Journal of Applied Artificial Intelligence
https://jaai.sabapub.com
ISSN: 2709-5908

2023 Volume 4, Issue 1: 45–56

DOI: https://doi.org/10.48185/jaai.v4i1.727

Development of a Lightning Prediction Model Using Machine Learning Algorithm: Survey

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Received: 07.03.2023 • Accepted: 20.07.2023 • Published: 07.10.2023 • Final Version: 07.10.2023

Abstract: This research is aimed at preventing broadcast equipment from lightning damage. Inview of the location in which my broadcast outfit is located (located in a valley; some few meters above sea level in the Confluence of Lokoja Kogi State Nigeria). Several improvements of earthing and installation of lightning arresting facilities, there has not been significant change protecting broadcast equipment from lightning. The solution I proffered is to isolate all electrical connection from equipment. Lightning as a natural phenomenon is very unpredictive and destructive which can occur during transmission. How do we know the day and time distructive lightning will come? The answer is to develop a lightning prediction system that is accurate. When lightning lead time is known, personnel on duty will be alerted to isolate all broadcast equipment from the mains and central earth connection. Since the lightning prediction system has to be localized. Deployment of machine learning algorithm is most appropriate. The use of ten (10) years Weather Numerical Values(2012-2022) such as rainfall, atmospheric pressure, relative humidity, temperature and lightning records which are gotten from Nigeria Meteorological Agency (NIMET), Lokoja Area Office, Kogi State. This parametization are factors that are used to work on the lightning forecast system as lightning will occur at their certain threshold values. The model is intended to be deployed on a web application. Prediction model can be localized to support Numerical Weather Prediction in any environment in Nigeria.

Keywords: Thunderstorm, Parameterization, Electrification, Lightning Prediction, Numerical Weather prediction

1. Introduction

Lightning strike is the direct discharge of an electrical charge between the atmosphere and the object of the earth [1]. Most lightning occurs within the clouds. During a storm, colliding particles of rain, ice, or snow inside storm clouds increase the imbalance between storm clouds and the ground, and often negatively charge the lower reaches of storm clouds. Objects on the ground, like steeples, trees, and the Earth itself, become positively charged—creating an imbalance that nature seeks to remedy by passing current between the two charges. Lightning is extremely hot; a flash can heat the air around it to temperatures five times hotter than the sun's surface. This heat causes surrounding air to rapidly expand and vibrate, which creates the pealing thunder we hear a short time after seeing a lightning flash. Lightning occurs in the form of plasma and sound in the form of thunder.

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Prime FM Lokoja has been suffering the menace of lightning attacks since its establishment. This has led to the loss of expensive equipment which worth millions of dollars [2]. Federal Radio Corporation of Nigeria(FRCN) has been privatized which means the station fends for resources to run the station. If lightning damage continues, a time will come that no station would be able to transmit. At present, most of the stations cannot make a straight ten hours transmission in a day. This is due to damage to equipment by lightning stroke and partial damage by lightning stroke which result to inability to transmit for 10 hours in a day. The overall effects are loss of listenership and low patronage of the station resulting to very low revenue [3]. As can be seen in Table 1.0

Table 1. Status and Cost of Equipment Affected by Lightning

Affected Equipment	Status	Cost
2 No Console (Dig)	Bad	15,000,000
Audio Processor	**Bad**	1,000,000
TVRO	**Bad**	100,000
Yamaha Mixer	Bad	500,000
Transmitter A	**Bad**	25,000,000
TX Power Module	Bad	2,500,000
7KVA UPS	Bad	500,000
Computers	Bad	500,000
250KVA AVR Panel	Bad	500,000
300KVA Voltage Reg	Bad	500,000
Network Switch	Bad	200,000
FM Monitor	Bad	150,000
Repair of 6 A/C		300,000
Antenna Switch	Bad	400,000
Audio Amplifier	Bad	250,000
Desktop Phone	Bad	25,000
Console D-75	Bad	500,000
Total		**53,925,000**

In view of the above, this challenge has necessitated the finding of a lasting solution through the development of a lightning prediction system that would alert personnel of the time lightning with higher intensity would occur so that the engineering personnel on duty would take all necessary preventive actions to save broadcast equipment from lightning stroke [4]. This research would be done to predict lightning before it happens thereby enabling quick preventive mechanism to be adopted before lightning strikes. Control measures such as emergency shutdown and isolation from the mains and exit can be made.

