DETERMINATION OF THE BEST VIRTUAL REFERENCE STATION POSITION USING GEOGRAPHIC INFORMATION SYSTEMS

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ABSTRACT

This paper describes an approach for determining the best position of Virtual Reference Station (VRS) in a given working area using the information from a Geographic Information System (GIS). Virtual Reference Stations are a type of ground based differential reference stations, usually called radiobeacons. The basic purpose of radiobeacons is to calculate pseudorange corrections (PRC) for every space vehicle (SV) in the sky view belonging to a Global Navigation Satellite System (GNSS), and to transmit these corrections to the GNSS users via radio channel or internet in real time. Using the differential corrections generated by a Reference Station significantly increases the accuracy of GNSS positioning. From an economic point of view, Virtual Reference Stations are cheaper than real ground reference stations, and therefore a VRS is more preferable than a real reference station. On the other hand, the accuracy of GNSS positioning using virtual reference station corrections is similar to the GNSS accuracy corrected by data from a real reference station. For both types – Virtual and Real Reference Stations, it is very important to know their exact position in the working area. Various types of GIS software is used to analyze 3D map of a given area and to get decision for an appropriate VRS position with respect to the best observation of GNSS satellites.

Keywords: GIS, GNSS, GPS, DGPS, PRC, Virtual Reference Station, Radiobeacon

INTRODUCTION

Since their development, GNSS have gone through a long way of transformation. They have been constantly subjected to modernization with respect to improving their accuracy. Virtual Reference Stations are a type of ground based differential reference stations. The basic purpose of reference stations is to calculate pseudorange corrections for every space vehicle (SV) in the sky view belonging to a GNSS, and to transmit these corrections to the GNSS users via radio channel or internet in real time. Usually a number of real ground based differential reference stations for establishments of virtual reference stations is needed. An illustration of this concept – the virtual reference station concept is shown in Figure 1. Creating such a virtual reference station (VRS) requires the use of a network of real reference stations. The data produced by the VRS are processed in real time and, by interpolation or extrapolation; the corrections to the pseudoranges of the VRS position are generated. There is another concept of virtual reference station – with consecutively calculation of ionosphere error, troposphere error and space vehicle error sum of that represent approximately 82.35 of the User Equivalent Range Error (UERE) described in [1].

No matter what kind or type the virtual reference station is, the most important part is its position determination and establishment.

The virtual reference station must be positioned on such a place with respect to:

1. Enabling the observation of maximum space vehicles in the sky view;
2. Minimal distance between VRS and users with respect to minimizing the effect of degradation of pseudorange correction [3].

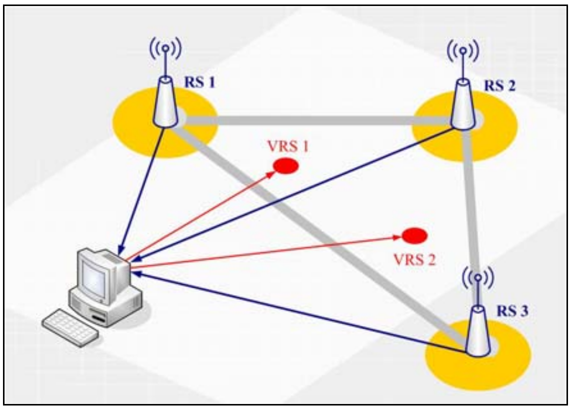

Fig. 1 A Virtual Reference Station (VRS)

OUR APPROACH

In most of cases of deploying VRS, these two requirements are incompatible, and some compromises are needed. In order to determinate the best virtual reference station position, the best solution is to use geographic information systems. The following example of checking the possibilities to positioning one virtual reference station in campus of University of Architecture, Civil Engineering and Geodesy (UACG) for delivering differential corrections on GNSS Navstar users in Sofia describes our approach.

Figure 2 shows the campus of University of Architecture, Civil Engineering and Geodesy and an arbitrary point for virtual reference station called UACG, with approximate coordinates: Latitude: 42.6852 degrees, Longitude: 23.3313 degrees and Altitude: 586 meters in WGS84 datum.

Fig. 2 Campus of University of Architecture, Civil Engineering and Geodesy (UACG)

Using Mapping Toolbox of MatLab and GTOPO30 files from USGS Earth Resources Observation and Science (EROS) Center [2] all terrain data around the selected point UACG can be drawn and viewed in 3D - Figure 3. It is clear to view that around the selected point there are a lots of mountains which can make it impossible to observe maximum space vehicles in the sky view (first requirement).

