



IoT Based Fire Accident-Avoidance System in EV Vehicles

D.S Nivetha Joice¹, B. Anitha², R. Balaji³, S. Bhuvaneshwaran⁴

Assistant Professor, Dept. of BME, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India¹

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India²

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India³

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India⁴

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India⁵

Publication History: Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03.2026; Published: 28.03.2026.

ABSTRACT: Electric vehicles (EVs) are widely adopted due to their energy efficiency and environmental benefits; however, fire accidents caused by battery overheating, short circuits, and thermal runaway pose serious safety challenges. To address this issue, this project proposes an IoT-Based Fire Accident-Avoidance System for electric vehicles that continuously monitors critical parameters such as battery temperature, voltage, and the presence of smoke or gas using embedded sensors. The collected data is processed using a microcontroller and transmitted through an IoT platform for real-time monitoring. When abnormal conditions are detected, the system generates instant alerts to the vehicle owner and initiates preventive actions such as power cutoff to reduce fire risk. The proposed system aims to enhance EV safety, improve reliability, and minimize fire-related accidents, making it suitable for practical implementation in modern electric vehicles.

KEYWORDS: Temperature sensor, smoke/gas sensor, flame sensor, microcontroller, relay module, buzzer & led, IoT cloud platform, mobile app/web dashboard

I. INTRODUCTION

Electric vehicles (EVs) are rapidly becoming a key component of modern transportation systems due to their environmental benefits and high energy efficiency. Unlike conventional internal combustion engine vehicles that rely on fossil fuels, electric vehicles operate using electrical energy stored in rechargeable batteries. This significantly reduces greenhouse gas emissions, air pollution, and dependence on non-renewable energy resources. As a result, many countries around the world are encouraging the adoption of electric vehicles through government policies, subsidies, and investments in charging infrastructure.

The increasing popularity of electric vehicles has led to major advancements in battery technologies, motor efficiency, and vehicle control systems. Most modern electric vehicles use lithium-ion batteries, which offer high energy density, lightweight design, and longer lifespan compared to traditional battery technologies. These batteries provide sufficient energy storage for long-distance travel and efficient power delivery for electric motors.

Despite these advantages, electric vehicles also face certain safety challenges, particularly related to battery systems. One of the most serious concerns is the risk of battery overheating and fire accidents. Lithium-ion batteries contain highly reactive chemical materials that can become unstable under certain conditions. If the battery temperature rises beyond safe limits or if internal damage occurs, it may result in dangerous situations such as smoke generation, gas release, or fire.

Several incidents of electric vehicle fires have been reported in recent years, often caused by battery faults, electrical short circuits, or charging system failures. These incidents highlight the importance of implementing advanced safety systems that can detect potential hazards early and prevent fire accidents.

Traditional safety systems in vehicles often rely on passive protective measures such as thermal insulation, fuses, and circuit breakers. While these mechanisms provide basic protection, they may not always detect early warning signs of



battery malfunction. Therefore, there is a growing need for intelligent monitoring systems that can continuously observe battery conditions and identify abnormal behaviour before it develops into a dangerous situation. To address these challenges, modern electric vehicles are increasingly incorporating smart monitoring technologies that use sensors, microcontrollers, and communication networks. These systems allow real-time observation of battery parameters and enable early detection of potential fire hazards. By integrating advanced monitoring technologies, electric vehicles can achieve higher safety standards and improved reliability.

II. PROBLEM STATEMENT

Electric vehicles (EVs) use high-capacity lithium-ion batteries and power electronic systems that operate at high voltage and current. These components are sensitive to abnormal conditions such as overheating, overcharging, internal short circuits, and insulation failure. Such issues may lead to thermal runaway and fire accidents. Traditional Battery Management Systems (BMS) mainly focus on charge balancing and basic protection. However, they often lack real-time fire prediction and remote monitoring capabilities.

