USE OF OPEN-SOURCE DATA AND 3D VISUALIZATION OF REMOTE INACCESSIBLE AREAS IN TOPOGRAPHIC MAPPING

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Abstract: ***Remote areas by their geographical inaccessibility or location in hostile/foreign territory present numerous challenges in their mapping despite advances in the field of remote sensing. The primary challenge still remains in achieving reasonable accuracy standards in locational and feature extraction domains. The plethora of open domain RS and GIS resources present us with a credible feasibility of obtaining information to generate mapping products. This research is an attempt to identify, utilize and assess quantitatively and qualitatively the open domain resources in mapping of remote inaccessible areas.***

The research identifies various open domain resources for obtaining Ground Control Points (GCPs), images and GIS data both physical and cultural for mapping requirements. On the quantitative assessment aspect, the location intelligence obtained in the form of GCPs has been verified using field verification. The research has been instrumental in arriving at robust methodology of online DGPS processing without uploading own sensitive raw GNSS observation data in the open domain.

Key words: open domain, DGPS, XML, geospatial web services, visualization, model builder, automation, remote, inaccessible area mapping, digital vector data

1. INTRODUCTION

The remote sensing technology today gives us an opportunity to remotely obtain data of inaccessible areas. The definition of inaccessible areas can be many; it could be inaccessible because of its typical geographic layout or it happens to be in hostile areas within or outside the country. The detailed planning, visualization and analysis required for operating in such areas for developmental, peaceful or corrective engagements necessitate an approach primarily dependent upon remote means of obtaining information.

A topographic map is a comprehensive document with detailed information on the topography of the area. These maps also known as topo maps, and are generally representing the landform of the area in a detailed manner.

The landforms include contours and hill shading, streams and water features and man-made physical features like transportation, network of roads, tracks, or even ocean routes. These maps can also have detailed cultural information viz. boundaries, feature names, place names, for a non-local to operate effectively in the designated area, particularly during man-made or natural disasters. Synthesis and pH dependent catalytic activity of a di-nuclear and a mononuclear Cu (II) complex were done and some interesting observations were noted. The catalytic activity of di-nuclear copper complex is always higher compared to the mononuclear analogues.

Again, the catecholate activity increased in basic solvents. This is probably because reactions in which oxidation happens is enhanced in a medium that can trap the residual protons. This study can therefore help in designing excellent oxidizing catalysts with high turnover numbers.

The topographic maps were initially prepared for revenue or military purposes only, so they were part of a series of maps with detailed referencing schemes. The referencing schemes were designed to refer a map sheet and a portion of map with letters and grid co-ordinates. The topographic maps used by Indian defence forces were designed by the British with polyconic projection on Everest datum and a military grid in Lambert Conic Conformal projection. The accuracy requirement of such maps necessitated a network of robust ground control points (GCPs).

The Great Trigonometric Survey (GTS) conducted by the British in India was for creating the topographic map series which is in use till today. The new Defence Series Maps (DSM) based on LCC projection on WGS84 datum have been formulated and are being disseminated in the defence forces. The Open Series Maps (OSM) is another variation of the Survey of India (SOI) maps for general public. These maps are in UTM projection and the map sheet naming system follows the international map sheet numbering pattern. The primary difference between DSM and OSM is the projection system and military grid, the other difference being deletion of vital details generally known as the vital areas (VAs) and vital points (VPs).

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1.1. Research Identification

The plethora of geo-spatial open resources on the web, like Geonames utilizing RDF technology for contextual search, OSM (Open Street Maps), Google Earth, IGS / CORS (Continuously Operating Reference Stations) providing RINEX data services, Google with XML based geo-services and other mapping websites/portals provide us the opportunity of obtaining varied geographic information of almost any place on the planet earth. These resources can provide contextual, images, GIS data and even precise GNSS information. However the accuracy standards and completeness of the obtained information from such sources is not known or documented. Also the information in the open domain is available in varied formats despite being governed by open standards, thus necessitating due conversion or processing to obtain actionable information.

