Interdisciplinary course of

Design and Robotics

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Project:
Splashy

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Abstract

"Design and Implementation of an Intelligent Water Dispenser Robot for the Promotion of Sustainable Behaviours and the Reduction of the Environmental Footprint"

This project aims to address the problem of excessive use of plastic bottles, queues, long waiting times and manual refill in water dispensers through the implementation of a smart water dispenser robot.

After careful observation and analysis of survey data conducted, it emerged that one of the main reasons for excessive consumption of plastic water bottles is boredom caused by long queues at vending machines. This behaviour not only leads to reduced water intake, but also contributes to the production of plastic waste and an increase in the CO2 footprint.

Our goal is to design and develop a water dispenser robot equipped with interactive and encouraging features to entice users to drink more water and reduce the use of plastic bottles. The robot will be able to interact with users through screens, touch and motion sensors, and visual indicators to provide information on the amount of water consumed, the health benefits and environmental impact of choosing to use reusable bottles.

Furthermore, the robot will implement gamification strategies to make the water bottle filling experience more fun and rewarding. Using recognition, NFC tags and fill detection sensors, the robot will be able to personalise user interactions.

Through this project, we expect to promote healthy and sustainable behaviours regarding water consumption, while simultaneously reducing the environmental impact associated with the production and disposal of plastic bottles. Creating a more inviting and interactive environment at water dispensers could represent a significant step towards a more environmentally conscious and responsible society.

Phase 1: Discover

In this phase we start to organise ourselves, the team management, the tools we will use to communicate and we start to develop a common language.

Team Organization

Our team is composed of 4 members, 2 Industrial Product Designers Enrico and Sofia, and 2 engineers, a computer science engineer Davide and an automation and control engineer Gianluca. The team leader is Gianluca, and Sofia is the report manager.

Our responsibilities as designers are to define the concept and identity of the product, the aesthetic appearance, the industrial design and the creation of a visual presence that reflects the objectives and use, the design of the user interface and the usability, ergonomics and comfort as the product is intended to physically interact with users and therefore also accessibility to a wide range of people, without neglecting the ethical and social aspects. Furthermore there is the responsibility of the materials to be selected and used in the construction, considering factors such as durability, lightness, strength and other specific requirements of the project. In summary, ensure that the product is not only functional but also attractive, safe and capable of satisfying user needs effectively.

Our responsibilities as engineers range from mechanical and electronic design to software programming. It is necessary to guarantee correct Mechanical Design which includes the creation of components and mechanical parts necessary for operation, Electronic Design from electronic circuits, to the selection of electronic components, and the integration of sensors and actuators into the product architecture, Programming of the Software by developing the code necessary for operation, together with Control Systems to manage movement and behaviour, and finally optimising product performance through testing and Optimization, always working in Safety and Regulatory Compliance. Overall, engineers contribute to design, construction, programming, testing and optimization.

Project Management

Our team plans to solve the tasks according to the Gantt

Research

During the initial phase of our research, we immersed ourselves in the Bovisa campus to identify existing challenges and, finding great interest in water dispensers, we sought to draw inspiration from them for an innovative solution. We've noticed a recurring problem: people's reluctance to refill their water bottles due to long queues and the associated boredom. Rather than face the queues, many preferred to buy new plastic bottles, thus exacerbating the problem of plastic waste production and disposal.

The water dispensers, therefore, showed an alternation between periods of intense flow and moments of inactivity, creating inefficiencies in the service and dissatisfaction among users.

Subsequently we planned to carry out direct interviews with the students of the Politecnico Bovisa, and through questions, we confirmed that boredom, frustration caused by long waits, and manual water refill, were the main reasons behind the behaviour observed.

Based on direct observation, we decided to focus our efforts on designing a solution that would improve the user experience at water dispensers. The need emerged for an innovative approach that would not only solve the problem of slow and inefficient dispensers, but also actively encourage people to use reusable bottles, thus reducing the environmental impact resulting from the excessive use of single-use plastic, but also encourage them to drink more.

This research context provided a solid foundation for the development of our project, guiding us towards the design of an intelligent water dispenser robot capable of addressing the identified challenges and promoting more sustainable behaviours among students on the Bovisa Politecnico campus.

Web research

Plastic pollution, particularly from bottles, represents a major threat to global ecosystems and human health. This research aims to examine the impact of plastic pollution on water resources, with a particular focus on glaciers, and to analyse the importance of water consumption for human health.

In order to know more information on the topic and to better understand all the problems related to this, we carried out research on on the topics mentioned above, to find specific information , through authoritative sources to guarantee the accuracy of the information, such as the World Health Organization (WHO), National Geographic, the Ellen MacArthur Foundation, the United Nations Environment Program (UNEP), and scientific publications in accredited journals such as Nature, Science, Environmental Science & Technology.

Environmental Footprint of Plastic Bottles:
Plastic bottles are a significant source of environmental pollution. According to recent estimates, over 8 million tons of plastic end up in the seas and oceans every year, of which a large part is represented by water bottles. This plastic can persist in the environment for hundreds of years, releasing microplastics and toxic substances that damage aquatic and terrestrial ecosystems.

