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An Improved Fuzzy-Based Model for Fault Detection and Solution of Power Transmission Lines Using Case-Based Recommender Technique

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ABSTRACT:*The studyaddresses the issues of faultdetection and the recommended solutions for power transmission linesusing a fuzzy-basedapproach. A major problemfaced by power transmission companies in Nigeria is the inability to interpretdetected power-linesfault and channel the interpreted information to the appropriate maintenance team. From an in-depthfeasibilitystudy of related issues carried out, the mentionedproblemis a system-basedproblemthatrequiresimprovement in order to acceptdatasets on power-linesfault diagnose the faults and obtain the required maintenance action. In thisstudy, an ImprovedFuzzy-based Model for FaultDetection and Solution of Power Transmission Lines using Case-basedRecommender technique wasdeveloped. Furthermore, Structured System Analysis and Design Methodologywasadopted in thisapproach, and wasimplementedHypertext Pre-processor (PHP), JavaScript ProgrammingLanguage and MySQL database as backend. The resultsobtainedfrom the studyshowed more efficiencywhencompared to the Existing System in terms of processinginputted validation details, speed in registration process and speed in recommending Power Transmission Line (PTL) solution on the detectedfaults. The speed efficiency values of the mentionedparameterswere 12 seconds, 8 seconds and 14 seconds respectively as comparedwith the Existing System whichhadefficiency values of 20 seconds, 14 seconds and 11 seconds respectively, and furthershowedthat the Proposed System outperforms the Existing System in terms of speed and time complexity. In addition, the studycouldbebeneficial to the Power Holding Company of Nigeria (PHCN), to Ministry of Power and to ResearchersCommunitieswithkeeninterest in faultdetection and power transmission lines.*

KEYWORDS-*Fault Detection, Fuzzy-based, PTL, PHCN, Transmission lines*

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I. INTRODUCTION

The study addresses the issue of fault detection and the recommended solutions for power transmission lines using a fuzzy-based approach. A major problem faced by power transmission companies in Nigeria is the inability to interpret detected power-lines fault and channel the interpreted information to the appropriate maintenance team. From an in-depth feasibility study of related issues carried out, the mentioned problem is a system-based problem that requires improvement in order to accept datasets on power-lines fault diagnose the faults and obtain the required maintenance action.

Fuzzy Logic is an approach to variable processing that allows for multiple values to be processed through the same variable. Fuzzy set theory and fuzzy logic are a highly suitable and applicable basis for developing knowledge-based systems in power transmission system. An overhead power line is a structure used in electric power transmission and distribution to transmit electrical energy across large distances. It consists of one or more conductors (commonly multiples of three) suspended by towers or poles. Since most of the insulation is provided by air, overhead power lines are generally the lowest-cost method of power transmission for large quantities of electric energy [1]

1.1 Statement of the Problem

The issue of fault detection in Power Transmission Lines (PTLs) is an alarming problem for the Power Holding Company of Nigeria (PHCN). This is due to the lack of a fuzzy-based system that will effectively interpret detected power-lines fault and channel the interpreted information to the appropriate maintenance team, and further proffer solution to the detected fault.

1.2 AIM AND OBJECTIVES

The aim of this study is to develop an Improved Fuzzy-based System for Fault Detection in Power Transmission Lines (PTLs). The specific objectives are to:

i) design a recommender system for fault detection and solution of power transmission lines
ii) implement the proposed system with Hypertext Pre-processor, JavaScript programming language and MySQL as database.
iii) compare our results with the existing system performance

II. RELATED WORK

Prakash et al [2] looked at the Review of Power System Distribution Network Architecture. The authors presented a review of fundamental distributed network architecture including radial, ring and meshed distributed network looking at the concept of distributed network architecture, types, operation; controlling, management, growth model, advantages and disadvantages of existing distributed networks. The authors did a good job. However, there was no practical implementation and the results of the Power System Distribution Network Architecture were also missing.

Martin [3] proposed an Electric Power Transmission and Distribution Systems: Cost and their Allocation. According to the work; The recent increase in costs of generation and the pass through to customers of these costs via "fuel adjustments" has elicited unprecedented reaction from the public and consumer groups to potential inequities in currently existing electricity pricing practices. However, there was no unsupervised learning approach to their developed system, which could have made it more intelligent in the long run.

Elavarasan et al [4] presented on Wireless Power Transmission using Distinguished Methodologies. According to their work, Electrical power accounts for greatly of the energy developed. A great deal of this power is unemployed during transmission from power plant manufacturers to the customers. The resistances of the wire used in the electrical grid distribution arrangement cause a thrashing of 26-30% of the energy produced. This hammering infers that our current structure of electrical distribution is simply 70% competent. A scheme of power supplies with minute or merely no failure would preserve energy. The authors did a good job but there was no trained datasets for the Wireless Power Transmission System under study.

Paras [5] looked at Wireless Power Transmission. The aim of the work was to give an overview on the research and development in the field of wireless power transmission. The author also focused on the loss occur during wireless power transmission and distribution, how to minimise the loss and make the efficient use of power through microwave transmitters like klystron, magnetron etc. the advantages and disadvantages of wireless power transmission including cost effective. The author carried out a good job. However, he could not practically implement the issue with a model.

