International Journal of Computer Sciences and Engineering
Vol.**11**, Issue **6**, pp.**37-44**, June **2023**
ISSN: 2347-2693 (Online)
Available online at: www.ijcseonline.org

Research Paper

Automated Health Monitoring System for the Elderly using Internet of Things

Nwokoma Queen Maclean[1*], Taylor Onate Egerton[2]

[1,2]Computer Science Department/Faculty of Science, Rivers State University, Port Harcourt, Nigeria

**Corresponding Author: macqueen2011@yahoo.com*

Received: 17/Apr/2023; **Accepted**: 20/May/2023; **Published**: 30/Jun/2023. **DOI**: https://doi.org/10.26438/ijcse/v11i6.3744

Abstract: Healthcare delivery in recent years has gained massive improvement. Information Technology has been used to improve the way medical practitioners administer healthcare which has further impacted on the lives of the general populace. This study present an automated system in health monitoring of the elderly. Human Activities Recognition (HAR), heart rate, body temperature, stress level and blood pressure sensor dataset has been used in implementation and a mobile software was developed to simulate the activity, health monitoring and response of the medical personnel to the elderly. The HAR dataset contains 77 sensors in subject 1 and 84 sensors in subject 2. The Agile software development methodology was used in the process of development. The mobile software is used to get the readings of the various wearable and home stationary sensors from which the medical personnel can receive notification of the health information and activity of the patient. The MATLAB scientific programming language has been used to analyze and demonstrate the HAR dataset with some unique activity spikes shown on the graphical illustrations. A mobile application was developed to simulate the readings gotten from the wearable sensors and the activity triggers in the home. The R programming language was used to train and test the wearable sensor performance of the artificial neural model. The body sensor data has been evaluated and analyzed and the performance accuracies are thus: for Heart rate, the performance accuracy recorded for training is 70.4% with a misclassification of 29.6% and testing performance accuracy was 57.4% with a misclassification of 42.4%, Body temperature recorded 65.7% with misclassification of 34.3% for training and 66.7% with misclassification of 33.3% for testing. The performance for Stress level in the training was 65.7% with misclassification of 34.3 and 64.1% with misclassification of 35.9% for testing performance and the performance of blood pressure was 73.1% with a misclassification of 26.9% for training and in testing, 70.4% with misclassification of 29.6% was recorded. The mobile application has performed well during simulation, presenting the readings of the smart wearable devices from the patient and the activities of the patient at home.

***Keywords*: **Health Monitoring System, Internet of Things, Patient Monitoring, Human Activity Recognition,

1. Introduction

In recent years, we have experienced an increased activities and communication between one another and also among things (devices). People are beginning to get very busy with work and career pursuit and the elderly ones in our communities are receiving less attention and care by their children or caregivers who are supposed to pay attention to them. More so, when they are ill or having some health issues, they need more care and monitoring to be able to manage any health challenge that may arise but, due to work pressure and technology in the society we are living-in nowadays, our elderly parents are prone to neglect. Many lives are threatened every day because patients are not provided with healthcare in a timely and effective manner. The main aim was to establish and implement a dependable patient tracking system that would enable healthcare providers to keep track of patients who are either sick or going about their everyday lives. The healthcare system is now transitioning from a conventional (i.e. Doctor-centered approach) to a modernized patient-centered approach [3]. It is because of these facts, the need to monitor the health and wellbeing of our elderly ones with corresponding innovative technological implementation by exploring every possible means necessary to improve clinical care given to the elderly [25].

Health monitoring system is a way of keeping an eye on a patient(s) beyond the conventional medical settings which increases access to care and reduces cost in healthcare delivery. This helps to smartly track patient's activities and parameters of their vital body conditions remotely while they go about their normal activities at home, office or anywhere [23]. This monitoring system is characterized as being utilized to observe the clinical signs which incorporate such parameters as the electrocardiogram (ECG), respiratory signs, intrusive and non-invasive blood pressure, body temperature, and gases associated parameters and so on. This technological advancement is a mobile health (M-Health) innovation which is being exploited in medicinal and general health practice through the assistance of a mobile device or smart phone. Monitoring of patients or the elderly is not something new in the medical sphere or services: because, it has been in existence since 1625 and its application has only widening to include both single parameter monitoring system and multi-parameter monitoring system. While the single monitoring is utilized in measuring the human body blood pressure or the oxygen level in the blood (SPO2) or observing ECG, the multi-parameter monitoring is utilized in checking various crucial clinical signals at the same time by transmitting these data which may include breath rate, human blood pressure, ECG etc. [20].

The innovative concept of Internet of Things was brought about by a member of the Radio Frequency Identification (RFID) development community in the year 1999 and it is gaining more application and relevance in recent years because of the increase in mobile applications. The Internet of Things is a network communication or interactions between things (physical devices) and people. It is categorized as device (machine) to device (machine), device (machine) to people as well as people to people with the aide of the internet. Its general idea is having devices we use every day that is readable or has the ability to sense and can be controlled through the internet via communication means like WAN, wireless LAN, WiFi, RFID and so on. And these devices can also be addressable, recognizable and locatable [18, 19, 4]. Ramamoorthy [19] also added that IoT is described as things with identity and virtual personalities operating in smart space using intelligent interfaces to link and interact within social, environmental, and user contexts and assists in strengthening the highlights of the existing medical services process by allowing executives to check patient data on a regular basis and the board to deal with health-related crises, thus broadening the scope of medical care arrangements [16].

