Artificial Neural Network Embedded Optimal Mobile Communication System

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Abstract: Recent advancement in information and communication has witnessed the involvement and application of embedded system in mobile communications and Internet of Things (IoT) deployment in form of Multiple Operator Enabled SIM (MOES) System. This newly introduced system has shown to have capability to switch from one network to another seamlessly based on Received Signal Strength (RSS). However, such switching capability has shown not to be optimal in nature due to non-application of Artificial Intelligence (AI) in network selection process. Hence, this paper aims at developing Artificial Neural Network (ANN) based system for optimal network selection using RSS. The RSS parameters were collected over time using an existing hardware which reads RSS and the parameters were compiled. The datasets obtained were from four different Mobile Network Operators (MNOs) and used as prediction parameters which were used as input and target parameters for ANN trainings and testing. The parameters were simulated and the results obtained showed high accuracy of 0.99 as the most stable value which means that the developed method was efficient for optimal selection of network as the output regression plots were linear and the graph results of the trainings showed high selection of best RSS values when compared to the actual value results obtained and plotted on the graph. The performance evaluation was carried out by checking the accuracy of the system and the result obtained shows that the system is efficient with 1 as the highest regression value obtained and can be deployed for handing over from one mobile network to another.

Keywords: Quality of Service (QoS); Call Set-up Time (CST); Independent Measurement; Key Performance Indicator (KPI); Mobile Network; Mean Squared error (MSE).

I. INTRODUCTION

In recent times, mobile communications have become more available to the society, thus increasing the number of mobile phones and wireless internet users considerably. The current changing private and professional routines have created a rolling demand for communications on the move, reachability irrespective of one's location and wireless broadband (Abolfazl & Jalil, 2005; Oyediran *et al*., 2019; Aliu & Momoh, 2021).
Mobile cell phone terminal devices are normally operated with SIM cards that are put in interchangeably into the mobile telephony terminal devices (Azeta *et al*., 2016; Afeez 2017). The SIM card provides the identity of a particular subscriber to the GSM operator network, and the operator in turn provide a set

of services to the subscriber based on his/her identity. The SIM cards contain among other things the identity of the user and serve to identify the user in a mobile telephone network and to check user's authorization to use services of the mobile telephone network.
However, the network availability on this SIM card have become an issue for concern as the further one moves away from the Base Transceiver Station (BTS), the more the Received Signal Strength (RSS) decreases thereby making most subscribers use more than one phone for communication. Different mobile network operators have different Quality of Services (QoS) at different areas in the country (Afolabi, 2014; Aibinu *et al.*,2017; Jonathan *et al*., 2019). This has resulted in dropping of ongoing calls. Newly introduced technologies have shown to have capabilities to switch from one mobile network to another seamlessly using Received Signal Strength (RSS) (Salubuyi, 2016; Chinedu, *et al.*, 2020).
Recent advancement in the field of computing has witnessed the involvement and application of embedded system in mobile communication and Internet of Things (IoT) deployment in form of Multiple Operators Enabled SIM (MOES) system. (Naseer, *et al.*, 2015; Aibinu, *et al.*, 2016; Ameer, *et al.*, 2021). However, such switching capabilities have shown not to be optimal in nature due to non-application of Artificial Intelligence (AI) in the network selection process.
One notable AI technique that can be used to achieve seamless connection is the Artificial Neural Network (Jeon, *et al*., 2018; Hau, *et al*., 2020; Sørensen, *et al*., 2020). Thus, this paper is aimed at reducing the challenges that comes with the use of multiple cell phones by optimally switching seamlessly with fluctuating network signals and mobile networks.

II. REVIEW OF LITERATURE

Advancement in Wireless Mobile Communication System (WMCS) handover processes have been extensively discussed in literature. In later subsection, review of similar works in this area are covered. Handover in cellular communications is the process of exchanging a continuous call or information session from one channel of a system associated with the center system of another channel. However, Handover has several limitations, one of which was presented in (Khalid, *et al.*,2020; Behera, 2010) with the problem viewed as the Multiple Optimization Problem (MOP) concept. This was identified and used to symbolize multiple number of vertical handoff criteria that chooses the best available network with enhanced parameter values such as latency of network which ought to be minimum in the heterogeneous wireless network (Bhattachara, *et al.*, 2013; Gamal & Hesham, 2013; Khalaf and Badr, 2013; Richa & Khera, 2014; Fiona & Jayan, 2014; Azeta *et al.*, 2016). The figured various target capacities were executed utilizing hereditary algorithm.

