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Road Access Tracking Using GNSS Receiver at Taman Universiti, Parit Raja, Johor

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Abstract: Global Navigation Satellite System (GNSS) plays a significant role in maximum precision in navigation, positioning, timing and scientific issues related to precise positioning. The GNSS observation including Precise Point Positioning (PPP) method that estimate the observation with errors as small as a few centimeter (up to 3 cm) and provide a high level of accuracy position from a single receiver. In addition, the current GNSS receiver in the engineering world will improve efficiency and provide better customer service. In contrast, the PPP also has disadvantage such as the amount of time required to resolve the cycle's difficulty. The data were collected using the Leica Viva GS10/GS15 and processed using the Canadian Spatial Reference System Precise Point Positioning (CSRS-PPP), RTKLib and Translation, Editing and Quality Checking (TEQC) services. Moreover, the data was analyzed using Microsoft Excel tools. The file is format .m00 and must be output in observation (.21o) and navigation (.21n) RINEX file. In addition, the value of displacement must under the limit range to more accurate. The value of elevation cut-off in CSRS-PPP is 7.5° and the elevation mask in RTKLib software used is 15%. In addition, the value of fixed ambiguities from the results is 51.47%. Lastly, GNSS technology also helps the country in facility of safe, secure and reliable navigation for marine transportation, navigation for air transportation, infrastructure engineering and construction and disaster, search and rescue management.

Keywords: GNSS, Leica Viva GS10/GS15, CSRS-PPP, RTKLib and TEQC.

1. Introduction

GNSS is a common concept for satellite navigation systems offering autonomous geo-spatial positioning nationwide coverage such GPS, GLONASS, Galileo, Beidou, and other regional networks. This technology represents the most cost-effective, easy, and dependable method of obtaining accurate timing and precise location in various applications, including surveying. In the last several years, GNSS has functioned on a global or regional scale. At the other sides, GNSS may be characterised as a satellite-based system that determines a user's geographic location, regardless wherever the person is in the world. There are currently two components of GNSS such global and regional constellation. Global constellations are such Global Positioning System (GPS) from United State of America (USA),

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Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS) from Russia, Galileo from Europe and BeiDou Navigation Satellite System (BDS) from China. Regional constellations also are Quasi-Zenith Satellite System (QZSS) from Japan and Indian Regional Navigation Satellite System (IRNSS) from India [11].

The efficiency of the GNSS can be calculated based on four criteria, namely accuracy, integrity, continuity, and availability. Firstly, accuracy is a calculation of how close the navigation approach given by the device is to the absolute position and speed of the user. Integrity is the ability of the device to provide prompt alerts to consumers that the appliance cannot be used for navigation purposes. Continuity also is the ability of the entire device to fulfil its purpose without interruption during the scheduled time of service. Besides, availability is the percentage of time during which the service is available for use, taking into account all outages, whatever their cause. Typically, the service is available if the standards for accuracy, fairness, and continuity are fulfilled. Doubtfully, civilian users were developing countries, like Malaysia, have independent access to networks at their own expense due to a lack of regulations and guidelines on the facilities rendered by the professional authority in the country concerned.

PPP method is a very appealing option to Real-Time Kinematic, RTK in places for those where RTK coverage is restricted or not available. In an absolute coordinate reference frame, high-accuracy navigation and positioning might well be conducted anywhere in the earth, as well as other PPP applications can be used [2]. One of the main disadvantages of PPP method was it generally take a long time which is more than 20 minutes in the convergence period. However, there are some way to reduce and eliminating the weakness of the method such established the various online software such as use software Translation, Editing and Quality Checking (TEQC) and Leica SmartWorx Viva Field Software. Thus, this research is aimed to observe the software that varies in terms of performance and accuracy. In addition, this study also observed the difference value between CSRS-PPP and RTKLIB software.

This experiment's scope focuses on processing the data using a few online software which are CSRS and RTKLib online services. Leica SmartWorx Viva Field Software is used to collect the data from GNSS receiver. besides, Microsoft Excel software also is an additional aid to do the northing and easting (latitude and longitude) along with other online post-processing services. In addition, after the data completed process, it must transfer to Receiver Independent Exchange Format (RINEX). The RINEX data file consists of components such observation (o), navigation (n) and meteorological data (m). All RINEX file also have to be printed in American Standard Code for Information Interchange (ASCII) with prescribed field widths including data and labels.

