SOFTWARE ENGINEERING INTERNSHIP

Real time visualization of point clouds in a web application

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EPITECH'S STUDENT- 3RD YEARS | INTERNSHIP REPORT | APRIL 1ST, 2022 > JULY 31ST, 2022

Acknowledgements

I would like to thank Mrs. Anne-Sophie Didelot, CEO and co-founder of ALERION, for having welcomed me in her team, during these four months of training. I also thank her for her availability and her advice.

A special thanks to Mr. Louis Viard, R&D engineer and tutor of my internship, with whom I had the pleasure to work directly, for the time he devoted to me, in particular the transmission of his knowledge, the sharing of his experiences and our rich exchanges.

Foreword

As part of my third year of training at the EPITECH school in Nancy, I did a four-month internship, from April 1 to July 31, 2022, in the company ALERION located in the start-up pool of the Ecole des Mines de Nancy, on the Artem campus.

Very interested in the world of drones and the development of innovative applications, I sent a spontaneous application to Mrs. Anne-Sophie Didelot, director of the company ALERION, an indisputable reference on these two subjects.

The main mission of my internship was to display in real time data from sensors producing point clouds (bathymetric probe, lidar) in a web application.

Afterward I had the opportunity to define and realize my own subject to tackle on Artificial Intelligence applied to ground robotic.

This internship report is organized in 2 parts:

► The first section is intended for a new employee in the company where I did my internship and who will take over the project I worked on.
It presents the context of the company, the organization of the team, and the two projects I worked on.

► The second section is for Mrs. Didelot.
It presents the arguments to convince her to integrate me in a new project that her company is developing and that interests me.

SECTION 1 - Company presentation and projects I worked on

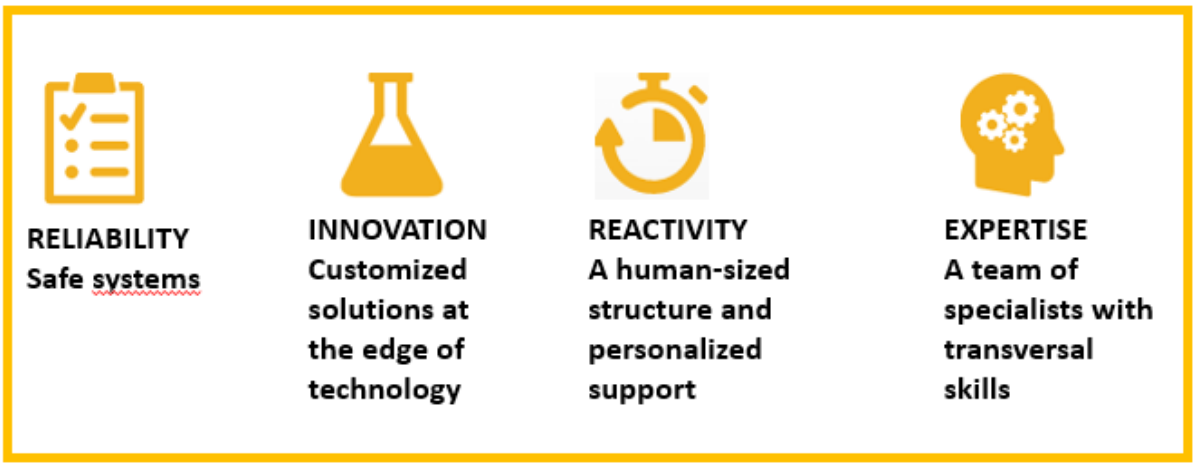
1.1. Presentation of the company

ALERION is a young innovative company created in 2015. This start-up was born out of research work by LORIA (Laboratory for Research on Computer Science and Automation in Nancy) and is housed at the heart of the Artem Campus in Nancy.

ALERION creates high quality hardware and software components to make Unmanned Aerial Vehicles (UAVs) so called drone more intelligent and adapted to the needs of the industry on functions such as security, safety and autonomy.

Drones are not systematically flying robots. They also include ground or underwater robots.

