

A Novel Prevention Conceptual Development of Implementing the Safety Mechanisms in Indian Railways to Prevent Accidents

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Abstract—The project "Connecting Safety on the Railway Tracks" introduces an innovative strategy for preventing train accidents, specifically tailored for implementation within the Indian Railways system. Emphasizing the paramount importance of railway safety, the initiative employs cutting-edge technologies and strategic measures to reduce accident risks. Central to the strategy is the integration of advanced sensors, machine learning algorithms, and communication systems to establish a robust safety network along the railway tracks. Through real-time monitoring and predictive analytics, the system aims to identify potential hazards, detect track irregularities, and predict accidents before they happen. The implementation plan for Indian Railways involves a phased approach, including sensor deployment, data infrastructure development, and collaborative partnerships with stakeholders. The project's objectives extend beyond safety enhancement, aiming to optimize train operations and improve overall efficiency and reliability of the railway network. By addressing the unique challenges of Indian Railways, the project sets a new standard for railway safety, showcasing the transformative potential of technology in accident prevention and serving as a model for railway systems worldwide. The project also introduces an innovative strategy for preventing train accidents, specifically tailored for implementation within the Indian Railways system. Emphasizing the paramount importance of railway safety, the initiative employs cutting-edge technologies and strategic measures to reduce accident risks. Central to the strategy is the integration of advanced sensors, machine learning algorithms, and communication systems to establish a robust safety network along the railway tracks. Through real-time monitoring and predictive analytics, the system aims to identify potential hazards, detect track irregularities, and predict accidents before they happen. The implementation plan for Indian Railways involves a phased approach, including sensor deployment, data infrastructure development, and collaborative partnerships with stakeholders. The project's objectives extend beyond safety enhancement, aiming to optimize train operations and improve overall efficiency and reliability of the railway network. By addressing the unique challenges of Indian Railways, the project sets a new standard for railway safety, showcasing the transformative potential of technology in accident prevention and serving as a model for railway systems worldwide.

Index Terms—Rail, Safety, Hardware, Software, Sensor, Track, Autonomous Inspection, IoT

Technologies, Track Cracks, Embedded Systems, Rail Safety, Machine Learning, Cloud Computing, YOLOv3 Algorithm, Level Crossings, Railway Monitoring.

I. INTRODUCTION

Railway safety is of utmost concern in India, where accidents often arise from track issues like cracks. Conventional monitoring methods are prone to oversights due to irregular maintenance and manual inspections. This synthesis paper draws insights from four key papers that tackle railway safety challenges with innovative technologies. The first paper introduces "Rail-Rakshak," a solar-powered autonomous vehicle for efficient railway track inspection. Utilizing Cloud Computing and Natural Language Processing (NLP), Rail-Rakshak autonomously detects and reports track cracks, addressing the limitations of manual monitoring [1]. The second paper addresses persistent problems in railway level crossings, proposing an IoT and machine learning-based system to enhance automated railway gates. By integrating a comprehensive embedded system with Train Detection Subsystem (TDS) and Level Crossing Subsystem (LCS), the model significantly reduces fatal accidents and contributes to economic well-being [2]. This pressing issue underscores the critical need for effective crack detection systems, given the widespread use of railway lines. The Fig. 1 illustrates the proposed system for Rail-Rakshak: Railway track detection [3].

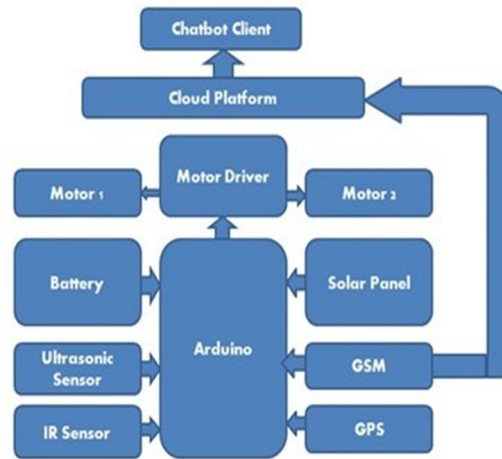


Fig. 1: Proposed system for Rail-Rakshak: Railway track detection

The number of incidents in 2015 to 2020 along with the accident in news report datas is shown in the Tables 1 & 2 respectively [4] [5].

