sampled data control systems, multi-agent robotic systems, nonlinear control systems and networked control systems. Dr. Salman Ahmed has received some prestigious awards in his academic career such as the university Gold Medal (UET Peshawar), Provost Doctoral Award (University of Alberta, Canada) and Research Assistantship (NSERC, Government of Canada), Graduate Assistantship (Universiti Teknologi Petronas, Malaysia).