Patrick et al [6] looked at Fault Detection and Location in Power Transmission Lines using Concurrent Neuro-Fuzzy Technique. The work analysed and adopted neuro-fuzzy techniques to anticipate upcoming fault and their location by predicting them using a powerful artificial intelligence technique to improve power transmission line reliability and sustainability. Furthermore, the results from the study show that the utilization of the technique could be time saving for technical team, and could improve the transmission line yield as follows:

i) They failed to implement their system on more than the two real-life PTLs
ii) Their system was only able to detect only 11 faults in both short and long terms and
iii) Their system was designed to only detect power line faults but could not proffer solution to the detected faults. This is what our work intend to address.

Paras [7] looked at Wireless Power Transmission. The aim of the work was to give an overview on the research and development in the field of wireless power transmission. The author also focused on the loss occur during wireless power transmission and distribution, how to minimise the loss and make the efficient use of power through microwave transmitters like klystron, magnetron etc. the advantages and disadvantages of wireless power transmission including cost effective. The author carried out a good job. However, he did not practically implement the discussed issue to a model.

Mystica [8] looked Wireless Power Transmission. The author discussed about the history, evolution, types, research and advantages of wireless power transmission. There are separate methods proposed for shorter and longer distance power transmission; Inductive coupling, resonant inductive coupling and air ionization for short distances; Microwave and Laser transmission for longer distances. The pioneer of the field, Tesla attempted to create a powerful, wireless electric transmitter more than a century ago which has now seen an exponential growth. The author carried out a good job. However, he did not practically implement the discussed issue to a model.

Linlin [9] researched on the Design and Optimization of a Wireless Power Transfer System Allowing Random Access for Multiple Loads. According to the author, Wireless Power Transfer is generally used to supply power on a one-to-one basis. For example, wireless charging has been applied to electric vehicles and to supply power to embedded medical equipment. In addition to this, the wireless charging of intelligent electronic devices is also a popular application, one which has developed into an industry in itself. The author did a good job. However, performance evaluation of the developed system showed deficiencies in benchmarking and lifecycle assessment.Chavan [10] researched on Tesla Coil Wireless Power Transmission. The motive of the author was to present design of wireless power transmission using tesla coil. There are two ways of electrical energy transmission one is wired and another is wireless. Wired electric transmission is complicated in design, easy way to overcome this disadvantage by using wireless transmission. Furthermore, the author also explained how the electrical energy is transferred from a source to the load, without any wired conductive physical connection. The authors did a good job. However, there was no adequate comparative analysis of the Tesla Coil Wireless Power Transmission with other Transmission Systems.

III. MATERIALS AND METHODS

3.1 METHODOLOGY

The Methodology for the Proposed System Design is Structured System Analysis and Design Methodology (SSADM). Structured Systems Analysis and Design Methodology is a systems approach to the analysis and design of information systems.

3.2 ANALYSIS OF THE EXISTING SYSTEM

Having reviewed numerous related works, we showed keen interest on the most current and related issue as carried out by Patrick et al (2018). The authors carried out a research on Fault Detection and Location in Power Transmission Lines using Concurrent Neuro-Fuzzy Technique (figure1). The work analyzed and adopted neuro-fuzzy techniques to anticipate upcoming fault and their location by predicting them using a powerful artificial intelligence technique to improve power transmission line reliability and sustainability. Furthermore, the results from the study show that the utilization of the technique could be time saving for technical team, and could improve the transmission line yield. The Existing System was also designed to predict 11 faults type for Power Transmission Lines (PTLs).

The phases of the Existing System include a new technique in this power system field and the comparison of the results obtained for the high voltage and very high voltage PTL and, finally, to determine whether CNF (Concurrent Neuro-Fuzzy) can be successfully applied to one or the other PTL studied. The main objective of the Existing System is to demonstrate the robustness of the CNF technique. This was achieved by comparing the results obtained from two PTLs of different parameters. The first PTL is characterized by its length of 600 km and its voltage of 735 kV and the second PTL is characterized by its length of 120 km and its voltage of 400 kV. The use of such a method in fault prediction could reduce the time required by the technical team for restarting a PTL and specially to increase the percentage of line reliability. Hence, the Existing System is quite beneficial for consumers because service continuity is necessary for a prosperous life in a competitive economic market.

