Analysis of Error in Geodetic Networks using Different Observation Methods

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Abstract. Now a day, the Global Positioning System (GPS) is used in engineering surveying application, civil engineering construction and for correct object positioning, as in other fields (soil mapping characterization, military applications, and so on). As a result of the multipath error that increases when GPS signal is reflected by smooth surfaces around the antenna, the accuracy of positioning is reduced. For GPS signals this effect mainly appears in the neighbourhood of large buildings. In this research the faculty of engineering at University of Tikrit was chosen as a study area and the points were established at nearby building whose surface was able to reflect the incoming signals. The reflected signal takes more time to reach the receiver than the direct signal. The multipath effect is caused by reflection of satellite signals (radio waves) on objects. This paper shows the result of error obtained by (RTK and static observations) in different situations based on the GPS signals with different differential GPS receiver’s system that was caused by multipath error reflected.

1. Introduction
Using an old GPS antenna, the measurement campaigns were implemented, and the RBFNN reference system was found to reject multiple path effects. RBFNN performance was evaluated based on multi-track rejection during the acquisition period and compared with measures taken by the business future LEICA SR530 [1]. With all multi-track technologies, excellent correlation data and reliable SNR features are used for both multi-path evaluation (where multipath should be indicated only) and multipath modeling (where oscillations are used in SNR data to correct GPS codes). In contrast, moderate correlation data and reasonable SNR characteristics are limited to multipath techniques where data only needs to refer to multiple paths and are not converted to GPS monitoring corrections [2]. The results indicate that ELS reduces multiple path errors by 25% to 50% under normal conditions. The ELS gives the DLL a multi-channel demotion at the throttle level on the pseudo range measurements without the use of choke rings [3]. RTK GPS monitoring is recommended at a distance longer than the height of the vertical surface when the surrounding observation corresponds to the geometry of Mode C. For tasks requiring high resolution (2 cm or less), it is also best to keep them under supervision to study reflective surface sites and satellite configurations to troubleshoot multiple paths before making GPS observations [4]. This paper first analysed the CMCD frequency spectrum for GPS satellites, GLONASS and BDS. Frequency and periodic peaks were found in satellites GPS,
GLONASS and BDS MEO / IGSO. Compared with GPS and BDS, GLONASS satellites showed much higher noise than high frequency. To remove the frequency peaks and period fluctuations resulting from the multipath effect, a new method was proposed to mitigate the effect of multiple paths in GNSS networks with adaptive frequency range filters. The results showed that the proposed method can effectively reduce the frequency peak effect and the effects of multi-cyclic tracks decreased significantly [5]. The impact of multi-track error on individual placement based on C / A based on GPS code was evaluated. For analysis, 72,000 continuous GPS observations were performed with a single second period under four different multi-track environments using three geodetic GPS units [6]. This research introduces a new algorithm that can estimate many real-time path errors for a single-frequency constant in the case of multiple multi-pass signals that are dominant and justified. This algorithm uses an important link between signal-to-noise (SNR) measurements and multiple path errors [7].

A comprehensive analysis of the GPS receiver code was performed to identify behavior and formulate errors in terms of multiple path parameters. The signal-to-noise ratio (SNR) was also associated with the same parameters [8]. The error resulting from the multipath of each satellite in each antenna was then estimated and removed from the initial measurements. The residue was obtained, with and without multipath correction, and the comparison of the remaining statistics showed that this technique is effective in a multi-track environment while minimizing the significant impact of up to 65% for the blade and 50% for the carrier in the user's future. User position accuracy was improved by up to 55% for code and 35% for carrier using this technique which supports multiple paths of remote reflectors. Further investigations should be undertaken to overcome this shortcoming [9]. The effectiveness of multipath correction depends largely on frequency quality estimates, which are limited to two factors: the accuracy at which frequencies can be estimated, and the fact that frequencies are actually changing in time. Finding the FFT methods do not provide a sufficient solution at low-frequency multi-frequency frequencies. The performance of the multi-track correction technology also depends on the accuracy of the SNRA measurements, the assumed antenna gain pattern, and the assumptions that caused direct signals and multipath of fixed capacity [10].

Figure 1. The Faculty of Engineering at the University of Tikrit
2. Study area

The study area was the Faculty of Engineering at the University of Tikrit that is inside the boundary of Salah Aldean governorate (Iraq). This area has boundaries with geographical coordinates, in the left top corner (43° 39’ 00” E, 34° 40’ 49” N) and in the right down corner (43° 39’ 03” E, 34° 40’ 45” N) by WGS 1984 system as shown in Figure (1).

3. Methodology

3.1 Multipath errors and satellite positioning

Multipath is defined as "the methods by which the signal to the receiver reaches different paths". This can occur as a result of any reflective surface close to the antenna, as shown in figure (2). The signal to the receiving antenna may cross over more than one path, due to signs of apostasy from surrounding structures or land. For short baselines (less than 5 km) Multipath is usually the biggest source of error. Under simple multi-track conditions, errors can reach a single wavelength (e.g. the length of a single chip) for code observations or 1/4 of the wavelength of phase observations. Recently, the optimization was done in receiver design to reduce the multipath effect in code measurements, with equal percentages to 75% depending on the multi-track delay [11]. The Satellite positioning allows the 3D positioning of fixed and moving objects based on data received from the geostationary satellite system using the distance measured by spatial intersections (Earth's future - orbital satellites). Two types of GPS measurements can be used: pseudo-scale scales and phase. GPS satellites are sent on two frequencies, L1 (1575.42 MHz) and L2 (1227.6 MHz). The C/A code is modulated only on L1carrier whereas the P code is set on both frequencies [3].

