AI-BASED IOT ENABLED SELF HEALING SMARTELECTRICAL FAULT PREDICTION AND RECOVERY SYSTEM USING RASPBERRY PI

[1]Shreeleka B Jagadale, [2]Dr. Meghana Kulkarni, [3]Mr.Prashant Dhope
[1]Student of M.Tech, [2]Professor, [3]Assistant Professor [1]
Department of Electronics and Communication Engineering,
Visvesvaraya Technological University, Belagavi, India.

Abstract The embedded AI system in this project has the ability to heal and recover on its own. The system is capable of automatically identifying and resolving errors in a real-time setting. The fire sensor is here used to detect the flames or fire, while the DHT11 sensor is used here to monitor humidity and temperature sensor measures the ambient temperature and humidity. The PZEM-004T sensor monitors the voltage, current, power, and energy. All sensors like PZEM004T, DHT11, and fire sensor connected to the Raspberry Pi acts as the input devices. The Raspberry Pi receives sensor data, and processes it and it keep on monitor. The sensors are used to monitor the electrical parameters then it transmits this data to the Internet of Things platform, where it can be analyzed and gives the output in graphical form. The system also detects errors and it will remove malfunctions using machine learning algorithm techniques like Random Forest. The system starts the recovery process on its own as soon as a problem arises. This may involve restarting certain modules, fixing malfunctioning modules, or sending messages to users via IoT services.

Keywords—AI Based embedded system**,** Machine Learning Algorithm**,** Predictive maintainance, Self-Healing, IoT

I.INTRODUCTION

The Embedded systems play an important role in a wide range of applied fields, including industrial automation processes, medical field, home appliances, and intelligent monitoring systems. Embedded systems are some more automated than recent developments in the field of edge computing, IoT field, and artificial intelligence field. Number of issues arise from both hardware components and interacts with the environment can impede their operation. Most of the time embedded systems are used in everywhere from home appliances to medical equipment and wearables, industrial automation, and monitoring systems. Now in recent advancements in edge computing, IoT, and AI have given embedded systems they have capability they didn't have before, giving them some degree of independence. And they have an issue that from their hardware, software, and interaction with the environment. In order to detect fault and defective patterns, and future damages, and start repair processes, such a system uses algorithm real-time IoT concept.

II.LITERATURE SURVEY

[1] Seba et al. in 2024, shows that predictive maintenance using AI it should be a game-changer for IoT environments. [2] Papaioannou et al. (2024**)** introduced LP-OPTIMA, a framework for prescriptive maintenance and resource optimization in low-power embedded systems. [3] Dini et al. (2024**)** presented a review of artificial intelligence models and tools now used in Industrial Internet of Things applications. They emphasized the role of machine learning algorithm and deep learning in predictive maintenance, process optimization, then fault diagnosis, cybersecurity, and control of industrial processes. [4] Prakash et al. (2024) proposed a machine learning-based framework for anomaly detection and security in IoT networks. The system analyzed device behavior patterns to detect abnormal activities and improve network reliability. [5] Researchers Ortiz-Garces and their group found how faults are in IoT networks. They used some kind of computer system i.e Edge-AI it processes information same from where it is collected.

III.RESEARCH METHODOLOGY

The proposed Self-Healing Embedded System is integration of Embedded System, Internet of Things (IoT), and Machine Learning technologies to achieve intelligent fault prediction and automatic recovery. The system continuously take data from multiple sensors connected to the raspberry pi controller and monitors the health status of the embedded device in real time. The collected sensors information is transmitted to an IoT cloud platform for visualization, storage, and remote access.

A. Self-Healing mechanism

Whenever a fault is predicted, the self-healing module automatically starts correct actions such as restarting affected subsystem, fault modules, switching to backup resources, and generating alert notifications to the user**.**

B. Machine Learning Algorithm

AI-Based Usage pattern learning using CNN-LSTM model will be integrated to learn the normal electrical behaviour of connected appliances from voltage, current, power, energy and temperature data. The CNN will extract electrical usage features, while the LSTM will analyze long term temporal patterns to identify abnormal operating conditions, overloads and potential faults with higher accuracy than conventional threshold-based techniques.