2. Literature Reviews

There are three segments of GNSS including space segment, control segment and user segment. The space segment is formed that the satellite was encircling the earth or Satellite Vehicle (SV). The control segment also that the stations who are controlling and monitoring. Besides, it also controls and check the SV conditions. Lastly, user segment is an owned receiver by users with to track the signal received from the satellite (e.g. GPS) [2]. The space segment consists of GNSS satellite and continuous orbiting about 20,000 km above the earth which is in medium earth orbit (MEO) (27 and 3 active spare satellite), its time and status [17]. Users can receive information at least four satellite at any time at any place in the earth. These satellites are distributed across 6 orbital planes evenly spaced, including a target angle of 55° [19].

Next, operational control segment consists of a network of ground control station that are monitor and control the GNSS space segment. It can operate and control of the system through monitoring signal transmission and sending commands to the GPS constellation [17]. All four remote monitoring stations help to regulate the satellite by tracking and transmitting this information by monitoring each satellite. Each of the satellite can track and monitored 20 to 21 hours each day in four stations.

For the user segment, it comprises of a very reliable clock antenna whether internal or external, receiver-processor unit, a control unit displays the positioning information and set towards satellite transmission frequencies. The GNSS receivers will be in format of integrated devices, cars, phone and specialised devices such handheld GPS receiver, GPS/GLONASS survey receiver item and GPS/Galileo receiver component.

2.1 Error and Application

The major causes of inaccuracy affecting GNSS systems including clock-related error, dilution of precision (DOP) which measurement index for the geometric features of visible satellite, user equivalent range error (UERE) and system error. Figure 1 shows the categories of error sources dependent on the nature for the fault by itself [10]. There are three elements may influence GNSS satellite clock error which are clock stability, relative effects and timing group delay (TGD). Firstly, the satellite stability has value about 8.64 to 17.28 ns (nanosecond) a day which corresponds to a range error of about 2.59 to 5.18m. Next, both general and special relativity theories will influence a clock aboard a satellite in relativistic effects. As a result, this clock will appear to operate faster than a similar clock on earth by approximately 38.4 µs/day. This is comparable to a range inaccuracy of roughly 11.512 meters when scaled by the speed of light. Before launch, a suitable offset is applied to the satellite clock rate to compensate for this impact. Finally, TGD is the navigation message's satellite clock corrections are referred to a single GNSS signal or signal combination. In this case, this signal is the ionospheric-free combination of L1 and L2 frequency bands and P-code transmissions [15].

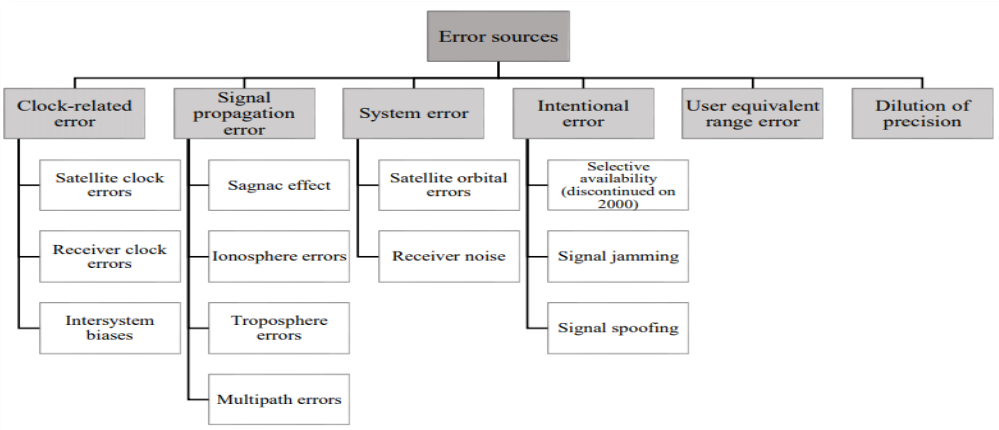


Figure 1: Categories of error sources [10]

2.2 Data Management of GNSS (RINEX file)

The first major European GPS (EUREF 89) program was intended to accommodate data of four distinct recipient kinds that were transformed into RINEX from proprietary formats [23]. The latest RINEX version is version 3.04 built on 2018. There are three ASCII file types in RINEX version 3.04 such as observation data file, navigation message file and meteorological data file. Each of the file contained of a header and a data section. File in observation data is C/A code, P or Y code, L1 and L2, or time, phase and range.

