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Exploring the Usability and Suitability of Smartphone Apps for Precise and Rapid Mapping Applications

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ABSTRACT

This study explored the usability and suitability of freely available smartphone positionig apps for precise and rapid mapping applications. The study takes eight smartphone applications (GPS Data, Geo-location, Map coordinate, My GPS location, Mobile Topographer, Super GEO GPS, UTM GEOMAP and GNSS logger Application) and Garmin Map76s handheld GPS into consideration with observations from Hi-Target V30 GNSS receiver as basis for comparison. Eleven stations distributed all over the main Campus of Ahmadu Bello University in Nigeria were used for the study. The study treated Garmin Map76s and seven smartphone applications (GPS Data, Geo-location, Map coordinate, My GPS location, Mobile Topographer, Super GEO GPS, and UTM GEOMAP) first. Garmin Map76s turns out to be the best with an RMSE value less than 0.3m on both easting and northing components. UTM GEOMAP gave the best result among the seven smartphone applications with and RMSE value of 0.3m on both easting and northing. The GNSS logger application used on a Samsung galaxy S9+ was later treated separately and compared its performance alongside the Hi-Target V30 observation. The application performed well at most of the stations but showed less precision to the Hi-Target V30 observation but assumably better than the oyther positioning apps.

1. INTRODUCTION

Numerous applications in surveying and mapping have been made easier and more exact because of the advent of the Global Navigation Satellite System (GNSS), and along these lines, the interest for utilizing forefront GNSS strategies in surveying and mapping applications have become imperative. GNSS is one of the most creative and useful advances created as of late. Since its origin, it has developed to give overall all-weather navigation as well as exact position assurance capacities to all users particularly for surveying and geodetic applications (Isioye et al. 2018).

The GNSS receivers in smartphones normally belong to the family of 'high-sensitivity' receivers that are equipped for receiving GNSS signals with a power ratio under −150 dBm which is higher than that of a typical receiver (around −130 dBm) (Tomaštík et al., 2020). The Assisted-GPS function of a smartphone utilizes the capacity of the smartphones to connect with the Web to determine data about satellite signals, which ought to be accessible in the estimated area of the smartphone. Hence, the receiver doesn't need to look through every single imaginable signal and the time to First Fix can be lessened. Generally, mid-and high-level smartphone GNSS receivers can get signals from different satellite systems. There are receivers equipped for getting signals from all systems operational at a global scale including GPS (USA), GLONASS (Russia), Galileo (EU), Beidou (China) just as Regional systems, like QZSS of Japan and IRNSS of India (Tomaštík et al., 2020). Many usable satellites offer better positioning.

The GNSS antenna contained within the smartphone uses linear polarization, making it especially liable to multipath effects resulting from GNSS signals bouncing off the ground or nearby surfaces before reaching the antenna (Schwieger and Gläser 2005). In the process of computing the observations, the GNSS receiver must discriminate between the direct signal and the reflected ones, resulting in noisier and possibly biased measurements. More often than not the accuracy of positioning apps in the smartphone are degraded by these conditions.

It is a well-known fact that the accuracy of smartphone apps for the survey is very low compared to the geodetic grade receiver. Many studies have focused on the evalaution of the performances of smartphones apps (see, Bauer 2013; Hwang et al., 2012; Lee et al., 2017; Merry and Bettinger, 2019; Paziewski, 2020; Schaefer and Woodyer, 2015; Szot et al. 2019; Tomastík et al., 2017; Tomaštík et al., 2020).

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This study aims to explore the usability and suitability of smartphone applications for precise and rapid mapping applications.

2. METHOD

Data used for this study were obtained from a geodetic grade GNSS receiver (Hi-Target V30), Garmin Map76s (handheld GPS) and eight Android Smartphone Applications (GPS Data, Geo-location, Map coordinate, My GPS location, Mobile Topographer, Super GEO GPS, UTM GEOMAP and GNSS logger Apps of Samsung S9+) stationed over 11 stations distributed all over the Ahmadu Bello University (ABU) Main Campus, Zaria. Each smartphone application was allowed to observe for a period of 20 minutes. The Fig.1 shows the distibution of the stations within the ABU main campus.

Figure 1. Distribution of Eleven Verification Stations within the Campus of ABU

Observations from seven smartphone applications and the Garmin Map76s were in direct coordinates. On the contrary, those obtained from the geodetic grade receiver and the GNSS logger application of Samsung galaxy S9+ were in Receiver Independent Exchange format (RINEX) files which were further processed in order to obtain the respective coordinates of individual stations. The Hi-Geomatics Office (HGO) and GNSS analysis window software were respectively used to accomplish the task.

Results from Garmin Map76s and seven smartphone applications (i.e. GPS Data, Geo-location, Map coordinate, My GPS location, Mobile Topographer, Super GEO GPS, and UTM GEOMAP) were treated separately. The GNSS logger Apps of Samsung S9+ was also treated alone.

