GeoMundus 2020

Abhishek Pandey
TERI School of advanced studies,
Plot no. 10, Vasant Kunj
New Delhi, Delhi India 110075
Tel.: +91 8510870511; +91 7982524019
Pandey.abhi3112@gmail.com; abhishek.pandey@terisas.ac.in

Abstract

5G, the upcoming mobile network is the fastest network ever developed having potential to provide speed of 10 gigabits per second and ultra-low latency. It consists of high band mmWave frequencies which cannot penetrate buildings and canopies hence requires spatial decision support tools to maximize its coverage and select best possible site for radio frequency (rf) planning. This site selection process requires high resolution GIS inputs called 'geodata' using simulation in a 'digital twin' with submeter accuracy. Here, a methodology has been proposed to create high resolution geodata which can help in site selection and effective planning of 5G networking such as line of sight analysis & coverage analysis. Specifically, these geodata are, Clutter i.e. land use surface information, 3D building models, Digital terrain model i.e. bare earth elevation, Tree crown cover or canopy model. Support vector machine algorithm was carried out to produce land use with an accuracy of 87% and further merged with building footprint data to produce clutter based on Maryland classification scheme. The 3D building model was created using footprint data consisting of height attribute with vertical accuracy of 50 cm. Terrain model was obtained from lidar data & this lidar data was further segmented using PointCNN. The precision and recall achieved from PointCNN for canopy is 98.3% and 96% respectively. Analytic hierarchy process (AHP) and weighted overlay analysis were carried out with geodata to locate suitable sites. 90 locations were identified to be highly suitable for RF planning.

Keywords: 5G, spatial planning, geodata, PointCNN, AHP

1 INTRODUCTION

5G, the 5th generation mobile network, is a new world-wide wireless standard after 2G, 3G, & LTE(4G) network. 5G facilitates a new type of networking which is designed to connect virtually the whole world including devices, objects and machines (Qualcomm, 2020). It will take mobile connectivity to the next level but developing the necessary infrastructure can be time consuming and expensive. Knowing the exact location of natural and manmade obstacles is essential for 5G, as its cell sites require clear lines of sight (HERE, 2019).

5G's high band frequency, which involves massive amount of information transfer can be obstructed by small objects because of its short range. And as the signal is very sensitive it can easily be blocked by even tree leaves. Thus, precise, accurate & reliable spatial data is fundamental. It also requires denser telecom network where antenna/cell or towers are placed strategically & selectively for propagation optimization.

According to HERE technologies, the 3D digital representation & simulation in the form of 'Digital Twin' can provide a 5G RF engineer or network planner to conduct remote survey and plan precisely location of 5G antenna to obtain optimal and maximum coverage. They also mention that in order to do so the significant features of Geodata Models obtained using 3D GIS and Remote Sensing for 5G RF planning should include: a) Digital Terrain Model (bare earth model) with resolution ± 1 meter or better b) representation of surface cover with resolution of ± 1 meter or better; c) 3D representation of Building Geometry and location with precision of ± 1 meter or better; d) 3D representation of Tree foliage with precision of ± 1 meter or better;

In this study AHP is used to create a predictive classification of suitable sites based on various parameters such as bare earth elevation, Canopy height, LULC, Building Elevation, Road Distance and Existing telecom poles. The general suppositions which were considered in this study of 5G rf planning are based on the response of 5G High Band (mmWave, 20-50 Ghz) to different spatial features and how these geographical factors work together to affect signal health and coverag

2 MATERIAL AND METHODOLOGY

STUDY AREA

The study area selected for this research is Central part of Bengaluru, the capital of Karnataka. Various telecom industries have indicated that Bengaluru would be having the first round of deployment. In 2017, Airtel deployed India's first MIMO technology in Bengaluru which is considered a step toward future 5G network.

DATASET & SOFTWARE

Objective	Dataset	Resolution	Date (Year)	Software used
LULC (clutter)	Worldview 2 RGB imagery	50 cm	December 2019	R Studio, ArcMap 10.7
3D Building	Building Footprint polygon	1 Meter with vertical accuracy of 50 cm	2020	ArcGIS Pro
Terrain Model	Terrestrial Lidar	1 Meter with vertical accuracy of 24.5 cm	2019	ArcGIS, LasTool
Canopy Extraction	Terrestrial Lidar	1 Meter vertical accuracy of 24.5 cm	2019	Arcgis.learn module in jupyter notebook, Autodesk Recap Pro
Site Selection	Road Polyline layer		2020	ArcGIS Pro
Site Selection	Existing Pole Point Layer		2019	ArcGIS Pro

METHODOLOGY

Using R scripting, SVM classification method was applied on the Worldview Imagery to obtain LULC. Using 2D building footprint having height attributes, 3D building multipatch were obtained by making use of *feature to 3D* and *layer to 3D* function of arcpy in python script. DTM was obtained using last return values of lidar and binning interpolation with void fill method. To obtain tree canopy height and 3D model, lidar was segmented using PointCNN in Jupyter notebook and then canopy class was used to create a 3D mesh in Autodesk Recap pro which was then imported as a multipatch geometry in ArcGIS pro.

