Immersive virtual visit of a district with multimodal transportation model and panoramic street views

Lab: COSYS-GRETTIA (with ESIEE-LIGM)

Project: ISite Future/Eiffage E3S

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

Tutor: Rachid Belaroussi, rachid.belaroussi@univ-eiffel.fr Thierry Grandpierre thierry.grandpierre@esiee.fr

Filière: Informatique

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 2022. The figure below illustrates the virtual future look of LaVallée district.

3D model of LaVallée Phase I (© *SEMOP Châtenay-Malabry - Parc Centrale) used for research studies on architectural ambiances at large scale. The goal of the internship is to update the 3D model with the additional buildings of Phase II and integrate the motion of people calculated by a multimodal transportation simulation.*

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

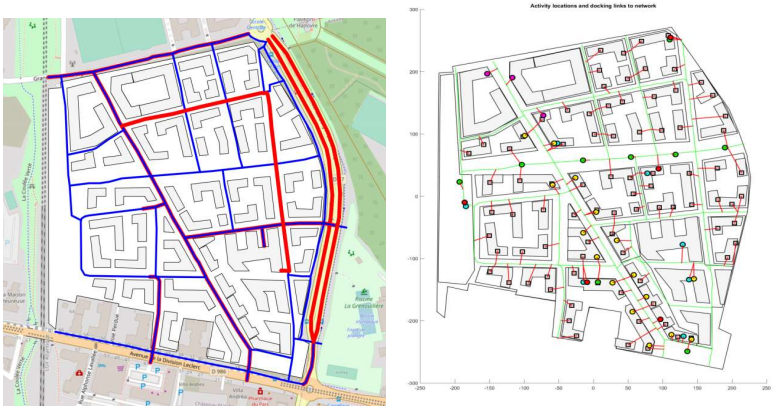
[1] https://www.programme-e3s.com/en/the-programme/

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 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 using an activity based model called MATSIM.

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.

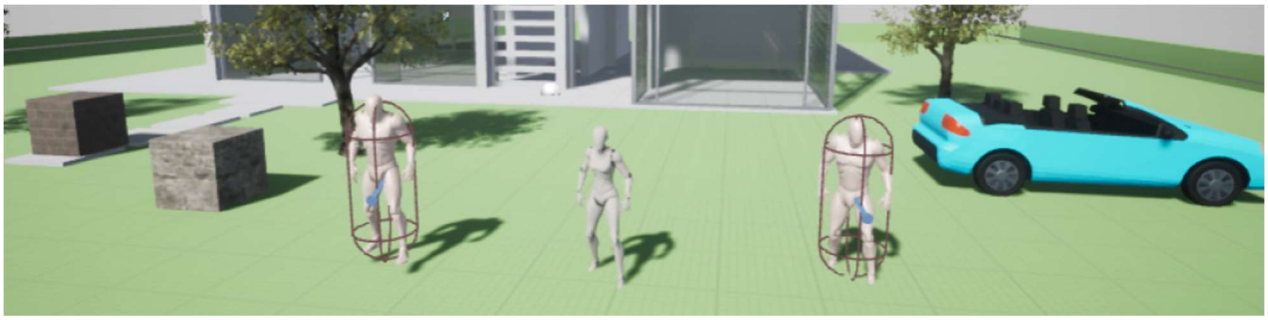
In order to be able to estimate the validity of the results in a project situation, we want to:

- **Visualize details of the future district in 3D in an immersive tour with virtual reality glasses**
- **Export into Unreal Engine the multimodal agent travels simulated with MATSIM**
- **Add panoramic views to the UE scene (StreetView functionality) for the buildings already built**

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 to enhance the texture of buildings 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. Modification of textures, foliages, illumination choices will be coded through Python script so that they can automatically applied on new buildings and landscape data produced by the architect and partners of Eiffage.

Technically it requires to use Revit to export IFC files to TwinMotion with DataSmith, then onto Unreal Engine. TwinMotion is used as a canvas for the artwork and registering buildings, road networks and landscapes. Unreal Engine is used to insert the motion of people (pedestrian, bicycle, cars) into the 3D scene through Python scripting.

One focus of the internship will be in parsing the events file output by MATSIM and translate them into movement of people in the 3D scene. It implies acquiring the knowledge of developing UE assets such as 3D models of cars, humans, cyclists and their behavior.



