Virtual & Physical Prototyping

Monica Bordegoni
Marina Carulli
Marco Rossoni

POLITECNICO
MILANO 1863

L I L Y

Final Exam Report
Groups 3-11

Santiago Monroy | **Thi Lanh Peruzy** | **Edward Praun** | **Ilaria Torcolacci**

1. Context Definition

Scenario

The project will aim to enhance the experiential aspect in luxurious perfume stores, providing customers with the opportunity to customise their own fragrances, creating a unique and personalised shopping experience.

Users

- Young customers (20-35 y.o.), curious, and tech friendly.
- Interested in perfumes in general.
- Open to try new experiences related to the luxurious brand.

2. Design Problems & Project Objectives

Project Objectives

The project aims to develop an Olfactory Display System prototype to elevate the perfume testing experience for customers exploring new fragrances. Using AR, this system should further immerse users in the role of a perfumer, providing them with in-depth knowledge of the fragrances they encounter, allowing them to experiment and test various perfume mixtures.

The objective is to facilitate the user testing of fragrances by giving them a physical system with a defined catalog of scents while complementing it with an Augmented reality environment that enriches the experiences by providing knowledge to the user of what the fragrance is.

Requirements

1. The Device should be able to hold **6 scents**.
2. The user should be able to operate the system **physically** while being guided **virtually (AR)**
3. The Device should allow easy disassembly for the replacement/refill of fragrances and components
4. Rely on **piezo-atomiser** technology
5. Select set of fragrances in **AR**
6. Use AR control board with **AR-Markers**
7. **Display fragrance information** when interacting with the scent

3. Brainstorming & Idea Screening

While brainstorming about the actual perfume testing, our primary concern was the issue of fragrance dispersal being too overpowering if directed straight into the user's nose. This was particularly problematic for perfumes, which have strong, sharp scents. To mitigate this, we chose to distance ourselves from devices that would be directly attached to XR glasses.

Olfactory Display Concept Proposals

We explored three options: **the first concept** was a wearable device that could be worn around the neck and indirectly disperse the scent away from the user but still in front of their face. This design aimed to provide a diffused experience without overwhelming the user.

The second idea involved a scent-strip carousel. This device would feature a rotating strip perfumed by a selection of atomizers. However, this concept was quickly discarded in its formative stages.

Finally, for **our last proposal** we devised a standalone system capable of dispersing six different scents towards the user. During the final screening, we opted for this standalone system over the wearable device. The decision was influenced by the intended use case of our product, which would be displayed in perfume shops. In such environments, a wearable device would have been unnecessary and impractical.

4. Design & Prototyping

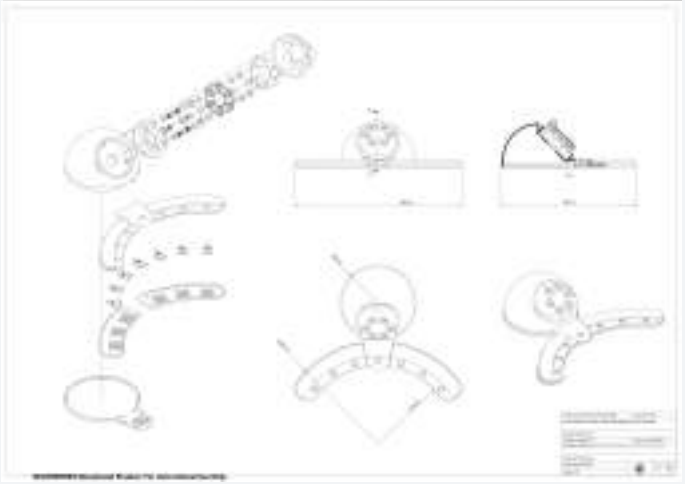
First Stage

The initial prototype was conceptual. We determined the need for 6 fragrance dispensers using 6 piezo atomisers. To control the system, we integrated an AR control board that would display the different fragrances virtually using augmented reality. It would actuate the atomisers in the physical world using 7 capacitive touch sensors, 6 for selection and 1 for activation. We arranged the atomisers in a hexagonal pattern, mimicking the "stigmas" of a Lily. A 3D-printed component held the fragrance and connected to the atomisers with a liquid-absorbing material. For optimal dispersion, we angled this "nozzle component" at 45° towards the user. Initially, the spherical casing housed all electronic components, including microcontrollers, cables, and atomiser modules. However, we found that the full sphere was unnecessarily large, so we decided to halve it.

Second Stage

In the second iteration, we discovered that the 3D-printed component absorbed both liquid and scent, making it unsuitable for holding fragrances. Additionally, it was difficult to refill, disassemble, and clean. The AR board's alignment with the main chassis was also problematic. We redesigned the nozzle assembly to hold six 2ml glass vials, which were pressed onto the atomizers in a screwed assembly. However, the caps holding the atomizers were not strong enough, causing the atomizers to be ejected from their casing. The semi-spherical chassis worked well, but the orientation of the semi-circular AR board did not make sense from a user standpoint, as it was turned towards the main device rather than the user. This lead to some virtual icons being hidden and not providing an "arena" feeling. We flipped the board's orientation to address this issue.

