Validation of android-based mobile application for retrieving network signal level

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ABSTRACT

In recent years, the evolvement of mobile devices which perform sophisticated functions have been on the rise. Mobile applications which solved engineering challenges are now available due to the high computational capabilities, large random access memory and storage location of the mobile devices. An Android application called signal detect, which measures network signal strength value from 2G-4G received on an android mobile device has been developed using android app development environment called Android studio. Validation becomes necessary because different readings were obtained on smartphones with different specifications. Two validation techniques were used to validate the data obtained. To know the efficiency of the application; a field strength meter was used to compare the readings received on the mobile device with the meter. It was observed that there is a time lag on the received values of the mobile device to the field strength meter. Therefore, a moving average technique was used to correlate the two data which increased the correlation coefficient to about 0.85.

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1. INTRODUCTION

In the 21st century, communication system applications are utilized in the day-to-day activities of human lives, these include telecommunication, terrestrial television, transportation (maritime & air), military and security. Communication system engineering applications have evolved from the era of line telegraphy, radio telephony to real-time communication through the use of sophisticated smartphones that can perform various tasks including online shopping, cloud gaming, financial processes, controller, measurements and mapping etc [1-4]. Contemporary smartphones are versatile portable computers-on-chip that exploit the flexibility conferred on them by the existence of operating systems in this case Android that manages and controls operations of the smartphones depending on the architecture. Simple push email and web services were the definition of smartphones application some years back but now have geared up with applications which need data networks to perform its functions [5]. Therefore, smartphones are usually managed by the combination of different network frameworks of computing, sensors and communication systems [6, 7].

In Africa, especially in Nigeria, the services provided by the network infrastructure of service providers do not meet the specified standards set by both local and global regulators [8]. As most network signals received by smartphones often fall short of what can be classified as good quality of service (QoS) in terms of signal strength, resource distribution, connection and traffic control, security, call drop rates, data transfer speed, and so on [9-11]. Various factors such as noise, computation speed of mobile switching centre, propagation mechanism, handover, path-loss, network infrastructure setup and atmospheric conditions can affect the quality of signal strength as it travels between the transmitter and the receiver [12-15]. Therefore, it is wise to explore ways and means of utilizing especially whereas in this case the versatile smartphone is used as a vehicle for building indigenous android applications that can support germane uses of smartphones for development of suitable apps for communication engineering to solve challenges, enhance teaching, and research.

An application is simply a set of instructions written in a specific language which are used to perform user-defined tasks [16]. These user-defined tasks are developed using various high-level languages available such as JAVA, C++, C#, Python, and so on. Mobile applications are hosted on mobile devices and performed user-defined tasks by interacting with the various hardware components on mobile devices [17], [18]. There are about 2.7 million apps available for download on Google play store [19]. A look at the play store shows Facebook, Instagram and WhatsApp are the most downloaded with each having more than 1 billion downloads.

There are many android applications on google play store available on-purchase or free which can retrieve and display signal strength value in dBm of the mobile network signal received on an android phone. Network cell info lite, location finder & GSM mapper and RF signal tracker are few relevant android apps that can measure GSM, 3G and LTE signal received on a smartphone. Network cell info lite as presented in [20] displays received signal strength value and a display gauge which responds to the changes in the value received on the mobile device. The major challenge of the app is that it is not user-friendly. Location finder & GSM mapper given in [21] shows the received signal strength with the base transceiver station (BTS) information serving the smartphone. These applications do not display the pictorial plot of the signal strength values plot in real-time against the time been investigated. The RF signal tracker is an android app which also shows the received signal strength value and the signal-noise-ratio (SNR) level of the smartphone. Similarly, this app does not display the pictorial plot of the signal strength values [22].

