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MINNA 2019

EXPLORING THE FRONTIERS OF SURVEYING AND GEOINFORMATICS FOR NATIONAL DEVELOPMENT

4TH -7TH FEBRUARY, 2019

School of Environmental Technology, Federal University of Technology, Minna, Niger State

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TABLE OF CONTENTS

Development of an Android Application for Transformation of Nigerian Projected Coordinates from Local to Universal Transverse Mercator

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Abstract

This paper presents an Android application for Coordinate Transformation. The developed Android application called Nigeria PCS transforms Nigerian Transverse Mercator (NTM) coordinates to Universal Transverse Mercator (UTM) coordinates and vice versa. It can also convert UTM coordinate to geographic coordinate, NTM coordinate to geographic coordinate, geographic coordinate to UTM coordinate and geographic coordinate to NTM coordinate. Five (5) random coordinates were generated on each zone of the UTM and belt of the NTM to compare the computational accuracy of Nigeria PCS (herein developed) with Blue marble geographic calculator and Franson coordinate transformation software using the Student's t-test for independent samples and one-way ANOVA at 99% confidence interval on SPSS version 22. The results after the statistical analysis show that there is no significant difference between Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation software. Nigeria PCS can be installed on an Android phone with a minimum of Android 4.0.3 Ice Scream Sandwich operating system.

Keywords: *Android phones, Map projection, UTM and NTM, Coordinate Transformation, Statistical test*

1.0 Introduction

One of the most important electronic gadgets to people today is the computer. This is because of its capability to record, store, process, analyse, query, retrieve and display information within a short time with the help of installed application software [1]. An application software is a software that is designed to allow users of the computer to perform specific tasks that solves problems in the real world.

Development in computer hardware and software has led to the development of mobile and android phones (smart phones) and software than run them. Android phones, unlike the classic mobile phones are built to perform computer-like functions. Therefore, they are regarded as

computers with limited features [3]. Android phones unlike their computer counterparts, have a unique property of always being on hand, a near companion to their users. This unique property offers a novel in computation software programming. Certain tasks that were handled by the computer are now incorporated into android phones thereby, relieving the stress of going about with a personal computer always.

This paper therefore seeks to take advantage of the Android phone technology for the transformation of NTM coordinates to UTM coordinates adopting the General Case Transverse Mercator Transformation formulae published by European Petroleum Survey Group [4].

Nigeria Transverse Mercator (NTM)

Nigeria Transverse Mercator has been in use in Nigeria since 1926. NTM was adopted as a result of a decision to coordinate the whole of Africa to produce maps and surveys would be easily assembled to form the Map of Africa [7]. Nigeria is divided into three belts in the NTM system; NTM West, NTM Mid and NTM East Belt. The reference ellipsoid chosen for Nigeria was Clarke 1880 ellipsoid with the following parameters:

semi-major axis (a) = 6378249.145m semi-minor axis (b) = 6356514.900m

flattening of the ellipsoid (f) = 293.465m

Adoption of Universal Transverse Mercator (UTM) in Nigeria

In 1975, the Federal Government of Nigeria introduced the UTM for surveying and mapping to replace the existing NTM so as to conform with the worldwide plane coordinates system which was suggested by the United States of America Army Corps of Engineers in 1940 [5]. Nigeria is covered by three Northern Hemisphere zones of the UTM; UTM zone 31, UTM zone 32 and UTM zone 33.

2.0 Methodology

Identification of Map Projection Parameters

All Transverse Mercator Projections are defined by these parameters: Latitude of natural origin, Longitude of natural origin, Scale factor at natural origin, central meridian, False Northing and False Easting [4]. The Nigeria Transverse Mercator and Universal Transverse Mercator of Nigeria are defined by the projection parameters shown in Table 1.

Table 1: Projection parameters for Nigeria NTM and UTM

PROJECTED COORDINATE IN NIGERIA	ZONE/ BELT	LATITUDE OF NATURAL ORIGIN	CENTRAL MERIDIAN	SCALE FACTOR OF NATURAL ORIGIN	FALSE EASTING (m)	FALSE NORTHING (m)
UTM	31	0°N	3°E	0.9996	500,000	0.000
	32		9°E			
	33		15°E			
NTM	WEST	4°N	4°30'	0.99975	230738.207	0.000
	MID		8°30'		670553.984	
	EAST		12°30'		1110369.761	