1.1. Statement of the Problem

Broadcast equipment worth billions of naira are being damaged by lightning strikes [4]. In 2008 lightning strike damaged two (2) newly installed consoles worth Twenty Million naira then. In 2010, lightning damage a Transmitter that worth Fifty Million naira which made the station to be off-air for almost two (2) months. A presenter at the console was injured during the lightning and strike this had an effect on the on-air time. This is really affecting the transmission time as well as the revenue generated. Re-installation of lighting conductor was awarded yet almost no was recorded although the lightning strike destruction was minimized a little. The lightning conductor installed has not yielded appreciable result. No FRCN station or broadcast station in Lokoja or Nigeria has worked on lightning predicting model or lightning alerting model to the best of my knowledge.

1.2. Aim and Objectives of the Study

The aim of the research is to develop a model to predict the occurrence of lightning strikes in Lokoja Metropolis to safeguard broadcast equipment.

The objectives are to:

I. curate standardized dataset for lightning prediction,
II. design a machine learning framework for lightning prediction,
III. create a machine learning model to predict lightning occurrences, and
IV. evaluate the model created in (iii).
V. deploy the model in web application.

1.3. Significance of the Study

This study would be a great advantage to Lokoja and its environs. This model could be deployed and made use of in other organization that is making use of electronic gadgets like computers and its accessories to protect them from lightning stroke damage. The model can also be adapted to work in other FRCN FM stations where lightning strikes are destroying broadcast equipment. The use of weather parameters is most appropriate [5].

1.4. Limitation of the Study

Despite atmospheric parameters such as rainfall, windspeed, atmospheric pressure, temperature and lightning are used in the designed, it can only predict lightning strikes. The model cannot stop lightning occurrence. The model performs better in a remote and limited area. Applicable to Lokoja metropolis, would work for other locations only when dataset is expanded and remodeled.

1.5. Definition of Terms

- **Lightning:** the occurrence of a natural electrical discharge of very short and high voltage between a cloud and the ground or within a cloud, accompanied by a bright flash and typically also thunder [6].
- **Lightning Prediction:** a type of lightning detection equipment that determines when atmospheric conditions likely to produce lightning strikes and sounds an alarm [7].
- **Numerical Weather Prediction:** This is the use of weather parameterization for lightning forecast, always in numerical formats [8].
- **Lead Time:** This is the skill of lightning forecast statistically which ranges from minutes to days depending on the types of forecast time of year and region [9].
- **Machine Learning (ML):** It is a branch of AI that enables software applications become more accurate at predicting outcomes without being explicitly programmed to do so [8].

2. Literature Review

Using machine learning techniques in Switzerland, [5] reported on nowcasting lightning probability from easily available meteorology variables. They built a four-parameter model based on four commonly used weather numerical parameters, comprising atmospheric pressure, air temperature, relative humidity, and wind speed. The produced signal is then confirmed using lightning tracking mechanisms. They were subjected to the random forest machine learning algorithm. Based on the evaluation's conclusions, its lead time has been between 0 and 10 minutes.

[9] focused on slashing machine learning algorithms for benchmarking building performance estimates. The book presents various machine learning concepts that will assist make systems which are more reliable and efficient. Using an artificial neural network (ANN), degree-day-based ordinary least square regression, and extreme gradient boosting (XG Boost), he demonstrates the growth of an energy model. As more than just a result, this was revealed that (XG Boost) yields highly specific energy models.

[10] presented a paper on the modeling of lightning strike events and its correlation with power outages. A particular region, a coastal distribution network in south-west Nigeria, was designated as case study, and 84 months of cloud-to-ground lightning statistics from NIMET being utilized. A 36-month record of lightning-related power failures was gathered from a specific substation. Dataset was investigated for power outages and lightning activities at voltage levels of 11 KV, 33 KV, and 132 KV. In accordance with the observations, there is a connection between lightning strikes and power outages in the distribution network.

