Final Report NGI

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1 Introduction

The goal of our project was to develop a modern user interface that deviates from the conventional WIMP metaphor. We set out to create a special and useful solution that not only functions as a real-world product that might one day be on the market but also adds a fun and fresh way for users to interact with it. With this in mind, we designed a SmartTable system that utilizes a cube-based interface that used LED lights and sensors specifically to tailor for client-waiter interactions in coffee shops or other food-based service facilities.

Central to our project is the emphasis on aiding individuals with disabilities by providing them with a visually intuitive means of communication with the waiter, while also simplifying the waiter's tasks during busy periods. By integrating a cube-based interface, we offer a fresh and engaging method for clients to interact with the system and for waiters to streamline their operations during peak hours.

The intended users of our SmartTable system are both the waitstaff and the customers of the dining facility. By incorporating different modes and functionalities, such as requesting the waiter's attention, asking for the bill, indicating a preference not to be disturbed, or marking the table as occupied, we ensure a seamless and intuitive interaction experience for clients. Similarly, waiters can use the system to set a table as reserved or turn off specific functionalities as needed, enhancing their workflow improving the workplace's productivity To further enhance the user experience, our SmartTable system features an ultrasonic sensor that accurately detects when a client is seated. This eliminates the need for manual communication or signaling, ensuring a more convenient and inclusive dining experience for individuals with disabilities.

In the sections that follow, we will provide a more detailed explanation of our SmartTable system's design, requirements, technical aspects, and implementation challenges. By prioritizing accessibility and user satisfaction, we aim to contribute to the advancement of human-computer interaction and create a more inclusive environment for both clients and waitstaff in food-based service establishments.

2 Problem statement

This project aims to create a SmartTable. What necessitates the need for it? Consider being in a busy restaurant where you have to wait for the host to assign you a vacant table. After being seated, you must signal the waiter to take your order and subsequently bring you the bill. In case you are there during rush hour, you need to be loud and active so that you can make sure the waiter heard you. It is not an ideal situation and it is even worse for individuals with social anxiety or disabilities. Dining out is supposed to be an enjoyable experience for all and there is no reason for the customers to be subjected to any kind of donating or stressful tasks. So with this problem in mind, our table aims to alleviate this challenge.

3 Requirements

3.1 Initial Functional requirements

- The system should identify when a user is seated at the table.
- The system should provide an interface for both user types (client, waiter) to input commands.
- The system should visually show the confirmation of a command executed by both user types (client, waiter).
- The system should show visually the current state of the table.
- The system recognizes these commands: occupied table, the client wants the attention of the waiter, the client does not want to get disturbed, client requests the bill, table reserved.
- For each of the commands the visual confirmation should use a different color.

3.2 Added Functional requirements

- The system should display a default color without receiving any command.
- The system should have a gradual and not sudden change in color from the default display to a different color when receiving any of the recognized commands.
- The system should through auditory means(there is a sound to indicate the system received the commands) show the confirmation of a command executed by both user types (client, waiter).
- The system should shut down for a command outside of the cube interface. (when the waiter used a sticker not in the cube)

- The system should identify when a user is seated at the table for the first time and switch to requesting waiter mode.

3.3 Initial Environmental requirements

- The system's visual indicators should be visible in a variety of lighting conditions.
- The system interface should be able to work under different light and sound conditions.
- The system's visual indicators should be visible no matter the position of the table.
- The system should not interfere with the intended use of the table.
- The system should withstand any incident common to restaurant tables.

3.4 Added Environmental requirements

- The system should have auditory indicators that alert but do not disturb the client.
- The system should not have more than 10 seconds of delay to respond to commands.

3.5 User characteristics

- Client: The expected skill set of the client is a novice and he is supposed to intuitively understand how to use the device through the visual stickers we have provided.
- Waiter: The expected skill set of the waiter is expert.

3.6 Usability goals

- Learnability: The user can work out how to use the interface intuitively and by seeing the stickers.
- Safety: The waiter can use an outside command (sticker) to turn off the system.
- Efficiency: Once a user has input a command, the system must be 100% correctly responsive.