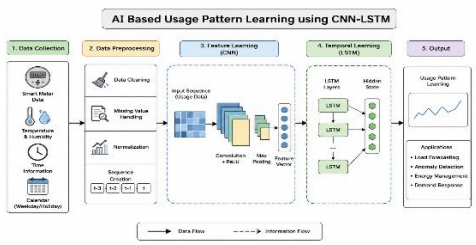

Figure: AI Based Usage Pattern Learning CNN-LSTM

C. Intelligent Over Usage Detection and Predictive Alerts

Instead of using only fixed threshold, the proposed AI model will detect abnormal energy consumption, prolonged appliance operation, unusual operating hours and changing usage patterns by comparing real-time data with previously learned behaviour. The system will generate early warnings for excessive energy usage, possible equipment deterioration and impending overloads before critical failures occur.

D. Cloud based monitoring using MQTT, AWS and a Custom Mobile Application

The MQTT-Based communication framework integrated with AWS Cloud. A custom Anroid application will be developed to provide real-time monitoring, historical data visualization, AI-generated alerts, energy consumption analytics, fault notification and remote c control of connected electrical loads from anywhere.

IV.RESULTS AND DISCUSSION

A.Overload Detected

When board is switched on, we have given the load 100W and 200W, it will take it as overload because our load range is 400W so detect the over voltage drives suddenly PZEM004T sensor will sends the signal to controller and controller sends alert message so relay will disconnect the load immediately.

Figure1: output when overload detected

B.Output when Fire Detected

The flame brought near to sensor, it will detect the flame and convey a message signal to the controller and controller immediately takes action. The controller passes the message and turns off the relay. Also get the text message with the status of the system fault which is sent simultaneously**.**

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Figure. 2. Output when fire detected

C.Output when over temperature detected

The DHT11 sensor determines whether a temperature input is above or below the limit by comparing the reading to a predetermined threshold. The system detects an overtemperature condition if the measured temperature surpasses the predetermined threshold. The controller then receives a signal from the sensor, verifying the situation and sending an alert message to the authorized user.

Figure3: output when over temperature detected

V.CONCLUSION

Internet of Things (IoT), and Embedded System technologies to develop an intelligent and autonomous fault management solution. The system continuously monitors critical electrical and environmental parameters using sensors interfaced with Raspberry Pi and analyzes the collected data through a machine learning algorithm. The proposed self-healing embedded system successfully demonstrates an intelligent approach for automatic fault detection and recovery in electrical systems. By continuously monitoring electrical parameters and environmental conditions, the system can quickly identify faults such as overcurrent, overheating, and fire hazards. Upon detection, it isolates the faulty load and maintains safe operation without requiring human intervention. The integration of sensors, relay modules, LCD display, buzzer alerts, and GSM communication enhances the system's effectiveness by providing real-time monitoring, instant alerts, and remote notifications. This improves overall system safety, reliability, and continuity.

REFERENCES

[1] Institute of Electrical and Electronics Engineers, "IEEE Standard for Artificial Intelligence and Machine Learning Applications in Industrial Systems," IEEE Standards Association, 2024.
[2] Papaioannou et al., "LP-OPTIMA: A Lightweight Prescriptive Maintenance Framework for Embedded IoT Systems," Sensors, vol. 24, no. 7, pp. 1–22, 2024.
[3] Dini et al., "Artificial Intelligence Models and Tools for Industrial Internet of Things Applications," Electronics, vol. 13, no. 12, pp. 1–30, 2024.
[4] Prakash et al., "Machine Learning-Based Anomaly Detection and Security Enhancement in IoT Networks," Discover Internet of Things, Springer, 2024.
[5] Jammalamadaka et al., "Fault-Tolerant IoT Architecture for Predictive Maintenance and Recovery," Future Internet, vol. 14, no. 2, pp. 1–20, 2025.
[6] Ortiz-Garces et al., "Edge-AI Based Fault Detection for Smart IoT Networks Using Raspberry Pi," Discover Internet of Things, Springer, 2025.
[7] Varalakshmi and Kumar, "Predictive Maintenance in Industrial IoT Using Deep Reinforcement Learning and Ensemble Learning Techniques," Scientific Reports, vol. 15, 2025.
[8] Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, A. Géron, O'Reilly Media, 2023.