Optimal Cell Phone Tower Location Based on 3D GIS

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Abstract

Optimal cell phone tower locations in dense built-up areas can be identified using viewshed analysis. Viewshed analysis gives information about the line of sight and perception which is crucial for tower siting. The area selected for the analysis and identification is a dense built-up area with high rise buildings. Aerial photographs of 10 cm resolution are photogrammetrically adjusted and topography and buildings with height as attribute attributes are derived. Statistics of each building polygon like area, shape, and volume are calculated. The tallest building is selected based on query and a buffer of 1 km is drawn around the four tallest buildings that are selected within the study area. Optimum The optimum location of towers is calculated based on the number of buildings covered, volume, and building type (Residential, Commercial). Buildings with maximum volume is are given more weightage of 60%, the total number of buildings has weightage of 30%, and building type with weightage of 10%. Four buildings of height 67m, 67m, 65m, and 64m are selected as optimum tower locations using viewshed analysis. Optimum locations of towers are identified only based on spatial and attribute information from high resolution images. It doesn't take into consideration the tower capacity with the number of channels, raster elevation and ownership of land for the selected building for the tower.

Keywords: Cell phone, Hyderabad, Viewshed analysis

Introduction

The cell phone tower location is essential for users of cell phones as the signal strength depends on the proximity to the tower. The dead zone occurs when a cell phone user (receiver) has fluctuating signal reception at different locations or poor signal within the building. To have an acceptable signal strength in urban area, a mobile phone tower has to be placed in an optimal location and at an appropriate height. In addition, the optimal site is determined by the placement of the building's features, terrain data points, ground points, and other things in the vicinity (Shruti Bhardwaj et al.).

Mobile telecommunication has emerged as a technological marvel, allowing users to communication, anywhere and anytime through effortless plug and play (Alaa H. AL-Hamami et al.). Viewshed calculates areas visible from the tower location, but the intent is to find optimal tower locations using spatial query and analysis in GIS. Therefore, results assume that the line of sight works from the target to the source. Physical considerations regarding Line of Sight (LOS) and perception will also be crucial for tower siting. The Viewshed shows visibility from a camera-like observer to a specified target. It allows us to identify visible and non-visible objects to a specific extent. Viewshed can help assess tower visibility within buffer regions and areas of interest. The first part of the paper explains the methodology for deriving 3D buildings from 10 cm aerial photographs using the photogrammetric technique.

The second part explains spatial analytic techniques like buffers and viewsheds to determine the optimal number of tower locations from the geodata.

Materials and methods

Study area: Hi-tech city and its surroundings have a fast growth in Hyderabad. Hyderabad Information Technology and Engineering Consultancy City, abbreviated as HITEC City, is the largest information technology park in India, which offers class state-of-the-art IT infrastructure under one roof to companies operating in the field of IT services, IT-enabled services, Telecom, Engineering Consultancy, and related domains. The study area covers 10.65 square kilometres of Hyderabad city (650 km²). It lies in 17° 21′ 57.6″ N Latitude, 78° 28′ 33.6″ E Longitude. It lies on the Deccan plateau, 541m above sea level, over 625 sq. km. The infrastructural facilities for basic research in Hyderabad are some of the bests in the country, hosting a large academic population from all over the country and beyond; the city has an estimated population of around 8 million, making it 4th largest city in India.