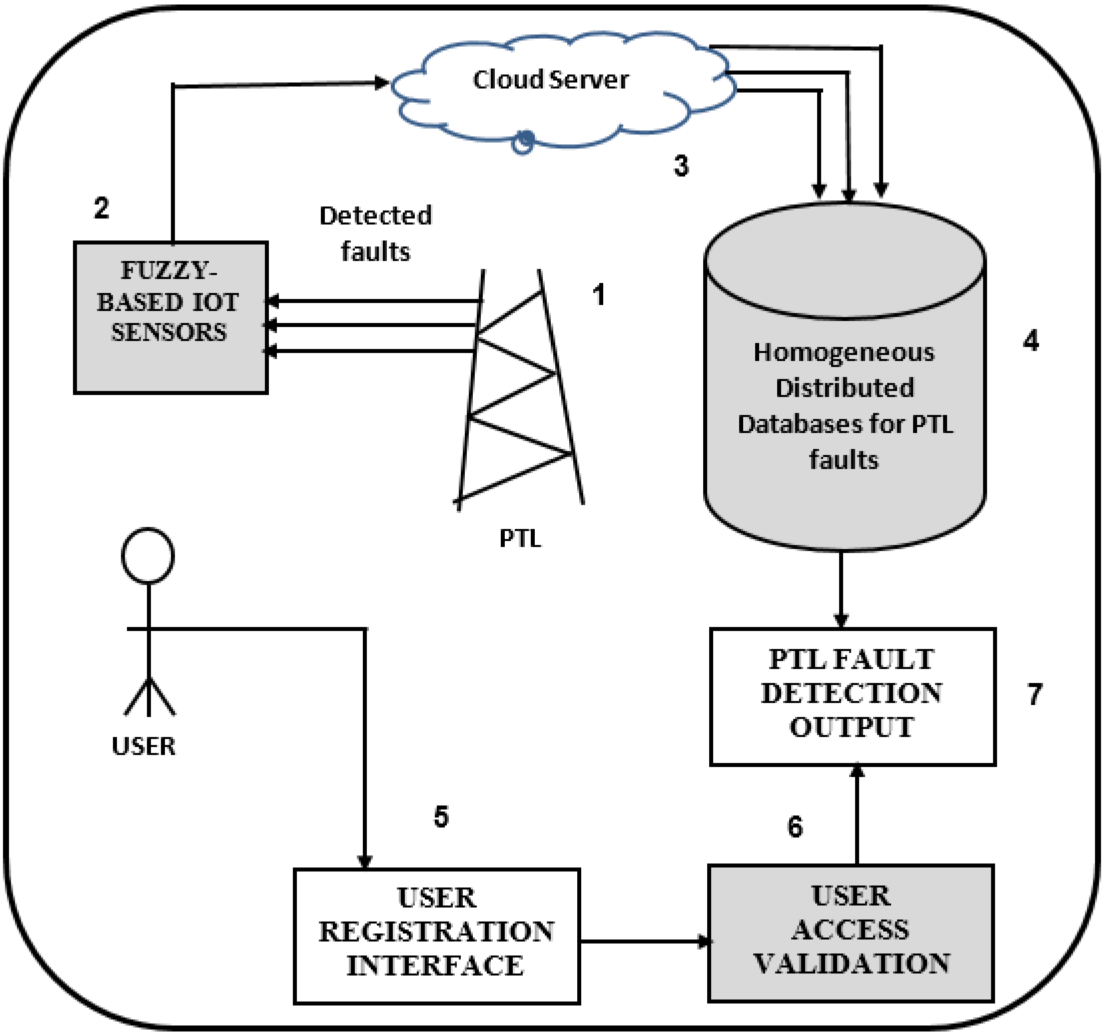

Fig. 1: Existing Architecture of Fault Detection and Location in Power Transmission Lines using Concurrent Neuro-Fuzzy Technique(Source: [6])

3.3 EXPLANATION OF THE EXISTING COMPONENTS

The following components of the Existing System are:

i) Cloud Server:

This component is a virtual server (rather than a physical server) that runs in a cloud computing environment. It is built, hosted and delivered via a cloud computing platform via the internet, and can be accessed remotely. They are also known as virtual servers.

ii) Fuzzy-based IOT Sensor:

The Fuzzy-based Internet of Things (IOT) component is a device that uses fuzzy logic to detect changes in an environment. By itself, a sensor is useless, but when we use it in an electronic system, it plays a key role. A sensor is able to measure a physical phenomenon (like temperature, pressure, and so on) and transform it into an electric signal.

iii) Power Transmission Line (PTL):

They are sets of wires, called conductors that carry electric power from generating plants to the substations that deliver power to customers. At a generating plant, electric power is “stepped up” to several thousand volts by a transformer and delivered to the transmission line.

iv) Homogeneous Distributed Databases for PTL fault:

This component is an organized storage of related faults of PTLs. Furthermore, the homogeneous distributed database uses single software and is implemented on a network.

v) User Registration Interface:

This component is a platform where potential users of the system register in order to be allocated a username and corresponding password for using the system.

vi) User Access Validation:

This component provides a message to help users who input data that is not valid. When data is entered, Access checks to see whether the input breaks a validation rule – if so, the input is not accepted, and Access displays a message.

vii) PTL Fault Detection Output:

This component displays the detected Power Transmission Line Output to the user of the system.