Transformation of Coordinates from UTM to NTM and Vice Versa

Coordinate transformation is the process of establishing a relationship between coordinate systems in order to convert points from one coordinate system to their equivalent position in another coordinate system [5]. Methods of transformation of projected coordinates can generally be grouped as direct and indirect methods. The direct method involves the use of that contains the coefficients of polynomials as used by Arinola [2] for transformation of NTM coordinates to UTM coordinates and vice versa. The indirect method involves the systematic conversion from a grid coordinate to an intermediate geographic coordinate and then to another grid coordinate as illustrated in Figure 1. G in Figure 1 represents geocentric ellipsoid and L represents local ellipsoid. The indirect method is easier to programme into computer software; therefore, it was adopted in this paper and EPSG general case Transverse Mercator transformation formula was synchronized with this method.

Figure 1: Conversion of NTM to UTM or Vice Versa (Source: Ono[6])

The EPSG general case Transverse Mercator transformation formula is presented in case 1 (Conversion of Grid Coordinates to Latitude and Longitude) and case 2 (Conversion of Latitude and Longitude to Grid Coordinates).

Case 1: Conversion of Grid Coordinates to Latitude and Longitude

$$\text{Latitude, } \varphi = \varphi_1 - (v_1 \tan\varphi_1 / \rho_1)(D^2/2 - (5+3T_1+10C_1-4C_1^2-9e'^2)D^4/24 + (61+90T_1+298C_1 + 45T_1^2-252e'^2-3C_1^2)D^6/720) \quad (1)$$

$$\text{Longitude, } \lambda = \lambda_o + (D - (1+2T_1+C_1)D^3/6 + (5-2C_1+28T_1-3C_1^2+8e'^2+24T_1^2)D^5/120)/\cos\varphi_1 \quad (2)$$

Case 2: Conversion of Latitude and Longitude to Grid Coordinates

$$\text{Easting, } E = FE + k_o v(A + (1-T+C)A^3/6 + (5-18T+T^2+72C-58e'^2)A^5/120) \quad (3)$$

$$\text{Northing, } N = FN + K_o(M - M_o + v\tan\varphi(A^2/2 + (5-T+9C+4C^2)A^4/24 + (61+58T+T^2+600C-330e'^2)A^6/720)) \quad (4)$$

Where FE = False Eastings

FN = False Northings

Zone of Universal Transverse Mercator

$$Z = \text{int}((\lambda + \lambda_1 + W)/W) \quad (5)$$

Where λ_1 = initial longitude (longitude of origin)

W= width of the longitude

Computer Algorithm for Identification of the belt of Nigeria Transverse Mercator

This research designed an algorithm for the identification of NTM belts. The computation approach is as summarized by the algorithm below:

NTM Belt = int(((λ-2.5)/4) + 1)

If (belt == 1) {"NTM West"}

elseif (belt ==2) {"NTM Mid"}

else {"NTM East"}

The application displays an error message if $\lambda<2.5$ and $\lambda>14.5$ (Nigeria longitudinal boundary)

Android Application Development

For the purpose of this paper, the android application that was developed was named Nigerian Projection Coordinates System Toolkit (Nigeria PCS). Android studio 3.0.1 was used to design the graphic user interface, write the java codes that implement the GUI and also build the android application which can then be installed on any Android device with a minimum of Android 4.0.3 Ice cream sandwich operating system (OS). Android Studio combines Extended Mark-up language (XML) and java programming to build an Android application.

3.0 Data Acquisition

Data for testing the application were acquired by generating random coordinates on the UTM ZONE 31, 32, 33 and NTM West, Mid and East BELT using MATLAB. Five (5) random coordinates were generated on each Zone of the UTM and Belt of the NTM. Table 2 shows the list of NTM coordinates generated on WEST, MID and EAST belt of Nigeria. Table 3 shows the

list of UTM coordinates generated on UTM zone 31, UTM zone 32, and UTM zone 33. Figures 2 shows the spatial distribution of the generated NTM coordinates on the map of Nigeria and Figure 3 shows the spatial distribution of the generated UTM coordinates on the map of Nigeria.

Generation of Random Coordinate on MATLAB

The formula for generating a specified set random numbers within a given range in MATLAB is stated below:

$$r = (b - a). *\text{rand}(5,1) + a$$

where a = lower limit, b = upper limit

Setting the Upper and the Lower Limit for each belt of NTM and Zone of UTM

Each belt of the NTM and zone of the UTM have a specified decimal degrees boundary in longitude and Nigeria has a specified boundary in latitude. 1° of an arc is approximately 111km, that is, 111,000m. The upper limit of latitude of NTM and UTM are defined by the maximum latitude boundary of Nigeria and the lower limit of latitude was defined by the minimum latitude boundary of Nigeria converted to metres. The upper limit of longitude of NTM and UTM are defined by the maximum longitude boundary of each zone or belt and the lower limit of longitude was defined by the minimum longitude of each zone or belt converted to metres.

