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CONCEPTUALIZATION AND PROTOTYPING

INTERFACE TECHNOLOGIES

UNDER THE GUIDANCE OF PROFESSOR TIAGO CRUZ

2024

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INTRODUCTION:

This report focuses on the conceptualization and prototyping stages of the proposal. In this scope, we will present the project's concept and explain the complete design and implementation process up to this moment, including the development of the idea, the implementation strategy, the critical issues analysis and the current stage of development of our functional prototype. The goal is to show the whole development process, explaining every step from abstract, to concrete, to physical.

THE PROJECT:

1 - CONCEPT:

Our project is a New Media Art installation that intends to attribute to the visitors a central role in the creation of the piece in itself, enabling participation through interaction. The goal is to create a digital portrait based on each person's opinions and choices, which will affect the visual results, which is then uploaded onto a digital mural. The installation is divided into two different parts featuring two different devices, one of which is designed by us and collects the data inputs, and the other being FeedNPlay, where the results will be outputted. The visitors will have the opportunity to interact with the first object, answering questions and taking a "picture" of themselves; this data will be stored and used to output the visual result on FeedNPlay. The answers are stored in .dat files and associated to a RFID card's unique ID. The visual results feature the body outline of the visitors filled with textures generated by a Processing sketch based on each visitor's questionnaire answers that represent themselves, since the questions are designed to do so, much like a personality quiz but taking a different approach to what is asked.

2 - DEVELOPMENT OF THE IDEA:

2.1 - THE CONCEPTUALIZATION PROCESS

2.1.1 - Researching References

After researching the fields of interest related to our project as well as work references we focused on narrowing down the options and on selecting works that directly influenced the development of the concept, as shown on the state of the art report. The process of research allowed us to understand what already existed in order to think outside the box and to try and explore new elements, like the usage of RFID tags, which seemed largely unexplored thus far.

2.1.2 - Conceptual Definition

The research process helped us to define the concept behind the project. After concluding the research stage, the first step we took was to reanalyse both the proposal and the research to better outline what we needed to take into consideration while developing the concept. After determining the needs that needed to be met, we started to discuss ideas that fitted those criteria.

Since we wanted people to feel like they were a part of the experience, interaction was a key concern, and, like also shown previously on the state of the art, we felt that retrieving people's data was an excellent way of giving a crucial role to people that interacted with the artifact, so that they felt completely immersed in the experience. This also lines up with our idea to include the visitor's outline, which constitutes a very important representation of individual identity. The definition of a theme came into play at this phase of the development. The idea was for people to share their opinions or feelings regarding a certain thematic, this way visuals deriving from data could be produced to reflect someone's thoughts or emotions. In this scope, we determined that it would be interesting to use personality tests as a reference because they aim to represent the individuality of each person which is what we were looking for with our concept. Although the idea was fitting we felt like the approach was not, since it is overused and cliché. Taking this into consideration, we have decided to opt for a more nonchalant approach asking questions that reflect opinions but without an extremely serious tone, opening space for a carefree reflection about choices we could make as individuals and about what we prefer and why, even though there is no deep sense underneath. The goal was to make the experience fun and joyful, setting it apart from the usual approach works like this tend to choose.

2.1.3 - Target Audience

The definition of the target audience was important to understand the wants and needs of the public we were directing our project towards. This helped in the decision making process later on, when defining the object and its interactive features.
We determined that our target audience is mostly the people in the Department of Informatics Engineering (this includes students, teachers, researchers, and faculty members), and especially those who are usually prone to see and experience the projects displayed on FeedNPlay. From our experience, that subgroup usually includes more curious people with a tendency to enjoy exploring and taking part in these "social" projects, however, this audience has also seen several projects displayed on FeedNPlay, and so our projects need to visually stand out and capture the audience's attention.

2.2 - DEFINING THE PROJECT

2.2.1 - Artifact and Interaction Definition

At this stage of the development, defining the artifact we wanted to create based on the information we gathered previously was crucial. The starting point was to brainstorm different approaches to the problem. After sharing multiple concepts that could inspire our project, we developed an idea that stood out among everything. It emerged from the game *Keep Talking and Nobody Explodes,* particularly from the modules of the bomb featured in the game. We found the interactions with the gadget to be entertaining and started to think about the modules, the interactions they allowed and how they could be implemented in the scope of this different approach directed to New Media Art. One of the modules has various wires with different color schemes and we thought that it would be fun if we allowed people to interact with multiple color wires with certain meanings and their choice could be translated to visual graphics, like we defined previously.