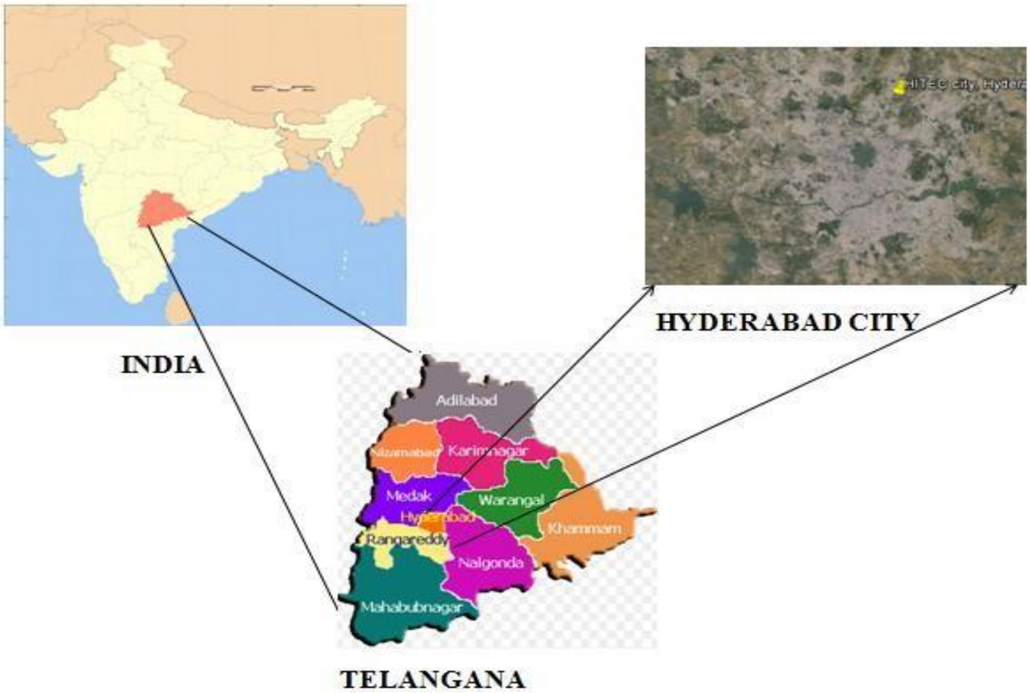


Fig. 1 Location of Study Area.

Methodology: The aerial photographs of 10cm resolution were flown around the Hitech city area and surroundings using a Large Format Digital camera (LFDC) with the integration of GPS and inertial sensors with sufficient overlap. The exterior orientation information for each photograph was derived for each images using photogrammetric techniques from the Physical sensor model. The bundle adjustment was done for entire block of images with position and attitude information with ground control points and derived stereo models. Semi-global matching (SGM) (Heiko Hirschmüller), a computer vision algorithm was used for generating Digital surface model from a rectified stereo image pairs.

The DSM as a dense point cloud including buildings, trees, and ground. Using morphological filters, bare earth was derived, and orthoimages of 10 cm resolution were generated from the Digital elevation model. Buildings were digitized from orthoimages using geodatabase format, and a Spatial model editor was used to derive individual heights of buildings from DSM. The 3D buildings are analysed in the ARCGIS software for spatial query and analysis to determine the optimum location of towers based on height, volume of individual buildings.