Therefore, an Android-based mobile application for retrieving received network signal level has been developed in this work. The proposed app called SignalDetect can detect received signal strength values for 2G, 3G and 4G networks, network bar gauge, pictorial plot and most importantly the introduction of timestamp of the received signal strength values on the application this is because time is a critical factor in predicting the behavior of network, propagation modeling and effective network coverage of BTS. The uniqueness of this work is that the work has been able to validate signal strength with respect to android app using field strength meter. The rest of this paper is structured as follows. Section 2 describes the design block, programming languages and important libraries of the developed app, while Section 3 discusses the results obtained from the developed app tested on various smartphones and the performance evaluation of the developed app at different specifications is presented. Further analysis with a field strength meter was used to validate the results obtained from the developed app with two validation techniques; and finally, Section 4 concludes the paper.

2. MATERIALS AND METHOD

The design and implementation of Android apps are achieved on the integrated development environment (IDE) called Android Studio, which is based on either JAVA or C/C++ programming languages [23]. To develop an android application, an IDE like Android Studio or Eclipse, software development kit (SDK), the java software development kit (JDK) and a virtual device called an emulator are all requisites. A developed Android application can be packaged and made available for download on different platforms such as google play store, and Amazon Appstore. Each application developed in Android Studio contains one or more modules with source code files and resource files such as Android app modules, library modules and google app engine modules. The most important of the app build files are found in the following folders:

a) Manifests: Contains the AndroidManifest.xml file, which describes the fundamental characteristics of the app.
b) Java: Contains the MainActivity.java code files, having an activity class that script the user defined tasks of the app.
c) Res: Contains all non-code resources, such as XML layouts, UI strings, and bitmap images, which generally describe the app user interface.

It is imperative to mention the important libraries in developing the application as these libraries created the means of interacting with the hardware features of the smartphone as in this case of the register, baseband processor, and system clock. Androidtelephony.signal strength [24] is the function when invoked contains mobile phone signal strength related information as received on the mobile device and will detect the related information as network signal switches automatically between 2G, 3G and 4G. The signal strength value received is an arbitrary strength unit (ASU), which is just a representation of the rate at which the phone is able to update its signal power and quality by connecting to a nearby BTS. ASU basically measures the same thing as dBm, but on a more linear scale. As dBm is the acceptable form of measuring signal strength, (1) converts ASU to dBm:

$$\mathrm{dBm} = (2 * \mathrm{ASU}) - 113 \quad (1)$$

(2) and (3) snippets transformed the ASU value received on an android mobile phone to dBm.

$$\mathrm{mSignalStrength} = \mathrm{SignalStrength.getGsmSignalStrength()} \quad (2)$$

$$\mathrm{mSignaStrength_{dBm}} = (2 * \mathrm{mSignalStrength}) - 113 \quad (3)$$

The other important library is android.telephony.telephonymanager, which designed a graphical tool known as network bar that displays the signal strength in bar as received on a mobile phone [25]. The phone manufacturer and operating system driving the mobile phone determines the design of the network bar showed on the phone. Android.os.systemclock [26] simply synchronized the system time on the mobile phone with the timestamp widget on the application and jjoe64. Graphview does a real-time plot of the data against the time. Figure 1 shows the design flow of developing Android application.