Monitoring or observing a patient or the health of the elderly; the medical practitioner as well as a caregiver have to be on-site and at the location of the patient constantly to get their pulse readings, heartbeat rate etc. This is why some patients have to be admitted (in some cases) in the hospitals so as to enable one put an eye on them [16] especially if such patient lives very far from the medical center. The challenge of our aged parents living alone or have to be at home alone when others have gone to work or out is an increasing fact especially, as society continue to experience changes in lifestyle (i.e. the busy schedule of people) [14]. Hence, the problem statement has to do with keeping track of the abnormalities/ health of the aged ones and their activities within the home, therefore the specific problems include: Inefficient monitoring of the aged ones/ the elderly that have been diagnosed with specific conditions, no effective activity monitoring of the aged ones at home for abnormalities, no real-time monitoring system on the aged ones on their specific conditions. The main aim of this research work is to develop an automated health monitoring system for the elderly using the internet of things. The specific objectives include: To develop a framework for the IoT system mechanism and operations, collection of dataset for home activity recognition (HAR) and body sensor dataset of Body Temperature, Blood Pressure (BP), Heart Rate (Pulse Rate) and pre-process them for analysis and implementation with the model, to develop a mobile application that simulates the readings from the body sensors and activity recognition, to build an Artificial Neural Network (ANN) Model to train the acquired dataset with R programming language and to analyse the activity triggers of the patient with MatLab scientific language, and test the trained artificial neural network model with the test dataset, carry out the analysis and check for performance and accuracy using artificial neural network for each dataset.

2. Related Works

In a paper presented by Iqbal *et al*. [19] in a closed loop healthcare system, a smart task mapping device was employed to build an HMS for older patients. As more resources are required to monitor the health of the senior population, the issues of an aging population have a direct impact on a country's socioeconomic structure. Iranpak *et al.* [10] presented a system of Monitoring and classifying patients from afar using Cloud Computing with the Internet of Things Platform. Bokefode & Komarasamy [5] presented the need, trends, challenges and opportunities there is with distant patient tracking system. The focus of the work was to determine the need, obstacles, and potential for a Remote Patient Monitoring System (RPMS). In Hong Kong, a tailored health monitoring system for community-dwelling older individuals was introduced. Tele-health is an effective approach to enhance traditional medical-care organisations, particularly in today's aged society [26]. A remote health monitoring sensor network was design and implemented by Lihua & Qing [13] which was based on IoT. This paper proposed the human body biological information collection endpoints, the coordinator node, the mobile communication mechanism using the CC2430 micro - controller, and the extensive design information of the human body sensor (heart rate, temperature, ECG / pulse) circuit diagram from a practical standpoint.

Horvarth [8] was able to look into the networks of smart systems and design. Both smart design and smart systems have to do with contemporary breakthroughs in artificial intelligence, despite their differing origins. An automated database for smart health surveillance was tracked by these authors with an android device. The device uses an infrared sensor to track patient's ECG and temperature sensors to measure the patient's mouth and wrist temperatures [12]. Guan *et al.* [6] based on a smart home gateway presented a remote health monitoring system for elderly, the work proposed a remote health monitoring system for the elderly based on a smart home gateway. Mohith *et al.* [15] examined the smart systems security and privacy capabilities in their paper. Their work addresses smart device, its technical stacks, and security problems, all of which serve as a solid foundation for the security and privacy of these systems. Pascual *et al.* [17] presented an industry 4.0 smart system handbook. Obtaining accurate and dependable information from equipment and their components is the first step in designing a Cyber-Physical Systems (CPS) application. Romero *et al.* [21] did a systematic literature review characterization of smart computers. Their standpoint was required to offer a mutual platform for the creation or application of Smart Systems in a variety of domains, especially those that have yet to be addressed. Seydoux & Drira [24] presented the application of a smart data system. To help Big Data analytics, smart data systems and applications support the collection and integration of data from diverse Big Data sources, data centres, sensory devices in the IoT, social networks, and databases, whether on premises or in the cloud, organized or unstructured, and software-as-a-service applications.