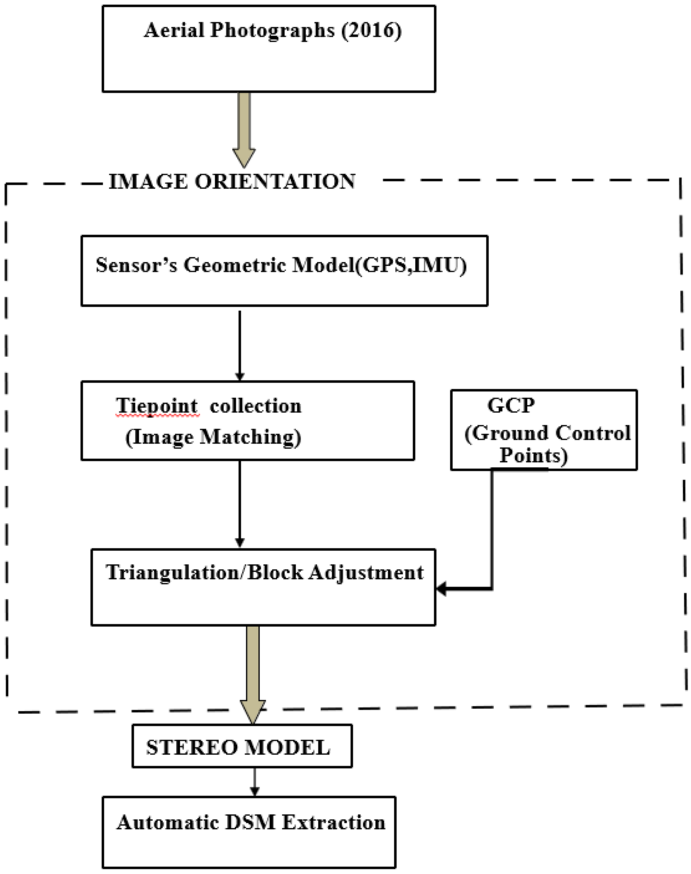


Fig. 2 Methodology.

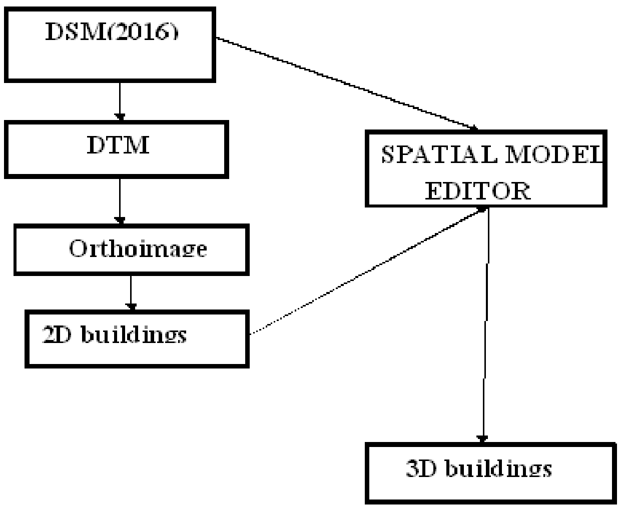


Fig. 3 DSM and 3D building extraction.

Results and discussions

The 3D buildings geometric properties like area and volume are derived as fields in attribute table along with height information. The figure shows a perspective view of buildings. The tallest buildings in the 3D model are identified using spatial query, and buffers are drawn at 1 km distance around the selected buildings.