3.7 User experience goals

- Using the command interface should be an enjoyable experience.
- The system engages with the user through a tangible user interface.

3.8 Use Cases

This is an overview of the specific use cases we have implemented for our users: There are five use cases for the client:

- When they sit in the chair, the sensor knows there is a difference in distance and the LED lights turn from green to blue.
- When the client turns the cube to the bill sticker (they want the bill, the LED lights turn yellow.
- When the client turns the cube into the waiter's cube (they require the waiter's attention), the LED lights turn blue.
- When they turn the cube to the do not disturb stickers, the cube turns white.
- When they want to set the table as occupied (they may need to go outside for a call, or use the bathroom but not lose their spot) they turn the cube to the reserved sticker and the lights turn red.

There are three use cases for the waiter:

- When they need to reserve the table for a client, they turn the cube into a reserved sticker and the LED lights turn red.
- When they want to turn off the system, they put another sticker on the reader, and the lights are turned off.
- When the client leaves, the waiter can set the table back to available by turning the cube to that sticker and the color turn to green.

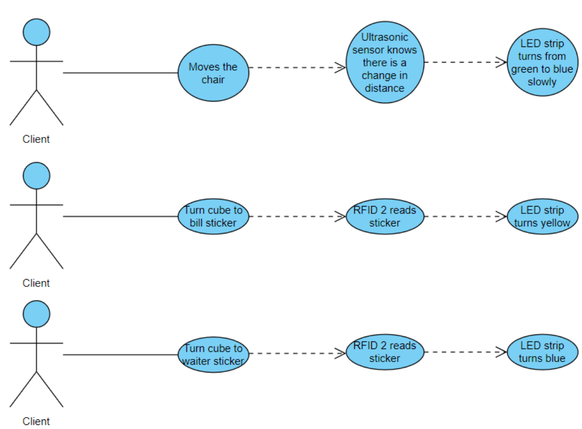


Figure 1: The different use cases for the client

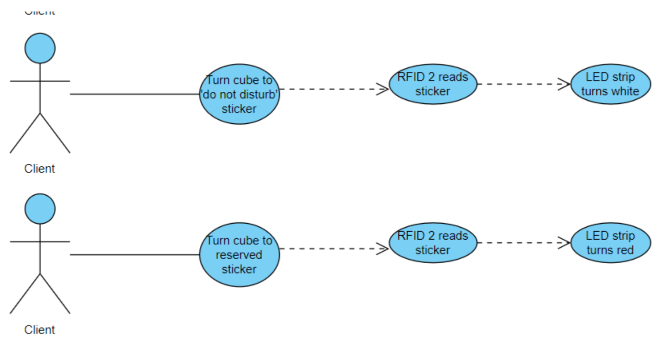


Figure 2: The different use cases for the client

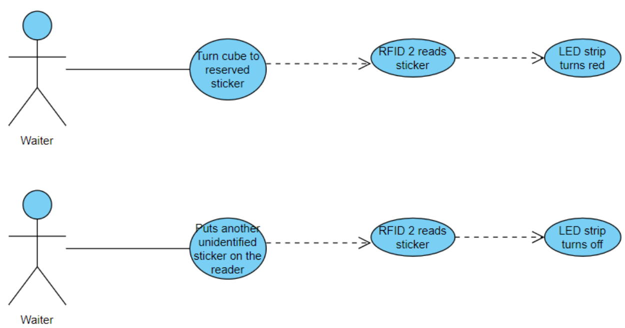


Figure 3: The different use cases for the waiter

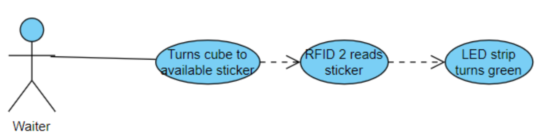


Figure 4: The different use cases for the waiter

4 Design of the SmartTable

In our design, we drew inspiration in the examples discussed in the lecture: Tangible, Embedded and Embodied Interaction by Prof. Beat Signer[1] as well as in the cover story Radical Atoms: Beyond Tangible Bits, Toward Transformable Materials by y Hiroshi Ishii, Dávid Lakatos, Leonardo Bonanni, and Jean-Baptiste Labrune [2]. This was our initial design:

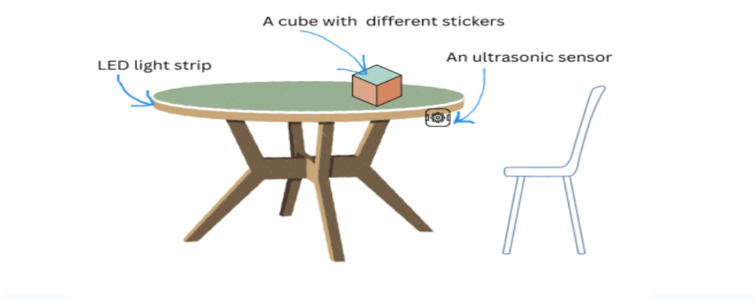
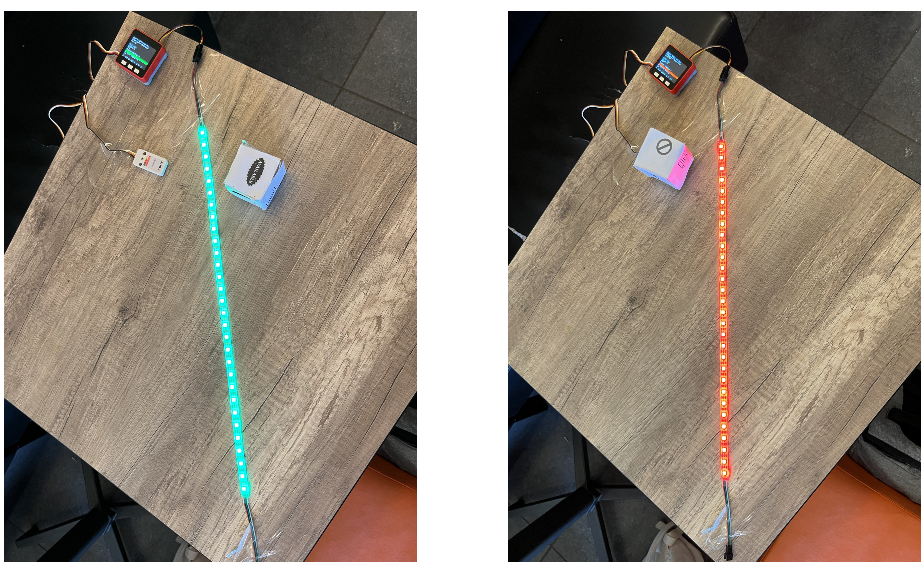


Figure 5: Design of the table

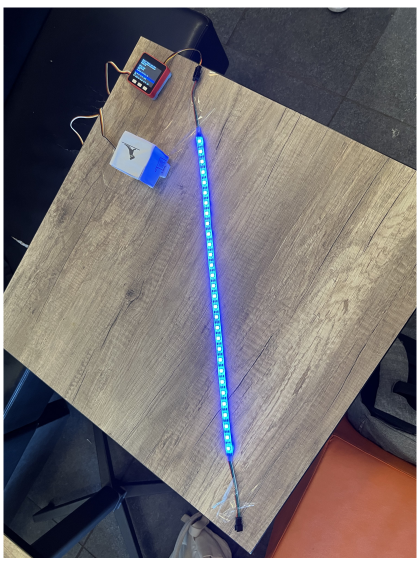
The final product:



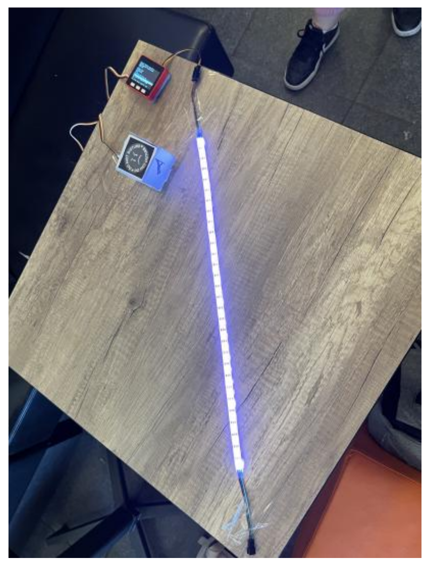
(a) Available

(b) Reserved

Figure 6: The table for reserved or available mode



(a) Waiter please!



(b) Do not disturb

Figure 7: The table for when the waiter is needed or the clients want to not be disturbed

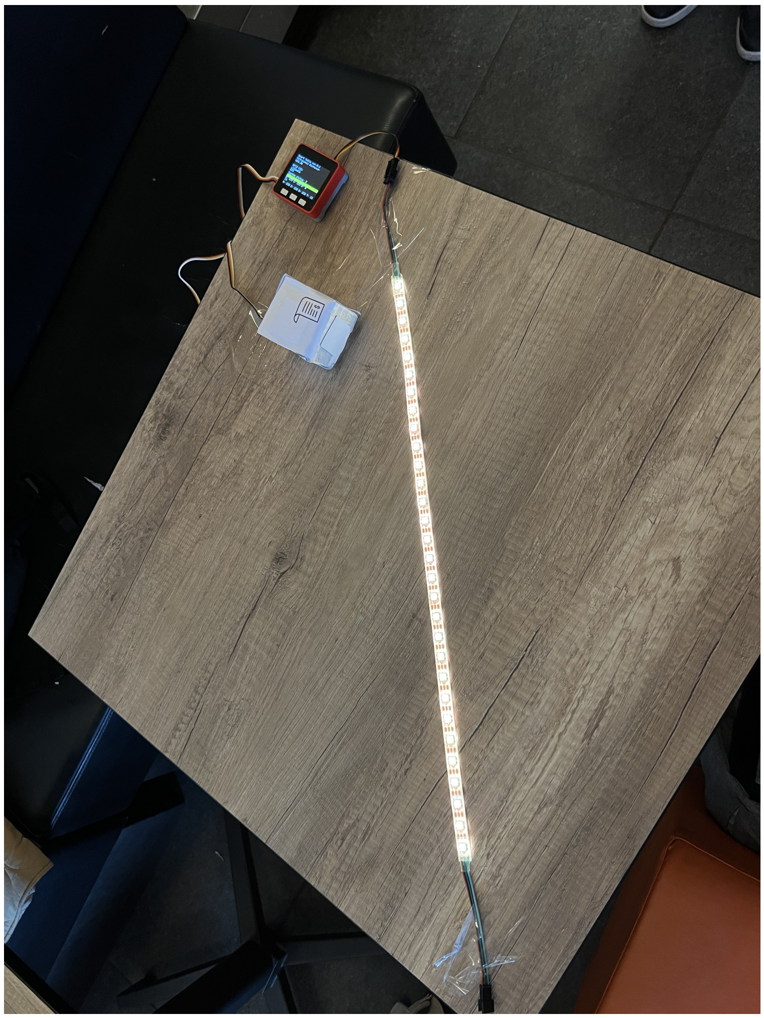


Figure 8: Bill, please!

As we can see in the pictures, the only difference is the fact that the LED lights are now across the table and not on the side. This was a more practical decision as the LED strip we used was not wide enough to cover all the sides of the table. The cube has stickers on five sides and it is quite intuitive to see, what each sticker means.