For Site Selection analytical hierarchy process (AHP) weighted overlay method was used. The Geodata (CHM, 3D Buildings, DTM, Clutter) along with distance to road and poles were reclassified according to the relative weight estimated using the method of AHP and Pairwise comparison matrix.

3 RESULT & DISCUSSION

Land use was generated using SVM technique using linear kernel and cost 100. The overall accuracy was 87% and kappa 0.8. Built-Up covered 65.4 % from the total area of 0.7 Sq. km while open land and shrubs covered 2.5% and 2.6% each, Vegetation covered 29.2% and inland water-bodies covered only 1.8%. This Land-Use (figure 13) was merged with building layer and classes were converted as per the Maryland classification scheme to create Clutter. 3D Building Multipatch were successfully created using the building footprint 3D building elevates network planning from theoretical to physical. Since the desired resolution for bare earth Terrain model was 1 meter and point spacing in the idar Data was 0.034, Binning with linear void fill and cell assignment type as IDW was used to fill any gap or voids present. Segmented Canopy obtained using PointCNN Deep learning model had an overall accuracy of 95.2%. Precision achieved was 98.3% and 96% recall for canopy class. This means that only 1.7% of the canopy volume does not lie within the actual real canopies, and only 4% of the true canopy point cloud is missing from the predicted canopy. This classified canopy was used for obtaining 3D mesh through Autodesk Recap. Based on pairwise comparison matrix developed, the consistency ratio achieved was 0.062 or 6%. The map generated using AHP shows that out of total area 1% and 10.5% of area falls in Very high and High suitability zone respectively. 32% belongs to Moderate suitability zone, 39% belongs to low suitability zone and 17.7% belongs to not suitable zone which is basically area under influence of dense vegetation. Centroid of Very High suitability zone were extracted and from that 90 location were identified. Line of Sight & viewshed coverage analysis was carried out on these location using the "Digital Twin" to estimate pinpoint location & their subsequent area coverage. The produced geodata can be used in rf planning software such as atoll.

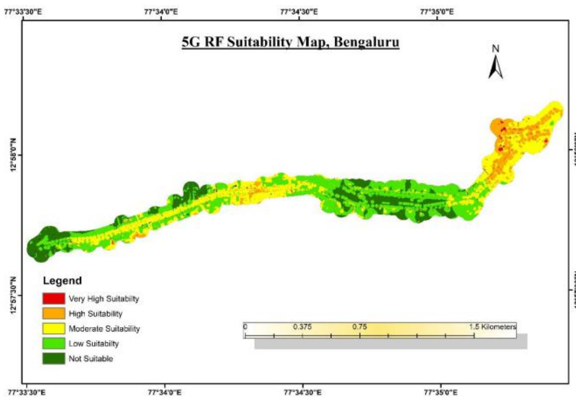

Image 1 Suitability Map obtained using AHP

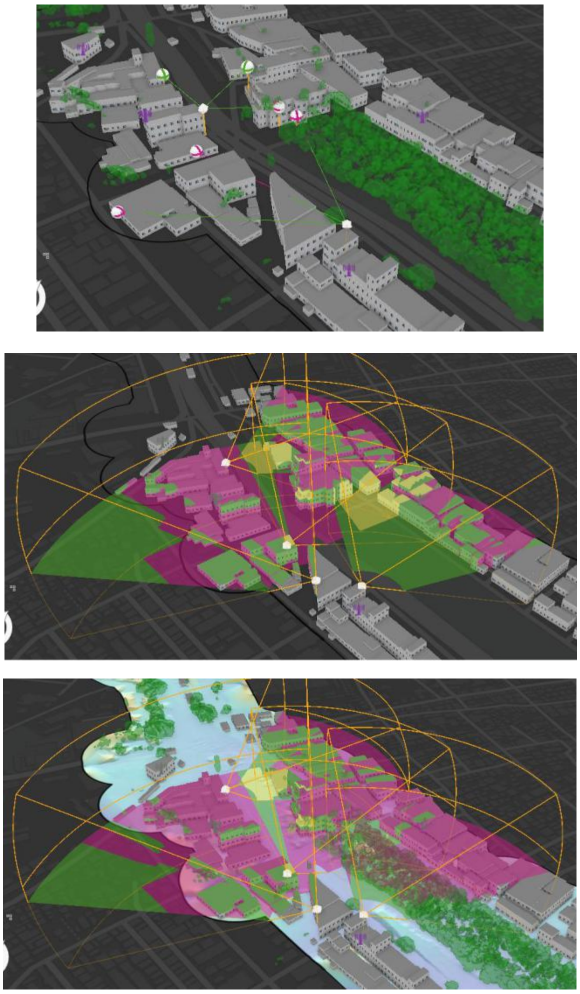

Image 2 a) Line of sight analysis based on suitable sites for fine tuning, b) View shed analysis without canopy and DTM & c) View shed analysis with Canopy and DTM (green color = area with coverage, yellow= overlapping coverage from 2 or more towers, magenta= no coverage or obstructed coverage)