Table 2: Generated NTM Coordinates (Random coordinate from MATLAB)

NTM WEST		NTM MID		NTM EAST	
725411.691	54568.827	838106.022	521204.800	780964.392	953868.204
39532.461	132411.329	822260.748	875959.055	35192.780	1075632.908
938819.066	251115.196	434050.059	872180.428	306440.067	1294183.745
1033391.553	428976.604	724671.263	664152.794	51140.428	1240067.159
751008.277	434100.264	189380.082	803579.199	107654.145	1314197.810

Table 3: Generated UTM Coordinates (Random coordinate from MATLAB)

UTM ZONE 31		UTM ZONE 32		UTM ZONE 33	
983473.967	551246.745	927041.499	498921.072	1352446.917	434543.383
935112.833	706856.306	864830.323	804239.060	1210636.388	321657.041
1157068.472	696232.155	1288487.165	395608.464	793427.865	206929.680
1226219.106	507546.507	1321178.656	555703.935	1494063.356	215634.684
1276337.915	490895.185	648902.384	316537.741	480570.549	238484.257

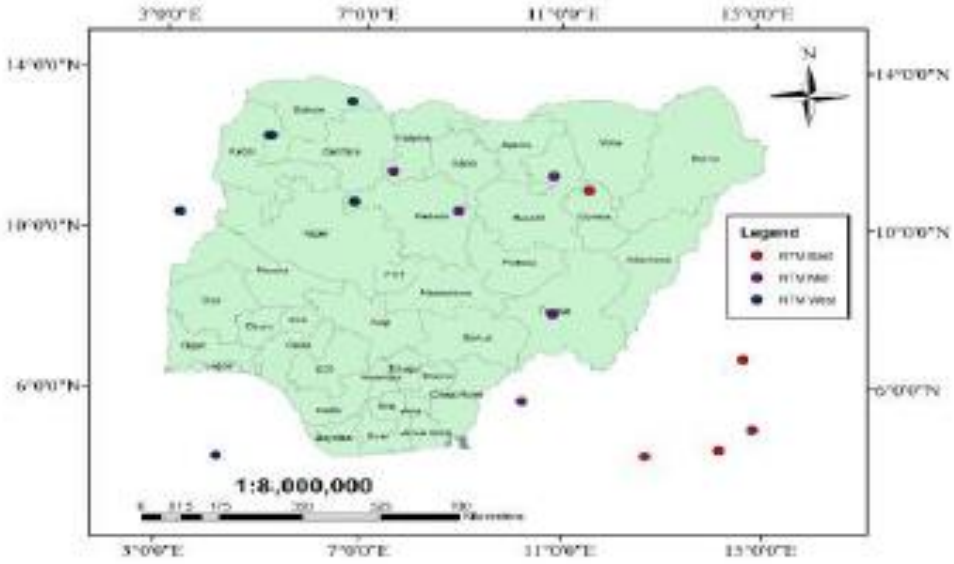

Figure 2: Spatial distribution of acquired NTM coordinates

Figure 3: Spatial distribution of acquired UTM coordinates

4.0 Results

The acquired UTM coordinates and NTM coordinates where transformed to NTM and UTM respectively with Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation software. The discrepancies between the results obtained from the three software was first analysed. The student's T-test for independent samples and one-way analysis of variance (One-way ANOVA) statistical test was used to compare the means of the results (Northing and Easting coordinate). This analysis was done using the International Business Machine Statistical Package for Social Sciences version 22 (IBM SPSS 22). Table 4 shows the comparison of result from Nigeria PCS with Franson coordinate transformation software (NTM to UTM). Table 5 shows the comparison of result from Nigeria PCS with Franson coordinate transformation software (UTM to NTM). Table 6 shows the comparison of result from Nigeria PCS with Blue marble geographic calculator (NTM to UTM). Table 7 shows the comparison of result from Nigeria PCS with Blue marble geographic calculator (NTM to UTM).

