GIS-based Smart Campus System using 3D Modeling

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Abstract

To represent the three dimensional world around us, it is relevant to carry out 3D modeling and use 3D environment while portraying the Geographical data (geodata). Geographical data can be represented both in 2.5D and 3D environment. Geographic Information Systems (GIS) combined with 3D visualization technology is an emerging tool for urban planning and landscape design applications. This tool handles spatial and attributes information of 2D as well as 3D objects through which 3D navigating and querying is possible. It has become an essential tool since its purpose is to extract the relevant information in the available data, thus helping it in Exploring, Analyzing and Designing process.

This paper is the part of a proposed project that has been named "IITB Smart Campus GIS Grid" or Smart Campus in short. The main purpose of Smart Campus will be to offer a platform to build state-of-art geo-spatial technology based applications for monitoring, managing and planning of the resources as well as the environment. This paper outlines why 3D GIS technologies are a key factor in establishing and maintaining large-scale, reality-based 3D geoinformation services. In this paper, we present the photo-realistic outdoor and basic indoor modeling results obtained using available software such as Google SketchUp, AutoCAD. The 3D models are also converted into KML (Keyhole Markup Language) and CityGML (Geography Markup Language).

The new developments in the GIS technology include the storage, processing and visualization of 3D geodata. The applications now need to represent complex 3D objects in GIS environment. Much of earlier work in this area has relied on multi-polygon representation for visualization of complex geometry. However, as long as a multi-polygon uses a 2.5D-approach there will always be certain limitations in representing complex objects. It is possible to use and store 3D geodata, using standards of the Open Geospatial Consortium (OGC) and CityGML.

CityGML is an XML (Extensive Markup Language) based format for the storage and exchange of 3D urban models through a file or served through WFS (Web Feature Service). It provides possibilities to store semantic and geometric information and has the potential to incorporate topological models. However, it is still in testing stages to create a 3D urban

model according to theoretical schema of CityGML. In this paper, we briefly review these standards and demonstrate their using in the SmartGrid application.

1. Introduction

IITB has over-500 acre campus where more than 10,000 people live and work. The campus has a rich geography (natural, man-made) with continuous changes and newer investments happening in building/extending the infrastructure. "IITB Smart Campus GIS Grid" or Smart Campus in short will offer a platform to build state-of-art geo-spatial technology based applications for managing, planning and monitoring the resources, the environment and serving the community. The platform will integrate demands and responses from environment, community, administrators and planners by employing GIS based computing platforms. Smart Campus will become a model solution for communities, campuses, and cities for GIS-based operations management and planning.

Initially, Smart Campus will focus on creating a base by making 3D Model making and integrating different feature layers of the campus. It will have the ability to store information and useful for decision making process and will deal with variety of static and dynamic data related to nature, environment, resources, population and plans. As Smart Campus rolls out, the vision will be fine-tuned and can also be extended / modified accordingly.

This paper mainly focuses on the need for 3D representation in GIS mainly for 3D parcels. The main components of 3D GIS are: 3D Visualization and 3D Modeling and Data Management. 3D GIS include **3D urban modeling** which can be defined as Cityscape modeling, Terrain-visualization, Virtual reality (VR) and analysis of complex spatial data of the surrounding of a city area. A 3D GIS system should be scalable with multiple representations so that a user can really interact with the 3D Objects. 3D Visualization is success keys to plan and design the future. The presentation of 3D GIS should be focused on reality-based geospatial objects.

The main benefit of 3D GIS is that it deals with space and infrastructure management, event management, energy and resource management (including such as water), campus security, movement tracking, just to name a few.

2. Scope and Objectives

The main objective of this paper is to present the current status, of using 3D GIS to model, visualize and analyze geo data. It describes how free software like Google SketchUp and standard like CityGML can be used to represent IITB campus data in a 3D environment making it a Smart Campus. This paper tries to answer following questions:

• How can 3D urban objects be modeled in a Google SketchUp?

• Which object representation methods have been suggested for representing 3D parcels?

The following are the main functions and benefit of 3 D Modelling:

➢ Monitoring of in-building, in-office and in-home infrastructure and its integration into the Smart Grid to achieve monitoring, administration, planning
➢ Geo-spatial Information architecture for modeling and integration of various kinds of Spatio-temporal data.
➢ The process of visualizing geodata in distributed environments can be generalized through the model of the OGC.

