A Proposal on My

Final Year Project

Undertaken at: University of Lagos, Akoka, Yaba, Lagos.

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Project Topic: Machine Learning-Based Solutions for Enhancing Power Reliability and Safety in Nigeria: A Focus on Lagos

1. Introduction:

Nigeria, a country with significant potential, faces a significant hurdle in its quest for sustainable development: an unreliable and inefficient energy sector, with major concerns around electrical power disruptions caused by erratic weather conditions. Electricity outages, a dominant issue, plague the country, disrupting economic growth, daily life, and impeding progress towards the Sustainable Development Goals (SDGs). This project attempts to address this dire challenge by involving machine learning and data science techniques to predict electricity outages in Lagos, Nigeria's most populous city, and optimise energy management in Nigeria.

The focus aligns with Sustainable Development Goals (SDGs), emphasising the importance of access to affordable, reliable, sustainable, and modern energy for all (SDG 7).

The project addresses the pressing issue of power disruptions in Lagos, with an emphasis on the impact of weather on electricity distribution.

2. Background of the Study:

Frequent power interruptions, exceeding 10 occurrences per month in areas served by Ikeja Electric (IKEDC), present a significant challenge for both residences and businesses in Africa. The Energy for Growth Hub and the World Bank emphasise that unreliable power is a primary obstacle for businesses across the continent. The International Monetary Fund (IMF) estimates an annual cost of approximately $29 billion to Nigeria due to this unreliable electricity. Aligned with the United Nations Sustainable Development Goal (SDG) 7, which aims for universal access to affordable, reliable, sustainable, and modern energy by 2030, energy reliability holds a crucial position in achieving access (SDG 7.1).

While power outages are a familiar concept in Africa, the comprehensive scope and patterns of these disruptions remain largely unknown to everyday citizens. Existing research has predominantly focused on the causes and impacts of power outages, often neglecting nuanced insights into outage patterns. Understanding the when, where, and how of outages is vital for society to proactively prevent and manage disruptions effectively.

Adverse weather conditions consistently hinder electricity distribution in Lagos, as witnessed during my SIWES Industrial Training at the Power unit. This project acknowledges gaps in achieving SDG-related energy targets and contributes to addressing broader sustainability and development issues by shedding light on Nigeria's current energy situation.

3. Literature Review:

Ogunlami et al. (2021) conducted a study on the impact of electricity outages, focusing on the performance of micro-enterprise firms in selected semi-urban areas of Lagos and Ogun States, Nigeria. Their research, relying on purposive sampling for survey data collection, aimed to gather information from business owners about their perceptions of the extent and impact of outages rather than modelling the outage patterns.

In contrast, Farquharson et al. (2018) employed a distinct approach, utilising a Monte Carlo Analysis framework to estimate the implications of backup diesel generator utilisation in Sub-Saharan Africa. Their findings emphasised the adverse effects of depending on backup generators due to recurrent power outages, including increased net air emissions, consumer costs, and fossil energy consumption. The study highlighted the challenges arising from the unreliable electricity supply in the region.

Samuel et al. (2019), recognizing voltage instability and collapse as prevalent issues in electricity reliability, developed a "new line stability index" (NLSI_1) for predicting voltage collapse on the Nigerian grid. Their index considered switching logic based on the difference in voltage angle between two load buses. Similarly, Maliki et al. (2011) created regression and artificial neural network models for predicting electrical power generation in Nigeria.

The above papers are helpful contributions to the field. However, they do not directly address the outages themselves and offer insights that can aid planning in the presence of these outages. Quantitative analyses geared towards predicting the frequency of outages, and occurrence of outages among others can help address the perceived erratic nature of the outages which is often most frustrating. It will be highly beneficial to know, for example, if, when and where one might lose power.