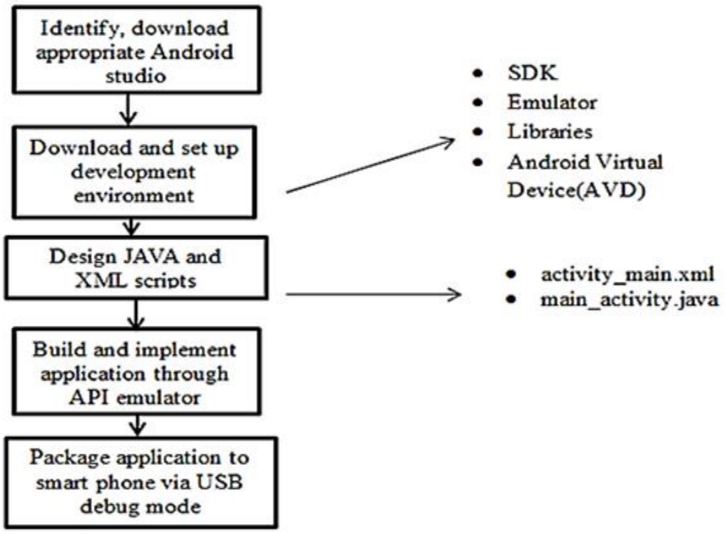

Figure 1. Block diagram of the application flow

3. RESULTS AND DISCUSSION

The performance of the developed SignalDetect app was tested on three smartphones. These smartphones and their features are listed in Table 1. Figures 2, 3 and 4 show the SignalDetect running on Nokia 6, Samsung A-6 and Samsung S7 Edge respectively. As shown in Table 1, the major smartphone manufacturers do not use the same components in the design of their phones which resulted in different interfaces obtained from the developed application on smartphones. The major reason is that Android UI (user interface) interactive and view components such as text-view, edit-view and buttons which design the user interface are all embedded in the android operating system. Since the versions of operating systems installed on the smartphones differ from one another, the interfaces are also different.

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Table 1. Smartphones and specifications

S/N	Smartphone	Specification
1	Nokia 6	Technology: GSM, HSPA, LTE Operating System: Android 7.1.1 (Nougat) Chipset: Qualcomm MSM8937 Snapdragon 430 (28 nm) CPU: Octa-core 1.4 GHz Cortex-A53 GPU: Adreno 505 RAM: 3GB
2	Samsung A-6	Technology: GSM, HSPA, LTE Operating System: Android 8.0 (Oreo) Chipset: Exynos 7870 Octa (14 nm) CPU: Octa-core 1.6 GHz Cortex-A53 GPU: Mali-T830 MP1 RAM: 3 GB
3	Samsung S7 Edge	Technology: GSM,HSPA,LTE Operating System: Android 6.0 (Marshmallow) Chipset: Qualcomm MSM8996 Snapdragon 820 (14 nm) CPU: Quad-core(2x 2.15 GHz Kyro & 2 x1.6 GHz Kyro) GPU: Adreno 530 RAM: 4 GB