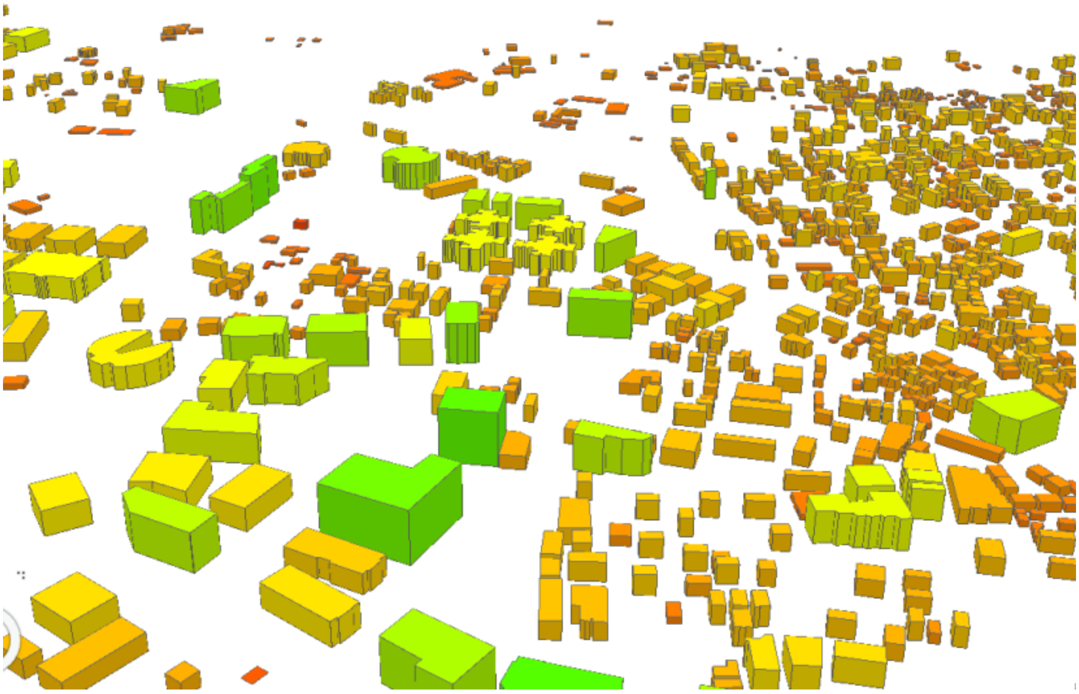


Fig. 4 Perspective view of buildings.

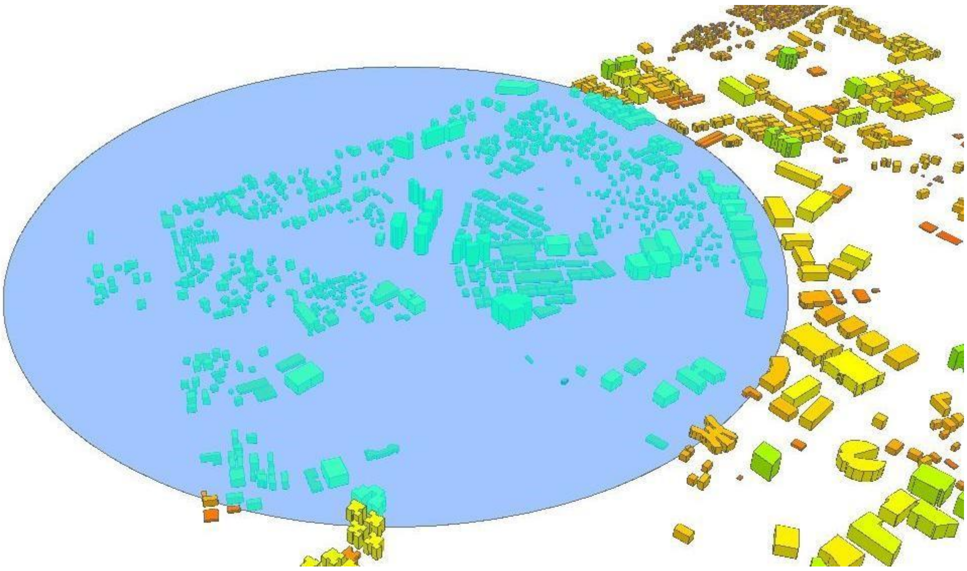
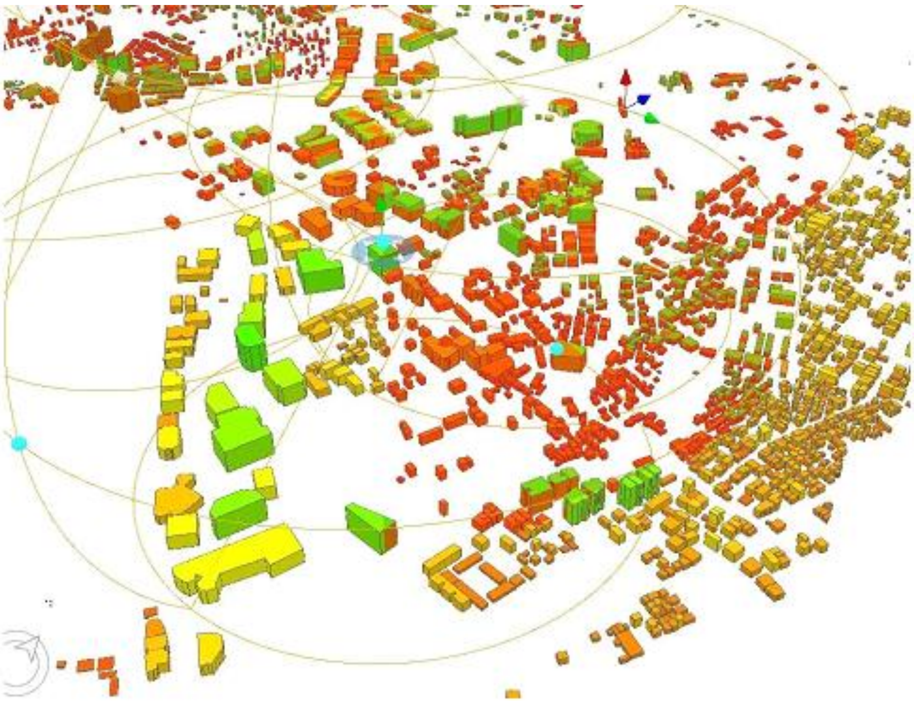