1.2. The company's values



Source: www.alerion.fr

Organization of the team

The company involves seven people, including 3 Research & Development engineers.
The activity is divided into two poles: software and hardware.
During my internship, I worked on a project related to the software division.

1.3. Academic and institutional partnerships

The high added-value products created by ALERION are developed thanks to the expertise of the team and the surrounding academic community as well as to institutional partnerships.

. Partners :

Source : www.alerion.fr

1.4. Innovative projects and partnerships carried out by the company since its creation

Since its creation, ALERION has worked on several ambitious and innovative projects, in partnership with major industrial groups.

HYDRADRONES™

Objective: develop and use amphibious drones as active elements in a complete environmental monitoring system. They will allow an operator to simply perform measurements and sampling in the field, minimizing the need for manual piloting, limiting the number of human actions, and multiplying his measurement possibilities.

Partners :

Source: www.alerion.fr

MULTIDRONE

Objective: to develop an innovative and intelligent platform for media coverage of major sporting events.

Partners :

Source: www.alerion.fr

GRONE

Objective: to create a cross-border cluster in the field of services based on UAVs, to develop and structure the offer so that companies in the Greater Region can benefit from it, in the context of a very high-potential market with a multitude of SMEs / start-ups that are too small to develop rapidly, with the need to break down technological barriers (innovation).

Partners :

Source : www.alerion.fr

CEOS - Criticité mixte pour les systèmes embarqués critiques communicants

Objective: to offer a reliable and secure system of inspections of structures by professional mini-drone for Vital Infrastructure Operators coupled with their Geographic Information System.

For example: the monitoring of the ENEDIS network. In order to facilitate the monitoring processes of the electricity distribution network, ALERION has developed, alongside ENEDIS, a solution for the automated processing of overhead line visits. Enedis used to monitor its high voltage lines by helicopter. From now on, drones will carry out these rounds to detect defects or trees to be pruned, a less expensive solution.

Partners :

Source: www.alerion.fr

5G!DRONES

Objective: European collaborative H2020 Research and Innovation Action (RIA) project that brings together 20 partners including 2 universities, it aims to integrate and test several cases of UAV services on 5G platforms in order to collect information that will validate the use of 5G for a wider deployment of UAV services. In addition, the project aims to highlight areas where 5G needs to be improved to ensure these services.
Objective for ALERION within the project: the Search & Rescue mission on a body of water consists in working on the technical aspects of the UAV in the context of the integration with the 5G infrastructure, its use during scenario tests, developing new modules compatible with the 5G network allowing the communication of the UAV by means of the various services provided by 5G, and developing a system compatible with the 5G infrastructure for the analysis of data coming from the various sensors integrated in the UAV.

Partners :

Source : www.alerion.fr

1.5. Presentation of the two projects I worked on

The mission entrusted to me by ALERION consists in displaying in real time data from sensors producing point clouds (bathymetric probe, lidar) in a web application.

ALERION's need is to improve human-machine collaboration. This translates into:

- ⇨ Use of autonomous robotics.
- ⇨ Use of various sensors and robots (even one-shot).

The two projects I worked on to meet these needs:

- ⇨ Display geolocated bathymetric data in real time on a 2D background map with a 3D representation in connection with the European project 5G!Drones).
- ⇨ Using a Spot Boston Dynamics robot to recognize door handles with artificial intelligence and open them automatically.

1.5.1. Presentation of the project #1

Objectives: Display geolocated sensor data in 2D and 3D in a web browser.

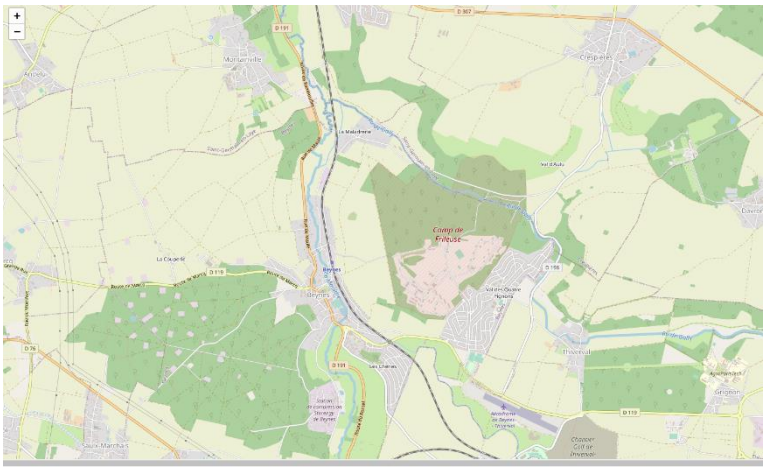
Results obtained: display of a live Digital Elevation Model on a localized 2D base map and display of the same model in 3D on a web platform.