TABLE I. NUMBER OF INCIDENTS IN 2015 TO 2020

	2015	2016
No of Deaths		
Protected Level Crossing	10	9
Unprotected Level Crossing	2	0
Total	12	9
No of Casualties		
Protected Level Crossing	35	30
Unprotected Level Crossing	0	0
Total	35	30

TABLE II. ACCIDENT IN NEWS REPORT

Year	No of Deaths	No of Injuries
2018	14	4
2019	18	22
2020 (January)	0	1

II. METHODOLOGY UTILIZED

The Rail-Rakshak system presents a holistic solution to enhance railway track safety, utilizing cutting-edge technologies for efficient crack detection. The system's methodology revolves around a mobile robotic platform, named Rail-Rakshak, which is powered by an Arduino UNO microcontroller. The design focuses on mobility, utilizing dedicated rechargeable Li-ion batteries and integrating solar energy harnessing capabilities for extended operational durations. Figure 2 illustrates the data flow diagram of the overall proposed system, showcasing its intricate workings and integration of various components [8][9]. The Rail-Rakshak system embodies a sophisticated approach to railway track safety, amalgamating state-of-the-art technologies to ensure accurate crack detection. Central to its operation is a mobile robotic platform, the Rail-Rakshak, which is driven by an Arduino UNO microcontroller. The system prioritizes mobility, featuring specialized rechargeable Li-ion batteries and incorporating solar energy harvesting functionality to enable prolonged operation. The system's intricate workings and component integration are depicted in Figure 2, providing a visual representation of its comprehensive design and functionality [6][7].

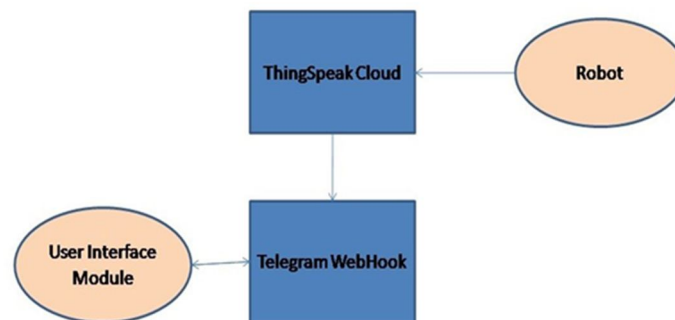


Fig. 2 : DFD of overall system

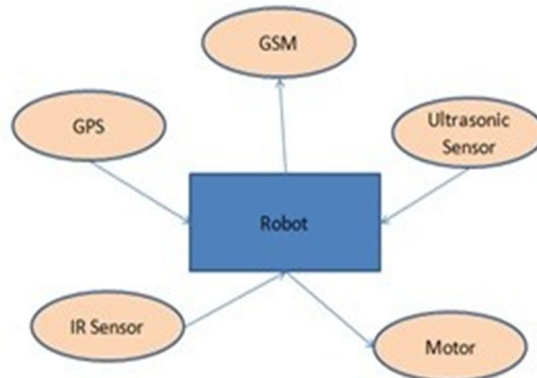


Fig 3 : DFD of Sub-Modules

The Fig. 3 gives the data flow diagram of the various sub-modules used in the project work. The communication architecture involves a cloud platform, specifically an IoT Cloud Service provided by Mathworks, Inc. This cloud infrastructure serves as a repository for sensor data and coordinates, facilitating seamless communication between the robot and a Chatbot interface [10][11]. The Chatbot handles message context comprehension, intelligent replies, and provides a visual representation of the robot's location coordinates. The proposed system, named "Rail-Rakshak," exemplifies a sophisticated integration of hardware components, cloud-based communication, and an intelligent Chatbot interface. The architecture's modularity, with distinct sub-modules such as Chatbot, Webhook, Cloud, and Robot, showcases a well-structured and scalable system for railway track crack detection [12][13].

The RF transmitter ensures reliable data transmission over a considerable radius, addressing line-of-sight challenges. Location of vibration sensor in railway track is shown in the Fig. 4 [16][17]. The Level Crossing Subsystem (LCS) is powered by a Raspberry Pi B+ module, offering enhanced processing power and storage capacity compared to traditional Arduino microcontrollers. The subsystem integrates a camera module for obstacle detection, inductive proximity sensors for gate control, an RF receiver for data reception, and motors for gate operation. The Fig. 5 gives the detection of train with directions, i.e., the percentage wise in the form of a graph [14][15].