In the work of (Aibinu *et al.*, 2017), they developed a hybrid ANN based on prediction model. They fed the developed model into Fuzzy Logic using the Received Signal Strength (RSS) obtained over time to form a time series data. The data obtained was fed to the newly proposed k-step ahead ANN-based RSS estimate system for predicting the estimate model coefficients. The synaptic weights and adaptive coefficients of the trained ANN was used to compute the k-step ahead ANN based RSS estimate model coefficients and the estimated RSS values were later codified as Fuzzy sets in conjunction with other measured network parameters and fed into the Fuzzy logic controller in order to complete handover decision process. The use of a cascaded ANN and Fuzzy logic for handover decision in a wireless mobile communication system was achieved for effective estimation of RSS level in handover decision management system. The limitation of this work is the use of multiple network parameters and handover algorithms for decision making (Aibinu *et al.*, 2017; Mebawondu, 2020; Kamble and Kounte, 2020). More so, (Afeez, 2017), developed a seamless switching algorithm for multiple operator enabled SIM (MOES) card. The developed system comprises fuzzy logic system which is the main algorithm for handover, a Simulink model of the fuzzy logic system, a mobile application and a hardware device. Fuzzy logic system serves as the control box for the whole system while the algorithm used fuzzy logic considering four parameters for the input and a set of nineteen optimized for controlling the decision of the algorithm and the decision of the system to handover or to maintain present state. The system was able to automatically read the received signal (RSS) strength of each network of the different network providers and used the network with the highest RSS to initiate calls. The system was limited to making or initiating calls once the best RSS value has been obtained and the switching is done.

The review of previous work on design of a seamless switching algorithm for multiple operator enabled SIM (MOES) card and the development of hybrid artificial intelligent based handover decision algorithm which are closely related works shows that although much efforts have been put in to achieve a seamlessly switching system for handover, the algorithms obtained from the works are a little more complex and require more parameters for consideration. Hence the need for a system that would require less inputs and less complex algorithms to achieve the same objective.

III. IMPLEMENTATION OF OPTIMAL NETWORK SELECTION EMBEDDED SYSTEM (ONSES).

This section presents the design details, the block diagram, flow chat on the implementations of the system. The Optimal Network Selection Embedded System (ONSES) is expected to obtain RSS values of mobile SIM cards and switch to the best available Mobile Network Operator (MNO) seamlessly to avoid call drops due to poor quality of service. The switching technique to be used to achieve the operation is the feed forward back propagation method of artificial neural network.

a) Optimal Network Selection Embedded System (ONSES) – Block Diagram

The block diagram for the implementation of the Optimal Network Selection Embedded System (ONSES) is shown in Figure 1. The block diagram consists of three sub units namely:

i. The ONSES Controller unit
ii. The SIM cards interface unit
iii. The SIM cards holder

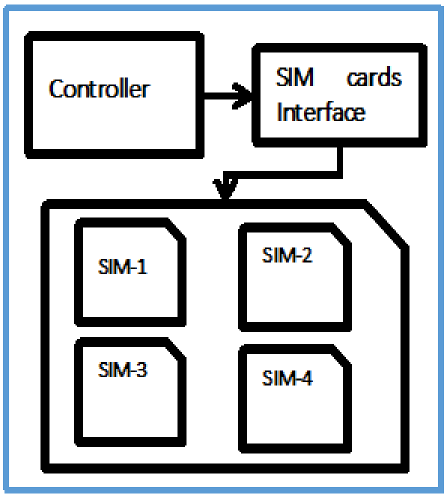


Figure 1 – Block Diagram of Optimal Network Selection Embedded System setup

i. The ONSES controller unit

The ATmega328 microcontroller sends message to the SIM card interface which in turn sends a message to the SIM cards holder to retrieve the RSS values of the available SIM cards and selects the best RSS value based on the ANN training.

ii. The SIM card Interface unit

The SIM card interface sends message to the SIM cards holder and also receives feedback of message sent. The SIM card interface requests for the RSS values of the SIM cards inside the SIM holder and receive the values, scan the values and sends the best value to the microcontroller.

iii. The SIM card Holder

The SIM cards holder carries the four available SIM cards. It obtains the RSS values of the available SIM cards and sends the values to the SIM card interface for scanning.

b) The Operational Principle of Optimal Network Selection Embedded System (ONSES).