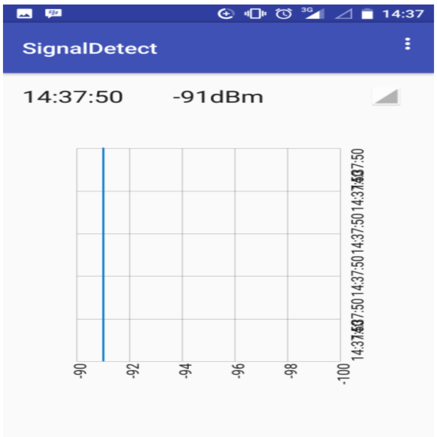

Figure 2. Signaldetect on nokia 6 smartphone

Figure 3. signaldetect on samsung A-6

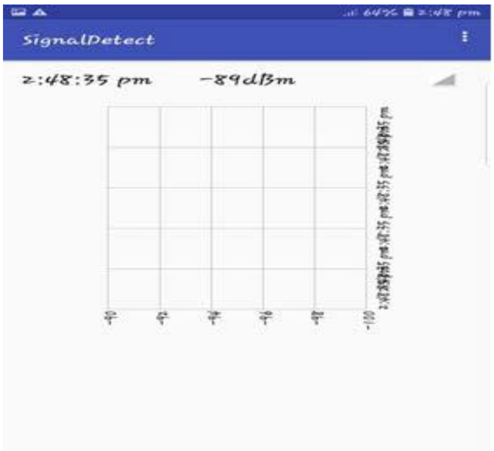

Figure 4. Samsung S7 edge smartphone respectively

3.1. Performance evaluation

Apart from the aforementioned features of SignalDetect, it was used to collect data simultaneously along with other existing apps on the same smartphones with similar specifications. The data collected was simulated as shown in Figure 5, with a correlation coefficient of 0.99 among them when computed. This implies that the developed app retrieved accurate data appropriately on the smartphone. The developed app was used to obtain samples on the smartphones shown in Table 1, all smartphones were initiated at the same time and each collected received signal strength level samples. Figure 6 shows the performances of the app on the various smartphones. The plot of signal strength values obtained from SignalDetect on the three different smartphones indicates that the data obtained on the smartphones differs from one another as a result of the composition of the smartphones. Consequently, the signal strength value received is a function of the processes (hardware and software of a smartphone) that delivered this value. Since the compositions of the phones are different, the performance of the app on the smartphones was slightly different as expected.

Hence, this justifies the different values in terms of signal strengths obtained in Figure 6. Since the diversity of hardware structure of smart phones vary from each other, hence the performance of the receiver sensitivities on the smart phones due to thermal noise and degradation are not similar which makes the values obtained on them to vary as well. Equally, smartphones manufacturers have different shifting approaches used on the smart phones to covert the ASU values of the received signals to values in dBm, this leads to differences in values obtained on the smartphone at the same location.

