Internship - University Of Louisiana at Lafayette

erwan martin

July - October 2023

Contents

1 Introduction **3**

2 Presentation of the university **3**

3 Work Environment **5**
3.1 Team Presentation 5
3.2 Projects Presentation 6
3.2.1 Omni-Directionnal robot 6
3.2.2 surgery robot, Raven II 7

4 Work done during the internship **8**
4.1 Vision 8
4.1.1 PAL Camera 8
4.1.2 ZED 2i camera 10
4.2 Omni-Directional robot 11
4.3 RAVEN II surgery robot 13
4.4 Global results 14

5 Acknowledgements **15**

6 Cultural differences **15**

7 Carbon analysis **19**

8 Conclusion **20**

9 Appendix **20**

1 Introduction

International mobility is a required part of the Master of Engineering program. It must be completed for the degree. It lasts at least 12 weeks for interns and 17 weeks for students. it permits :

* To validate a professional or research assignment at a level suitable for graduate students
* To experience a country with a different culture, language, environment, and way of life
* To learn about organizational and management characteristics (technical, human, economic, and legal) in an international context
* To deepen and validate mastery of intercultural dimensions and language skills
* To produce a written and oral report that is organized, analytical, and synthetic

International mobility also helps students develop personally, as it requires them to be independent and to organize and position themselves in a new environment. By successfully completing this assignment, students will broaden their horizons and gain perspective on their professional and/or academic practices. The internship in a company has several professional advantages. Students can:

* Create relationships with other companies
* Expand or transfer a project they have worked on in the past
* Strengthen customer/supplier relationships
* Promote technological exchanges or skills transfers

2 Presentation of the university

I made my internship in the University of Louisiana at Lafayette. The University of Louisiana (UL Lafayette) is a public research university in Lafayette, Louisiana. It is the largest university in the University of Louisiana System and the flagship institution of the University of Louisiana at Lafayette System. UL Lafayette is classified among "R1: Doctoral Universities – Very high research activity". The university is among the top universities in the country and the world recognized for it's impressive academic programs, research projects that make an impact, sustainability initiatives, and diversity and inclusion practices. UL Lafayette was founded in 1898 as the Southwestern Louisiana Industrial Institute. It was renamed the University of Southwestern Louisiana in 1960, and the University of Louisiana at Lafayette in 1975. UL Lafayette offers over 100 undergraduate and graduate programs through its ten colleges and schools:

- College of the Arts
- B.I. Moody III College of Business Administration
- College of Engineering
- College of Education
- College of Humanities, Social Sciences, and Arts
- Honors College
- College of Liberal Arts
- College of Nursing and Allied Health Professions
- College of Science
- University College
- Graduate School

The University has a student body of over 19,000 students from all 50 states and over 100 countries. The university offers a variety of student activities and organizations, including athletics, fraternities and sororities, and student government.

UL Lafayette is a major research university, with annual research expenditures of over $100 million. The university is home to a number of research centers and institutes, including the Center for Advanced Materials Research, the Louisiana Immersive Technologies Enterprise (LITE), and the UL Lafayette Petroleum Center. The researchers are engaged in a wide range of research areas, including:

- Advanced materials
- Biomedical engineering
- Catalysis
- Coastal studies
- Cybersecurity
- Data science
- Energy
- Environmental engineering
- Food safety
- Health and wellness
- Information technology

- Maritime transportation
- Nanotechnology
- Petroleum engineering
- Robotics
- Smart cities
- Sustainability

UL Lafayette research has a significant impact on the economy and well-being of the region. The university's research generates over $1.2 billion in annual economic activity and supports over 10,000 jobs. UL Lafayette researchers have also made significant contributions to the advancement of knowledge in a wide range of fields. The University of Louisiana at Lafayette is a major research university with a strong commitment to excellence in academics, research, and student life. UL Lafayette is a valuable asset to the region and the state of Louisiana.