Navigation data also has epoch and data satellite clock information. For a meteorological data, it has pressure (mbar), relative humidity, dry temperature (°C) and wet zenith path delay (mm) (%). According to Cozzens (2019) states that all open signals, including GPS (United States), GLONASS (Russia), Galileo (Europe), BeiDou (China, QZSS (Japan), and IRNSS (India), may be supported in the present version of the RINEX programmed.

All RINEX data files have to be printed in ASCII text formats with prescribed field widths, including data and labels, to facilitate both human and machine reading. ASCII readings from 0 to 255, all for the upper and the bottom characters, arithmetic digits, marks of pointing, and so on. The characters were divided into three categories including non-printable control codes (0 to 31), lower ASCII characters (32 to 127), and higher ASCII characters (128 to 255) [5].

2.3 Precise Point positioning, PPP

Precise Point Positioning (PPP) is a positioning technology based on satellites that aim at maximum precision in near real-time. In 1997 JPL presented the first studies employing dual frequency data from a single GPS recipient data for a certain centimeter location in post-processing mode [9]. The remaining necessary model information, such as accurate orbits and clocks given by the IGS, has been employed using an ionosphere-free linear combination. In the recent decade, this technology has taken several methods to serving applications in almost real-time. The PPP approach could be anywhere or anything else globally because it does not require a base station so that the baseline length is not affected. But the approach has drawbacks because of the longer and lower initial convergence period shown in Figure 2.

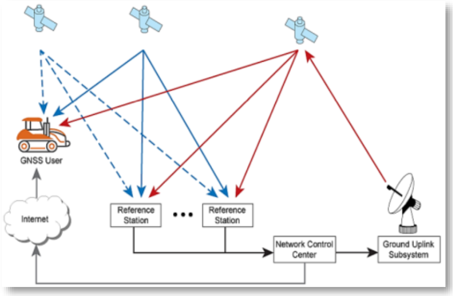


Figure 2: Precise Point Positioning, PPP system [14]

2.4 Precise Point Positioning based on RTK networks (RTK-PPP)

RTK-PPP is a method that to overcomes the limitations and give centimeter accuracy in a few seconds. This approach can deliver real-time field locations while the survey is carried out. The base receiver is stable when the roaming receiver is activated and has a radio transmission connection [3]. The base receiver samples the data every second and transmits them together with their position to the roaming recipient using the communication connection (i.e., satellites, mobile phones, or radio). The rover receives the sent data from the base receiver with its radio receiver. It utilizes built-in software to aggregate and process the GNSS/GPS measurements collected from the base and rotating receiving systems [3]. A short coverage (30 - 50 kilometers) is significantly limited by RTK generated by distance-related biases such as an ionospheric and troposphere signal refraction and an inaccuracy of the orbit. RTK shows in Figure 3 enables an immediate and high precision placement of up to 1cm + 1ppm near the base station about 10 to 20 km [7]. In addition, RTK also is the most popular GNSS signal enhancement method.

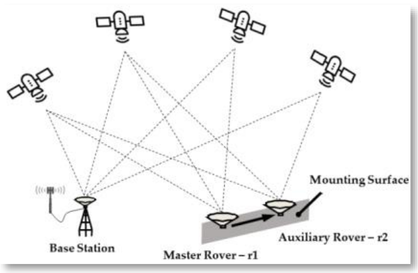


Figure 3: Real-Time Kinematic (RTK) system [4]

2.5 Canadian Spatial Reference System (CSRS)

CSRS is a global satellite navigation data post-processing web application. It can process from single or dual-frequency GPS observation operating in static or kinematic mode. It also can provide kinematic solution for using RINEX file. CSRS uses the accuracy of GNSS satellite orbit ephemerides for corrected the coordinates with constant absolute precision regardless of the location for the users and presence identified for base stations [8]. However, if the user not use a web browser, they can also use the CSRS direct desktop application (Figure 4) to submit the RINEX file.

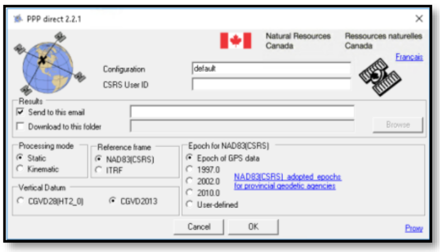


Figure 4: CSRS direct desktop application [13]

2.6 RTKLib Software

RTKLib is an open source package and precision for positioning GNSS. It also consisting of a portable program software and certain application program (APs) (Figure 5) for window are included in the package that use the library including satellite and navigation system functions, coordinate transformation, positioning models, RINEX functions, precise ephemeris and clock functions and so on. Besides, it supports many GNSS positioning methods both in real-time and post-processing such Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed [20].

