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Machine Learning Based Niger Delta Management Information System

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Abstract
Niger Delta is a very significant area in the Nigeria as most of the oil pipelines pass through its communities. It has also become the most targeted by vandals. This has also led to increased crime, reduced economy and more health threats due vandal's activities in the regions. This makes enhanced information management technologies very crucial in this region. Information such as the effect of climatic/geographical changes, vandalization rates, population changes, education and crime on the lives of Niger Delta citizens need to be made available freely online to help the Niger Delta government in her decision-making processes. This information is also made available to the citizens in order to live a healthy life and make improved decision too. The use of machine learning has brought great improvement in the world of information management. This paper has proposed a Niger Delta Management Information System (NDMIS) development, leveraging machine learning and analytics. The proposed system will develop a web application interface (ndmis.gov) that will make all necessary Niger Delta host community data available freely online. This site will act as a portal to all sorts of amazing information about the region. BIG-data analytics pulls from existing information to look for emerging patterns that can help shape the decision-making process in Niger Delta. On the other hand, machine learning can learn from the existing data and provide the foundation required for a machine to teach itself. The software tool that can be use is Python, Jupita Notebook and VS Code.

Keywords: *Anti-pipeline vandalization, Oil pipelines, Information management, Climatic changes, Decision-making, Machine Learning, Big-data analytics.*

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I. Introduction

Information management systems are aimed at ensuring proper collecting of data, storing, processing and retrieving them for future uses or better decision making. This research develops a system for enhanced management of very crucial information about the Niger Delta region especially with respect to pipeline vandalization activities and its corresponding effects on the citizens. The real time information derived from this system will equip the Niger Delta government to make better policies and ensure a more effective decision-making process.

Pipeline vandalization or oil bunkering can be seen as the illegal act of puncturing or destroying oil pipelines in order to primarily steal petroleum products. The other reasons vandals carry out such acts are to obstruct the distribution of oil for personal use, the sales on black market or to process the oil further in illegal refineries. The vandals most times carry out these acts especially in the dark or when it is raining or when the fisher men, farmers and other inhabitants are not around.

Ahmed et al, (2017) defined vandalism as a deliberate hostile behavior aimed at environmental objects with the motive of damaging the property. It can also be looked at from the Marxian perspectives as a productive force that fought against exploitation of the capitalist system. Vandalism may include Tactical vandalism e.g. sabotage at the work place; Vindictive behavior, e.g. form of revenge; Play vandalism e.g. breaking of window panels and Malicious vandalism e.g. vandalism out of boredom, exasperation, resentment, and frustration.

Niger Delta is a very significant region in Nigeria considering their unique terrain. According to Omawumi (2023), Niger Delta people had been into the business of farming, fishing, oil palm production, coral beads making, trading and travelling. This is because of their unique terrain. It is characterized by swamps, coastal rivers, rain forest, fresh water etc. The discovery of oil in 1956 together with the digging of the first oil well with a total production of 5100 BBls/Day led to the dominance of oil and gas production in Nigeria's economy. This particular sector in Nigeria has contributed about 10.29% of the total GDP growth in the first quarter of 2016. As a result, the Niger Delta Region of the country has been at the fore front in global politics.

According to The Niger Delta region of Nigeria is the most targeted as Over 7000 km of these oil and gas pipelines are situated in the region, with over 1500 communities hosting these facilities. These regions face severe vandalization due to the following reasons: corrosion and rupture due to old age (50%), sabotage (28%), production operations (21%), and poor pipeline security. Vandalization in these regions have also been accompanied by oil spills, fire outbreaks, and blow outs. These effects have contributed to the reduction in oil production rates in Nigeria. It has also led to the loss of life and invaluable properties. (Omawumi , 2023)

Hence, this region needs an enhanced information management system. Information such as the climatic/geographical changes, vandalization rates, change in population, educational conditions and crime rates in Niger Delta need to be made available freely online to help the Niger Delta government in her decision-making processes. This information is also made available to the citizens in order to live a healthier, safer life and make improved decision too.

The use of machine learning has brought great improvement in the world of information management. The integration of machine learning in the traditional information systems has created the ability for a system to learn from a knowledge base and make better predictions. This will help the government and other bodies to take good decisions.

This paper has designed a Niger Delta Management Information System (NDMIS) development, leveraging machine learning and analytics. A case of Niger Delta anti-pipeline vandalization programme has been considered. The system will develop a web application interface (ndmis.gov) that will make all necessary Niger Delta government data available freely online. This site will act as a portal to all sorts of amazing information on the most important factors. BIG-data analytics pulls from existing information to look for emerging patterns that can help shape our decision-making process in Niger Delta. On the other hand, machine learning can learn from the existing data and provide the foundation required for a machine to teach itself.

II. Review Of Related Works

Ajao et al, (2018) developed an anti-theft oil pipeline vandalization system-based internet of things technology using ATmega328, GSM and GPS to render a remote information monitoring. The prototype was implemented and tested in a lengthy pipeline of 10m with configuration threshold range from 28 to 210. The result obtained contain sensor nodes position in a pipeline network, geographic locations (longitude and latitude) and distance, which are transmitted as SMS alert to the base station (BS). However, the system did not integrate machine learning technology to enable it learn from a knowledge base, predict and display results on a web interface. This will enable the citizens to access very importance information online.