The lack of continuous sensor monitoring and IoT communication can delay fault detection during critical situations. This increases the risk of sudden ignition, vehicle damage, and danger to passengers. Therefore, an IoT-based fire accident -avoidance system is needed to monitor parameters in real time, detect faults early, and automatically take safety actions to reduce fire hazards in electric vehicles

III. EXISTING SYSTEM

Traditional warehousing and logistics systems mainly depend on manual labour and conventional material handling equipment such as forklifts, pallet jacks, and conveyor belts. In these systems, workers are responsible for picking, transporting, sorting, and organizing goods within the warehouse. While this method has been widely used for many years, it often results in inefficiencies such as slower order processing, higher labour costs, and increased chances of human error.

Many warehouses use fixed automation systems like conveyor belts and Automated Storage and Retrieval Systems (AS/RS). Although these systems improve efficiency to some extent, they require complex infrastructure and high installation costs. Additionally, they lack flexibility because they operate within predefined paths and layouts. If the warehouse layout changes or if the demand increases, modifying these systems becomes difficult and expensive.

Another limitation of the existing system is the dependency on human workers for repetitive and physically demanding tasks. This can lead to fatigue, workplace injuries, and inconsistent productivity. Furthermore, manual inventory tracking can cause inaccuracies in stock management, leading to delays in order fulfilment and customer dissatisfaction.

In large distribution centres, the increasing volume of e-commerce orders has made it even more challenging for traditional systems to keep up with the demand for faster delivery and real-time inventory management. As a result, many warehouses face operational bottlenecks, inefficient space utilization, and higher operational costs.

IV. PROPOSED SYSTEM

The proposed system introduces **Autonomous Mobile Robots (AMRs)** to improve efficiency, flexibility, and productivity in warehouse and logistics operations. AMRs are intelligent robotic systems capable of navigating warehouse environments autonomously using sensors, cameras, artificial intelligence, and advanced navigation algorithms.

Unlike traditional automated systems, AMRs do not require fixed infrastructure such as tracks or conveyor lines. They can dynamically plan their routes, avoid obstacles, and adjust to changes in the warehouse layout. This flexibility allows warehouses to easily scale operations and adapt to changing demands without significant infrastructure modifications.

In the proposed system, AMRs are integrated with warehouse management systems (WMS) to perform tasks such as item picking, goods transportation, inventory movement, and order fulfilment. The robots communicate with

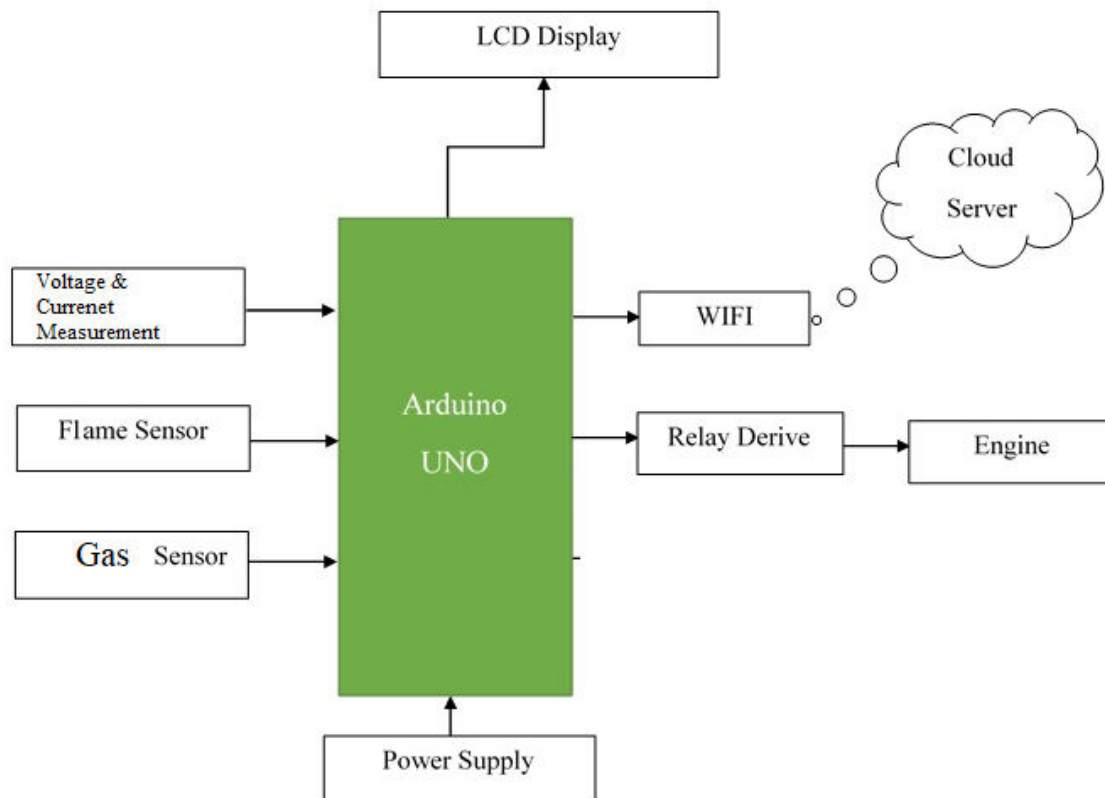
centralized control systems to receive task instructions and coordinate with other robots in the warehouse. This coordination ensures efficient task allocation and reduces idle time.