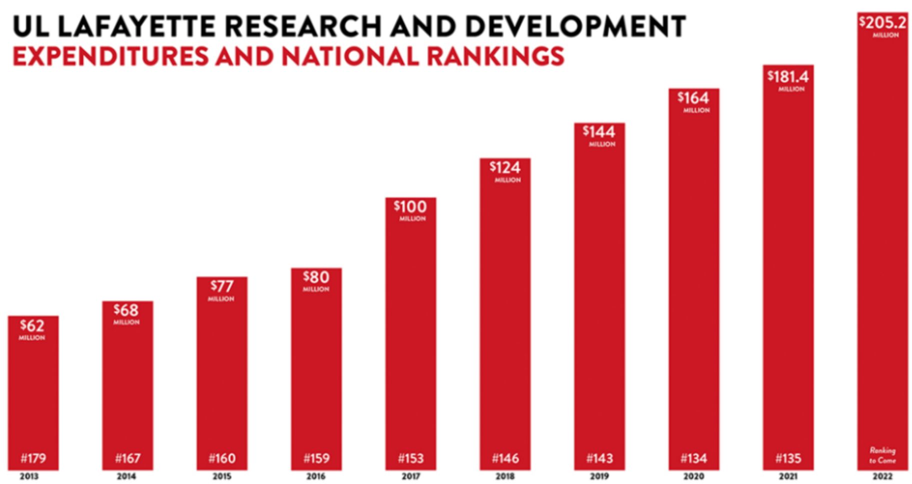

Figure 1: ULL Research and development Expenditures and national rankings

3 Work Environment

3.1 Team Presentation

I worked under the responsability of the Dr. Raju Gottumukkala. In the laboratory, I used to see other research assistant students and PhD students. Then, I was part of the Informatics Research institute, in order to perform robotics missions I had connections with the mechanical research institute as well.

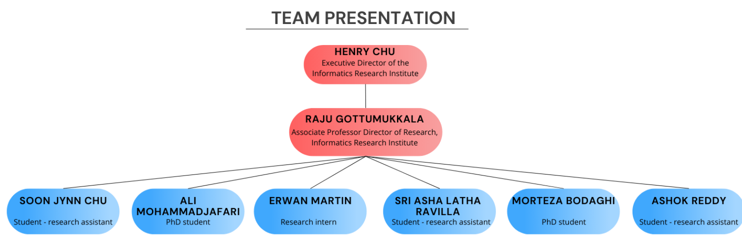

Figure 2: Team Presentation

3.2 Projects Presentation

3.2.1 Omni-Directionnal robot

This project involved the development of a new omni-directional robot for playing racquetball. The robot must track and predict the position of a small, high-velocity ball, and place itself in the optimal position using a navigation algorithm or reinforcement learning model. This requires a fully integrated sensor and control system. The real-time ball tracking model was developed by Prithvi Raj Singh and performs exceptionally well.

The mechanical design of the robot was based on the work of Logan Marks, Haydan Parker, Nicolas Pinto, and Dawson Besson. This paper focuses on the ROS2 package that was developed to control the robot, the integration of sensors such as an IMU, the robot simulation environment, and the controllers that allow the robot to be controlled in both real and simulated environments.

The document "A ROS2 Package for the University of Louisiana's Omnidirectional Robot" (provided in the appendix) provides a detailed explanation of the integrations provided by the ROS2 package I developed and how to use it. Please read this document for more detailed information about my work on this project.

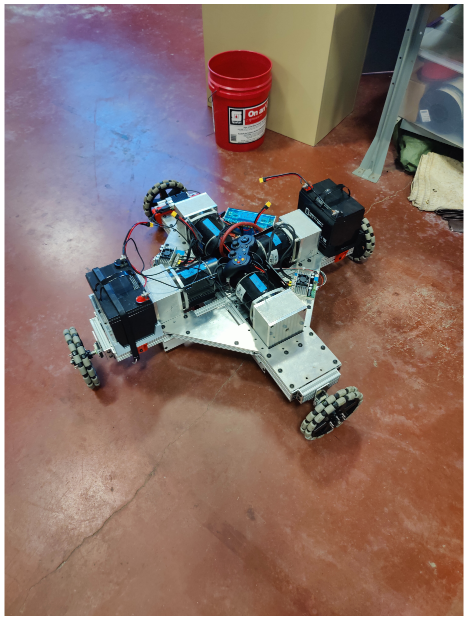

Figure 3: Picture of the omni-directional robot

3.2.2 surgery robot, Raven II

The Raven II is a surgical robot designed for remote-operated surgery. It runs on the Robot Operating System (ROS) but requires additional sensors, remote video, and remote control capabilities.

This project is a cybersecurity research project focused on performing an attack on the Raven II during surgery. My contributions to the project involved enabling remote-operation of the robot for the surgeon.