Tool used: Gitlab for the management of my projects in several tasks, React.js for the development of the web application, leaflet to display the map, three.js for the 3D representation, proj4 for the conversion between geographic coordinate systems and Docker to containerize the application.

Methodology deployed:

A/ Development of a web application with the React.js language contained in a Docker container for better management of dependencies and their versions. Docker is a tool that can package an application and its dependencies in an isolated container, which can be run on any server.

B/ Added the Leaflet map using the JavaScript library 'react-leaflet' to accurately display the location of the Digital Elevation Model.

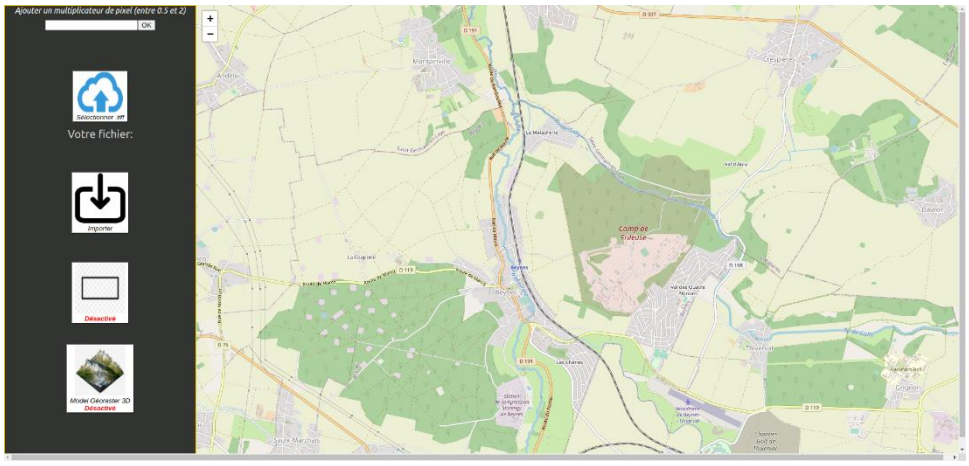


C/ Adding different interactions:

- A button to load a '.tiff' or '.tif' file that contains all the data of a Digital Elevation Model such as its location.

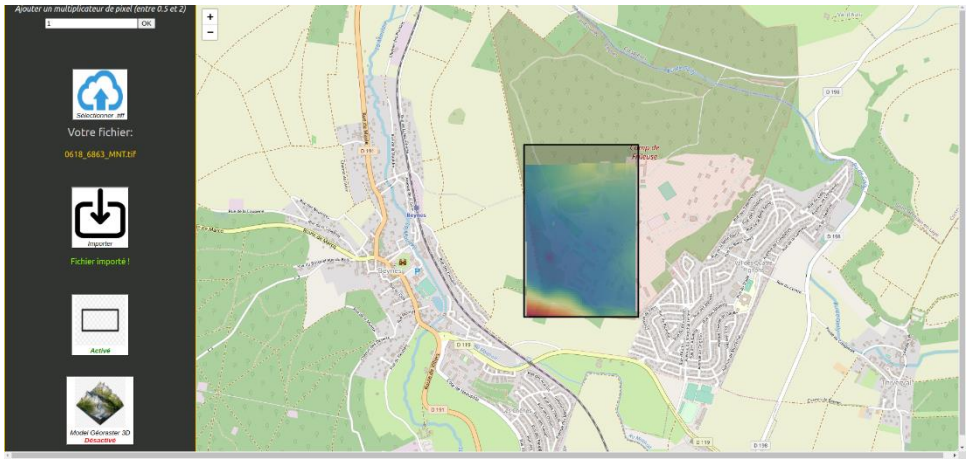
- An input to define the display speed of the Digital Elevation Model which is displayed according to the movements of the drone.