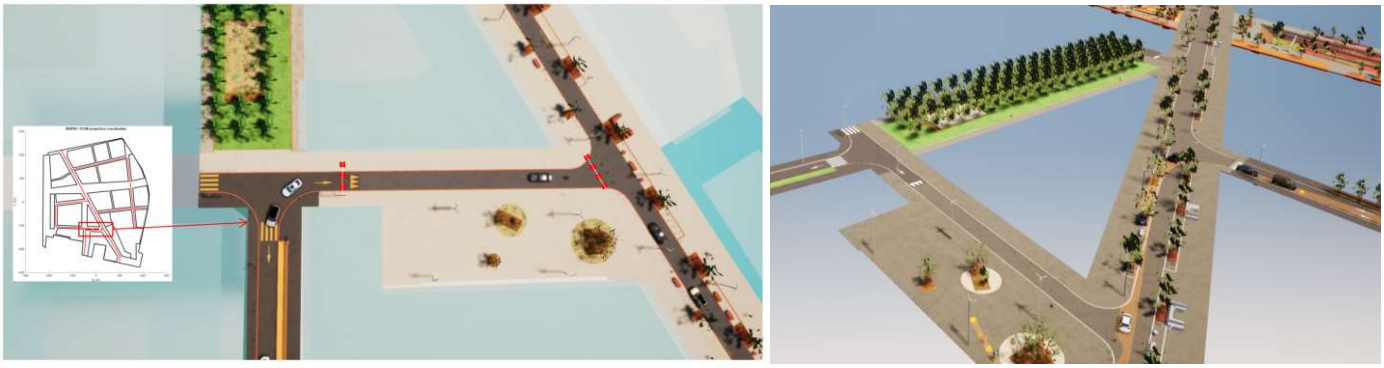
A second focus will be the integration of panoramic views of the real district acquired on the buildings of Phase I that are already built in LaVallée. Part of the internship may be dedicated to a field work to acquire these pictures or update them on-site in Châtenay-Malabry. We will use the Insta 360 pro (8k) camera:

https://www.insta360.com/fr/product/insta360-pro. The panoramic images showing the reality of the real estate will have to be integrated to the virtual visit in the graphical engine. This step is necessary to prepare a study comparing virtual reality sensation to real experience of the environment.

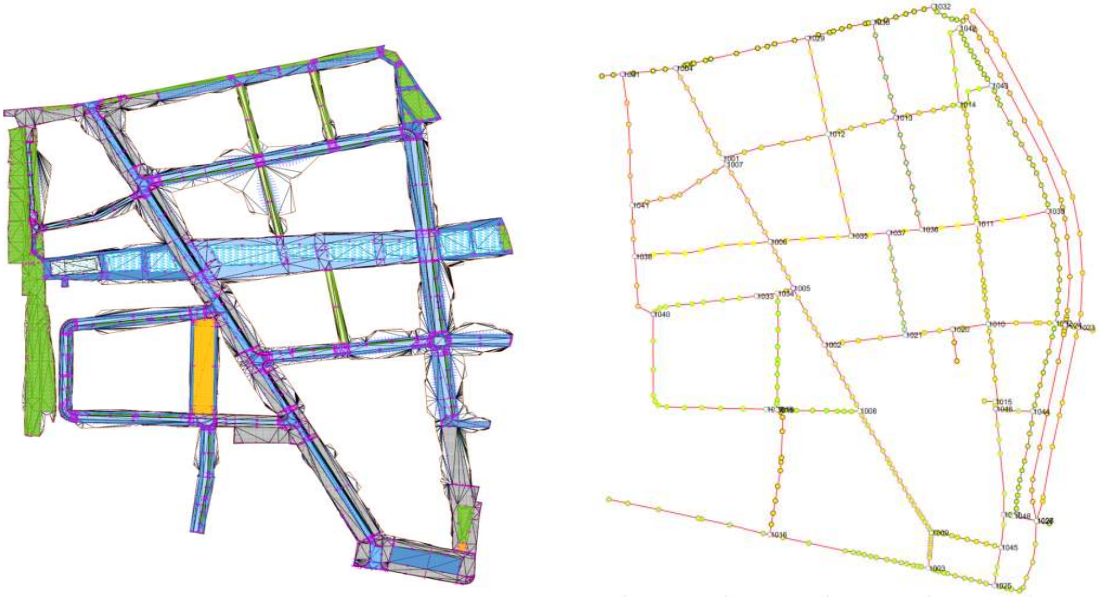
A large part of the district has already been built by 4E student Huiying Dai during her Tremplin project in 2022: the mission of the intern is to update the district with the new buildings coming from Eiffage. An underlying problem will therefore be the optimization of the 3D models as the VR display suffer from a slow video signal communication due to the heavy size of a CIM (several Gigabit) with a very high level of detail.