4. Aim and Objectives of the Study:

- Aim:

  The overarching aim of this research is to address Nigeria's energy challenges, specifically focusing on the prediction and management of electricity outages in Lagos. By employing advanced machine learning techniques, the study aims to contribute innovative solutions that align with Sustainable Development Goals (SDGs), particularly SDG 7, which emphasises universal access to affordable, reliable, sustainable, and modern energy by 2030.
- Objectives:

  Predictive Modelling for Electricity Outages:
  - Develop and implement machine learning algorithms to predict the occurrence, and frequency of electricity outages in Lagos, Nigeria, utilising Ikeja Electric's network fault logs.

  Real-Time Safety Monitoring System:
  - Design and implement a machine learning-based safety monitoring system that provides real-time alerts and reminders for safety measures during electricity outages. This includes an established orientation guideline for residents and engineers.

  Geospatial Visualization of Outages:
  - Utilize Nigeria's shape file for geospatial visualisation, creating a map viewer to visually represent outage locations. This aims to enhance stakeholders' understanding of the geographical impact of electricity disruptions.

5. Methodology:

The project will utilise historical outage data, weather patterns, and energy generation records. Machine learning algorithms will be employed for outage prediction, safety monitoring, load forecasting, and compliance tracking. The research design will incorporate SDG indicators, and data will be collected, analysed, and interpreted in alignment with SDG goals.

- Data Sources:
  - Utilising Ikeja Electric Network Fault Logs available at Ikeja Electric Fault Logs, comprising outage date, location, fault details, and affected areas.

    - Employing Visual Crossing Weather Data to access atmospheric pressure, precipitation, radiation, relative humidity, temperature, wind direction, wind gusts, and wind speed, providing comprehensive weather information for Lagos, Nigeria.
    - Integrating Nigeria Electricity System Operator Data for Daily Energy Operational Reports, encompassing critical power system conditions:
        - Peak Generation
        - Lowest Generation
        - Energy Generated
        - Energy Sent Out
        - Generation at 06:00Hrs
        - Highest System Frequency
        - Lowest System Frequency
        - Highest Voltage Recorded
        - Lowest Voltage Recorded
    - Utilising Nigeria's Shape File for spatial visualisation, facilitating the mapping of outage locations on a map viewer for enhanced geographical understanding.
- Machine Learning Model:
    - Developing a predictive model using machine learning algorithms to analyse historical outage data and weather parameters.
    - Implementing regression analysis to correlate weather factors with outage occurrences, enabling the identification of patterns and trends.
    - Utilising classification algorithms to predict outage detail based on historical and real-time data.
- Data Processing:
    - Cleaning and preprocessing raw data to handle missing values and ensure compatibility across diverse datasets.
    - Feature engineering to extract relevant information and create new variables for model training.
    - Time-series analysis to understand temporal patterns in outage occurrences and align predictions with operational hours.
- Model Validation:
    - Splitting datasets into training and testing sets to evaluate model performance accurately.
    - Utilising cross-validation techniques to ensure robustness and reliability of the predictive model.
    - Assessing model accuracy, precision, and recall to validate its effectiveness in forecasting outages.

- Visualisation:
    - Employing geospatial visualisation tools to map outage locations, providing a comprehensive overview of affected areas.
    - Integrating visual representations of weather patterns and energy operational conditions to enhance interpretability and insights.
- Ethical Considerations:
    - Ensuring data privacy and compliance with relevant regulations in handling outage and weather data.
    - Adhering to ethical standards in obtaining and utilising Nigeria Electricity System Operator Data for research purposes.

This comprehensive methodology integrates diverse datasets, employs advanced machine learning techniques, and emphasises ethical considerations to develop a robust predictive model for electricity outages in Lagos, Nigeria.

6. Significance of the Study:

- Addressing Critical Energy Challenges:
    - This research is pivotal in addressing Nigeria's persistent energy challenges, particularly the prevalent issue of power disruptions in Lagos. By focusing on the unpredictable nature of these disruptions caused by erratic weather, the study aims to contribute innovative solutions that align with the United Nations Sustainable Development Goals (SDGs).
- Aligning with SDGs:
    - The project's primary goal is tightly aligned with SDG 7, emphasising universal access to affordable, reliable, sustainable, and modern energy for all by 2030. By utilising machine learning, the study seeks to enhance the reliability of electricity supply, thus supporting Nigeria in achieving its SDG targets.
- Economic Implications:
    - Unreliable power, as highlighted by the World Bank, is a significant obstacle to business in Africa. This study, by addressing the root causes of power disruptions, aims to contribute to the economic development of Nigeria. The estimated $29 billion annual cost attributed to the lack of access to reliable electricity, as stated by the International Monetary Fund, underscores the economic significance of this research.
- Data-Driven Decision-Making:

    - The research not only investigates the patterns of electricity outages but also leverages advanced data analytics to predict outage occurrences. This predictive capability enables stakeholders, including residents and engineers, to make informed decisions and implement safety measures when outages are detected. This is particularly crucial for maintaining safety protocols and optimising load shedding strategies.
- Collaborative Solutions:
    - The project is a result of collaborative efforts, involving professionals from academic institutions and the Ikeja Electric Distribution Company (IKEDC). The overwhelmingly positive responses received during consultations underscore the potential positive impact of the research on the community and the environment.
- Comprehensive Approach:
    - Beyond outage prediction, the study addresses broader challenges in the energy sector, including safety compliance, power distribution optimization, and load shedding decisions. By proposing a machine learning-based safety monitoring system and load forecasting system, the research aims to provide holistic solutions that contribute to sustainable development goals.
- Visualising Impact:
    - The use of geospatial visualisation tools and Nigeria's shape file enhances the study's significance by providing a clear visual representation of outage locations. This spatial understanding is crucial for stakeholders to grasp the geographical spread of outages and implement targeted interventions.
- Ethical Considerations:
    - Emphasising ethical standards in data handling, the study ensures privacy and compliance with regulations. This commitment to ethical considerations reinforces the credibility and responsible conduct of the research.
- Overall Impact:
    - The significance of this study lies not only in its potential to predict and mitigate electricity outages but also in its broader implications for sustainable development, economic growth, and collaborative problem-solving in Nigeria's energy sector.

7. Scope and Limitations:

The study focuses on Lagos, Nigeria, particularly units in Lagos receiving electricity from Ikeja Electric Distribution Company, which is the largest Nigerian power distribution company, serving over 700,000 customers.

- Scope of the Study:
  - This research focuses on the electricity network of Lagos, Nigeria, utilising Ikeja Electric's network fault logs data as a primary source. The geographic scope encompasses various regions within Lagos, providing a comprehensive understanding of the localities affected by power disruptions. The study leverages the Visual Crossing weather data to analyse atmospheric conditions, and the Nigeria Electricity System Operator data supplements the research with daily energy operational reports.
- Comprehensive Data Integration:
  - The integration of diverse datasets, including Ikeja Electric's network fault logs, Visual Crossing weather data, and Nigeria Electricity System Operator data, enhances the study's scope. The comprehensive approach allows for a nuanced analysis of the intricate relationship between weather conditions, system operational parameters, and the occurrence of electricity outages.
- Geospatial Visualisation:
  - To enrich the research, Nigeria's shape file is employed for geospatial visualisation. This spatial component provides a map view that aids in understanding the distribution of outages across different locations. The visual representation is instrumental in communicating the geographical impact of electricity disruptions.
- Predictive Analytics:
  - The scope extends to the application of machine learning for predictive analytics. By utilising advanced algorithms, the study aims to predict the frequency, duration, and occurrence of electricity outages. This predictive capability adds a forward-looking dimension to the research, allowing for proactive measures in outage management.
- Safety Compliance and Load Shedding:
  - The study's scope encompasses the development and implementation of machine learning-based systems for safety monitoring and load forecasting. These components address broader challenges in the energy sector, including ensuring safety compliance during outages and optimising power distribution to prevent overloads.
- Collaborative Engagement:

    - The collaborative nature of the research involves engagement with professionals from the Ikeja Electric Distribution Company (IKEDC), ensuring a real-world perspective on the challenges faced in the field. This engagement broadens the scope by incorporating practical insights and aligning the research with industry needs.
- Limitations of the Study:
    - Despite its comprehensive scope, the study acknowledges certain limitations. The generalisation of findings beyond the specific context of Lagos may be limited, and the machine learning models' predictive accuracy depends on the quality and completeness of the available data.
- Data Availability and Accuracy:
    - The study is dependent on the availability and accuracy of data from Ikeja Electric, Visual Crossing, and Nigeria Electricity System Operator. Any limitations or inaccuracies in the provided data may impact the robustness of the analysis and predictions.
- External Factors:
    - External factors such as changes in government policies, unforeseen natural disasters, or alterations in the electricity distribution infrastructure may introduce uncertainties. These externalities are beyond the control of the study and may affect the generalizability of the findings.
- Ethical Considerations:
    - Ethical considerations related to data privacy and security are inherent limitations. Adherence to ethical standards may impose constraints on the extent of data access and sharing, ensuring responsible and legal use of sensitive information.
- Continuous Improvement:
    - Acknowledging these limitations, the study commits to continuous improvement and refinement of methodologies. Iterative adjustments will be made to enhance the research's accuracy and relevance, contributing to the ongoing evolution of the field.

8. Innovation and Contribution:

This research contributes innovative solutions aligned with specific SDGs, emphasising the integration of machine learning for outage prediction, safety monitoring, and load optimization. The proposed systems aim to revolutionise power management in Lagos and potentially serve as a model for broader applications.

In conclusion, this project addresses critical energy challenges in Nigeria, leveraging machine learning to provide practical solutions with far-reaching implications for sustainable development and the achievement of SDGs.

- Innovative Integration of Diverse Data Sources:
    - A key innovation of this research lies in the seamless integration of disparate datasets. By combining Ikeja Electric's network fault logs, Visual Crossing weather data, and Nigeria Electricity System Operator data, this study pioneers a holistic approach. This integration provides a multifaceted understanding of the factors influencing electricity outages, setting a precedent for comprehensive data-driven analyses.
- Advanced Predictive Analytics Using Machine Learning:
    - The application of machine learning algorithms for predictive analytics is a groundbreaking aspect of this research. By harnessing the power of artificial intelligence, the study aims to predict not only the occurrence of electricity outages but also their frequency and duration. This predictive capability is an innovative step towards proactive outage management, contributing to the evolution of smart grid technologies.
- Geospatial Visualization for Enhanced Understanding:
    - The incorporation of Nigeria's shape file for geospatial visualisation represents a significant contribution to the field. The utilisation of map viewers enhances the communicative power of the research, providing stakeholders with a visual representation of outage locations. This innovation fosters a deeper understanding of the geographical impact of electricity disruptions, facilitating more targeted interventions.
- Real-Time Safety Monitoring and Compliance Tracking:
    - Addressing the broader challenges in the energy sector, the research introduces innovative solutions for safety monitoring and compliance tracking. The development of a machine learning-based safety monitoring system, coupled with an orientation system, establishes a real-time approach to ensuring strict adherence to safety protocols during outages. This innovation contributes to the enhancement of safety measures in the electrical engineering domain.
- Optimising Power Distribution Through Load Forecasting:
    - Another notable innovation is the introduction of a machine learning-based load forecasting system. By optimising power distribution and preventing overloads, this system offers a proactive approach to balancing electricity demand. The integration of load forecasting into the study's framework contributes to the efficiency and sustainability of power

distribution, aligning with the broader goals of the Sustainable Development Goals (SDGs).

- Industry Collaboration for Practical Insights:
    - The collaborative engagement with professionals from the Ikeja Electric Distribution Company (IKEDC) adds a practical and industry-specific dimension to the research. This collaborative approach ensures that the innovations proposed are grounded in real-world challenges, making the study not just academically rigorous but also practically relevant.
- Contributions to Sustainable Development Goals (SDGs):
    - The research makes a substantial contribution to the United Nations Sustainable Development Goal 7 (SDG 7) by addressing the challenges of reliable and sustainable energy. The alignment of the research objectives with specific SDG targets ensures that the innovations proposed have a direct impact on advancing the global agenda for universal access to affordable, reliable, sustainable, and modern energy for all by 2030.