The implementation of AMRs significantly reduces manual labour requirements and minimizes human errors. Workers can focus on supervisory and value-added tasks instead of repetitive material handling activities. Additionally, AMRs improve safety by reducing accidents associated with heavy machinery and manual lifting.

Another advantage of the proposed system is real-time monitoring and data collection. Sensors and software systems allow warehouse managers to track robot movements, monitor inventory levels, and analyse operational performance. This data-driven approach helps in optimizing warehouse operations and improving decision-making.

Overall, the proposed system enhances operational efficiency, reduces costs, improves accuracy in order fulfilment, and supports the growing demands of modern supply chains and e-commerce logistics.

V. BLOCK DIAGRAM



VI. DESIGN AND SELECTION OF COMPONENTS

ARDUINO IDE

Arduino/Genuine Uno is a microcontroller board based on the ATmega328P . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again

FLAME SENSORS

The flame sensor is used to detect the flame occurrence. When the sensor detects the fire then it became short-circuit. When there is no fire the sensor become open circuit



GAS SENSORS

Ideal sensor for use to detect the presence of a dangerous LPG leak in your car or in a service station, storage tank environment. This unit can be easily incorporated into an alarm unit, to sound an alarm or give a visual indication of the LPG concentration. The sensor has excellent sensitivity combined with a quick response time. The sensor can also sense iso-butane, propane, LNG and cigarette smoke.

RELAY

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical. The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

LCD DISPLAY

A **liquid crystal display (LCD)** is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube (CRT) displays in most applications. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888. By 2008, worldwide sales of televisions with LCD screens had surpassed the sale of CRT units.

VII. SOFTWARE INSTALLATION

Software is an essential component in the development of embedded systems and IoT-based applications. It acts as the interface between the hardware components and the user, allowing the system to perform specific tasks automatically. In embedded systems, software is responsible for controlling sensors, processing data, managing communication modules, and executing programmed instructions to achieve the desired functionality. In most embedded and IoT projects, the microcontroller is programmed using specialized software tools that allow developers to write, compile, and upload programs to the hardware device. The efficiency of the software determines how effectively the system can collect data from sensors, process it, and control output devices.

For many embedded projects, Arduino IDE is used as the development environment, while Embedded C is used as the programming language. These tools provide a simple and flexible platform for designing and implementing embedded applications. The software continuously monitors input signals from sensors and performs operations based on predefined conditions. It also enables communication between the system and external devices such as displays, IoT platforms, or mobile applications. Proper software design ensures that the system operates reliably, responds quickly to changing conditions, and performs its functions efficiently. Therefore, selecting the right programming tools and developing optimized code are important aspects of embedded system development.

Arduino IDE

The Arduino Integrated Development Environment (IDE) is an open-source software platform used to develop and upload programs to Arduino boards and other compatible microcontrollers. It provides a user-friendly interface that simplifies the process of writing and testing embedded system programs. Arduino IDE supports multiple operating systems including Windows, Linux, and macOS, making it accessible to a wide range of users. The environment contains a built-in text editor where programmers can write their code, known as a sketch. These sketches are written using a simplified version of the C/C++ programming language.