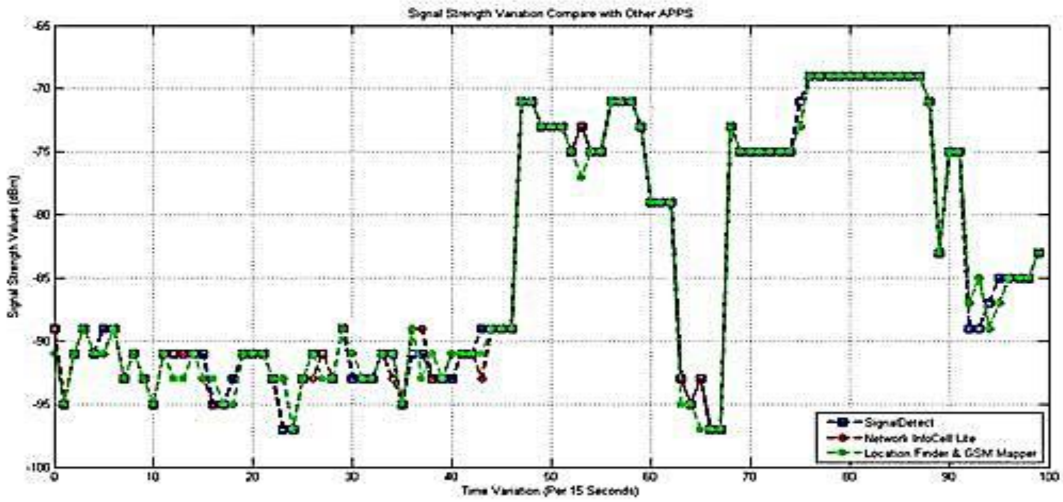

Figure 5. Measured signal strength plot of the three apps

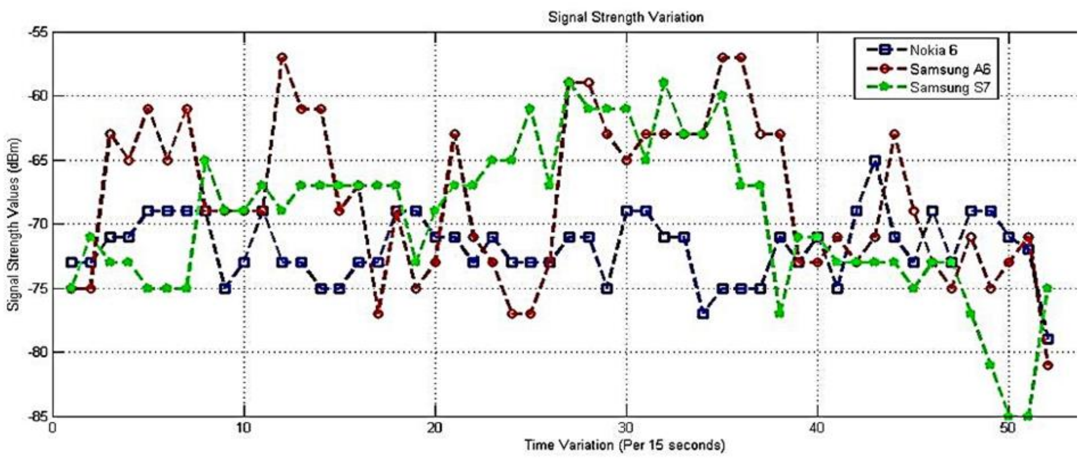

Figure 6. Performance of signaldetect on the three smartphones

3.2. Validation

As the values obtained on the smartphones running SignalDetect are slightly different, it will be wise to validate it with a standard measuring device before using to ascertain the correlation coefficient and necessary adjustment to be considered. A field strength meter and nokia smartphone running SignalDetect shown in Figure 7 were used to obtain the signal strength values. Figure 8 shows the plot of field strength meter and smartphone readings values obtained from them respectively; the plot shows that there is a time delay on the smartphone before the values are registered on the application. A moving average technique was done to shift the data by one to improve the plot, as shown in Figure 9. This improves the correlation coefficient between the two data to about 0.85. Thus a solid positive relationship exists between the two data obtained as both measured variables responded to the fluctuation of signal strength received from the BTS.

