3D City/Landscape Modeling Non-Building Thematic: Vegetation

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Brief. Shafarina Wahyu Trisyanti is a master's student in Geodetic and Geomatic Engineering at Institute of Technology Bandung (ITB), Indonesia. Her current research focuses on 3D city or landscape modeling, especially for vegetation and city furniture. She completed her bachelor's degree in Architecture at ITB.

Abstract. 3D city model is a digital representation of the original environment that can be used in a variety of applications, such as the process of planning, building, and maintaining a city. However, 3D City models are currently more focused on building modeling. Whereas other thematic features, such as vegetation and city furniture, are important for planner to visualize and represent the whole of urban planning. The aim of this research is to evaluate and develop 3D city model non-building for vegetation that can be used in landscape architecture. Due to the need for analysis of landscape architecture, then the classification, information, level of detail, and visualization of those models must be created. The used data are generated by survey and mapping using UAV-Photogrammetry technology. Data can be an orthophoto and Digital Surface Model (DSM). Tree position and crown diameter are obtained by manual segmentation using orthophoto. Filtering DSM will generate Digital Elevation Model (DEM), and will be processed to generate Normalized Digital Surface Model (NDSM). Tree height obtained from NDSM semi-automatically. For tree species, can be classified manually using orthophoto. Those informations were used for 3D vegetation modeling. The modeling results can be used for spatial analysis, especially visibility analysis and visualization in landscape architecture.

Keywords: 3D City Model, CityGML, Vegetation

1. Introduction

1.1. 3D City Modeling

The process of urban development must involve various disciplines, so it takes a model that can represent the city and become a media coordination of the various disciplines. A 3D city model is a representation of an urban environment with a three-dimensional geometry of common urban objects and structures, with buildings as the most prominent feature (Biljecki, et al., 2015). For the smaller area than the city, landscape modeling can be done.

Currently 3D city modeling is more concentrated on the representation of building geometry, whereas non-building objects are also important in the process of urban development. The non-building thematic objects such as tunnel, bridge, vegetation, city furniture, and water bodies. 3D models of vegetation in city modeling are needed as the visualization and analysis tools for various fields, as well as the basis of urban design simulation, such as for urban greening, water conservation, and flood prevention.

Objects of 3D city model will be stored in a data model, it can be City Geography Markup Language (CityGML). CityGML is an open data model and Extensible Markup Language (XML)-based format for the storage and exchange of virtual 3D city models (OGC Member, 2012). CityGML defines classes and relationships for topographic objects that are related in the city or region model with regard to geometric, topology, semantics, and their properties. One of the CityGML characteristics is multi-scale modeling, which distinguishes object's level of detail into Levels of Detail (LoD) to 5 levels (0-4). In this study, objects that will be modeled are vegetations in campus of Institut Teknologi Bandung (ITB) Jatinangor.

1.2. Previous work

The study about estimating tree position, tree height, and crown diameter has been done in Calculation of Tree Height and Canopy Crown from Drone Images Using Segmentation (Lim, et al., 2015). The used data in that study are DTM, which was the available data in this study, orthophoto and DSM from aerial photography using drone. Based on those data, nDSM was generated by subtracting DTM from DSM using ERDAS IMAGINE. Combine that nDSM with ortho-image, and then do the segmentation. In Figure 1 (from left to right) shows DSM, the result of segmentation with ortho-image, and eleven identified trees at study area. The result of the segmentation is used to estimate the parameters of each tree (tree position, tree height, and crown diameter).

