Université Paris Cité

English Group Assignment

Project L3Q1: Robotic Chandelier

Team members	**Signature**
Lina Djihane AZIZA	
Mohamed El-Amine MAZOUZ	
Simon GROC	

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1. Context

Flora Lumina is an innovative light art project designed to resemble a flower. It is a robotic chandelier that boasts eight petals capable of fluidly opening, closing, and illuminating in an array of colors. Integrated with a myriad of sensors and orchestrated by a WEMOS D1 microcontroller. Our objective is to emulate the organic behavior of a flower, engaging visitors through dynamic interactivity. Furthermore, we aim to develop a website, granting users remote control capabilities to manipulate the chandelier and elevate their immersive experience.

Our team, guided by Mr. Olivier Gossat, aims to enhance and showcase this sophisticated robotic chandelier at Nuit Blanche in Paris on June 1, 2024. The goal is to create a highly interactive and dynamic light installation that mimics the natural behavior of a flower, responding to environmental changes and visitor interactions.

2. Goals and Problems to Solve

2.1. Goals

- Complete and enhance the existing robotic lighting project.
- Ensure the chandelier can be controlled via a website
- Ensure the chandelier can interact dynamically with its environment.
- Exhibit the final product at Nuit Blanche 2024.

2.2. Problems to Solve

- Ensure reliable control via the microcontroller.
- Achieve smooth, realistic petal movements.
- Integrate multiple sensors seamlessly.
- Ensure functional lighting.
- Create an engaging and interactive user experience.

2.3. Resources Available

- Existing robotic chandelier prototype.
- Computers equipped with the software necessary for development.
- Various electronic components: a microcontroller, LEDs, sensors, stepper motor and its driver.
- Team of students majoring in computer science.

2.4. Time Frame and Deadlines

- Project start date: January 22, 2024.
- Intermediate review: April 2024.
- Final testing and adjustments: May 2024.
- Exhibition date: June 1, 2024.

2.5. Team Members

- Olivier GROSSAT (Supervisor)
- Lina Djihane AZIZA
- Mohamed El-Amine MAZOUZ
- Simon GROC

3. Planning

3.1. Role Assignments

- **Olivier GROSSAT (supervisor):** Overall project coordination, communication, and milestone tracking.
- **Lina Djihane AZIZA:** Developing the website's interface while ensuring connectivity between the front-end and the hardware components, WiFi configuration, structuring the codebase, light effects and color changing functionality and automating the chandelier's behavior to mimic a real flower.
- **Mohamed El-Amine MAZOUZ:** Reading real-time sensor data and displaying it on the website. Controlling LEDs and their different light modes. Automating the flower's behavior to mimic a real flower. Working on the hardware and physical assembly of the chandelier.
- **Simon GROC:** Programming the movement of the petals using a stepper motor to bring the chandelier to life with manual and automatic positioning systems, using environmental sensors to simulate the behavior of a real flower.

3.2. Organization and working methods

- Project management tool (La forge de Maths-Info) for task tracking and collaboration.
- Throughout the project, agile methodologies were employed to ensure flexibility and continuous improvement. We adopted an iterative approach, breaking down the 12-week timeline into smaller sprints, each lasting one week. At the end of each sprint, we conducted reviews to assess progress, gather feedback, and identify areas for enhancement.

4. Technological Tools

4.1. Hardware

- **Component Placement:** Arrange and integrate all necessary electronic components within the chandelier structure. This includes:
  - Microcontroller: WEMOS D1 mini.
  - Sensors: brightness sensor, weather sensor, motion sensor, microphone.
  - LEDs: RGB LED rings and strips
  - Stepper motor and its driver.
- **PCBs (printed circuit boards):** Design custom PCBs to ensure precise and organized component placement, optimizing space and providing reliable, durable connections.
- **3D Printed Supports:** Design and print supports for electronic cards using a 3D printer to ensure secure and organized placement within the chandelier.

4.2. Software

- **Backend (Microcontroller Programming):**
  The backend development for our project involved coding the WEMOS D1 mini microcontroller using C++. Our primary goal was to create efficient, responsive control algorithms for the chandelier's various functions, including sensor data processing, petal movement, and lighting effects. We prioritized writing clean and optimized code to ensure smooth operation and minimize latency.
  To maintain a lightweight and efficient codebase, we minimized the usage of external libraries. Instead, we relied on core C++ functionalities and a few essential libraries only when absolutely necessary. This approach helped us maximize the microcontroller's limited memory and processing power, ensuring reliable performance and quick response times. By writing most of the control logic and sensor integration code from scratch, we were able to fine-tune the operations to meet our specific needs and constraints.

- **Frontend (Website Development):**
  The frontend development focused on creating a user-friendly website interface to allow remote control of the chandelier. We used HTML, CSS, and JavaScript to build a clean, intuitive interface that exhibition visitors could easily navigate. The website's design emphasized simplicity and responsiveness to ensure a smooth user experience across different devices.
  Similar to the backend, we aimed to keep the frontend code lightweight by

minimizing the use of external libraries. We opted to write most of the functionality using plain HTML, CSS, and JavaScript, avoiding heavy frameworks that could slow down loading times. This decision was critical not only for ensuring quick interactions but also for making sure the code could be efficiently uploaded and run on the microcontroller.
To enable real-time communication between the website and the microcontroller, we used AJAX for asynchronous HTTP requests. This allowed us to update the chandelier's state based on user inputs without needing to reload the entire page, providing a seamless and interactive experience.

5. Project Progress

5.1 Progress

- **Week 1-2:** Established project scope, detailed planning, and assigned roles. Initial setup of project management tools.
- **Week 3-4:** Conducted in-depth technical research. Began preliminary hardware setup and coding.
- **Week 5-10:** The development phase of the project spanned six weeks, during which we employed an iterative approach to prototyping. In each cycle, we developed new prototypes, gradually integrating additional features and refining the chandelier's functionality.
- **Week 11-12:** Made final adjustments, conducted comprehensive testing, and prepared for the exhibition.

5.2. Obstacles

- Ensuring the chandelier can position its petals at any angle.
- Developing a system for acceleration and deceleration to ensure smooth petal movements.
- Noise reduction: implementing strategies to minimize motor noise.
- Thermal management: overheating Prevention by designing a pattern for electronic card placement and ventilation.
- Calibration of sensors to ensure accurate data.
- Ensuring smooth and responsive control through the website.
- Managing team dynamics after the departure of a key team member.
- Managing defective material.

6. Final Results

The final result was a fully functional robotic chandelier that met the initial project goals. It successfully opened, closed, and changed colors in response to environmental stimuli, providing an engaging and interactive experience for exhibition visitors. Additionally, the website we developed, which allowed visitors to control the chandelier remotely. This added a significant layer of interactivity, enabling users to influence the chandelier's behavior in real-time.

7. Final Reflections

Throughout this project, we gained invaluable insights into the complexities and challenges of electronics projects. We learned how to effectively integrate various sensors, manage microcontroller resources, and develop interactive user interfaces. Additionally, we discovered the importance of efficient teamwork, project management and agile methodologies in overcoming obstacles and ensuring timely delivery.

For future improvements, we aim to code additional features that could enhance the chandelier's interactivity and functionality. This could include more advanced lighting effects, additional automatic modes and refining the web interface to include more customization options for users would further elevate the interactive experience.