Fig. 5 Buffer of 1km around selected tallest building.

The optimum location for towers is computed based on weightage on the number of buildings covered, volume of buildings and building type (commercial, residential). Buildings with maximum volume is given more weightage (60%), number of buildings (30%), building type (10%). Four buildings with height 67m, 67m, 65m, 63m are identified at different locations within the study area and optimal tower location was identified based on spatial query and viewshed analysis. The Viewshed analysis shows visibility of camera like observer to other points within landscape. The viewshed attributes are shown in figure 8 below and the statistics of buildings with one of the selected buildings as tower location is shown in Figure 8. Invisible and visible locations from a building identified for tower location are shown in figure 9.



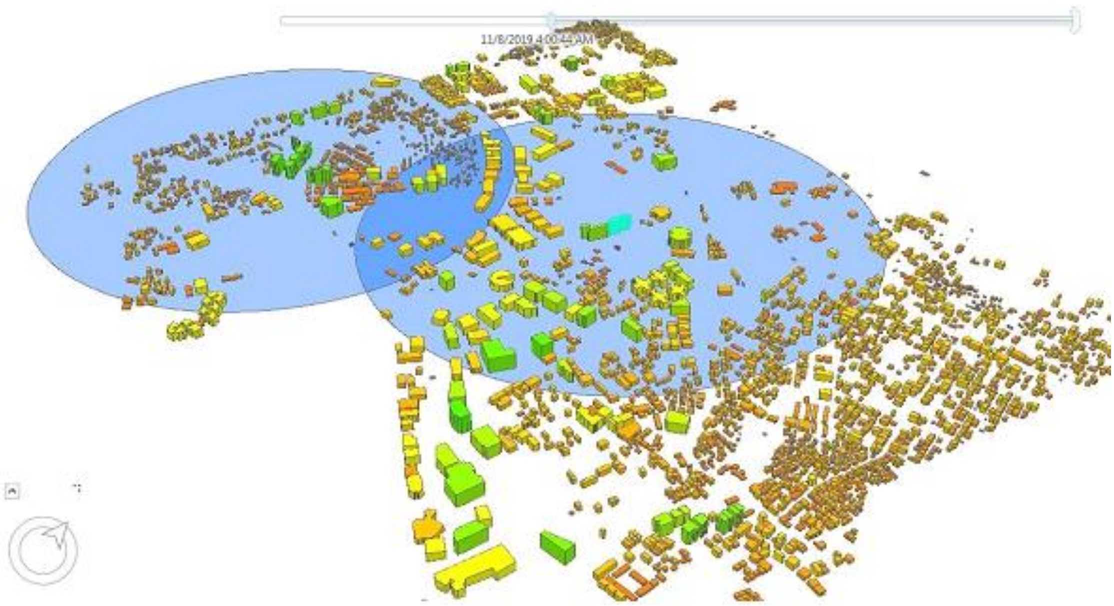


Fig. 6 (top) and 7 (down) Optimal location of towers with buffer and query.