The output VR visit will be used by University de La Laguna in the work of Elena Diaz, architect and PhD student. Elena starts a PhD on the subject of architectural ambiance through immersive virtual reality. The internship at ULL will have a large experimental part with hardware glasses and will require help Elena with her experimentation on participants (mainly based on questionnaires).

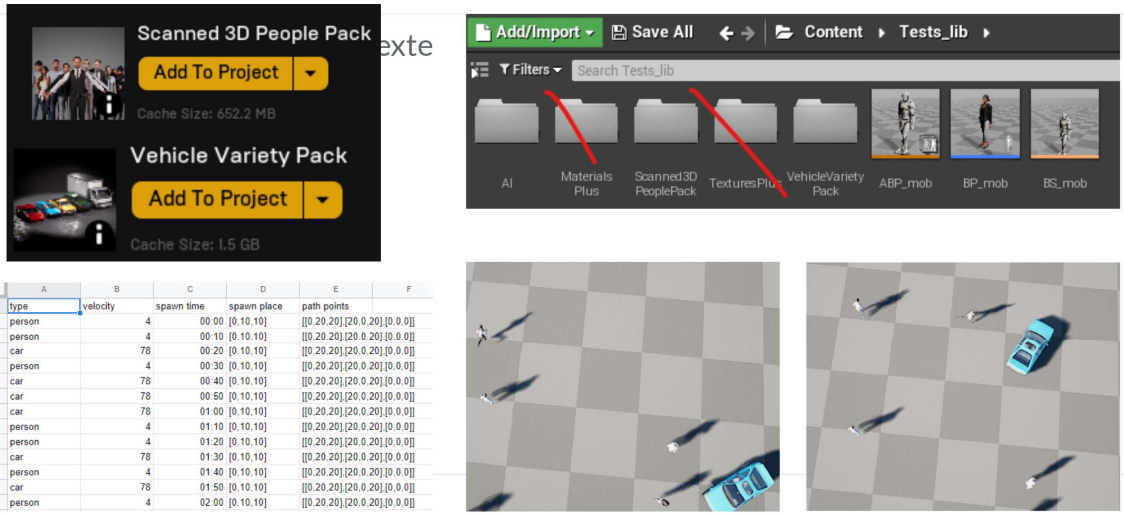
It will also be the opportunity to participate in the building of a CIM which is not just a collection of BIMs from various partners and architecture firms, but also the integration of process and data important to decision makers, at the scale of a district.



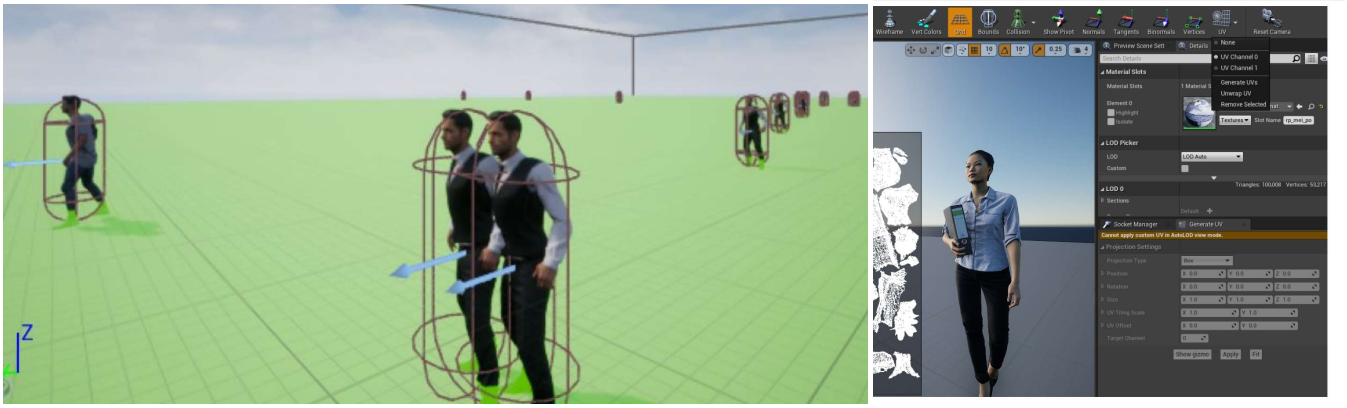
Road and landscape BIMs displayed and colored with TwinMotion