The Arduino IDE includes several important components that help developers during program development. The code editor is used to write and modify the program. The toolbar provides quick access to commonly used functions such as verifying the program, uploading code to the microcontroller, and saving files. The message area and console display error messages, compilation results, and debugging information. One of the major advantages of Arduino IDE is the availability of a large collection of libraries. These libraries simplify programming by providing ready-made functions for sensors, communication modules, displays, and other hardware devices. By using these libraries, developers can easily integrate different components into their projects without writing complex code.

Another important feature of Arduino IDE is the Serial Monitor, which allows developers to view real-time data from the microcontroller. This feature is very useful for debugging and testing sensor readings during system development. When a program is written in the Arduino IDE, it must first be compiled. During compilation, the software checks the program for syntax errors and converts it into machine code that the microcontroller can understand. After successful compilation, the program is uploaded to the Arduino board using a USB connection.

Once the program is uploaded, the microcontroller executes the instructions continuously. The Arduino IDE therefore serves as a complete development platform for programming, testing, and debugging embedded systems.

Embedded C

Embedded C is a programming language used for developing software in embedded systems. It is an extension of the C programming language and is specifically designed for programming microcontrollers and hardware-based devices.

Embedded C provides direct access to hardware components such as input/output ports, timers, communication modules, and memory registers. This allows programmers to control sensors, actuators, and other electronic devices efficiently. In embedded system development, the program must interact closely with the hardware. Embedded C allows the programmer to read data from sensors, perform logical operations, and control output devices such as LEDs, motors, buzzers, and displays.

A typical Embedded C program contains several sections, including header files, variable declarations, initialization routines, and the main program loop. In Arduino-based systems, the program structure mainly consists of two functions: `setup()` and `loop()`. The `setup()` function is executed once when the microcontroller starts running. It is used to initialize input and output pins, configure communication modules, and prepare sensors for operation. The `loop()` function runs continuously after the setup function. It performs the main tasks of the system such as reading sensor values, processing data, and controlling output devices. Since the loop runs repeatedly, the system can continuously monitor inputs and respond to changes in real time. Embedded C supports various programming structures such as conditional statements, loops, and functions. Conditional statements such as `if-else` allow the program to make decisions based on sensor readings. Loops such as `for` and `while` are used for repetitive operations.

Embedded C also supports communication protocols such as UART, SPI, and I2C, which allow the microcontroller to communicate with external devices. These protocols enable data exchange between sensors, displays, memory devices, and IoT communication modules. Because embedded systems often operate in real-time environments, Embedded C programs must be optimized for speed, memory efficiency, and reliability. Proper programming ensures that the system responds quickly and operates without errors.

Importance of Software in Embedded Systems

Software plays a critical role in the functioning of embedded systems. It acts as the intelligence of the system, controlling hardware components and ensuring that the device performs its intended tasks.

The main functions performed by software in embedded systems include:

- Reading data from sensors and input devices.
- Processing and analyzing collected data.
- Controlling output devices such as LEDs, displays, and motors.
- Managing communication between different hardware components.
- Enabling data transmission to external systems or IoT platforms.
- Implementing safety and control mechanisms.
- Providing real-time monitoring and automation.

Well-designed software improves system performance, reliability, and efficiency. It also makes the system easier to maintain and upgrade. In modern embedded and IoT systems, software enables automation, remote monitoring, and intelligent decision-making.



VIII. RESULT AND ANALYSIS

The **IoT-Based Fire Accident-Avoidance System in Electric Vehicles (EVs)** was developed and tested to evaluate its ability to monitor battery conditions and detect potential fire hazards in real time. The system integrates temperature sensors, voltage monitoring circuits, and smoke/gas detection sensors connected to a microcontroller. The collected sensor data is continuously transmitted to an IoT platform where it can be monitored remotely through a user interface. The experimental setup was designed to simulate different operating conditions of an electric vehicle battery to analyze the performance and reliability of the proposed system.