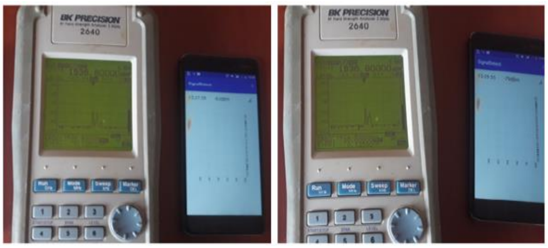

Figure 7. Field strength meter and smartphone reading displays

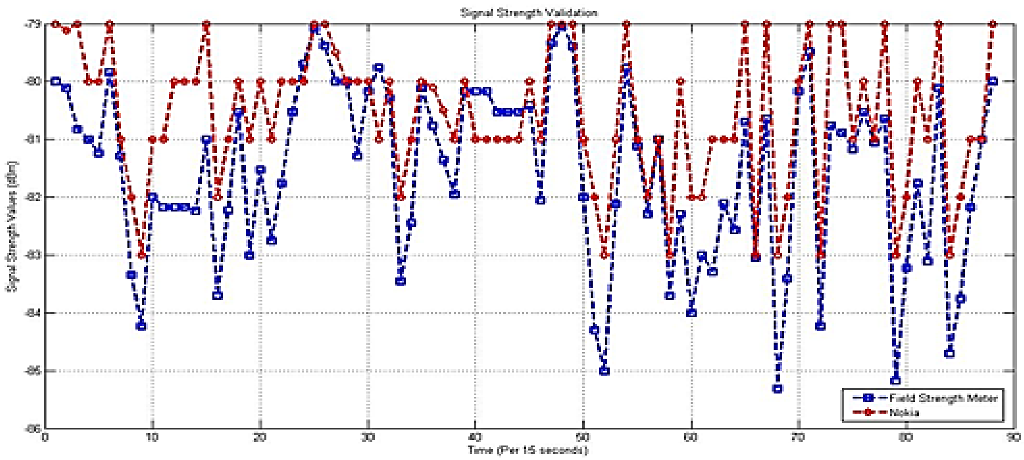

Figure 8. Signal strength plot for field strength meter and nokia

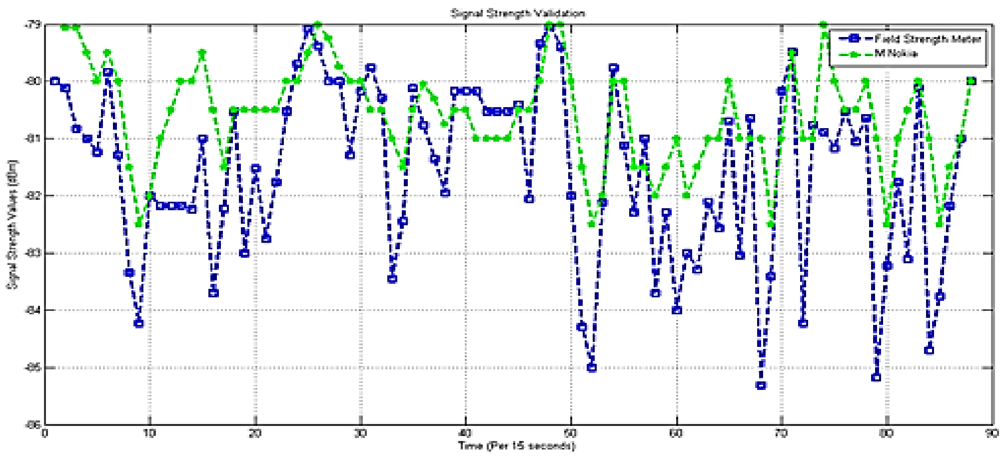

Figure 9. Moving average plot between field strength meter and nokia

3.2.1. Scatter plot and regression line

The two data sets are plotted on a scatter plot, the pattern of the resulting points on the scatter plot helps to determine if there is a presence of a strong correlation between the two variables. The plot shows good visualization of the correlation between the data sets. The value of one variable determines the position on the horizontal axis and the value of the other variable determines the position on the vertical axis of the scatter plot. The values obtained from the field strength meter and the developed app were plotted using scatter plot function with (4):

$$Plot = scatter(X, Y) \quad (4)$$

where x and y are the field strength and developed app dataset respectively.

Figure 10 shows the scatter plot of the data sets for the field strength meter and the developed app. A strong correlation between the data sets is indicated by the regression line which passes through the data plotted because the data points are uniformly distributed above and below the regression line. This implies strongly correlated data between the two variables.

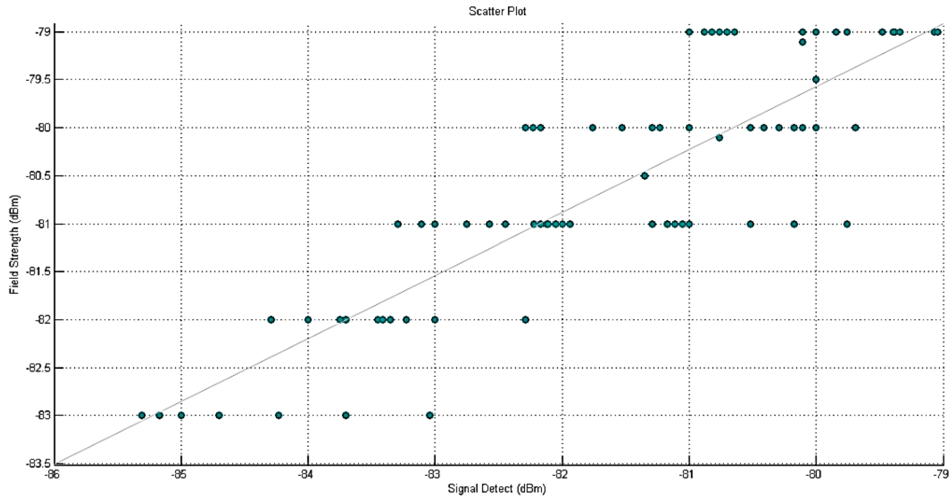

Figure 10. Scatter plot of signal strength values: field strength meter and nokia

3.2.2. Histogram and shewness

Histogram is a good tool to show the distribution of the obtained data with a normal density curve. Figure 11 shows the comparison of the obtained data with a normal distribution curve. The distributions of the sampled data appear to be left skewed and also the majority of the histograms are considerably peaked relatively to a normal distribution curve.