- A button to create a display rectangle allowing the user to select only a portion of the Digital Elevation model to display.



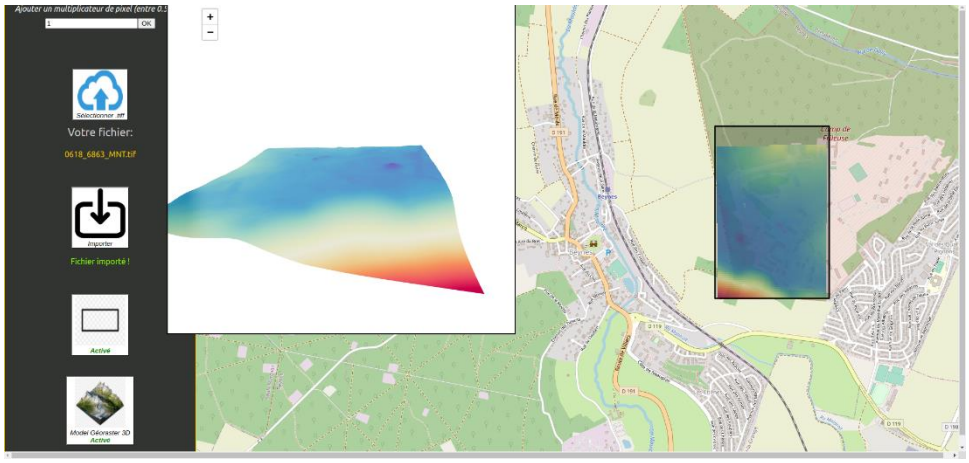
D/ Realization of the 2D display of the Digital Elevation Model, by varying colors according to the altitude using the JavaScript library 'chroma-js' (from red for the deepest to blue for the highest).

E/ Use of the JavaScript Library 'proj4' to transform geospatial coordinates from one coordinate reference system (CRS) to another.



F/ Adding the 3D display functionality of the Digital Elevation Model to have a much more understandable view (using the JavaScript Library Three.js). This was a difficult task to accomplish since I had never done 3D on the web before.

⇨ Test results: display of a live Digital Elevation Model on a localized 2D background map and display of the same model in 3D on a web platform.



1.5.2. Presentation of the project #2

Context: this scenario was imagined for the emergency services. In the case of a gas or chemical leak in a building, the robot would be sent in place of a human to close a valve or perform hazard measurements. The user then becomes the supervisor: there will be few manipulations to perform.

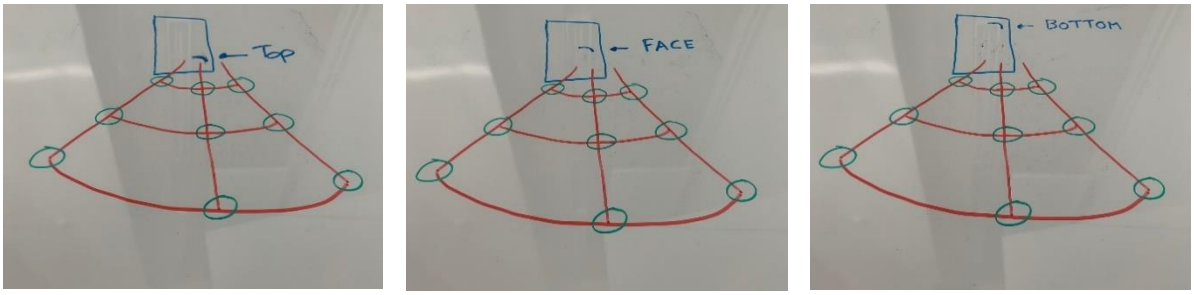
Objectives: exploring a building with a Spot from Boston Dynamics by detecting and opening closed doors.

Results obtained: the robot is positioned in a corridor, it detects door handles. A door is then chosen by clicking on it; the robot opens it.