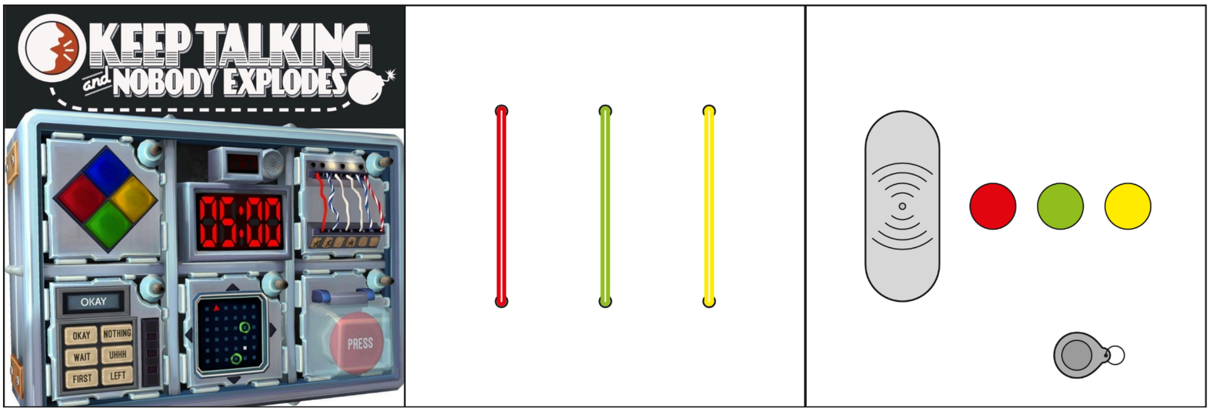


Fig. 1 - *Development of the Idea*

The idea evolved into using RFID tags to select multiple options which were combined in different forms to achieve a visual result that derived from data inputs, but we wanted something that represented even more each person that interacted with our object, and so we decided to implement a camera to capture people's body outline and integrate that with the idea of combining multiple layers through textures. Generating textures to fill the shapes created enabled the combination of both ideas into one concept that made sense. At this stage, we realized that the perfect way to showcase this concept would be through the creation of a FeedNPlay installation, divided into two separate parts: an interactive object that allowed the retrieval of data, and the screen that showed the final result. We also thought about the possibility of adding more sensors to detect further data, personalizing the experience to a larger extent.

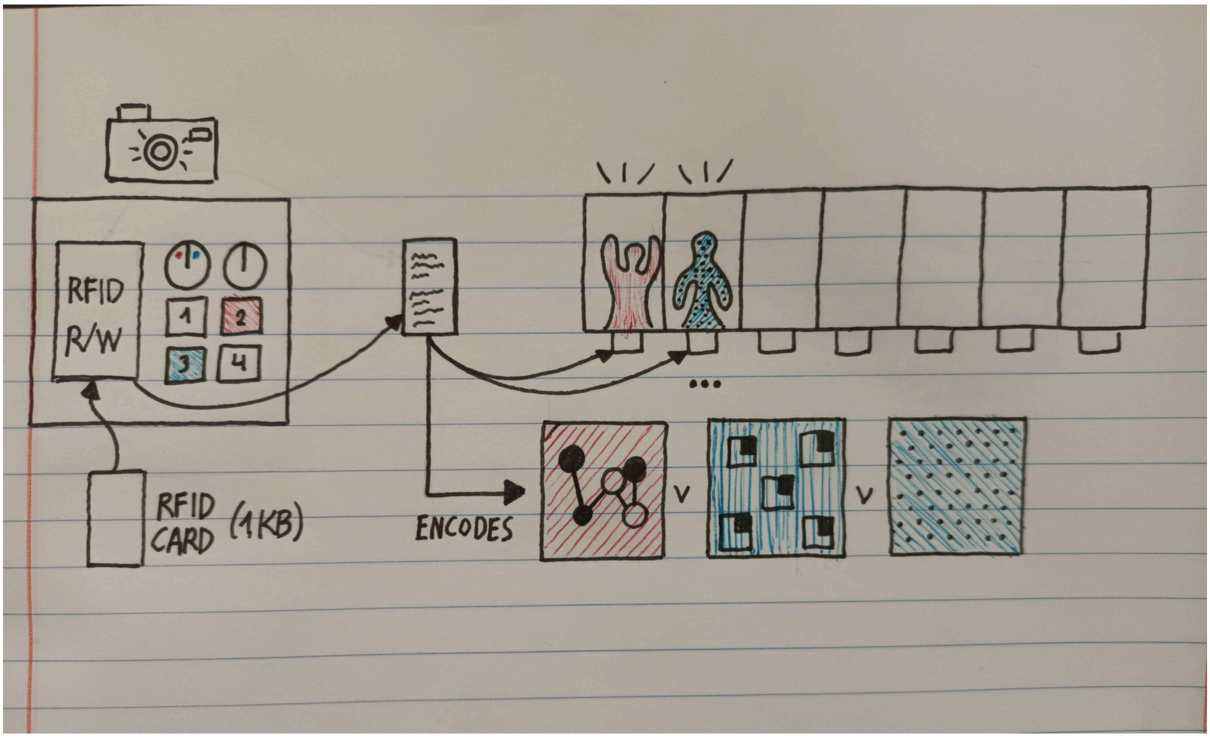


Fig. 2 - *First sketch of the project*

Refining the interaction was the next step of the process. The goal was to develop an interactive device that was intuitive and fun but that translated people's thoughts and opinions, so we needed to consider our target audience and user interaction.

2.3 - PROTOTYPING

The prototyping phase was decisive in the artifact's development. This phase helped us to test options for the development of the final artifact, allowing us to identify potential problems that could later appear. Being mindful of the interaction with the visitor was crucial so that we could understand how to translate to a physical object the idea behind it. We started by making low fidelity prototypes to better determine the best fit among the possibilities. Testing several options for the interactive installation's objects and respective layouts allowed us to come to a final result regarding our goals.