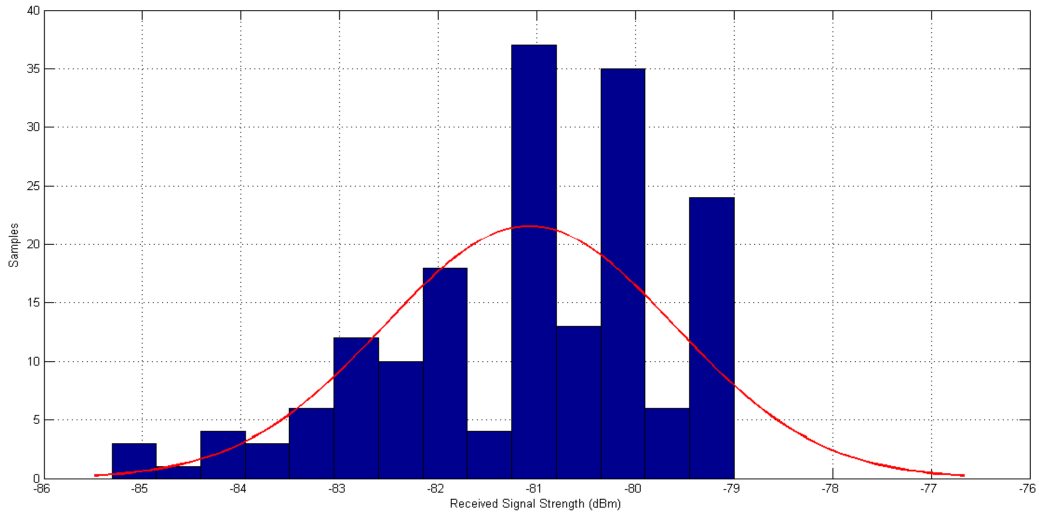

Figure 11. Histogram of the received signal strength samples

4. CONCLUSION

As smartphone architecture keeps evolving with the introduction of improved hardware, the development of smartphones applications have been enhanced by this improvement. Steps must be taken to mitigate the errors that could arise in the data obtained from such applications as shown that the data collected is a function of the composition of the smart phones. With a correlation coefficient of about 0.85, it is acceptable to use SignalDetect as the relationship between the two data is significant enough to be considered for usage. However, appropriate steps need to be taken to cover up for the error that will arise due to the hardware features of the smartphone. Therefore, this reseach shows that validation of android mobile apps is necessary especially before its usage for research and performance evaluation. SignalDetect can be installed on any android device with a minimum API level 16 to the latest release ones and can be used by any network planner, network providers and regulators, and on any research work that involves measuring the mobile signal strength of a coverage area.

REFERENCES

[1] H. Abubaker, A. Ali, S. Mariyam Shamsuddin and S. Hassan, "Exploring permissions in android applications using ensemble-based extra tree feature selection," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 19, no. 1, pp. 543-552, 2020.

[2] M. Gasah, A. Baharum and N. Mat Zain, "Measure learning effectiveness among children using EEG device and mobile application," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 17, no. 1, pp. 191, 2020.

[3] D. Prasetya Kristiadi, F. Sudarto, E. Fabian Rahardja, N. Rayfi Hafizh, C. Samuel and H. Hendric Spits Warnars, "Mobile cloud game in high performance computing environment," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 18, no. 4, pp. 1983, 2020.

[4] C. Soon et al., "Bluetooth embedded digital ammeter with android app data logging," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 18, no. 3, pp. 1400, 2020.

[5] A. Charlesworth, "The ascent of smartphone," *Engineering & Technology*, vol. 4, no. 3, pp. 32-33, 2009.