The development of the Optimal Network Selection Embedded System would comprise three major stages for its principle of operation which includes:

i. The scanning stage

This stage involves obtaining the RSS values of the networks available in an environment by scanning through. The obtained parameter from the SIM cards are scanned for the best value based on quality of service and sends the output of the result to the display unit.

ii. The switching stage

This switching stage involves handing-over the SIM connections between the SIM cards by switching seamlessly done by the microcontroller.

iii. The selection stage

The Microcontroller unit activates the SIM card with highest value of the signal strength and network module seamlessly for communication. This optimum selection would be done via the circuitry interface that connects all the components.

c) Dataset compilation

The datasets used for this work was the RSS values of four different mobile network operators; MTN, Glo, Etisalat, and Airtel collected at different places over time. A total of five hundred RSS values each of the different networks were collected. The best of the values were compiled and used for ANN trainings and testing.

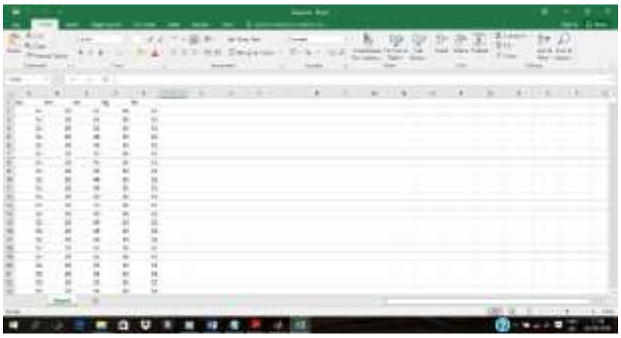


Figure 4 – Datasets compilation

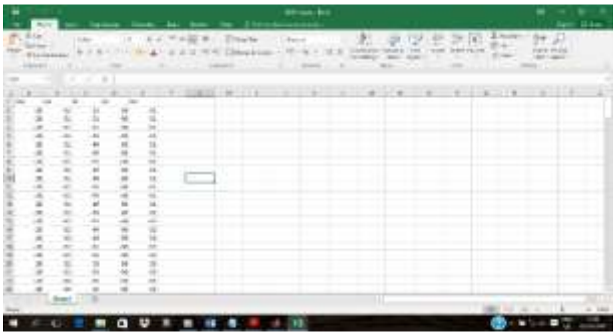


Figure 5 – ANN input datasets

IV. RESULTS AND DISCUSSION

This session discusses the various results obtained from the Artificial Neural Network training and testing. The training regression plots were presented and the results were also discussed.

a) SIMULATION OF ANN TRAINING AND TESTING

The various trainings and testing were simulated on MATrix LABoratory (MATLAB) computing environment using datasets of four mobile networks obtained at different times. The highest of the datasets at different times were determined before inputting the raw datasets into computing environment for simulations.

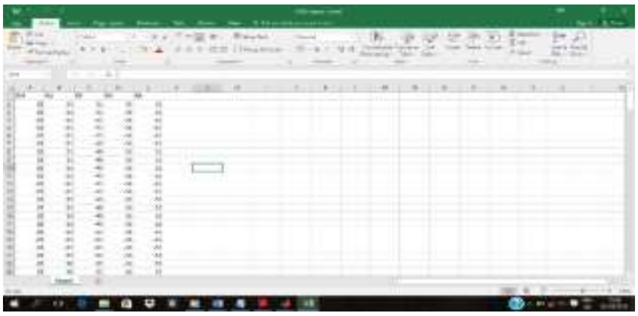


Figure 6 – Datasets obtained

The datasets in Figure 6 were converted into absolute values in Figure 7 using MATLAB codes and also reverted as training input values for ANN; ANN takes in input horizontally in Figure 8 before training. A total of 200 datasets each of the four mobile networks were used for the training input and the best 200 values from the datasets as training target inputs as shown in Figure 9.

Figure 7 – Absolute values of datasets.