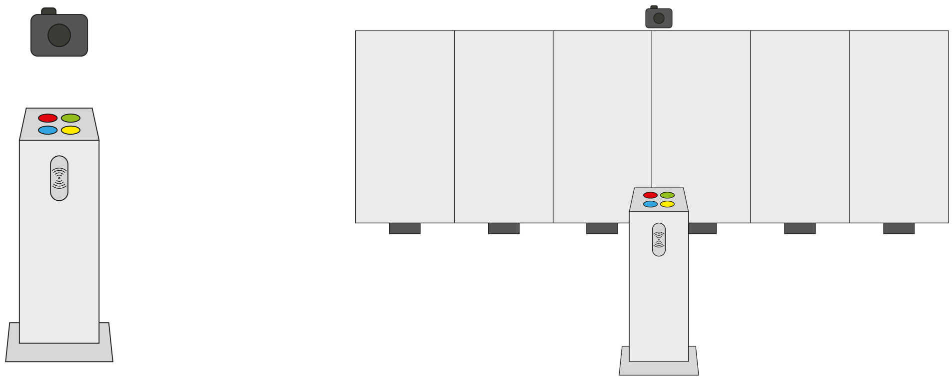


Fig. 3 and 4 - *Prototype test of the device and installation, respectively*

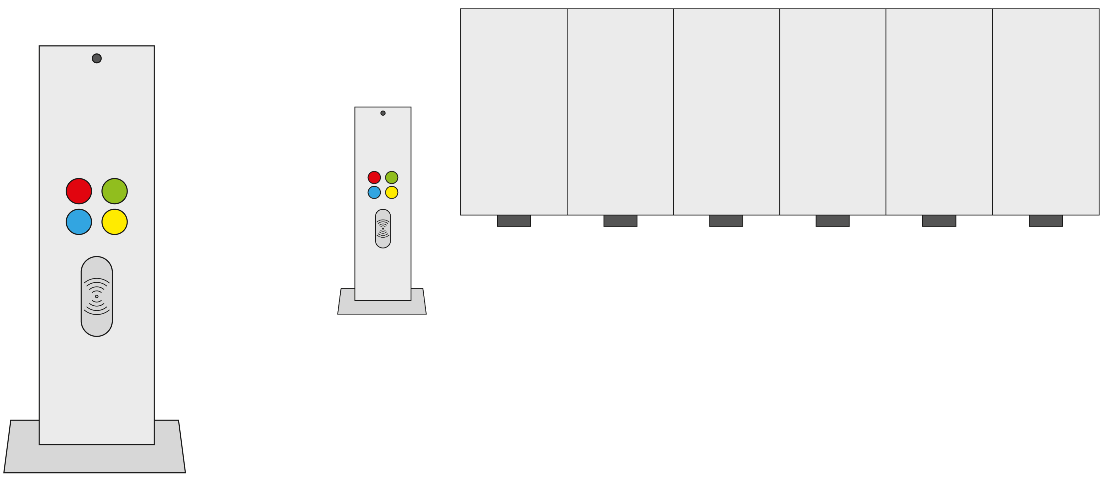


Fig. 5 and 6 - *Prototype test of the device and installation, respectively*

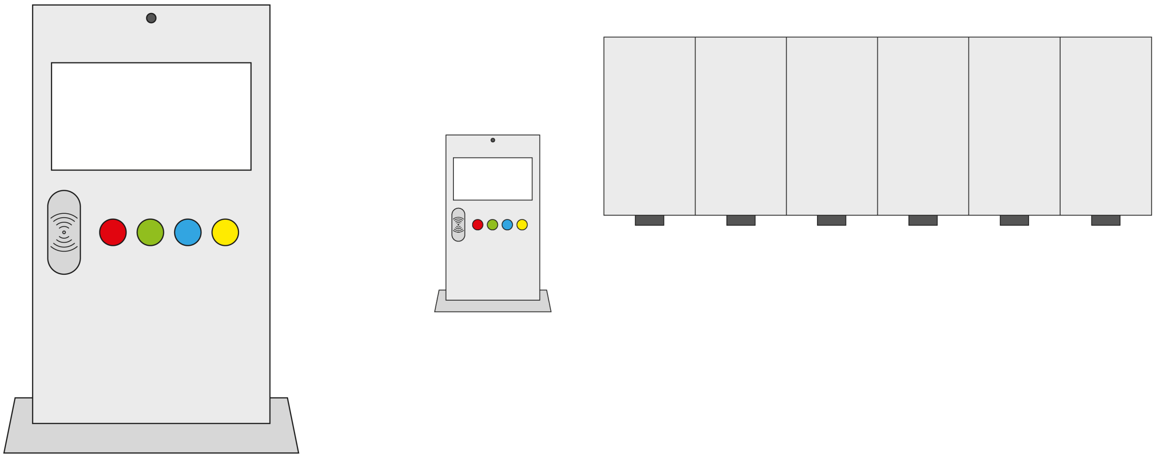


Fig. 7 and 8 - *Prototype test of the device and installation, respectively*

With the testing of different options we concluded that the usage of the FeedNPlay camera was not ideal for our project, since the angle at which the camera is positioned (high angle) did not correspond to the angle we wanted the camera to capture. Furthermore, to allow FeedNPlay to portray the visual results at all times, we needed to include a screen in the separate object that we are developing. This way, visitors can directly see and answer the questions without disrupting the visibility of the results on the FeedNPlay part of the installation. Another problem that emerged was the fact that people could not change their answer, when attributing the pressed buttons immediately to the variables in order. To avoid frustration and unwanted errors, we decided to include a "lock answer" button, to allow the visitor to better control the interaction. We also added a LED to easily confirm that the tags were read.

