Exploitation of a City Information Model : conception of a VR-immersive visit from 3D model at the scale of a district and extraction of road network, parcels and buildings basic elements from IFC files

Lab: COSYS-GRETTIA (with ESIEE-LIGM)

Project: ISite Future/Eiffage E3S

International Partners: University La Laguna, Tenerife (Jorge Martin Gutierrez)

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Context

E3S[1] program is a partnership between University Gustave Eiffel and Eiffage made of 8 research projects on urban innovation. E3S stands for Eco-district Smart, Sure, Sustainable: the project uses the opportunity of a large construction project called LaVallée recently started in Paris's suburb. Its spatial extent is about 500 m x 400 m, part of a larger city called Châtenay-Malabry. The whole district is to be delivered in 2024. We are in the first phase of the project with the first roads being built and the first inhabitants expected by the end of 2021. The figure below illustrates the virtual future look of LaVallée district.

3D digital twin of LaVallée (its CIM): assembling of buildings and roads with BIM360 (Credits : *Atelier M3, Arcadis, SEMOP Châtenay-Malabry - Parc Centrale)*

In its design, the LaVallée district is physically open to the outside and will offer services that will be of interest to other residents or users of the surrounding area. To know the effect of this opening on a potential transit of visitors in the district, as well as the places of interest for the inhabitants, it is necessary to predict the flows of micro-trips within the district in a project situation (ie the eco-district once built).

The work carried out at GRETTIA lab addresses dynamic traffic modeling (road, public transport and active modes) based on travel demand and infrastructure supply. The travel supply is made of the road network and facilities location. We build daily activity planning for a set of agents (a synthetic population), and

[1] https://www.programme-e3s.com/en/the-programme/

calculate the temporal evolution of planned trips, that is to say the predicted path of people during a typical day as well as their mode of travel.

Research and development mission of the internship

This internship is part of the workshop 8 of E3S: the objective of action 8.1 is to develop methods able to model and predict the potential visitation of the various equipments and public spaces of the district, from which to infer indication of the quality and vitality of public spaces (ie the future hotspots of the district).

Left : Map of the road network (car/walker/bicycle) with parcels and building. Right : activities locations (Home, Work, Leisure, Shopping, Education, Restaurant and Kindergarten) with their access nodes and links to the network.

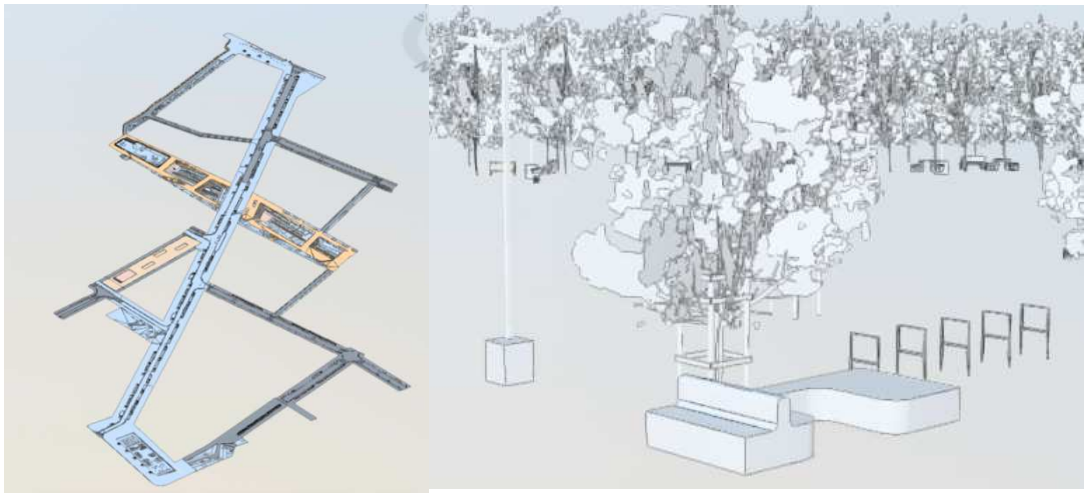
In order to be able to estimate the validity of the results in a project situation, we want to:

- **Visualize details of the future district in 3D in an immersive tour with virtual reality glasses (HTC Vive).**
- **Develop tools to automatically extract basic elements from the high precision CIM of the project**

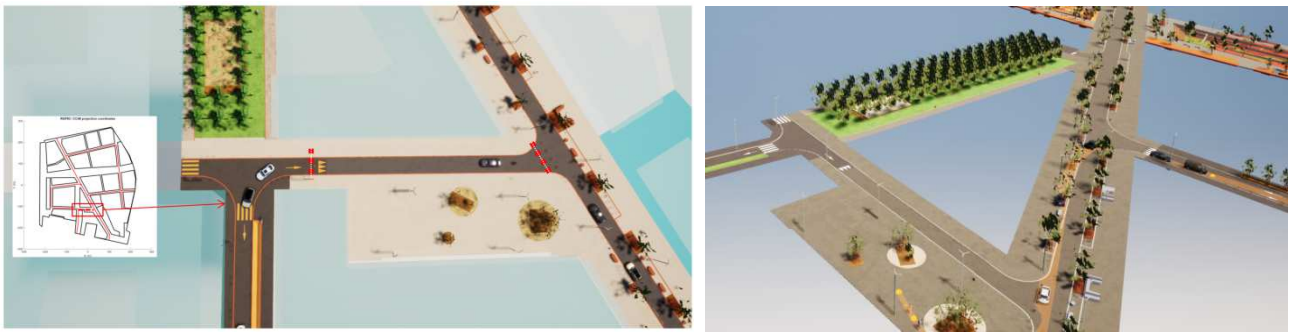
As part of the E3S project, we have access to the CIM of LaVallée (all the BIMs of the works to be carried out including road, gas, water networks, street furnitures, fontains and landscaping). LaVallée's BIM360 document contains 3D models of planned buildings, in IFC format. Revit can convert this format to FBX format exportable to TwinMotion. This format can be used by virtual reality glasses such as Oculus Rift or HTC Vive. The first task of the intern will be to collect, assemble and color the available BIM objects into a 3D digital twin and design a walk through visit. The intern will have to sign a specific non disclosure agreement to be granted access to the BIM360 of LaVallée. This part of the project requires some architectural research and creativity since the choice of visualization in BIM360 were somehow arbitrary. BIM360 also have some capabilities that will be used to read properties of object and have a first insight of what the IFC files contains such as materials, dimensions and other features related to a building or a road. Technically it requires knowing how to use Revit to convert IFC files to FBX objects, and TwinMotion for the artwork and registering buildings, road networks and landscapes. A larger problem is the optimization of the 3D models as the VR display suffer from a slow video signal communication due to the heavy size of a CIM (several Gigabit) with a very high level of detail.

