ISSN 2829-4998

AQuamoAS: unmasking a wireless sensor-based ensemble for air quality monitor and alert system

Victor Ochuko Geteloma [a,1,*], Fidelis Obukohwo Aghware [b,2], Wilfred Adigwe [c,3], Chukwufunaya Chris Odiakaose [d,4], Nwanze Chukwudi Ashioba [d,5], Margareth Dumebi Okpor [c,6], Arnold Adimabua Ojugo [a,7], Patrick Ogholuwarami Ejeh [d,8], Rita Erhovwo Ako [a,9], Emmanuel Obiajulu Ojei [c,10]

[a] Department of Computer Science, College of Compuitng, Federal University of Petroleum Resources Effurun, Nigeria
[b] Department of Computer Science, Faculty of Computing, University of Delta Agbor, Nigeria
[c] Department of Computer Science, Faculty of Information Technology, Delta State University of Science and Technology Ozoro, Nigeria
[d] Department of Computer Science, Faculty of Information Technology, Dennis Osadebay University Anwai-Asaba, Nigeria
[1] geteloma.victor@fupre.edu.ng; [2] fidelis.aghware@unidel.edu.ng; [3] adigwew@dsust.edu.ng; [4] osegalaxy@gmail.com;
[5] nwanze.ashioba@dou.edu.ng; [6] okpormd@dsust.edu.ng; [7] ojugo.arnold@fupre.edu.ng; [8] patrick.ejeh@dou.edu.ng; [9] ako.rita@fupre.edu.ng;
[10] ojeie@dsust.edu.ng
* corresponding author

ARTICLE INFO

Article history
Received April 20, 2024
Revised July 10, 2024
Accepted August 02, 2024
Available online August 04, 2024

Keywords
Wireless sensor networks
Internet of things
Blynk platform
Air quality monitor
Environmental monitoring

ABSTRACT

The increased awareness by residents of their environment to maintain safe health states has consequently, birthed the integration of info tech to help resolve societal issues. These, and its adopted approaches have become critical and imperative in virtualization to help bridge the lapses in human mundane tasks and endeavors. Its positive impacts on society cannot be underestimated. Study advances a low-cost wireless sensor-based ensemble to effectively manage air quality tasks. Thus, we integrate an IoT framework to effectively monitors environment changes via microcontrollers, sensors, and blynk to assist users to monitor temperature, humidity, detect the presence of harmful gases in/out door environs. The blynk provides vital knowledge to the user. Our AQuaMoAS algorithm makes for an accurate and user-friendly mode using cloud services to ease monitor and data visualization. The system was tested at 3 different stages of rainy, sunny and heat with pollutant via alpha est method. For all functions at varying conditions, result revealed 70.7% humidity, 29.5OC, and 206 ppm on a sunny day. 51.5% humidity, 20.4OC and 198ppm on a rainy, and 43.1 humidity, 45.6OC, 199ppm air quality on heat and 66.5% humidity, 30.2 OC and 363 ppm air quality on application of air pollutant were observed.

1. Introduction

With the fast-paced urbanization, environmental problems have since become of crucial concerns [1] that needs immediate addressing both to residents and companies [2]. The rise in adoption of technology especially with the consequent adoption of the Internet of Things (IoT) in every facet of human endeavor [3] have made it the new frontier to help mitigate environment related and associated hazards. IoTs have become a significant discourse as it involves the better utilization of resources that are rippled with sensor-based functions, and their unfettered access cum untethered nature by wires [4] as they provide businesses with new schemes to enhance monetization [5]. Environmental monitoring has and still benefits from IoT-based interventions [6]. Studies show that IoT-sensor networks use superior gadgets to identify the presence of pollutants both in air and water [7]. And thus, promote better sustainability measures to healthy-living that ensures purer air-water-quality with safer, cleaner society via smart environment tracking solution [8]. With closed off area like underground mines, workplace premises, or rooms – it becomes both critical and essential to hold positive surroundings [9]–[11].

Air and water information, captured via the sensors [12] are dispatched via gateways to provide residents and workers with an alert mode for early warning [13]. By these, businesses can easily retrieve knowledge in a user-friendly form via dashboard [14], and analyse such for higher outcomes [15]. Air quality situation today, requires the careful targeted monitoring of a variety of environmental features that accounts for solution to such tasks. A technical form display of environmental situations with ongoing modifications as measured by these sensors, have become vital. IoTs offer an efficient means to track such [16] efficiently as well as retrieve numerous feature statistics. IoTs have become veritable tools today, to track changing-environment conditions such as smoke [17], liquid gas [18], carbon gases [19], air temperature [20], and humidity [21] are the specified indices which are required to be monitored and investigated to have a complete concept of the encompassing environment .

IoTs adoption and adaptartion have since become a great deal and interactive for the consumer as it aids global sustainable boom that relies on a variety of societal factors ranging from finance system, high-quality schools, agriculture, and industries etc all of which plays their role in the improvement of lives [22]–[25]. Health key feats for sustainable humanity comes from a smooth, pollutants-loose, and threat-free environment. Thus, its tracking becomes critical to make certain that the citizens of any state can lead a wholesome lifestyle [26]. Environment tracking includes right making plans and control of disasters, control varying pollutions and successfully addressing inherent challenges with unhealthy environ-situations [27]. It resolves water and air pollution, radiation, climate adjustments, earthquake events, etc as contributed via several factors. Environ tracking must be targeted to resolve these challenges in order to provision for a wholesome society [28]. Businesses today, that integrate the use of physical servers with onsite/off-site locations will often profit from low-cost implementation [29]–[31], reduced maintenance cost, improved simplification that accompanies a virtualized mode [32], [33] of shared resources. Virtualization enables the expansion of hardware without restrictions that results in accompanying dearth of possibilities that can be harnessed in one location [34]–[36].

2. Method

2.1. Sensor-Based Networks (SBN): Related Literature

SBN have often been found to be fastidious in their adoption, flexibility of use and extensive in their adaptation of the wireless virtual technology [37]. Virtualization as used by many systems globally includes a variety of automation ranging from virtual remote-based light controllers, smart interfaces etc. At its core is the embedded system that can adjusted with little modification to actualize virtual assistive techs [38]. These can be retrofitted to fully utilize mobile devices capabilities – enhancing life's quality [39]–[41]. With fast-paced advances, SBN provide users with cost-effective, robust, and low-maintenance solutions [42]–[44].

Kong et al. [45] designed an RFID-based automatic access control system that employed its Universal Serial Bus (USB) as an effective means to communicate/interface with a host computer machine using the PIC 16f877A. [46] improved the system via RFID scanner to rule out unauthorized access [47]–[49]. Pradeepa and Parveen [50] presented a smart home technology using the Bluetooth of a mobile device. The hardware design for its door-lock system is the combination of an android smartphone features such as the taskmaster, Bluetooth module as command agent, Arduino microcontroller was used as its controller and data processing center, and solenoid door lock [51], [52]. Joshi et al. [53] focused on the use of SBN and IoTs in fuel stations on a wider utilization. Zawislak et al., [54] investigated the automatic password-based door locks by utilizing electronic technology to build an integrated, fully customized home security system at a reasonable cost. The project is useful in keeping thieves and other sorts of dangers at bay [55]–[58].

Bhavani et al. [59] extended Singh et al. [60] via RFID-based automatic access control system that used a Universal Serial Bus (USB) to communicate with a host machine via a PIC-16f877A. System features registration and deletion of IDs makes the system more flexible [61]; But, lacks faculties for computer vision [62]. Zardi et al., [63] designed a password-protected system controlled by the ATmega-328. The system was also built so it could be locked via one-key. If the password is matched with a pre-decided password, then the Arduino simply operates the relay to open the lights and fan. The Arduino simultaneously operates a DC motor through a motor driver for operating the door [63]–[65].

2.2. Smart Environment Monitoring (SEM) Systems

A smart environmental monitoring system (SEM) is a tool and/or technique that monitors the quality of the environment. It often explores the use of programs with real-time parameters needed for monitoring of a variety of forms [66]. The SEM proffers solutions to relative humidity, temperature, frost factor, differential stress, stress, float, lux, and CO2 etc [67]. SEM captures data in a variety of format that contributes to showing how the world behaves, how living changes and conditions impacts on it and vice versa, and how all these can be controlled. EM data may be retrieved from nature and industrial processes (e.g. waste, vehicle emissions etc). The adoption of IoT has traversed a specific range of use to include smart buildings [68], smart cities [69], and smart industry [70]–[72]. Its use in air monitor can result in geographical info systems, monitor pollution, and meteorological data to analyze air pollutants. It can also be used in water monitor analysis, radiological and biological data in water samples [73], [74].