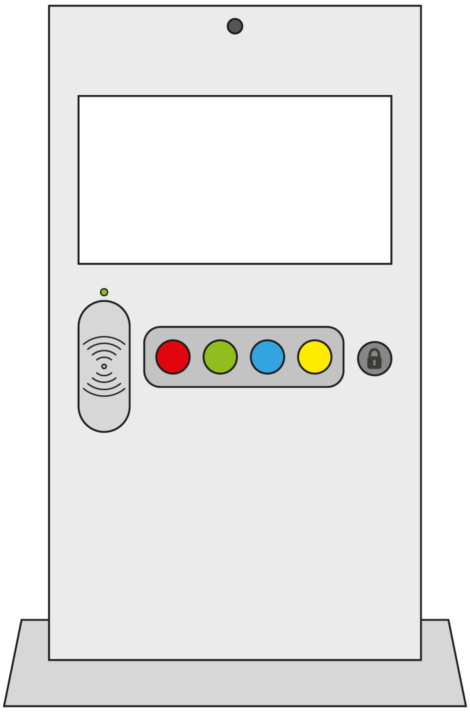


Fig. 9 - *Final device prototype*

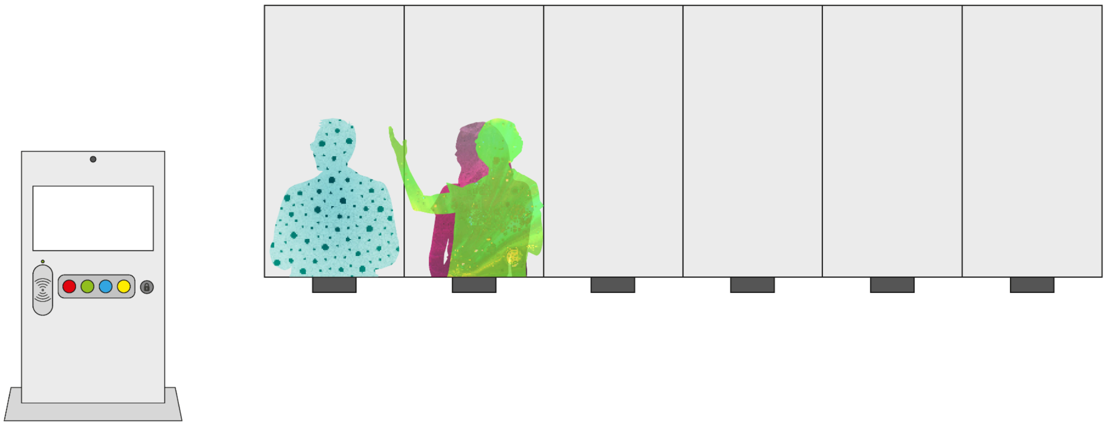


Fig. 10 - *Final installation prototype*

We also tested several ideas for the texture generation, to see what could better work visually in this context, as it will be explained later. With a better understanding of what we wanted to produce in mind, we made a storyboard to comprehend how people would interact with the installation and to settle if our prior decisions aligned with a practical and intuitive interaction we wanted to provide to visitors.