It will also be the opportunity to participate in the building of a CIM which is not just a collection of BIMs from various partners and architecture firms, but also the integration of process and data important to decision makers, at the scale of a district.

Examples of BIM of buildings. Credits: *Atelier M3, Urbanita Architecture, Arcadis, SEMOP Châtenay-Malabry - Parc Centrale*

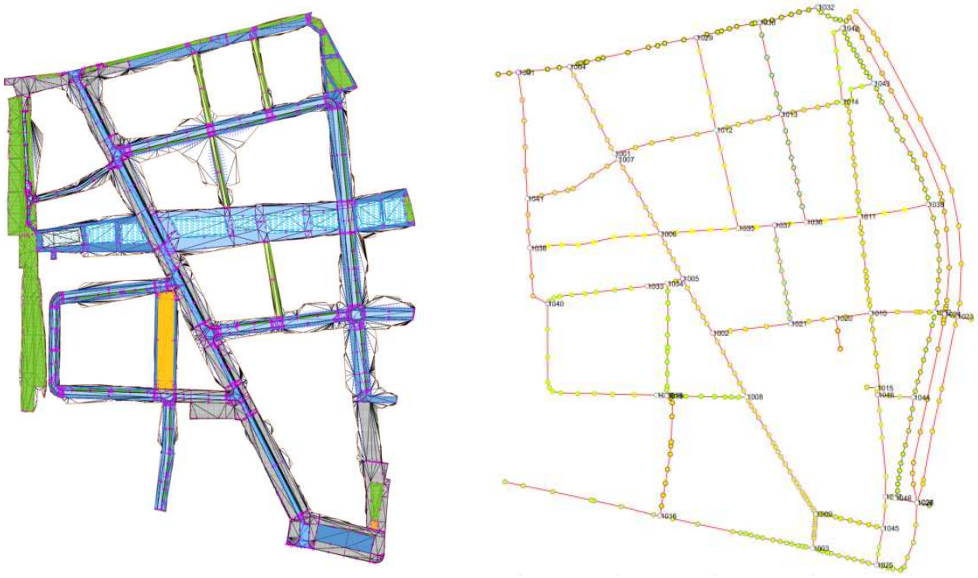


Road network (phase 1) and landscape : urban furnitures et vegetations. Credits: *OTCI, Base, Arcadis, SEMOP*



Road and landscape BIMs displayed and colored with TwinMotion

A second objective of this internship is to build tools to automatically extract some primitive information from the CIM. The Level Of Detail in LaVallée BIMs objects is LOD=5 (or LOD500 in US) which is a very high accuracy. In our work a LOD=1 or LOD=2 is required, which means a low resolution version of the BIMs : nodes, links for roads, and polygons for buildings. Surprisingly enough, there is no tool to do that without the intervention of a manual operator. For instance, below is a view of the road BIM : a very detailed 3D model made of a mesh of triangles whereas what transportation model require is a wire model (nodes+links). A similar problem occurs with buildings : a lot of applications only requires rough 2.5 models (ie 2D footprint+height), such as CFD for wind flow simulation or thermic analysis, sky vew factor SVF calculation etc. We believe that operation could be done by parsing the IFC files to extract some features such as slabs, floors, roofs and postprocessing them: the intern will use Matlab for this task, with an application to SVF calculation.



Road BIM versus road wire network (nodes, links and intersection)

Building KML polygons drawn as 2.5models from footprint plan, displayed with Google Earth Pro

Acquired Skills and tools

Programmation: Matlab

Visualisation 2D: Leaflet (JavaScript) to update the GIS at
http://137.121.121.18/leaflet_reseau/BuildingsReseauRoutes-v1aFermeUrbainReservee.html

Visualisation 3D: Google Earth Pro, TwinMotion

File format (polygones, polylines, points): KML, geojson, IFC

Building Information Model : BIM360, Revit, IFC

References

Work at University La Laguna:

[1] Gómez-Tone et al. The Drawing and Perception of Architectural Spaces through Immersive Virtual Reality. *Sustainability 2021*

https://sketchfab.com/johnbel/collections/rv4

Work at COSYS-GRETTIA:

[2] Delhoum, Y et al. Activity-Based Demand Modeling for a Future Urban District. *Sustainability 2020*

https://www.youtube.com/watch?v=UQB0S16a4m4

Work at ESIEE:

[3] Virtual reality room of ESIEE: https://perso.esiee.fr/~grandpit/salleRV2.html