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AI – driven Hybrid lightning prediction system using LORA IOT

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Abstract

This paper proposes a smart and efficient lightning prediction system that combines Artificial Intelligence with LoRa-based Internet of Things technology. Lightning strikes are a serious concern, especially in rural areas where proper early warning systems are not available.

In this system, environmental data such as temperature, humidity, rainfall, and atmospheric variations are continuously collected using sensors. The collected data is transmitted over long distances using LoRa communication and analyzed using an LSTM-based deep learning model to identify patterns and predict lightning events in advance.Based on the prediction results, alerts are generated through different methods such as SMS, alarms, and mobile notifications. The system provides improved prediction accuracy and reduces false alerts compared to traditional methods. It is also cost-effective and suitable for deployment in remote locations.

Keywords: LoRa IoT, LSTM Model ,Weather Monitoring System, Time- Series Analysis, Hybrid Prediction System.

1. Introduction

Lightning is one of the most dangerous natural phenomena, causing loss of life and damage to property, particularly in rural areas where access to advanced warning systems is limited. Most of the existing systems only monitor current weather conditions and depend on fixed threshold values, which makes it difficult to predict lightning in advance. To overcome these limitations, this work presents a hybrid system that combines IoT-based sensing devices, long-range communication using LoRa, and deep learning techniques. The system continuously collects environmental data and uses intelligent analysis to forecast lightning events before they occur. This approach helps in providing early warnings and improving safety in vulnerable regions.

2. Literature Review

Many researchers have worked on weather monitoring and lightning prediction using different technologies. Environmental parameters such as temperature, humidity, atmospheric pressure, and wind speed are commonly used to study weather behavior and detect storm conditions. Machine learning techniques have been widely applied to analyze weather data and identify patterns related to lightning occurrences. Models such as regression methods and neural networks have shown good performance in predicting weather-related events. In recent years, IoT-based systems have gained importance due to their ability to collect real- time data using sensors and transmit it over long distances. Technologies like NodeMCU and LoRa modules are especially useful in remote areas because of their low cost and low power consumption. Some systems also include alert mechanisms such as SMS and web-based notifications to inform users about possible risks. These studies highlight the importance of integrating sensing, communication, and intelligent data analysis to build an effective lightning prediction system.

3.Proposed System

The proposed system aims to develop a reliable and intelligent solution for predicting lightning and providing early warnings. It mainly focuses on rural areas where traditional systems are not effective.The system continuously monitors environmental conditions such as temperature, humidity, and rainfall using IoT sensors connected to a microcontroller. The collected data is transmitted using LoRa technology, which allows long-distance communication with low power usage.

An LSTM-based machine learning model is used to analyze the collected time-series data and estimate the possibility of lightning occurrence. If the predicted value crosses a certain limit, the system automatically generates alerts through different communication methods. This approach improves accuracy and ensures timely warnings.

3.1System Architecture

The system consists of five major components:

Environmental Sensing Unit

Various sensors are used to measure atmospheric conditions such as temperature, humidity, pressure, wind speed, and electrical changes in the atmosphere. A microcontroller collects and performs initial processing of this data.

LoRa Communication Module

LoRa technology is employed to transmit sensor data over long distances while consuming very little power. This makes it ideal for areas with limited or no internet connectivity.

Data Processing Unit

The received data is stored on a server or cloud platform. Before analysis, the data undergoes preprocessing steps such as cleaning, normalization, and formatting for time-series modeling.

LSTM Prediction Model

An LSTM neural network is trained on historical weather data to identify patterns associated with lightning events. The model predicts the likelihood of lightning in advance rather than relying solely on current conditions.

Alert System

When the predicted risk crosses a set threshold, warning messages are automatically sent through SMS, alarms, or other communication channels.