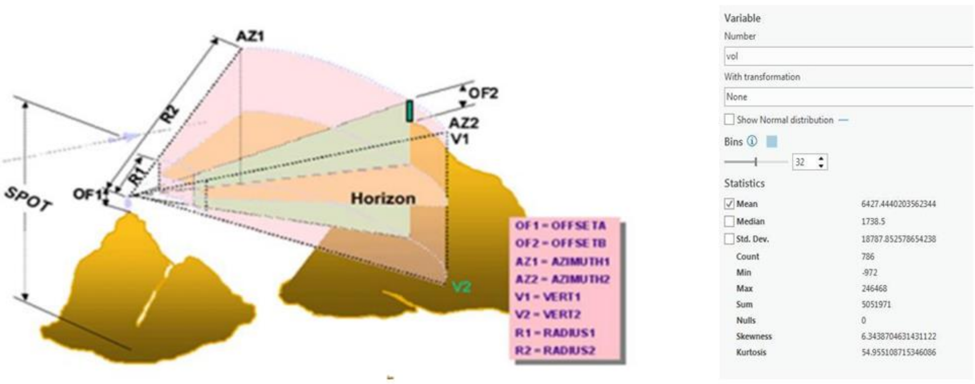


Fig. 8 Viewshed attribute and statistics for tower location.

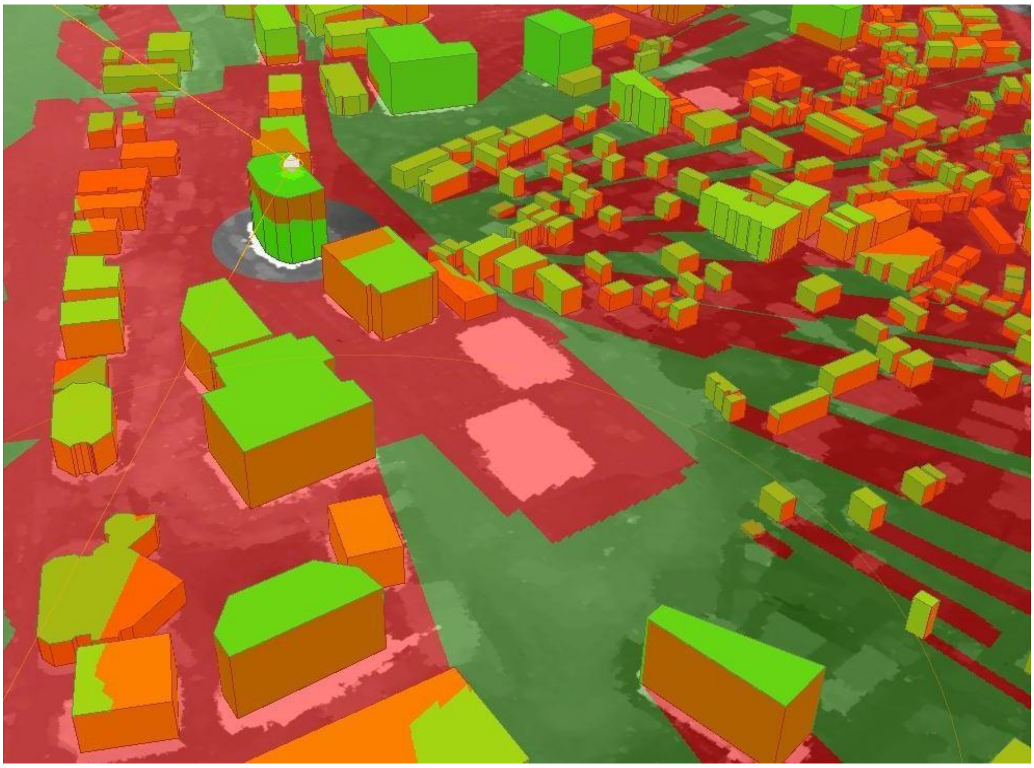


Fig. 9 Tower location with selected buildings**.**

Conclusions

Optimum location of tower has considered only the heights of building and 1km buffer which may not be true for all towers. Additional parameters like tower capacity with number of channels, raster elevation at potential location need to be considered. The buildings are identified as optimal location of tower without knowing ownership of land and effects of Electromagnetic (EM) radiation on the nearby buildings also need to be evaluated before placing the tower.

References

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