In tracking, soil grabs are monitored for salinity, contamination, and acidity to research soil pleasant in farming and to are expecting the capability for erosion, flooding, and threats to environmental biodiversity [75], [76]. Environmental monitoring includes data tracking and analysis such as traffic volume, security, resource scarcity trace, city infrastructure, and food security. It can also extend to monitoring in greenhouse gases (GHGs), which has since today – become the biggest challenge in smart environs [77]. These massive data need to be sifted, monitored, analyzed, and proactively used to create solutions for everyday challenges.

The goal of SEM thus, is to help individuals and businesses cope with the rising trends and demands therein from the unwarranted effects on the environ via smart tracking using key indicators that dictates and ensures that the health of the society, is well-regulated. Its strategies are performed using a set of diverse tools and techniques aiming to serve certain functions such as weather forecast, air pollutants management, water exceptions control, and agriculture monitoring and crop damage evaluation, etc [78]. It seeks to advance favorable environmental situations for earth's inhabitants [79]. IoTs have eased tracking of the surroundings for ease of manageability. SEM systems are reported inside the literature using special sorts of smart sensors, wireless sensor networks (WSNs) [80], and IoT devices; those devices, communicating through the networks, have helped the environment monitoring as a clever tracking device, capable of deal with the challenges in variable situations [81]–[83].

2.3. Study Motivation

The study is motivated as thus [84]–[87], and seeks to achieve the following:

- Security: To ensure the ensemble is secured from unauthorized access and tampering – we use the blynk system via the mobile smartphone or over a user firewalled PC. With security a critical component, it can be applied to other aspects of our daily endeavour.
- Privacy Integration with IoTs: A key challenge in the deployment of Internet of things (IoT)-based and enabled systems is that of privacy from adversarial attacks, threat cum unauthorized-to-compromised access. To enhance user-trust and privacy, such IoT-based mechanisms are linked to the Internet via smart mobile devices. This is aimed at ensuring the generated system is robust, productive and innovative.
- Low Cost, Efficient Energy: Deploying for use, virtual keycard door lock system often makes it energy-efficient, it reduces its implementation cost, and ensures it is at a cheaper cost of maintenance. While, cheaper maintenance is not a panacea for improved system reliability – its use is very restrictive so that only a few clients, individuals or organizations can afford it. Biometric systems often have been found to violate users' privacy as some users often consider them to be personally invasive due to loss of anonymity.

Study seeks to deploy a wireless sensor-based air quality monitor ensemble via the IoT-enabled device(s).

2.4. The Experimental Air Quality Monitor and Alert Ensemble

The existing output design primarily revolves around a seamless and efficient user experience as with Obruche et al., [12] – an air pollution monitoring system that seeks to monitor the amount of gas in the air. The system uses blynk as its mobile interface, where outputs are shown using gauges to read the air conditions. The wireless sensor senses pollutant in the air, it sends the signal to the Arduino processor, which then transmit, to the analytical module. Then the output is gotten from the gauge. The more the air is polluted the higher the gauge rises – as in Fig. 1.

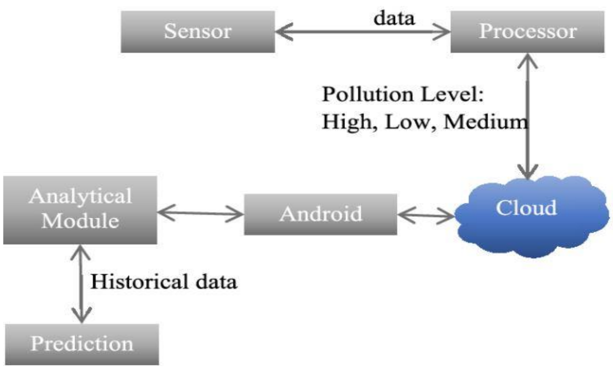

Fig. 1. Dataset before applying SMOTE

The proposed wireless sensor-based IoT system is built to monitor air pollution via recognition of gases as well as monitor the temperature of the environment. It allows users to monitor environ temperature, humidity and the presence of dangerous gases for both in/out-door uses. The ensemble consists of the ESP8266 (i.e. node-MCU), sensors and others processing units that aids the ensemble to accomplish a variety of task [88]. The ESP8266 is responsible for sensor data collection, formatting the data, and sending it to the sensor gateway. The ESP8266 initiates requests and activates the power control unit, and ensuring that the appropriate current cum voltages, is set for the activated sensor unit.

The ESP8266 (i.e. node-MCU) then reads the retrieved data from the sensor, and either turns off the power along the sensor to ensure a low current consumption. The data is stored in the web server [89] so that a user can get access the information anywhere in the world through an internet connection. In the proposed work, a web application is will be developed to provide vital information to the user [90]. The user can also set up a notification for critical changes in the sensor data. In comparison to related works [91], the proposed system is low-cost, accurate, and user-friendly. It is also cloud-based and has easy monitoring and data visualization modules. Scematic diagram of the experimental system as show in Fig. 2. Circuitry diagram of the Experimental System show as Fig. 3.

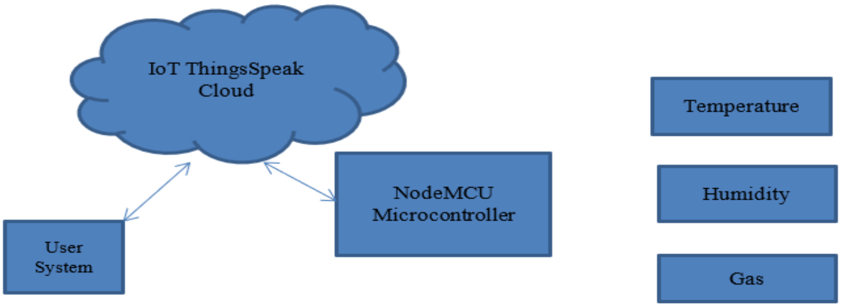

Fig. 2. Scematic diagram of the experimental system

Table 1 shows the confusion matrix before/after the application of SMOTE and agrees with [92], [93] with outlier effects, which also agrees with [11], [84], [94], [95] that RF outperformed other benchmark models as it was best in its ability to balance accuracy, recall, and precision successfully. It also supports the effectiveness and efficiency of the RF ensemble offering a detailed perspective of the ensemble's performance in differentiating between genuine positives, true negatives, false positives, and false negatives.

Table 1. Performance metrics of 'before' feature selection compared with SMOTE

Test Metrics	Conditions	Humidity	Temparature	Air Quality
Time Complexity	Heat	43.1	45.6	199
	Gas	66.5	30.2	363
Sensitivity	Heat	51.5	20.4	198
	Gas	79.4	24.3	192
Precision	Heat	62	28.7	199
	Gas	70.7	29.5	206

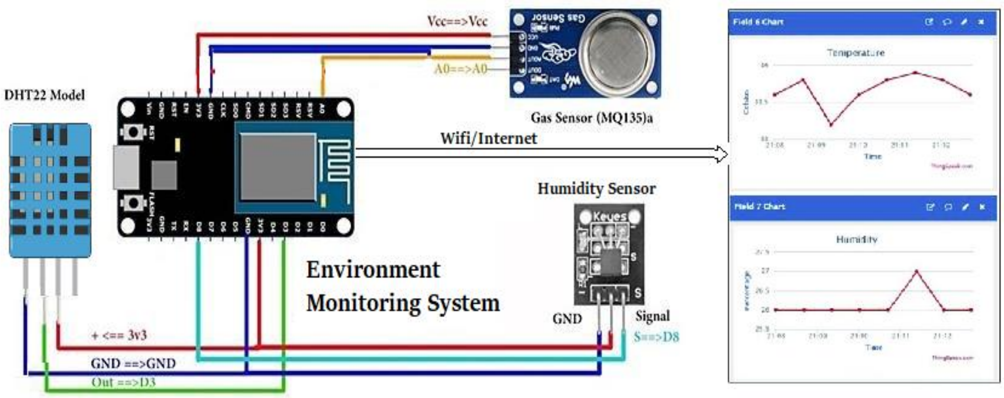

Fig. 3. Circuitry diagram of the Experimental System

The system will run on a mobile platform where it will give its user a friendly interface to interact and access sensor data from the designed hardware. The blynk platform will be used for the IoT integration and the Node MCU board will be used to connect the temperature and gas sensor. It values from these sensors will be shown in a control called a gauge which will enable the readings of data from sensors. Its mobile platform will alert the user of air pollution when the system senses pollutants in the air and notify the user when the temperature becomes dangerous to health. The proposed system will be an IoT-based system built to monitor both air pollution and the temperature of the environment. The system will run on a mobile platform where it will give its user a friendly interface to interact and access sensor data from the designed hardware. The blynk platform will be used for the IoT integration and the Node MCU board will be used to connect the temperature and gas sensor. It values from these sensors will be shown in a control called a gauge which will enable the readings of data from sensors. Its mobile platform will alert the user of air pollution when the system senses pollutants in the air and notify the user when the temperature becomes dangerous to health.