During normal operating conditions, the sensors continuously monitored the battery temperature, voltage levels, and surrounding environmental parameters. The collected data was successfully transmitted to the IoT dashboard without significant delay, demonstrating the system's capability for real-time monitoring. The temperature readings remained within the safe operating range of the battery, and the voltage levels were observed to be stable. This confirms that the system can effectively track the normal operational parameters of the EV battery

IX. CONCLUSION

The increasing adoption of electric vehicles has significantly contributed to sustainable transportation by reducing greenhouse gas emissions and dependence on fossil fuels. However, safety concerns related to battery failures and fire accidents remain a critical challenge in the widespread use of EVs. Issues such as battery overheating, internal short circuits, thermal runaway, and gas leakage can lead to severe fire hazards if they are not detected at an early stage. Therefore, the development of an efficient monitoring and preventive system is essential to improve the safety and reliability of electric vehicles. The proposed **IoT-Based Fire Accident-Avoidance System in Electric Vehicles** provides an intelligent solution for monitoring critical parameters that may lead to fire incidents. By integrating sensors such as temperature sensors, voltage sensors, and smoke or gas sensors with a microcontroller, the system continuously observes the condition of the EV battery and surrounding environment. The collected sensor data is processed and transmitted through an IoT platform, enabling real-time monitoring and remote access for vehicle owners or system administrators.

REFERENCES

1. S. Kang, M. Kwon, J. Y. Choi, and S. Choi, "Full-Scale Fire Testing to Assess the Risk of Battery Electric Vehicle Fires in Underground Car Parks," *Fire Technology*, vol. 61, pp. 4133–4163, 2025. ([Springer](#))
2. H. Zhang, R. Zhang, and J. Sun, "Developing Real-Time IoT-Based Public Safety Alert and Emergency Response Systems," *Scientific Reports*, vol. 15, 2025. ([Nature](#))
3. D. Kavitha and B. Sharmila, "Smart Battery Management in Electric Vehicles Using IoT, Blockchain, and Machine Learning," *Scientific Reports*, vol. 15, 2025. ([Nature](#))
4. S. Pawar, S. Mitkari, and S. Kodgire, "Battery Management System and Fire Protection in Electric Vehicles," *Journal of Control Systems and Converters*, vol. 1, no. 3, 2025. ([MAT Journals](#))
5. A. Venumadav, N. Yeshwanth, M. Venugopal, S. Shirisha, and Y. Jalajakshi, "IoT-Enabled Smart Battery Monitoring System for Electric Vehicles," *American Journal of Management and IoT Medical Computing*, vol. 4, no. 4, pp. 15–21, 2025. ([ResearchGate](#))
6. Y. Chen et al., "Study on Fire Characteristics of Lithium Battery of New Energy Vehicles in a Tunnel," *Process Safety and Environmental Protection*, vol. 186, pp. 728–737, 2024. ([ScienceDirect](#))
7. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor & Francis, *Electric Power Components and Systems*, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
8. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - *Journal of Electrical Engineering*, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
9. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, *Electrical Engineering*, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
10. S.Tamilselvi, R.Prakash, C.Nagarajan, "Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" *Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering*, DOI10.1007/s40998-025-00917-z,2025