3.4 DISADVANTAGES OF THE EXISTING SYSTEM

The following disadvantages of the Existing System include:

- i) Limited implementation of real-life power transmission line issues
- ii) Limited fault detection technique for power transmission line in both short and long terms
- iii) Inability to proffer solution to the detected power transmission line faults

3.5 ANALYSIS OF THE PROPOSED SYSTEM

The proposed system of this study is an Improved Fuzzy-based system for Fault Detection and Solution of Power Transmission Lines (figure 2). This is achieved through the improvement of the existing system through the addition of a Case-based Recommender (CBR) technique that uses a fuzzy neural network. The added CBR technique will complement the fault detection process of the existing system through the recommendation of solutions of twenty faults of power transmission lines. In a Case-Based Recommender System (CBR-RS) the effectiveness of the recommendation is based on: the ability to match user preferences with solution description; the tools used to explain the match and to enforce the validity of the suggestion;

The range of available functionalities and the graphical interface that support the user in browsing the information content, either the cases or the products to recommend; the case-based approach is considered complementary to the other approaches. In this approach, knowledge about customers and the application domain are used to reason about what products fit the customer's preferences. The most important advantage is that this approach does not rely exclusively on customer's rates, hence avoiding the mentioned difficulty in bootstrapping the system. Knowledge can be expressed as a detailed user model, a model of the selection process or a description of the items that will be suggested.

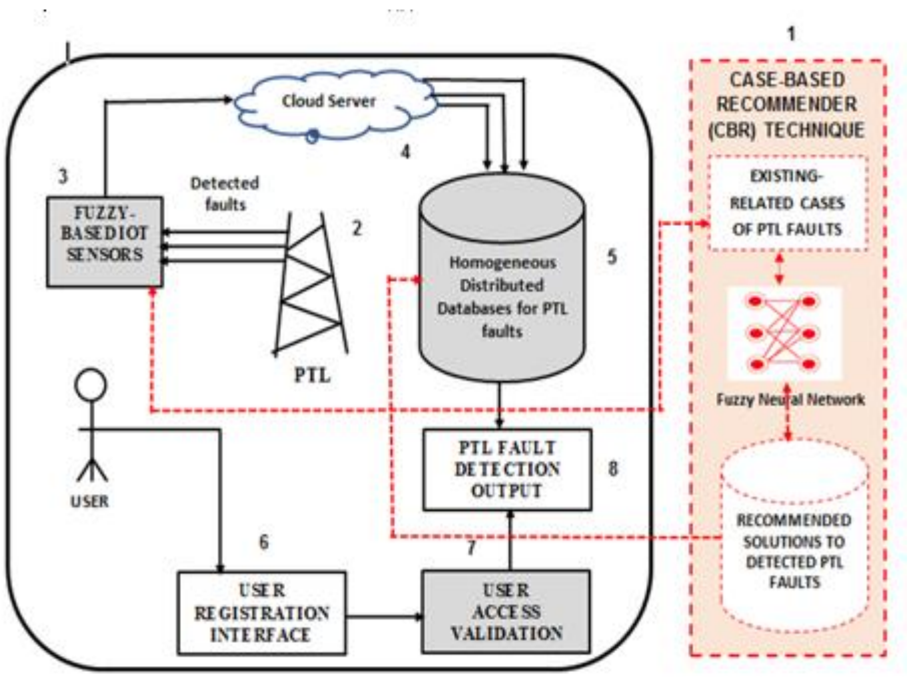

Figure 2: Proposed System Architecture of an Improved Fuzzy-based System for Fault Detection and Solution of Power Transmission Lines (PTLs)

3.6 CASE-BASED RECOMMENDER TECHNIQUE:

This component consists of sub-components which include existing related cases of PTL faults, a fuzzy neural network and a database of recommended solutions to the detected PTL faults. The first sub-component enables the proposed system to detect more PTL faults, while the fuzzy neural network is a learning machine that finds the parameters of a fuzzy system (i.e., fuzzy sets, fuzzy rules) by exploiting approximation techniques from neural networks. In addition, the third component recommends useful solutions to the detected PTL faults.

3.7 ADVANTAGES OF THE PROPOSED SYSTEM

The following advantages of the Proposed System include:

i) Ability to detect twenty PTL faults using existing related cases of PTL faults.
ii) Ability to proffer solution to the detected PTL faults
iii) A Fuzzy-based Neural Network that enables the proposed system to be intelligent in short and long terms.

3.8 EXISTING SYSTEM ALGORITHM

```
STEP 1:     START
STEP 2:     DECLARE VARIABLES
            UN, PW, CISP, PTLF, QS, UAV
STEP 3:
            UN      =   USERNAME
            PW      =   PASSWORD
            CISP    =   CLOUD INTERNET SERVICE PROVIDER
            PTLF    =   POWER TRANSMISSION LINE FAULT
            QS      =   QUIT SYSTEM
            UAV     =   USER ACCESS VALIDATION
STEP 4:
            INITIALIZE CISP
STEP 5:
            INITIALIZE UAV
STEP 6:
            UAV  =  UN + PW
STEP 7:
            QUERY FOR PTLF
STEP 8:
            VIEW PTLF
STEP 9:
            STOP
STEP 10:
            QS
```

