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Horizontal Accuracy Assessment of Differential-GPS Survey

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Abstract— In this research investigation, the assessment of the horizontal accuracy of Differential-GPS (DGPS) survey with comparison of Total Station instrument data was performed. Total station instrument was used to collect horizontal data and these data were compared with DGPS data. The accuracy of DGPS surveying also depends upon the time of observation and the geometry of the satellites. In this study it has also been investigated the effect of observation time and the PDOP value on the accuracy obtained. The variation of accuracy with time and PDOP value has been analysed by using curve fitting technique. Final result showed that RMSE in horizontal direction of Single frequency Differential-GPS after comparison of total station data was 0.170 m, 0.185m, 0.232 m, 0.076 m, 0.054 m and 0.046 m for observation time of the interval of 5, 10, 15, 20, 25 and 30 minute respectively.

Keywords—Accuracy, DGPS, PDOP, Total Station

I. INTRODUCTION

In the earlier days surveying was labour intensive, time consuming and less accurate. The development of GPS technologies have made the acquisition of highly accurate and reliable data possible with reduced physical efforts. These technologies reduced about one half of project cost and save about two third of the project time, when compared to the conventional methods [1, 3, 5]. The modern survey instruments like DGPS. Total Stations help in cross checking the data quickly in the field. In the past, a lot of time should consume in the preparation of field book and drawing. In the modern era there is good demand for accurate map from various industries [6].

Many authors investigate the application of GPS techniques in different field conditions.

Kuter et al, 2010[7] briefly summarized different commonly used GPS accuracy measures and then compared the horizontal and vertical accuracies of GPS and differential-GPS (DGPS) by taking instant measurements, instead of making measurements for long periods of time at sampling locations. In this study, result of kolmogorov-Simmov and Shapiro-wilk tests shows horizontal and vertical error of GPS and DGPS were not normally distributed. But wilcoxon single rank test with alpha level 0.05 was applied.

And according to this paper Vertical accuracy in terms of \( z \) are \( 5.190 \pm 2.349 \) m and \( 2.140 \pm 1.002 \) m for GPS and DGPS receivers respectively.

Naesset et al, 2001[8] used a 20-channel, dual-frequency receiver observing dual-frequency pseudo range and carrier phase of both GPS and GLONASS, to determine the positional accuracy of 29 points under tree canopies. The mean positional accuracy based on differential post-processing of GPS/GLONASS single-frequency observations ranged from 0.16 m to 1.16 m for 2.5 min to 20 min of observation at points with basal area ranging from <20 m²/ha to 230 m²/ha.

Valbuena et al, 2010[9] worked on accuracy and precision of GPS receivers under forest canopies. True coordinates obtained in a total station traverse were compared against GPS/GLONASS occupations computed from one navigation-grade and three survey-grade receivers. Horizontal component of the absolute error was a better descriptor of the performance of GPS/GLONASS receivers compared to the precision computed by the proprietary software. Differences among methods and receivers were only observed for recording periods between 5 and 15 minutes.

Yoshimura et al, 2003[10] checked the performance of GPS in forest area to turn-off SA and field test on horizontal and vertical position error of GPS positioning at different point in forested area. Horizontal precision and accuracy error of autonomous GPS in plantation forest area were 2.16m – 6.79m and 3.26m – 6.19m respectively.

Total station was used to collect horizontal data and these data were compared with DGPS data. In this study it has also been investigated the effect of observation time and the PDOP value on the accuracy obtained. The variation of accuracy with time and PDOP value has been analysed by using curve fitting technique.

II. STUDY AREA AND DATA RESOURCES

Study area is MANIT Bhopal (Lat. 23° 12’ 59.80”, Long. 77° 24’ 23.18”). For this research work 19 points were established around the campus (within line of sight to successive point), and observations were taken by using Total Station and DGPS instruments. Study area is shown graphically in figure 1.
III. METHODOLOGY

This research investigates the accuracy of DGPS instrument for horizontal aspect and compares it with total station. The comparative analyses of these instruments have been conducted with the data collected in the MANIT Campus, Bhopal, 19 ground control points was established during data collection in MANIT campus, Bhopal.