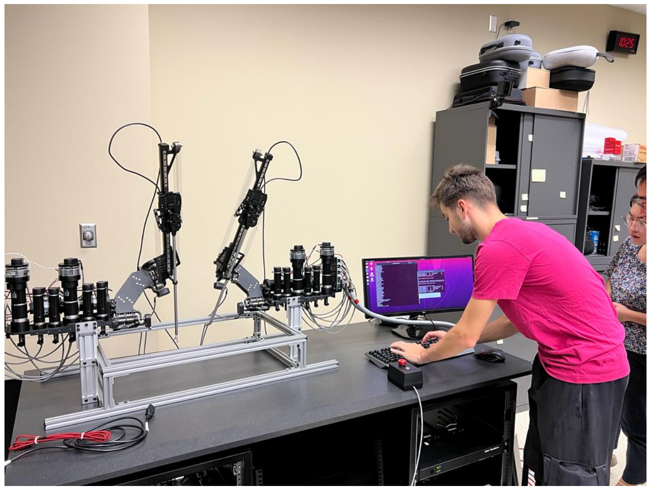

Figure 4: Picture of the Raven II robot

4 Work done during the internship

The Appendix 1 table summarizes the work I did during this internship. Rather than following a chronological approach, I have grouped the projects I worked on into subsections, followed by a summary of my contributions to each project. This will make it easier to understand my different contributions.

4.1 Vision

4.1.1 PAL Camera

We initially tested a specialized camera, the PAL USB, which has a 360° field of view and depth sensing capabilities. We planned to mount it on top of the robot to locate the ball and integrate navigation tools such as obstacle detection with the depth measurements.

Figure 5: Picture of the PAL camera

However, the PAL USB camera is computationally expensive to run. It must reshape the image captured by its circular mirrors into a rectangular shape, which consumes significant processing resources and introduces latency. As a result, we were unable to track the ball accurately due to the low frame rate.

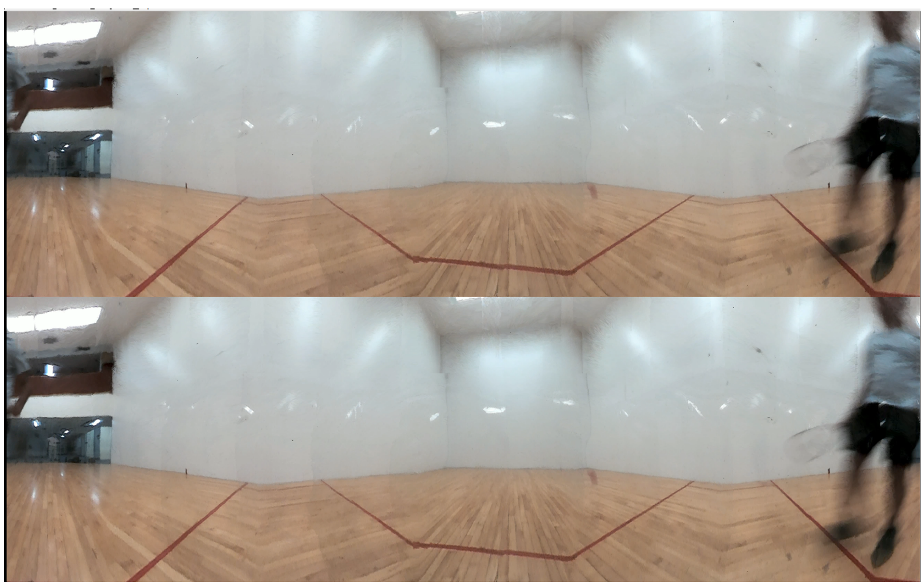

Figure 6: Example of a PAL camera frame

The image above shows that the ball is barely visible in the PAL USB camera output.

4.1.2 ZED 2i camera

The ZED 2i camera is one of the best cameras on the market today. It is a stereo camera with high resolution and frame rate, depth sensing capabilities, and diverse applications, especially in AI.

Figure 7: Picture of the ZED 2i camera

Our next idea is to add multiple ZED 2i cameras (e.g., three) to cover the robot's environment. This camera should eliminate any ball tracking issues. We now need to identify a computer that can handle three cameras and three machine learning models in real time. The trained model can track the ball in 3D, and the camera is precise enough to follow the ball's movements, as shown in the images below.