3D GIS includes 3D Modeling exploring through 3D Navigation and Querying since its purpose is to extract the relevant information in the available data. Following flow chart will explain the work flow of 3D GIS and principal objectives of 3D Modeling.
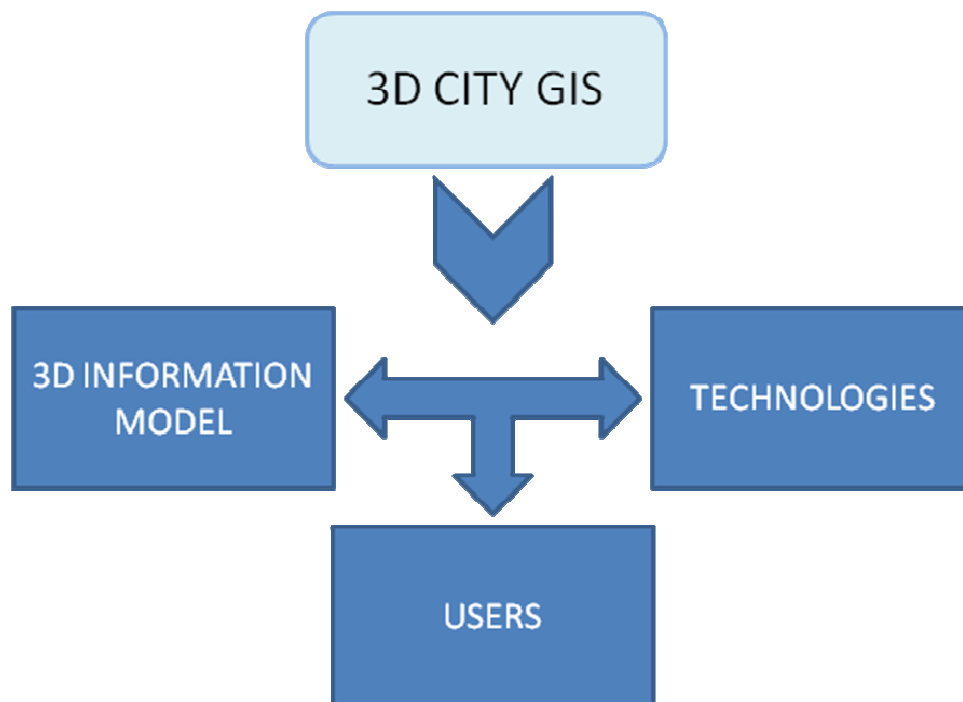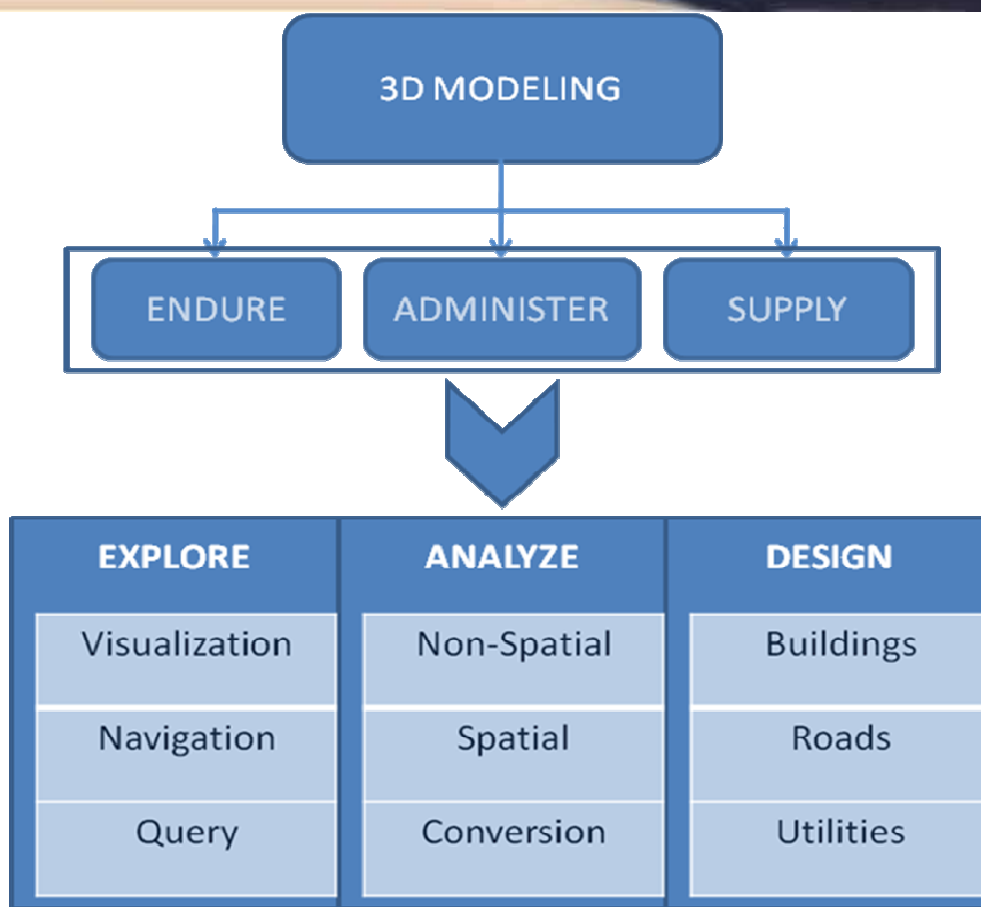