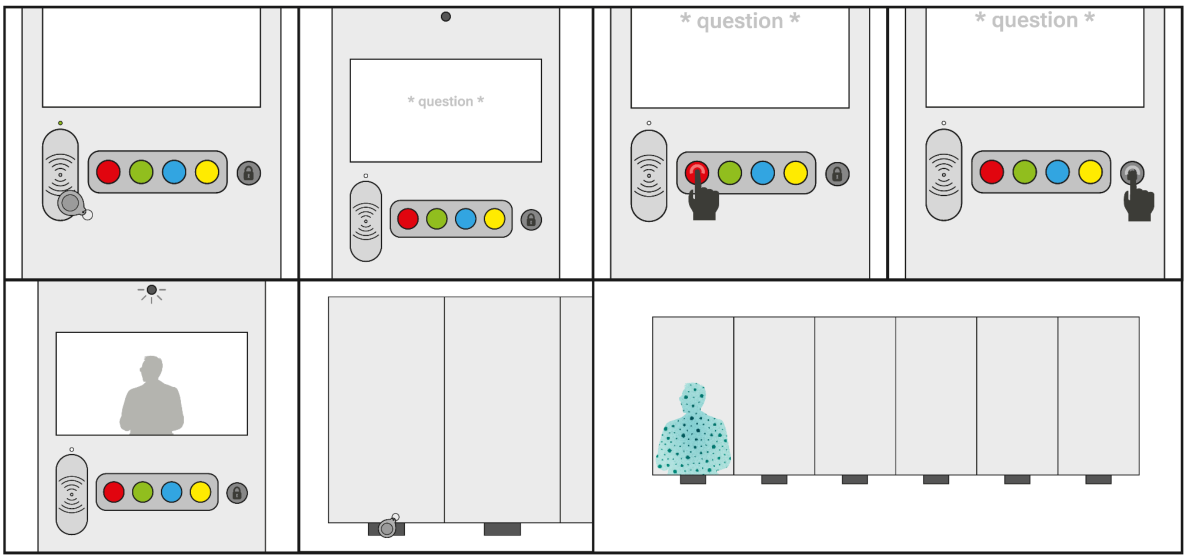


Fig. 11 - *Interaction storyboard*

The first step of the interaction is to use the available sensor to read the assigned RFID tag or card to allow the association of the resulting data to an unique ID. The next step is to press the buttons on the device placed next to FeedNPlay to make choices regarding the questions that will appear on the screen, similarly to a *Buzz* controller. It will only be allowed one answer per question, and if two choices are made, the latter will automatically substitute the previous one. To lock in the desired answer the visitor needs to press the lock button. This process is repeated a number of times equal to the number of questions. After that, a text will

appear warning the visitor to position for a photo and, subsequently, the countdown will trigger the photographic capture made by the installed camera. The next step is to take the RFID tag to the FeedNPlay installation and use the sensor on one of the screens to read the tag. The screen will be divided and the image will appear in the section/screen chosen by the visitor, depending on the placement of the sensor they use to read their tag.
With the artifact and respective interaction established, the next step was to plan the implementation stage and start developing the prototype.

3 - IMPLEMENTATION:

3.1 - THE STRATEGY

The strategy behind the implementation process was defined through the key characteristics of our object: we listed the features to implement and prioritized them, in order to understand how to divide tasks and plan the development step by step. This strategy allowed the guarantee of a solid basis, starting with the necessary features and building the complexity as we go. The implementation was, then, subdivided into three central portions, being: the development of the processing software, the implementation of several Arduino elements that feed data to that software and the creation of some form of data storage.
The Processing software includes question display, image capture, body shape recognition through computer vision, texture generation based on a set of rules and consequent textural application to the identified shape. The Arduino portion consists of the implementation of five push buttons: four for option choice and one to lock the options, an RFID sensor to ensure data storage, enabling the association of data to an individual ID, and a LED that indicates when the sensor reads a tag or card. These data sets will be used in the Processing software to generate textures. Our objective is to complement the Arduino portion with a set of sensors that can provide more individualized data, to create an even more personal experience. We anticipate the implementation of a proximity sensor, such as the HC-SR04 Ultrasonic Sensor and of an infrared temperature sensor, such as the MLX90614. The data storage will be created to save datasets that the interaction provides.
With the work outline defined, we established the priority of each feature. Since we opted to start with the base and add complexity, the first step was to implement the Arduino elements and ensure that they were working properly and to create a primary Processing software that displays questions and generates textures through data, applying them to shapes. The next stage included the development of a form of data storage to save the inputs coming from the Arduino side. Afterwards, it will be necessary to capture and create the body outline of the visitor and apply the respective generated texture to it on Processing. With these features implemented a stable basis is established and the installation is already possible, creating appealing visual results and making visitors part of the experience, which achieves the main goals of the project. The further usage of sensors will only affect the parameters of the texture generation, being solely necessary to properly install them on the Arduino side and confirm if the inputs are being stored, as well as alter slight elements on the Processing side.
Initially, our group planned to develop one single Processing software, storing directly the Arduino inputs in a file that could be read by the software when the data was needed, but this did not happen since we discovered that the Arduino could not write directly into a system file. Because of this, we needed to change our strategy and decided to implement two separated Processing softwares, one for the input device and questions and another for the output device. The first one presents the questions, takes a camera capture and saves it, receives the inputs and sends that data to a .dat file as an array of bytes. The second one

reads the information, uses computer vision to identify the body outline on the image, generates textures with the stored data and applies them to the shape, outputting the final visuals on the screen.

MUST HAVE	SHOULD HAVE	COULD HAVE	WILL NOT HAVE
- Texture generation - Choice buttons - RFID sensor - Data storage files - LED	- Photographic capture and body recognition - Lock answer button - Multiple screens	- Additional sensors: proximity and temperature - More questions/inputs	

Fig. 12 - *MoSCoW prioritization*
Division of features according to their weight on the project's completion.
The Must Have box includes the key features of the project.
The Should Have box includes important but not essential features and the Could Have box includes features that can constitute good additions to the project. Regarding the Will Not Have box, at this stage we did not discard any elements.

3.2 - CRITICAL ISSUES

When analyzing the development process ahead, it was fairly easy to identify some challenges that we were going to face during the implementation. Taking into consideration our previous knowledge, we felt like the processing side would be simpler to implement, but the detection of the body shape to create an outline could be a challenge due to the lack of control of the surrounding environment, which could lead to the identification of shapes that do not correspond to the person who is interacting with the object. We also felt like the translation of the body outline into a coherent shape could be a difficulty.
In addition to that, we found the most challenging task to be data storage. Some form of storage is needed to save each ID's respective data inputs so it is possible for visitors to later interact with the FeedNPlay installation, ensuring the right visual output. Since we didn't have any previous contact with RFID tags, we anticipated this portion to be potentially harder to implement.