Table 4: Comparison of Result from Nigeria PCS with Franson (NTM to UTM)

Belt	Generated Coordinates		Nigeria PCS (UTM)		Franson (UTM)		Residual	
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
NTM WEST	725411.691	54568.827	1166938.202	487987.365	1166938.202	487987.365	0.000	0.000
	39532.461	132411.329	481583.217	568129.320	481583.217	568129.320	0.000	0.000
	938819.066	251115.196	1381341.948	683388.340	1381341.948	683388.340	0.000	0.000
	1033391.553	428976.604	1476148.470	210760.656	1476148.468	210760.660	0.002	-0.004
	751008.277	434100.264	1193610.500	211246.608	1193610.499	211246.612	0.001	-0.004
NTM MID	838106.022	521204.800	1280376.423	296138.960	1280376.423	296138.961	0.000	-0.001
	822260.748	875959.055	1263915.897	650811.497	1263915.897	650811.497	0.000	0.000
	434050.059	872180.428	875862.211	646464.752	875862.211	646464.752	0.000	0.000
	724671.263	664152.794	1166703.196	438895.553	1166703.196	438895.553	0.000	0.000
	189380.082	803579.199	631346.883	577633.478	631346.883	577633.478	0.000	0.000
NTM EAST	780964.392	953868.204	1223340.643	725865.609	1223340.643	725865.608	0.000	0.001
	35192.780	1075632.908	477844.603	187735.726	477844.604	187735.732	-0.001	-0.006
	306440.067	1294183.745	748246.024	407491.844	748246.025	407491.844	-0.001	0.000
	51140.428	1240067.159	493250.051	352300.811	493250.051	352300.811	0.000	0.000
	107654.145	1314197.810	549478.101	426608.297	549478.101	426608.297	0.000	0.000

Table 5: Comparison of Result from Nigeria PCS with Franson (UTM to NTM)

Zone	Generated Coordinates		Nigeria PCS (NTM)		Franson (NTM)		Residual	
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
ZONE 31	983473.967	551246.745	541594.934	117041.238	541594.933	117041.238	0.001	0.000
	935112.833	706856.306	492621.438	272452.304	492621.438	272452.304	0.000	0.000
	1157068.472	696232.155	714546.175	262786.848	714546.176	262786.848	-0.001	0.000
	1226219.106	507546.507	784624.805	74429.056	784624.805	74429.055	0.000	0.001
	1276337.915	490895.185	834852.890	58027.616	834852.890	58027.617	0.000	-0.001
ZONE 32	927041.499	498921.072	485061.234	724531.148	485061.234	724531.149	0.000	-0.001
	864830.323	804239.060	421882.350	1028604.647	421882.350	1028604.647	0.000	0.000
	1288487.165	395608.464	846391.439	620657.787	846391.440	620657.787	-0.001	0.000
	1321178.656	555703.935	879373.774	780719.276	879373.774	780719.275	0.000	0.001
	648902.384	316537.741	206707.634	542437.951	206707.635	542437.951	-0.001	0.000
ZONE 33	1352446.917	434543.383	911149.134	1316895.418	911149.134	1316895.418	0.000	0.000
	1210636.388	321657.041	768318.922	1205229.382	768318.922	1205229.382	0.000	0.000
	793427.865	206929.680	350549.009	1093429.995	350549.009	1093429.995	0.000	0.000
	1494063.356	215634.684	1050615.076	1096645.251	1050615.076	1096645.251	0.000	0.000
	480570.549	238484.257	38083.559	1126328.157	38083.559	1126328.158	0.000	-0.001

Table 6: Comparison of Result from Nigeria PCS with Blue Marble (NTM to UTM)

Belt	Generated Coordinates		Nigeria PCS (UTM)		Blue Marble (UTM)		Residual	
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
NTM WEST	725411.691	54568.827	1166938.202	487987.365	1166938.202	487987.365	0.000	0.000
	39532.461	132411.329	481583.217	568129.320	481583.217	568129.320	0.000	0.000
	938819.066	251115.196	1381341.948	583388.340	1381341.948	583388.340	0.000	0.000
	1033391.553	428976.604	1476148.470	210760.656	1476148.468	210760.660	0.002	-0.004
	751008.277	434100.264	1193610.500	211246.608	1193610.499	211246.612	0.001	-0.004
NTM MID	838106.022	521204.800	1280376.423	296138.960	1280376.423	296138.961	0.000	-0.001
	822260.748	875959.055	1263915.897	650811.497	1263915.897	650811.497	0.000	0.000
	434050.059	872180.428	875862.211	646464.752	875862.211	646464.752	0.000	0.000
	724671.263	664152.794	1166703.196	438895.553	1166703.196	438895.553	0.000	0.000
	189380.082	803579.199	631346.883	577633.478	631346.883	577633.478	0.000	0.000
NTM EAST	780964.392	953868.204	1223340.643	725865.609	1223340.643	725865.608	0.000	0.001
	35192.780	1075632.908	477844.603	187735.726	477844.604	187735.732	-0.001	-0.006
	306440.067	1294183.745	748246.024	407491.844	748246.025	407491.844	-0.001	0.000
	51140.428	1240067.159	493250.051	352300.811	493250.051	352300.811	0.000	0.000
	107654.145	1314197.810	549478.101	426608.297	549478.101	426608.297	0.000	0.000