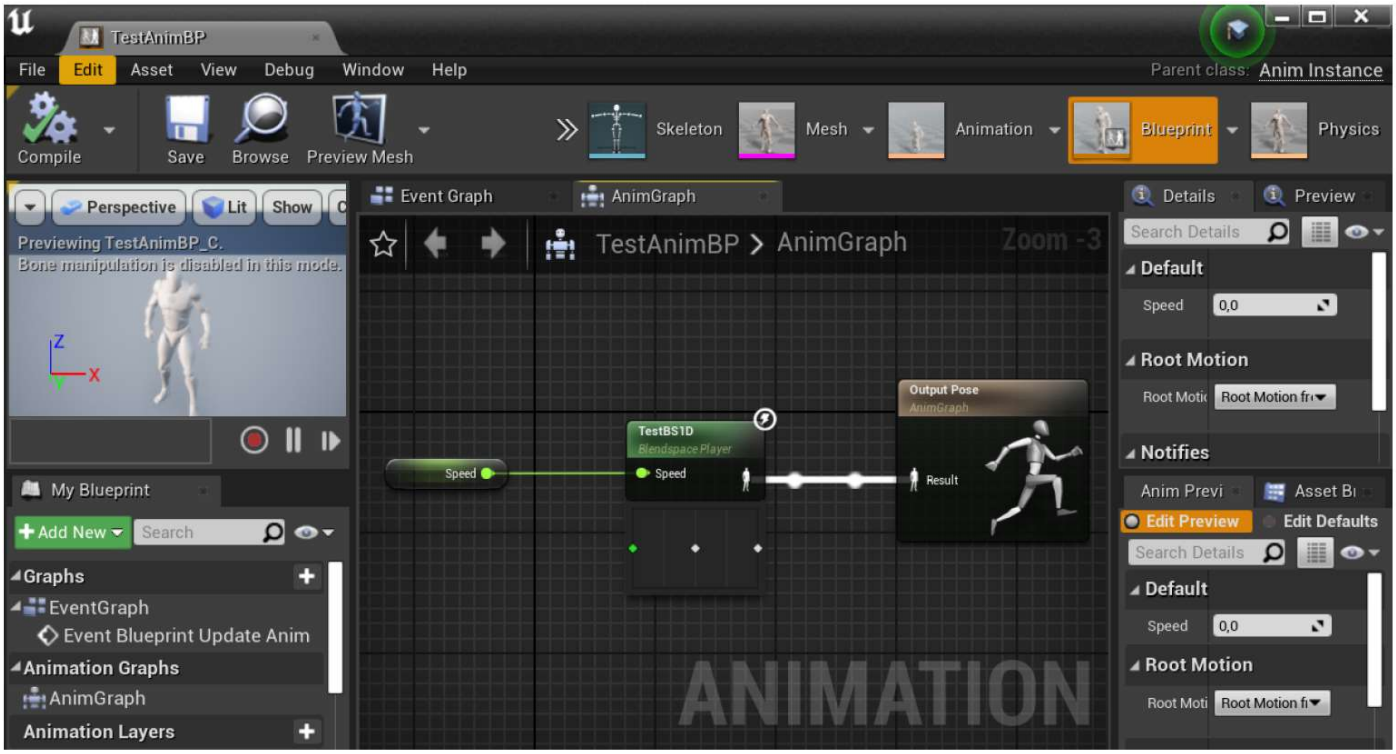
Road BIM versus road wire network (nodes, links and intersection): traveler path from MATSIM need to be imported into UE. Coordinates from the road BIM (high precision) and from the wire network (coarse) requires some registration process.



	type	velocity	spawn time	spawn place	path points
2	person	4	00:00	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
3	person	4	00:10	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
4	car	78	00:20	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
5	person	4	00:30	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
6	car	78	00:40	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
7	car	78	00:50	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
8	car	78	01:00	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
9	person	4	01:10	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
10	person	4	01:20	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
11	car	78	01:30	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
12	person	4	01:40	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
13	car	78	01:50	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]
14	person	4	02:00	[0,10,10]	[[0,20,20],[20,0,20],[0,0,0]]