Fig. 1: Work-flow of 3D GIS

Fig. 2: Work-flow of 3D Modeling

3. Approach and Tools for 3D Modeling

In the paper a semi-automatic approach is taken to develop a 3D GIS environment. It has been done using various tools and spatial data formats. Some of them are mentioned below:

GOOGLE EARTH: 3D interactive earth browser

It is a virtual globe program that shows the earth by the superimposing and mosaicing the images obtained from satellite imagery, over a 3D globe. Google Earth is able to show all kinds of images overlaid on the surface of the earth and is also a Web Map Service client.

GOOGLE SKETCHUP: 3D modeling tool

Google SketchUp is a 3D modeling program designed for architects, civil engineers, GIS, and related professions which is highly compatible and user friendly. It is available with Shape files plug-in for importing the Shape files into SketchUp; lot of project work is done using SketchUp software. It has the ability to make Geo-referenced models which can be seen directly on Google Earth. SketchUp can be a great tool for any urban simulation and visualization work. It has functionality of modeling, editing, texturing, and creating walkthroughs of the scene created thus making it a very useful tool for planning professionals. Models created in SketchUp can be exported to AutoCAD and other CAD programs, 3Dstudio format (.3ds), Collada (.dae), KML (Keyhole Markup Language)/KMZ, VRML(.wrl),etc. SketchUp can also export 2D images (JPG, TIFF, etc.).

What is Google Earth Modeling?

Google Earth and Google SketchUp are compatible with each other helping us to build and visualize our 3D world. SketchUp can import Google Earth snapshot of the study area where modeling is to be done and can be used to make geo-located features by using integrated tools for uploading GIS content to Google Earth and to the Google 3D Warehouse, a repository of models created in SketchUp.

Keyhole Markup Language (KML):

Keyhole Markup Language (KML) is an XML-based language provided by Google for defining the graphic display of spatial data in applications such as Google Earth and Google Maps. KML enables these applications to support the open integration of custom data layers from many GIS users. KML files have either a .kml file extension or a .kmz file extension (for compressed and zipped KML files). KML can be used to:

- ➢ Symbolize and display GIS data as elements within Google Earth and Google Maps using symbols, color, images and information tags.
- ➢ Stores attribute information about geographic features.
- ➢ Define the user's interaction with those features -- for example, to control fly-to and camera location settings in Google Earth.

Geography Markup Language (GML):

CityGML: CityGML is a common information model for the representation of 3D urban objects. It defines the classes and relations for the most relevant topographic objects and regional models with respect to their geometrical, topological and semantical properties. The thematic information of CityGML goes beyond graphic exchange formats and allows developing virtual 3D city models for sophisticated analysis. This can be used in different

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application domains like simulations, urban data mining, facility management, and thematic inquiries.

CityGML is realized as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema for the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC211. CityGML is intended to become an open standard and therefore can be used free of charge.

CityGML defines five levels of detail numerated from zero to four :- (Fig 2)