Chinwe et al, (2018) proposed an integrative systems model comprising of a machine intelligence technique called Hierarchical Temporal Memory (HTM) and a sequence learning neural network called the Online-Sequential Extreme Learning Machine (OS-ELM) for monitoring and prediction of pipeline pressure data. But they did not use decision tree algorithm in their data analysis. Also, the information is not displayed on a very user-friendly web interface for the public to access online.

Vincent et al, (2017) proposed an artificial intelligence monitoring system capable of performing predictive classification and pattern recognition on pipeline datasets. The predictive system is based on a sparse predictive Deviant Learning Algorithm (p-DLA) designed to synthesize a sequence of memory predictive data clusters for monitoring, control and for decision making purposes. The system uses two feature pipeline datasets and the pattern recognition monitoring ability of the DLA (p-DLA) is compared with a variant of an emerging machine learning algorithm, the Hierarchical Temporal Memory based on Cortical Learning Algorithms (HTM-CLA).

Ogujor et al, (2013) proposed a microcontroller based anti-pipeline vandalism system that was capable of alerting the operator in the control Centre about ongoing theft in the field by indicating area at which pipeline attack is taking place. The system is packaged using insulated copper cable sensor wrapped around the pipeline for the detection of sabotage act around the pipeline and simultaneously displays the acquired information on Liquid Crystal Display (LCD). This system is developed using wired technology for the information transmission, and it completely kept within the pipeline environment for security against vandals.

A pipeline vandalism detection system that communicates information to the control room by alarming and SMS notification was developed in Ezeh et al, (2014). This system design is functioning using resistance sensor as a continuous flow of electrical path. Any break in the signal path causes interruption of signal and considered as deviations in the state of the system. Whenever this state occurs, the control unit send out signal to alarm unit for the activation of buzzer and indicate the transmission signal through light emitting diode (LED). But, this system cannot communicate over a remote network and does not include prediction using any machine learning algorithm. Also, it does not provide a web application optimized for easy access to prediction results and other necessary details on the Niger Delta environment.

In a similar approach, a microcontroller-based pipeline monitoring system is proposed by Igbajar et al, (2015). This research centered on architectural design and modelling of oil spillage detection using both real life

scenario and simulation approach. The leakage location and detection were based on imbalance between inflow and outflow pressure as the leakage of pipeline which causes low in pressure at the pipeline outlet. The system design based on the technique such that whenever a low pressure detected in the outlet oil pipeline, it will trigger alarm and send a short notification message to the dedicated system in a control unit. This system can only be effective in the presence of large leakage of oil, as the small leakage may not show significant reduction in the outlet pressure and oil pipeline punctured is not considered. However, this does not integrated machine learning and hence cannot ascertain the possibility of vandalization ahead of time.

Obodoeze et al, (2014) developed oil pipeline vandal detection and surveillance system. This work based on automated electronic pipeline vandalism detection and surveillance system with feature of intruder detection module. It is developed by integrate video camera for surveillance and capturing of any criminal intends on oil pipeline destruction. The system seems to be efficient in capturing of criminal identities, but no provision for sabotage countermeasure. Therefore, the system developed in this paper provide early notification of information acquired based on the ongoing criminal activities, so that oil pipeline vandalism can be prevented in advance before the process of digging a hole or illegal construction will be taken place. This can be enabled by integrating machine learning for prediction of vandalization and prevention.

III. Proposed System

A system was designed which displays Niger Delta government environmental data on a user-friendly web interface in order to enable the citizens to access them freely. The system uses machine learning algorithms to learn from a knowledge base and is able to give reliable information about the very critical conditions in Niger Delta.

The system has input data, the processing unit and the output. The following sections discuss the analysis of the different units of the system new system.