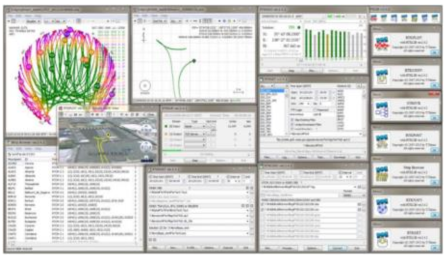
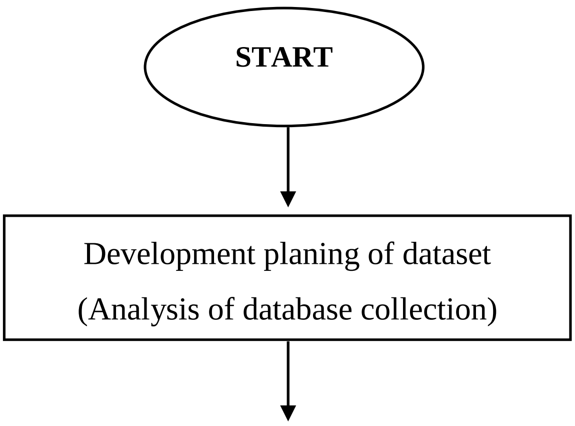


Figure 5: Application Program, APs in RTKLib Software [20]

3. Methodology

3.1 Introduction

In general, the method as seen in the steps below tells us the research methodology (Figure 6) encompasses many stages such:



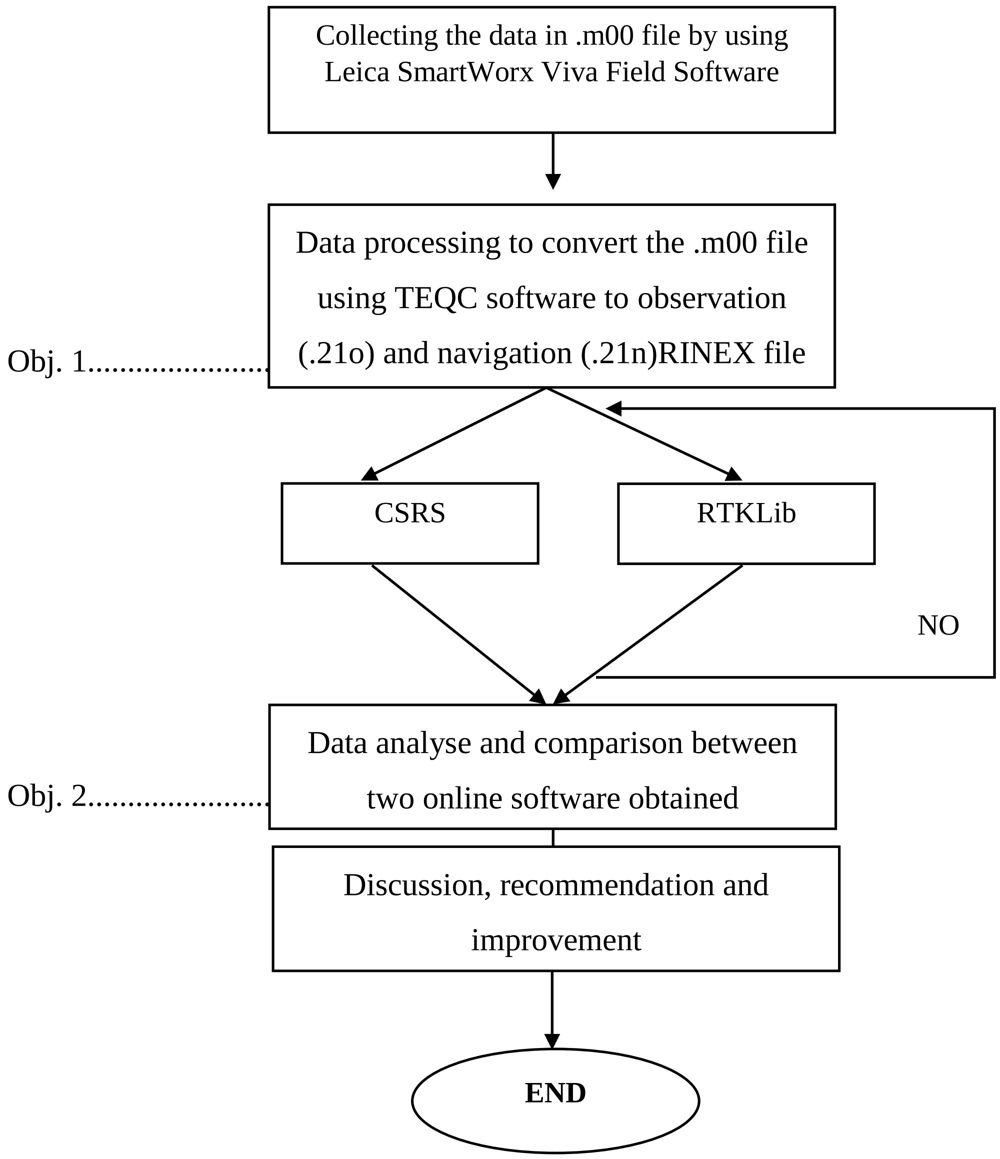


Figure 6: Flowchart of study's methodology

3.2 Data Processing

In order process, before the raw data continue processed into software, it must transform into RINEX file format. The data file can be read in format .m00 file. The file data in .m00 must be convert to observation (.21o) and navigation (.21n) RINEX files. The DOS command in Command Prompt should be write on “teqc +nav OUTFILE.21n BASESTATIONFILE.m00 > OUTFILE.21o” ad shown in Figure 7.

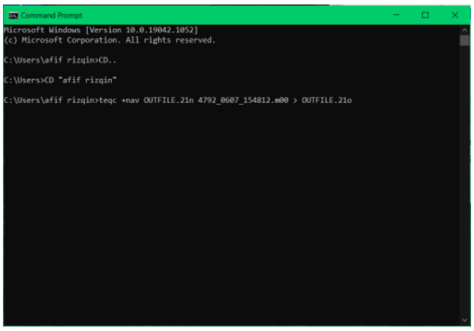


Figure 7: Example of DOS Command in Command Prompt (Desktop)

Step for this study is to convert the .m00 file to RINEX file (OUTFILE.21o). This step was ignored if the data already in RINEX file. After get the data in RINEX file, users must convert to CSRC and RTKLib software to get the result. The software shows in Figure 8 and Figure 9.

Figure 8: CSRS software [13]

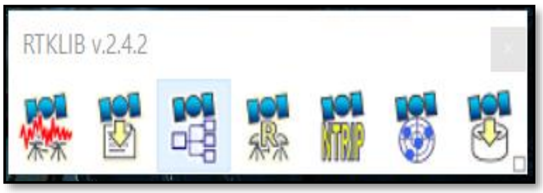


Figure 9: RTKLib Software [20]

4. Result and Discussion

4.1 Data Processing from Software

The data about 352 points named GPS0001 – GPS0352 were collected. This is a part of road at Taman Universiti, Parit Raja, Johor are shown in Figure 10. The researcher used the data on 06/06/2021 to make a comparison because it took a lot of data on that day. Figure 11 shows that the longitude, latitude and height differences from the result of CSRS-PPP while Figure 12 shows the results from RTKLib online software differences.