LOD 0:- 2.5 D digital terrain model
LOD 1:- Block model comprising buildings structure (Height Data)
LOD 2:- Differentiated roof structures and textures.
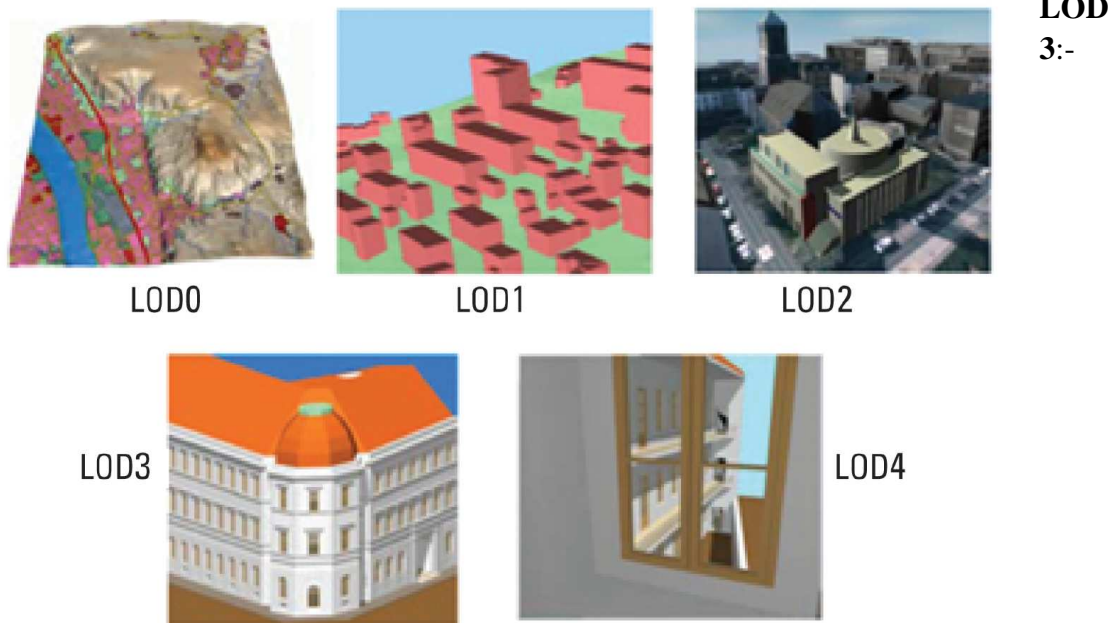
LOD 3:-

Architectural models with detailed wall and roof structures, detailed vegetation and transportation objects.
LOD 4:- LOD3 model + adding interior structures for 3D objects. For example, buildings are composed of rooms, interior doors, stairs, and furniture.

Fig. 3: The five levels of detail (LOD) defined by CityGML (source: IGG Uni Bonn)

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4. Methodology

Initially 3D buildings are created using Google SketchUp and are converted to GML format using SketchUp CityGML plugin. There are two approaches of creating a 3D environment in Google SketchUp. (fig. 3 - 5)

1. Convert the Shapefiles (Feature layers) into different KML format layers by using Shape to KML tool, and then import it into Google SketchUp or directly view on Google Earth viewer.2. Import the CAD files of the feature layers directly into Google SketchUp and model it by giving extrusion with accurate height information.