Some major benefits the proposed system offers will include: (a) an enhanced device compatibility, supports a wide range of NFC-enabled devices for seamless access, (b) advanced security measures, including two-factor authentication and data encryption, ensure robust protection against unauthorized access and data breaches, (c) a fail-safe mechanism that provides continuous access control with fault tolerant features for the system failure or network connectivity, (d) an equally streamlined integration with existing infrastructure to facilitate efficient data synchronization and operations, (e) an intuitive user interface that ease management of access permissions, (f) an improved user experience, and (g) improved security that will therein improve user-trust, confidence level and safeguards personal information. Algorithm: The AQuaMOAS Algorithm

```
Step 1: System reads the environment through sensors
Step 2: The system displays the value of the readings on the user interface via blynk
Step 3: If air quality above 300 ppm, then display "Air Pollution Detected"
    Else: take readings
Endif
Function Get temperature readings:
Read data from DTH11 sensor
If sensor data value exist Then
          Show temperature and humidity value
        Display "Data Readings" in smart Phone and PC app
        If temperature value is greater 300C then
        Display notification "Temperature is above 300C"
Else-if
    Sensor data value does not exist then check connections
End-if
Function: Get Air Quality Readings:
Read data from MQ5 sensor
If sensor data value exist then
        Show air quality value
        Display "Data Readings" in smart Phone and PC app
        If air quality value is greater 300 ppm then
        Display notification "Air Pollution Detected"
Else-if
    Quality value does not exist then
          Check connections
End-if
```

3. Results and Discussion

3.1. Experimental System Performance and Evaluation

Its user interface allows the user to interact with the system, and it determines how commands are sent or given to the program as well as how much information is to be displayed on the screen [96], [97] as in Fig. 4.

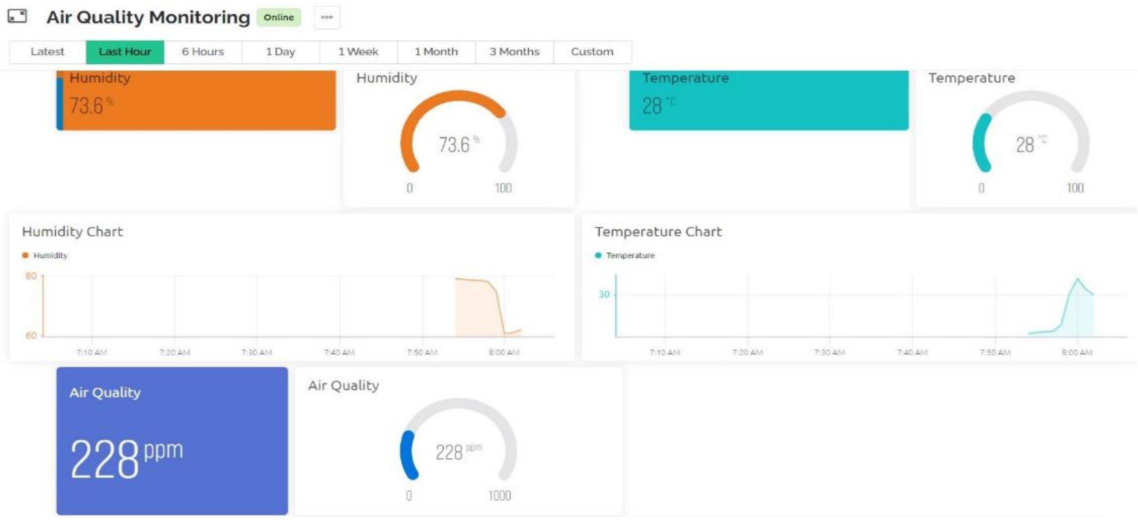

Fig. 4. Main system control dashboard with gauges for measurement

Fig. 4 shows the output interface of the system with gauges for humidity as measured in percentage, temperature as measured in degrees, and air quality monior and alert as measured in part per million (PPM) as used in expressing a completely dilute concentration stage of pollutants inside air, water, and other fluids. The interface also shows additional charts as sensors read the environment. This agrees with [98].

The system has been evaluated in different stages. After trying out all the capabilities in one of kind situations, it suggests a high degree of accuracy and reliability. From the readings, it is seen that a change in temperature and air quality is observed and read by the system at the different stages of test. The system yields a 99.5% accuracy in reading the societal conditions of both the heat and gas for the measures of: (a) precision, (b) sensitivity, and (c) time complexity to reach a solution cum reading at various times – which is based on the access rights as defined in the web application.

The system was found to have great fault-tolerance and was compatible with a major of the near feature compatible tags and its accompanying devices. This agrees with [99]. Table 1 also shows performance result that can allow the wireless sensor ensemble to be integrated on to a variety of other applications and platforms as embedded system. Making it a more efficient and effective unit to be integrated on to existing system designs. We also evaluated based on several key metrics to include access control speed, its reliability, and user convenience respectively as in agreement with. This quick response time allowed for smooth and efficient access management. This is in agreement with [100]–[102].

3.2. Discussion of Findings

We successfully used an ESP32 controller, a solenoid lock, a web API, and a web app to manage the access of authorized personnel. It yields several benefits like increased security, efficiency, and convenience. It eliminates the issues associated with traditional approach [103] and inconvenience of operations of physical monitoring, and the lack thereof – of real-time access control [104]. The commercialization of this system will bring consciousness to the inhabited environment. This consciousness is driving the need to develop a reliable air quality monitoring system in lieu of its uniqueness to industrial applications [105], [106]. In mining and/or heavy industry, there may be an opportunity of air infection by way of unique dangerous gases [107].

In such hazardous situations, air quality monitors can potentially save the lives of workers [108]–[110]; And its deployment on a massive-scale can effectively aid data collection and retrieval, records control, and minimize all power consumption troubles [111]–[113]. IoT technology is specifically suited for this sort of need especially with its inherent security schemes against phshing attacks and threats [114]–[116]. Thus, in this study we presented an IoT-based wireless sensor-based environmental monitoring and alert framework cum ensemble that successfully monitors the change in a surrounding using sensors, microcontrollers, and IoT-based technology. Users can monitor temperature, and humidity, and detect the presence of dangerous gases both within the indoor and outdoor environment using proposed module [117]. The study has also contributed by demonstrating the inherent potentials in the use of IoTs/embedded systems to provide innovative solutions to complex problems in various industries [118]–[120].

4. Conclusion

The air quality monitor system is made from low cost components easily available and is used to monitor a variety of environmental parameters. This is also in agreement with [121]–[123]. The system can also be easily adopted and adapted for both indoor and outdoor environmental usage. The proposed system has been tested several times with different parameters, with successful all round performance in reachability, availability, throughput, and scalability yielding results that also agrees with [124], [125].

Finally, this device can connect to the gateway via WiFi [126] without many design changes; Thus, making it suitable for different scenarios [127], [128]. This system is consequently flexible, adaptable, robust and scalable. In the future, the research work is intended to introduce several machine-learning techniques that will give more insight to the user. Besides, to manage changes efficiently, the records can be kept in a secure immutable digital ledger using technologies like Blockchain.