Hassan *et al.* [7] in their research work presented a comprehensive survey and some applications of Internet of Thing. They gave a description of previous correlated surveys, a general overview of IoT technology, an analysis of the major IoT applications, and a section on IoT challenges comprise the four main parts of their research work. In other to understand the Internet of Things, its potentials and the role it plays in the society, Atzori *et al.* [2] has presented a research on the fast-evolving paradigm of the IoTs. The widespread adoption of emerging technology in all aspects of daily life is fuelling the illusion that there will always be an ICT solution to effectively address any new social problem. These authors have developed a smart health monitoring application using the assistance of an IoT environment. The introduction of the IoT technologies has improved the healthcare system moving from face to face treatment to telemedicine [11]. Andersson & Nilsson [1] while looking at Internet of Things (IoT) presented a sample of people's opinions and expertise. The report introduces their readers to the IoT, including how it works, what it is, and statistics on society's awareness and opinions on the subject. Russo *et al.* [22] explores the regulations and the scope of the Internet of Things in contemporary companies. In an interconnected global network, the Internet of Things will link anything to anyone. By quantifying and tracking previously unquantifiable values, this network offers productivity and social and individual benefits.

3. Experimental Methodology and Design

The system is design to enhance the medical care supplied by physicians and caregivers to a patient in critical health condition. It help enhance response to treatment on the side of the medical personnel since the patient health information are gotten in real time. The where-about of the patient can be detected remotely in real-time. The architecture design depicts the system's structure, including the most significant elements, perspectives, and behaviours. It's made up of both software and hardware components. The developed automated health monitoring system (AHMS) using smart system and Internet of Things is a medical expert system that monitors the critical health condition of the elderly with special medical devices, smart enough to implement the Internet of Things technology. The developed system architecture is a skeletal illustration of the vital components of the system. It shows the flow of data and information or communications among components of the system.

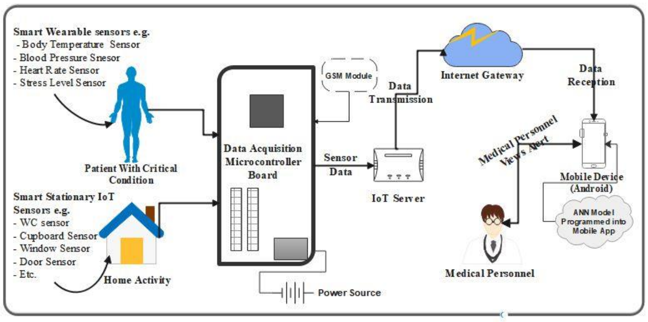

Figure 1. Architectural Design of the Proposed AHMS with Smart System and IoT

Figure 1 presents the architectural design of the proposed system showing the major components of the system. The smart wearable sensors attached to the patient with critical health condition and the smart stationary IoT sensors/ actuators place at strategic points in the home all sends data to the Microcontroller. The data are further parsed to the IoTs server that routes it through the Internet gateway to the mobile device of the medical personnel. The medical personnel are able to view the information on his/ her mobile phone to make recommendations for treatments and or other quick response to the patient. The activities carried out by the patient can also be routed through this means to the mobile device to be viewed by the personnel.