Current estimates of lightning-related deaths and injuries in around world were published by [2]. With a total loss of USD 110,982 and 2884 impacted individuals, 2019 had seen the worst number of deaths. In Nepal, there really are 1.77 deaths by extreme lightning per million people year. The most fatality density is now in Bhaktapur, which really is 0.067. He stressed that spike in lightning-related deaths in recent years is the result of increased internet use and other information-gathering approaches, that has resulted to reports reaching agencies that collect information. He highlighted that geographic distribution, population density, and economic activities are principally accountable for the high and low intensities of loss and damage.

[11] study used a convection permitting model to simulate lightning. They concentrated on the parameterization of lightning utilizing knowledge of the glacial and glacier water path to compute the total flash rate. Integrating datasets using lightning imaging sensors and transient monitors, evaluations were made with the World Lightning Location Network (WLLN) (Cloud to Ground) (Flash rate). The result reveals that there is an obvious abundance of lightning in the intertropical convergence zone.

[12] reported on lightning over but not the contrast between both the land and water. A precise CAPE x P proxy for lightning replicates the shapes, relative intensities, and timing of the diurnal cycle in lightning in addition to seasonal maps of lightning over the Northeast United States. Globally, CAPE

x P effectively identifies why flash rate densities will be diffused over land, but it unable to do so due to the significant contrast across land and ocean flash rate densities.

However according [13], lightning for Australia might be projected using multiple land-scale atmospheric variables. This paper investigated how well six statistical and machine learning classification techniques could discriminate between days containing and excluding lightning at the broad temporal and spatial scales of the latest general circulation models and reanalysis. Six sites in Australia from 2004 to 2013 were categorised using a combination of principal component analysis and logistic regression, classification and regression trees, random forests, linear discriminant analysis, quadratic discriminant analysis, and logistic lightning count. Performance on the classification assignment was measured via tenfold cross validation. The outcomes show that logistic regression was superior to other classifiers and that applying climatological values for prediction is massively inferior.

A baseline for the prediction of cloud to ground lightning in the United States was constructed by [14]. As hold for cloud to ground lightning in the United States, convective potential energy and precipitation rate product were used. This provides an easy technique for determining the threat of cloud to ground lightning by proxy computations from the output of numerical weather forecast models. Depending on the sort of forecast, this has generated a lead time of 15 days.

[15] released an article on enhancing climate with data mining knowledge discovery. The benefits and challenges of mining enormous climate datasets are presented in this paper, in addition to the potential for KDD (Knowledge Discovery by Data Mining) to discover patterns pertinent to climate. This work focuses on a complicated and dynamic analysis's beta MAPS. It is used to highlight the links between recent statistical recent results that are local and non-local. This has included contrasting and comparing the known teleconnections between the outputs of climate reanalysis and climate model..

[16] wrote about utilizing artificial intelligence to enhance real-time decision making for high impact weather. By minimizing errors, the use of AI, data science, machine learning, and data mining closes the gap between real-time prediction and numerical simulated results. This approach dramatically enhances the capacity to anticipate several high-impact weather patterns by integrating AI techniques with a physical understanding of the environment. They notably talked on projecting storm duration, severe wind, severe hail, classification of rainfall, forecasting renewable energy, and turbulence in the atmosphere.

[17] released a report on lightning activity over Bangladesh that was related to precipitation and CAPE. the assessment of the correlation between environmental variables and lightning activity over the Bangledesh land mass employing satellite-derived datasets covering 17 years. Time series Convection Available Potential Energy (CAPE) datasets were found and used as an additional variable. CAPE and precipitation product were extracted from ERA 40 reanalysed dataset while total and convective rainfall were from Tropical rainfall survey mission monthly. The impact of rainfall and CAPE on lightning activity were examined on three time scales: monthly, seasonal, and annual. The findings indicates that CAPE had the largest impact on lightning activity.

[18] issued a paper on the application of artificial intelligence to forecast storms. The University of Wisconsin created a machine learning algorithm. An area will have a 25% chance of lighting 50 minutes ahead of time according to AI.