5 Technical Implementation

5.1 Hardware

- A FIRE M5STACK device is used to make the connection between all the devices as well as to have another visual display to the change in state and the change in distance.
- Ultrasonic distance unit was used in order to calculate the distance between the sensor and the chair. When the chair moves therefore the distance changes we can assume the client wants to sit and we display a change of color from green to blue.
- LED Strip was used as a visual display of the change in command. When the system signaled a command the LED strip changed color.
- 5 NFC stickers on the sides of the cube: As mentioned in the design part, the stickers are under the paper so as to not be seen by the client. When they are read by the RFID 2 Unit, the system knows the command and changes the color accordingly.
- RFID 2 Unit was used in order to the NFC stickers.
- Carton cube was the interface through which the user can give different commands.
- Wires to make the connection in between the devices

5.2 Architecture

The code used as base the corresponding examples for each device in the M5Stack GitHub repository [3]. The device runs with the default sketch structure of Arduino using C++. There are two main functions that every Arduino program has: the setup and the loop. In the setup the sensors are initiated alongside the setup for the LED strip and the speaker in the device. In the loop is where the main logic of the program resides.

The system work as follows inside the loop function:

- The system checks if there change in the corresponding sensors:
  - RFID reader: when there is a new tag detected, the UID of it is stored in a string. With the UID the system can select the new

system status code depending on the value. These are in an array with the code being their position in it (going from cero to four, each for one of the statuses on the cube) and a fallback status for unregistered UID's (number nine).

  – Ultrasonic sensor: In the case of the ultrasonic sensor there need to be a total of ten consecutive reads with a threshold distance superior to 800 mm (and system status equal to zero) then the status code would become five.

- If the status changes it means that the LED colors need to update as well. In this case the target color and color transition steps are defined depending on the status code. For statuses zero to four and nine use the short transition with 15 steps (three seconds) and the long transition with 300 steps (one minute) for status code five.
- If the status changes a short beep would come from the device speaker to confirm the change.
- The color transition would continue until the target has been reached.
- The loop restart for new possible events.

5.3 Challenges

While initially we choose to use a M5Stack Core2, there was signal interference when we used all three ports. So with the suggestion of the teacher assistant, we switched to FIRE, through which we had no problems. The ultrasonic sensor had some trouble calculating the distance and was not always accurate. Eventually, we decided to make the LED lights change when it sensed a change in the initial distance. Therefore the lights turn from green to blue only the first time the client sits down. This will be better as there is no need for a change anytime the client moves.

6 Evaluation

6.1 User Feedback

For the user feedback, we presented our project to 10 users. One of them was the waiter in the "Opinio" cafe, who has years of experience and the other nine were random people who have been clients in dining establishments before. After displaying the project we gave them a form to evaluate our project where we asked them several questions about their experiance with the project and if they had any remarks.

In our questionnaire, we instructed them to indicate their level of agreement or disagreement based on a Likert scale which ranges from 1 to 7. On this scale, 7 indicates a strong positive response whereas 1 represents a strong negative response.

We have displayed the average of all the responses from the users in the graph below: In the graph, "supportive", "easy", "efficient", "clear", "exciting",