11. S.Tamilselvi, R.Prakash, C.Nagarajan, “ Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance” *Electric Power Systems Research* 253 (2026) 112428, doi.org/10.1016/j.epr.2025.112428
12. S.Thirunavukkarasu, C. Nagarajan, 2024, “Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller,” *Journal of Electrical Engineering And Technology*, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
13. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- ‘Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model’- *Acta Electrotechnica et Informatica Journal* , Vol.13 (2), pp.18-31, April-June.2013, DOI: 10.2478/aei-2013-0025.
14. C.Nagarajan and M.Madheswaran - ‘DSP Based Fuzzy Controller for Series Parallel Resonant converter’- Springer, *Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
15. C.Nagarajan and M.Madheswaran - ‘Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis’- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
16. C.Nagarajan and M.Madheswaran, “Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation” has been presented in ICTES’08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007
17. Suganthi Mullainathan, Ramesh Natarajan, “An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques”, *Revista Materia (Rio J.)* Vol. 30, 2025, DOI: <https://doi.org/10.1590/1517-7076-RMAT-2024-0721>
18. M Suganthi, N Ramesh, “Treatment of water using natural zeolite as membrane filter”, *Journal of Environmental Protection and Ecology*, Volume 23, Issue 2, pp: 520-530,2022
19. Y. Zhang et al., “Advances and Perspectives in Fire Safety of Lithium-Ion Battery Energy Storage Systems,” *Energy Storage and Transportation*, vol. 24, 2025. ([ScienceDirect](https://www.sciencedirect.com))
20. J. Yang, “A Physics-Aware Attention LSTM Autoencoder for Early Fault Diagnosis of Battery Systems,” *arXiv Preprint*, 2025. ([arXiv](https://arxiv.org))
21. S. Kang, H. Tu, and H. Fang, “BattBee: Early Detection of Thermal Runaway Triggered by Internal Short Circuits in Lithium-Ion Batteries,” *arXiv Preprint*, 2025. ([arXiv](https://arxiv.org))
22. Y. Liu et al., “Enhancing the Safety and Reliability of Electric Vehicles through Effective Battery Fault Diagnosis: A Systematic Review,” *Computer & Electrical Engineering*, vol. 129, 2026. ([ScienceDirect](https://www.sciencedirect.com))
23. Kiran, A., Rubini, P., & Kumar, S. S. (2025). Comprehensive review of privacy, utility and fairness offered by synthetic data. *IEEE Access*.
24. Gopinathan, V. R. (2024). Real-Time Financial Risk Intelligence Using Secure-by-Design AI in SAP-Enabled Cloud Digital Banking. *International Journal of Computer Technology and Electronics Communication*, 7(6), 9837-9845.
25. Udayakumar, R., Elankavi, R., Vimal, R., & Sugumar, R. (2023). Improved Particle Swarm Optimization with Deep Learning-Based Municipal Solid Waste Management in Smart Cities. *Environmental & Social Management Journal*, 17(4).
26. Anand, L. (2023). An Intelligent AI and ML-Driven Cloud Security Framework for Financial Workflows and Wastewater Analytics. *International Journal of Humanities and Information Technology*, 5(02), 87-94.
27. Soundappan, S. J. (2020). Big Data Analytics in Healthcare: Applications for Pandemic Forecasting. *International Journal of Advanced Research in Computer Science & Technology*, 3(1), 2248-2253.
28. Rajasekar, M. (2024). Real-Time Predictive DevOps Intelligence for Risk-Aware Digital Business Processes in Cloud and SAP Ecosystems. *International Journal of Advanced Research in Computer Science & Technology*, 7(4), 10713-10718.
29. Poornima, G., & Anand, L. (2024, May). Novel AI Multimodal Approach for Combating Against Pulmonary Carcinoma. In *2024 5th International Conference for Emerging Technology (INCET)* (pp. 1-6). IEEE.
30. Prabha, P. S., & Rengarajan, A. (2025). Adaptive Cloud Resource Allocation Using Attention-Driven Deep Reinforcement Learning. *Engineering, Technology & Applied Science Research*, 15(6), 29334-29340.
31. Jagadeesh, S., & Sugumar, R. (2017). A Comparative study on Artificial Bee Colony with modified ABC algorithm. *European Journal of Applied Sciences*, 9(5), 243-248.
32. Varma, K. K., & Anand, L. (2025, March). Deep Learning Driven Proactive Auto Scaler for High-Quality Cloud Services. In *International Conference on Computing and Communication Systems for Industrial Applications* (pp. 329-338). Singapore: Springer Nature Singapore.
33. Kumar, S. A., & Anand, L. (2025). A Novel EEG-Based Deep Learning Framework for Enhancing Communication in Locked-In Syndrome Using P300 Speller and Attention Mechanisms. *KSII TRANSACTIONS ON INTERNET AND INFORMATION SYSTEMS*, 19(11), 3841-3855.