4. Result and Discussion

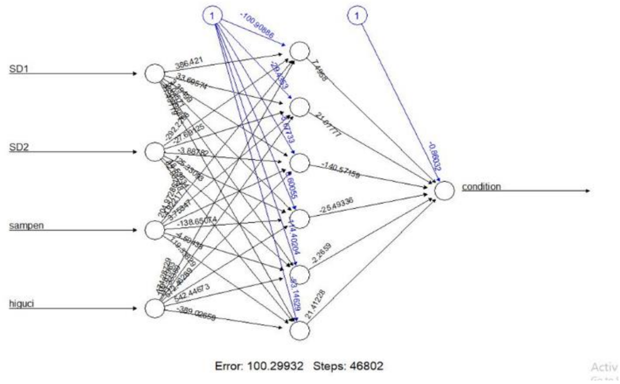

Figure 2. Heart Rate Neural Network Output Result

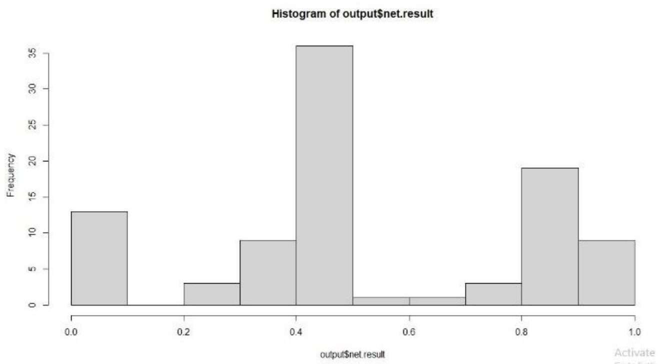

Figure 3. Histogram of Heart Rate Output Result of the Neural Network

Table 1: Confusion Matrix/ Misclassifications Training Result for Heart Rate

	Actual	
Prediction	**0**	**1**
0	90	48
1	13	55

Table 2: Confusion Matrix/ Misclassifications Testing Result for Heart Rate

	Actual	
Prediction	**0**	**1**
0	36	25
1	15	18

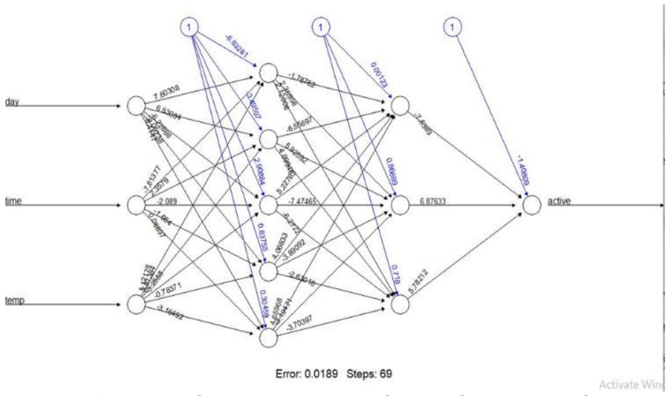

Figure 4. Body Temperature Neural Network Output Result

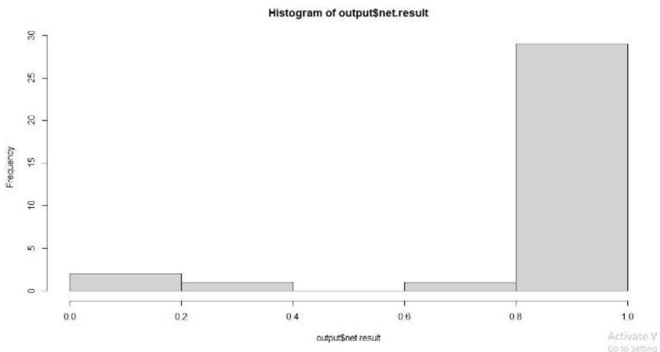

Figure 5. Histogram of Body Temperature Output Result of the Neural Network

Table 3: Confusion Matrix/ Misclassifications Training Result for Body Temperature

	Actual	
Prediction	**0**	**1**
0	1	0
1	23	43

Table 4: Confusion Matrix/ Misclassifications Testing Result for Body Temperature