1.2 Research Objective

The objective of the project is to use Open Source data in topographic mapping and 3D visualization of remote inaccessible areas.

1.2.1 Sub Objectives

- DGPS Point Processing through open domain services.
- Derive GCPs from open source (Google Earth), verify elevation format (orthometric / ellipsoidal) and check its accuracy.
- DEM, orthoimage generation with indigenous data using the above GCPs and accuracy assessment and validation.

2. STUDY AREA

The field observations were taken to the extent of the Cartosat-I scene which is primarily encompassing South West part of Dehradun city and surrounding areas as shown in the Figure 3.1. However Pléiades Tristereo images for Melbourne, Australia were also used in the study as a validation of Google Earth GCPs for use in remote inaccessible areas.

Apart from this open source data including IGS and CORS stations' a-priori position for more than 3000 GNSS antennas located the world over has also been considered in the project. The IGS Station MOBS located in Melbourne Observatory, Melbourne, Australia was used for validation of DEM generated with Pléiades Tristereo images.

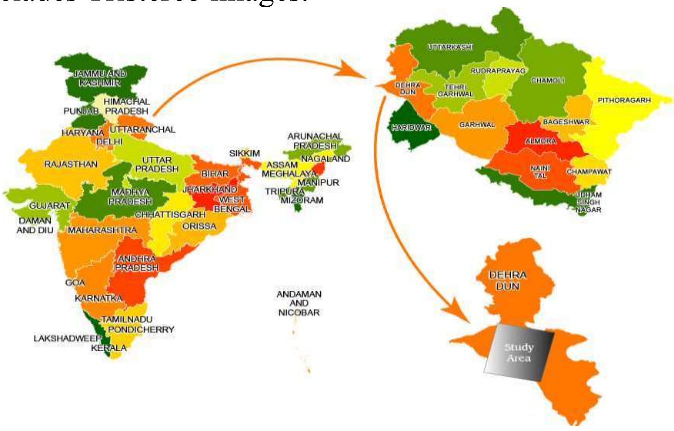


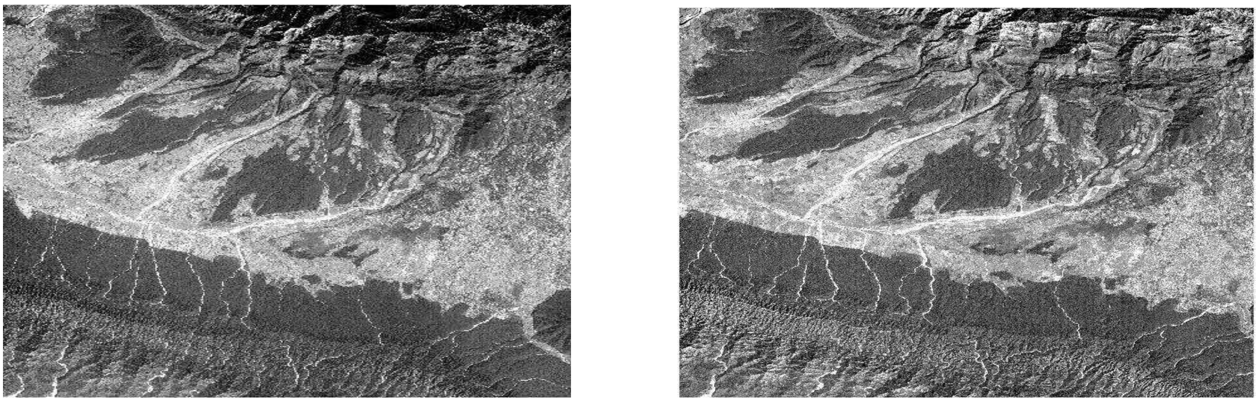
Figure 2.1 Field Based Study Area of the Project

2.1. Satellite Datasets

The study has utilized Cartosat-I and Pléiades Tristereo Images.