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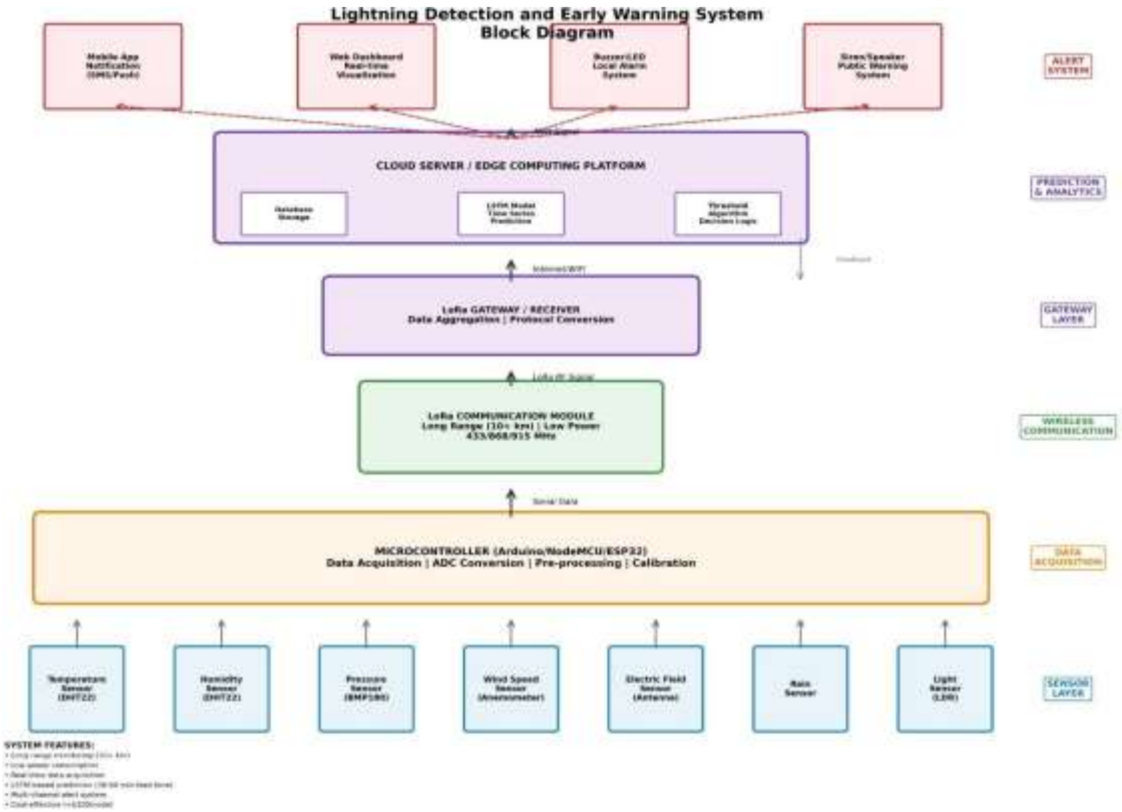

Fig : Block diagram of proposed system

4.Implementation (hardware + LSTM):

4.1 Hardware Implementation

ESP32 Microcontroller The ESP32 microcontroller acts as the central processing unit of the system. It collects data from connected sensors, performs initial preprocessing, and transmits the information using the LoRa transceiver. Its low power consumption and built-in communication features make it suitable for IoT-based environmental monitoring.

Temperature and Humidity Sensor (DHT11 / DHT22) The DHT11 (or DHT22) sensor is used to measure atmospheric temperature and humidity levels. These parameters play a crucial role in identifying thunderstorm conditions and improving the accuracy of lightning prediction using time-series analysis.

Rain Sensor The YL-83 rain sensor module detects rainfall intensity by sensing water droplets on its conductive plate. The collected precipitation data helps in identifying storm activity and enhances environmental condition monitoring.

Light Sensor (LDR / BH1750) An LDR (Light Dependent Resistor) or BH1750 digital light sensor is used to measure ambient light intensity. The sensor supports atmospheric analysis and can also assist in adaptive lighting control for hybrid smart lighting applications

LoRa Transceiver (SX1278 Module) The SX1278 LoRa transceiver module enables long-range and low-power wireless communication. It transmits sensor data from the ESP32 to the receiving unit over several kilometers, making the system suitable for rural deployments.

LoRa Receiver (SX1278 LoRa Receiver Module) The LoRa receiver module collects transmitted environmental data from sensor nodes. It forwards the received data to the central server or processing system for storage and LSTM-based prediction analysis.

4.2 LSTM-Based Prediction Model

In this system, an LSTM model is used to process sequential environmental data and predict lightning events. Since weather conditions change over time, it is important to use a model that can understand time-based patterns.

The collected sensor data is arranged in sequences and provided as input to the model. The LSTM network processes this data and learns important features that indicate possible lightning conditions.

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The model uses internal mechanisms to decide which information should be remembered and which should be ignored. Based on this learning process, it predicts whether lightning is likely to occur. The model is trained using historical data and evaluated using performance measures such as accuracy and precision.

Table1: Rainfall in all India and its departure from normal for Monsoon session from 1901-2021

Year	**Jun (mm)**	**Jul (mm)**	**Aug (mm)**	**Sep (mm)**	**Jun–Sep Total (mm)**
1901	112.3	241.5	268.9	126.1	748.8
1902	109.0	283.2	202.1	201.0	795.2
1903	117.0	292.0	272.0	200.1	881.1
1904	164.4	261.4	204.1	130.6	760.4