	Actual	
Prediction	**0**	**1**
0	3	0
1	11	19

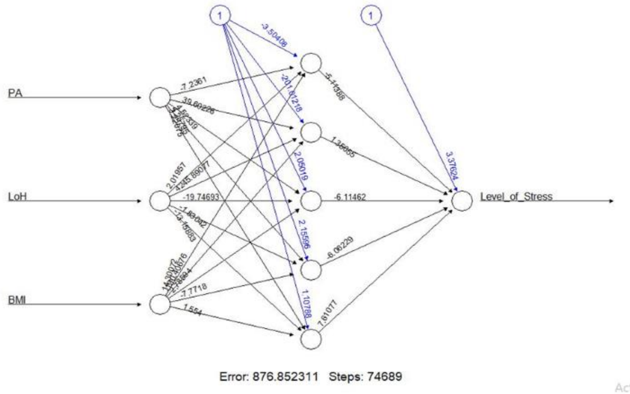

Figure 6. Stress Level Neural Network Output Result

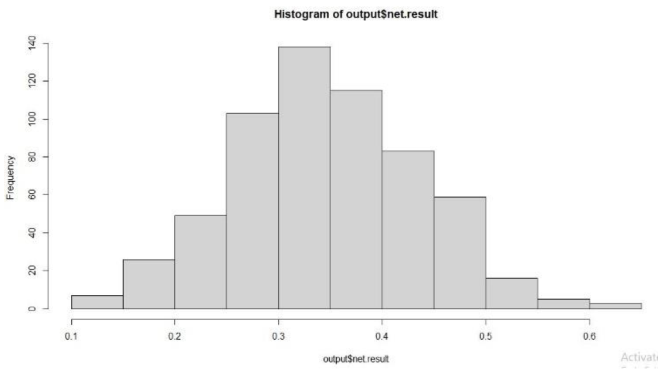

Figure 7. Histogram of Stress Level Output Result of the Neural Network

Table 5 Confusion Matrix/ Misclassifications Training Result for Level of Stress

	Actual	
Prediction	**0**	**1**
0	896	463
1	16	21

Table 6: Confusion Matrix/ Misclassifications Testing Result for Level of Stress

	Actual	
Prediction	**0**	**1**
0	380	200
1	17	7

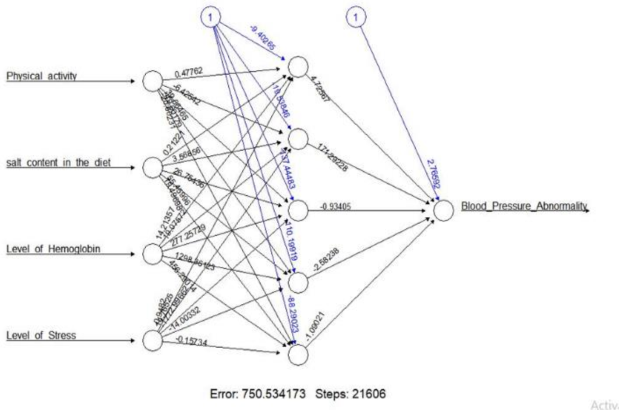

Figure 8. Neural Network Model Output Result of Blood Pressure

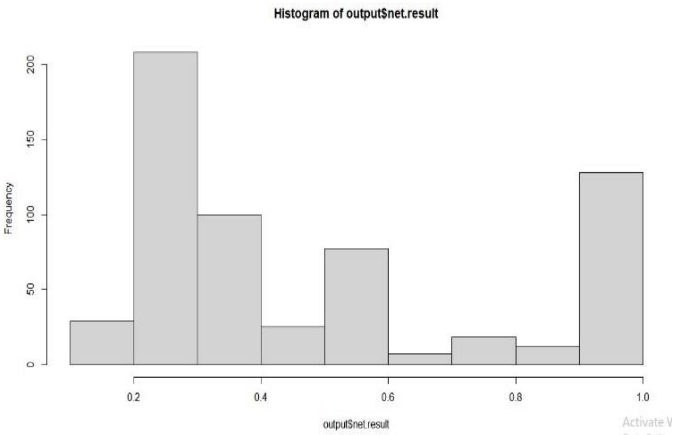

Figure 9. Histogram Representation of the Output Result of Blood Pressure of the Neural Network Model

Table 7: Confusion Matrix/ Misclassifications Training Result for Blood Pressure

	Actual	
Prediction	**0**	**1**
0	607	260
1	115	414

Table 8: Confusion Matrix/ Misclassifications Testing Result for Blood Pressure

	Actual	
Prediction	**0**	**1**
0	237	125
1	54	188

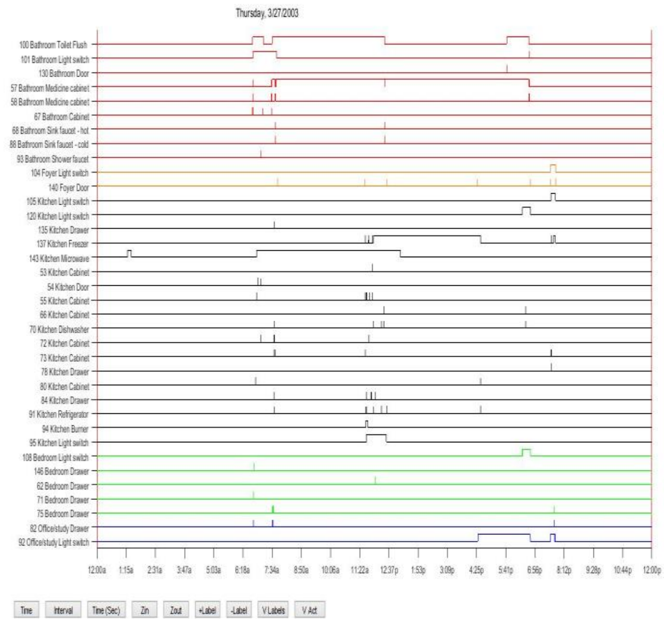

Figure 10. Home Activity Data Analysis for Subject 1 of the Acquired dataset

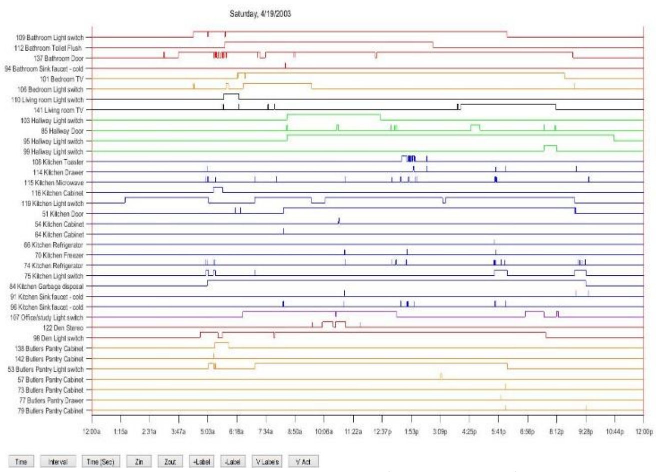

Figure 11. Home Activity Data Analysis for Subject 2 of the Acquired dataset

Table 9: Summary of Performance Accuracy Result of the Developed Models.

Dataset	Training Performance	Misclassification of Training	Testing Performance	Misclassification of Testing
Heart Rate	70.4%	29.6%	57.4%	42.4%
Body Temperature	65.7%	34.3%	66.7%	33.3%
Stress Level	65.7%	34.3%	64.1%	35.9%
Blood Pressure	73.1%	26.9%	70.4%	29.6%

Discussion of Results

This research work focused on automated health monitoring system for the elderly using internet of things technology. The system explored two (2) distinct areas which are monitoring the activities of the elderly patient around the home and monitoring the elderly patient body system through wearable body sensors. The result of the developed system has been analysed thus:

The dataset were obtained, analysed and pre-processed for use by the ANN model. Figure 10 and Figure 11 are the analysis of the home activity dataset acquired for the proposed monitoring system. The graphical representation shows a particular day's activities of both homes in view. It illustrates how events are capture when patient visit such places in the home while being monitored and at different time interval. The spikes shown in the figure are the captured signals from the sensors placed at different point.