Declarations

Author contribution. "Conceptualization: A.A. Ojugo, P.O. Ejeh and C.C. Odiakaose; Methodology, A.A. Ojugo., N.C. Ashioba; Software: R.E. Ako., M.D. Okpor and W. Adigwe; Formal Analysis: F.O. Aghware and E.O. Ojei; Investigation: R.E. Ako and F.O. Aghware; Resources: W. Adigwe and E.O. Ojei; Data Curation: N.C. Ashioba and M.D. Okpor; writing—original draft preparation: C.C. Odiakaose and P.O. Ejeh; writing—review and editing: V.O. Geteloma; visualization: A.A. Ojugo and V.O. Geteloma; supervision: A.A. Ojugo; funding: All

Funding statement. None of the authors have received any funding or grants from any institution or funding body for the research.

Conflict of interest. The authors declare no conflict of interest.

Additional information. No additional information is available for this paper.

References

[1] A. A. Ojugo, P. O. Ejeh, C. C. Odiakaose, A. O. Eboka, and F. U. Emordi, "Predicting rainfall runoff in Southern Nigeria using a fused hybrid deep learning ensemble," *Int. J. Informatics Commun. Technol.*, vol. 13, no. 1, p. 108, Apr. 2024, doi: 10.11591/ijict.v13i1.pp108-115.

[2] J. K. Oladele *et al.*, "BEHeDaS: A Blockchain Electronic Health Data System for Secure Medical Records Exchange," *J. Comput. Theor. Appl.*, vol. 2, no. 1, pp. 1–12, 2024, doi: 10.33633/jcta.v2i19509.

[3] C. C. Odiakaose *et al.*, "Hybrid Genetic Algorithm Trained Bayesian Ensemble for Short Messages Spam Detection," *J. Adv. Math. Comput. Sci.*, vol. 12, no. 1, pp. 37–52, 2024, doi: 10.22624/AIMS/MATHS/V12N1P4.

[4] F. Balducci, D. Impedovo, and G. Pirlo, "Machine Learning Applications on Agricultural Datasets for Smart Farm Enhancement," *Machines*, vol. 6, no. 3, p. 38, Sep. 2018, doi: 10.3390/machines6030038.

[5] M. I. Akazue *et al.*, "Handling Transactional Data Features via Associative Rule Mining for Mobile Online Shopping Platforms," *Int. J. Adv. Comput. Sci. Appl.*, vol. 15, no. 3, pp. 530–538, 2024, doi: 10.14569/IJACSA.2024.0150354.

[6] L.-M. Ang, K. P. Seng, G. K. Ijemaru, and A. M. Zungeru, "Deployment of IoV for Smart Cities: Applications, Architecture, and Challenges," *IEEE Access*, vol. 7, pp. 6473–6492, 2019, doi: 10.1109/ACCESS.2018.2887076.

[7] K. W. Brown and T. J. Armstrong, *Hydrocarbon Inhalation*, p. 263, 1st ed. StatPearls Publishing, 2023. [Online]. Available at: https://pubmed.ncbi.nlm.nih.gov/29262161/.

[8] A. A. Ojugo and O. Otakore, "Mitigating Social Engineering Menace in Nigerian Universities," *J. Comput. Sci. Appl.*, vol. 6, no. 2, pp. 64–68, Aug. 2018, doi: 10.12691/jcsa-6-2-2.

[9] D. Nahavandi, R. Alizadehsani, A. Khosravi, and U. R. Acharya, "Application of artificial intelligence in wearable devices: Opportunities and challenges," *Comput. Methods Programs Biomed.*, vol. 213, p. 106541, Jan. 2022, doi: 10.1016/j.cmpb.2021.106541.

[10] A. A. Ojugo and O. Debby Otakore, "Forging An Optimized Bayesian Network Model With Selected Parameters For Detection of The Coronavirus In Delta State of Nigeria," *J. Appl. Sci. Eng. Technol. Educ.*, vol. 3, no. 1, pp. 37–45, Apr. 2021, doi: 10.35877/454RI.ASCI2163.

[11] C. C. Odiakaose, "A Pilot Study to Enhance Semi Urban Tele Penetration and Services Provision for Undergraduates via the Effective Design and Extension of a Campus Telephony," *FUPRE J. Sci. Ind. Res.*, vol. 7, no. 3, pp. 35–48, Sep. 2023. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/226.

[12] C. O. Obruche and R. A. Abere, "Deployment of a Virtual Key-Card Smart-Lock System: The Quest for Improved Client Security, Eased User Mobility and Privacy," *FUPRE J. Sci. Ind. Res.*, vol. 8, no. 1, pp. 39–54, Jan. 2024. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/251.

[13] R. E. Yoro, F. O. Aghware, B. O. Malasowe, O. Nwankwo, and A. A. Ojugo, "Assessing contributor features to phishing susceptibility amongst students of petroleum resources varsity in Nigeria," *Int. J. Electr. Comput. Eng.*, vol. 13, no. 2, p. 1922, Apr. 2023, doi: 10.11591/ijece.v13i2.pp1922-1931.

[14] N. N. Wijaya, D. R. I. M. Setiadi, and A. R. Muslikh, "Music-Genre Classification using Bidirectional Long Short-Term Memory and Mel-Frequency Cepstral Coefficients," *J. Comput. Theor. Appl.*, vol. 2, no. 1, pp. 13–26, 2024, doi: 10.62411/jcta.9655.

[15] A. A. Ojugo and R. E. Yoro, "Predicting Futures Price And Contract Portfolios Using The ARIMA Model: A Case of Nigeria's Bonny Light and Forcados," *Quant. Econ. Manag. Stud.*, vol. 1, no. 4, pp. 237–248, Aug. 2020, doi: 10.35877/454RI.qems139.

[16] A. A. Ojugo and O. Nwankwo, "Spectral-Cluster Solution For Credit-Card Fraud Detection Using A Genetic Algorithm Trained Modular Deep Learning Neural Network," *JINAV J. Inf. Vis.*, vol. 2, no. 1, pp. 15–24, Jan. 2021, doi: 10.35877/454RI.jinav274.

[17] O. A. Onyan, D. U. Onyishi, and R. Onawharaye, "Development of an IoT-based wireless remote health monitoring device," *FUPRE J. Sci. Ind. Res.*, vol. 8, no. 2, pp. 01–11, Feb. 2024. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/271.

[18] S. U. Okperigho, B. Nwozor, and V. O. Geteloma, "Deployment of an IoT Storage Tank Gauge and Monitor," *FUPRE J. Sci. Ind. Res.*, vol. 8, no. 1, pp. 55–68, Jan. 2024. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/252.

[19] A. Shoeibi *et al.*, "Detection of epileptic seizures on EEG signals using ANFIS classifier, autoencoders and fuzzy entropies," *Biomed. Signal Process. Control*, vol. 73, p. 103417, Mar. 2022, doi: 10.1016/j.bspc.2021.103417.

[20] S. Sendra, L. García, J. Lloret, I. Bosch, and R. Vega-Rodríguez, "LoRaWAN Network for Fire Monitoring in Rural Environments," *Electronics*, vol. 9, no. 3, p. 531, Mar. 2020, doi: 10.3390/electronics9030531.

[21] B. Sarwar, I. S. Bajwa, N. Jamil, S. Ramzan, and N. Sarwar, "An Intelligent Fire Warning Application Using IoT and an Adaptive Neuro-Fuzzy Inference System," *Sensors*, vol. 19, no. 14, p. 3150, Jul. 2019, doi: 10.3390/s19143150.

[22] A. A. Ojugo and O. D. Otakore, "Investigating The Unexpected Price Plummet And Volatility Rise In Energy Market: A Comparative Study of Machine Learning Approaches," *Quant. Econ. Manag. Stud.*, vol. 1, no. 3, pp. 219–229, Jun. 2020, doi: 10.35877/454RI.qems12119.

[23] A. A. Ojugo *et al.*, "Forging a learner-centric blended-learning framework via an adaptive content-based architecture," *Sci. Inf. Technol. Lett.*, vol. 4, no. 1, pp. 40–53, May 2023, doi: 10.31763/sitech.v4i1.1186.

[24] A. A. Ojugo and O. Nwankwo, "Modeling Mobility Pattern for the Corona-Virus Epidemic Spread Propagation and Death Rate in Nigeria using the Movement-Interaction-Return Model," *Int. J. Emerg. Trends Eng. Res.*, vol. 9, no. 6, pp. 821–826, Jun. 2021, doi: 10.30534/ijeter/2021/30962021.

[25] V. Geteloma, C. K. Ayo, and R. N. Goddy-Wurlu, "A Proposed Unified Digital Id Framework for Access to Electronic Government Services," *J. Phys. Conf. Ser.*, vol. 1378, no. 4, p. 042039, Dec. 2019, doi: 10.1088/1742-6596/1378/4/042039.