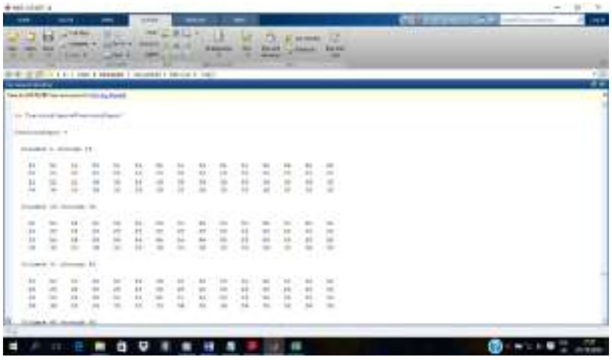
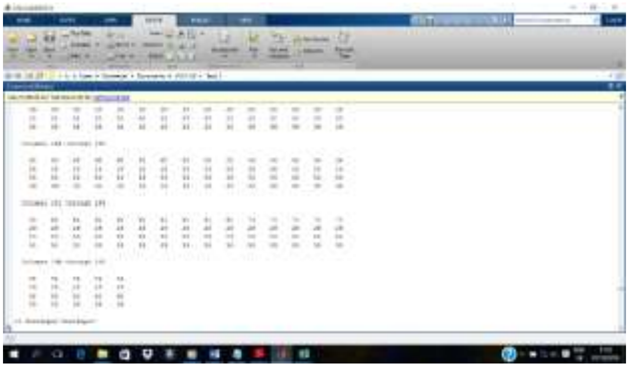


Figure 9 – ANN input datasets.



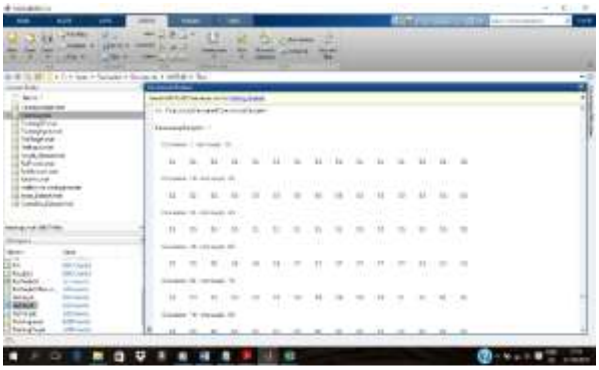


Figure 10 – ANN training input and target datasets.

i. Results from the training datasets

The results of the training using 10, 20 and 30 numbers of neurons with the input datasets are presented in Figure 11, Figure 12, Figure 13 respectively.

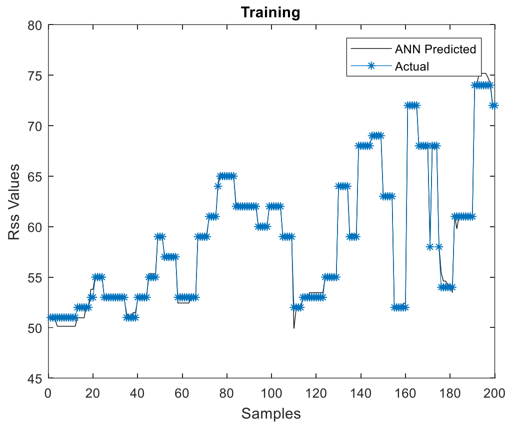


Figure 11 – Training result for 10 neurons.

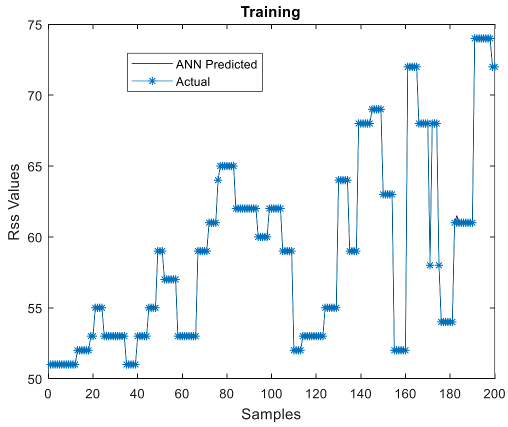


Figure 12 – Training result for 20 neurons.

