Intership Report

Group 1 CMI
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Host organization
CERI, Avignon Université

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I would like to thank my two colleagues, Lahcène BELHADI and Gabriel DESBOUIS, with whom I had the great pleasure to work during my internship. Their involvement in the project really helped us to persevere in both our robotics project and optimization project.
I also want to thank our other teammates for the robotics project, Thomas SATORY and Khaoula OTMANI, who were commited to the project as much as we were during the year.
My internship would also not have been possible without my supervisors : Ms Rosa FIGUEIREDO and Mr Philippe GOZLAN, who have supported us along the way, providing valuable knowledge.
Thank you all

Introduction

The purpose of this report is to explain what has been done during my 3rd Year Computer Science CMI Internship at the CERI, Avignon Université. This intership was divided in two distinct part : the first one consisted in a continuation of the work that had been done during the year on the robotics projet, as well as the participation to the French Robotics Cup that took place at Roche-Sur-Yon. This part took place from the 16th to the 28th of May 2022.

The second part focused on working on an optimization problem called **p-median problem (PMP)**, by continuing the work that had already been done by a former Software engineer of Avignon Université **Anthony DALLE**. It consists of an optimization problem for a geographical context, helping in the work of a Geography PhD student at Avignon Université , M. **Quentin GODOYE**. This work has been done in collaboration with two colleagues of my class : Lahcène BELHADI and Gabriel DESBOUIS. This part started from the 30th of May and will end at the 27th of June 2022.

1 Presentation of the Host organization

Since my internship was in two parts, I had two main host organizations, the first one being the **CERI** and the other one the **LIA**. The CERI (*Centre d'Enseignement et de Recherche en Informatique*) is a part of Avignon Université located at Agroparc, Montfavet. This Computer Science Department is situated right next to the LIA (*Laboratoire d'Informatique d'Avignon*). This is where works most of our teachers, working in many different fields of research including Artificial Intelligence and Operationnal Research. The lab is composed of roughly 75 people of which 65 are teachers at the CERI.

The first part of my internship was supervised by **Mr Philippe Gozlan**, CERI Lecturer and the second part was supervised by **Ms Rosa FIGUEIREDO**, Associate Professor at the CERI.

2 First Part : Robotics Project

2.1 Introduction

For the first part of my internship, I had to continue my group work on a robotic project that started at the beginning of the year, resulting at the end to take part to the French Robotics Cup. The goal was to produce one or two robots that would compete during five different runs against another team, to win points on a game area that was designed specifically for the competition. These robots had to respect certain specifications concerning their size and the fact that they were able to avoid the opposing robots. For the context, we worked in a group of 5 on a robotic project during the whole academic year. I was the one assigned to work on the sensors used on our robots that helped them avoid any obstacles or other robots that may come in our way during our runs. The robots had to compete on a given area (ccf annex 1), also regulated by some rules.

2.2 Working on the sensors

At the beginning of the project, we wanted to work with a LIDAR (ccf annex 2), a 360-degree sensor. I worked on it for some months, trying to see how it worked and how to implement it on our robots. But during the internship, I encountered some implementation problem concerning the communication between the Raspberry Pi 4, the card used to operate the LIDAR, and the Arduino card, the one that runs the whole robot. I worked on trying to implement the communication via a Serial communication port, with **Jules Arsac**, who was also an intern with MR GOZLAN. At the end, we decided to use TOF (*Time Of Flight*) sensor, that use a similar technology to the LIDAR using infrared invisible light, but with a straight field of view instead of a 360-degree one.

I then worked on writing a library that would be used to implement the functioning of the sensors in the movements of the robots. The library was written in **C++**. One of the main functions is one that measures the distance between the sensor and the object in front of it, and returns a Boolean value which would be True if the object is detected as less than a given threshold value. This function was then implemented in the library used to manage the motors for the wheels of the robots, coded by my colleague **Lahcène BELHADI**.