3.9 PROPOSED SYSTEM ALGORITHM

```
STEP 1:     DEF FIND_MAX (PTL_F):
STEP 2:     IF LEN(PTL_F) == 1:
STEP 3:     RETURN PTL_S[0]
STEP 4:     V1 = PTL_F[0]
STEP 5:     V2 = FIND_MAX(PTL_S[1:])
STEP 6:     IF V1 > V2:
STEP 7:     RETURN V1
STEP 8:     ELSE:
STEP 9:     RETURN V2
STEP 10:
            DECLARE VARIABLES
            UN, PW, CISP, PTLF, QS, UAV, ERCOPTLF, FNN, CBRT
            WHERE:
                UN        =   USERNAME
                PW        =   PASSWORD
                CISP      =   CLOUD INTERNET SERVICE PROVIDER
                PTLF      =   POWER TRANSMISSION LINE FAULT
                QS        =   QUIT SYSTEM
                UAV       =   USER ACCESS VALIDATION
                ERCOPTLF  =   EXISTING RELATED CASES OF PTL FAULTS
                FNN       =   FUZZY NEURAL NETWORK
                CBRT      =   CASE-BASED RECOMMENDER TECHNIQUE
```

RS = RECOMMENDED SOLUTION

STEP 11: INITIALIZE CISP

STEP 12: INITIALIZE UAV

STEP 13: UAV = UN + PW

STEP 14: QUERY FOR PTLF

STEP 15: VIEW PTLF

STEP 16: INITIALIZE CBRT

STEP 17: CBRT = ERCOPTLF + FNN + RS

STEP 18: VIEW SYSTEM OUTPUT

STEP 19: STOP

STEP 20:

IV. RESULTS AND DISCUSSION

4.1 CHOICE AND JUSTIFICATION OF PROGRAMMING LANGUAGE USED

We implemented the Proposed System design with PHP, JavaScript Programming Language, Hypertext Markup Language, Cascading Style Sheet and MySQL Relational Database Management System. JavaScript is a server-side scripting language that is used for making web pages interactive. It is supported by all major web browsers. This is a programming language that is used by web developers for the creation of contents that communicate with databases. Secondly, PHP can be used for the development of web-based applications, system function performance; HTML is an acronym for Hypertext Markup Language and is used for structuring web pages. It consists of tags and is also supported by all major web browsers. Cascading Style Sheet (CSS) is a web development content that is used for styling and beautifying web pages. MySQL is the world's most popular open source database. With its proven performance, reliability and ease-of-use, MySQL has become the leading database choice for web-based applications, used by high profile web properties including Facebook, Twitter, YouTube, Yahoo and many more. Oracle drives MySQL innovation, delivering new capabilities to power next generation web, cloud, mobile and embedded applications.

4.2 DISCUSSION OF RESULTS

The Proposed System is a Web Application that is backed up by a Local Host Server. Hence, we implemented the frontend of the system with Xampp Server as illustrated in figures 3 and 4.

a) APPLICATION FRONTEND PROCEDURES:

i) Start

ii) Launch XAMPP

iii) Launch Notepad++

iv) Enter source codes for Application Frontend, Run program on Mozilla Firefox or Google Chrome browser

b) STEP ONE: (Setting up Xampp Server Installation):

In order to install the Xampp Server, the user of the system must download the Xampp executable file, before running the installation as an administrator. Once the download is done, the user double clicks on the executable file to commence the

Fig. 3: Xampp Setup Page

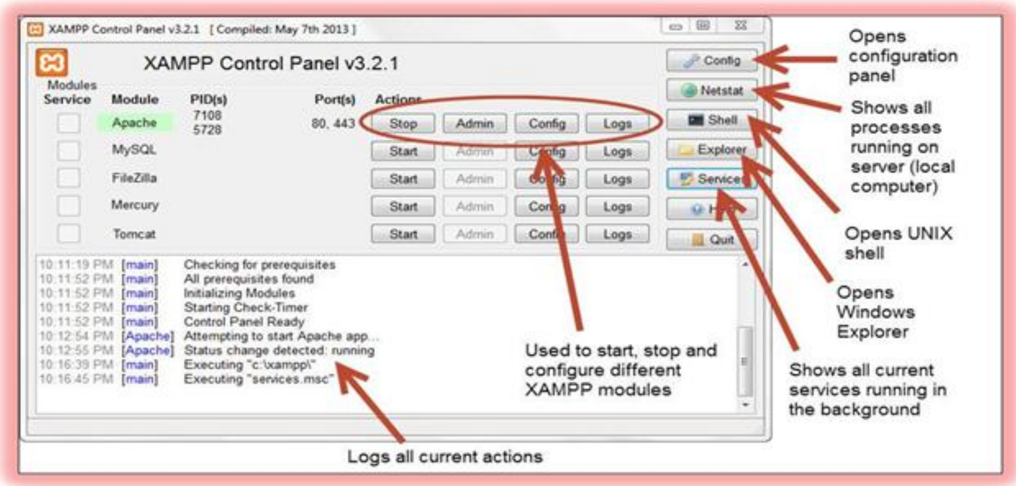

Fig. 4: Xampp Control Panel

Figure 5 shows the welcome page of the proposed system. The welcome page was structured with hypertext markup language, styled with cascading style sheet and made dynamic with hypertext pre-processor. There are two navigation links in the welcome page. The first link enables the user to sign in with a unique username and corresponding password, while the other link enables the user to register as an admin in order to be allocated login details such as username and password. Figure 6 shows the registration of the potential admin. The registration page was structured with hypertext mark-up language, styled with cascading style sheet and made dynamic with hypertext pre-processor. The registration page contains the following fields such as name of the potential administrator, date of birth, gender, and employment date, position in the company, username and password. After inputting the registered details, the user clicks on submit in order to end the registration process. On clicking on the submit button, the user receives a confirmation message for the submitted information. Figure 7 shows the sign-in page of the system in