[26] D. A. Oyemade, "Deploying an IoT Enabled Realtime Fire Detection and Alert Model for Residential Homes," *FUPRE J. Sci. Ind. Res.*, vol. 8, no. 2, pp. 219–229, Feb. 2024. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/285.

[27] P. Manickam *et al.*, "Artificial Intelligence (AI) and Internet of Medical Things (IoMT) Assisted Biomedical Systems for Intelligent Healthcare," *Biosensors*, vol. 12, no. 8, p. 562, Jul. 2022, doi: 10.3390/bios12080562.

[28] S. Og and L. Ying, "The Internet of Medical Things," in *2nd International Conference on Machine Learning and Computer Application*, 2021, pp. 273–276. [Online]. Available at: https://ieeexplore.ieee.org/document/9736747.

[29] F. O. Aghware, R. E. Yoro, P. O. Ejeh, C. C. Odiakaose, F. U. Emordi, and A. A. Ojugo, "DeLClustE: Protecting Users from Credit-Card Fraud Transaction via the Deep-Learning Cluster Ensemble," *Int. J. Adv. Comput. Sci. Appl.*, vol. 14, no. 6, pp. 94–100, 2023, doi: 10.14569/IJACSA.2023.0140610.

[30] F. O. Aghware, R. E. Yoro, P. O. Ejeh, C. Odiakaose, F. U. Emordi, and A. A. Ojugo, "Sentiment Analysis in Detecting Sophistication and Degradation Cues in Malicious Web Contents," *Kongzhi yu Juece/Control Decis.*, vol. 38, no. 01, pp. 653–665, 2023. [Online]. Available at: https://www.kzyjc.org/article/sentiment-analysis-in-detecting-sophistication-and-degradation-cues-in-malicious-web-contents.

[31] A. A. Ojugo, M. I. Akazue, P. O. Ejeh, C. Odiakaose, and F. U. Emordi, "DeGATraMoNN: Deep Learning Memetic Ensemble to Detect Spam Threats via a Content-Based Processing," *Kongzhi yu Juece/Control Decis.*, vol. 38, no. 01, pp. 667–678, 2023. [Online]. Available at: https://www.kzyjc.org/article/degatramonn-deep-learning-memetic-ensemble-to-detect-spam-threats-via-a-content-based-processing.

[32] J. R. Amalraj and R. Lourdusamy, "A Novel Distributed Token-Based Access Control Algorithm Using A Secret Sharing Scheme for Secure Data Access Control," *Int. J. Comput. Networks Appl.*, vol. 9, no. 4, p. 374, Aug. 2022, doi: 10.22247/ijcna/2022/214501.

[33] E. Ileberi, Y. Sun, and Z. Wang, "A machine learning based credit card fraud detection using GA algorithm for feature selection," *J. Big Data*, vol. 9, no. 1, p. 24, Dec. 2022, doi: 10.1186/s40537-022-00573-8.

[34] I. A. Anderson and W. Wood, "Habits and the electronic herd: The psychology behind social media's successes and failures," *Consum. Psychol. Rev.*, vol. 4, no. 1, pp. 83–99, Jan. 2021, doi: 10.1002/arcp.1063.

[35] I. Benchaji, S. Douzi, B. El Ouahidi, and J. Jaafari, "Enhanced credit card fraud detection based on attention mechanism and LSTM deep model," *J. Big Data*, vol. 8, no. 1, p. 151, Dec. 2021, doi: 10.1186/s40537-021-00541-8.

[36] Y. Gao, S. Zhang, and J. Lu, "Machine Learning for Credit Card Fraud Detection," in *Proceedings of the 2021 1st International Conference on Control and Intelligent Robotics*, Jun. 2021, pp. 213–219, doi: 10.1145/3473714.3473749.

[37] A. Ometov *et al.*, "A Survey on Wearable Technology: History, State-of-the-Art and Current Challenges," *Comput. Networks*, vol. 193, p. 108074, Jul. 2021, doi: 10.1016/j.comnet.2021.108074.

[38] D. Upadhyay and S. Sampalli, "SCADA (Supervisory Control and Data Acquisition) systems: Vulnerability assessment and security recommendations," *Comput. Secur.*, vol. 89, p. 101666, Feb. 2020, doi: 10.1016/j.cose.2019.101666.

[39] A. E. Ibor, E. B. Edim, and A. A. Ojugo, "Secure Health Information System with Blockchain Technology," *J. Niger. Soc. Phys. Sci.*, vol. 5, no. 992, pp. 1–8, 2023, doi: 10.46481/jnsps.2022.992.

[40] A. A. Ojugo and E. O. Ekurume, "Predictive Intelligent Decision Support Model in Forecasting of the Diabetes Pandemic Using a Reinforcement Deep Learning Approach," *Int. J. Educ. Manag. Eng.*, vol. 11, no. 2, pp. 40–48, Apr. 2021, doi: 10.5815/ijeme.2021.02.05.

[41] S. Sreejith, R. Ramya, R. Roja, and A. S. Kumar, "Smart Bin For Waste Management System," in *2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, Mar. 2019, pp. 1079–1082, doi: 10.1109/ICACCS.2019.8728531.

[42] M. Nasser Al-Mhiqani, R. Ahmed, Z. A. Zainal Abidin, and S. N. Isnin, "An Integrated Imbalanced Learning and Deep Neural Network Model for Insider Threat Detection," *Int. J. Adv. Comput. Sci. Appl.*, vol. 12, no. 1, pp. 573–577, 2021, doi: 10.14569/IJACSA.2021.0120166.

[43] R. A. Alsowail and T. Al-Shehari, "A Multi-Tiered Framework for Insider Threat Prevention," *Electronics*, vol. 10, no. 9, p. 1005, Apr. 2021, doi: 10.3390/electronics10091005.

[44] T. Sutikno, M. H. Ar-Rasyid, T. Wahono, and W. Arsadiando, "Internet of things with NodeMCU ESP8266 for MPX-5700AP sensor-based LPG pressure monitoring," *Int. J. Adv. Appl. Sci.*, vol. 12, no. 3, p. 257, Sep. 2023, doi: 10.11591/ijaas.v12.i3.pp257-264.

[45] S. G. Kong, D. Jin, S. Li, and H. Kim, "Fast fire flame detection in surveillance video using logistic regression and temporal smoothing," *Fire Saf. J.*, vol. 79, pp. 37–43, Jan. 2016, doi: 10.1016/j.firesaf.2015.11.015.

[46] A. Kim, J. Oh, J. Ryu, and K. Lee, "A Review of Insider Threat Detection Approaches With IoT Perspective," *IEEE Access*, vol. 8, pp. 78847–78867, 2020, doi: 10.1109/ACCESS.2020.2990195.

[47] P. T. Kortum and A. Bangor, "Usability Ratings for Everyday Products Measured With the System Usability Scale," *Int. J. Hum. Comput. Interact.*, vol. 29, no. 2, pp. 67–76, Jan. 2013, doi: 10.1080/10447318.2012.681221.

[48] A. A. Ojugo and A. O. Eboka, "Mitigating Technical Challenges via Redesigning Campus Network for Greater Efficiency, Scalability and Robustness: A Logical View," *Int. J. Mod. Educ. Comput. Sci.*, vol. 12, no. 6, pp. 29–45, Dec. 2020, doi: 10.5815/ijmecs.2020.06.03.

[49] A. A. Ojugo *et al.*, "Forging a User-Trust Memetic Modular Neural Network Card Fraud Detection Ensemble: A Pilot Study," *J. Comput. Theor. Appl.*, vol. 1, no. 2, pp. 1–11, Oct. 2023, doi: 10.33633/jcta.v1i2.9259.

[50] P. Kanagaraj and M. Parveen, "A Survey on Routing Protocols With Security in Internet of Things," *Int. Virtual Conf. Emerg. Trends Comput.*, vol. 63, no. 04, pp. 38–111, 2020, [Online]. Available at: https://www.researchgate.net/publication/352678798_Solid_State_Technology_8060_A_Survey_on_Routing_Protocols_With_Security_in_Internet_of_Things.

[51] C. Joshi, J. R. Aliaga, and D. R. Insua, "Insider Threat Modeling: An Adversarial Risk Analysis Approach," *IEEE Trans. Inf. Forensics Secur.*, vol. 16, pp. 1131–1142, 2021, doi: 10.1109/TIFS.2020.3029898.

