International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: *25 July 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 September 2023*

Development of an Artificial Intelligence based Railway Crack Detection and Monitoring System using Internet of Things

[1]J.Praveenchandar, [2]C.Navaneetha, [3]R Jennie Bharathi, [4]Jainish.G.R, [5]S.Thenappan, [6]Revathi Karthikeyan
[1]Department of computer science and engineering
School of Computer Science and Technology
Karunya Institute of Technology and Sciences
Karunya Nagar, Coimbatore, India - 641114
praveenjpc@gmail.com
[2]Department of Computer Science and Business Systems.
Panimalar Engineering College, Chennai, Tamil Nadu, India.
naveneetha27@gmail.com
[3]Department of ECE,
Saveetha Engineering College,Chennai, Tamil Nadu, India.
jenniebharathir@saveetha.ac.in
[4]Department of Computer Science and Engineering
Loyola ICAM college of engineering and technology,
Chennai
jainish.gr@licet.ac.in
[5]Department of Electronics and Communication Engineering
Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai
drthenappans@veltech.edu.in
[6]Department of VLSI Microelectronics
Saveetha School of Engineering,
SIMATS, Chennai
*Corresponding Author: rbrevathi@gmail.com

Abstract— This study suggests the concept of crack locating robot vehicle in the railway rails. India railways participates an important posture in asset with the necessary transportation to preserve needs of a rapidly emergent financial system. India now has the world's fourth-largest railway network. Therefore, travelling by train is risky. It does not work with the existing railway control system in India. Thus, robust, well-organized, and reliable new technology is required for both fracture detection in railway track and identification of objector items. This study proposes and clarifies a robust monitoring system to meet the limitations of the current rail surveillance system for detecting fractures of the railway tracks. Therefore, robust, well-organized, and reliable new technology is required for both fracture detection in railway track and the identification of objects or items. This study proposes and clarifies a robust monitoring system to meet the limitations of the current rail surveillance system for detecting fractures of the railway tracks. The goal of this study is to build and create an IoT-enabled robot that uses artificial intelligence (AI) to report to a railway controller any information it gathers concerning broken or cracked track. To solve this issue, we will be sending all data over wireless communication based devices and developing a corresponding application..

Keywords- Artificial Intelligence, AI, Railway Crack Detection, Track Monitoring, Internet of Things, IoT

I. INTRODUCTION

Our country's railway lines are particularly prone [1], which a big tragedy is given that the railway constitutes one of its most important sources of transportation here. As a result, a great many accidents take place annually because of this rudimentary form of railway tracks, leading to a great many deaths annually. When things like these happen, it makes us think about the aforementioned problem and want to do action to safeguard those lives. Through our proposed method, we need to construct more contemporary and safe railway system. In addition, no equivalent technology or mechanism exists in the United States to prevent a collision between trains travelling in different directions on the same track. We are serious about deliberating this issue and are inspired to do so. Furthermore, any object can be thrown onto the rail track by a natural disaster, and in the

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: 25 July 2023 Revised: 12 September 2023 Accepted: 30 September 2023

rural region, it will take a long time to remove it. We reasoned that if our system could identify those obstructions and relay that information to the command centre, the latter could take the precautionary measures needed to prevent an accident [2][11]. The following figure Fig.1 describes railway track crack.