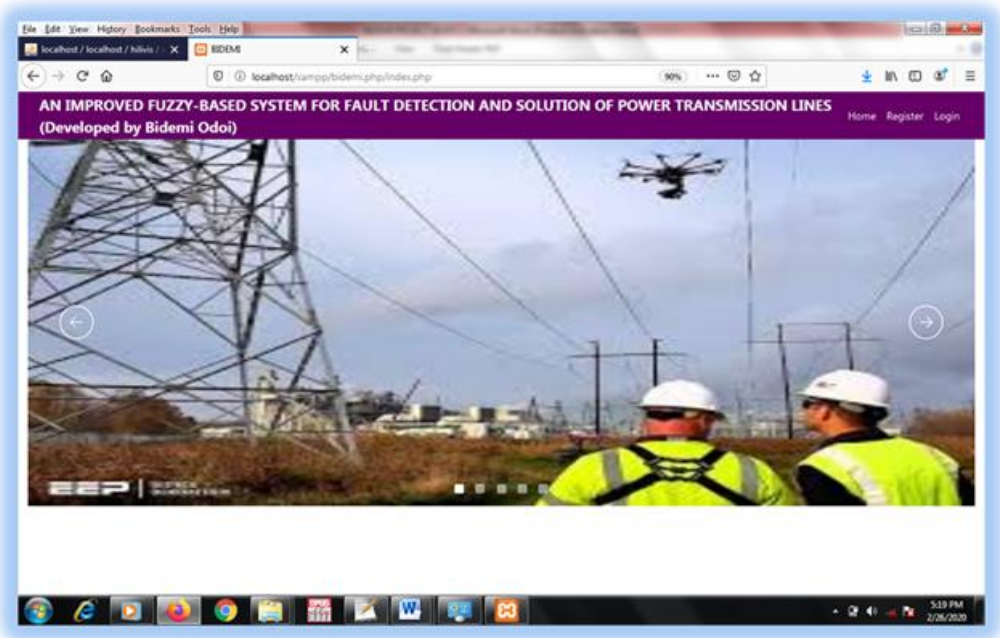

Fig. 5: Startup Page of the Proposed System

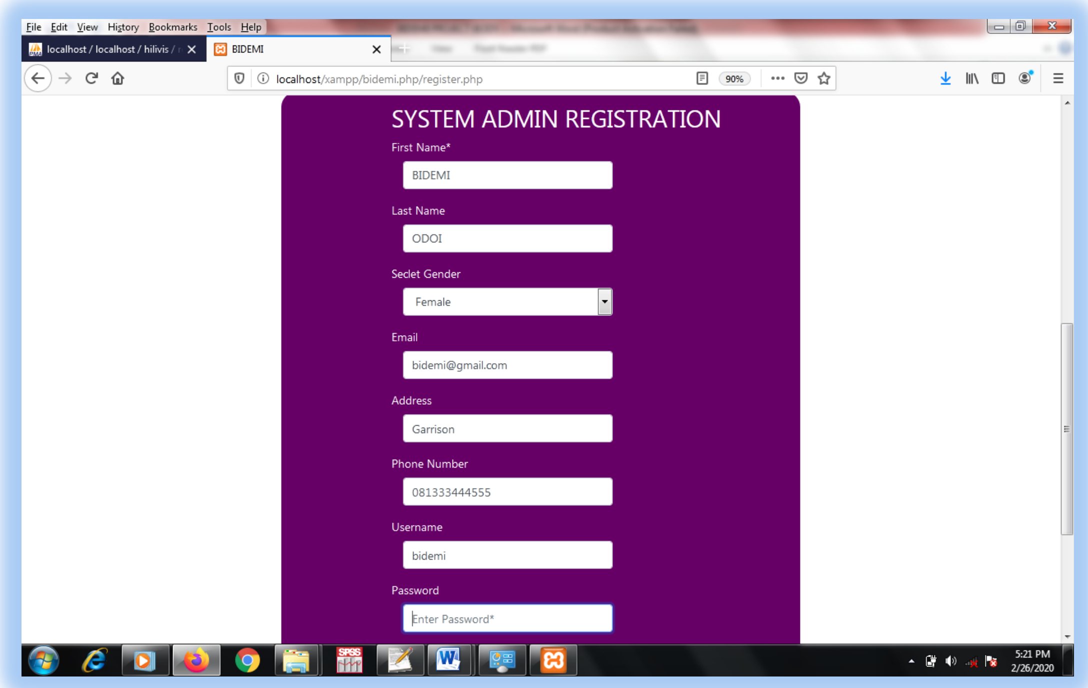

Fig. 6: Registration page for New Admin

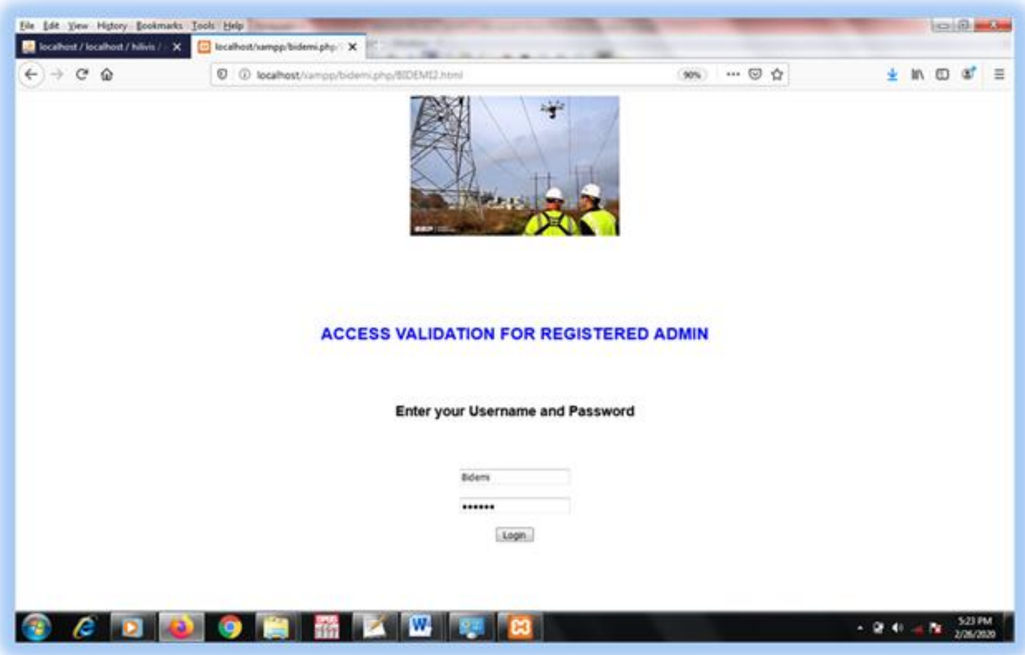

Fig. 7: Access Validation page for new user

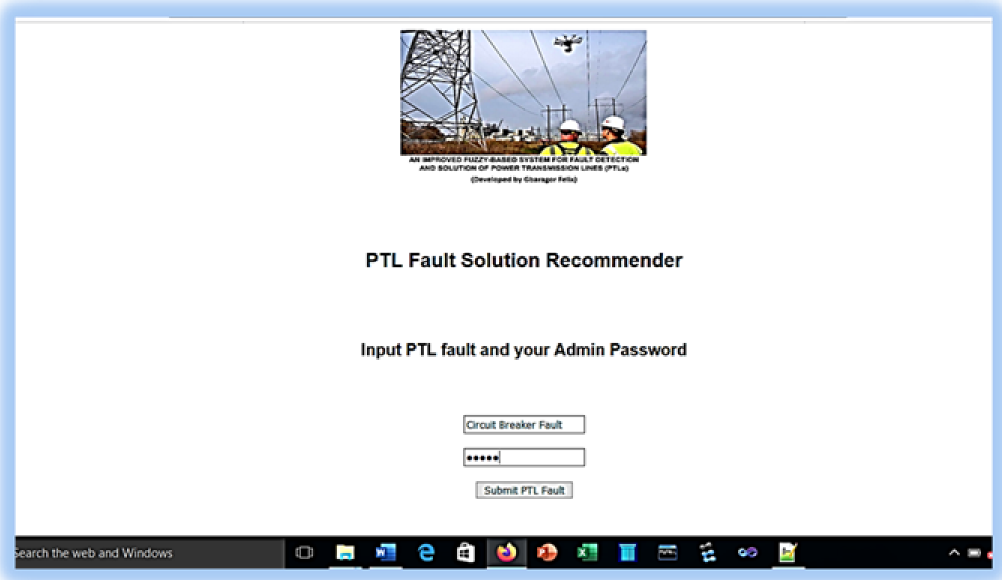

Fig. 8: PTL fault input page

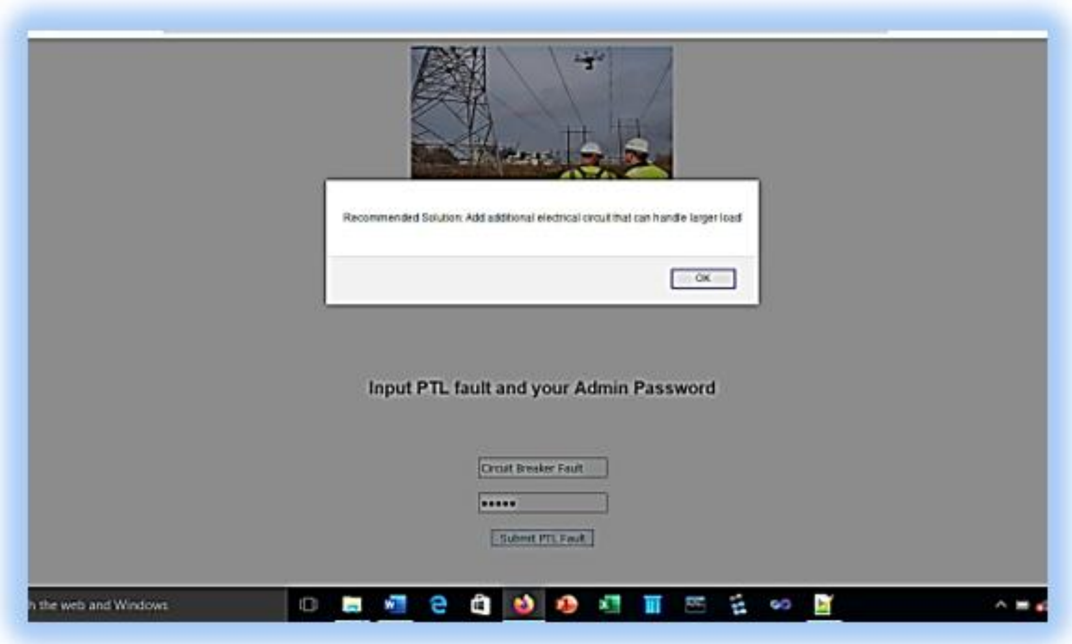

Fig. 9: Recommended Solution to PTL Fault

which the user will input a username and corresponding password. The sign-in page was structured with hypertext mark-up language, styled with cascading style sheet and made dynamic with hypertext pre-processor. Figure 8 shows the PTL fault input, and the recommended solution platform. The platform was structured with hypertext mark-up language, styled with cascading style sheet and made dynamic with hypertext pre-processor. There are two distinct fields for the platform are the suspected fault input, the password field, and view