Table 7: Comparison of Result from Nigeria PCS with Blue Marble (UTM to NTM)

Zone	Generated Coordinates		Nigeria PCS (NTM)		Blue Marble (NTM)		Residual	
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
ZONE 31	983473.967	551246.745	541594.934	117041.238	541594.934	117041.238	0.000	0.000
	935112.833	706856.306	492621.438	272452.304	492621.438	272452.304	0.000	0.000
	1157068.472	696232.155	714546.175	262786.848	714546.176	262786.848	-0.001	0.000
	1226219.106	507546.507	784624.805	74429.056	784624.805	74429.056	0.000	0.000
	1276337.915	490895.185	834852.800	58027.616	834852.800	58027.616	0.000	0.000
ZONE 32	927041.499	498921.072	485061.234	724531.148	485061.234	724531.148	0.000	0.000
	864830.323	804239.060	421882.350	1028604.647	421882.350	1028604.647	0.000	0.000
	1288487.165	395608.464	846391.439	620657.787	846391.440	620657.787	-0.001	0.000
	1321178.656	555703.935	879373.774	780719.276	879373.774	780719.276	0.000	0.000
	648902.384	316537.741	206707.634	542437.951	206707.634	542437.951	0.000	0.000
ZONE 33	1352446.917	434543.383	911149.134	1316895.418	911149.134	1316895.418	0.000	0.000
	1210636.388	321657.041	768318.922	1205229.382	768318.923	1205229.382	-0.001	0.000
	793427.865	206929.680	350549.009	1093429.995	350549.009	1093429.995	0.000	0.000
	1494063.356	215634.684	1050615.076	1096645.251	1050615.076	1096645.251	0.000	0.000
	480570.549	238484.257	38083.559	1126328.157	38083.559	1126328.157	0.000	0.000

Results from SPSS analysis of transformation data is presented in the following tables. Table 8 shows the Student's T-test for independent samples on comparison of Nigeria PCS with Blue marble geographic calculator. Table 9 shows the Student's T-test for independent samples on comparison of Nigeria PCS with Franson coordinate transformation software. Table 10 shows the One-Way ANOVA on comparison of the transformation result from Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation software.

Table 8: Student's T-test on Comparison of Nigeria PCS with Blue Mable

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									99% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Northing NTM	Equal variances assumed	.000	1.000	.000	28	1.000	-.000200	104869.628512	-289782.307368	289782.306968
	Equal variances not assumed			.000	28.000	1.000	-.000200	104869.628512	-289782.307368	289782.306968
Easting NTM	Equal variances assumed	.000	1.000	.000	28	1.000	.000000	163037.021763	-450514.081059	450514.081059
	Equal variances not assumed			.000	28.000	1.000	.000000	163037.021763	-450514.081059	450514.081059
Northing UTM	Equal variances assumed	.000	1.000	.000	28	1.000	.000067	132954.747763	-367388.862680	367388.862814
	Equal variances not assumed			.000	28.000	1.000	.000067	132954.747763	-367388.862680	367388.862814
Easting UTM	Equal variances assumed	.000	1.000	.000	28	1.000	-.000933	66110.799622	-182681.491418	182681.489551
	Equal variances not assumed			.000	28.000	1.000	-.000933	66110.799622	-182681.491418	182681.489551

Table 9: Student's T-test on Comparison of Nigeria PCS with Franson

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									99% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Northing NTM	Equal variances assumed	.000	1.000	.000	28	1.000	-.000133	104869.628490	-289782.307241	289782.306974
	Equal variances not assumed			.000	28.000	1.000	-.000133	104869.628490	-289782.307241	289782.306974
Easting NTM	Equal variances assumed	.000	1.000	.000	28	1.000	-.000067	163037.021773	-450514.081156	450514.081022
	Equal variances not assumed			.000	28.000	1.000	-.000067	163037.021773	-450514.081156	450514.081022
Northing UTM	Equal variances assumed	.000	1.000	.000	28	1.000	.000067	132954.747763	-367388.862680	367388.862814
	Equal variances not assumed			.000	28.000	1.000	.000067	132954.747763	-367388.862680	367388.862814
Easting UTM	Equal variances assumed	.000	1.000	.000	28	1.000	-.000933	66110.799622	-182681.491418	182681.489551
	Equal variances not assumed			.000	28.000	1.000	-.000933	66110.799622	-182681.491418	182681.489551