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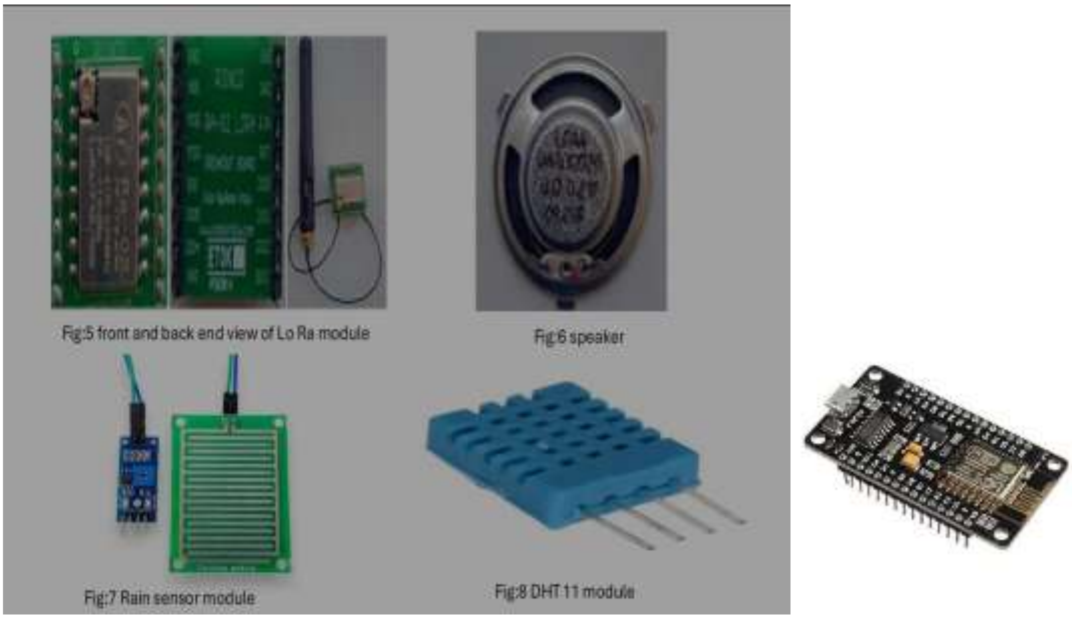

Fig : NodeMCU , LoRa Module , DHT11 , Rain Sensor , Speaker

4.3 Alert Transmission via SMS

The proposed system combines IoT hardware, an LSTM model, and SMS alerts for early lightning prediction. Atmospheric data such as rainfall, temperature, and humidity are collected using the NodeMCU (ESP8266) and processed as time-series input to the LSTM network. When the predicted lightning probability exceeds a set threshold, an alert message is sent to users through a GSM module like the SIM800L GSM Module, ensuring timely warning even in remote areas.

5 . Result

The developed system is capable of improving lightning prediction and providing reliable communication in rural areas. The use of an LSTM-based model allows the system to generate early warnings with better accuracy compared to traditional approaches.

LoRa communication ensures stable data transmission over long distances while consuming very little power. The use of multiple alert methods such as SMS and alarms helps in delivering timely warnings to users. Overall, the system offers a practical and efficient solution for reducing risks associated with lightning.

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Fig : Performance analysis of the Proposed AI-Driven Lightning Prediction System

6. Conclusion

This paper presents a smart lightning prediction system that combines IoT technology, LoRa communication, and an LSTM-based model. By analyzing environmental data over time, the system can predict lightning events and provide early warnings. The use of low-power communication and real-time monitoring makes the system suitable for rural areas. The integration of intelligent prediction and alert mechanisms improves safety and helps in reducing damage caused by lightning. In the future, the system can be enhanced by using advanced machine learning techniques and larger datasets to further improve prediction accuracy..

Authors Contribution

P. Naga Sudhakar supervised the overall research work and provided technical guidance for system design and implementation. G.V. Pallavi contributed to system design, data collection, and preparation of the research manuscript. D. Gagana and B. Sai Divya worked on the hardware implementation including NodeMCU, sensors, and LoRa communication setup. C. Venkatesh contributed to the development and integration of the LSTM-based prediction model. B. Hemanth assisted in data analysis, system testing, and documentation of the results. All authors reviewed and approved the final manuscript.

Conflicts Of Interest

The Authors declare no conflicts of interest regarding the publication of the paper.

References

Roopa M L, Varsharani Prathima S M and Rashmi H C :IoT based Real Time Weather Predication System using NODEMCU 12-E ESP266 and Lab View. *International Journal of Engineering Research & Technology (IJERT)* (Roopa M L, 2021)

G .Abhishek Hariharan, K.K. Vignajeth, R. Jijendiran , T.R.V. Anandharajan, Kushmita, : Weather Monitoring Using Artificial Intelligence .In: *2nd International Conference on Computational Intelligence (CINE)*, pp. 106-111,2016.

Gopinath N, Vinodh S, Prashanth P, Jayasuriya A and Deasione S:Weather Prediction using Machine Learning and IOT. *International Journal of Engineering and Advanced Technology (IJEAT) 9,1-5(2020).*

G. Pradeep Reddy and Y. V. Pavan Kumar : Demystifying LoRa Wireless Technology for IoT Applications: Concept to Experiment. In: *4th International Symposium on Advanced Electrical and Communication Technologies (ISAECT),pp.1-6,2021*
10.1109/ISAECT53699.2021.9668500

Faisel Illiya, Keshav Mohan Mohan , Shibu K. Mani and Pradeepkumar A.P, " Lightning Risk in India Challenges in Disaster Compensation", Economic and Political Weekly · Vol:23,pp.23-27, June 2014.

Lalit Kumar, Mahesh Kamthe, Namrata Mohakud , Pankaj Sharma and Kamlesh Singh Yadav.: Text to Speech using Arduino. International Journal of Engineering Science and Computing (IJESC), 11,27559-27562(2021)

Banibrata Ghosh, Antara Ghosh and Debangshu De : A Scheme For Local Lightning Detection And Prediction System. In: *Proceedings of 2020 IEEE Applied Signal Processing Confe*