solution button. Once the user enters the suspected fault, password and clicks on the view solution button, the system automatically use the fuzzy-based technique to display the detected fault and possible solution. This will now enable the maintenance team to promptly swift into action. There are several power line transmission faults that was implemented with the proposed system which include short circuit fault, symmetrical fault, unsymmetrical fault, circuit breaker, protective relays, lighting arrestor, transient fault, persistent fault, bolted fault, ground fault, realistic fault, arcing fault, mercury fault.

4.2 PERFORMANCE EVALUATION OF THE EXISTING SYSTEM

Table 1: Comparative Analysis

SN	EXISTING SYSTEM	Time in Seconds	Time in Seconds	PROPOSED SYSTEM
1.	Speed in Processing inputted validation details	20	12	Speed in Processing inputted validation details
2.	Speed in Registration Process	14	8	Speed in Registration Process
3.	Speed in Recommending PTL Solution to detected fault	11	14	Speed in Recommending PTL Solution to detected fault

(**Source of data:** Program Implementation and Research Findings)

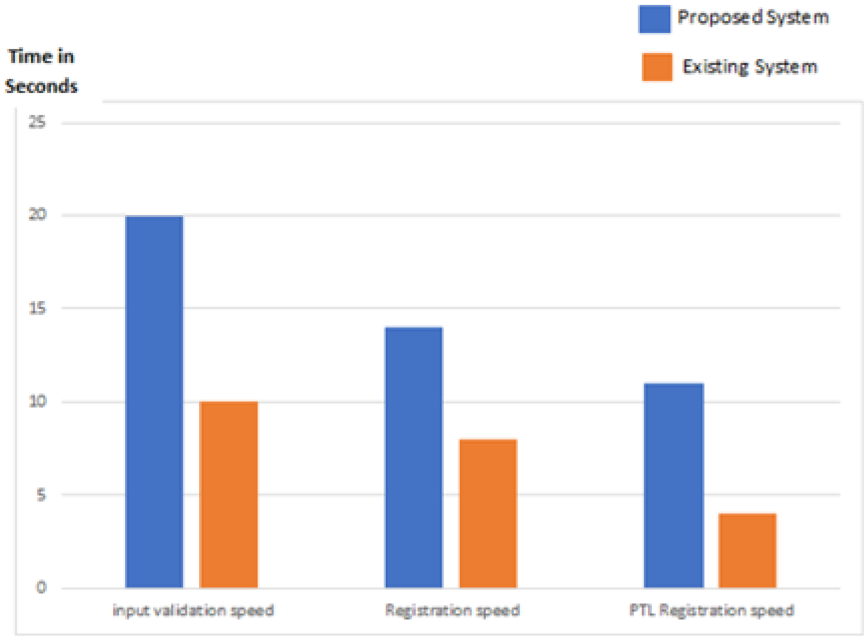

Fig. 10: Performance Evaluation Chart

V. CONCLUSION

In this study, we have developed an improved fuzzy-based system for the detection and solution of Power Transmission Lines Faults. The proposed system will utilize the efficiency of a Case-Based Reasoning (CBR) technique in proffering solutions to detected faults in Power Transmission Lines (PTLs). All transmission line types can carry 5 percent more or less voltage for normal operation. Upgrades to change line voltages can be divided into two categories: increase within a voltage class and changes to a different voltage class. In other words, the study will be beneficial to stake holders in the power sector.

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