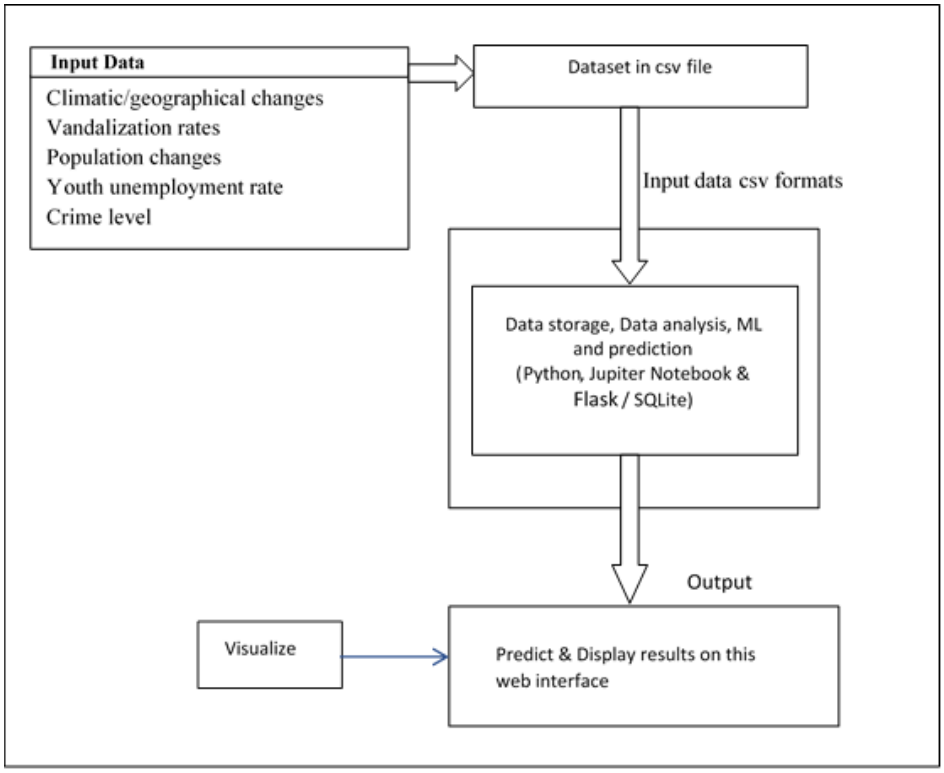

Figure 1: The overall model of the proposed system

System Description

The Input Data: The new system has sources of input data. These data are the some of the most important factors that determine the environmental conditions of Niger Delta with respect to oil vandalism and its related activities. In this study, the datasets of the following factors have been collected: Climatic/geographical changes, Vandalization rates, Population changes, youth unemployment rate and Crime level. These data collected shall also become input to the system. This dataset is converted to csv file for Machine Learning processing.

The Processing Unit: The processing of the data from the input or perception layer will be done using python programming language and its very powerful framework called Flask. At this level, the input dataset which is in csv file is stored, analyzed and used to predict the environmental conditions of the Niger Delta using Machine Learning Algorithm (Decision Tree). The data is also stored in the database (SQLite) for future retrieval and processing and display.

The output Unit: The output of the system is shown on the browser. It enables the user to visualize the prediction result and also the current data about the environmental conditions of Niger Delta Region. Flask which is a python framework has been used to design the web interface for the system. The output will include an input form where the user can enter new Niger Delta environmental data. The user then clicks the predict button and the system displays the prediction result on the screen. The result gives the user information about overall rating of the environmental features of Niger Delta.

System Implementation Tools

Anaconda Jupiter Notebook: This is required to use the .csv file retrieved to train the decision tree model for the prediction of both the vandal's activities and the display of very important information on the Niger Delta Region. The programming is done using Jupiter notebook. The file extension for Jupiter notebook is. Ipynb

Visual Studio Code: This text editor is used to write python code that will process the input data based on the decision tree model already trained with the dataset. Python and its rich libraries have made it possible for this design.

Flask python framework: Flask is a python framework for designing machine learning web application. This is also supported in the vs code. The main interface design has been done using flask. Flask also works with html and css in order to provide a good interface.

The DB Browser (SQLite database) : The DB Browser enables the retrieval and management of the data sent to the database. The database management system used is SQLite which is supported in DB Browser. The generated and sourced data are stored in the database for retrieval and processing.

IV. Discussion

The new system has been designed to provide a user-friendly web interface for the display of very critical data or information about the Niger Delta Region. This is intended to provide the Niger Delta citizens with a free (offline) access to such information and hence make effective decisions. This is very important as this region, due to its natural gifts, is the most targeted by vandals and the most vulnerable to oil explosions and other adverse effects.

The users are meant to visit the website and gain access to the current situation of things in the region. This information will be retrieved from a knowledge base and displayed for public access. The system also uses the machine learning tools to train and learn from the past experiences in the region and make a more reliable prediction. The users can also fetch new data from the current records and input them to the system for predictions.

The new system had to be tested to prove that it is very effective. The system was able to take display critical data on the web interface and the users were able to access them. Also, the system was able to take input from the users and made reliable prediction on the overall states of things in Niger Delta.

Test data: The data used for the testing is input from parameters considered as shown in Figure 2.

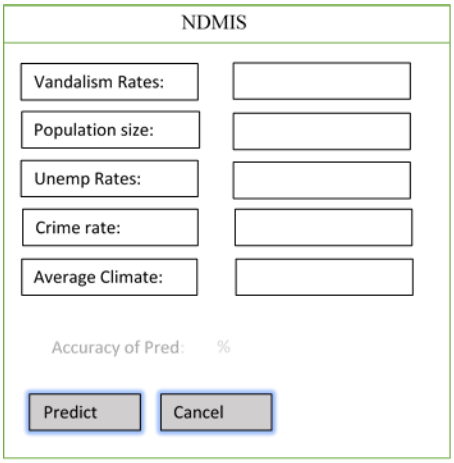

Figure 2: Parameter used in NDMIS

V. Conclusion

The Niger Delta Region of Nigeria has faced a lot of oil vandalism and other social crimes which have had effects on the citizens. The economy of the region has reduced due to incessant attacks from some groups. The development of NDMIS is very necessary as it will enable the citizens to have free access to certain data and be well informed and prepared ahead of time for any changes in the region.

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