[6] P. Zheng and L. Li, smart phone & next generation mobile computing, 1st ed. Oxford: Morgan Kaufmann, pp. 6-7, 2006.

[7] W. Win Myo, W. Wettayaprasit and P. Aiyarak, "A More Reliable Step Counter using Built-in Accelerometer in Smartphone," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 12, no. 2, pp. 775, 2018.

[8] N. Nkordeh, J. Olatunbosun, I. Bob-Manuel and O. Oni, "Analysis of Mobile Networks Signal Strength for GSM Networks," in WCECS 2016, San Francisco, vol. I, 2016.

[9] X. Fu, D. Hogrefe, S. Narayanan and R. Soltwisch, "QoS and Security in 4G Networks," in *GMC 2004*, China, pp. 1-6, 2004.

[10] W. Song, H. Jiang, W. Zhuang and X. Shen, "Resource management for QoS support in cellular/WLAN interworking," *IEEE Network*, vol. 19, no. 5, pp. 12-18, 2005. Available: 10.1109/mnet.2005.1509947.

[11] J. Kim and A. Jamalipour, "Traffic management and QoS provisioning in future wireless IP networks," *IEEE Personal Communications*, vol. 8, no. 5, pp. 46-55, 2001. Available: 10.1109/98.960340.

[12] J. Luomala and I. Hakala, "Effects of temperature and humidity on radio signal strength in outdoor wireless sensor networks," *2015 Federated Conference on Computer Science and Information Systems (FedCSIS)*, Lodz, pp. 1247-1255, 2015. doi: 10.15439/2015F241.

[13] J. Andersen, T. Rappaport and S. Yoshida, "Propagation measurements and models for wireless communications channels," *IEEE Communications Magazine*, vol. 33, no. 1, pp. 42-49, 1995.

[14] A. Gurtov and J. Korhonen, "Effect of vertical handovers on performance of TCP-friendly rate control," *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 8, no. 3, pp. 73, 2004.

[15] S. Sonntag, L. Schulte and J. Manner, "Mobile network measurements - It's not all about signal strength," *2013 IEEE Wireless Communications and Networking Conference (WCNC)*, 2013.

[16] K. Adeniji and O. Adaramola, "Web Applications Development Using Visual Basic. NET and Microsoft SQL for Mobile and PC Devices," *International Journal for Computer Science & Engineering*, vol. 1, no. 1, pp. 1-12, 2015.

[17] A. Wasserman, "Software engineering issues for mobile application development," *Proceedings of the FSE/SDP workshop on Future of software engineering research-FoSER '10*, pp. 397-400, 2010. Available: 10.1145/1882362.1882443.

[18] R. Harrison, D. Flood and D. Duce, "Usability of mobile applications: literature review and rationale for a new usability model," *Journal of Interaction Science*, vol. 1, no. 1, pp. 1, 2013. Available: 10.1186/2194-0827-1-1.

[19] J. Clement, "Google Play Store: number of apps 2019|Statista," *Statista*, 2019. [Online]. Available: https://www.statista.com/statistics/266210/number-of-available-applications-in-the-google-play-store/..

[20] Network Cell Info lite. Los Angeles,CA: Wilysis, 2019.

[21] M. Gill, "Location Finder and GSM Mapper," friendscorner, 2014.

[22] K. Hunt, RF Signal Tracker. 2017.

[23] Meet Android Studio Android Developers, Android Developers. [Online]. Available: https://developer.android.com/studio/intro/.

[24] Signal Strength Android Developers, Android Developers. [Online]. Available: https://developer.android.com/reference/android/telephony/SignalStrength.

[25] TelephonyManager, Android Developers, Android Developers. [Online]. Available: https://developer.android.com/reference/android/telephony/TelephonyManager.

[26] SystemClock, Android Developers, Android Developers. [Online]. Available: https://developer.android.com/reference/android/os/SystemClock.

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