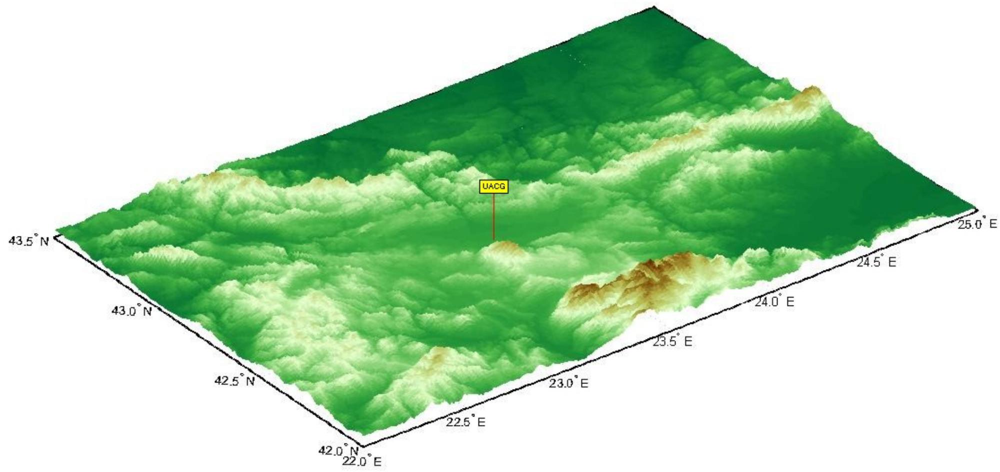

Figure 3. VRS UACG point and all around terrain data – MatLab 3D plot

Vitosha Mountain with the highest point of 2290 meters – Mt Cherni Vrah is on the South from VRS UACG and it is situated very close. At the same direction and far away is Rila Mountain with the highest point of 2925 meters – Mt Musala. On the NW-N-NE is Stara Planina Mountain spread out from West to East with the highest point of 2376 meters – Mt Botev, Central Stara Planina.

Using GTOPO30 GIS data and MatLab probable limitations of space vehicle observations in low elevation angles, causal by terrain oddity near selected point of virtual reference station can be calculated.

RESULTS

The results of calculations that are made to define probable limitations of elevation angles of space vehicles observations using MatLab and GTOPO30 GIS data in 3D view are shown on figure 4. On the figure it can be seen that only Vitosha Mountain "overshadows" the selected point of VRS UACG. The other eminences are far enough from selected point of VRS UACG and although they have high peaks, they do not cast "shadow" over VRS UACG point with respect to elevation angles.

Figure 5 shows the results in rectangular coordinate system, where abscissa is azimuth angle from VRS UACG point and ordinate is minimum elevation angle of space vehicle that is observed. It is obvious that Vitosha Mountain "overshadows" a general direction of 150 degrees and that space vehicles with elevation angle lower than approximately 7 degrees will be inaccessible for observations.