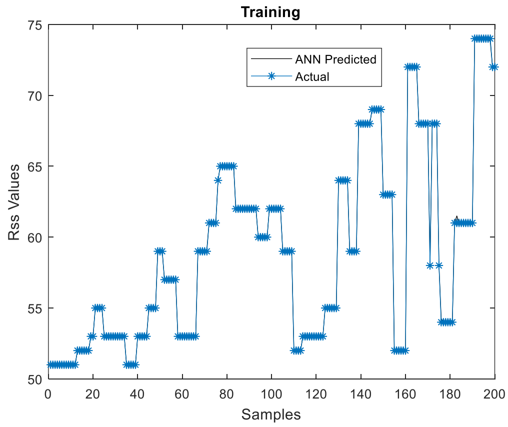


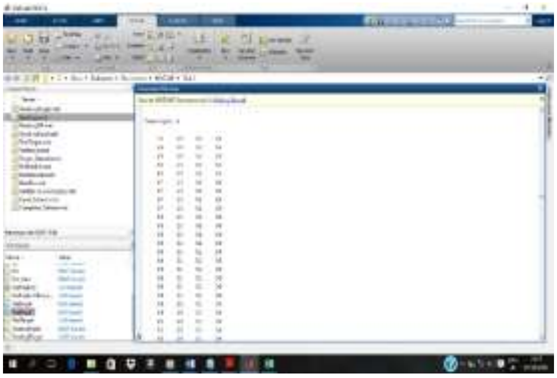
Figure 13 – Training result for 30 neurons.

ii. Discussion of training results

The training results in Figure 11, Figure 12 and Figure 13, shows that as the number of neurons used increased, the accuracy of predicted and actual values were 99% as the values obtained from the trainings were 0.99, 1 and 0.99 with a threshold of 1. This means that the more the input values are broken down into neurons, the greater the accuracy obtained at output. The predicted values are RSS values obtained with predetermined best RSS values of the same datasets that are trained while the actual values are RSS values inputted into the training. The result of the trainings using 10, 20, 30 number of neurons with the input datasets are presented in Figure 11, Figure 12 and Figure 13 respectively to obtain results. The results obtained showed high accuracy of the trainings carried out and this means that the ANN training was optimal in selection.

iii. Test datasets extraction

For each of the trainings, there are test inputs and target results which were carried out. The test inputs are a set of 200 numbers of dataset which was inputted into MATLAB and also reverted horizontally as ANN inputs as shown in Figure 14 and Figure 15 shows the test target inputs.



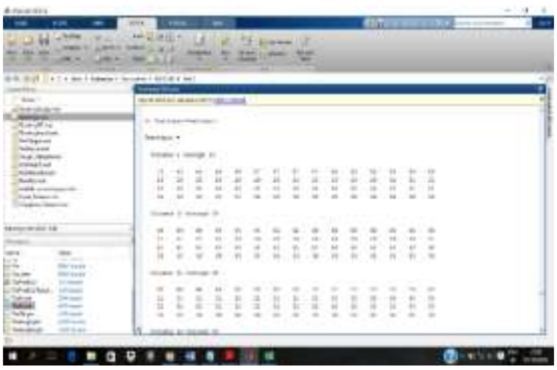
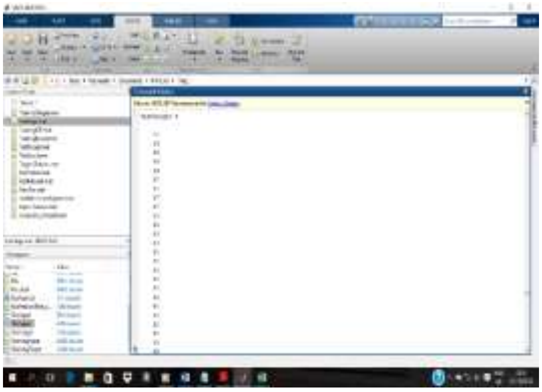


Figure 14 – ANN inputs as Test input datasets



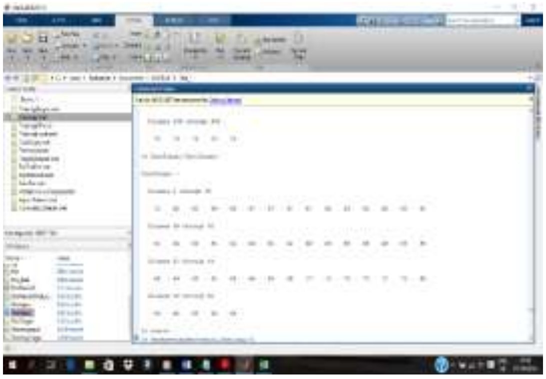


Figure 15 – ANN inputs as Test target datasets

iv. Testing datasets and results

The target datasets were used to determine the accuracy of the training as the output value of the predetermined datasets are plotted against the output value of datasets inputted into the training without the target value. The results obtained are shown in Figure 16 and Figure 17