Artificial neural network model was developed and the wearable body sensors dataset were trained, tuned and retrained to obtain a more acceptable result. During the model development, Figure 2 to Figure 9 were generated from the dataset. Figure 2 is the neural network model for heart rate dataset that was produces during analysis. The heart rate NN model showing the SD 1 and 2, SampEn and Higuchi as input into the model. The model has four (4) inputs via the input layer and one hidden layer with 6 inputs and the output layer. The model shows a fully connected layer with bias node fully connected; indicated by '1' in the nodes. It took 46,802 steps to converge and produced 100.299 errors. The best performance accuracy achieved after training, tuning and retraining the dataset was 70.4% with a misclassification of 29.6% as shown in the confusion matrix/ misclassification table in Table 1. This clearly showed that 90 patients were fine with no heart issue and the model predicted the same. It also showed that 55 patients have heart issue and the model predicted the same. 48 and 13 as seen in Table 1 means that, 48 patients have heart issues but the model predicted that they do not have heart issues and 13 patients that do not have heart issue; the model predicted that they have. The accuracy was gotten by summing the diagonal values of the confusion matrix and the misclassification was gotten by subtracting 1 from the summation. The histogram result in Figure 3 also highlights why the result tended toward a high number of misclassification. Figure 4 is the neural network model of body temperature dataset. The neural network comprises of an input layer, 2 hidden layers (of 5 and 3 nodes respectively) and an output layer. The input layer takes in three (3) inputs namely: day, time and temperature and are fully connected with the hidden layers and the output layer. The figures or numbers on the edges are the weights used to calculate the activation function. From Figure 4 it shows that it takes 69 steps to converge at a result with 0.0189 errors and it produced an accuracy of 0.6567164 (i.e. 65.7%) and a misclassification of 0.3432836 (i.e. 34.3%) in the training data. From Table 3 We can see that at one point in all the entry of the patient 1 was classified to be fine with the presence of a stable body temperature and the model predicted the same. It also showed that 43 readings of the patient's body temperature were classified to have fluctuated (i.e. the patient has some increase in temperature) and the model predicted the same. 23 times the model predicted that the patient's body temperature is high whereas in actual sense, their body temperature was normal which means the model was confused and misclassified the patient's data. The accuracy was gotten by summing the diagonal values of the confusion matrix and the misclassification was gotten by subtracting 1 from the summation. The accuracy achieved in the training of the model is 0. 0.6567164 (i.e. 65.7%) and the misclassification of the model with the training dataset is 0.3432836 (i.e. 34.3%). Figure 5 every value that falls between 0 and less than 0.5 are regarded as 0 and from 0.5 to 1 is regarded as 1. Hence, the graphical representation clearly shows where bulk of the figure will lie, which also affected the output result.

Figure 6 is the stress level dataset neural network model with 3 inputs in the input layer, 5 nodes in the hidden layer and a node at the output layer. All the nodes in the network are fully connected with a bias node at the hidden layer and the output layer. From the ANN model, we can see that the network took 74,689 steps to converge with 876.852311 errors recorded. The model produced an accuracy of 0.65687868 (i.e. 65.7%) and a Misclassification of 0.3431232 (34.3%). This is clearly shown through the confusion matrix in Table 5 as it shows relatively high misclassification of the training dataset. The model was able to predict 896 data correctly as having no stress as the 'actual' also says same and was able to predict 21 as having stress as the 'actual' also says same. Whereas, 463 data were misclassified as not having stress but the actual say differently and 16 data were classified as not having stress but the model predicted otherwise. Figure 7 is the histogram graphical representation of the artificial neural network output result of the level of stress dataset. From this histogram we can see that more of the dataset are less than 0.5 and the constraint states that any of the data result that falls below 0.5 is treated as 0 and above 0.5 is treated as 1. Hence, the output of the larger number in the "no stress" prediction. And finally, Figure 8 presented the blood pressure neural network model that was able to converge at 21,606 steps with 750.534173 errors. It has four (4) input nodes including Physical activity, salt content in the diet, level of hemoglobin and stress level, the hidden layer with 5 nodes and the output layer showing whether the blood pressure is normal or abnormal, all fully connected. The performance accuracy of this model for the training dataset is 0.7313754 (73.1%) with a misclassification of 0.2686246 (26.9%). This is as seen from the confusion/ misclassification table displayed in Table 7; the model predicted correctly 607 as having no issues with blood pressure and 414 as having blood pressure with the actual sense saying the same. But, 260 records were misclassified by the model as not having any blood pressure issue and 115 records as having blood pressure, while the actual data is saying otherwise. Figure 9 is used to demonstrate this difference.