3.3 - PLANNING

3.3.1 - Work Division

As previously discussed, the project will be developed in stages and, after the definition and prioritization of features, it was important to plan the implementation time accordingly. In order to do that, we determined both the time to conclude each task and which member of the team would develop each feature, to structure and organize the necessary work.
For this Milestone we distributed the two central work portions through the group: one element is in charge of developing the output portion of the project: creating a Processing software that receives data, generates textures and applies them to shapes, and the other is in charge of the input portion: assembling the Arduino circuit, receiving data inputs resulting from the interaction and implementing a Processing program that reads and stores the information and displays the questions.

3.3.2 - Texture

The textural generation includes a set of predetermined rules that were planned prior to starting the project's implementation process, since the texture will be composed of layers. The idea is that the layers combine themselves to form the final texture that will be applied to the outline of the visitor, captured by the camera. There are three layers and four available options for each layer, which also allow some diversity in the visual result.
To establish the rules, it was necessary to do some research about texture generation in processing, so that we could determine how textures could be created and the diversity of methods available to do so. Even though the general rules were previously defined, they were not concrete, since we did not know how the final outcome would be. In this context, some tests were made to experiment with visual results simultaneously to the software development. These tests helped us to understand if it was necessary to adapt some rules.

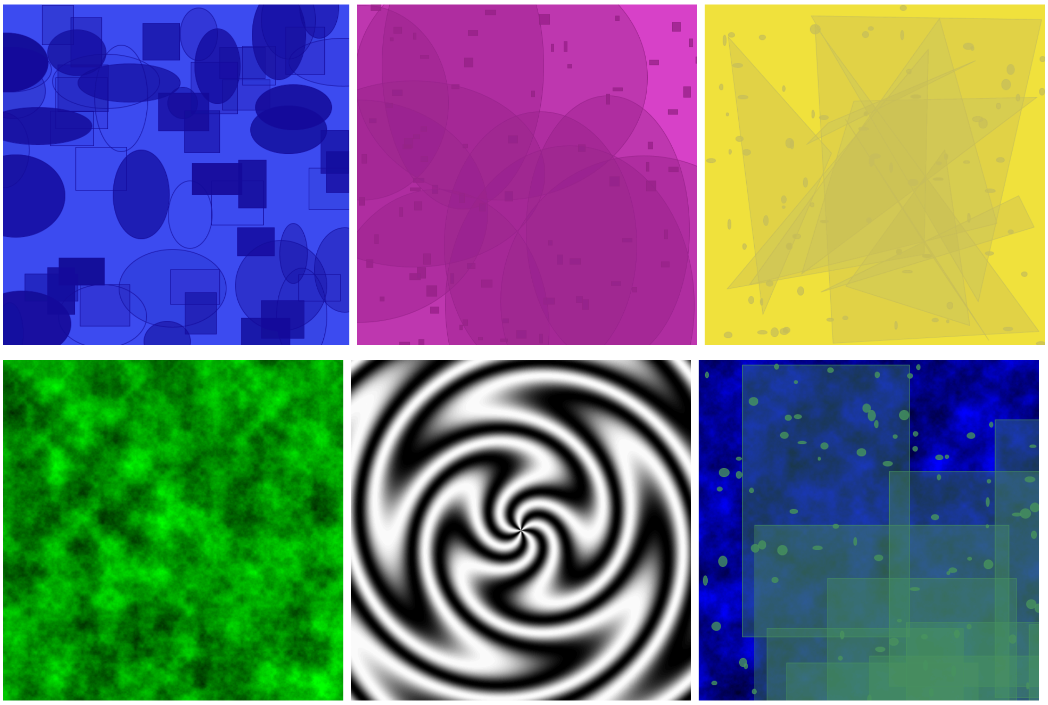


Fig. 13, 14, 15, 16, 17, 18 - *Textural generation tests*

Testing was extremely useful to ascertain how we wanted to proceed when analyzing the results. We determined that the final texture would be composed of the following elements: the first layer would be a base, the second layer would be color, and the final layer would be shape. The base layer has a "type" of texture associated with it, it dictates how the background is going to be, the color layer defines the color scheme of the texture and the shape layer relates to the shapes that will be used on top of the background to finalize the texture.