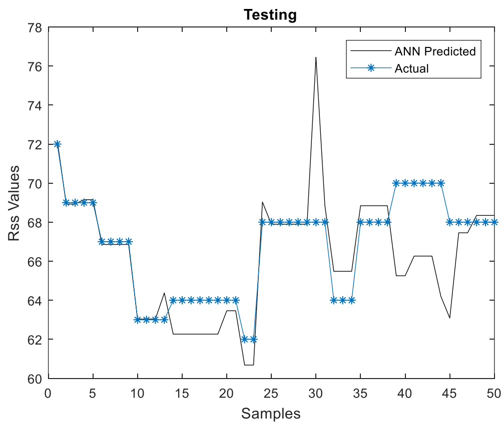


Figure 16 – Test input and target plot

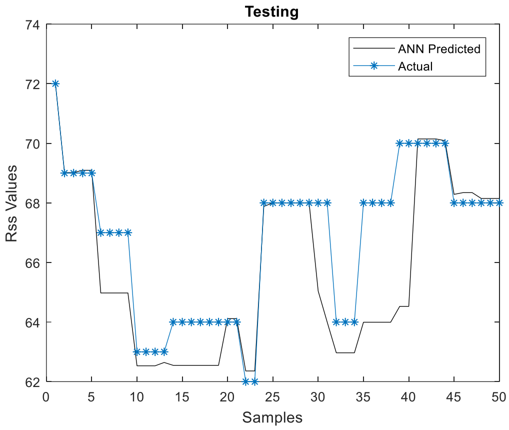


Figure 17 – Test input and target plot

The test inputs were trained and simulated using ANN codes to obtain the outputs manually. The sample output was plotted against RSS values and the accuracy of predicted values to actual values was 50%. This showed that the test results obtained would require more neuron numbers to obtain better accuracy.

v. Regression plots of training and testing

The regression plots of results obtained are also presented in the Figure 18, Figure 19 and Figure 20.