Third Stage



In a third iteration, we further refined the design. We fastened the atomisers in a fixed casing, allowing the nozzle assembly to be unscrewed and the atomisers to be extracted as one piece for easier cleaning and refilling. This design enabled easy separation of components, improving maintenance and transportation. The screws of the nozzle were hidden with a nozzle cap for aesthetics. The capacitive sensors on the AR board as well as the central button were also covered. This final design ensured that only the nozzle assembly had visible screws, streamlining the user experience and making the device more practical.

Currently, the two flanks of the control board can be dismantled allowing easier transportation. This was possible by having combined all 9 cables into 1 plug for each side. Additionally, the entire nozzle unit can be dismantled, decreasing the size further. Due to sizing constraints, the chassis must be opened to disconnect however. Further development will see that the separate components can be disconnected without having to open the main unit.

4. AR Experience Design

AR Designing

First, the users' interactions were discussed and defined to provide them with an educational experience enhanced by AR. This serves as a complement to the Olfactory Display, adding visual and informative content.
After selecting six fragrances, 3D models and images representing the same ingredients were downloaded and imported into Unity, using the Vuforia Package and License.
All 3D models were scaled, positioned, and animated to grow, elevate, and spin. Then, materials and colors were assigned to the objects. Meanwhile, images were printed on paper circles and uploaded to Unity as Image Targets.
The total number of targets in the AR camera's Inspector panel had to be specified, so the AR camera could recognize multiple targets at once. Objects were positioned on Image Targets, along with Canvas and Buttons, using previously designed graphic content. To enable full functionality, a script was created and uploaded. Additional buttons with related graphics were set up to function appropriately.
Lastly, the entire Unity project had to be exported to work properly on an Android smartphone.
Graphically, all content has full opacity to ensure the best visibility. Since the final objective is to implement physical interaction with additional content that is fully independent, the information provided had to be as understandable and clear as possible. For this reason, semi-transparency was not an option.

Challenges & Achievements

Throughout the process, many steps did not have positive outcomes at first, and some were not resolved at all. Nevertheless, working as a team and switching tasks with each other allowed us to achieve many results.
The main issues were related to making the camera work on the Android smartphone, as Unity had some scripts constantly running, which prevented the building and running process from exporting the project. The easiest aspects to perform and complete were the development of the graphics and their uploading to the software. Some tasks were a little more complex, but totally manageable, such as creating and animating the canvas and buttons and their interactions.

Meta Qest 3

From the start, involving VR would have ensured a fully immersive experience. However, considering the actual interaction with a physical device, AR emerged as the best-suited experience.
Still, having the opportunity to involve a visor to interact directly with the surroundings, instead of using a smartphone to tap on, enhanced the potential of this product.
The Meta Quest 3, with its outstanding high-quality resolution compared to other competitors' visors, revealed itself as a valid option for experiencing the best fragrance testing. It also offers the possibility to involve sounds in a more immersive way.

Conclusion

In conclusion, the development of the Olfactory Display System prototype with Augmented Reality (AR) was a multifaceted and ultimately successful project. We successfully integrated AR technology to enhance the perfume testing experience, meeting all of our initial requirements. Throughout the project's iterative cycles, we built on our findings and resolved issues effectively.

The system is capable of firing six scents, demonstrating robustness and ease of transportation due to its press-fitted design. However, as it is still a prototype, disassembly can be challenging because of the multitude of cables and the need to slightly open the chassis to disconnect them, which may pose a minor inconvenience. The nozzle assembly also shares this complexity.

A significant advantage is the implementation of new 2ml medical cartridges that prevent spillage by retaining liquid and can be removed together, making replacement convenient and safe. These cartridges feature a built-in hole for placing absorbing material to the atomizer, enhancing the system's usability.

The capacitive touch sensors function as intended, correctly controlling each atomizer with three different states: "SELECTED," "DISPLAY INFORMATION," and "DESELECTED." When the central control button is actuated, the correct combination of cartridges fires in the "SELECTED" state.

Regarding the AR functionalities, we successfully displayed all six scents using AR markers and provided an information window for each scent, detailing basic information and relevance. As users approach the product, they will observe that the labels on the Olfactory Display serve as markers for AR content. Users have continuous access to the project and information buttons, which, when activated, display the project description, instructions for interacting with the AR features, and guidelines for testing fragrances. By scanning the fragrance labels with their phones and tapping on them, users can trigger animations that illustrate the ingredients, causing them to enlarge and rotate, thereby enhancing the visual and informative experience.

However, integrating the AR and physical models proved challenging. While we managed to show the fragrance on the physical board correctly using the markers, the interaction remained separate since the AR control board of the olfactory system and the mobile device could not communicate. Consequently, each physical interaction on the device had to be mirrored in the AR environment. Future research and testing aim to combine these two components using the Arduino Bluetooth module.

Overall, having met all our requirements, the project was a success. The iterative process allowed for continuous improvement, and the prototype demonstrates a significant step forward in enhancing the perfume testing experience through innovative technology.