Here is the implementation of the library that I wrote for using the TOF sensors :

```cpp
class CapteurTOF{
  public:
    //Attributes
    Adafruit_VL53L0X* sensors;
    VL53L0X_RangingMeasurementData_t* measures;

    int* distances;
    int nbreSensors;

  public:
    CapteurTOF(int nbreSensors, int* sensorsPin);
    void measureDistances();
    int* getDistances();
    bool distanceTreshold(int sensorIndex, int treshold);
};
```

2.3 The result of our work : Participation to the French Robotics Cup

Participation at the Robotic Cup was part of my internship, and was all paid for by the CERI. We had to travel by car from Avignon to La-Roche-Sur-Yon, situated on the West coast of France. There, we had to setup a stand in the Exhibition Center where the Cup was held. We had to install all of the equipment that we brought along with us to work on the robots.

During the week, we all worked on our robots, trying to improve them for the upcoming runs. The first major step was to have our robot homologated, in order for them to be able to participate to the runs. Unfortunately, we encountered some issues regarding the size of them, even though we worked on it beforehand. We even had to abandon the secondary robot, since it had too many problems and didn't earn enough points to be worth working on it.

We took turns between us. While some were testing it on the Training table, one had to watch the stand. My job during the competition was to solve the problems linked to the sensors, especially one that consisted in a misplacement of one of the sensors, which was a little bit tilted and didn't measure accurately in front of the robot. This small problem has cost us a couple of hours before figuring it out.

After finally having our robot approved, we had already missed two out of the five possible runs. I took part in our second run, which was the fourth in total, with my colleague **Gabriel DESBOUIS**. During a run, we had to take our robot and other elements, and then go play in a sort of play area surrounded by bleachers and with five play tables. We had only five minutes to set everything up, which was a bit stressful with all the spectators watching us. Our run wasn't perfect, our robot got stuck on some pallets, something that never happened before on every training run that we had done beforehand.

We ended up ranking 52nd out of the 120 teams that participated in the competition, which is an honourable score considering the means that we had to work with.

After participating the French Robotics Cup, we weren't done with our internship, as the second part of it with **Ms Rosa FIGUEIREDO** would begin the week after.

3 Second part : The P-median Problem

3.1 Introduction

The second part of my internship was a group project with **Lahcène BELHADI** and **Gabriel DESBOUIS** on an optimisation problem called ***P-Median Problem (PMP)***. This problem consists of optimizing the placement of a number **P** of locations, those being Police stations, Emergency stations, Schools,..... in a given area, considering the ones that already exists. The heuristic used in this problems aims to consider various informations like the population density and its needs, to determinate where should we build more of the services.

Our work was to improve the usage of the already existing heuristic with a GUI (Graphical User Interface) and a better organization of the configuration and data used for the PMP. We were also assigned to perform some research based on the heuristic to make a slightly different one that would consider a given percentage of already existing services and see which ones should be relocated.

We were under the supervision of **Ms Rosa FIGUEIREDO**, an Associate Professor at the LIA, specialized in optimization. The whole internship was done in remote at home, with some in-person meetings at the CERI when needed.

3.2 The heuristic

As explained above, we worked on an already existing heuristic, coded by **David Woller**, a Czech Software Engineer who worked on it last year. The purpose of this heuristic is to help a PhD Student in Geography, **Quentin GODOYE**, with his work. The heuristic had been slightly modified by **Anthony DALLE**, a software engineer at Avignon Université.

The heuristic works as explained in the following pseudo-code :

```
TBHeuristic():

    sol_best = RandomSolution()
    Boolean foundSolution = true
    sol_candidate = null
    sol_temp = null

    while(foundSolution):
        foundSolution = false
        sol_candidate = sol_best
        for loc in locations :
            if (!sol_best.contains(loc))
                for p_location in sol_best.p_locations :
                    sol_temp = sol_best
                    sol_temp.replace(p_location, loc)
                    //We calculate the new obtained objective value
                    if sol_candidate.score - sol_temp.score > toleranceScore :
                        sol_candidate = sol_temp
                        foundSolution = true

        if foundSolution:
            sol_best = sol_candidate

    return sol_best
```

The algorithm stops searching when we don't find any new solution.