The evaluation and testing of the trained model was also carried to evaluate the model's performance. This evaluation was done for the heart rate, body temperature, stress level and blood pressure dataset. During the testing of the model, Table 2 is used to show the confusion matrix and misclassification of the test data for heart rate. We can see that 36 patients were fine with no heart issue and the model predicted the same. It also showed that 18 patients have heart issue and the model predicted the same. 25 and 15 as seen in Table 2 means that, 25 patients have heart issues but the model predicted that they do not have heart issues and 15 patients that do not have heart issue; the model predicted that they have. The accuracy achieved in the testing of the model is 0.5744681 (i.e. 57.4%) and the misclassification of the testing the model with the test dataset is 0.4255319 (i.e. 42.5%). Table 4 is used to show the confusion matrix and misclassification of the test data for body temperature. We can see that the actual prediction for low/ normal temperature of the data is 3 and the model predicted 3 also and the actual prediction for high temperature is 19 and the model predicted same too. The model was confused at predicting 11 recorded temperatures as high whereas the actual sense is that they are normal/ low. The accuracy achieved in the testing of the model is 0.6666667 (i.e. 66.7%) and the misclassification of the testing the model with the test dataset is 0.3333333 (i.e. 33.3%). The test dataset on the developed model for stress level produced an Accuracy of 0.6407285 (64.1%) and a Misclassification of 0.3592715 (35.9%). This is justified by the result of the confusion matrix in Table 6 that produced a misclassification of about 200 as predicted by the model to be stress free while in actual sense from the data, the patient is having stress and the model predicted 17 records to have stress but the data actually says the opposite. The model predicted 380 correctly as both the model and the actual says there is no stress and 7 of the records appear to have stress as the model and the actual predicted same. And finally, the testing dataset performance was able to produce an accuracy of 0.7036424 (70.4%) with a misclassification of 0.2963576 (29.6%). The model predicted 237 as not having blood pressure issue and the actual data presented same and the model predicted 188 as having blood pressure and the dataset presented same. The Actual data is predicting 125 as having blood pressure but the model misclassified it predicting that they don't have the blood pressure issue and the actual data is predicting that 54 records do not have blood pressure while the model is predicting otherwise.

The result summary of the models are tabulated in Table 9 to clearly show the performance of the Artificial Neural Network. The blood pressure neural network model for training and testing has performed better than other models because of the high performance accuracy of 73.1% and 70.4% respectively. The performance of other models were relatively high above average.

5. Conclusion

This research work has centered on the automation of health monitoring system for the elderly using Internet of Things technology. It has been able to highlight distinctly the key aspects of the system which are the patient's activity monitoring, patient's health monitoring and observation through the mobile application by the medical personnel. These have been carefully treated following the objectives of this research work.

Dataset for home activity recognition and body sensor data of blood pressure, heart rate, and stress level and body temperature were obtained, analyzed and used to implement the ANN model. The MITes wireless sensor of human activity dataset from activities recognition collated dataset of two different homes (known as subject 1 and subject 2) to simulate the developed automated health monitoring system using IoTs and the wearable body sensor dataset was acquire from the Kaggle online community of data scientist and machine learning practitioners. An artificial neural network model has been developed for heart rate, body temperature, stress level and blood pressure. The test evaluation for these dataset were also carried out and the various performance accuracies recorded.

Conflict of Interest
There is no conflict of interest.

Funding Source
This work was self-funded and was not supported by any institution

Authors' Contributions
Author-1 conceived the study, researched all relevant literature to the development of the study. Author-2 Guided and supervised the development of the study bringing out relevant details to be considered during the development of the study. All authors reviewed and edited the manuscript and Author-2 approved the final version of the manuscript.

Acknowledgements
All acknowledgments (if any) should be included at the very end of the manuscript before the references. Anyone who made a contribution to the research or manuscript, but who is not a listed author, should be acknowledged (with their permission).