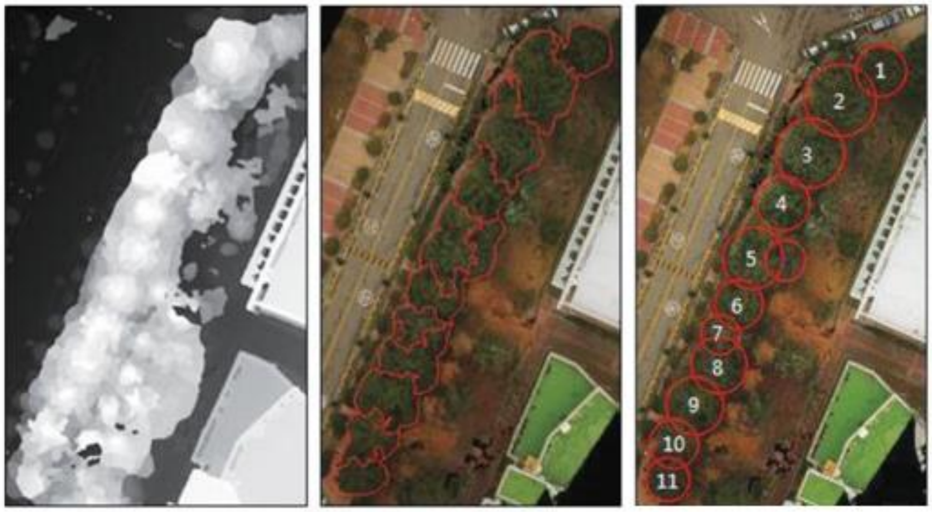


Figure 1 Result of segmentation and tree identification (Lim, et al., 2015)

While for 3D modeling of mesh, has been done in the study of LOD Generation for Urban Scenes (Verdie, et al., 2015). That study explained about algorithm used in making model for building and vegetation objects. 3D object modeling was divided into three processes, classification, abstraction, and reconstruction process. The classification process divides the mesh into four classes: ground, tree, roof, and façade. While in the process of abstraction divide the object into planar proxies and iconic objects. Iconic objects are tree, roof, and façade. Third process, the reconstruction process, describes the formation of LoD (0-3) which also refer to CityGML as shown in Figure 2. For Lod 0 (2D), ground is planar, trees are point, and buildings are polylines. For LoD 1 (3D), ground mesh, trees are vertical cylinder, and buildings are LoD 0-buildings elevated with horizontal roof. Lod 2, ground mesh with tree icons, and buildings reconstructed with simply roof. For LoD 3, building reconstructed with complex structure and enriched with façade elements.

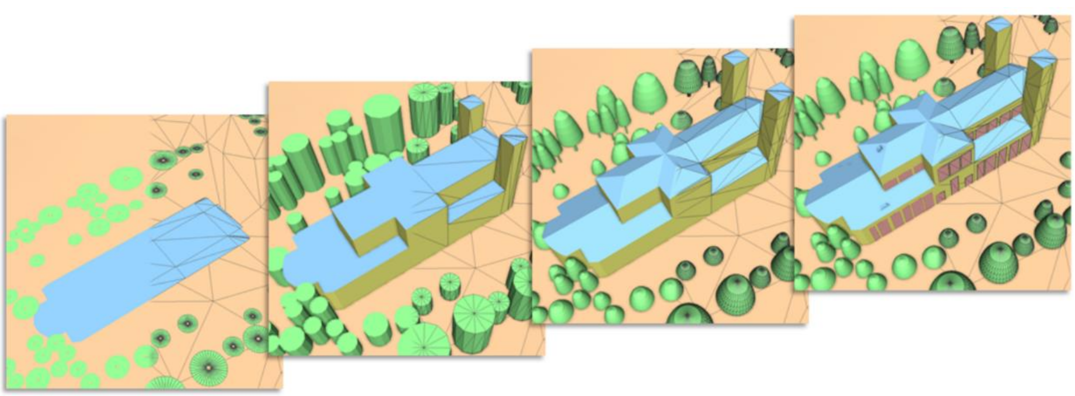


Figure 2 LoD 0-3 for ground, trees, and buildings (Verdie, et al., 2015)

2. Data and Methods

The used data in this study are the result of survey and mapping using UAV Photogrammetry at December, 2016. The results are orthophoto and DSM with horizontal resolution of 11.562 cm and vertical resolution of 19,256 cm (Firdaus, 2017). Tree position and crown diameter were obtained by manual segmentation using orthophoto. Filtering DSM will generate DTM, then NDSM was obtained by subtracting DTM from DSM. With NDSM, tree height can be obtained semi-automatically. Those information were used in previous study, *Implementasi Citygml Menggunakan Produk UAV-Fotogrametri* (Prameshwari, 2017). In that study, 3D model for building and terrain campus area of ITB-Jatinangor were generated from LoD 1-3, and vegetation model in LoD 1.