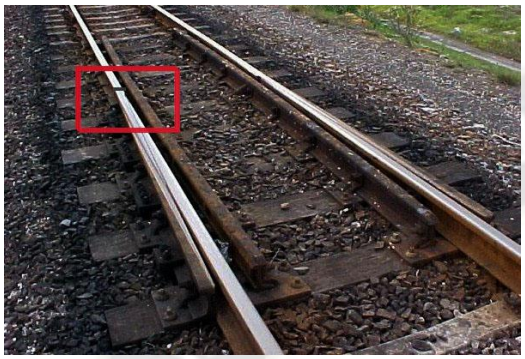

Fig.1 Railway Track Changes

Today, rail travel is crucial for moving people and goods, and it also accounts for the bulk of the money transferred between countries. The transport sector is the most important contributor to our country's growth, and concerns of security and sustainability within it are of crucial significance. India's railway network constitutes one among the largest in the world. The Indian railway system is a privately owned and operated business that is mostly governed by Indians [3]. There is a higher margin for error when trying to locate cracks in a system that spans 115,000 km for track across the country [4][12]. When put into place, a system that uses GSM, GPS, and microcontrollers to identify damaged railway track is an effective approach to detect fractures which are present in the rails and prevent train derailment. Currently, in order to detect cracks, deformations, and obstacles on the rail line, a group of people known as track men walk in the rail line through a manual vehicle with service components. This process is neither efficient nor acceptable, however, and often leads to delays in the detection of derailments. In this study, we propose a crack-detection vehicle with automatic scanning capabilities that can report the position of a fracture in a railway using specialized applications and an SMS system [5].

II. RELATED STUDY

The train is the most hassle-free means to convey people. Uncertain cracks in train rails continue to be a key cause for worry in terms of potential for accidents [6]. The breakdown of train infrastructure has led to human casualties and financial losses. Thus, we must introduce a cutting-edge technological advancement that can significantly lessen the number of casualties. Using a Raspberry Pi, an EM card module, a camera, and the Internet of Things, the authors of this work [6] present a system for detecting cracks in railway tracks. The Raspberry Pi is a crucial component of the system since it coordinates the many components. The position information recorded for Radio Frequency Identification tag using python programming with raspberry pi [6]. The EM-18 reader module picks up the signal from the RFID tag's resonant frequency. RFID modules generate a safe radio frequency (125 KHz) that may be used to read RFID tags. Regardless of signal strength, this method yields a more precise position with greater speed [6].

Nowadays, transit is essential. The human race is the fourth largest network of rail lines in India [7]. The identification of cracks within a railway track is the topic of this paper [7]. In earlier techniques GPS module as well as the GSM modem are utilized. This causes a great deal of expense. The simple components such as an RF transmitter as well as receiver, LED -LDR setup, make up an efficient railway crack detecting system. In comparison to conventional methods, it is inexpensive. In this work, an LED and LDR combination is used to detect the location of a break in a railway track. RF is a natural choice for communication since it allows greater data to be sent at higher rates and greater distances. This is where the sensor readings are sent to the monitoring centre. Using a solar-powered battery and an LED-LDR assembly, the authors of this research suggest an Internet of Things (IoT)-based crack detection system [13].

The 115,000-kilometer-long length of India's rail network makes it one of the longest in the world. The reliability and safety of Indian railroads are below international standards [8]. Major concerns are raised, for example, concerning the safety of rail transportation operations when fractures form in the rails owing to delayed detection. Recent research indicates that more than 25% of a track length needed to be replaced due to cracks. Manual track detection is inefficient and time-consuming since it necessitates the involvement of trained specialists. The authors of this work [14] set out to develop a method for automatically detecting fractures in railway tracks in order to address this issue. This overview presents a work with the goal of developing an ultrasonic sensor assembly system for detecting cracks on railway rails, with the ultimate goal of preventing accidents. Further capable of informing the authorities through SMS messages utilizing GSM modules. Automation has led to less work for humans to do. Use an ultrasonic sensor, which is less expensive but more accurate, to measure track distance instead of a more expensive LVDT that offers less precise results. The implications of this work are applicable to both day and nighttime surveillance. Some of the advantages include reduced costs, less energy use, and faster analysis times. Many lives might be spared if the exact location of the damaged section of track could be swiftly discovered and repaired using this technology [8].

Because of their dependability, passenger safety, and ease of travel, railways are the preferred mode of transportation. Loss of life can result from even the smallest misalignment or fracture [9]. We plan to create a method for detecting cracks in railway tracks as a solution to this issue. Here, we use basic

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: 25 July 2023 *Revised:* 12 September 2023 *Accepted:* 30 September 2023

equipment such a GSM modem, GPS receiver, BUZZER, infrared (IR) sensor, ultrasonic (USB) sensor, and ARDUINO. Sensor rays falling on the fissures delay the train to a halt as they discover the problem. Using GPS, we can pinpoint the exact location of the ace as well as use GSM to relay that information to the train networks. All of the connections are made with ARDUINO [9], so as soon as the ace is revealed; the alarm is activated to notify the passengers. Here, a wheeled robot powered by a dc motor stands in for a train. This straightforward idea has the potential to save many lives thanks to its pinpoint precision and lack of false positives during detection. It is employed in metro trains, video game consoles, and other crack detecting systems [9], not only at train stops.