[52] R. Joshi and P. S. Vaghela, "Online buying habit: an empirical study of Surat City," *Int. J. Mark. Trends*, vol. 21, no. 2, pp. 1–15, 2018. [Online]. Available at: https://www.researchgate.net/publication/305754198_online_buying_habit_an_empirical_study_of_surat_city.

[53] P. Joshi, A. Solomy, A. Suresh, K. Kachroo, and P. Deshmukh, "Smart Fuel Station," in *SSRN Electronic Journal*, Apr. 2020, pp. 1–3, doi: 10.2139/ssrn.3572319.

[54] P. A. Zawislak, F. M. Reichert, D. Barbieux, A. M. S. Avila, and N. Pufal, "The dynamic chain of innovation: bounded capabilities and complementarity in agribusiness," *J. Agribus. Dev. Emerg. Econ.*, vol. 13, no. 5, pp. 657–670, Nov. 2023, doi: 10.1108/JADEE-04-2021-0096.

[55] R. E. Yoro and A. A. Ojugo, "An Intelligent Model Using Relationship in Weather Conditions to Predict Livestock-Fish Farming Yield and Production in Nigeria," *Am. J. Model. Optim.*, vol. 7, no. 2, pp. 35–41, 2019. [Online]. Available at: https://www.sciepub.com/AJMO/abstract/11179.

[56] R. E. Yoro and A. A. Ojugo, "Quest for Prevalence Rate of Hepatitis-B Virus Infection in the Nigeria: Comparative Study of Supervised Versus Unsupervised Models," *Am. J. Model. Optim. Vol. 7, 2019, Pages 42-48*, vol. 7, no. 2, pp. 42–48, Nov. 2019. [Online]. Available at: https://pubs.sciepub.com/ajmo/7/2/2/index.html.

[57] D. Sun, M. Liu, M. Li, Z. Shi, P. Liu, and X. Wang, "DeepMIT: A Novel Malicious Insider Threat Detection Framework based on Recurrent Neural Network," in *2021 IEEE 24th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, May 2021, pp. 335–341, doi: 10.1109/CSCWD49262.2021.9437887.

[58] A. P. Singh and A. Sharma, "A systematic literature review on insider threats," *arXiv*, pp. 1–9, Dec. 2022. [Online]. Available at: https://arxiv.org/abs/2212.05347v1.

[59] D. B. A and N. Mangla, "A Novel Network Intrusion Detection System Based on Semi-Supervised Approach for IoT," *Int. J. Adv. Comput. Sci. Appl.*, vol. 14, no. 4, pp. 207–216, 2023, doi: 10.14569/IJACSA.2023.0140424.

[60] F. S. Leira, H. H. Helgesen, T. A. Johansen, and T. I. Fossen, "Object detection, recognition, and tracking from UAVs using a thermal camera," *J. F. Robot.*, vol. 38, no. 2, pp. 242–267, Mar. 2021, doi: 10.1002/rob.21985.

[61] A. A. Ojugo and A. O. Eboka, "Assessing Users Satisfaction and Experience on Academic Websites: A Case of Selected Nigerian Universities Websites," *Int. J. Inf. Technol. Comput. Sci.*, vol. 10, no. 10, pp. 53–61, 2018, doi: 10.5815/ijitcs.2018.10.07.

[62] P. Hakonen, "Detecting Insider Threats Using User and Entity Behavior Analytics," Jyväskylä: JAMK University of Applied Sciences, pp. 1-72, 2022. [Online]. Available at: https://www.theseus.fi/handle/10024/786079.

[63] H. Zardi and H. Alrajhi, "Anomaly Discover: A New Community-based Approach for Detecting Anomalies in Social Networks," *Int. J. Adv. Comput. Sci. Appl.*, vol. 14, no. 4, pp. 912–920, 2023, doi: 10.14569/IJACSA.2023.01404101.

[64] S. Gokarn and A. Choudhary, "Modeling the key factors influencing the reduction of food loss and waste in fresh produce supply chains," *J. Environ. Manage.*, vol. 294, p. 113063, Sep. 2021, doi: 10.1016/j.jenvman.2021.113063.

[65] B. O. Malasowe, M. I. Akazue, E. A. Okpako, F. O. Aghware, A. A. Ojugo, and D. V. Ojie, "Adaptive Learner-CBT with Secured Fault-Tolerant and Resumption Capability for Nigerian Universities," *Int. J. Adv. Comput. Sci. Appl.*, vol. 14, no. 8, pp. 135–142, 2023, doi: 10.14569/IJACSA.2023.0140816.

[66] R. E. Yoro, F. O. Aghware, M. I. Akazue, A. E. Ibor, and A. A. Ojugo, "Evidence of personality traits on phishing attack menace among selected university undergraduates in Nigerian," *Int. J. Electr. Comput. Eng.*, vol. 13, no. 2, p. 1943, Apr. 2023, doi: 10.11591/ijece.v13i2.pp1943-1953.

[67] V. G. Cerf, "On the internet of medical things," *Commun. ACM*, vol. 63, no. 8, pp. 5–5, Jul. 2020, doi: 10.1145/3406779.

[68] F. Omoruwou, A. A. Ojugo, and S. E. Ilodigwe, “Strategic Feature Selection for Enhanced Scorch Prediction in Flexible Polyurethane Form Manufacturing,” *J. Comput. Theor. Appl.*, vol. 2, no. 1, pp. 126–137, 2024, doi: 10.62411/jcta.9539.

[69] B. Akpoyibo, T. Peter, and U. Ifeanyi Destiny, “Development Of A Floating Surface Water Robotic Oil Spillage Surveillance (Swross) System,” *GSJ*, vol. 10, no. 11, pp. 2214–2230, 2022. [Online]. Available at: www.globalscientificjournal.comwww.globalscientificjournal.comwww.globalscientificjournal.com.

[70] A. O. Okewale, F. Omoruwou, and C. E. Anih, “Production of Biogas from Co-Digestion of Cow Dung, Saw Dust and Maize Husk,” *Adv. Chem. Eng. Sci.*, vol. 08, no. 03, pp. 113–123, Jun. 2018, doi: 10.4236/aces.2018.83008.

[71] A. A. Ojugo and D. O. Otakore, “Redesigning Academic Website for Better Visibility and Footprint: A Case of the Federal University of Petroleum Resources Effurun Website,” *Netw. Commun. Technol.*, vol. 3, no. 1, pp. 33–44, Jul. 2018, doi: 10.5539/nct.v3n1p33.

[72] F. U. Emordi, “Student’s Perception and Assessment of the Dennis Osadebay University Asaba Website for Academic Information Retrieval, Improved Web Presence, Footprints and Usability,” *FUPRE J. Sci. Ind. Res.*, vol. 7, no. 3, pp. 49–60, Sep. 2023. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/227.

[73] A. O. Okewale, F. Omoruwuo, and O. A. Adesina, “Comparative Studies of Response Surface Methodology (RSM) and Predictive Capacity of Artificial Neural Network (ANN) on Mild Steel Corrosion Inhibition using Water Hyacinth as an Inhibitor,” *J. Phys. Conf. Ser.*, vol. 1378, no. 2, p. 022002, Dec. 2019, doi: 10.1088/1742-6596/1378/2/022002.

[74] A. A. Ojugo and A. O. Eboka, “Empirical Bayesian network to improve service delivery and performance dependability on a campus network,” *IAES Int. J. Artif. Intell.*, vol. 10, no. 3, p. 623, Sep. 2021, doi: 10.11591/ijai.v10.i3.pp623-635.

[75] E. B. Wijayanti, D. R. I. M. Setiadi, and B. H. Setyoko, “Dataset Analysis and Feature Characteristics to Predict Rice Production based on eXtreme Gradient Boosting,” *J. Comput. Theor. Appl.*, vol. 2, no. 1, pp. 79–90, 2024, doi: 10.62411/jcta.10057.

[76] A. A. Ojugo and O. D. Otakore, “Intelligent cluster connectionist recommender system using implicit graph friendship algorithm for social networks,” *IAES Int. J. Artif. Intell.*, vol. 9, no. 3, p. 497-506, 2020, doi: 10.11591/ijai.v9.i3.pp497-506.