Basic statistical analysis of calculating the Root Mean Square Error (RMSE) was carried out to check the suitability of the smartphone apps for mapping. The mean coordinate errors were determined as in equations 1&2.

$$\mathrm{RMSE_E} = \sqrt{\sum_{i=1}^{n} \frac{\Delta Ei^2}{n}} \qquad (1)$$

$$\mathrm{RMSE_N} = \sqrt{\sum_{i=1}^{n} \frac{\Delta Ni^2}{n}} \qquad (2)$$

Where $\Delta Ei, \Delta Ni$ are the differences between the GNSS acquired and the reference (true) coordinates, and n is the number of points in the set.

Root Mean Square Error $\mathrm{RMSE_{EN}}$ in coordinate was calculated. This is a characteristic of point sets accuracy and is one of the most common accuracy measures in geodesy. The $\mathrm{RMSE_{EN}}$ is calculated as in Equation 3;

$$RMSE_{EN} = \sqrt{(RMSE_E)^2 + (RMSE_N)^2} \qquad (3)$$

3. RESULTS

The coordinates of these stations were obtained and were converted to equivalent Universal Traverse Mercator (UTM) coordinate system with projection on the WGS 84 ellipsoid. The coordinates of the stations used in this study as obtained from the Hi-Target V30 geodetic grade receiver is presented in Table 1. In addition, all coordinates were converted to UTM system for easy comparison.

To compare accuracy of the eight smartphone applications and Garmin Map76s, the coordinates of the stations obtained from Hi-Target V30 were processed and taken as reference. The coordinate differences of each smartphone application and Garmin Map76s subtracted from reference coordinates of all the stations and RMSEE, $\mathrm{RMSE_N}$, and $\mathrm{RMSE_{EN}}$ have been computed by Equations (1)– (3). The combined results of the performance measures ($\mathrm{RMSE_E}$, $\mathrm{RMSE_N}$, and $\mathrm{RMSE_{EN}}$) for the seven-smartphone applications is presented in Table 2 for observations at all the stations.

Table 1. Observed Stations from Hi-Target V30

POINT ID	**E (m)**	**N (m)**	**H (m)**
ABU2011	352459.943	1233203.374	692.1641
ABU2014	352696.679	1233424.392	690.7929
ABU2015	352846.384	1233659.501	694.9549
ABUBARDA 2548	352349.3366	1233363.464	692.9329
GSES21	352527.038	1233238.586	689.6248
ABU GEOM 2588	352409.461	1232991.232	688.8541
ABU2550	351837.6957	1233262.782	689.361
ABU2020	352233.2777	1233064.653	687.4559
ABU FOUNTAIN	353260.047	1233089.818	692.3665
ABU2053	352229.518	1233058.154	694.1548
ABU 2018	352915.937	1232591.472	684.357

The result for the Garmin Map76s and the seven smartphone applications shows that Garmin Map76s has the best RMSE value of typically less than 0.3 m. UTM GEOMAP, My GPS Location and Super Geo GPS amongst the seven smartphone applications were the best with 0.3, 0.4 and 0.4m respectively in both easting and nothing components. On the contrary, Map Coordinates gave the worst result with RMSE value of about 0.6m on both axes.

Figure 1 is a plot of the different performance measures RMSE of the seven smartphone applications and Garmin Map76s. The Fig.2 and table 2 presents the results.

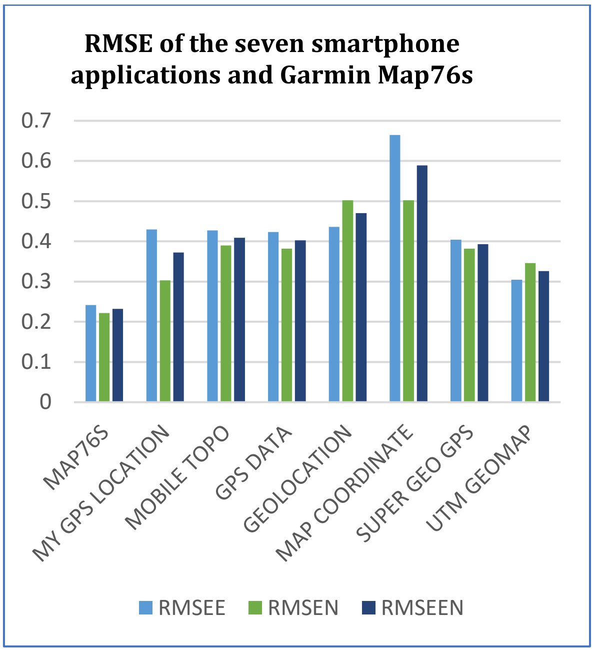

Figure 2. RMSE of the Seven-Smartphone Applications with Garmin Map76s

On the other hand, the result for the GNSS logger smartphone application used on Samsung galaxy S9+ on these 11 stations shows that the application performs best on the station ABU2020 with an RMSE value of roughly 0.2m on easting, northing and height. The application performs to the lowest at stations ABU2014, ABU FOUNTAIN and BARDA 2550 with RMSE value of 0.6, 0.7 and 0.5m respectively on easting, northing and height. This can be attributed to the effect of multipath because of high rising structures and vegetation cover. Table 3 shows the RMSE values obtained on all stations. Fig. 3 is a plot of the different performance measures RMSE on all stations using the GNSS logger application.