Accidents on trains are rarer than those on roads. Indian Railway possesses the third-largest railway system in the world [10]. This system can identify cracks and other obstructions in railway rails with great accuracy and reliability. The cracking of our railway tracks is an issue. For instance, the track contracts as well as extends owing to changes in season. Manual inspection and crack detection are both time-consuming and error-prone. Rail surface problems such as abrasion, scrape, and peeling often lead to damages to train wheels along with bearings [10]. There are two main types of inspection used for monitoring: visual and ultrasonic. In order to detect the fracture and other obstacles on the rail track, a GSM and GPS (IR as well as Ultrasonic sensors) with microcontroller is employed. The exact position is determined by the GPS, and a message is sent by GSM to the authorities, who then notify the train conductor and the nearest station master. This research is significant since it can be used for detection in both daylight and darkness. We prioritized security. This project provides the Indian Railway far more Reliable [10].

III. METHODOLOGY

Smart surveillance systems make advantage of IoT, a rapidly developing technology that is currently in widespread usage. This device is installed between two stations and uses ultrasonic sensors to broadcast sine waves down the track in order to identify any faults. The GPS receiver will be activated if the ultrasonic sensor detects a fracture and sends a signal onto the Arduino Uno board. The precise position will be relayed to the police via GPS receiver. Once the ultrasonic sensor provides a signal to a controller that will begins the monitoring camera to capture. The track may be viewed live via the camera. The website will be kept up-to-date with the latest live stream and GPS data.

Our system utilizes a detector and a Node MCU microcontroller to determine the exact location of a split in the rails. In this layout, an ultrasonic detector is used to detect and describe what is ahead of and behind the train. The distance between the two targets is calculated using this method. Ultrasonic detectors measure the distance among the two objects, and if there is even the slightest amount of friction setting up the communication, which contains corresponds to specific location, will be transmitted to the nearest station or as control room if a crack is passed in the track. Improve train operations' safety and dependability with real-time alerts regarding possible track faults thanks to an Internet of Things-based fault detection system. The following figure Fig.2 shows the system's block diagram.

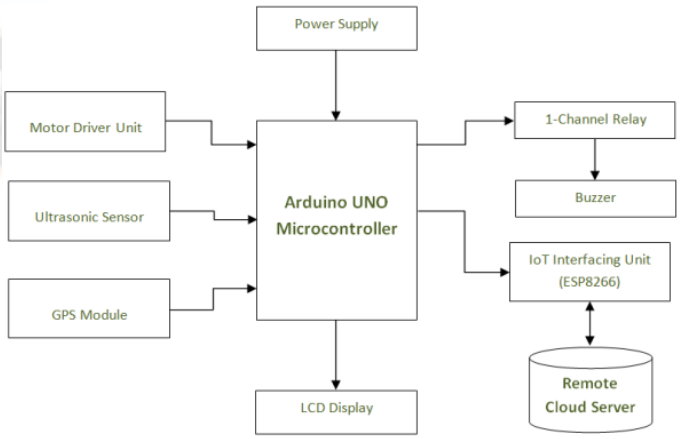

Fig.2 System's Block Diagram

(i) Arduino Microcontroller: The Arduino Uno is a free and open-source hardware platform ideal for electronics prototyping. It's the two parts working together. To dump the program's code on the viewable board, it must be written and uploaded to the system. The Arduino UNO is a board that contains a microcontroller with a variety of useful features, including 14 digital I/O pins (6 of which may be utilized as PWM output), 6 analogue inputs, a ceramic resonator with a frequency of 16 MHz a USB port, a power socket, an ICSP header, and a reset button. The following figure Fig.3 shows the Arduino UNO microcontroller.