The process includes modeling of the buildings using various tools in SketchUp by modifying their architecture and giving them textures from the images of the features. Various other urban objects like Roads, Landscapes, bridges, railways etc. can be modeled in same way.
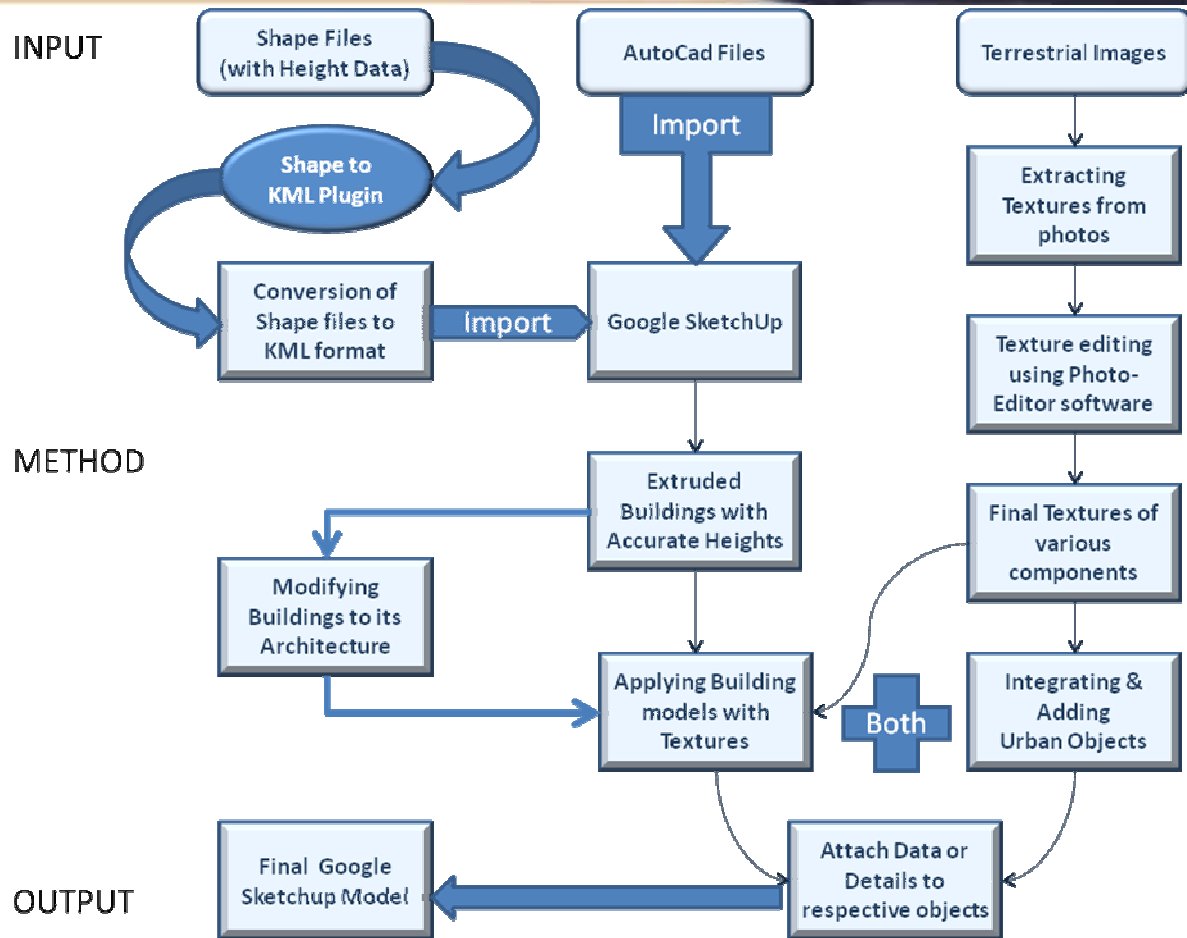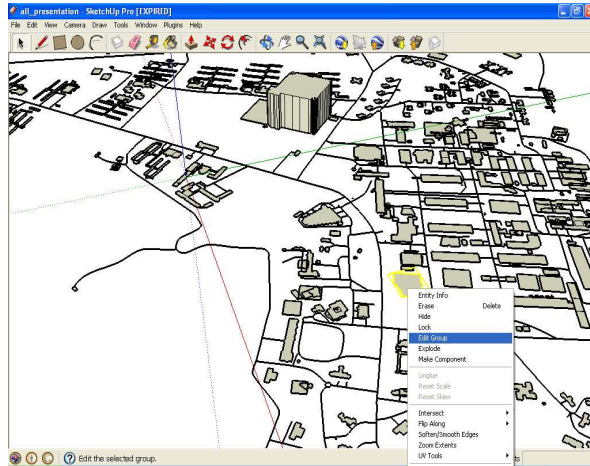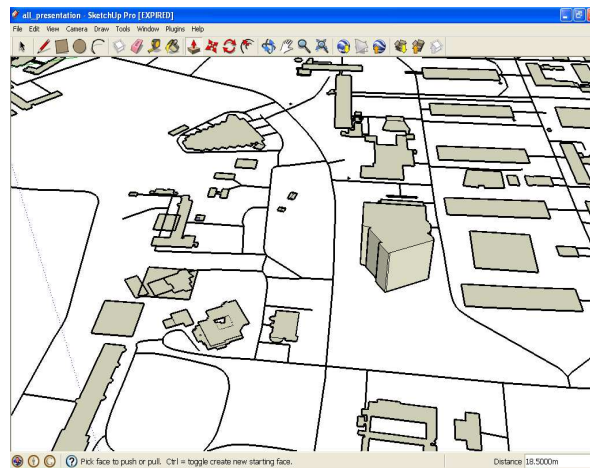
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INPUT

Shape Files
(with Height Data)

AutoCad Files

Terrestrial Images

Shape to
KML Plugin

Import

Extracting
Textures from
photos

Conversion of
Shape files to
KML format

Import

Google SketchUp

Texture editing
using Photo-
Editor software

METHOD

Extruded
Buildings with
Accurate Heights

Final Textures of
various
components

Modifying
Buildings to its
Architecture

Applying Building
models with
Textures

Both

Integrating &
Adding
Urban Objects

OUTPUT

Final Google
Sketchup Model

Attach Data or
Details to
respective objects

Fig. 4: Workflow explaining the whole process from conversion of Shapefiles into final 3Dmodel.