Figure 8: image from the ZED 2i camera

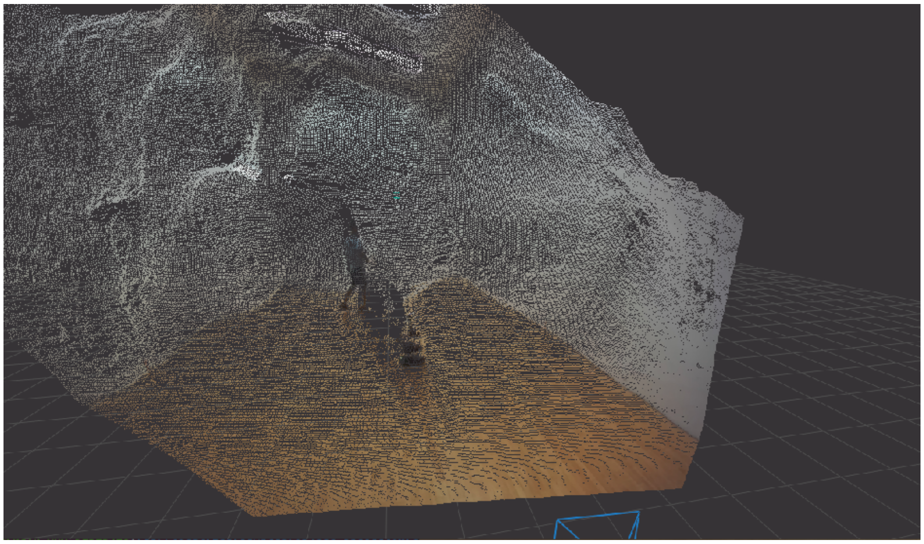

Figure 9: 3D point clouds from the ZED 2i camera

The strangely shaped images are 3D point clouds generated by the camera, representing each pixel in 3D space. For the vision work, I simply enabled cameras for the robot and took some videos in a test environment. I then used the model developed by Prithvi Raj Singh during his PhD course at the laboratory.

I created a ROS package and guide to allow the laboratory to use any camera with ROS/ROS2 after my internship. You can find this guide in the appendix, "Guide for Camera Streaming with ROS/ROS2."

4.2 Omni-Directional robot

I began by working with a single Python script that translated joystick inclination percentages to motor currents. Using ROS2 (Robot Operating System 2), I created a package that could handle the following:

- **Robot description**: This describes the robot's geometry, joints, and other physical properties. It is used for various purposes in ROS, including visualization, simulation, and control.
- **Controller**: This layer allows us to move the robot with a simple command. This could be a joystick input, but also a keyboard, voice, or program. The important thing is that the same controller is used in every case. For example, to move the robot forward, the command layer would provide the controller with a command to increase the robot's forward velocity. The controller would then calculate the output commands needed to drive the robot's wheels to achieve the desired forward velocity.

- **IMU**: An inertial measurement unit (IMU) is a device that measures a vehicle's acceleration, angular velocity, and orientation relative to a known reference frame. IMUs are commonly used in mobile robots to help them navigate and control their movement.

- **Simulation**: Simulation environments are a valuable tool for developing and testing robot controllers. They can also be used to train reinforcement learning models to control robots. Integrating simulation environments with real robots can help to improve the performance and reliability of robots.

This package combines all of these integrations. It allows the robot to be controlled in real or simulated environments with the same controller. You can find more information about this package in the appendix, "A ROS2 Package for the University of Louisiana's Omni-directional Robot."

The first diagram below shows the control architecture before adding the developed package. The second diagram shows the new control architecture. Note that this is a simplified architecture; the real one in ROS2 contains more layers, but these diagrams provide a better understanding of the overall control integrations.