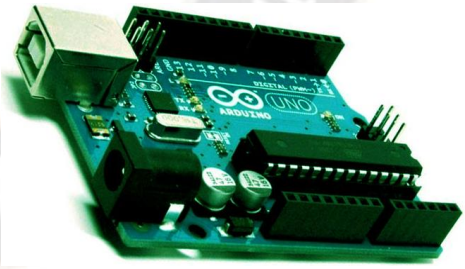

Fig.3 Arduino UNO

(ii) Node MCU: One such platform is NodeMCU, an inexpensive open-source Internet of Things platform. There are open source prototype board layouts for the firmware NodeMCU. The term "NodeMCU" combines the words "node" as well as "MCU" (micro-controller unit). Its original components were the ESP-12 module and firmware designed to

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: 25 July 2023 *Revised:* 12 September 2023 *Accepted:* 30 September 2023

operate on Espressif Systems' ESP8266 Wi-Fi system-on-a-chip. The following figure Fig.4 illustrates the NodeMCU.

Fig.4 NodeMCU

(iii) Ultrasonic Sensor: The use of ultrasonic sensors in the production process allows for more precise measurement and control, as well as more automated process control in the factory floor. Distances to objects of varying size, color, and surface roughness may all be accurately measured with ultrasonic sensors. They can gauge the distance to an item that is either becoming closer or further away. The following figure Fig.5 shows the ultrasonic sensor.

Fig.5 Ultrasonic Sensor

(iv) GPS Module: The global positioning system (GPS) module is an on-board wireless chip. GPS (Global Positioning System) serves as a satellite-based navigation systems. A GPS receiver, no matter where or close to the surface it may be, may use this signal to obtain time and location data. GPS is functional in any climate. The following figure Fig.6 shows the GPS module.

Fig.6 GPS Module

(v) DC Motor: A direct current (DC) motor is a device that can transform electrical energy into mechanical energy. The speed of a DC motor can be controlled by varying the supply voltage or by modifying the current through the field windings. The following figure Fig.7 illustrates the DC Motor.

Fig.7 DC Motor

IV. RESULTS AND DISCUSSIONS

The major objective is to locate any possible hazards that may be present in the railway lines and locate any openings that may be present in the rails. The associated loco pilot will be alerted of a fracture in the rail by the crack detection system via a pop-up message. This model is a cost-effective solution to the problem of crack detection on railroads since it is able to tell the associated loco pilot of the fracture. This pop-up notification service will be implemented with the help of a GPS module, and the data will be communicated to the command centre by means of an SMS in order to facilitate the avoidance of potentially hazardous circumstances. Eye examination, video transmission, and magnetic field techniques are some of the current ways that may be utilized to identify cracks in railway rails. One of the first procedures is called a physical examination, and it involves actually inspecting each individual component. In spite of the fact that it generates the poorest outcomes, this approach is commonly used in India. During the process of streaming content, a camera is used to do continuous monitoring of the track. This strategy conceals the fact that the equipment is extremely expensive as well as the presence of tiny cracks. The eddy current method is utilized in order to identify issues; however, the findings cannot be relied upon due to the fact that the current is transmitted via the rails. Because of the slow pace of the robot, using these strategies often requires a significant amount of both time and computational resources, which may be inconvenient for the user.

The proposed railway crack detection system solves some of the following problems, such as the requirement for human work and a long detection method, both of which are now handled manually and verbally via telephone and telegraph. The system also aims to reduce the amount of time spent on crack detection. When it came to identifying problematic rail lines, the proposed method performed far better than the current industry standard. The Arduino UNO board is something that we will be utilizing in the suggested configuration that we have. Arduino is an integrated development environment (IDE) that is open-source and significantly simplifies the process of programming. Infrared sensors for object detection and ultrasonic sensors for fracture detection are both included in the system that has been proposed. The motor driver helps to operate the DC motors, and the Arduino controller is primarily used for controlling the sensor outputs and for the transmission of information through the GSM module. The GSM module's purpose is to send the signal to the base station whenever it detects a crack or an obstacle in the form of an SMS. The motor

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: *25 July 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 September 2023*

driver helps to operate the DC motors. It is possible, with the aid of the GPS receiver, to ascertain the exact longitudinal direction and latitude of the crooked path. This equipment enables one to see even the minutest of fractures, which would otherwise likely go unreported. As a result, the proposed technology is viable for mining and yields useful results.

The following figure, Fig-8 represents the crack detection efficiency of the proposed AI based Railway Crack Detection (AIRCD) methodology, in which the same is cross-validated with the conventional Human based Railway Crack Detection (HRCD) methodology to prove the efficiency of the proposed scheme. This approach is evaluated with respect to the placement of proposed approach into the real-time environment for continuous 30 days to test the performance and the same is depicted into the following table, table-1 in descriptive manner.