[77] S. L. James *et al.*, “Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017,” *Lancet*, vol. 392, no. 10159, pp. 1789–1858, Nov. 2018, doi: 10.1016/S0140-6736(18)32279-7.

[78] R. F. R. Suleiman, “Gas Station Fuel Storage Tank Monitoring System using Internet of Things,” *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 8, no. 1.6, pp. 531–535, Dec. 2019, doi: 10.30534/ijatcse/2019/7881.62019.

[79] O. Zivenko, “Lpg Accounting Specificity During Its Storage And Transportation,” *Meas. Equip. Metrol.*, vol. 80, no. 3, pp. 21–27, 2019, doi: 10.23939/istcmtm2019.03.021.

[80] R. G. Alakbarov and M. A. Hashimov, “Application and Security Issues of Internet of Things in Oil-Gas Industry,” *Int. J. Educ. Manag. Eng.*, vol. 8, no. 6, pp. 24–36, Nov. 2018, doi: 10.5815/ijeme.2018.06.03.

[81] A. A. Ojugo and D. A. Oyemade, “Boyer Moore string-match framework for a hybrid short message service spam filtering technique,” *IAES Int. J. Artif. Intell.*, vol. 10, no. 3, pp. 519–527, Sep. 2021, doi: 10.11591/IJAI.V10.I3.PP519-527.

[82] A. A. Ojugo and A. O. Eboka, “Comparative Evaluation for High Intelligent Performance Adaptive Model for Spam Phishing Detection,” *Digit. Technol.*, vol. 3, no. 1, pp. 9–15, 2018. [Online]. Available at: https://www.sciepub.com/DT/abstract/9742.

[83] O. D. Voke, D. A. M, D. O. E. U, D. O. E.O, and P. I. A, “Survival Prediction of Cervical Cancer Patients using Genetic Algorithm-Based Data Value Metric and Recurrent Neural Network,” *Int. J. Soft Comput. Eng.*, vol. 13, no. 2, pp. 29–41, May 2023, doi: 10.35940/ijsce.B3608.0513223.

[84] E. U. Omede, A. Edje, M. I. Akazue, H. Utomwen, and A. A. Ojugo, "IMANoBAS: An Improved Multi-Mode Alert Notification IoT-based Anti-Burglar Defense System," *J. Comput. Theor. Appl.*, vol. 2, no. 1, pp. 43–53, 2024, doi: 10.33633/jcta.v2i1.9541.

[85] D. A. Oyemade, R. J. Ureigho, F. . Imouokhome, E. U. Omoregbee, J. Akpojaro, and A. A. Ojugo, "A Three Tier Learning Model for Universities in Nigeria," *J. Technol. Soc.*, vol. 12, no. 2, pp. 9–20, 2016, doi: 10.18848/2381-9251/CGP/v12i02/9-20.

[86] M. I. Akazue, R. E. Yoro, B. O. Malasowe, O. Nwankwo, and A. A. Ojugo, "Improved services traceability and management of a food value chain using block-chain network : a case of Nigeria," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 29, no. 3, pp. 1623–1633, 2023, doi: 10.11591/ijeecs.v29.i3.pp1623-1633.

[87] I. P. Okobah and A. A. Ojugo, "Evolutionary Memetic Models for Malware Intrusion Detection: A Comparative Quest for Computational Solution and Convergence," *Int. J. Comput. Appl.*, vol. 179, no. 39, pp. 34–43, 2018, doi: 10.5120/ijca2018916586.

[88] K. Kakhi, R. Alizadehsani, H. M. D. Kabir, A. Khosravi, S. Nahavandi, and U. R. Acharya, "The internet of medical things and artificial intelligence: trends, challenges, and opportunities," *Biocybern. Biomed. Eng.*, vol. 42, no. 3, pp. 749–771, 2022, doi: 10.1016/j.bbe.2022.05.008.

[89] F. Emordi *et al.*, "TiSPHiMME: Time Series Profile Hidden Markov Ensemble in Resolving Item Location on Shelf Placement in Basket Analysis," *Adv. Multidiscip. Sci. Res. J. Publ.*, vol. 12, no. 1, pp. 33–48, Mar. 2024, doi: 10.22624/AIMS/DIGITAL/V11N4P3.

[90] A. A. Ojugo and R. E. Yoro, "Extending the three-tier constructivist learning model for alternative delivery: ahead the COVID-19 pandemic in Nigeria," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 21, no. 3, p. 1673, Mar. 2021, doi: 10.11591/ijeecs.v21.i3.pp1673-1682.

[91] C. C. Odiakaose *et al.*, "DeLEMPaD: Pilot Study on a Deep Learning Ensemble for Energy Market Prediction of Price Volatility and Direction," *Comput. Inf. Syst. Dev. Informatics Allied Res. J.*, vol. 15, no. 1, pp. 47–62, 2024. [Online]. Available at: https://www.researchgate.net/publication/379654171_DeLEMPaD_Pilot_Study_on_a_Deep_Learning_Ensemble_for_Energy_Market_Prediction_of_Price_Volatility_and_Direction_Computing_Information_Systems.

[92] G. TekalignTujo, G. Dileep Kumar, D. ElifeneshYitagesu, and B. MeseretGirma, "Predictive Model to Predict Seed Classes using Machine Learning," *Int. J. Eng. Res. \& Technol.*, vol. 6, no. 08, pp. 334–344, 2017. [Online]. Available at: https://www.ijert.org/research/a-predictive-model-to-predict-seed-classes-using-machine-learning-IJERTV6IS080153.pdf.

[93] Q. Li *et al.*, "An Enhanced Grey Wolf Optimization Based Feature Selection Wrapped Kernel Extreme Learning Machine for Medical Diagnosis," *Comput. Math. Methods Med.*, vol. 2017, pp. 1–15, 2017, doi: 10.1155/2017/9512741.

[94] F. Mustofa, A. N. Safriandono, A. R. Muslikh, and D. R. I. M. Setiadi, "Dataset and Feature Analysis for Diabetes Mellitus Classification using Random Forest," *J. Comput. Theor. Appl.*, vol. 1, no. 1, pp. 41–48, 2023, doi: 10.33633/jcta.v1i1.9190.

[95] A. R. Muslikh, D. R. I. M. Setiadi, and A. A. Ojugo, "Rice Disease Recognition using Transfer Learning Xception Convolutional Neural Network," *J. Tek. Inform.*, vol. 4, no. 6, pp. 1535–1540, Dec. 2023, doi: 10.52436/1.jutif.2023.4.6.1529.

[96] A. A. Ojugo, C. O. Obruche, and A. O. Eboka, "Quest For Convergence Solution Using Hybrid Genetic Algorithm Trained Neural Network Model For Metamorphic Malware Detection," *ARRUS J. Eng. Technol.*, vol. 2, no. 1, pp. 12–23, Nov. 2021, doi: 10.35877/jetech613.

[97] A. A. Ojugo and A. O. Eboka, "An Empirical Evaluation On Comparative Machine Learning Techniques For Detection of The Distributed Denial of Service (DDoS) Attacks," *J. Appl. Sci. Eng. Technol. Educ.*, vol. 2, no. 1, pp. 18–27, 2020, doi: 10.35877/454ri.asci2192.

[98] I. E.I., A. M.I., O. Edith, and O. Deborah, "A Framework for Smart City Model Enabled by Internet of Things (IoT)," *Int. J. Comput. Appl.*, vol. 185, no. 6, pp. 6–11, May 2023, doi: 10.5120/ijca2023922685.

[99] A. A. Ojugo and R. E. Yoro, "Forging A Smart Dependable Data Integrity And Protection System Through Hybrid-Integration Honeypot In Web and Database Server," *Technol. Reports Kansai Univ.*,

vol. 62, no. 08, pp. 5933–5947, 2020. [Online]. Available at: https://www.kansaiuniversityreports.com/article/forging-a-smart-dependable-data-integrity-and-protection-system-through-hybrid-integration-honeypot-in-web-and-database-server.

[100] A. A. Ojugo. *et al.*, "Robust Cellular Network for Rural Telephony in Southern Nigeria," *Am. J. Networks Commun. 2013, Vol. 2, Page 125*, vol. 2, no. 5, pp. 125–132, Nov. 2013, doi: 10.11648/J.AJNC.20130205.12.

[101] A. A. Ojugo., "Technical Issues for IP-Based Telephony in Nigeria," *Int. J. Wirel. Commun. Mob. Comput.*, vol. 1, no. 2, p. 58, Jul. 2013, doi: 10.11648/j.wcmc.20130102.11.