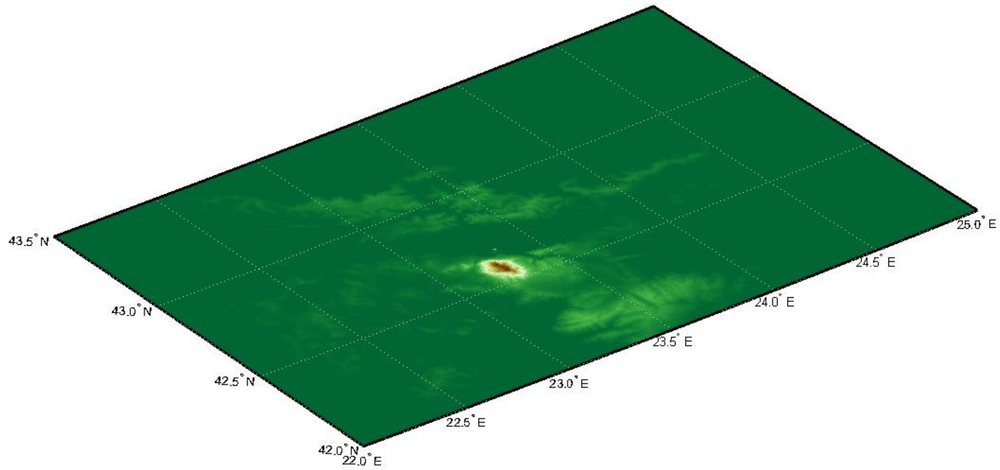

Fig. 4 VRS UACG Real space vehicles elevation angles – MatLab 3D plot

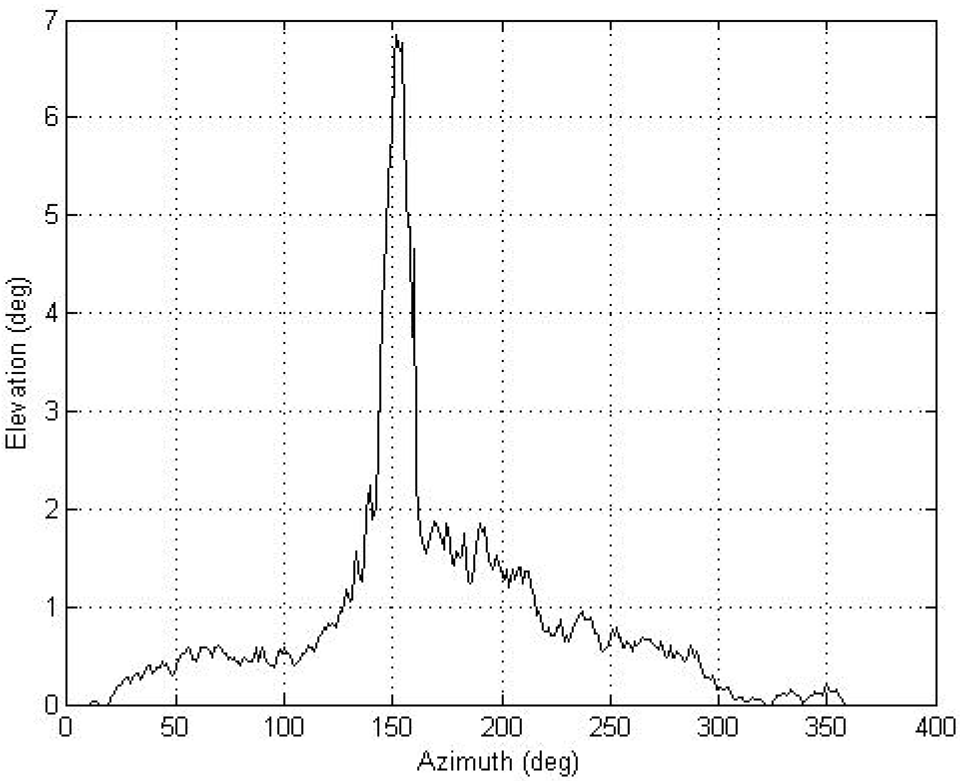

Fig. 5 VRS UACG Real space vehicles elevation angles

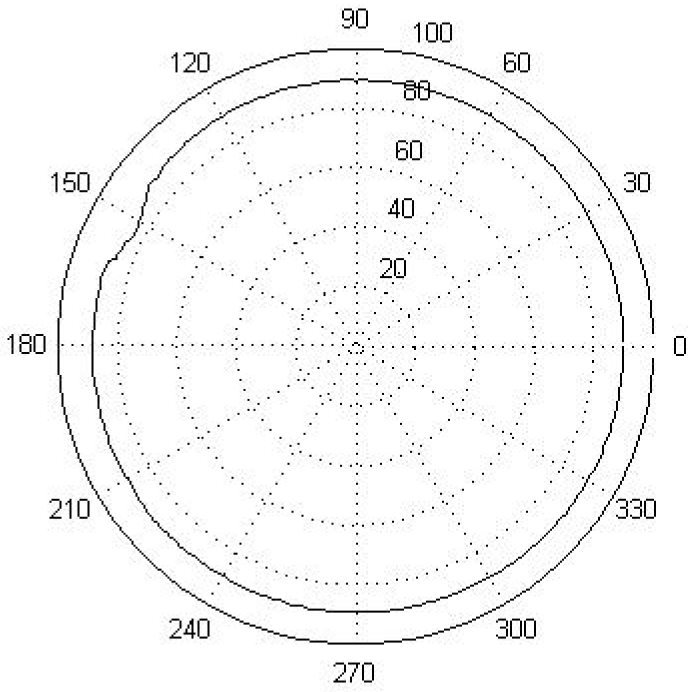

Fig. 6 VRS UACG Sky View (zenith angles)

Figure 6 shows the same results in graph usually called “Sky View” where zero is geographical North and zenith angles of space vehicles are from center to periphery. The “shadow” from Vitosha Mountain of 7 degrees elevation and 150 degrees azimuth is obvious.

Eventually the decision can be made that it is possible to establish a virtual reference station in the selected point into the campus of UACG. The VRS will satisfy the requirement concerning minimization of the effect of degradation of pseudorange corrections (since VRS is situated into the city, i.e. close to the users). Thanks to the Sky View plot, generated using GIS data, all terrain obstacles (except buildings, bridges and etc.), which are important with respect to dilution of precision (DOP) criteria of GNSS, are well known as minimum space vehicles elevation angles.

CONCLUSION

The proposed method of determination of the best virtual reference station position using geographic information systems can be used for checking the possibility of establishment of a VRS or VRS network in every point or area of the Earth.

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