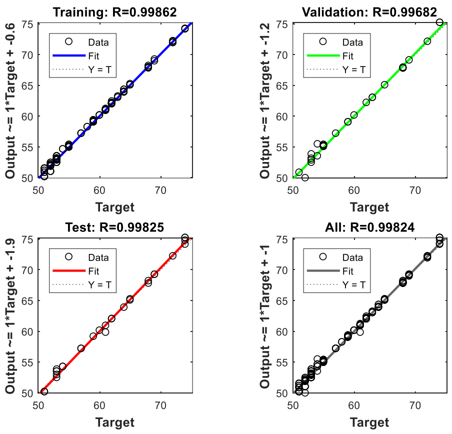


Figure 18 – Regression Plot for 10 neurons

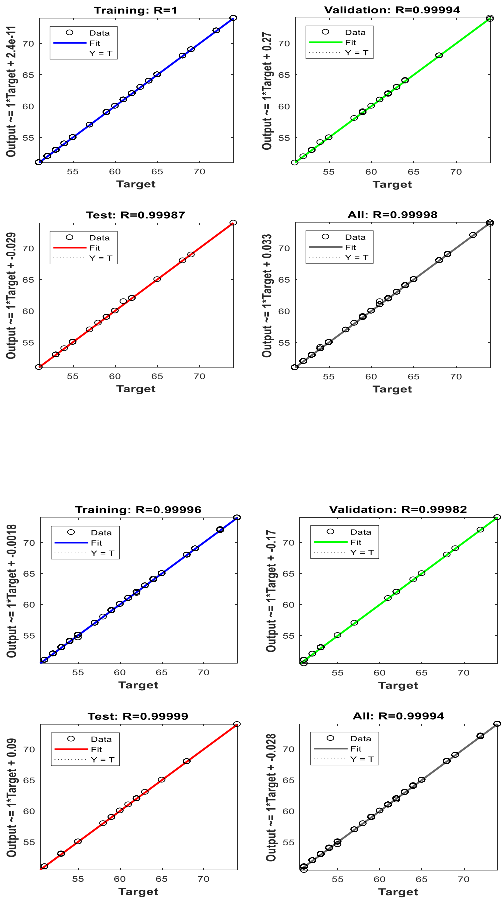


Figure 19 – Regression Plot for 20 neurons

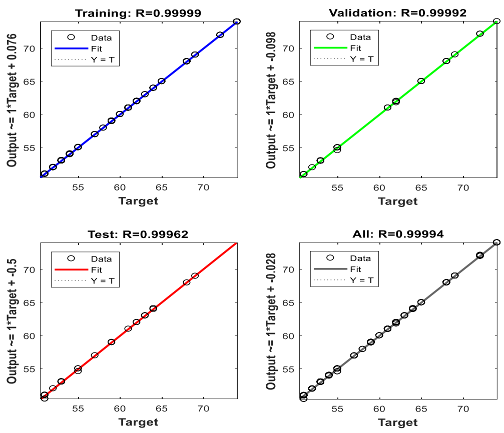


Figure 20 – Regression Plot for 30 neurons

The output of regression plots obtained showed also that as the number of neurons increase, the target datasets were almost linear with the regression values approximately 1in most case. The data were of close accuracy on a linear plot in the training, validation, and test plots in each of the regression plots because of the high number of neurons used to train the datasets except for Figure 18 where the datasets were trained using 10 neurons and that resulted to datasets not completely linear on the plot.

V. CONCLUSION

In this paper, the development of an optimal network selection embedded system using received signal strength parameters and artificial neural network has been implemented. Results obtained shows that the developed platform is able to optimally select best RSS value for handover decision appropriately as it gives an accuracy of 0.99 as the most stable value which means that the developed method was efficient for optimal selection of network as the output regression plots were linear and the graph results of the trainings showed high selection of best RSS values when compared to the actual value results obtained and plotted on the graph. The performance evaluation was carried out by checking the accuracy of the system and the result obtained shows that the system is efficient with 1 as the highest regression value obtained and can be deployed for handing over from one mobile network to another.

REFERENCES

Abolfazl, M. and Jalil. C. (2005). An Intelligent Vertical Algorithm for Next Generation Wireless Networks. In second IFIP International Conference on Wireless and Optical Communication Networs, 2005. WOCN 2005. (pp. 244-249). IEEE.

Afeez O. (2017). Development of a Handover Algorithm for Multiple Operators Enabled SIM (MOES) Card. Undergraduate Thesis (B.Eng). Department of Computer Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

Afolabi, T. I. (2014). Design and Construction of Operator Selective GSM SIM Interface. Undergraduate Thesis (B.Eng).Telecommunication Engineering Department, Federal University of Technology, Minna, Niger State, Nigeria.

Aibinu, A. M., Onumanyi, A. J., Adedigba, A. P., Ipinyomi, M., Folorunso, T. A., & Salami, M. J. E. (2017). Development of Hybrid Artificial Intelligent based Handover Decision algorithm. Engineering Science and Technology, an International Journal, 20(2), 381-390.

Aibinu, A. M., Onumanyi, A. J., Folorunso, T. A., Salubuyi, S. J., & Oziegbe, H. (2016). Development of Embedded-Multiple Operators Enabled SIM (E-MOES) Card System for Mobile-Phone Initiated Handover Across Various Network Operators. International Journal of Engineering Science and Technology.

Aliu, D. and Momoh, M.O., 2021. Optimal Resource Scheduling Algorithm for OFDMA-based Multicast Traffic Delivery over WIMAX Networks using Particle Swarm Optimization. International Journal of Software Engineering and Computer Systems, 7(2), pp.50-63.

Ameer, M., Abba, M.O., Momoh, M.T., Dauda, M. and Johnson, O.A., 2021. Transport and Telecommuting: Opportunities and Challenges Post COVID-19. ATBU Journal of Science, Technology and Education, 9(1), pp.321-335.

Azeta, A. A., Omoregbe, N. A., Gberevbie, D. E., Ikpefan, O. A., Ayo, C. K., Misra, S., & Williams, J. T. (2016). Motivating effective ICT users'support through automated mobile edu-helpdesk system. International Journal of Pharmacy & Technology. 2016, 8(4), pp. 22915–22925

Azeta, A. A., Omoregbe, N. A., Misra, S., Adewumi, A., & Olokunde, T. O. (2016). Adapted cloudlet for mobile distance learning: design, prototype and evaluation. In Advances in Digital Technologies (pp. 220-228). IOS Press

Behera P. (2010). Optimization of Vertical Handoff Performance Parameters in Heterogeneous Wireless Networks. International Journal of Modern

Engineering Research (IJMER), 1(2), pp-597-601.