![Figure 2. multipath graphical explanation](image-url)
3.1.1 Kinematic initialization. Special applications require kinematic GNSS without static initialization since the moving object whose position is to be calculated is in a permanent motion (e.g., a buoy or an airplane while flying). Translated to model equations, this means that the most challenging case is the determination of the ambiguities on-the-fly (OTF). The concepts of kinematic relative positioning is that one receiver referred to as a monitor is left on a known point while a second receiver referred to as a rover is moved over the path to be positioned.

3.1.2 Static monitoring methods. Fixed monitoring methods are the most appropriate GPS monitoring methods for geostationary and geodetic applications that require high accuracy (up to millimeters) in positioning. The traditional static method is the oldest and most accurate GPS monitoring method. In this way, the other device occupies the point (or dots) to be identified and at the same time starts all the devices in the reception of satellite signals. Dual-Frequency Geodetic Receivers are used in this study to achieve the level of accuracy required.

4. Data collection

The Data collection of five (GCP) network was carried out within the area shown in Figure (3), by means of the two measurement units without any treatment for multiple tracks, and at close intervals using a Leica G15 type and dual frequency (L1/L2) used to collect data from the work site where the main device is placed on each point for two hours and within four days. The effect of multipath error on positioning was then calculated by equation (1).

\[ \ell^2 = (\Delta E^2 + \Delta N^2 + \Delta H^2) + \Delta \text{rec} \]

\[ \tan \alpha = \frac{\Delta E}{\Delta N} \]

Where \( \ell \) is error in length value expressed in mm for each point; \( \alpha \) is the error in direction; \( \Delta \text{rec} \) is the receiver noise (white noise with standard deviation approximately equal to 1-2 mm). Thus, this study focuses on modeling of the L1, L2 data and generating corrections to dual-frequency GPS solutions after checking the readings and making the comparison between the main points and calculated as accurate points, which is the reference on which comparison and calculation of error will be based, which will be the source of multiple tracks, both linear error or angular error. Moreover, it is necessary to verify that estimates affect the value measurement without changing; a set of values has been collected for each of the following measurements. The result illustrated in table (1) has subsequently tested the difference between static position and the relative position (1st-1re), (2st-2re), (3st-3re), (4st-4re) and (5st-5re) see figure 2. Specifically, it has considered mean, Root Mean Square (RMS) of errors obtained after initial data were prepared within 4 hours of acquisition using all visible satellites that were used as reference observation. The retrieved results show the effect of multiple paths on average of 45% in RMS of 25%. Results shown in table (2) were measured based on the differential positioning device (DGPS) LEICA GNSS Base station.

This five (GCP) network allows easy calculation of the characteristics of multipath corrupted phase residuals and position solutions.
Figure 3: The five GCP network

Table 1. The Root mean square error of the network

| Line   | ∆E(mm) | ∆N(mm) | ∆Z(mm) | ℓ(mm) | RMS   |
|--------|--------|--------|--------|-------|-------|
| 1st-1re| 0.008  | 0.012  | 0.014  | 0.020 | 0.006 |
| 2st-2re| 0.007  | 0.015  | 0.022  | 0.027 | 0.002 |
| 3st-3re| 0.011  | 0.009  | 0.013  | 0.019 | 0.004 |
| 4st-4re| 0.013  | 0.010  | 0.014  | 0.021 | 0.003 |
| 5st-5re| 0.009  | 0.012  | 0.021  | 0.025 | 0.008 |

Table 2. The final coordinates of the GCPS after multipath error

| Measured GCP | Easting (m) | Northing (m) |
|--------------|-------------|--------------|
| GCP 1        | 376955.709  | 3838656.975  |
| GCP 2        | 376485.808  | 3838332.331  |
| GCP 3        | 376748.54   | 3838166.437  |
| GCP 4        | 377010.478  | 3838195.012  |
| GCP 5        | 376835.059  | 3838461.712  |

5. Conclusions

It should be recognized that multiple path errors in the tests are the result of the environment surrounding multiple tracks. This study presents results from two different methods, both of which address errors in positions determined with GPS. In the first static method, fixing the true position by finding the precise point positioning from the data collected within 8 hours from five stations (two hours for each day). In the second method, data are collected with relative GPS method to determine the situation of the station; these were used to understand potentially correct multipath errors in GPS.
carrier phase measurements. The systematic errors in high-rate GPS positions are estimated by taking mean of these two methods to record displacements in position as result of the multipath errors. Both methods are used to improve the precision and accuracy of GPS positions, either by directly acting on the GPS-derived positions or by analysing the GPS observables. The positions are determined for 5 GPS stations located in Tikrit University where the effect of multipath is significant. This research focuses on estimating noise in these positions by reducing the contributions of systematic errors in certain control sites such as urban canyons with buildings with shiny glass walls and construction sites. Multi-track engineering test results show that the biggest multi-track error is about 27 mm and the minimum error is 19 mm. However, the average size of the multi-track error in placements was found to be 2-3 cm in normal urban settings. Also, the RMS error range is from 2-8 mm. So, the Real Time GPS Kinetic method can easily be applied to any geometric and surveying tasks.

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