The modeling and simulation procedures were discussed in great detail by [19], who paid close attention to the materials used, the way they were built, how they were loaded, how they were analyzed, and the results they produced. Along with its existing limitations and future challenges, lightning strike modeling is examined.

Machine learning was applied by [20] to determine the possibility of fire ignition from predictions of lightning. One of the most unpredictable components of the fire environment remains to be lightning ignitions. In light of this, this research examines datasets on lightning ignition to predict the occurrence of lightning using machine learning. It would be advantageous to establish a lightning-ignition relationship in order to construct a model that would support early warning systems planned for fire control and prevention.

Based on lightning forecasts and external conditions, a machine learning (ML) method was employed to develop a predictive model for wildfire ignition. Three different binary classifiers—a decision tree, an AdaBoost, and a Random Forest—were applied. These three generated positive results, with both ensemble approaches (Random Forest and AdaBoost) getting an out-of-sample accuracy of 78%. Over 145 lightning-ignited wildfires in various parts of Australia during 2016 were leading up using statistics from a Western Australia wildfire database. This demonstrated that the ML models successfully predicted the occurrence of an ignition when a fire was began in at minimum 71% of the cases.

For the aim of assessing earth system model error, [21] applied an interpretable machine learning approach. Modern Artificial Intelligence (A.I.) algorithms have revealed that these errors can be successfully predicted. Investigating the weaknesses in the NASA GEOS model's forecasting of the incidence of lightning, a popular Earth System Model, utilizing XGBoost classification trees and SHapley Additive exPlanations (SHAP) analysis. The model error can be adequately projected by this interpretable error prediction method, which also shows that the errors are highly correlated to convective processes and the properties of the land surface.

For a multi-source spatiotemporal lightning forecast, [22] used a deep learning system. Studying a wide range of meteorological data in-depth is necessary for accurate weather forecasting. using a lightning scenario, a deep neural network-based data-driven forecasting tool called LightNet+. Our framework's framework supports LightNet+ to foresee by mining additional data from various sources, which may be diverse in terms of space (continuous versus discrete) and time (past observations versus future simulations). Using actual climatic data from North China, we assess LightNet+. The research results indicate that: (a) LightNet+ significantly outperforms three established lightning forecasting methods; and (b) the amount of data supplied into LightNet+ enhances the predicting quality.

Based on the electric potential and the lightning potential index, [23] reported lightning forecasting in Bangladesh. In this work, lightning flashes are estimated using a diagnostic lightning parameterization that is based on simulations. In terms of determining the primary lightning activity region, the LPI based prediction did quite well. The discoveries made it significantly simpler to put in place a functioning lightning warning system to stop lightning-related hazards in Bangladesh.

[24] published a research paper on the measures they obtained using machine learning on semantically segmented high-speed lightning footage. An assessment of the reliability of a semantic segmentation system in detecting the number of individual strokes, leaders' directions, and striking points in high-speed lightning footage. The last layers of the model are retrained on lightning imagery, and the work uses a pre-trained DeepLabv3+ network, which was chosen to allow for the lowest processing needs. The network creates conceptually segmented images in which every pixel has a numerical label that is evaluated to figure out the amount of strokes. Per strike, regions of

interest are made and used to dampen noise. When tested, the system's stroke detection performance is 70.1%, its direction accuracy is 80%, and its strike point accuracy is 89.5%.

[25]'s study concentrated on the use of suitable meteorological parameters to which was before distance-based lightning. The aim of this effort is to develop a warning that will enable lightning to be foreseen in ahead and safety precautions to be taken. By employing meteorological information obtained by an unique meteorological station, this work aims to anticipate lightning incidents one hour in advance. Ten atmospheric variables collectively make up the datasets used in this study. This is accomplished by looking in three groups while recording the lengths [DG-1, DG-2, DG-3] -2km, 2-4km, and 4-6km from the station, respectively. For each data group, the probability of lighting was calculated using the sequential forward selection (SFS) procedure. With a distance of 0–2 km, DG-1 generated

[26] developed a framework, a modular structure, and integrated warning approaches into the system to detect lightning a few minutes before it impacts. The system is capable to identify, detect, extrapolate, and distribute lightning and warning services in regions where lightning danger may occur. These products not only automatically reflect the changing trend of the lightning activity area but also the likelihood of lightning in significant locations. The system gives parameter interfaces and human-machine interaction capabilities. It can be used in many circumstances and locations.