A. Field Data Collection from Total Station & Its Processing

Distance and height between established points is calculated using Total station instrument using angle and distance method. After the collection of data the closing error of survey is compared with that of permissible error, if it is found more than permissible error than the survey work is repeated. Terramodel software is used for processing of data. Flow chart for data collection is given in Figure 2.

![Flow chart for Total station data collection](image)

After that this data is validated for precise levelling and permissible errors. Permissible error in distance is checked using the following formula,

\[ E_H = 0.0005 \times \text{length of traverse in meters} + 0.03 \text{ m} \quad \text{[2]} \]

Permissible error in height is checked using the following given below,

\[ E_v = \pm 0.006 \sqrt{D} \text{ m} \quad \text{[9]} \]

Where, \( E_H \) = acceptable closing distance in distance, \( E_v \) = acceptable closing error in height, D = total length of traverse in kilometres.
If closing error of collected horizontal data of our points using Total station is less than permissible error then closing error comes under limits of instrument and we take the distance between points as true value for further use otherwise recollect the data till it comes under permissible limits.

Observation time required for one point is 30 minute. Raw data was processed using Trimble business centre software. Data for 5, 10, 15, 20, 25 minutes is masked from 30 minute data. Distance calculated for successive points from DGPS data is compared with the distance calculated using total station. Afterward mean error, RMSE, standard deviation of distance calculated from DGPS is estimated from total station.

Figure 3: Flow chart for horizontal accuracy assessment of DGP

IV. RESULT AND DISCUSSION

The following figures 4 shows the variation of Root mean square error, Standard deviation of error of the DGPS points for horizontal accuracy with respect to the total station surveyed points for different duration of observation.

Figure 5: Variation of RMSE and Standard deviation of error with respect to time

Figure 5 shows the variation of Root mean square error and Standard error of the DGPS surveyed points for horizontal accuracy with respect to the total station surveyed points for different duration of observation.
Figure 5: Variation of RMSE and Standard error with respect to time

Figure 6 shows the variation of Root mean square error, mean error of the DGPS surveyed points for horizontal accuracy with respect to the total station surveyed points for different duration of observation.

Figure 6: Variation of RMSE and Mean error with respect to time

The figure 7 shows the variation of mean PDOP of DGPS with observation time.

Figure 7: Variation of mean PDOP with time

The figure 8 shows the relation between root mean square error and time of the DGPS surveyed points for horizontal accuracy with respect to the total station surveyed points for different duration of observation.

Figure 8: Relation b/w RMSE and Time
The figure 9 shows the relation between Standard deviation and time of the DGPS surveyed points for horizontal accuracy with respect to the total station surveyed points for different duration of observation.

![Figure 9: Relation b/w standard deviation and Time](image)

This analysis shows that the accuracy of the DGPS survey increases with the increase in the observation time. However the error in case of the 25 minute observation is less than the 30 minute observation. This is because of the variation of the PDOP value. The PDOP value at the 25 minute observation is better than that of 30 minute observation. The PDOP at 10 minute observation is best, but due to lesser observation time the accuracy is less. The relation between the accuracy and the observation time is found using curve fitting and is shown in figure 8 and figure 9.

V. CONCLUSION

25 minute observation time is sufficient as the accuracy in horizontal measurement for 25 minute observation Standard deviation and Standard Error is 0.013 meter and 0.003 meter respectively. Accuracy of DGPS survey is dependent upon the observation time. It is also affected by the PDOP value during observation. It is found in this study that for poor PDOP even long observation time does give better accuracy. This investigation is carried out for small baseline. This investigation can also be carried out for medium and long baseline and using Dual frequency DGPS.

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REFERENCES