2.1.1 Cartosat-I Stereo Images

Cartosat-I or IRS-P5 placed in a sun-synchronous orbit is a stereoscopic Earth observation satellite. The satellite Weighing around 1560 kg was built, launched and maintained by the Indian Space Research Organization (ISRO). Primarily designed for cartography applications the satellite covers the entire globe in 126 days cycle with 1867 orbits. Two state-of-the-art panchromatic (PAN) cameras with 2.5m spatial resolution acquire forward and aft look images simultaneously in the visible region of the electromagnetic spectrum. The forward image at +26 degree and aft image at -5 degrees generate a stereo pair with a swath of 30kms every 52 seconds.
The fore and aft scenes screenshots have been shown in Figure 2.2.



(a) Fore Image (b) Aft Image

Figure 2.2 : Cartosat-I Stereo Pair of the Study Area

3. RESULTS AND DISCUSSION

3.1 Phase I : Precision DGPS Point Processing utilising open domain services.

The DGPS point processing was carried out for an established base station in the IIRS Campus. For this Phase of research three IGS stations were chosen which form well-conditioned triangles with the IIRS base.

The IGS stations chosen were KIT3 (Kitab, Ujbekistan), LHAZ (Lhasa, Tibet) and HYDE (Hyderabad, India). Continuous observation at IIRS was taken for more than 96 hours for post processed solution. The data for same epoch was downloaded for each IGS Station and appended with TEQC software utility to generate single RINEX files for the full epoch. The post processed results are compared for two cases as given below:-

Case I : Processing base with apriori co-ordinates of the three IGS stations

Case II: Processing base with proposed methodology.

3.1.1 Processing base with apriori co-ordinates of the three IGS stations.

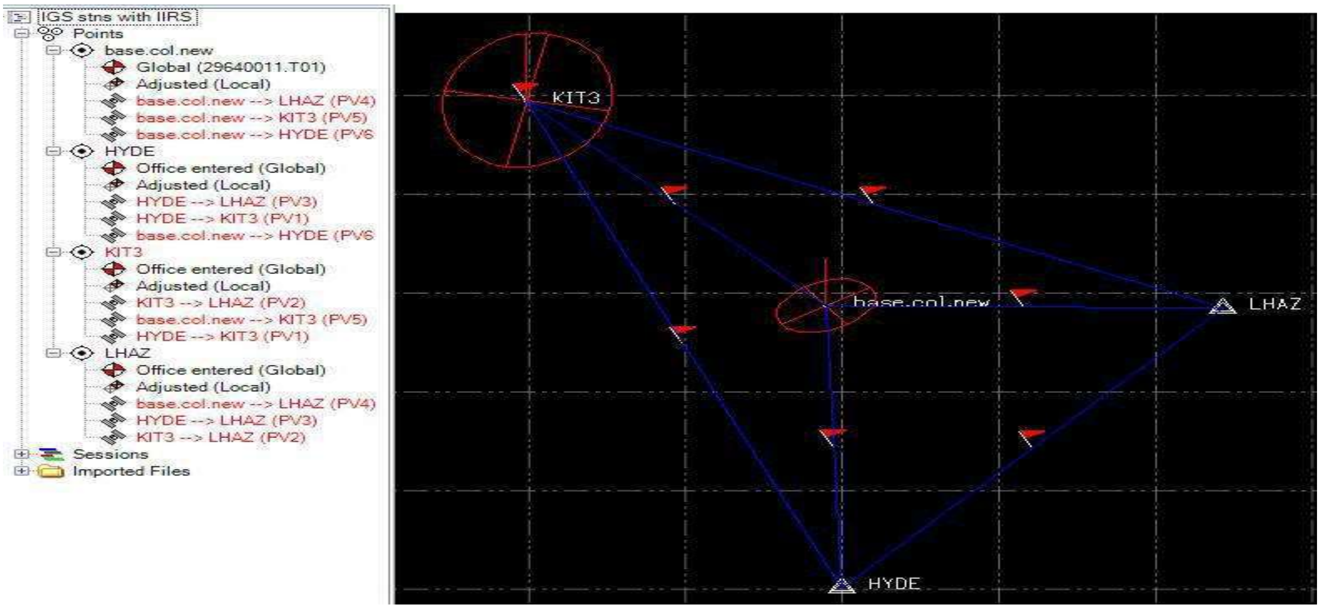


Figure 3.1 Processing Base with Apriori Co-ordinates of IGS Stations.