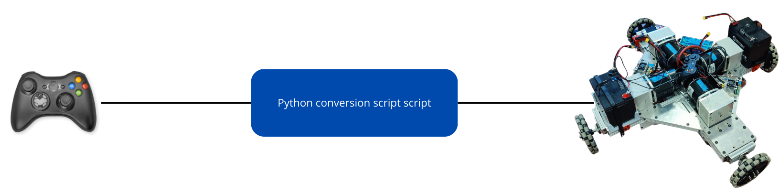

Figure 10: Diagram of the previous control architecture

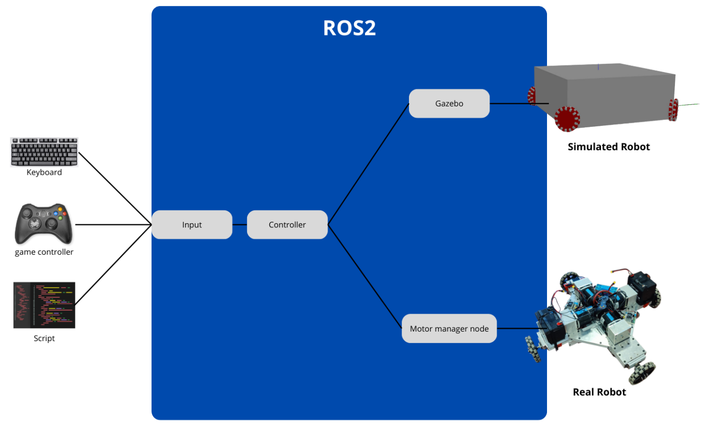

Figure 11: Diagram of the ROS2 control architecture

Note that in the second architecture, we can control the robot remotely, which was not possible in the first architecture. The IMU is integrated and provides all of its data, but it is not yet used.

As a PhD student needed an omni-wheel simulation of a different but similar robot, I reshaped my simulation and provided him with a custom package of the simulation I created for his robot. He will then use his reinforcement learning model, which he trained on this simulation, for testing purposes.

4.3 RAVEN II surgery robot

The RAVEN II surgery robot is a ROS-based robot. The university had only the robot, without sensors or visualization. My work here was to integrate sensors and cameras and to provide remote visualization of that data to enable remote surgery.

The first step was to get the data. For development, I used a virtual sensor that I created with a Python script. It was a virtual pulse sensor that returned the heart rate in beats per minute (bpm). To integrate the cameras, I used ZED cameras. I had a requirement to have multiple points of view, so I needed to integrate multiple cameras.

Next, I needed an easy way to visualize the data. I usually visualize my data through ROS, but ROS needs to be installed on an Ubuntu OS (not on Windows). This is inconvenient for medical workers who are not familiar with this type of tool. So, I used a package to display the data I was publishing through ROS in a web browser.

The surgeon or other personnel only need to be on the network through a VPN or similar to connect to the web page and see the data. Here is an example of the data visualization:

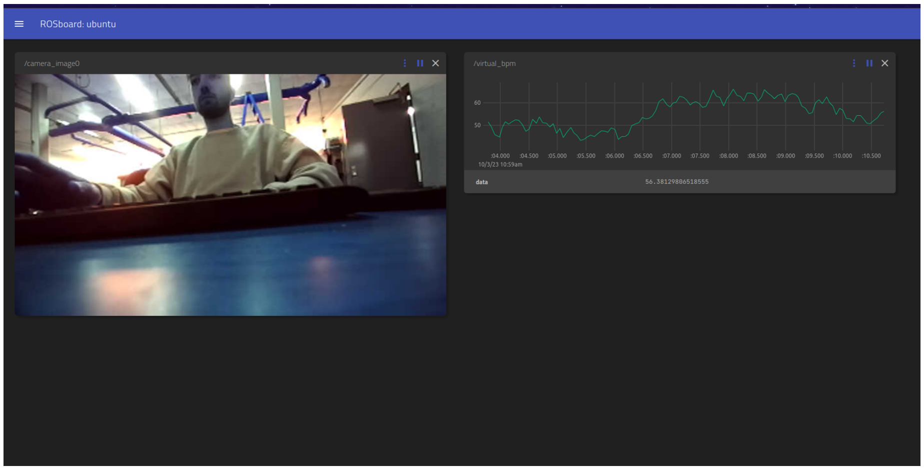

Figure 12: capture of the web monitoring from the sensors and camera data.

The surgeon can now access the robot's data and visualize the dashboard on his Windows, macOS computer, or even his phone.

In addition, I created three guides to show the team how to enable camera streaming, sensor data streaming, and how to display them on the dashboard. These guides are also in the appendix:

- Guide for camera streaming with ROS/ROS2
- How to integrate a sensor on ROS
- Guide for ROS dashboard

4.4 Global results

During this internship, I made several integrations and wrote documentation for them. I learned a lot, especially how to create a simulation of a robot from scratch. This is a challenging task, especially with an omni-directional robot, which is one of the most difficult robots to simulate.