Then, 3D city model (terrain, building, and vegetation) can be modeled using information about tree position, tree height, crown diameter, and 3D model for building and terrain. In addition, modeling process also depends on the needs of landscape architecture and urban planning. The needs of landscape architecture and urban planning affects the model, such as visualization, level of detail, and available information.

The used methods in this study shown in
Figure 3.

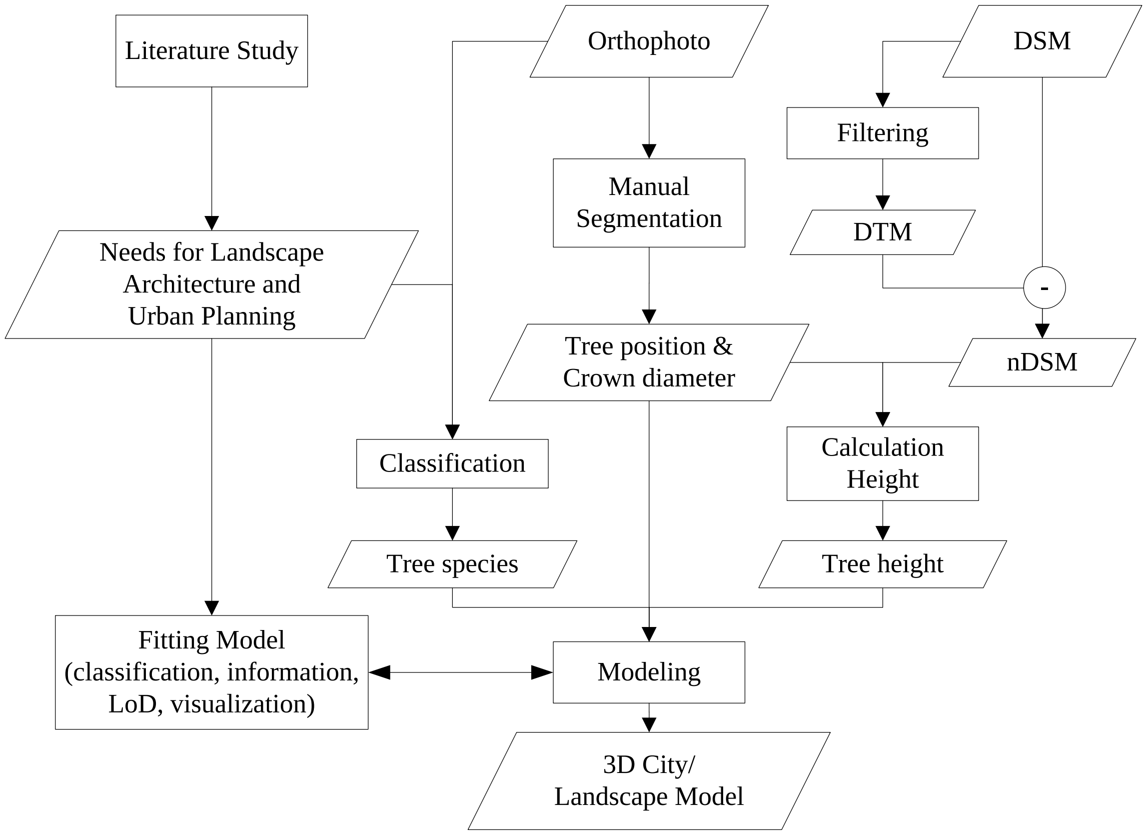


Figure 3 Research methodology

3. Result and Discussion

Based on the available data, various information can be obtained and used in modeling process. Using orthophoto, the trees identification can be obtained manually. Operator digitize orthopoto to generate vector data for vegetation, by giving the tree position point and the estimated diameter of the tree canopy. There were 3050 points of vegetation have been digitized in orthophoto of ITB-Jatinangor campus. Besides the center-point, operator was estimated the crown diameter by giving circle polygon around the center-point. Using orthophoto, tree species can be classified manually based on CityGML standard in OGC CityGML document (2012). The classification divides vegetation into eleven species, there were shrub, low plants, medium high plants, high plants, grasses, ferns, coniferous, deciduous, bushes, aquatic plants, and climber. While the tree height can be obtained semi-automatically using NDSM. Then, the information obtained from all of those data are tree ID, tree position, tree height, crown diameter, and tree species. All of those information are used to do tree modeling process using some software.