References

[1]. Andersson, D., & Nilsson, E. "Internet of Things: A Survey about Knowledge and Thoughts", Faculty of Computing, Blekinge Institute of Technology, SE-371 79, Karlskrona, Sweden, **2018**.
[2]. Atzori, L., Iera, A., & Morabito, G. "Understanding the Internet of Things: Definition, Potentials, and Societal Role of a Fast-Evolving Paradigm", Ad Hoc Networks, Vol. **56**, pp.**122-140, 2017**.
[3]. Bangal, S. P., Akshay, N., Shubham, S., & Sameer, M. "Multipurpose Smart Health Care Monitoring System using IoT", International Journal of Information and Computing Science, Vol. **6**, Issue **5**, pp.**60-66, 2019**.
[4]. Banka, S., Madan, I., & Saranya, S. S. "Smart healthcare monitoring using IoT", International Journal of Applied Engineering Research, Vol. **13**, Issue **15**, pp.**11984-11989, 2018**.
[5]. Bokefode, J. D., & Komarasamy, G. "A Remote Patient Monitoring System: Need, Trends, Challenges and Opportunities", International Journal of Scientific & Technology Research, Vol. **8**, Issue **09**, pp.**830 – 835, 2019**.
[6]. Guan, K., Shao, M., & Wu, S. "A Remote Health Monitoring System for The Elderly Based on Smart Home Gateway", Journal of Healthcare Engineering, **2017**.
[7]. Hassan, R., Qamar, F., Hasan, M. K., Aman, A. H. M., & Ahmed, A. S. "Internet of Things and Its Applications: A Comprehensive Survey", Symmetry, Vol. **12**, Issue **10**, pp.**1674, 2020**.
[8]. Horváth, I. "Connectors of Smart Design and Smart Systems. Artificial Intelligence for Engineering Design, Analysis and Manufacturing", pp.**1-19, 2021**.
[9]. Iqbal, N., Ahmad, S., & Kim, D. H. "Health Monitoring System for Elderly Patients Using Intelligent Task Mapping Mechanism in Closed Loop Healthcare Environment", Symmetry, Vol**. 13,** Issue **2,** pp.**357, 2021**.
[10]. Iranpak, S., Shahbahrami, A., & Shakeri, H. "Remote Patient Monitoring and classifying Using the Internet of Things Platform Combined with Cloud Computing", **2021**.
[11]. Islam, M., & Rahaman, A. "Development of Smart Healthcare Monitoring System in IoT Environment", SN Computer Science, Vol. **1**, Issue **3**, pp.**1-11, 2020**.
[12]. Karthi, A., Rajendran, R., & Mathiarasan, P. "Smart Health Surveillance with Automated Database using Android Mobile Device", Brazilian Archives of Biology and Technology, pp**.60, 2017**.
[13]. Lihua, Z., & Qing, L. "Design and Implementation of Remote Health Monitoring Sensor Network based on the Internet of Things", In AASRI International Conference on Industrial Electronics and Applications (IEA), pp.332-334, 2015.
[14]. Lv, Z., Xia, F., Wu, G., Yao, L., & Chen, Z. "iCare: A Mobile Health Monitoring System for the Elderly", In 2010 IEEE/ACM Int'l Conference on Green Computing and Communications & Int'l Conference on Cyber, Physical and Social Computing, pp.**699-705**, **2010**, IEEE.
[15]. Mohith,M., Naresh, E., & Vijaya K. B. P. "Security and Privacy in Smart Systems", Alliance International Conference on Artificial Intelligence and Machine Learning (AICAAM)', pp.**90-99, 2019**.
[16]. Ogunbolu, M., & Fadipe, S. "An Enhanced Remote Monitoring of Patients Heartbeat and Body Temperature Using Internet of

Health Things (IoHT)", Journal of Science, Engineering, Technology and Management ISSN: 2795-3955, Vol. **3**, Issue **01**, pp.**1-11**, **2021**.
[17]. Pascual, D. G., Daponte, P., & Kumar, U. "Handbook of Industry 4.0 and SMART Systems", CRC Press, **2019.**
[18]. Patel, K. K., & Patel, S. M. "Internet of things-IOT: definition, characteristics, architecture, enabling technologies, application & future challenges", International journal of engineering science and computing, Vol**. 6**, Issue **5, 2016**.
[19]. Ramamoorthy, S. "Personalized Health Monitoring System Using IOT and Cloud", International Journal of Computer Science Trends and Technology (IJCST), pp**.5, 2017**.
[20]. Rani, S. U., Ignatious, A., Hari, B. V., & Balavishnu, V. J. "IoT patient health monitoring system", Indian Journal of Public Health Research and Development", Vol. **8**, Issue **4**, **2017**.
[21]. Romero, M., Guédria, W., Panetto, H., & Barafort, B. "Towards a Characterisation of Smart Systems: A Systematic Literature Review", Computers in industry, pp.**120, 2020.**
[22]. Russo, G., Marsigalia, B., Evangelista, F., Palmaccio, M., & Maggioni, M. "Exploring Regulations and Scope of the Internet of Things in Contemporary Companies: A First Literature Analysis", Journal of Innovation and Entrepreneurship, Vol. **4**, Issue **1,** pp.**1-13, 2015**.
[23]. Senthamilarasi, C., Rani, J. J., Vidhya, B., & Aritha, H. "A Smart Patient Health Monitoring System using IoT", International Journal of Pure and Applied Mathematics, Vol. **119**, Issue **16**, pp.**59-70**, **2018**.
[24]. Seydoux, N., Drira, K., Garzone, G., Hernandez, N., & Monteil, T. "Making Smart Knowledge from Not-So-Smart Data", In Smart Data Systems and Applications, pp.**2p, 2017**.
[25]. Sritha, P. & Valarmathi R.S. "A Reliable Remote Health Monitoring System for Elderly People", International Journal of Scientific & Technology Research, Vol**. 9**, Issue **01**, pp.**1562-1565, 2020**.
[26]. Wang, H., Zhao, Y., Yu, L., Liu, J., Zwetsloot, I. M., Cabrera, J., & Tsui, K. L. "A Personalized Health Monitoring System for Community-Dwelling Elderly People in Hong Kong: Design, Implementation, and Evaluation Study", Journal of Medical Internet Research, Vol. **22**, Issue **9**, pp.**e19223, 2020**.

AUTHORS PROFILE

Nwokoma, Queen Maclean earned her HND, and PGD. in Computer Science from the then Rivers State Polytechnic, Bori in 2006 and 2020, respectively. She is currently working as an Admin Officer in Rivers State Senior Secondary Schools Board, Port Harcourt since 2013. She has 8 years of banking experience and 10 years of Admin experience.