The teams on each project can now use the integrations I made and add their own integrations using the guides I provided. The omni-directional robot is fully controllable and ready for the next steps, although there are some mechanical issues that need to be fixed first. With the three months I had, I did my best to manage my time and contribute as much as possible to all of the projects I worked on.

5 Acknowledgements

I would like to express my sincere gratitude to all of those who have helped me to complete this Internship.

First and foremost, I would like to thank my advisor, Dr. Raju Gottumukkala, for his guidance and support throughout this project. Dr. Gottumukkala has been a trusted and encouraging mentor, and I am grateful for his expertise and insights. I truly believe that Dr. Gottumukkala has leadership qualities, and this internship went well thanks to the trust relationship we built.

I would also like to thank Dr. Henry Chu and Dr. Martin Margala, who were the first persons from the university I met, for introducing me to Dr. Gottumukkala and for their accompaniment.

In addition, I would like to thank everyone I met in the laboratory: Soon Jynn Chu, Ali Mohammadjafari, Sri Asha Ravilla, Morteza Bogadhi, and Ashok Reddy. They welcomed me and made me feel like part of the group.

Finally, I would like to thank everyone at the University of Louisiana at Lafayette for their warm welcome, especially the Global Engagement Office and Rose Honegger, who helped me with my visa and housing.

6 Cultural differences

In this section will be about my personal experiences, we are going to underline the culture differences I noticed between France ant the United States of America during my stay here.

Climate in Louisiana: The moment I stepped foot in Louisiana, the intense climate hit me like a wall of heat and humidity. Arriving in the heart of summer, I was greeted by scorching temperatures that regularly soared above 100°F (38°C). The combination of this heat and the region's notoriously high humidity, often hovering between 60% and 90%, created a stifling sensation that felt far hotter than the actual temperature. It was like perpetually living in a 46-50°C sauna, sometimes even hotter. Adapting to this climate took weeks, and every venture outdoors left me drenched in sweat within minutes.

Students life:

One aspect that truly stood out during my time in Louisiana was the incredible student life. I've never witnessed such a strong connection between a city and its university back in France. The Ragin' Cajuns, the University of Louisiana's sports team, enjoy unwavering support not just from the university but from the entire city of Lafayette, where everyone proudly identifies as a Ragin' Cajun.

The students themselves are incredibly active and engaged, organizing a plethora of events, almost one every day! It's amazing to see their level of involvement and enthusiasm.

Sports play a significant role in university life, with the Rec Center serving as a hub for athletic activities. This massive sports facility is exclusively for university students and staff. I took full advantage of it, playing tennis several times a week. All I needed was to scan my intern ID card, and I could borrow all the necessary equipment, like rackets and balls. They have facilities and equipment for almost every sport imaginable.

To my great surprise, the university's dining hall was surprisingly good. As a Frenchman, I had low expectations for American food, but I was pleasantly proven wrong. I've been told that this level of food quality is unique to Louisiana. The dining hall offers unlimited food and drinks, including typical American fare like burgers and pizzas, but also a wide range of healthy options. Ultimately, it's up to each individual to make informed choices, which I believe is a matter of education. I'll touch on this point later in the section. Overall, the abundance of events and facilities at the university contributed greatly to my positive experience there.

We have to note that every students pays a lot of money to get in the university. Those aren't free like public university in France. The University have then more economical resources to organize events or provide facilities.

While the University of Louisiana at Lafayette is not considered a large campus by American standards, I found it to be quite expansive. The above map, with all the red zones indicating university property, gives a clear sense of its size. I've never seen anything comparable in France.