Fig. 5: Editing Google information   the building layer in SketchUp by adding and height data

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Conversion of SketchUp Model into Markup Language Formats
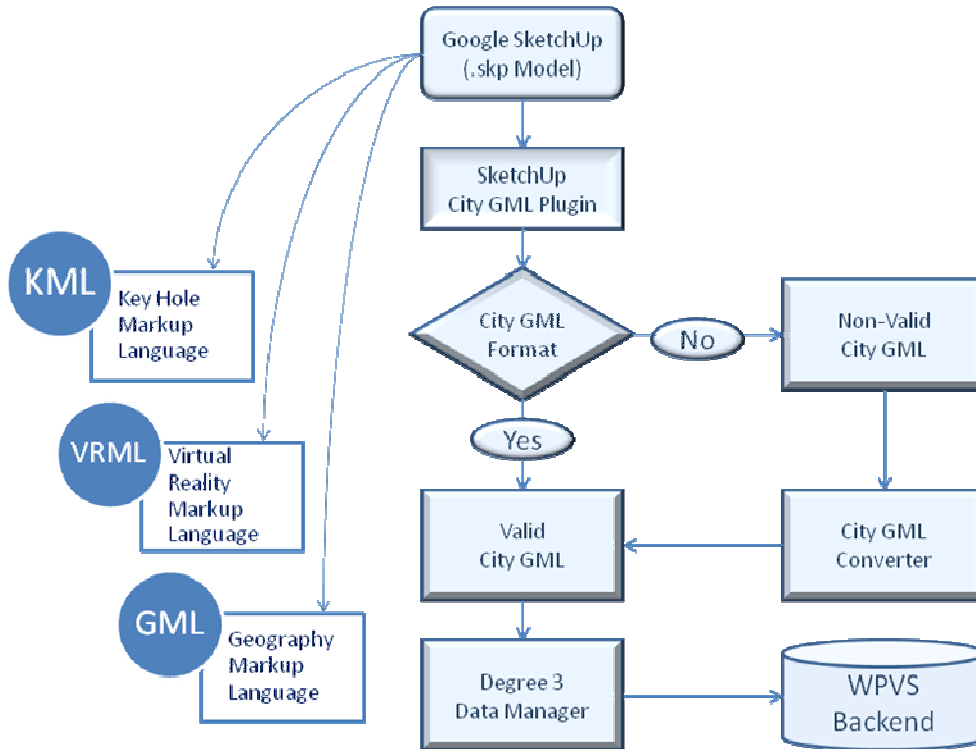

Fig. 6: Process of converting a 3D model into Valid CityGML format supported by Degree 3 Data Manager.