This heuristic works perfectly on small instances, as we have observed on the city of Toulon, but the end goal is to work on the whole PACA region instance, which takes much more resources and time to compute. It's mainly because for the moment, the heuristic thinks that a new solution is found when the new score is better by 10^{-6} points. So we were assigned to improve the stop conditions of the heuristic.

3.3 Improvements brougth to the heuristic

Since I was hospitalized during the first week of the internship with **Ms Rosa FIGUEIREDO**, my colleagues started working on the project without me. I have however followed their progress via the regular reports that they made along the way. For the beginning, they worked on understanding the work that had already been done, as well as adding some small, but useful improvements. This consisted of adding a configuration *toml* file that avoids having to put every elements manually in the command line at each run.

We also added a new stop condition based on the CPU time and not the results. This means that, based on the elapsed time by the CPU, we would stop the heuristic from running if it didn't find a solution yet. For instance, running the code on the PACA's instance for a whole night was not enough time for it to find a definitive solution. This also meant that we had to consider the fact that the instance may be run on a CPU with multiple threads, which would distort the measured time. This problem was since fixed.

```
p locations: 334 666 557 622 582 534 92 485 368 355
objective: 881854.91346125
TB loop: Elapsed time: 16 ms


p locations: 304 334 666 557 622 582 534 485 368 355
objective: 879233.318154631
TB loop: Elapsed time: 16 ms

```

```
............

p locations: 472 574 580 376 298 304 666 557 283 534
objective: 832962.030798473
TB loop: Elapsed time: 29 ms


Final solution:
p locations: 472 574 580 376 298 304 666 557 283 534
objective: 832962.030798473

Elapsed time: 1936 ms
```

Above is a sample output of the Toulon instance, where the values given in the p-locations are ids used on a software called *ArcGis Pro*. These ids, called p locations, correspond to existing locations in the city.

For our work, we decided to split the tasks in different parts, and distributed them between us. For instance, Lahcène was the one who worked on the clock restriction and the configuration file, while Gabriel worked on improving the help commands, making them clearer for the user. Since I was absent for a good part until now, I couldn't provide a lot of work on the project. I helped translating the meeting reports in English, as well as improving error messages.

3.4 Remaining work

For the following weeks, we will continue our work on the heuristic by adding more features and improvements. First, the most important part left to be done would be the new modified heuristic aiming to move already existing locations instead of adding or deleting some. This part will require further research on the algorithm. We also aim to develop an interface to facilitate the usage of the application to users that may struggle to work with command line, making it accessible for people in geography that would potentially need it for their work.

We may have more features to work on, but those are what's left to be done for now.

4 Assessment of the experience so far

With this internship, I had the opportunity to continue our work on the robotic project that took us a whole year to prepare. The participation to the cup was maybe only a week long, but the fact of having been able to exchange with the other big teams on their work was very enriching, culturally speaking. We learned a lot about the different ways to apprehend a problem in robotic, how to carefully chose which technologies to use and to avoid. This allowed me to further comprehend how to work on a robotic project, something totally different from a software project for example.

We could have done a better score if we didn't encounter all those problems, but that is also part of the experience.

For the PMP part, we still have a lot of work left to be done, but the fact that we have a research part in our work is what makes it interesting in my opinion. This will give me a brief idea of the work of researcher in computer science, even if it's not as important as a work resulting in a research paper for example.

Conclusion

As explained above, our internship is not over yet. We still have some work to do to improve the usage of the heuristic and making a new one. I hope that the research part will give use interesting results and will not deceive us on the the computer science research field. I may develop an interest to it and want to continue my studies with a PhD if it really galvanizes me. For now, I'm not decided yet on what I will be doing after my Master's degree.

Appendix

Figure 1. Game area for the cup

Figure 2. The LIDAR that I worked on