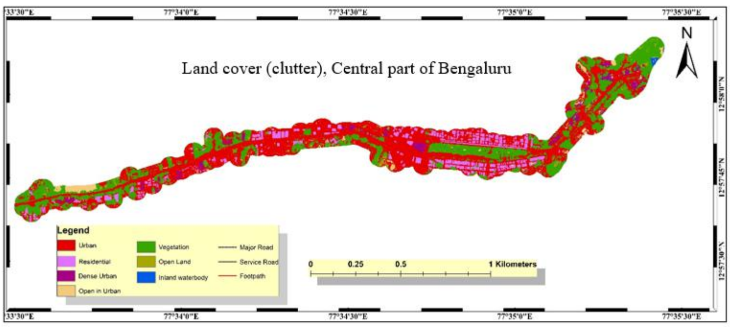

Image 3 Clutter obtained from worldview RGB imagery

Acknowledgements

I would like to express my deepest appreciation to **Mr. Deekshant Saxena, Mrs. Nisha Sharma & Ms. Senjuti Sen** for giving me the opportunity to contribute my knowledge of GIS and Remote Sensing to the daunting and onerous task being faced by them on daily basis. I am extremely thankful to **Mrs. Nisha Sharma** for her guidance and constant support in my best and worst times. I would like to thank **Ms. Senjuti Sen** for mentoring me and helping me with any kind of problem I faced, paving a way for the success of this project. Heartfelt thanks to **Mr. Deekshant** for believing in me and providing me with opportunity to work on live and on-going projects.

I thank everyone in HERE, specially **Process Design Team** for their hardworking spirit and for boosting my confidence.

Last but not the least, I would like to thank **my parents** who are my inspiration, for their love, prayers, support and sacrifices for educating and preparing me for future. My special thanks goes to my brother and my dear friends who have been encouraging me and supporting me throughout this project.

References

Blogger, G., Rees, E. and Rees, E. (2020). How 5G is used for creating and consuming live traffic maps - SPAR 3D. [online] SPAR 3D. Available at: https://www.spar3d.com/news/software/how-5g-is-used-for-creating-and-consuming-live-traffic-maps/ [Accessed 16 Jan. 2020]. 38

Cisco White paper (2019). Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2017–2022 White Paper. [online] Cisco. Available at: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-738429.html [Accessed 4 Feb. 2020].

Digitalglobe.com. (2020). DigitalGlobe | Telco advanced geodata in 5G world. [online] Available at: https://www.digitalglobe.com/products/telco-geodata [Accessed 16 Jan. 2020].

Esri. (2020). NextTech: AI, Big Data, Location Intelligence and Prediction Tools Fuel 5G. [online] Available at: https://www.esri.com/about/newsroom/publications/wherenext/5g-network-buildout-with-ai/ [Accessed 1 Feb. 2020].

Geospatial World. (2020). Geospatial and 5G rollout: Why they are critical for each other?. [online] Available at: https://www.geospatialworld.net/article/geospatial-and-5g-rollout-why-they-are-critical-for-each-other/ [Accessed 1 Feb. 2020].

Geospatial World. (2020). 5G and geospatial will together power future cities - Geospatial World. [online] Available at: https://www.geospatialworld.net/article/5g-and-geospatial-will-together-power-future-cities/ [Accessed 1 Feb. 2020].

Infovista.com. (2020). [online] Available at: https://www.infovista.com/sites/default/files/resources/2018-09/ds_infovista_planet.pdf [Accessed 1 Feb. 2020].

J. G. Andrews et al., "What Will 5G Be?" in IEEE Journal on Selected Areas in Communications, vol. 32, no. 6, pp. 1065-1082, June 2014

Korem. (2020). How Location Intelligence is Essential for a Successful 5G Deployment | Korem. [online] Available at: https://www.korem.com/how-location-intelligence-is-essential-for-successful-5g-deployment/ [Accessed 22 Jan. 2020].

Maxar Blog. (2020). Next-Generation 5G Networks will be Enabled from Space. [online] Available at: https://blog.maxar.com/earth-intelligence/2019/next-generation-5g-networks-will-be-enabled-from-space [Accessed 2 Feb. 2020].

N. Bhushan et al., "Network densification: the dominant theme for wireless evolution into 5G," in IEEE Communications Magazine, vol. 52, no. 2, pp. 82-89, February 2014

Schindler, F., W. Worstner, and J.M. Frahm. Classification and reconstruction of surfaces from point clouds of man-made objects. in 2011 IEEE International Conference on Computer Vision Workshops (ICCV Workshops). 2011.

S. Chen, H. Xu, D. Liu, B. Hu and H. Wang, "A Vision of IoT: Applications, Challenges, and Opportunities with China Perspective," in IEEE Internet of Things Journal, vol. 1, no. 4, pp. 349-359, Aug. 2014

Westoby, M.J., et al., ‘Structure-from-Motion’ photogrammetry: A low-cost, effective tool for geoscience applications. Geomorphology, 2012. 179(0): p. 300-314.

Whitmore, A., Agarwal, A. & Da Xu, L. The Internet of Things—A survey of topics and trends. Inf Syst Front 17, 261–274 (2015).