5. Results

The following screen shots show the different stages of IITB Data in the process for the development of 3D environment. The Fig. 6 shows the overall 3D model of IITB with different colors according to the building use. As shown in Fig. 6,7and 8; 3D model of KRESIT building is taken as an example to show different level of details (LoD) of a particular building.
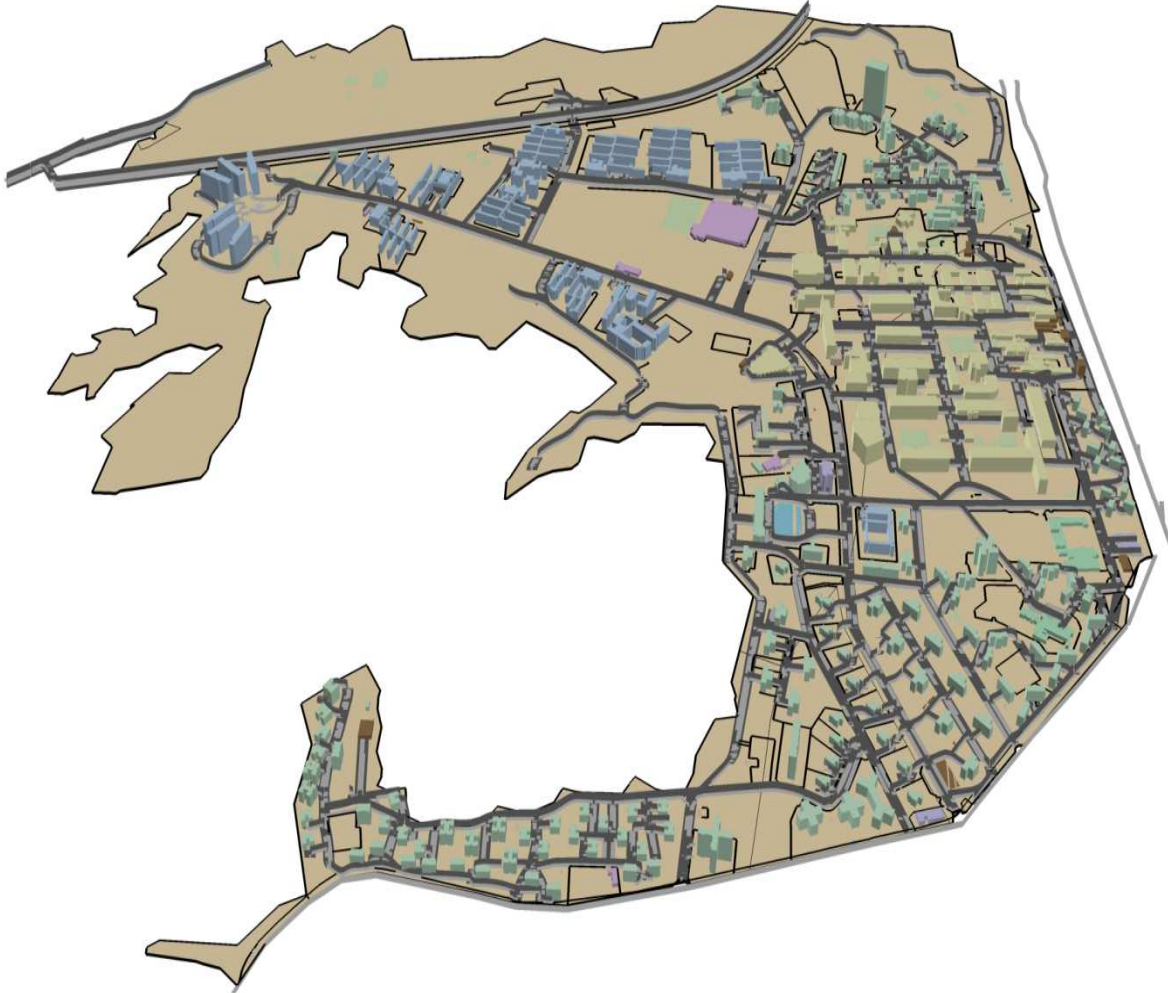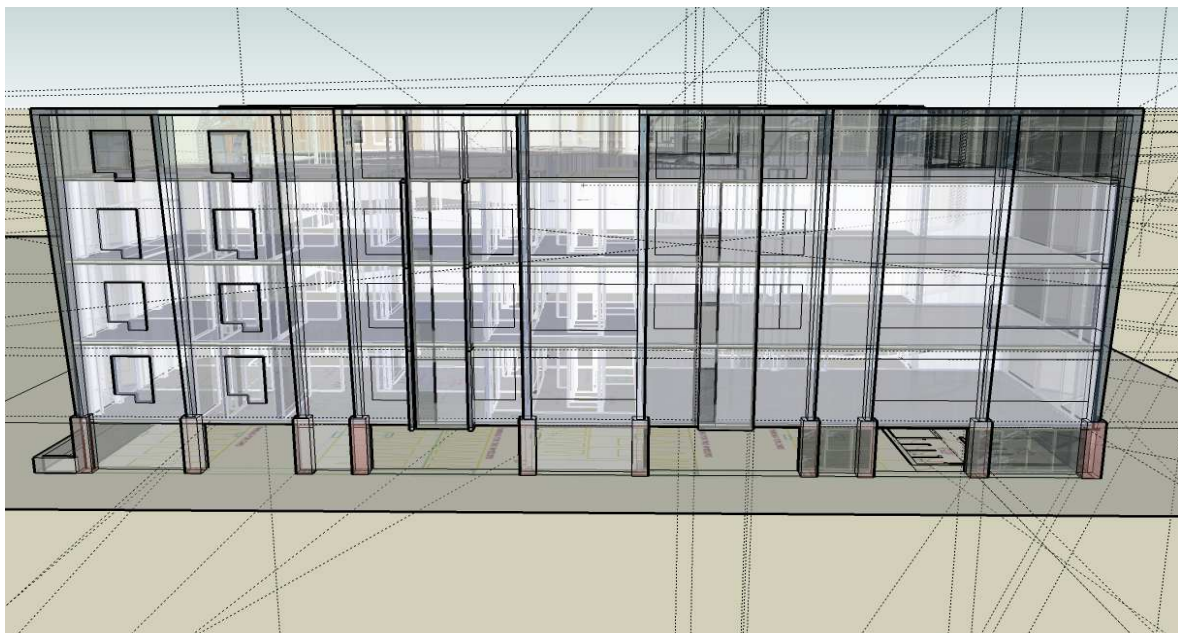
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Fig.7: LoD1 building data set of the IITB Campus(Overall 3D model of IIT Bombay)