Table-1: Crack Detection Efficiency

Days	HRCD (%)	AIRCD (%)
2	86.29	96.37
5	85.27	96.54
8	86.34	96.12
10	85.16	96.47
12	85.19	96.35
17	84.95	96.33
22	84.72	96.32
25	84.49	96.31
28	84.26	96.30
30	84.03	96.29

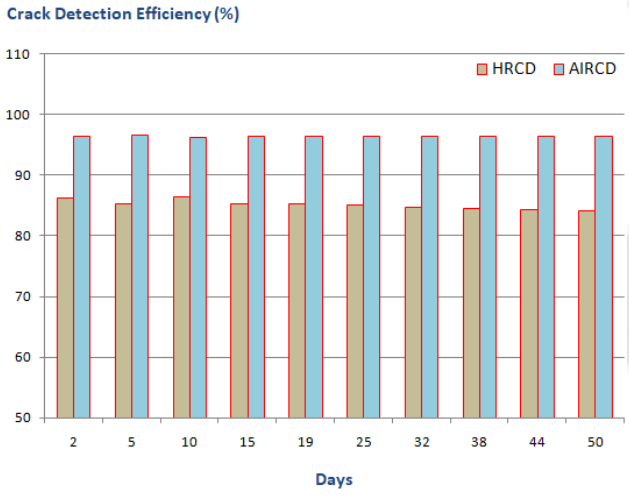

Fig.8 Crack Detection Efficiency

The following figure, Fig-9 represents the emergency alert mechanism performance of the proposed AI based Railway Crack Detection (AIRCD) methodology, in which the same is cross-validated with the conventional HRCD methodology to prove the working nature of the proposed scheme. The same is depicted into the following table, table-2 in descriptive manner.

Table-2: Alert Mechanism Analysis

Days	Alerts Sent	Alerts Received (HRCD)	Alerts Received (AIRCD)
2	15	10	15
5	17	12	16
8	23	17	23
10	25	21	24
12	28	22	27
17	36	31	34
22	39	32	38
25	42	37	41
28	45	39	44
30	46	41	45

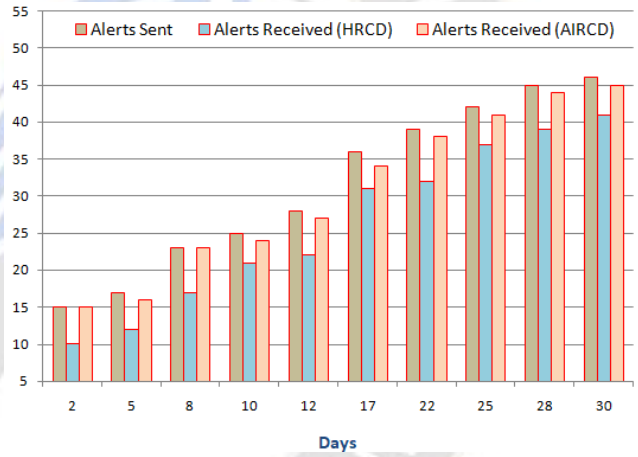

Fig.9 Alert Mechanism Analysis

The following figure, Fig-10 represents the IoT data storage efficiency of the proposed AI based Railway Crack Detection methodology, in which the same is cross-validated with the conventional HRCD methodology to prove the data storage efficiency of the proposed scheme. The same is depicted into the following table, table-3 in descriptive manner.

Table-3: Data Storage Efficiency

Days	Data Sent	Data Received (HRCD)	Data Received (AIRCD)
2	6012	5245	6000
5	6143	5326	6126
8	6324	5407	6320
10	6539	5488	6509

12	6695	5569	6683
17	6871	5650	6854
22	7047	5731	7028
25	7224	5812	7212
28	7400	5893	7392
30	7576	5974	7524