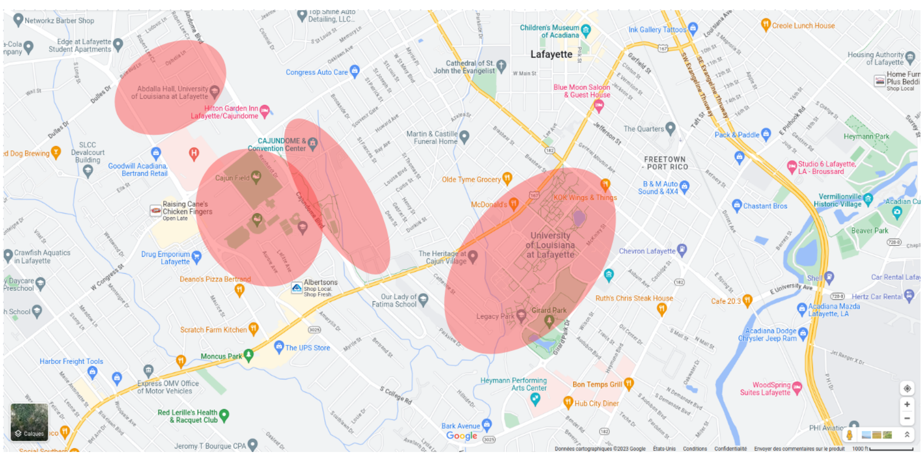

Figure 13: Map of Lafayette

Athletes:

The athletes on the Ragin' Cajuns sports teams are treated like local celebrities, and they certainly act the part. They receive a salary for representing the university team and competing in various events, and they enjoy a host of privileges. Free entry to nightclubs and the ability to skip queues are just a few examples of the special treatment they receive.

People Kindness in Louisiana:

Upon arriving in Louisiana, I was struck by the genuine warmth and kindness of the people. It was a refreshing change to have cashiers in shops genuinely inquire about my well-being, something I'd never experienced back home. I believe this friendliness is a hallmark of the American South, where casual conversations with strangers are common and people genuinely seem to enjoy interacting with one another.

Cost of life:

As many are aware, healthcare costs in the United States are notoriously high. However, I was also surprised by the cost of food. While portion sizes are generally larger than in France, the overall cost of groceries is still higher. I can't comment on housing costs as I lived on campus, but from what I've heard, rent prices are also on the higher side.

Food and Average Health of people :

The contrast in dietary habits and their impact on health is stark in Louisiana. From a young age, children are exposed to an abundance of sugary drinks, even in school settings. The dining hall's soda fountain, offering unlimited refills, epitomizes this pervasive culture of excess sugar consumption. People tend to gravitate towards cheeseburgers, fried chicken, and pizzas, with vegetables often taking a backseat. As a result, many Americans struggle with weight issues, sometimes to an alarming degree. A telling example is the presence of electric scooters in Walmart, a store where you can buy virtually anything. These scooters are designed to carry shoppers who find it difficult to walk for extended periods due to their weight.

On the other hand, the university's strong emphasis on sports and its provision of ample athletic facilities create an environment where those who engage in regular exercise can maintain a healthy lifestyle. Thus, we witness a stark dichotomy between two extremes: those struggling with weight issues due to unhealthy dietary habits and those who prioritize fitness and maintain a healthy weight.

Guns and truck culture:

My time in Louisiana exposed me to two cultural elements that are vastly different from my experiences in France. Firstly, the prevalence of firearms was a stark contrast to my home country. Gun ownership is widespread in Louisiana, and the city of New Orleans grapples with gun violence on a daily basis. The frequency of these incidents has almost desensitized people to the issue, whereas in France, even the sound of a gunshot would be major news.

The other thing I saw a lot is big trucks. Everyone loves having a truck there. I talk with a girl that told me that on their tinder picture almost every guys have a picture with a truck and the fun fact is that girls are sometimes looking for a guy with a truck. Everyone is using cars in USA, I am going to develop this in the next part.

Ecology:

People here use the car a lot. I had a 10min walk and some american friends told me: "are you sure you don't want a ride? It's a long way!" In France we only take the car if we have to. In Houston or Los Angeles, you have 6 lines (only one way so 12 lines in to ways) roads, this is a huge surface and even with it there is so many cars that the traffic can still be heavy on it.

The excessive use of plastic bags is another striking difference. I once forgot to decline a bag at a store, and despite buying just three items, I ended up with four plastic bags. The government and media seem to play a minimal role in raising awareness about pollution compared to the efforts in France and Europe. Recycling is uncommon, and waste generation is high. Several times I came back from work in the apartment, I had two Americans roommates, they weren't here but the lights and the TV was still on.

Economic inequalities:

During the internship, I had a week to travel. then with my roommate we explored the west coast. I saw Los Angeles and what I saw almost shocked me. There is a palpable contrast between the rich people and the poor ones. In some quarters you can almost smell the money, in some others, in downtown for example everything you can smell is weed and urine, you can find a homeless or a crackhead every 20 meters (without exaggeration). California is the state where I felt the most the inequalities. In Louisiana in New Orleans, I could feel it too but but it manifests as a more widespread condition rather than the extreme contrasts seen in Los Angeles.