Fig.8: LoD2 model of the KRESIT Building, created and visualized in Google SketchUp.
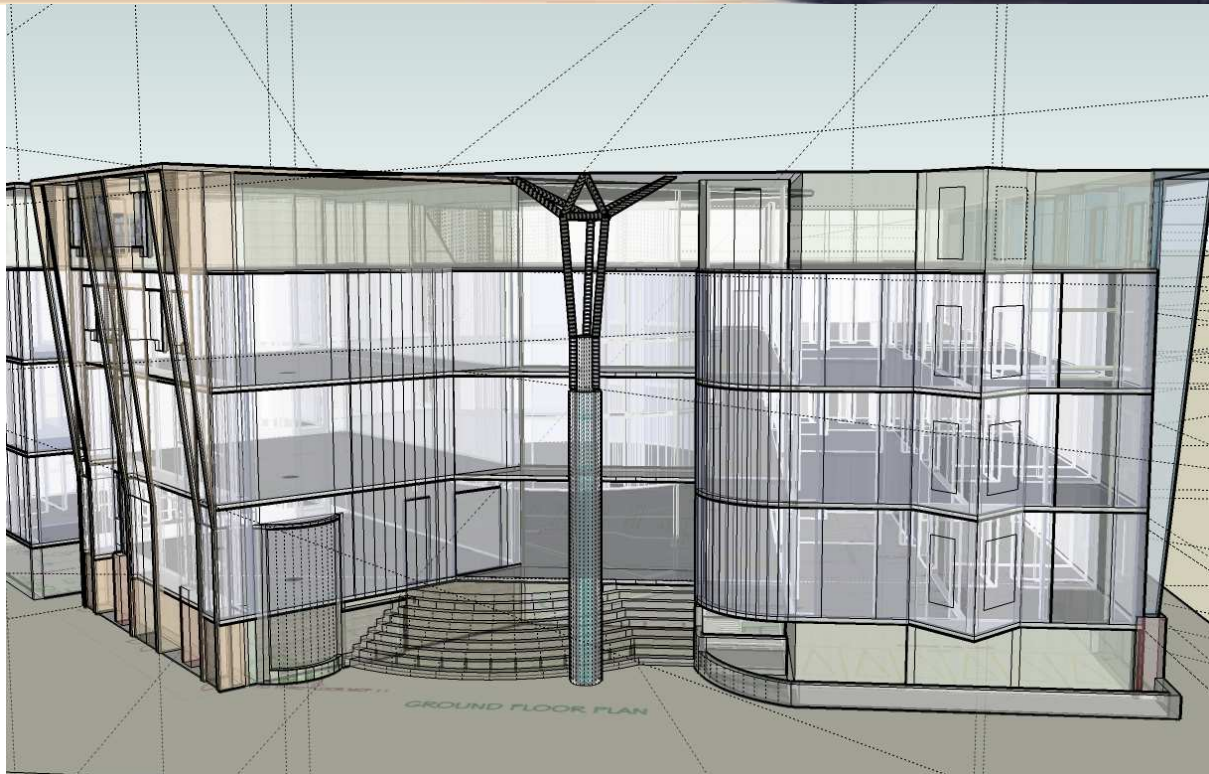
Fig.9: LoD3 and LoD4 model of the KRESIT building visualized in Google Sketchup.

6. Further Work

Main benefits of making a 3D information system are:

- Urban Planning and Economic Development

- Infrastructure Management and Monitoring

- Risk assessment system

- Public Safety and Security

- Virtual Navigation System

The further work for the next phase of the Smart Campus undertaken by us is to develop a Building Indoor Navigation System. It will help us in planning building layout and utilization planning for effective evacuation in situation of fire and other dangers.

The system will be an evacuation simulator to help make certain decisions regarding building layout and fire protection system. Given building occupation details and exit points, the simulator will plan various evacuation strategies, paths and schedules. It will includes an

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integrated user interface and 3D results visualization which will allows us to evaluate the evacuation models more quickly by producing graphs showing collection of vertices or 'nodes' (a room or a lab) and a collection of edges that connect pairs of vertices (corridors, stair cases etc.).

The proposed 3D GIS data model can be integrated with current GIS functions for storing and retrieving spatial data in 2D, and for implementing 3D spatial queries using new spatial indexing methods and building a Node Network.

The system will work on Shortest Path Algorithm. Optimal path searching algorithms can be applied to the network problems in 3-D space.

7. Conclusions

The Smart Campus concept can be useful in providing an information enabled infrastructure for IIT Bombay.

A semi-automatic approach for creating 3D building information can be done using Google SketchUp. It is feasible to develop Geo Reference Model (GRM) in line with Google Earth using SketchUp. Visualization on the location will have many advantages. Because of these reasons Google Earth modeling has gained much importance in GIS field.

In this paper it was shown, that it is possible to setup an open standards based application for internet based distribution and visualization of 3D geodata.

There is a lack of certainty for 3D urban modeling and storing the related information in GIS system. It can be very functional to use a defined standard for displaying and storing 3D geodata. CityGML format defined by OGC can bridge the gap for exchange and re-usage of 3D geodata. CityGML is a means to share the information contents of virtual 3D models. It is emerging as a model for defining the structures for organizing urban information.

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