[102] D. S. Charan, H. Nadipineni, S. Sahayam, and U. Jayaraman, "Method to Classify Skin Lesions using Dermoscopic images," *arXiv.*, pp. 1-16, Aug. 2020. [Online]. Available at: https://arxiv.org/abs/2008.09418.

[103] A. A. Ojugo and E. O. Ekurume, "Deep Learning Network Anomaly-Based Intrusion Detection Ensemble For Predictive Intelligence To Curb Malicious Connections: An Empirical Evidence," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 10, no. 3, pp. 2090–2102, Jun. 2021, doi: 10.30534/ijatcse/2021/851032021.

[104] S. R. Guntur, R. R. Gorrepati, and V. R. Dirisala, "Internet of Medical Things," in *Medical Big Data and Internet of Medical Things*, no. October 2018, Boca Raton : Taylor & Francis, [2019]: CRC Press, 2018, pp. 271–297, doi: 10.1201/9781351030380-11.

[105] R. Kasana *et al.*, "Fuzzy-Based Channel Selection for Location Oriented Services in Multichannel VCPS Environments," *IEEE Internet Things J.*, vol. 5, no. 6, pp. 4642–4651, Dec. 2018, doi: 10.1109/JIOT.2018.2796639.

[106] H. A. Ibrahim and H. S. Syed, "Hazard Analysis of Crude Oil Storage Tank Farm," *Int. J. ChemTech Res.*, vol. 11, no. 11, pp. 300–308, 2018, doi: 10.20902/IJCTR.2018.111132.

[107] J. Louis and P. S. Dunston, "Integrating IoT into operational workflows for real-time and automated decision-making in repetitive construction operations," *Autom. Constr.*, vol. 94, pp. 317–327, Oct. 2018, doi: 10.1016/j.autcon.2018.07.005.

[108] A. A. Ojugo and O. D. Otakore, "Computational solution of networks versus cluster grouping for social network contact recommender system," *Int. J. Informatics Commun. Technol.*, vol. 9, no. 3, p. 185, 2020, doi: 10.11591/ijict.v9i3.pp185-194.

[109] A. Adimabua Ojugo, "Dependable Community-Cloud Framework for Smartphones," *Am. J. Networks Commun.*, vol. 4, no. 4, p. 95, Aug. 2015, doi: 10.11648/j.ajnc.20150404.13.

[110] A. A. Ojugo and A. O. Eboka, "Modeling the Computational Solution of Market Basket Associative Rule Mining Approaches Using Deep Neural Network," *Digit. Technol.*, vol. 3, no. 1, pp. 1–8, 2018, doi: 10.12691/dt-3-1-1.

[111] P. Naveen kumar, P. Kumaresan, and Y. Babu Sundaresan, "IoT based retail automation of fuel station and alert system," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 263, no. 4, p. 042072, Nov. 2017, doi: 10.1088/1757-899X/263/4/042072.

[112] S. Nazir, S. Patel, and D. Patel, "Assessing and augmenting SCADA cyber security: A survey of techniques," *Comput. Secur.*, vol. 70, pp. 436–454, Sep. 2017, doi: 10.1016/j.cose.2017.06.010.

[113] B. Bengherbia, S. Chadli, M. O. Zmirli, and A. Toubal, "A MicroBlaze based WSN sink node using XBee transceiver," in *2016 8th International Conference on Modelling, Identification and Control (ICMIC)*, Nov. 2016, pp. 831–834, doi: 10.1109/ICMIC.2016.7804229.

[114] E. Adishi, P. O. Ejeh, E. Okoro, and A. Jisu, "Reinforcement deep learning memetic algorithm for detection of short messaging services spam using filters to curb insider threats in organizations," *FUPRE J. Sci. Ind. Res.*, vol. 6, no. 3, pp. 80–94, 2022. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/225.

[115] P. O. Ejeh, E. Adishi, E. Okoro, and A. Jisu, "Hybrid integration of organizational honeypot to aid data integration, protection and organizational resources and dissuade insider threat," *FUPRE J. Sci. Ind. Res.*,

vol. 6, no. 3, pp. 80–94, 2022. [Online]. Available at: https://journal.fupre.edu.ng/index.php/fjsir/article/view/228.

[116] A. A. Ojugo *et al.*, "CoSoGMIR: A Social Graph Contagion Diffusion Framework using the Movement-Interaction-Return Technique," *J. Comput. Theor. Appl.*, vol. 1, no. 2, pp. 37–47, 2023, doi: 10.33633/jcta.v1i2.9355.

[117] F. O. Aghware *et al.*, "Enhancing the Random Forest Model via Synthetic Minority Oversampling Technique for Credit-Card Fraud Detection," *J. Comput. Theor. Appl.*, vol. 2, no. 2, pp. 190–203, 2024, doi: 10.62411/jcta.10323.

[118] A. A. Ojugo, A. O. Eboka, R. E. Yoro, M. O. Yerokun, and F. N. Efozia, "Framework design for statistical fraud detection," *Math. Comput. Sci. Eng. Ser.*, vol. 50, pp. 176–182, 2015, [Online]. Available at: https://www.inase.org/library/2015/books/bypaper/MCSI/MCSI-33.pdf.

[119] A. A. Ojugo, A. O. Eboka, E. O. Okonta, R. E. Yoro, and F. O. Aghware, "Predicting Behavioural Evolution on a Graph-Based Model," *Adv. Networks*, vol. 3, no. 2, p. 8, 2015, doi: 10.11648/j.net.20150302.11.

[120] A. A. Ojugo and A. O. Eboka, "Inventory prediction and management in Nigeria using market basket analysis associative rule mining: memetic algorithm based approach," *Int. J. Informatics Commun. Technol.*, vol. 8, no. 3, p. 128, 2019, doi: 10.11591/ijict.v8i3.pp128-138.

[121] G. Barker, *The Engineer's Guide to Plant Layout and Piping Design for the Oil and Gas Industries*. Elsevier, pp. 1-510, 2018. [Online]. Available at: http://www.sciencedirect.com:5070/book/9780128146538/the-engineers-guide-to-plant-layout-and-piping-design-for-the-oil-and-gas-industries?via=ihub=.

[122] R. Braddock and C. Chambers, "Tank gauging systems used for bulk storage of gasoline," *Inst. Chem. Eng. Symp. Ser.*, no. 156, pp. 553–559, 2011, [Online]. Available at: https://www.icheme.org/media/9288/xxii-paper-77.pdf.

[123] J. Figueiredo, M. A. Botto, and M. Rijo, "SCADA system with predictive controller applied to irrigation canals," *Control Eng. Pract.*, vol. 21, no. 6, pp. 870–886, Jun. 2013, doi: 10.1016/j.conengprac.2013.01.008.

[124] O. Okonta, U. Wemembu, A. Ojugo, and D. Ajani, "Deploying Java Platform to Design a Framework of Protective Shield for Anti– Reversing Engineering," *West African J. Ind. Acad. Res.*, vol. 10, no. 1, pp. 52–67, Jul. 2014. [Online]. Available at: https://www.ajol.info/index.php/wajiar/article/view/105790.

[125] O. Emmanuel, A. Arnold, W. Uchenna Raphael, and A. Dele, "Embedding Quality Function Deployment In Software Development: A Novel Approach," *West African J. Ind. Acad. Res.*, vol. 6, no. 1, pp. 50–64, Apr. 2013. [Online]. Available at: https://www.ajol.info/index.php/wajiar/article/view/87437.

[126] U. Raphael, O. Emmanuel, A. Adimabua, and I. Love, "A Framework for Effective Software Monitoring in Project Management," *West African J. Ind. Acad. Res.*, vol. 10, no. 1, pp. 102–115, Jul. 2014. [Online]. Available at: https://www.ajol.info/index.php/wajiar/article/view/105798.

[127] D. Uckelmann, M. Harrison, and F. Michahelles, "An Architectural Approach Towards the Future Internet of Things," in *Architecting the Internet of Things*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2011, pp. 1–24, doi: 10.1007/978-3-642-19157-2_1.

[128] J. I. Chang and C.-C. Lin, "A study of storage tank accidents," *J. Loss Prev. Process Ind.*, vol. 19, no. 1, pp. 51–59, Jan. 2006, doi: 10.1016/j.jlp.2005.05.015.