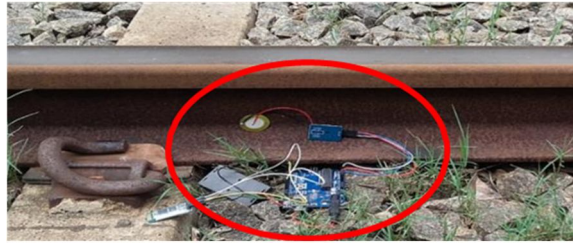


Fig. 4 : Location of Vibration Sensor in Railway Track

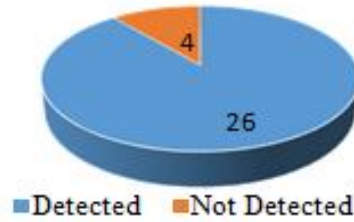


Fig. 5 : Detection of train with direction

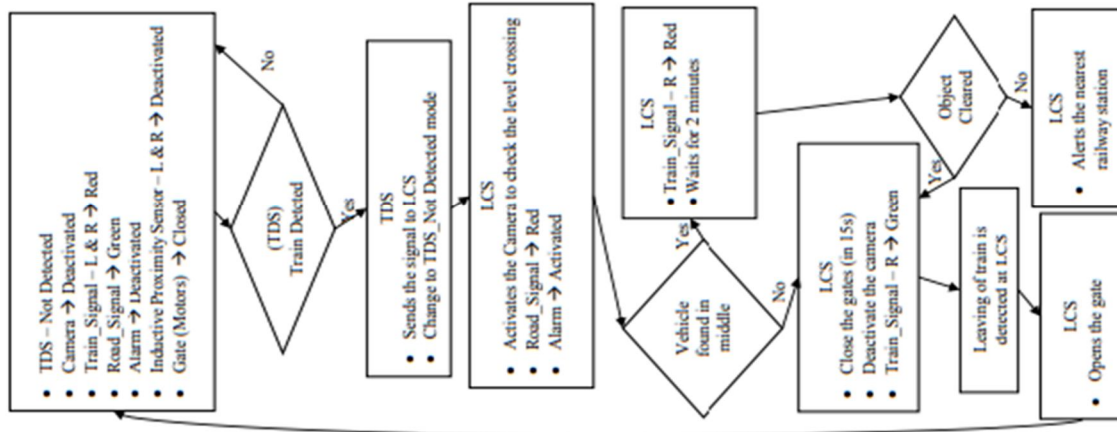


Fig. 6: Working Mechanism

The working principle shown in the Fig. 6 involves the TDS detecting trains, transmitting encrypted data to the LCS via RF communication, and initiating dynamic gate control based on obstacle detection. The comprehensive system design effectively minimizes the risk of accidents at railway [18][19].

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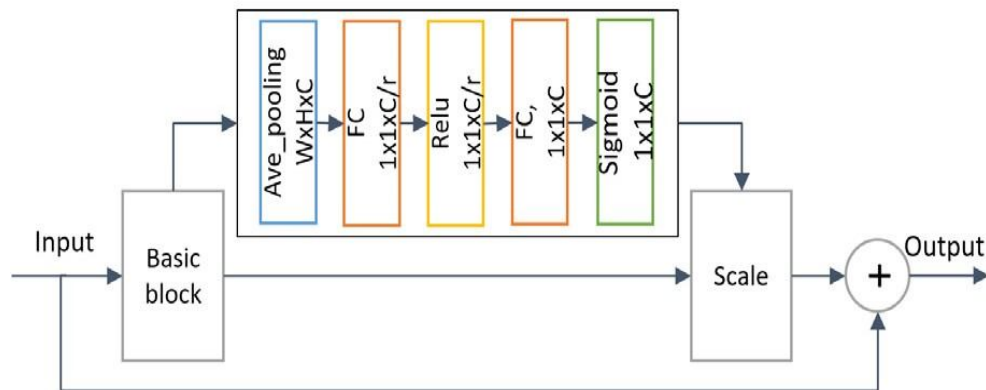


Fig. 7 : The basic unit residual unit structure diagram

III. NEURAL NETWORKS WITH BOTTOM-UP PATH AGGREGATION METHODS

The neural network proposed in this study employs a feature pyramid structure to optimize feature extraction for crack detection. Recognizing the need for detailed information to enhance detection capabilities, the network integrates a bottom-up path aggregation strategy [20][21]. This innovative approach maximizes the utilization of shallow features, ensuring a richer and more nuanced understanding of input data. The network's architecture, depicted in Figure 7, illustrates the synergy between the feature pyramid network and the bottom-up path aggregation strategy. The feature pyramid network, with its ability to capture semantic information, is complemented by the detailed insights derived from the bottom-up path aggregation [22][23].