Tool used: YoloV5 which contains a ready-to-use artificial intelligence, openCV which is a python library for image processing, and the Spot robot from Boston Dynamics with its SDK.

The methodology deployed for the data acquisition and training process:

A/ Test of a neural network with images of door handles thanks to a precise procedure that I defined and documented:

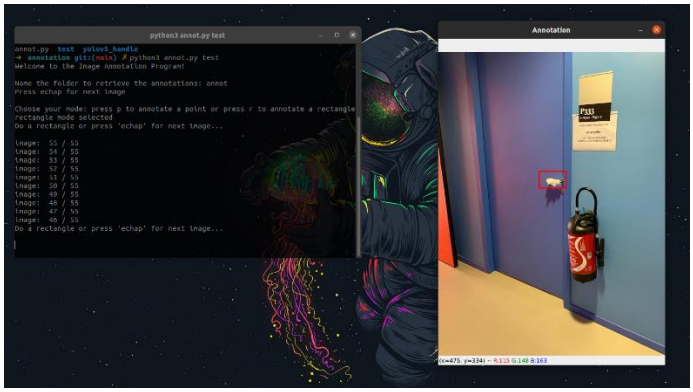


Each green circle indicates a position to take the picture and thus cover the entire door handle in image.

The procedure needs to be done on different types of doors (both sides) with different handles.
Photos of the doors were taken with different sensors: camera, phone camera and RealSense to get photos of different size and quality.
The images were then edited to transform the colors and resolution and add noise to greatly increase the data.

B/ Once the data is acquired, the images are annotated so that the neural network can be used for tests. The annotation of an image consists in creating a rectangle around the object that we want the Artificial Intelligence (AI) to recognize, recovering the position of the four angles, and saving them in a '.txt' file.

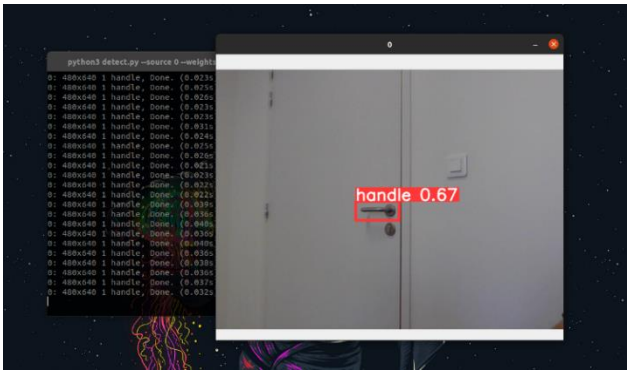
C/ Creation of a python script using the 'OpenCV' library to open an image, annotate it and save the annotation file in a dedicated folder, allowing to annotate hundreds of images, very quickly.



D/ Creation of another python script to classify the images folder and the annotations folder into three subfolders: train, val and test.
This script consists in separating in the three folders the images and the annotations so that 10% of the elements are in the test folder, 10% in the val folder and 80% in the train folder. The train folder will be used to train the neural network, the test folder and val to test the AI to verify its functioning and accuracy.

E/ Recovery of a neural network ready to be trained and named YoloV5, thanks to the folders containing about 1,000 images and 1,000 annotations divided into 3 subfolders. This process of training lasted in approximately one hour.