4. DISCUSSION

Based on the findings of this study, Fig. 2 shows that Garmin Map76s has the best result and hence above all the remaining seven smartphone application in the pecking order. In its absence, UTM GEOMAP can be used as a substitute because of its performance. My GPS Location and Super Geo GPS also did very well and can be used in carrying out a precise and rapid mapping exercise.

GNSS logger application as seen in Fig. 3 showed good performance on the station ABU2020. However, it gave some bad result as seen in stations ABU2014, ABU FOUNTAIN, and BARDA 2550. As stated earlier, this performance was attributed to multipath effect and also very short reception time. With advancement in technology, the smartphone applications might be improved to make GNSS observations better. For the better the accuracy, the more they will be accepted into surveying and geodesy activities (such as precise and rapid mapping).

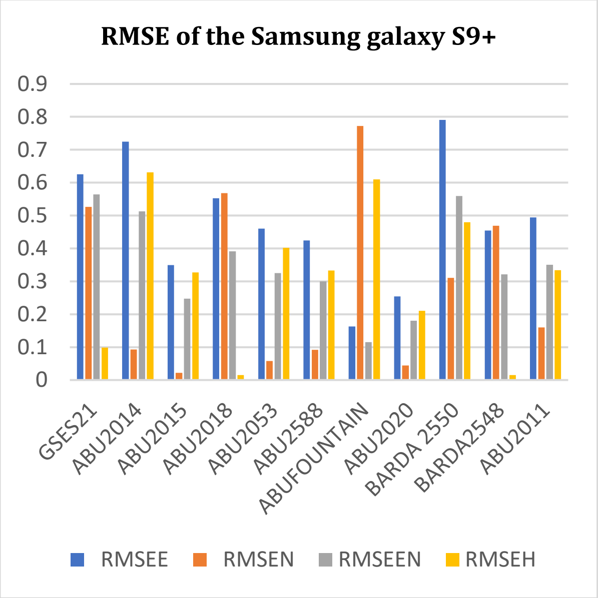

Figure 3. RMSE on all stations using the GNSS logger application

5. CONCLUSION

The study tests the usability and suitability of the use of smartphone applications for precise and rapid mapping. The first set of applications used are the Garmin Map76s, UTM GEO MAP, MY GPS LOCATION, SUPER GEO GPS, GPS DATA, MOBILE TOPO and GEO LOCATION. Garmin Map76s performs better than all the smartphone applications. UTM GEO MAP amongst the smartphone applications gave the best result. On the other hand, GNSS logger application that gives observations in RINEX file format was also used and its results compared to the Hi-Target V30 geodetic grade receiver. It performs well on station ABU2020 but was bad on other stations due to multipath effects. The results clearly point out to UTM GEO MAP as the best smartphone application used in this study.

Table 2. RMSE of the seven smartphone applications and Garmin Map76s

APPLICATIONS	E (m)	N (m)	E^2	N^2	$RMSE_E$	$RMSE_N$	$RMSE_{EN}$
MAP76s	1.935	1.779	3.745	3.166	0.242	0.222	0.232
MY GPS LOCATION	3.444	2.425	11.860	5.880	0.430	0.303	0.372
MOBILE TOPO	3.417	3.119	11.673	9.731	0.427	0.390	0.409
GPS DATA	3.385	3.056	11.459	9.337	0.423	0.382	0.403
GEOLOCATION	3.485	4.013	12.146	16.108	0.436	0.502	0.470
MAP COORDINATE	5.320	4.015	28.299	16.121	0.665	0.502	0.589
SUPER GEO GPS	3.233	3.060	10.451	9.361	0.404	0.382	0.393
UTM GEOMAP	2.443	2.766	5.970	7.651	0.305	0.346	0.326

Table 3. RMSE on station using the GNSS logger application

STATIONS	E (m)	N (m)	H (m)	E^2	N^2	$RMSE_E$	$RMSE_N$	$RMSE_{EN}$	$RMSE_H$
GSES21	2.074	1.745	0.329	4.301	3.045	0.625	0.526	0.564	0.099
ABU2014	2.404	0.31	2.094	5.779	0.096	0.725	0.093	0.513	0.631
ABU2015	1.159	0.074	1.085	1.343	0.005	0.349	0.022	0.247	0.327
ABU2018	1.834	1.884	0.05	3.364	3.549	0.553	0.568	0.391	0.015
ABU2053	1.524	0.191	1.333	2.323	0.036	0.460	0.058	0.325	0.402
ABU2588	1.407	0.304	1.103	1.980	0.092	0.424	0.092	0.300	0.333
ABUFOUNTAIN	0.539	2.562	2.023	0.291	6.564	0.163	0.772	0.115	0.610
ABU2020	0.843	0.145	0.698	0.711	0.021	0.254	0.044	0.180	0.210
BARDA 2550	2.623	1.032	1.591	6.880	1.065	0.791	0.311	0.559	0.480
BARDA2548	1.506	1.555	0.049	2.268	2.418	0.454	0.469	0.321	0.015
ABU2011	1.64	0.531	1.109	2.690	0.282	0.494	0.160	0.350	0.334

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