Workers conditions:

The working conditions in the US stand in stark contrast to those in France. Employees lack the job security that is commonplace in my home country. Employers can terminate employment at will, often with little or no notice. Many individuals are forced to juggle multiple jobs to make ends meet. My friend Will, for instance, is working grueling hours, sometimes starting at 4 AM or finishing as late as 11 PM, to finance his final semester of college. This reality is all too common for many Americans, and I find it pretty unfair.

Globally:

My internship in Louisiana was a transformative cultural immersion. Despite stark contrasts with my French background, I was captivated by the warmth of the people, the vibrant student life, and the unique traditions. While I observed challenges like economic disparities and environmental concerns, I also witnessed resilience and spirit. This experience expanded my worldview, leaving me with a deeper understanding of Louisiana's complexities and a profound appreciation for its warmth, resilience, and diversity.

7 Carbon analysis

During the internship, as the university is huge, I bought a Bike. I estimate the carbon amount for the bike crafting at 5g, I won't count it in my global carbon analysis. I took a plane to actually go to the internship. For economical issues I did not took a direct flight. According to hellocarbo.com, the global carbon amount for a passenger in a plane is 9 kgCO2/100km/passenger

France - USA:

flight	distance	carbon amount
Paris - Munich	684.27 km	61.6 Kg
Munich - Houston	8 719 Km	784.7 Kg
Houston - New Orleans	510.36 km	45.9 Kg
Total		892.4 Kg

USA - France:

flight	distance	carbon amount
New Orleans - Washington	1 552.28 Km	139.7 Kg
Washington - Montreal	790,43 km	71.1 Kg
Montreal - Paris	5.507,11 km	495.6 Kg
Total		706.4 Kg

As I mentioned in this report I visited some trips and visited other states. I took flights for it because internal flights are really less expensive than bus. the common transportation are really underdeveloped in the USA. (I had some flights for $10 for example)

I visited Boston:

flight	distance	carbon amount
New Orleans - Boston	2.185,80 km	196.7 Kg
Boston - New Orleans	2.185,80 km	196.7 Kg
Total		394.4 Kg

I visited the West Coast:

flight	distance	carbon amount
New Orleans - Los Angeles	2.696,04 km	242.6
Los Angeles - Las Vegas	361.45 Km	32.5
Las Vegas - Grand Canyon(By car + we were two)	209 km (round trip with 2 people)	20.3
Los Angeles San Francisco	559.12	50.3
San Francisco - Houston	2627	236.43
Total		582.13

I visited Houston:

I rented a car and we were 5. According to fournisseurs-electricite.com, the amount of a car for a full reservoire from a car is in average 0.259Kg we used 2 times the reservoir, so 0.518/5 = 0.1036 Kg.

I took bus several times for new Orleans:

According to ecoinfo.cnrs.fr, the carbon footprint of a bus is 0,0743Kg/km/passenger.

the driving distance is 221.60Km, my footprint carbon on each traven is then 0.0743*221.6 = 16.4 Kg.

I took the bus let's say 10 times (because I may take it again before my departure) so the global footprint of my bus travels are 164Kg of CO2.

Globally:

If we take the previous totals:

892.4 + 706.4 + 394.4 + 582.13 + 0.1036 + 164 = 2739.43

With 2739.43 Kg of CO2, my carbon footprint with this mobility is almost 3 tons.

The CO2 footprint for a french person is in average 6.9T/year. In four monthes, with only transportations, I am almost at the half.

8 Conclusion

To conclude, I had a wonderful experience in The University of Louisiana at Lafayette. People in Louisiana are chill and I had a warm welcome. Dr Gottumukkala trusted me and offered me really interested projects. He let me do things my way with some supervision. I enjoyed working in the laboratory. I expanded my network, made friends, visited awesome places. I had a really amazing and interesting experience, I discovered a new culture, and I won't see the world in the same way as before from now.

9 Appendix

Provided with this document, should be the following elements:

- A ROS2 Package for the University of Louisiana's Omni- directional Robot (PDF)
- Work Done List Table (CSV)
- Guide for camera streaming with ROS/ROS2 (PDF)
- How to integrate a sensor on ROS (PDF)
- Guide for ROS dashboard (PDF)