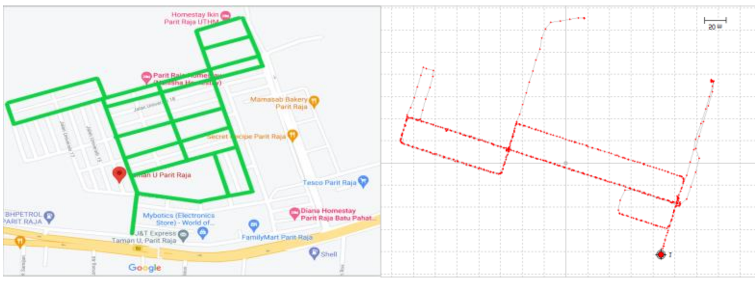


Figure 10: Location of case study and point that are pick-up on 06/06/2021

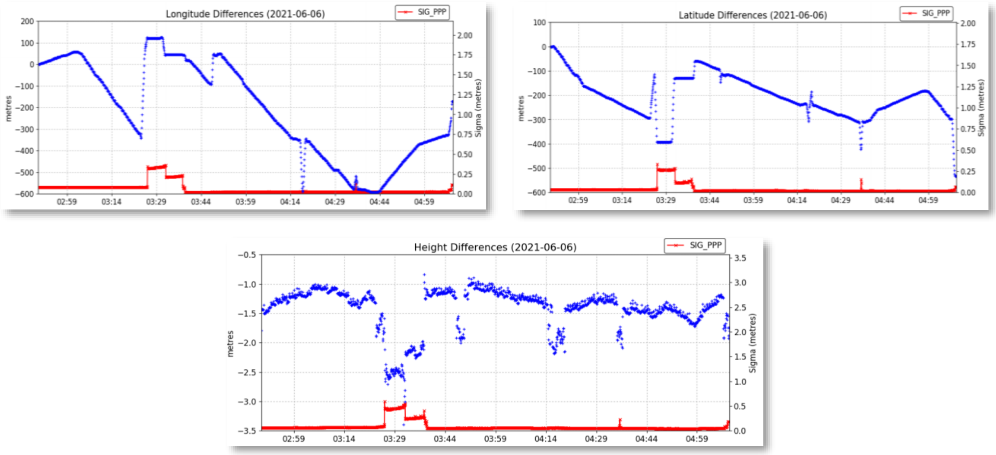


Figure 11: Longitude, Latitude and Height from CSRS-PPP

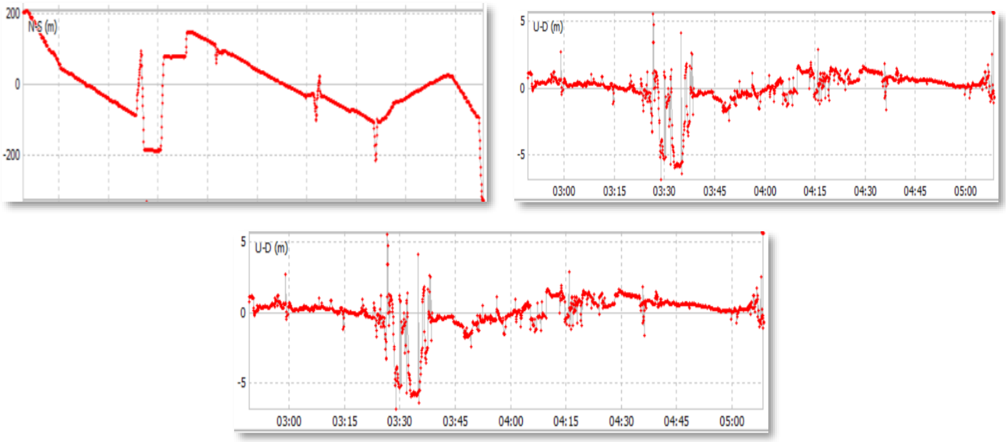


Figure 12: Longitude, Latitude and Height from RTKLib

Based on the result from the online software services, the value for L1 and L2 from CSRS-PPP software are 0.202m and 0.201m. The value of elevation cut-off in CSRS-PPP is 7.5° and the elevation mask in RTKLib software used is 15%. In addition, the value of fixed ambiguities from the results is 51.47%. Type of observation that the software from CSRS-PPP used is using phase and code. From both results, the pattern of the graph almost same.

Table 1: Differences between two online software

SOFTWARE	CSRS-PPP	RTKLib	Differences, m
Latitude	1.854365	1.854359238	0.000006
Longitude	103.0739	103.073858581	0.000042
Receiver clock offset	2.056	2.5408	0.4848

From the Table 1, the value of latitude and longitude from RTKLib is 1.854359, 103.073858 and from CSRS-PPP is 1.854365, 103.0739. The average differences height between both software is 0.000006m and 0.000042m. The value of receiver clock offset from RTKLib and CSRS-PPP are 2.5408m and 2.056m. The differences value of receiver clock offset is 0.4848m.

4.2 Data Comparison

The results of the post processing from the online software are shown in Table 2 for ellipsoidal height (m) of ten points.

Table 2: Ten points data of ellipsoidal height (m) from RTKLib and CSRS-PPP software

No.	RTKLib	CSRS-PPP	Differences, m
1	8.5925	6.4976	2.0949
2	8.9440	6.8453	2.0987
3	8.9433	6.8546	2.0887
4	8.9774	6.8608	2.1166
5	8.9843	6.8605	2.1238
6	8.9739	6.8507	2.1232
7	8.9715	6.8518	2.1197
8	8.9668	6.8545	2.1123
9	8.9697	6.8539	2.1158
10	9.0630	6.9289	2.1341

The results in Table 2 show that the difference value of ellipsoidal height range 2.0949 to 2.1341 m. Besides, from the data results also can be that the value of RTKLib is 6.2605m smaller than the value of CSRS-PPP with 6.4976m. Moreover, this mean that the data from CSRS-PPP is better than RTKLib software because the data is small and near to datum. RTKLib is better used in construction because it has many functions that can be operate such Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed. The software derived value was found within centimeter-level accuracy without the necessity of any refence station data even within global reference frame. All the data mostly calculated from website such CSRS. This is very simple and easy to understood. The user does not need to fill the detailed information but just need to register under the student's university email address.