Bhattacharya, P. P., Ananya, S., Indranil, S. and Subhajit, C. (2013). An ANN Based Call Handoff Management Scheme for Mobil Cellular Network. International Journal of Wireless & Mobile Networks, 5(6), pp. 125-134.

Fiona, A. A., Shaji, R. S. and Jayan, J. P. (2014). An Optimized Network Selection for Coverage under Cellular Network. International Conference on Control, Instrumentation, Communication and Computational Technologies, pp. 1043-1047.

Gamal, A. M. K and Hesham, Z. B. (2013). A comprehensive approach to vertical handoff in heterogeneous wireless networks. Journal of King Saud University, 1(25), pp. 197-205.

Hau, Y.W., Lim, H.W., Lim, C.W. and Kasim, S., 2020. P204 Automated detection of atrial fibrillation based on stationary wavelet transform and artificial neural network targeted for embedded system-on-chip technology. European Heart Journal, 41(Supplement_1), pp.ehz872-075.

Jeon, Y., Kim, C.S. and Kim, Y.J., 2018, January. Performance acceleration of neural networks on mobile embedded systems. In 2018 IEEE International Conference on Consumer Electronics (ICCE) (pp. 1-2). IEEE.

Jonathan, O., Misra, S., Ibanga, E., Maskeliunas, R., Damasevicius, R., & Ahuja, R. (2019, June). Design and implementation of a mobile webcast application with google analytics and cloud messaging functionality. In Journal of physics: conference series (Vol. 1235, No. 1, p. 012023). IOP Publishing.

Kamble, S.J. and Kounte, M.R., 2020. Machine learning approach on traffic congestion monitoring system in internet of vehicles. Procedia Computer Science, 171, pp.2235-2241.

Khalaf, G. A. F. M., and Badr, H. Z. (2013). A comprehensive approach to vertical handoff in heterogeneous wireless networks. Journal of King Saud University-Computer and Information Sciences, 25(2), pp. 197-205.

Khalid, S., Alam, A. and Ilyas, M., 2020. Optimized Security Context Switching with Low Latency in Vertical Handover: Optimized Security Context. *Proceedings of the Pakistan Academy of Sciences: A. Physical and Computational Sciences*, *57*(1), pp.37-44

Mebawondu, J.O., 2020, November. Comparative Analyses of Machine Learning Paradigms for Operators' Voice Call Quality of Service. In International Conference on Information and Communication Technology and Applications (pp. 66-79). Springer, Cham

Misra S., A Step by Step Guide for Choosing Project Topics and Writing Research Papers in ICT Related Disciplines, Communications in Computer and Information Science, Volume： 1350 Page： 727-744 the Publication year 2021 (pp. 727-744). Springer International Publishing.

Nasser, M. A. and Sanni, S. A. (2015). A Neural Network Based Handover Management Strategy for Heterogeneous Networks. 2015 IEEE 14th International Conference on Machine Learning and Application, pp. 1210-1214.

Oyediran, O., Omoshule, A., Misra, S., Maskeliūnas, R., & Damaševičius, R. (2019). Attitude of mobile telecommunication subscribers towards sim card registration in Lagos State, Southwestern Nigeria. International Journal of System Assurance Engineering and Management, 10(4), 783-791.

Paschal Uchenna Chinedu, Wilson Nwankwo, Daniel Aliu, Saliu Mohammed Shaba and Muyideen Omuya Momoh (2020). "Cloud Security Concerns: Assessing the Fears of Service Adoption"

Archive of Science & Technology 1 (2) (2020) 164 – 174

Richa, & Khera S., (2014). QOS Parameters based Vertical Handoff Decision in Heterogeneous Network: A Practical Approach. International Journal of Advanced Research in Computer and Communication Engineering, 3(7), pp. 7359-7362.

Salubuyi, S. J. (2016). Design and Construction of Embedded Multiple Operator Enabled SIM (E-MOES) Card. Undergraduate Thesis (B.Eng). Electrical Electronics Department, Federal University of Technology, Minna, Niger State, Nigeria.

Sørensen, P.M., Epp, B. and May, T., 2020. A depthwise separable convolutional neural network for keyword spotting on an embedded system. EURASIP Journal on Audio, Speech, and Music Processing, 2020(1), pp.1-14.