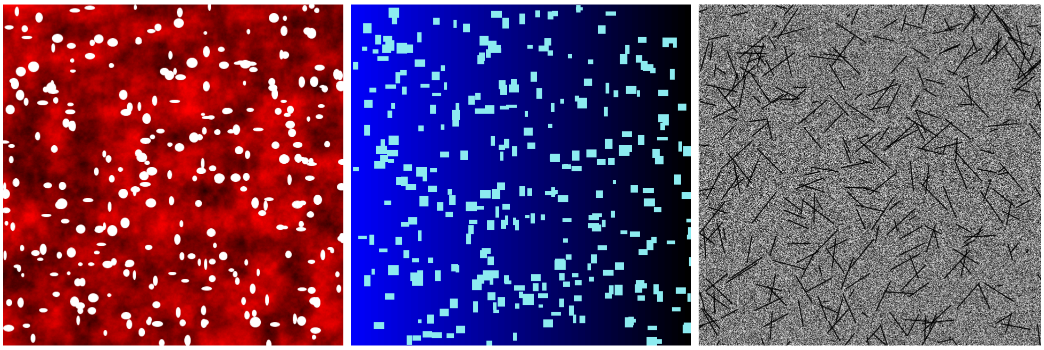


Fig. 19, 20, 21 - *Refined textural generation results*

3.3.3 - Arduino Circuit

Testing and planning the circuit was also imperative to the post-development stage, to avoid difficulties in identifying circuit errors while programming. This circuit includes the RFID sensor, one LED and five push buttons. The jumper cables running upward connected to the Arduino pins 3.3v, GND, 13, 12, 11, 10 and 9 are also connected to the RC-522 RFID reader pins, from left to right: 3.3V, GND, SCK, MI, MOSI, SDA, RST. The push buttons are connected to the pins 6, 5, 4, 3 and 2, respectively, as well as to a 5v and a GND pin. They make use of external pull-down resistors, which means that each button is connected to ground by default, maintaining the digital input level LOW, when the buttons are pressed the digital input changes to HIGH. The utilized resistors are 10KOhm. The LED is connected to pin 7 and GND and we also used a 220 Ohm resistor to limit the current.

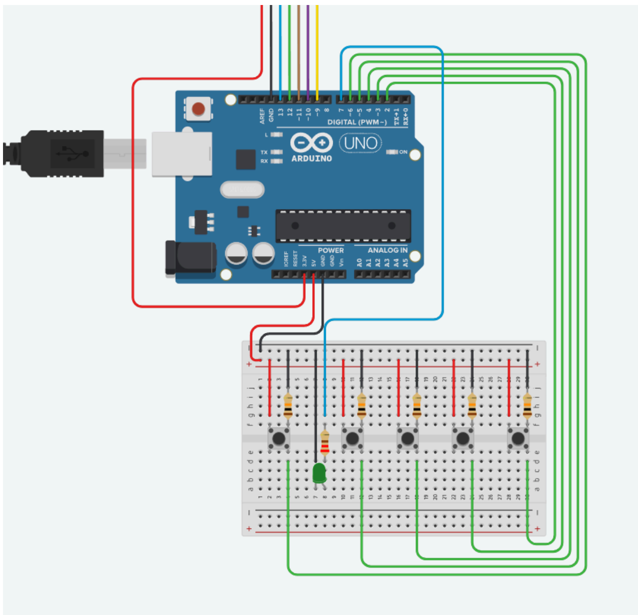


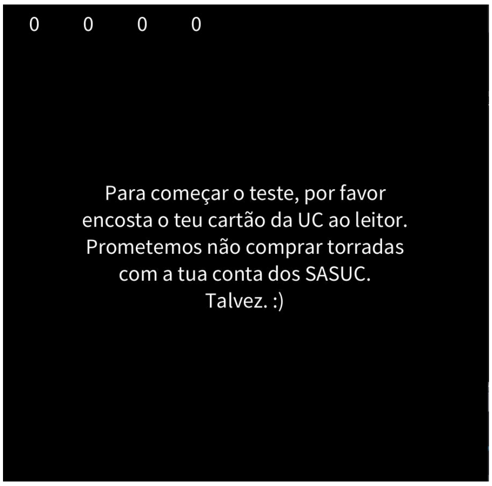
Fig. 22 - *Arduino circuit*

3.4 - FUNCTIONAL PROTOTYPE

3.4.1 - Inputs

On the Arduino side, both the five push buttons, the LED and the RFID sensor are implemented. The state of the buttons allows the program to detect which one is currently pressed. When the “lock answer” button is pressed the software saves that question’s data in the respective variable. The RFID sensor reads both the RFID tags as well as the university

RFID cards. Because of that, we thought interaction with FeedNPlay through the usage of student cards would be a great feature to implement, and would allow anyone in the department to experience it. Regarding this matter, we assure that personal information will not be saved after the conclusion of the project or an eventual implementation on FeedNPlay. When the cards are read, the LED lights up to inform the visitor.
The Processing software on the input device displays the questions, receives the inputs and saves the data on a .dat file unique for each card. It also saves the unique ID's and doesn't allow a new card/tag to be recognised without additional confirmation. Currently, the data is saved by pressing the "Save" button once all the questions have been answered, and the photo prompt is shown.