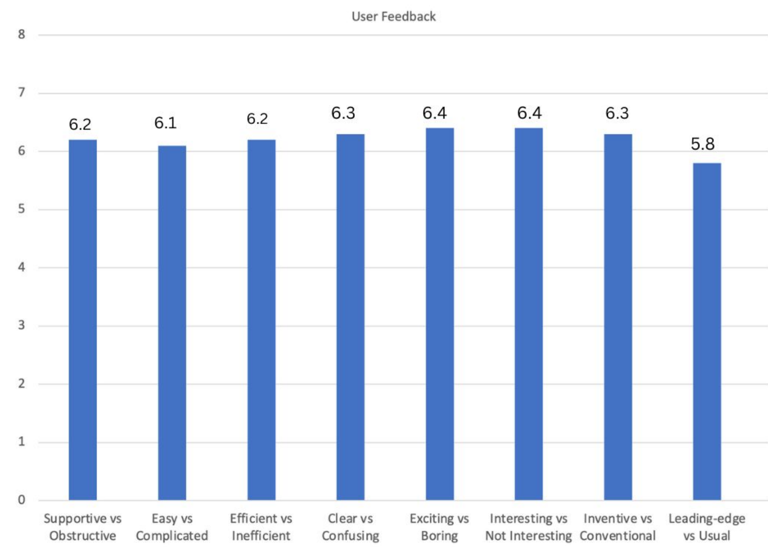


Figure 9: User Feedback

"interesting" and "leading-edge" refers to the positive attributes. On the other hand "obstructive", "complicated", "inefficient", "confusing", "boring", "not interesting", "conventional", and "usual" refers to negative attributes. These negative attributes highlight limitations.

We have calculated the average of all the feedback we got from different users and put it on the bar chart. As we can see most users find the product exciting and interesting but not really as cutting-edge.

6.1.1 Insights from the waiter

As we said earlier that we went to our school's cafe and took feedback from the waiter. He enjoyed our product and stated that it touches upon a real need in the market, as Brussels is a busy metropolis with many dining establishments but there is not much innovation in regards to the service and the heavy workload. Some of the things he suggested we improve:

- Adding a dashboard that displays all the tables and their current color. This way the waiters could see the status of the tables when they are in the kitchen for example.
- Integrating a whole network of tables on a central hub for the staff would be a useful development for the product.

6.1.2 Insights for Improvement from Users' Perspective

Other than rating through the Likert scale, the users also gave a few feedbacks both positive and negative that can be improved. Some of the major points are stated:

- It would be useful for the cube to be integrated into the table.
- Not all the stickers give a clear idea on what mode to use the cube for.

6.2 Performance Metrics

1. Response Time: When it came to the distance detector, it takes on average 7 seconds for the system to realize the client is sitting at the table. We run the evaluations 20 times.
2. LED Lights Responsiveness: We run the system 20 times in order to get a fair average. The system detects the command right away, but it takes on average 9 seconds for the color to fully change. The slow change is on purpose as we do not want the change to be too soon and bother the client's eye.
3. Consistency of LED Lights: The lights are 100% consistent. We run the commands 20 times and they were never wrong.
4. Sound Indicator Accuracy: The sound is 100% consistent. We run the commands 20 times and the sound was never missing.

6.3 Limitations and Future Work

There are some limitations to our project. The ultrasonic sensor is not very reliable, as it takes some time for it to understand there is a change in distance, and therefore to alert the system. As there is only one sensor, it can only tell if one person is sitting, and they need to be sitting in the position where the sensor it. LED lights changing is a bit slow, we believe this is better so as to not disturb the client's eye. But some clients may not like having to wait. The fact that the product is not water resistant in not ideal for a device used in dining and drinking establishments.

There are also some things we would like to improve upon in future implementations. The material of the cube would be wood and the stickers would not be paper but plastic. This would make the cube less delicate as well as more ascetically pleasing. As mentioned in the limitations part, We would like to find a way to make the device water-resistant. The ultrasonic sensor would also need to be replaced. The product uses wires to make connections, in the future, we would like to implement something seamless. Right now the cube is placed on top of the RFID sticker, in the future we would like for there to be a set station for the cube.

7 Conclusion

In conclusion, the SmartTable project is implemented as a new and creative user interface. It offers the use of a cube-based interface supported by ultrasonic sensors, LED lights, and NFC card readers to give the user an easy experience in a coffee shop or restaurant. Our user feedback, taken through forms also shows positive results, with most testers finding the product supportive and interesting to use. Of course, the project has its limitations and shortcomings, but overall we think it showcases an innovative way to improve the dining experience.

References

[1] P. Beat, "Tangible, embedded and embodied interaction." Lecture, 2022.

[2] H. Ishii, D. Lakatos, L. Bonanni, and J.-B. Labrune, "Radical atoms: beyond tangible bits, toward transformable materials," *interactions*, vol. 19, no. 1, pp. 38–51, 2012.

[3] "m5stack/M5Stack: M5Stack Arduino Library," Sept. 2022.