The first step in modeling process is making model template for each tree species in LoD 1, LoD 2, and LoD 3 using SketchUp software. Then export the *.skp* (from SketchUp) file into Collada (Collaborative Design Activity) file. Then convert Collada file into CityGML file (*.gml*) using Feature Manipulation Engine (FME) software. For LoD 1, trees are modeled in two intersecting polygons 90° with texture. Models in LoD 2 and

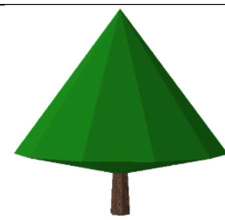
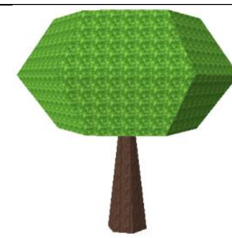
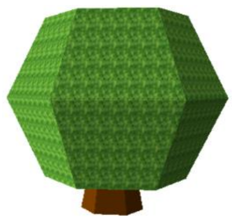
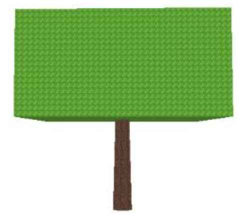
3 are made to follow real tree geometry, but models in LoD 3 are more detail than models in LoD 2. The detail affects the number of polygons that make up the tree models. Example for tree model in LoD 1-3 shown in Figure 4.

Figure 4 3D models for coniferous tree in LoD 1 (2 polygons), LoD 2 (46 polygons), LoD 3 (358 polygons) without texture (top) and with texture (bottom)

The models are saved in GML format file, and will be visualized using LandXplorer CityGML viewer. The GML geometric primitive of models can be a MultiSurface, Solid, MultiSolid, or CompositeSolid. But the models in this research must be a MultiSurface, to be viewable using LandXplorer. Visualization of tree models for all species in LoD 2 shown in Table 1.

Table 1 Visualization tree models in LoD 2

Shrub	**Low Plants**	**Medium Plants**	**High Plants**
			
112 polygons	96 polygons	96 polygons	80 polygons
Grasses	**Ferns**	**Coniferous Tree**	**Deciduous Tree**

			
36 polygons	84 polygons	46 polygons	112 polygons
Bushes	**Aquatic Plants**	**Climber**	**Unknown**
			
112 polygons	22 polygons	24 polygons	52 polygons

Second, add the template of tree model into the 3D model for terrain and buildings of ITB-Jatinangor campus in CityGML using Matlab. There are 3050 trees to be modeled. A program created in Matlab to make it easier to add tree models into the terrain model according to coordinates of tree position. That program include transformation matrix for each tree. The result of modeling in CityGML with viewer LandXplorer CityGML Viewer software shown in Figure 5.