34. Poornima, G., & Anand, L. (2025). Medical image fusion model using CT and MRI images based on dual scale weighted fusion based residual attention network with encoder-decoder architecture. *Biomedical Signal Processing and Control*, 108, 107932.
35. Archana, R., & Anand, L. (2025). Residual u-net with Self-Attention based deep convolutional adaptive capsule network for liver cancer segmentation and classification. *Biomedical Signal Processing and Control*, 105, 107665.
- Kumar, S. A., & Anand, L. (2025). A Novel EEG-Based Deep Learning Framework for Enhancing Communication in Locked-In Syndrome Using P300 Speller and Attention Mechanisms. *KSII Transactions on Internet and Information Systems*, 19(11), 3841-3855.
36. Rengarajan, A. (2025). Cloud-Based AI-Driven Threat Detection Framework for Smart Grid Cybersecurity. *International Journal of Future Innovative Science and Technology*, 8(6), 16065.
37. Murugeswari, B., Sudharson, K., Panimalar, S. P., Shanmugapriya, M., & Abinaya, M. (2020). SAFE–Secure Authentication in Federated Environment using CEG Key code.
38. Raj A. A., & Sugumar, R. (2023). Early Detection of COVID-19 with Impact on Cardiovascular Complications using CNN Utilising Pre-Processed Chest X-Ray Images. *2023 International Conference on Applied Intelligence and Sustainable Computing (ICAISC)*, IEEE.
39. Jagadeesh, S., & Sugumar, R. (2017). A Comparative study on Artificial Bee Colony with modified ABC algorithm. *European Journal of Applied Sciences*, 9(5), 243-248.
40. Selvi, G. V., Anbarasan, A. B., Murthy, B. A., & Prabavathy, S. (2023). An Application Oriented Integrated Unequal Clustering Algorithm for Wireless Sensor Network. In *Underwater Vehicle Control and Communication Systems Based on Machine Learning Techniques* (pp. 140-154). CRC Press.
41. Sruthi, R. S., Ananya, S., & Murugeswari, B. (2010). Web Based Virtual Control System Laboratory and On-Line Temperature Control of Electrophoresis Equipment using LabVIEW. *International Journal of Computer Applications*, 975, 8887.
42. Vimal Raja, G. (2021). Mining Customer Sentiments from Financial Feedback and Reviews using Data Mining Algorithms. *International Journal of Innovative Research in Computer and Communication Engineering*, 9(12), 14705-14710.
43. MATHEW, A. R. (2025). Neurosecurity and Brain-Computer Interfaces.
44. Soundappan, S. J. (2024). AI-Driven Customer Intelligence in Enterprise Lakehouse Systems Sentiment Mining Governance-Aware Analytics and Real-Time Data Synchronization. *International Journal of Advanced Engineering Science and Information Technology (IJAESIT)*, 7(5), 14905.
45. Mathew, A. (2025). Human–AI Collaboration in Security Operations: Measuring Alert Trust, Automation Bias, and Analyst Upskilling in AI-Augmented SOC Environments. *International Journal of Computer Technology and Electronics Communication*, 8(5), 11375-11380.
46. Soundappan, S. J. (2022). AI-Based Fault Detection and Isolation for Reliability in Modern Power Systems. *International Journal of Research Publications in Engineering, Technology and Management (IJRPETM)*, 5(4), 7106-7110.
47. Poornima, G., & Anand, L. (2024, April). Effective Machine Learning Methods for the Detection of Pulmonary Carcinoma. In *2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM)* (pp. 1-7). IEEE.
- Garg, V. K., Soundappan, S. J., & Kaur, E. M. (2020). Enhancement in intrusion detection system for WLAN using genetic algorithms. *South Asian Research Journal of Engineering and Technology*, 2(6), 62–64.
48. Rengarajan, A., Jayakumar, C., & Sugumar, R. (2012). Optimization Of Recent Attacks Using Internet Protocol. *National Journal of System and Information Technology*, 5(1), 8.
49. Mathew, A. (2024). AI TRiSM: Trust, Risk, and Security Management in Cybersecurity. *Cybersecurity*, 4(3), 84-90.
50. Mathew, A. (2025). Deep seek vs. ChatGPT: A deep dive into AI Language mastery. *Int J Multidisciplinary Res*, 7(1), 1-5.