4.3 Analysis on the Online Software Characteristic

Table 3: Differences between two online software

SOFTWARE	CSRS-PPP	RTKLib
POST PROCESSING	Only used in website	Downloaded to internal disk
USAGE OF SOFTWARE	Easy to use (Just Email to admin)	A little bit difficult to handle it.
USER FRIENDLY	Very Good	Good
USAGE OF TOOLS	Just static or kinematic	Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed

Based on Table 3, post processing for CSRS-PPP only used in official website to get the results while RTKLib software must downloaded it into internal disk in PC. CSRS-PPP usage also just key in our registration form (student's university email), then email the data in observation (.21o) to admin. After a few minutes, we can get the data in WinRAR then must be extract to file PDF. It also has a free service to user. Moreover, if we used the RTKLib, we must download it into internal disk PC. The software is a little bit difficult to handle it such key in the data of processing mode. It must use the specialist person to run the software. Weakness for usage of tools of CSRS-PPP is just can operate the static or kinematic for post-processing but RTKLib software can organize the Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed for its post-processing. In term of user-friendly factor, the CSRS-PPP is more friendly and easier to be used because its free services and not complicated to use the official website. In addition, both of software can upload the file of an unlimited size.

5. Conclusion

PPP method has better in working including efficiency, accuracy, speed and fieldwork flexibility. Leica GNSS can also give greater flexibility, cheaper capital, and operating expenses for high precision positioning. Nowadays, the rapid advancement of wireless communications and networks has sparked a burst in interest in GNSS and the development of supporting techniques and processes. In future, GNSS chips are also planned to be included in all 3G and future generations of cellular phones.

This study was carried out of observation period as site at Taman Universiti, Parit Raja, Johor. The data were processed using online software and better in terms of speed, efficiency, accuracy and fieldwork flexibility. Another benefits for using this online software is mostly this service is very useful for any places where cellular or coverage of internet is not applicable. Furthermore, the services still do not support other global system such Galileo and BDS.

In conclusion, the RTKLib software is much better recommended than CSRS-PPP service. In term of accuracy, CSRS-PPP software also is more accurate than RTKLib service because the data is small and near to datum. RTKLib is better used in construction because it has many functions that can be operate such Single, DGPS/DGNSS, Kinematic, Static, Moving-Baseline, Fixed, PPP-Kinematic, PPP-Static and PPP-Fixed. For the new users or researcher, the CSRS-PPP software is recommended than RTKLib because it easy to handle and operate it.

Besides, in term of user-friendly factor, the CSRS-PPP is more friendly and easier to be used because its free services and not complicated to use the official website. In addition, both of software can upload the file of an unlimited size. The objective of the research had been achieve such observation of the method kinematic-PPP processing for the data survey and comparison the result of accuracy and characteristic analysis between CSRS-PPP and RTKLib software. Overall, of this study, although the Precise Point Positioning, PPP method has their weakness, it is better in term of speed, accuracy, efficiency, and fieldwork flexibility.

6. Recommendation

There are some recommendations for further research based on accuracy, usage of equipment and condition environment of this study:

1) Use the RTKLib software frequently more than CSRS-PPP because it has many functions to get the result.

2) For CSRS-PPP, the software is recommended for new users because it easy to operate and handle compare the RTKLib software requires a competent person to control the software.

3) Must be analysed the environment factor such weather and condition of road.

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References

[1] Abou-Galala, M., Rabah, M., Kaloop, M., & Zidan, Z. M. (2018). Assessment of the accuracy and convergence period of Precise Point Positioning. *Alexandria Engineering Journal*, *57*(3), 1721–1726. https://doi.org/10.1016/j.aej.2017.04.019.

[2] Angrisano, A., Dardanelli, G., Innac, A., Pisciotta, A., Pipitone, C., & Gaglione, S. (2020). Performance assessment of PPP surveys with open source software using the GNSS GPS-GLONASS-Galileo constellations. *Applied Sciences (Switzerland)*, *10*(16). https://doi.org/10.3390/APP10165420.