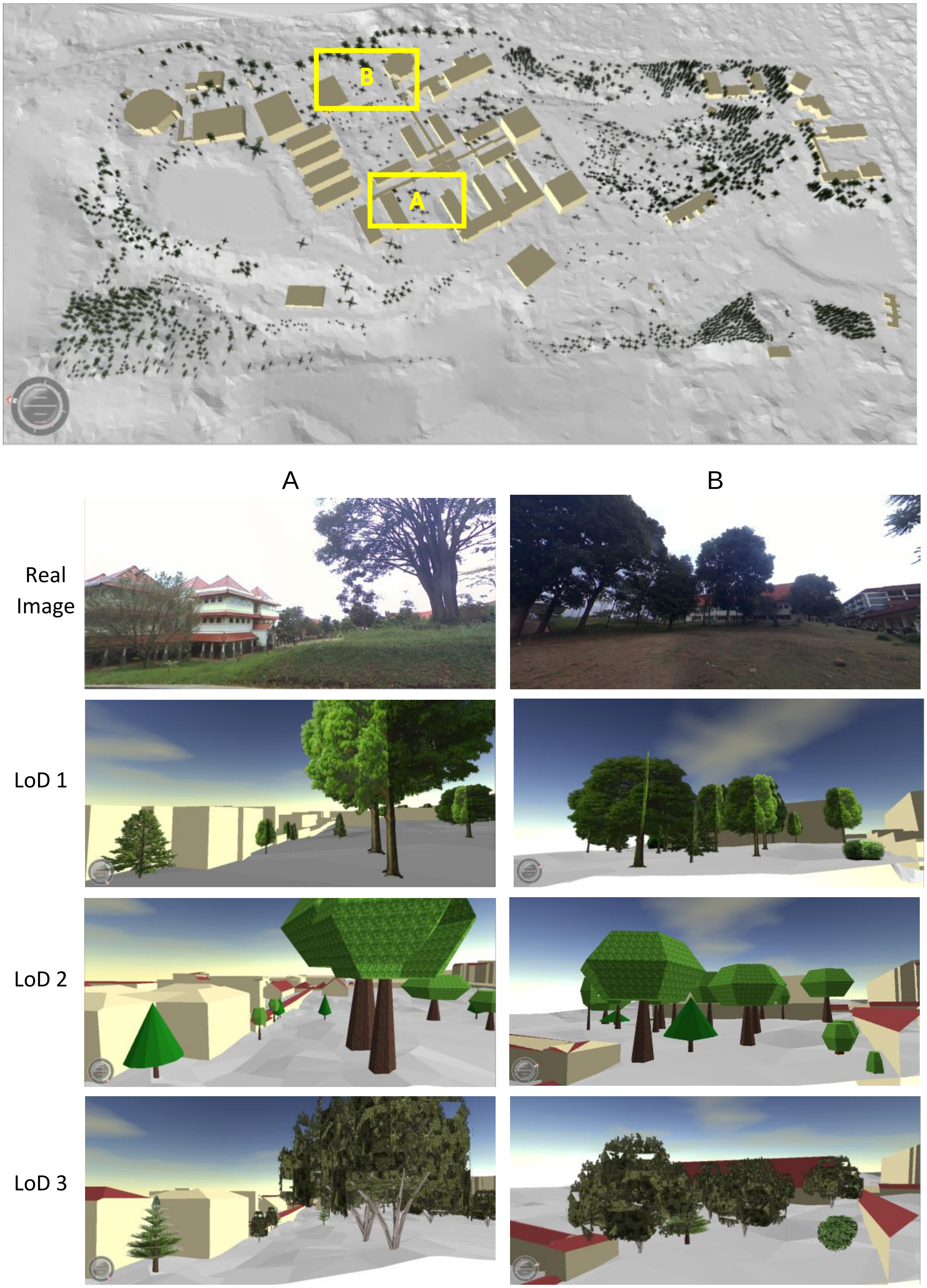


Figure 5 3D landscape model (terrain, building, and vegetation) of ITB-Jatinangor Campus

From the modeling result, visualization in LoD 3 is more informative and more interesting than the lower level. But the data size is bigger than lower level, because the model have more polygons. The selection of LOD depends on the needs of its users. The form of some vegetation models didn't close to the real object because the tree species were only classified manually using orthophoto.

4. Conclusion

Vegetation modeling is an important thing in 3D city modeling. The used data are orthophoto and Digital Surface Model (DSM), generated by survey and mapping using UAV-Photogrammetry technology. Tree position, tree height, crown diameter, and tree species were obtained from orthophoto and DSM. Objects of 3D city model can be stored in CityGML data model, and can be visualized in some level of details according the user's needs. Tree species of vegetation's model can be closer to the real object using terrestrial data. Integrating and modeling data into 3D city model becomes an interesting challenge for advance research, especially for automation process.

5. References

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