A research by [27] outlined the use of a machine learning algorithm to extract different electrical field and energy characteristics from air gaps in the range of 5mm–40mm when positive polarity lightning impulses were applied as the stimuli. These features, as well as gap lengths, are taken into consideration when developing the model. With the help of the features, a machine learning method based on Gaussian Process Regression (GPR) was trained to create the model. With the help of measured experimental data, the model's findings are validated. The forecast model's accuracy is established by a comprehensive comparison of the projected data with the observed data.

According to [28], an adaptive neural fuzzy inference system was used to forecast the value of the lightning density tower. Using Adaptive Neuro-Fuzzy Inference, this research seeks to calculate the value of the transmission tower lightning density (ANFIS). One of the inevitable causes of transmission problems and other natural events is lightning. The region of South Sulawesi is close to the equator and has a lot of lightning activity. Owing to this circumstance, electrical system lines are more vulnerable to disturbances from lightning, particularly in high-voltage aircraft and substations. Based on the type of membership function, an Adaptive Neuro-Fuzzy Inference System (ANFIS) will show the Root Mean Square Error (RMSE). Based on the ANFIS predictions, the value of the lightning strike density index can later be obtained. Mainly three metes of lightning density can be used to categorize the value calculation system of structural lightning strikes in the South Sulawesi region of the Sungguminasa-Tallasa route (Nd). The results of the calculation system were validated between manual calculations and ANFIS with an average percentage of 0.0554% for the value of structural lightning strike in the South Sulawesi region.

In a lightning-located system that was put into place, [29] applied artificial neural networks. A lightning locating system employs a variety of bases, such as the time difference of arrival (TDOA) approach, to identify lightning strikes (LLS). To correctly locate a lightning strike using this method, at least four measuring sensors are required. Usage. Even with only three measurement sensors being used, this research hopes to locate the strike point correctly. Using time of arrival collected data at the three measuring stations over a specific time period, an artificial neural network (ANN)-based algorithm was designed for a 400 km2 coverage area in Southern Malaysia. With an average deviation of 350 m, the Levenberg-Marquardt algorithm is shown to correctly identify the lightning impact coordinates. The three-station TDOA-based LLS was able to locate the lightning strike spot with remarkable accuracy that was on par with commercial systems thanks to the algorithm.

On the basis of internet-of-things technology, [30] advanced the research on intelligent lightning protection. The safety and interests of people are closely tied to the industry of lightning protection. It is necessary to connect the Internet of Things with traditional lightning protection. The architecture-level view of the regional lightning intelligent monitoring and early warning system is used to present the framework. The Internet of Things and machine learning techniques were utilized to forecast the visitors' quality of life. Make intelligent lightning protection a reality.

The INR-ELEC model was used by [31] to evaluate lightning activity. The comparison of the INR-ELEC model with the World Wide Lightning Location Network (WWLLN) and satellite-based lightning data from the Lightning Imaging Sensor is the main objective of this study (LIS). Considered are the severity frequency as well as some of the physical and dynamical features of the lightning that occurred during an 11-year span of time (2004-2014). The observations and numerical simulations are juxtaposed both quantitatively and qualitatively.

The study showed that there is relatively good agreement between the locations of lightning occurrence of WWLLN date as well as LIS observations and the simulated tune-averaged horizontal patterns of the lightning potential index (LPI) derived from ERA-Interim-based experiments. Furthermore, GFS-based simulations beat FNL (Final Analysis) and ERA-Interim simulations quantitatively in terms of NOL prediction, based on values of standard deviation (SD) and centered Root Mean Square Error (RMSE). Additional statistical analysis using numerous variables has shown that the ERA-Interim initialization has the highest performance for predicting lightning activity.