Table 10: One-Way ANOVA on comparison of the transformation result from Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation software

ANOVA							
			Sum of Squares	Df	Mean Square	F	Sig.
NTM	Northing	Between	.000	2	.000	.000	1.000
		Within	3464256279538.261	42	82482292369.959		
		Total	3464256279538.261	44			
	Easting	Between	.000	2	.000	.000	1.000
		Within	8373037197282.822	42	199358028506.734		
		Total	8373037197282.822	44			
UTM	Northing	Between	.000	2	.000	.000	1.000
		Within	5568243958170.254	42	132577237099.292		
		Total	5568243958170.254	44			
	Easting	Between	.000	2	.000	.000	1.000
		Within	1376750911363.376	42	32779783603.890		
		Total	1376750911363.376	44			

5.0 Discussion of Results

For the student's T-test for independent samples in Table 8 and Table 9 on comparison of Nigeria PCS with Blue marble geographic calculator and Franson coordinate transformation software when transforming UTM coordinates to NTM coordinates and vice versa, the rationale of testing is:

Null hypothesis: $H_0 : \mu_0 = \mu_1$

Alternative hypothesis: $H_0 : \mu_0 \neq \mu_1$

Level of significance $\alpha = 0.01$

The null hypothesis states that, there is no significant difference between the means of the result obtained from the two software.

From Table 8, the computed significant 2-tailed value is 1.000 which is greater than the testing level of significance 0.01, we therefore, reject the alternative hypothesis at 99% confidence interval, i.e we uphold the null hypothesis that there is no significant difference between the mean of the result obtained from Nigeria PCS and Blue marble geographic calculator at 99% confidence interval.

From Table 9, the computed significant 2-tailed value is 1.000 which is greater than the testing level of significance 0.01, we again reject the alternative hypothesis at 99% confidence interval, that is, there is no significant difference between the mean of the result obtained from Nigeria PCS and Franson coordinate transformation software at 99% confidence interval.

The One-Way ANOVA was used to compare the means of the three software together in Table 10. This is just to buttress the student's t-test for independent samples analysis in Table 8 and Table 9. The rationale for this test is:

Null hypothesis: $H_0 : \mu_0 = \mu_1 = \mu_2$

Alternative hypothesis: $H_0 : \mu_0 \neq \mu_1 \neq \mu_2$

Level of significance $\alpha = 0.01$

The null hypothesis stated above means that, there is no significant difference between the means of the result obtained from transformation with Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation at 99% confidence interval.

From Table 10, the computed significant level value is 1.000 which is greater than the testing level of significance 0.01, we therefore, reject the alternative hypothesis at 99% confidence interval, that is, there is no significant difference between the mean of the result obtained from Nigeria PCS, Blue marble geographic calculator and Franson coordinate transformation software at 99% confidence interval.

Figure 4 shows the user interface of Nigeria PCS during computation. (a) shows transformation for UTM to NTM coordinates, (b) shows transformation from NTM to UTM coordinates.

6.0 Conclusion

This study has been able to develop an android application for Nigeria projected coordinate system transformation named Nigeria PCS. This offers a unique advantage over the desktop counterpart, since android phones are always on-hand and are near companion to their users. Also, the computer software that were used for comparison require the selection of input coordinate system and output coordinate system zone or belt when transforming UTM coordinates to NTM coordinates and vice versa. Nigeria PCS only requires the selection of input coordinate system and it automatically identifies and displays the corresponding zone or belt of the output coordinate based on the overlap and intersection of the UTM and NTM coordinate system in the geographic coordinate system. The algorithm for this capability was developed in this study. This capability will improve the accuracy of output even as the knowledge of the NTM belts are decreasing and transformation of NTM coordinate to UTM coordinate system is still a current and recurring problem.

Figure (4a): Screen shot of the Nigeria PCS for transforming NTM to UTM coordinates

Figure (4b): Screen shot of the Nigeria PCS for transforming UTM to NTM coordinates

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