Humans and cars assets in Unreal Engine



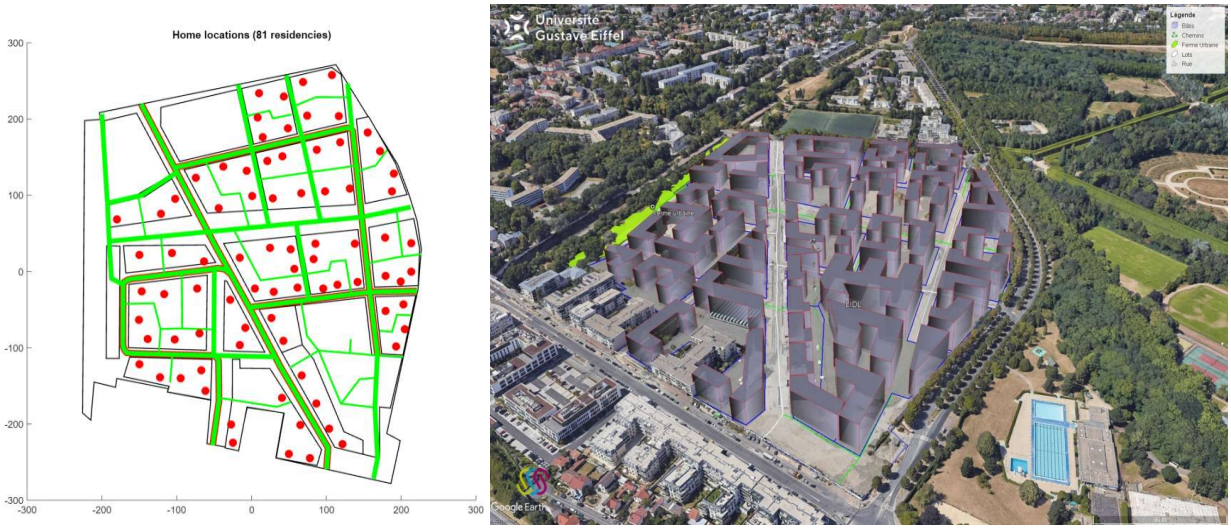
AnimGraph: Blueprint of an AI controlled Non Playing Character

Left: real building under construction. Right: 3D models with TwinMotion. One aspect of the internship is to add panoramic images of the real world to the 3D models in Unreal Engine. It will requires onsite acquisitions with a panoramic camera.

Quelques détails techniques concernant les sorties de la simulation MATSIM

Dans sa conception le quartier LaVallée est physiquement ouvert vers l'extérieur et proposera des services qui intéresseront d'autres habitants ou usagers des environs. Pour **connaître l'effet de cette ouverture sur un potentiel transit de visiteurs** dans le quartier, ainsi que **les places d'intérêt pour les habitants**, il est nécessaire de prédire les flux de micro-déplacements à l'intérieur du quartier en situation de projet (ie l'éco-quartier une fois construit).

Les travaux menés au **GRETTIA** adressent ce type de modélisation **dynamique** de trafic (routier, transport publiques et mode doux) à partir de la demande de déplacement et de l'offre en infrastructures. La demande est construite en synthétisant des populations dont le planning d'activités est estimé à partir de données d'enquête de recensement INSEE et de données de catégorie socio-professionnelle projetés des futurs habitants. L'offre est constituée du réseau routier et des données horaires de transports publiques. On en déduit l'évolution temporelle des déplacements prévus, c'est-à-dire le cheminement prédit des personnes durant une journée typique ainsi que leur mode de déplacement.



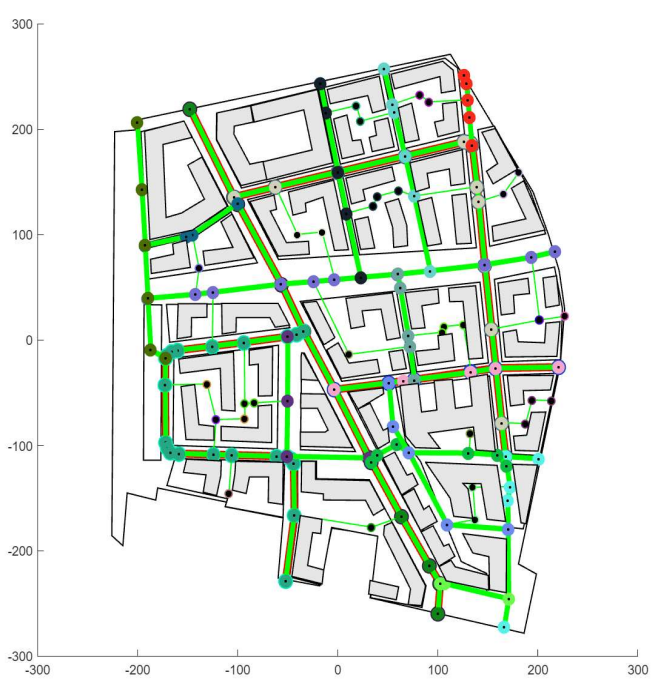
Chemins piétons et lieux de résidence des agents, ainsi que plan de masse (lots+bâtiments)