An intelligent lightning warning system based on electromagnetic field and neural network was reported by the [32]. The objective of this study is to create an intelligent (LWS) lightning warning system that utilizes an electromagnetic field and artificial neural networks to more correctly estimate lightning. Both a pair of loop antennas and data featuring the application of an electric field sensor were produced in order to detect the magnetic field connected with lightning in real time. Using the back propagation algorithm, the perimeters were generated using the charge rate of the field temperature and humility recorded two minutes before lightning hits. This was performed for a duration of six months to observe and forecast lightning strikes. He proposed (HWS) and it had 93.9%

[33] tried to address the constraints of radar observation in temporal and spatial study in its research effort. In order to convert FC-4A lightning data into maximum FC-4A proxy depicting the profile of radar reflectivity, maximum FC-4A reflectivity is extended to 3D FC-4A proxy reflectivity. A logarithmic relationship between FC-4A lightning density and maximum radar reflectivity is shown. Four groups of continuous cycling data assimilation and forecasting tests are run for a severe rain fall case to compare with radar assimilation. The 3D FC-4A proxy reflectivity is assimilated in RMAPS-ST (Rapid-refresh Multi-scale Analysis and prediction system-Short Term).

The study showed that cycling assimilation of 3D FC-4A proxy reflectivity can effectively adjust the moisture condition and indirectly affect the temperature and wind fields, which improves the quantifiability of the thermal and dynamic analysis. By incorporating 3D FC-4A proxy reflectivity, fractions skill scores (FSSs) show that rainfall forecasts are highly better with a 6 hour timeframe. It should be noted, however, that other cycling data assimilation tests are carried out in hilly areas without radar data. The capacity to forecast precipitation in mountainous areas has improved thanks to the use of 3D FC-4A proxy reflectivity. When radar parameters are missing, this method can be successfully used to predict lightning.

Using a generalized regression neural network, [34] reported on the prediction of lightning interruptions of transmission lines. The primary goal of this research is to find ways to stop transmission line-related power outages. It is feasible to predict lightning outages of transmission lines due to the volume of recorded lightning and lightning outages of transmission lines in the electricity system. In this study, it is proposed that general regression neural networks (GRNN) be used in an artificially intelligent method to forecast transmission line illumination outages. The datasets collected from the transmission business (TRASMICO) are evaluated, and the features are obtained for use as the GRNN's input parameters. The forecasting model was developed predicated on GRNN to perform prediction. By contrasting this work with Back Propagation, its performance is verified.

The Schrodinger-Electrostatic Algorithm was used in a study by [35] to simulate lightning threat forecasts. The mathematical model showed considerable improvements in its use of micro-scale plasmas to produce the macro-scale atmospheric plasma, which has a major impact on lightning. With this approach, lightning may be detected more efficiently and precisely. The simulation also revealed that the primary factor influencing lightning forecast is air density in the high atmosphere.

In southwest Utah, [36] evaluated different dual-polarization radar lightning forecasting methods. The processing on the ground, forecasts for the launch window, and lightning events brought on by rockets are all significantly threatened by lightning. Two weather radar-based forecasting methods for lightning initiation that were developed by Gremillion and Orville in 1999 and Travis in 2015 for Cape Canaveral Air Force Station and Kennedy Space Center in Florida are being tested in a new location. To accomplish this, the highest-performing radar parameters from Gremillion and Orville (1999) and Travis (2015) are implemented across southwest Utah's multi-dimensional lightning detection network, the Telescope Array Lightning Mapping Array: resistivity (Z) 40 dBZ with differential reflectivity (ZDR) 0.31 dB at the -10°C thermal height (TA LMA). On 102 isolated warm-season thunderstorms between August 2015 and August 2018, both strategies are tried.

Travis' parameters were used in a subsequent study in the Washington, D.C., area by Olsen (2018), where poor performance was noted. Calculated forecast metrics and lead times are compared to Gremillion and Orville (1999), Travis (2015), and Olsen's findings (2018). The outcomes of this study confirm that Utah does not respond well to the lightning prediction techniques used in the previous two trials. The forecast lead times of all three study locations are statistically significant despite being examined in various climates. Additional findings support the notion that Z is the deciding parameter in the algorithms used by Utah to predict lightning initiation and that ZDR lightning prediction is not geographically resilient.