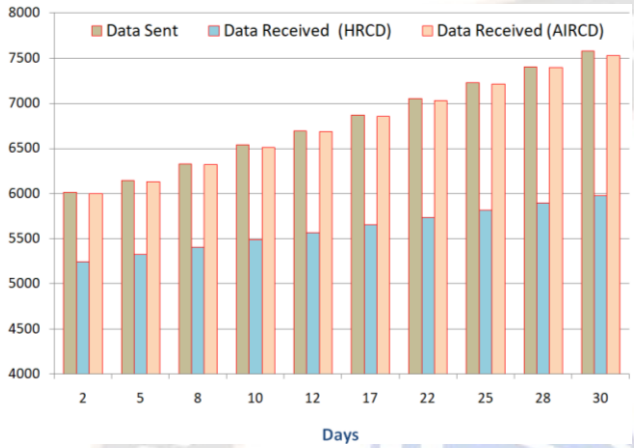

Fig.10 Data Storage Efficiency

V. CONCLUSION

This technology may be used to identify cracks at any time of day or night and pinpoint the precise position of the fault. Therefore, we conclude that by utilizing the AI based Railway Crack Detection (AIRCD) technology, we may simply alert the Railway Controller of any identified cracks or damaged track information. The use of cloud computing and Internet of Things (IoT) association, together with the Internet protocol that allows data transfer, will make things much simpler.

REFERENCES

[1] Laxmi Goswami, "Railway Route Crack Detection System", International Journal of Innovative Technology and Exploring Engineering, DOI: 10.35940/ijitee.L1043.10812S19, 2019.
[2] R. T. et al, "Automated Crack and Damage Identification in Premises using Aerial Images based on Machine Learning Techniques," (I-SMAC), Dharan, Nepal, 2022, pp. 498-504, doi: 10.1109/I-SMAC55078.2022.9987391.
[3] Zunzarrao Thorat, Nikhil Ranjane, et al., "Automatic Railway Track Crack Detection System Using GSM & GPS", International Research Journal of Engineering and Technology, 2023.
[4] Naveen et al "Hybrid Model for Detection of Corrosion in Water Pipeline Images Using CNN and Comparing Accuracy with SVM", ECS Transactions, 2022.DOI: 10.1149/10701.13861ecst
[5] Krishna Vamsi Thatiboyina, Salady Bala Murugan, et al., "TRAIN TRACK CRACK CLASSIFICATION USING CNN", International Research Journal of Modernization in Engineering Technology and Science, 2022.
[6] Dhivya, Rukmani N, et al., "RAILWAY CRACK DETECTION SYSTEM USING RASPBERRY PI 3", International Journal of Applied Engineering and Technology, 2020.
[7] S. Sakena Benazer, M. Sheik Dawood, et al., "Efficient model for IoT based railway crack detection system", Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.11.743, 2021.
[8] Sanapathi Harika, Vellanki Lalitha Ramya, et al., "AUTOMATIC RAILWAY TRACK CRACK DETECTION SYSTEM USING GSM AND GPS", Mukt Shabd Journal, 2023.
[9] Y.Saraswathi, A. Siva Kumari, et al., "ROBUST RAILWAY TRACK CRACK DETECTION USING GSM AND GPS SYSTEM ", Journal of Engineering Science, 2019.
[10] Roushan kumar Prasad, Dheeraj Kumar, et al., "Study of Railway Track Crack Detection System", International Journal for Research in Engineering Application & Management, DOI:10.35291/2454-9150.2022.0122, 2022.
[11] B. S. Sathish, P. Ganesan, et al., "Advanced Automatic Detection of Cracks in Railway Tracks", 5th International Conference on Advanced Computing & Communication Systems, DOI: 10.1109/ICACCS.2019.8728451, 2019.
[12] CHETHAN S, SEBIN MATHEW, et al., "Railway Track Crack and Break Detection System with Onboard Signalling", Journal of Emerging Technologies and Innovative Research, 2019.
[13]Mansoor, C.M.M., Vishnupriya, G., Anand, A., ...Kumaran, G., Samuthira Pandi, V, "A Novel Framework on QoS in IoT Applications for Improvising Adaptability and Distributiveness", International Conference on Computer Communication and Informatics, ICCCI 2023, 2023.
[14] Samuthira Pandi, V., Singh, M., Grover, A., Malhotra, J., Singh, S, "Performance analysis of 400 Gbit/s hybrid space division multiplexing-polarization division multiplexing-coherent detection-orthogonal frequency division multiplexing-based free-space optics transmission system", International Journal of Communication Systems, 2022, 35(16), e5310.