IV. RAILWAY TRACK CRACK DETECTION ROBOT

The Railway Track Crack Detection Robot introduces an innovative robotic unit designed for autonomous crack detection in railway tracks. The robot's architecture centers around an Arduino Uno microcontroller, providing the computational intelligence for decision-making during monitoring periods. The system leverages a four-wheeled design with DC-powered wheels, offering a balance of stability and maneuverability. Block diagram of battery management system is shown in the Fig. 8 [24][25].

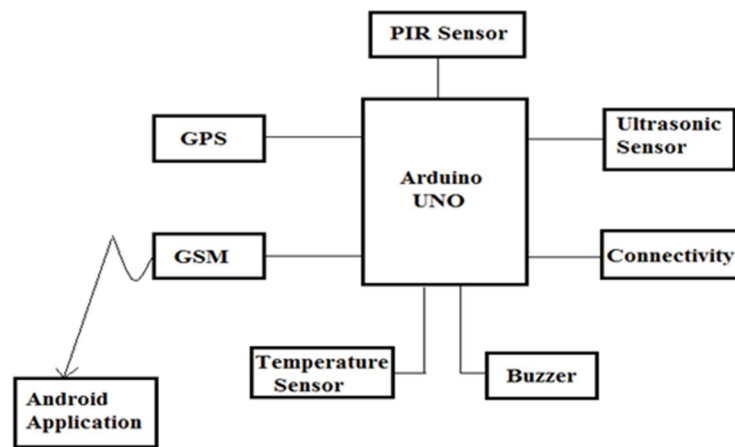


Fig. 8: Block diagram of Battery Management System

V. RESULTS & CONCLUSIONS

In the normal scenario, the robot's continuous movement along the track was seamlessly integrated with periodic cloud uploads of sensor data, guaranteeing uninterrupted monitoring [30]. During the detection of obstacles or when the robot was lifted, the system's immediate response in halting movement and transmitting relevant data to the cloud showcased its quick reaction time. Telegram messages containing precise location details were then dispatched to users, ensuring real-time communication. The normal working robot (moving) is shown in the Fig. 10 [26][27].

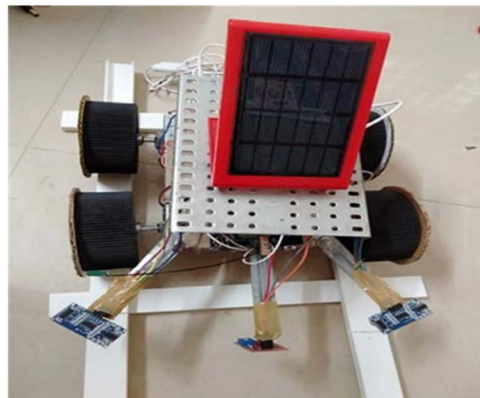


Fig. 10: Normal Working Robot (Moving)

The simulation results are shown in the Figs. 11 to show the obstacle being detected & the robot lifting the obstacle [28][29].



Fig. 11: Obstacle detected

VI. CONCLUSIONS

In conclusion, the project “*Connecting Safety on the Railway Tracks*” represents a significant advancement in enhancing safety within the Indian Railways system. Through its innovative approach to accident prevention, leveraging cutting-edge technologies and proactive interventions, the project offers a comprehensive solution to the longstanding challenge of railway safety. The integration of state-of-the-art sensors and machine learning algorithms enables real-time monitoring and predictive capabilities, ensuring the timely prevention of potential accidents. This strategy not only prioritizes passenger and crew safety but also aligns with broader objectives of optimizing railway operations for increased efficiency. The project's phased implementation plan, tailored for the unique challenges of Indian Railways, demonstrates a pragmatic approach to addressing safety within the vast and complex railway network. By deploying sensors strategically, developing robust data infrastructure, and fostering collaborative partnerships, the project is poised to significantly impact the safety landscape of one of the world's largest railway systems. The project sets a benchmark for safety initiatives in the railway sector, showcasing the transformative potential of innovative strategies and technology in preventing accidents and enhancing the safety and reliability of railway infrastructure worldwide.