[3] Baloch, Q. B. (2017). *No: GWI_PartII_Geodetic Title*. *11*(1), 92–105.

[4] Cui, X., Fan, P., Li, W., & Lu, M. (2019). Precise and robust RTK-GNSS positioning in urban environments with dual-antenna configuration. *Sensors (Switzerland)*, *19*(16). https://doi.org/10.3390/s19163586.

[5] Computer Hope. (2020). *ASCII*. https://www.computerhope.com/jargon/a/ascii.htm.

[6] Cozzens, T. (2019). *RINEX 3.04 supports new BeiDou, GLONASS and QZSS signals*. GPS World. https://www.gpsworld.com/rinex-3-04-supports-new-beidouglonass-and-qzss-signals/.

[7] European GNSS Agency. (2019). *PPP-RTK market and technology report*. 62.

[8] Farah, A. (2018). Kinematic-PPP using Single/Dual Frequency Observations from (GPS, GLONASS and GPS/GLONASS) Constellations for Hydrography. *Artificial Satellites*, *53*(1), 39–46. https://doi.org/10.2478/arsa-2018-0004.

[9] Huber, K., Heuberger, F., Abart, C., Karabatic, A., & Berglez, P. (2010). PPP : Precise Point Positioning – Constraints and Opportunities. *FIG Congress - Facing Challenges - Building the Capacity, GNSS Modernisation and Trends*, 11–16.

[10] Karaim, M., Elsheikh, M., & Noureldin, A. (2018). GNSS Error Sources. *Multifunctional Operation and Application of GPS, May*. https://doi.org/10.5772/intechopen.75493.

[11] Kröger, J., Kersten, T., Breva, Y., Schön, S., Kröger, J., Kersten, T., Breva, Y., & Schön, S. (2020). *Multi-GNSS Receiver Antenna Calibration Multi-GNSS Receiver Antenna Calibration (10415) Johannes Kröger , Yannick Breva , Tobias Kersten and Steffen Schön (Germany) FIG Working Week 2020 Smart surveyors for land and water management Amsterdam , the Ne*. *May*, 10–14.

[12] Lashiley. (2010). GNSS Solutions. *Inside GNSS, July/August 2010*, 18–22. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:GNSS+Solutions+:#0

[13] Natural Resources Canada. (2020a). Desktop Applications. https://webapp.geod.nrcan.gc.ca/geod/toolsoutils/applications.php?locale=en#ppp

[14] Novatel Hexagon. (2020). *An Introduction to GNSS: Chapter 5 Resolving Errors (Precise Point Positioning (PPP))*. https://novatel.com/an-introduction-tognss/chapter-5-resolving-errors/precise-point-positioning-ppp#:~:text=What is Precise Point Positioning,accuracy from a single receiver.&text=These corrections are used by,with no base station required.

[15] Paulo, J., & Marreiros, R. (2012). *Kinematic GNSS Precise Point Positioning Application to marine platforms*.

[16] Pellikka, T. (2019). *Global Navigation Satellite System – Signal Interference Errors and Mitigation Techniques*.

[17] Pinchin, J. T. (2011). *GNSS Based Attitude Determination for Small Unmanned Aerial Vehicles*. *March*.

[18] Shen, N., Chen, L., Liu, J., Wang, L., Tao, T., Wu, D., & Chen, R. (2019). A review of Global Navigation Satellite System (GNSS)-based dynamic monitoring technologies for structural health monitoring. *Remote Sensing*, *11*(9), 1–49. https://doi.org/10.3390/rs11091001

[19] Sholarin, E. A., & Awange, J. L. (2015). Global navigation satellite system (GNSS). *Environmental Science and Engineering (Subseries: Environmental Science)*, *9783319276496*, 177–212. https://doi.org/10.1007/978-3-319-27651-9_9

[20] Takasu, T., & Yasuda, A. (2013). *RTKLIB ver. 2.4.2 Manual*. *C*, 181. http://www.rtklib.com/rtklib.htm

[21] The Royal Institution of Surveyors Malaysia. (2020). *Geomatics and Land Surveying Division (GLS) – Royal Institution of Surveyors Malaysia.* https://rism.org.my/geomatic-and-land-surveying-division-gls/

[22] Unavco, B. P. (2018). *A few TEQC tips for getting started*. *Windows 10*, 2–3.

[23] Version3.04, I. (2012). International GNSS Service , RINEX(the receiver independent exchange format). *IGS Workshop 2012*, *104*, 1–74.