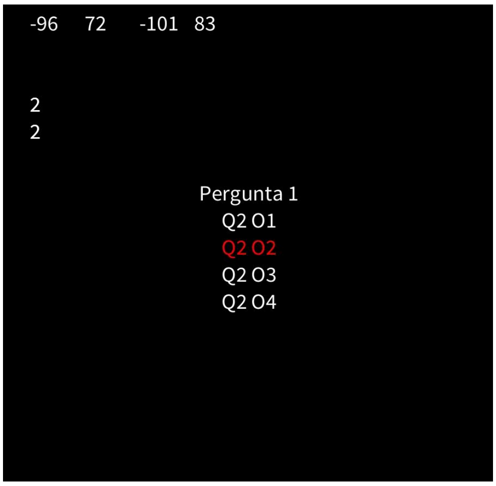


Fig. 23 and 24 - *Input device Processing software*

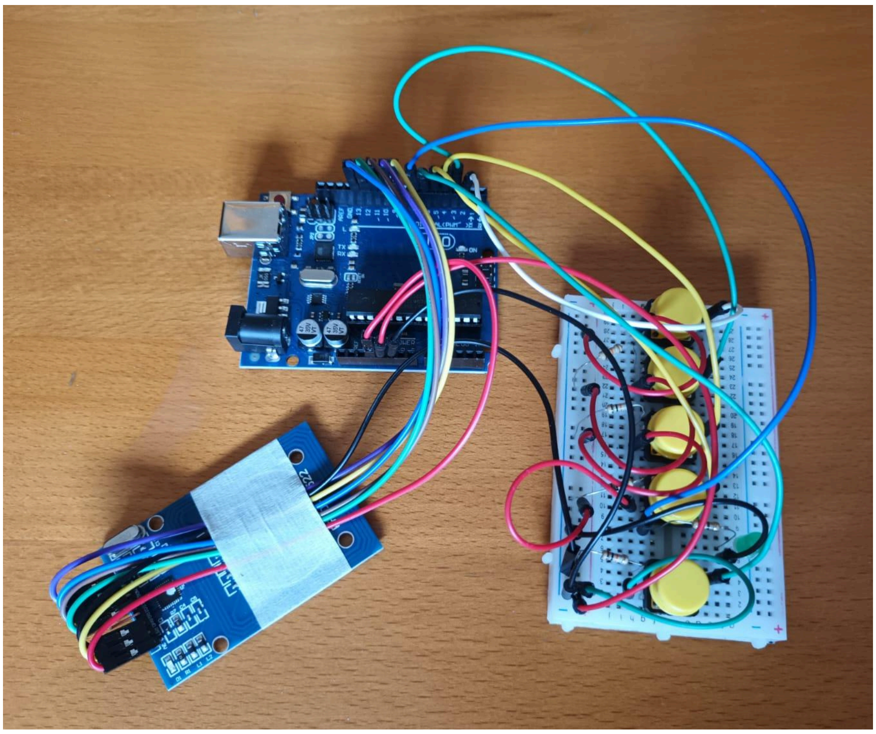


Fig. 25 - *Final Arduino circuit*

3.4.2 - Outputs

The Processing software for the output device generates textures and applies them to shapes. The texture generation is done through a *PGraphics* type function that returns the final image when called. Several parameters are needed to execute this function, such as the values retrieved from the arduino side that control the different layers and also the width and height of the image we want to produce. Inside this function we used both the *createImage()* and *createGraphics()* functions, the first one allows the creation of the base image that is going to be applied as a background to a *PGraphics* object in order to achieve the final texture. The background image is created through pixel manipulation in various forms, using the chosen colors to do so. The shapes are applied on top of that layer to the *PGraphics* object, and their filling is also defined by the selected color scheme. The resulting textures can be applied to shapes through the *texture()* method. There are global variables that control how the texture is produced, those variables receive the input data by reading the respective .dat file, allowing the software to know which options to use regarding the layers that build each texture. The .dat files' names correspond to each card/tag ID that has already interacted with the first device. Once they are read by the final RFID sensor, Processing receives the information and the ID gets stored in an array which enables the software to know which file to read, presenting the correct result.

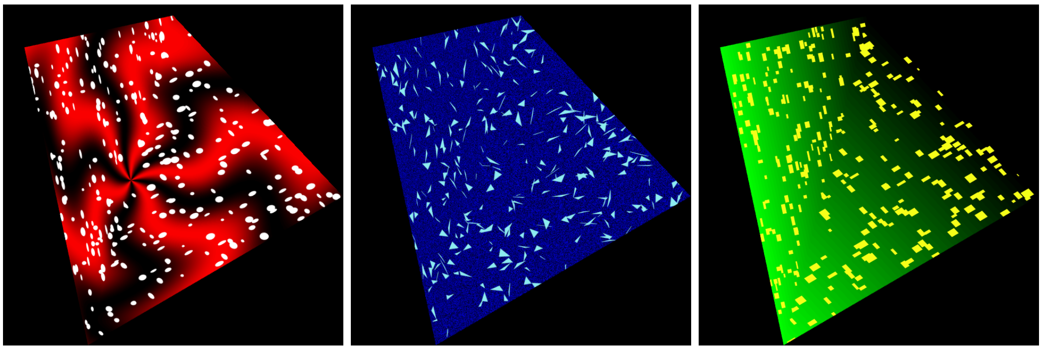


Fig. 26, 27 and 28 - *Output device Processing software*

3.5 - FUTURE WORK

The next stage of the project, as explained above, includes the further development of both Processing softwares, capturing images and saving them and using computer vision to identify people. For that, we anticipate the usage of the *OpenCV* library for Processing that includes the blob detection technique. This technique enables the identification of areas that are substantially different from their surrounding environment through intensity or color (blobs), which will allow body recognition and the creation of an outline shape.
If possible, we will include the proximity and temperature sensors which will require the implementation of both elements on the Arduino circuit and consequent alteration of the softwares that receive new data inputs. The addition of new parameters for the texture generation on the output Processing software is also needed. Regarding these parameters, the proximity values would control the size of the texture's shapes and the temperature values could alter the color's shade varying from lighter to darker.

CONCLUSION:

The developed work and the current state of the project are very satisfactory, since we created an appealing concept enabling a personal, unique, experience, determined by an interactive artifact that followed the previous proposal allowing the visitors to have a central role; we met the established implementation goals for this milestone achieving a solid base to work with and have a defined plan for the subsequent implementation stages.

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