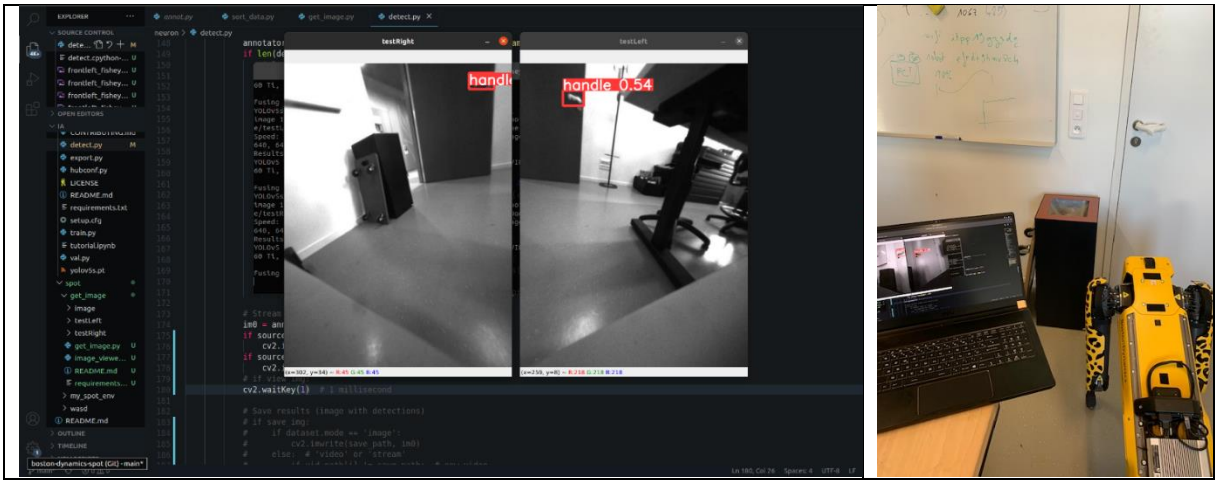
F/ Verification of the result with the computer's webcam facing a door. The confidence index above the rectangle varied between 60% and 90% and was sufficient for the rest of the project.



G/ Real-life test: using the Boston Dynamics robot's camera to detect a door handle and open it with the motorized arm.

H/ Read the full Sport SDK Boston Dynamics documentation to understand how the robot and its motorized arm work.

I/ Developed a python script to retrieve the image stream from the robot's front cameras for processing in the door detection algorithm.
The robot already has a python script to open a door with its arm. However, a user must be behind a tablet to click on the exact location on the door handle and inform the direction of the door opening. Once this is done, the robot deploys its arm to open the door.



J/ Resume and modify the script so that the user has fewer actions to perform.

K/ Replacing the user's click on the door handle with the coordinates of the detection rectangle and replacing the user's click on the door opening direction with a single click on the hinge.

⇨ **Result of the test: I position the robot in the corridor, it detects several door handles, I select the door to open by clicking on it and on its hinge, and the robot opens the door.**

SECTION 2 - Argumentation to convince my manager that I can join a new company's project

Dear Mrs. Didelot,

ALERION is starting a project to detect gas leaks and close gas valves using a robot equipped with dedicated sensors. This project would benefit from the results of two projects that I conducted within your company.

The first one consisted in displaying geolocalized data from sensors in a web browser. It would intervene on the graphical user interface used by the rescue team. The second one resulted in a robot able to recognize door handles thanks to an Artificial Intelligence and to open them autonomously. These results could be transferred to close gas valves without the rescue team being on site.

These projects took place during my four months internship in the software division in ALERION. To detail, the objectives of these projects were:

- to display live sensor readings from an embedded bathymetric probe in 2D and 3D on a web platform.
- to explore a building using the robot Spot from Boston Dynamics by recognizing door handles with Artificial Intelligence and by opening those doors automatically.

These concrete and interesting projects made me understand the various aspects of software engineering:

- **Matching state of the art solutions** by reading academic articles on point cloud processing based on machine learning.

- **Managing a project** by planning and tracking progress using gitlab.

- **Gathering requirements** by analyzing and experimenting with the robot Spot.

- **Validating solutions** by demonstrating and showcasing my projects to the team.

Moreover, this internship was also an opportunity to develop both technical skills and professional know-how. I increased my Python programming (AI algorithms) and React.js (web development) skills through the operational missions I was given. In the context of these missions, I demonstrated my ability to quickly adapt to operational fields of activity that were unknown to me at time.

My curiosity has been an asset as well as my sense of initiative to take part in these Research and Development missions. I also proved my ability to understand problems and to come up with appropriate solutions.

Finally, I enjoyed working with all members of your team. The success of these projects proceeds from our fruitful collaboration.

I look forward to carrying on this collaboration if you give me the opportunity to take part in the rescue project. Thank you for your consideration.

Best regards,

Maxence Marques-Pierre