The spliced files of the three IGS stations and own observed data at IIRS were post processed in TBC with apriori co-ordinates of the IGS stations as available in the RINEX files. The result is shown in Figure 3.1. As can be observed in the figure, all six baselines have been red flagged signifying that the solution does not satisfy the default tolerances of TBC

3.1.2. Discussion and Analysis

The analysis of the results show that in the plane areas the GE heights and DGPS heights agree better than those in the rugged terrain; as can be seen from point id Pt09 which was observed in the hilly terrain of Mussorie. However in plains barring one case of point id Pt15 wherein the height variation was found to be above 5m, the rest agree within 1 to 3 meters.

The Google height values thus agreed with orthometric heights obtained through DGPS survey in the study area to an RMS error of 2.75m and to approximately 2m if the two outliers Pt09 and Pt15 are removed.

Thus it can be concluded that Google Heights are conforming better to orthometric heights observed in the study area. The RMS error of 2.75m in Google Heights from DGPS orthometric heights would make it suitable for satellite triangulation of Cartosat-I or lower resolution stereo products.

The Easting (X) and Northing (Y) errors yield RMS of 1.218m and 1.491m which again would be highly suitable for Cartosat-I or lower resolution products.

In the Field No.1 GE heights agreed with MSL heights with an RMS error of 1.97m. Also in the Field No.2 with more observations and removing the outliers, GE heights agreed with orthometric heights with 2m of RMS error. The geoidal separation of WGS84 ellipsoid in the the study area is approximately -40m, thus it can be concluded that the format of GE heights agrees with MSL or orthometric heights in the study area with an RMS error of 2m. However, to use GE heights for triangulation of remote areas, its format and accuracy needs to be ascertained all over earth, the same has been attempted this document.

4. CONCLUSION

This chapter is the summary of the objectives achieved in this thesis work with recommendations for future work. The work carried out involves use of open domain or free to use geospatial data for mapping of remote and inaccessible areas. As it is known, map making requires the knowledge of geodesy, photogrammetry, GIS and visualization, the same has been attempted in this research albeit with open domain datasets.

The web based open domain IGS based DGPS processing service was implemented and found to be accurate to cms levels in Easting and Northing and decimeter level in height. The DGPS processing of rover stations with apriori co-ordinates of the base station was found to be varying in decimeter levels in Easting and Northing, however height variation of up to two meters were observed with different base stations. The DGPS processing of same rover stations with IGS corrected base station co-ordinates resulted in cm level variation in Easting and Northing whereas the height variation reduced to decimeter level with different base stations. These accuracies have been achieved without uploading own GNSS data to the online DGPS services.

VBA was found suitable for automating access to open domain geospatial XML services for obtaining address, height, geoidal separation in MS Excel. VBA was also found to be suitable for complex calculation of ECEF to Geodetic conversion directly in MS Excel without conversions or interfaces to other software modules.

The Google Earth height agreed with MSL / orthometric heights to an RMS variation of about 2m with the GCPs in the study area. Google Earth heights were also checked with more than 3000 CORS stations data all over the world and agreed with orthometric height with an RMS error of approximately 10m.

The stratified sampling also yielded similar results with RMS error of 11.1m for 0 to 500m height, 10.8m for 500 to 1500m, 5.8m for 1500m to 2500m and 7.7m for above 2500m. The reason for RMS error being the maximum for plain areas of less than 500m height could be attributed to antenna domes mounted on top of buildings whose height is not available for corrections.

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