An Adaptive Neuro-Fuzzy Inference System (ANFIS), developed by [37], shows the Root Mean Square Error (RMSE) based on the type of membership function. This journal used the ANFIS method to predict the value of the transmission tower lightning density. ANFIS predictions were used to compute the lightning strike density index value. Three characteristics of structural lightning strikes were found via analysis of the value calculation system in the South Sulawesi region of the Sungguminasa-Tallasa route (Nd). An average percentage of 0.0554% was applied to validate the analysis system's findings for the value of structural lightning strikes in the South Sulawesi region.

The Artificial Neural Network (ANN) model for [38] was created using the Multilayer Perceptron Neural Network (MLPNN) structure, and the simulation results were compared to the actual data. Meteorological information was collected from Meteorological Malaysian Services and utilized

(MMS). For the purpose of training and testing, simulation is carried out using the Matlab Neural Network Toolbox. The outcomes of the simulations demonstrated that MLPNN is capable of foreseeing the occurrence of lightning.

Kuala Lumpur International Airport (KLIA) served as the case study for [39]. He addressed the usage of five meteorological characteristics as the output target: temperature, mean relative humidity, mean pressure, mean surface wind speed, amount of rainfall, and the incidence of lightning strikes. The MATLAB toolbox was employed to create the ANN model. The Levenberg-Marquardt training algorithm was used to train the model. According to data collected from the simulations, the model was capable of accurately forecast the occurrence of lightning with a high Best Fit, low RMSE, and good R-value, which were 94.64%, 0.000786 and 0.99999, respectively.

According to [40]'s analysis, up to a forecast horizon of five days, the utilization of an occurrence model outperforms a reference climatology based on seven years of data. This method has yielded accurate lightning prediction, and the flash count model is calibrated and beats climatology for exceedance probability.

In order to forecast thunderstorms and lightning, [41] used categorization techniques. This analysis focuses on the classification of thunderstorms and the prediction of lightning. To do this, it is required to gather data about the thunderstorm, a seasonally happening weather phenomenon that can range in size from a few kilometers to 100 kilometers and last for several hours. The main factors in the formation of thunderstorms are unstable air and lifting mechanisms. With the use of these parameters, a thunderstorm forecasting model was developed which can also predict lightning. This model has an accuracy of 97.2% in predicting lightning and is efficient for a small area where datasets are obtained.

Working with the weather research and forecasting model, [42] created an explicit electrification parameterization. A selected lighting characteristic scheme is the foundation on which this model functions. Convection-parameter simulations have been run using case studies of 10 high impact weather events. Lighting was examined, and the results suggest the possible utilization of real-time lightning prediction given its comparatively low computational cost.

The [1] used geostationary lightning mapping and satellite technologies to forecast the time of a lightning strike. The GOES-R satellite was launched into orbit with sensors that could detect lightning. (GLM) Geostationary Lightning Mapper This ground-breaking instrument is a paradigm shifter. A computer algorithm will be fed the collected data. This trains computers on the patterns in the atmosphere that occur both before and during lightning events. There is a 75% possibility of lightning on the Geostationary Lightning Mapper (GLM).

2.1. Technological Gaps Discovered from the Literature Reviews.

- Designed models have high accuracy with alacrity but the lead time is very low [35]. This is well addressed in this model.
- Spatiotemporal (ST) data seems to be advantageous but problematic research for lightning forecast. To handle this problem, we planned to design a data driven forecasting framework base on Numerical Lightning Prediction using lightning scenario
- It validates the performance of Lightning Location System (LLS) by discovering remote areas with high tendencies of lightning.
- To the best of my knowledge, nobody has worked on lightning related power outages in Kogi State despite Kogi State being a Power Generating State. Since there is correlation

between lightning and power outages [11]. The system can appropriately predict power outages due to lightning.

- If properly deployed, it would help to making policies in aviation industries as well as validating lightning prediction from Geo-satellite forecast,

Acknowledgment

My gratitude is to Almighty God for His mercies. My profound gratitude also goes to my supervisors, erudite and seasoned scholars. Dr. Emeka Ogbuju (Major) and Prof. Fransisca Oladipo (Minor) both of Department of Computer Science Federal University Lokoja, Kogi State Nigeria their advice and mentorship have been great.

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