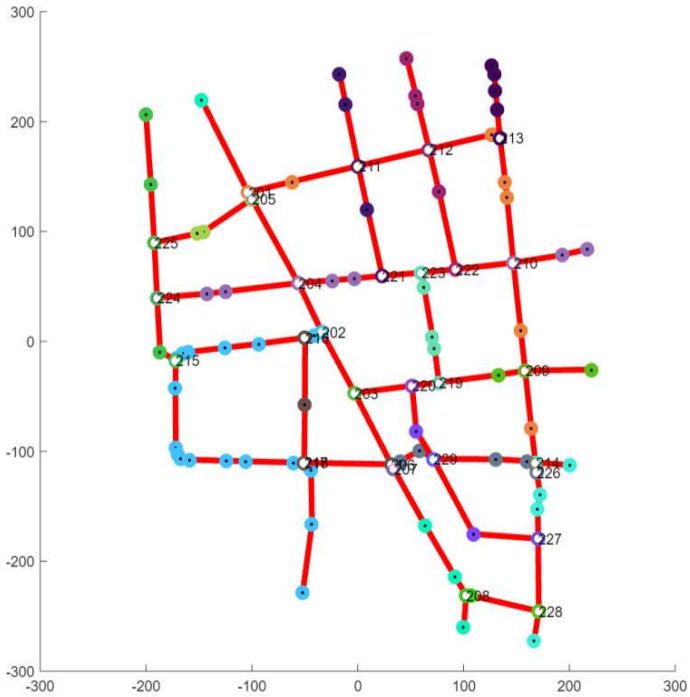
Afin de pouvoir estimer la validité des résultats en situation de projet, l'objectif du stage est multiple :

- Visualiser ces déplacements dans le temps : nécessite de parser des fichier xml (événements, facilities, network) en une structure à définir.
- Améliorer nos interfaces de visualisation de l'infrastructure (routes, bâtiments et lots).

Le réseau routier lors de la simulation des déplacements se présente sous la forme d'un fichier xml regroupant ses noeuds et arcs, leurs coordonnées dans un repère spatial (Projection RGF/CC49).

Il faudra en particulier implémenter des parsers XML exploitant ces fichiers compatibles avec l'interface Simunto Via actuellement utilisé pour la visualisation 2D des déplacements.





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<network>
    <nodes>
        <node id="1000880183" x="-413187.869341368" y="5484188.984903636" >      </node>
        <node id="1000880191" x="-413535.426413386" y="5484343.808612176" >      </node>
        <node id="1000880202" x="-413187.97015311883" y="5484182.865392386" >    </node>
    </nodes>
    <links capperiod="01:00:00" effectivecellsize="7.5" effectivelanewidth="3.75">
        <link id="1" from="252098648" to="4739794791" length="9.200755913852875"
              freespeed="13.889" capacity="3000.0" permlanes="2.0" oneway="1" modes="car" >
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            </attributes>
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                <attribute name="type" class="java.lang.String" >residential</attribute>
            </attributes>
        </link>
    </links>
</network>
```

Réseau routier filaire au format xml

Le fichier event est un fichier xml contenant pour chaque mobile (personne/véhicule) les instants d'entrée et de sortie sur chaque arc emprunté durant la journée.

```
<events version="1.0">
    <event time="47191.0" type="VehicleArrivesAtFacility" vehicle="320_bus_4" facility="244885198" delay="-69.0" />
    <event time="47191.0" type="VehicleDepartsAtFacility" vehicle="320_bus_4" facility="244885198" delay="-89.0" />
    <event time="47192.0" type="left link" vehicle="320_bus_4" link="10688" />
    <event time="47192.0" type="entered link" vehicle="320_bus_4" link="7860" />
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</events>
```

Acquired Skills and tools

Programmation: Python, Unreal Engine asset development through blueprints

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, Unreal Engine

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