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GNSS Geodetic Positioning Referred to SIRGAS2000 using a Smartphone
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1 - Introduction

The rapid development of mobile computing has allowed any citizen to use positioning and navigation applications on smartphones, achieving nominal accuracy equal to or better than 9 m (horizontal) and 15 m (vertical) 95% of the time. The possibility of obtaining pseudo-distance and carrier wave phase observations collected by a smartphone equipped with Android 7.0 or later, together with the availability of dual-frequency GNSS processors, unveiled new potential in terms of positioning quality. This work presents preliminary results of a research that seeks to obtain sub-metric and centimetric accuracies in GNSS relative and precise point positioning, in post-processing mode, using single and dual frequency GNSS observations collected by state-of-the-art smartphones . For this purpose, a survey was carried out on the equipment available on the market that generate L1 carrier phase observations of GPS, GLONASS, Galileo and BeiDou, and L5 of GPS and Galileo, with the Huawei P30 PRO being acquired.

2 - Geometry Quality of GNSS Constellations

The characteristics of the GNSS systems (GPS, GLONASS, Galileo and BeiDou) were reviewed using the Trimble GNSS Planning Online application in 6 locations (Figure 1) throughout Brazil: North, South, East, West, plus Brasília and Niterói, with 5 scenarios to assess the number of visible satellites and the impact of constellation geometry on coordinate quality (PDOP). The 24h-average number of satellites visible simultaneously on Apr 27, 2021 using four constellations varied from 30 to 33 (maximum number from 36 to 38), with average PDOP values less than 1.01 (maximum values less than 1.25) (Figure 2).

Figure 1: Locations in Brazil (North, South, East, West, plus Brasília and Niterói) used to assess the geometry quality of GNSS constellations
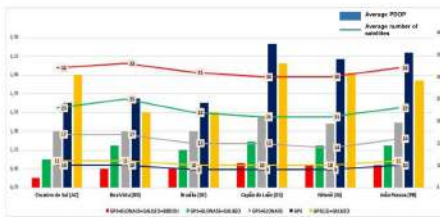

Figure 2: Comparison of 24h-average number of satellites and PDOP values, in 6 locations throughout Brazil, based on the available GNSS constellations

3 - Geodetic Station Selection

For the execution of the project, it has been necessary to collect observations at a point with SIRGAS2000 reference coordinates. Thus, IBGE's Geodetic Database was accessed to find a suitable station to be used in the survey. Station 91877 (Figure 3) of the Brazilian Geodetic System, located in Barra da Tijuca, Rio de Janeiro (RJ), was selected.

Figure 3: Geodetic station 91877 that has been occupied, as shown by the red arrow

4 - Android Apps for GNSS Data Recording

An evaluation of the applications that record pseudorange and carrier phase observations in RINEX format was carried out on the Google Play Store, having been selected: Geo++ RINEX Logger, rinex ON and GnssLogger.

5 - Collecting Observations

Observations were recorded at 91877 station on July 21, 2021, for two hours, using the selected applications simultaneously (Figure 4). A Topcon geodetic antenna was used to support the smartphone to help the set up and to provide some sort of multipath mitigation.
Geo++ recorded the observations for two hours; rinex ON, for one hour; GnssLogger had problems and did not save the observation file.

Figure 4: Smartphone collecting observations at the geodetic station

6 – Data Processing/Results

Observations collected by the smartphone using Geo++ and rinex ON were submitted to the RTKLIB software, version 2.4.3 Demo5 b43b, using the RBMC/SIRGAS-CON RJNI station as the base station, in static relative mode (21.6 km baseline), and to the IBGE-PPP service. Single frequency carrier phase and pseudorange observations of the 4 GNSS constellations were processed in case of RTKLIB and of GPS/GLONASS observations in case of IBGE-PPP. The results indicate sub-metric accuracies in the IBGE-PPP solutions and centimetric or sub-metric accuracies in the RTKLIB solutions, depending on the application used to record the data (Table 1).

Table 1: Discrepancies (in meters) between SIRGAS2000 coordinates determined by RTKLIB and IBGE-PPP and the reference coordinates using data recorded simultaneously by Geo++ (2h-session) and rinex ON (1h-session) on July 21, 2021. RTKLIB "PPS" (single point positioning) pseudorange solutions are also included for comparison

Processing	Latitude	Longitude	Altitude	TOTAL
RTKLIB Demo5 b34b				
rinex ON "PPS"	-0,258	-0,904	5,608	5,687
Geo++ "PPS"	-3,820	6,299	13,980	15,803
rinex ON "static"	-0,043	-0,005	-0,071	0,083
Geo++ "static"	0,126	0,134	-0,536	0,624
IBGE-PPP				
rinex ON	0,528	-0,147	0,144	0,567
Geo++	-0,345	-0,004	-0,756	0,831

7 - Future Work

Additional collection of observations in longer sessions using a chokering antenna underneath the smartphone; post-processing of these observations using single frequency data from 1, 2, 3 and 4 constellations and dual frequency (L1/L5) GPS+Galileo data.

8 – Acknowledgement