REFERENCES

- [1] Sanket Salvi ,Shashank Shetty, “AI based Solar Powered Railway Track Crack Detectionand Notification System with Chatbot Support” *Scopus Journal* Q3 , Jul 2022.
- [2] M.I.M.Amjath, T.Kartheeswaran, “An Automated Railway Level Crossing System”, *Released on 2022 May*.
- [3] YaoXing Zhang, Wenju Li, Maoxian He, Huiling Chen, “CRTSII Track Slab Crack Detection Based on Improved YOLOv3 Algorithm” *released on 2021 jan*.
- [4] Nilisha Patil, Dipakkumar Shahare, Shreya Hanwate, Pranali Bagde, Karuna Kamble, Prof. Manoj Titre ,

- "Designing of Improved Monitoring System for Crack Detection on Railway Tracks", *Conference Paper*.
- [5] Shashank S., Kushal K., Abhay Surya Shankar, Madan Kumar G., Dr. Pavithra G., Dr. Sindhu Sree M., Padmavathy M., Dr. T.C. Manjunath, "RFID based attendance system with SMS Alert", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 774 – 782, Jul. - Sept. 2023.
 - [6] Abhishek, Sujith M.S., Jeevan D., P. Kamalesh, Dr. Sindhu Sree M., Dr. Pavithra G., Dr. T.C. Manjunath, "Design & Development of a Table Assisted Robotic Arm", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 818 – 822, Jul. - Sept. 2023.
 - [7] Apeksha U., Chithrashree G.S., Divya N.M., Shalmali S. Mankikar, Dr. Sindhu Sree M., Dr. Pavithra G., Dr. T.C. Manjunath, "Wireless LoRa Communication Between Two Arduino Uno for Military Application in Soldier Tracking", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 768 – 773, Jul. - Sept. 2023.
 - [8] Akarsh Kesharwani, Ayush P. Chaudhary, Bhanu Pratap Singh, Ved Kumar, Padmavathi M., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "A Study on Hand Motion Controlled Robotic Arm", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 812 – 817, Jul. - Sept. 2023.
 - [9] Leena Jeyakumar, Prerana Aithal, Vismitha R., Pradhan Aithal, Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Development of Smart Bridge – Automatic Height Increase When Floodings Take Place", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 763 – 767, Jul. - Sept. 2023.
 - [10] Sushanthi Raj, Manohar R., Bhuvan G.S., Deepthi. S.R., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Design and Development of Obstruction Detection and Removal Bot", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 807 – 811, Jul. - Sept. 2023.
 - [11] Anagha, Jhanavi M., Khushi M.S., Nithin Kumar S., Dr. Sindhu Sree M., Dr. Pavithra G., Dr. T.C. Manjunath, "Paralysed Patient Healthcare Monitoring Device", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 758 – 762, Jul. - Sept. 2023.
 - [12] Ashmeet Singh, Harshit Goenka, Prakhar Sahu, Venkatesh L., Padmavathi M., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Development of an Automatic Fire Extinguisher", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 802 – 806, Jul. - Sept. 2023.
 - [13] Vaishnavi Patil, Dr. Pavithra G., Dr. T.C. Manjunath, "Design, Development of a Diversified Implementation of a Supervisory Control And Data Acquisition based VLSI System (SCADA) framework Utilizing Microcontroller based Programmable Logic Controllers", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 879 – 890, Jul. - Sept. 2023.
 - [14] Kavya P., Sanjana S., Harika, Teju R., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Design & Development of Drones Using Radio Frequency Controllers", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 707 – 710, Jul. - Sept. 2023.
 - [15] S.G. Swathi, Aliya Bhandari, Srushti M. B. Kavya A., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Voice Control Robot – Design & Development for Various Domestic Applications", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 791 – 801, Jul. - Sept. 2023.
 - [16] Vaishnavi Patil, Dr. Pavithra G., Dr. T.C. Manjunath, "Design of Smart Wheelchair For Disabled (Handicapped) Persons Using Real Time Embedded Systems & Internet Of Things Approach", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 871 – 878, Jul. - Sept. 2023.
 - [17] Biswendu Biswas, Madan V.L., Rakesh B.S., Prathik Chandrapal, Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Development of remotely operated military purpose aerial vehicles", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 638 – 641, Jul. - Sept. 2023.
 - [18] Akanksha Dash, Amrutha G., Krutika S. Ganpur, Sneha Chatter, Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T.C. Manjunath, "Obstacle Avoiding Robotic Car Using Arduino with Bluetooth and Voice Control", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 783 – 790, Jul. - Sept. 2023.
 - [19] Vaishnavi Patil, Dr. Pavithra G., Dr. T.C. Manjunath, "Simulation & design of a VLSI embedded system using Verilog Coding with Modelsim approach in FPGA scenarios for AI applications in automotive sectors", *Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology*, ISSN : 1001-4055, Vol. 44, No. 3, pp. 862 – 870, Jul. - Sept. 2023.
 - [20] Sagaragouda, Sahana. G. Malagali, Srujana C.H., Dr. Pavithra G., Dr. T.C. Manjunath, "Connecting safety on the railway tracks : A novel train accident prevention strategy & its implementation in Indian Railways", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact

Factor 5.672 (2022), pp. 1-5, Nov-Dec. 2023.

- [21] Sharon Rodrigues, Shubhangi Saha, Siddhant Singh, Vipul Singh, Dr. Pavithra G., Dr. T.C.Manjunath, "Advaya Bot - Radiologist assistant robot development & its usage in healthcare applications", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 6-11, Nov-Dec. 2023
- [22] K. Nanda Kiran, Kumari Ayush, Kishore V.M., Vinod Kumar Malkapure, Dr. Pavithra G., Dr. T.C.Manjunath, "SILKBOT : Orchestrating Silk Symphony - A Comprehensive Approach towards Silk Production and Enhancement in Sericulture Applications", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 17-22, Nov-Dec. 2023.
- [23] Madan Kumar C., Manvanth G., Mohan Y., Nagesh B.R., Dr. Pavithra G., Dr. T.C.Manjunath, "Dhenu Svasthya Bot: An AI driven well-being and health monitoring setup for science and engineering applications", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 23-28, Nov-Dec. 2023.
- [24] Vaishnavi Patil, Vaibhav V.K., Thyagaraj B.G., Suprith Gowda G., Dr. Pavithra G., Dr. T.C.Manjunath, "MUG MAGIC - Design and Development of Low-Cost Mini Tea and Coffee Machine using AI-ML concepts", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, pp. 29-34, Impact Factor 5.672 (2022), Nov-Dec. 2023.
- [25] Geethanjali G.C., Dr. Pavithra G., Dr. T.C.Manjunath, "Design Of Voltage Level Shifter Using Regulated Cross Coupled Pull Up Networks", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, pp. 35-39, Impact Factor 5.672 (2022), Nov-Dec. 2023.
- [26] Lakshmi N., Dr. Pavithra G., Dr. T.C.Manjunath, "Design Of Three Stage Comparator Using 90nm Technology", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 40-43, Nov-Dec. 2023.
- [27] Afira Ansari, Akshat Kumar, Ananth Agarwal, Anupriya D., Dr. Pavithra G., Dr. T.C.Manjunath, "Development Of Solar Powered Cold Storage For Agricultural Purposes", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 44-49, Nov-Dec. 2023.
- [28] Madhushree K., Keerthana M., Poornima J., R. Kavya, Padmavathi M., Dr. Pavithra G., Dr. T.C.Manjunath, "An Advanced Multi-Functional Robotic dog with Enhanced Sensory and Communication Proficiencies", *International Journal of Engineering Technology and Management Sciences (IJETMS)*, Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 50-56, Nov-Dec. 2023.
- [29] Pratik Kumar Singh, P.J. Mohammed Shoaib, Prakhar Tibrewal, Naveen, Padmavathy M., Dr. T.C.Manjunath, "Recent advances in the development of data access system using remote means with raspberry pi & cloud computing", *International Conference on Advances in Engineering and Technology (ICAET-2023)*, Organized by RSP Conference Hub, Coimbatore, Tamil Nādu, India, RSP Conference Hub, Coimbatore, Tamil Nādu, India, Paper ID : 2305060, 27-28 May 2023.
- [30] Nikhil Bhutra, Gaurav Singh, Madhur Mehta, Ohshin Bhat, Padmavathi M, Dr. T.C.Manjunath, "Establishment of Secure Network using Reinforcement Learning", *International Conference on Advances in Engineering and Technology (ICAET-2023)*, Organized by RSP Conference Hub, Coimbatore, Tamil Nādu, India, RSP Conference Hub, Coimbatore, Tamil Nādu, India, Paper ID : 2305061, 27-28 May 2023.