Impact on Glaciers:
Plastic pollution has a direct impact on glaciers, as plastic carried by rivers and winds can accumulate on the surface of glaciers, accelerating their melting. The plastic particles absorb solar heat, facilitating the ice melting process. This phenomenon contributes to sea level rise and the loss of habitat for mountain fauna and flora.

Importance of Water Consumption for Human Health:
Water consumption is essential for maintaining human health. Water plays a vital role in regulating body temperature, transporting nutrients and eliminating toxins from the body.

Proper hydration is crucial for the optimal functioning of the organs and systems of the human body.

Estimated Values:

- Over 90% of plastic bottles are not recycled, contributing to the accumulation of plastic waste in the environment.
- It is estimated that glaciers lose around 335 billion tonnes of ice per year due to air pollution, which also includes plastic particles.
- According to World Health Organization guidelines, adults should drink at least 2 litres of water a day to maintain proper hydration.

Market research

It was necessary to carry out market research to understand the current market proposals, advances, new technologies, types of dispensers, as well as to have a peripheral vision of the work context, also to understand which type of product to target. We also carried out a brief research on trends and trends regarding water dispensers to understand the growth prospects of the market and our competitive advantages in the market.

Types of Water Dispensers

1. *Bottled Water Dispenser:*
    - Top and Bottom Loading: Bottle dispensers are widely used for both their ease of installation and their convenience. Bottom-loading models are particularly popular for their ease of use.

2. *Dispenser Without Bottle (Point-of-Use):*
    - These systems connect directly to the water supply, eliminating the need to replace bottles. They are considered greener and, in the long term, can be cheaper (Cognitive Market Research) (Global Market Insights Inc.).

Segmentation by Application

- *Commercial*: Demand is driven by offices, hospitals, schools and other public facilities that need continuous access to clean water.

- *Residential*: Interest in home dispensers is growing thanks to greater awareness of the health benefits and the convenience offered

Market Trends

- *Smart Technologies*: The integration of advanced technologies such as touchless control, IoT connectivity and water quality monitoring is gaining popularity, improving user experience and ensuring higher hygiene standards.

- *Sustainability*: There is a growing focus on eco-friendly designs and recyclable materials, with a particular emphasis on bottleless systems to reduce the environmental impact of plastic bottles.

Growth Prospects

- *Global Growth*: The global water dispenser market is expected to grow significantly, reaching a value of USD 5.35 billion by 2030, with a CAGR of 8.6% from 2024 to 2030.
- *Regions*: Asia Pacific, in particular, is showing robust growth thanks to increased demand for water purification devices in countries such as China and India. North America and Europe are also seeing stable growth, driven by increased awareness of water quality and technological innovations.

Main Market Companies:

- Whirlpool Corporation
- First Water Corporation
- Waterlogic Holdings Limited
- Culligan International Company
- Honeywell International Inc.

Examples of Bottle Dispensers

1. *Avalon Bottom Loading Water Cooler Water Dispenser*:
    - Features: This bottom-loading model is designed to be easy to load, without the need to lift heavy bottles. It has three temperatures: cold, hot and roomy. It also includes a child safety system on the hot water tap.
    - Pros: Easy to use, elegant design, suitable for both offices and homes.
    - Cons: Requires regular purchase of water bottles.
    - Price: Approximately $200-$250.

2. *First Top Loading Water Dispenser:*
    - Features: This top-loading model is one of the most traditional and common on the market. It offers cold and hot water, with a compact design ideal for small spaces.
    - Pros: Affordable, easy to install and use.
    - Cons: Replacing bottles can be cumbersome and cumbersome.
    - Price: About $100-$150.

Examples of Dispensers Without Bottle

1. *Brio Self-Cleaning Bottleless Water Cooler Dispenser:*
    - Features: This dispenser connects directly to the water supply, eliminating the need for bottles. It has an ozone self-cleaning system that keeps the tank sanitised. Provides cold, hot and room temperature water.

- Pros: Sustainable, comfortable and hygienic.
- Cons: Requires professional installation.
- Price: Approximately $300-$400.

2. *AquaTru Countertop Water Purifier:*
    - Features: This countertop model is a reverse osmosis water filtration system. It requires no installation and can be placed on any surface. It is capable of removing up to 99% of contaminants.
    - Pros: High water quality, easy to use.
    - Cons: Limited tank capacity, requires frequent filter maintenance.
    - Price: Approximately $400-$450.

Examples of Innovative Dispensers

1. *Midea Smart Water Dispenser:*
    - Features: Equipped with touchless control, connected via Wi-Fi to monitor water quality and tank level via a mobile app. It also has an advanced filtration function.
    - Pros: Advanced technology, comfortable and hygienic.
    - Cons: High price.
    - Price: Approximately $500-$600.

2. *Evian (re)new Dispenser*:
    - Features: Innovative design made with recycled materials. Uses 5 litre water bubbles which reduce plastic use by 60% compared to traditional bottles. Designed by Virgil Abloh.
    - Pros: Eco-friendly, modern design.
    - Cons: Limited availability.
    - Price: Varies, generally around $300.

Market and Trends

- *Sustainable Trends*: Many manufacturers are developing dispensers with recyclable materials and bottleless systems to reduce environmental impact.

- *Smart Technologies*: The integration of smart functions such as touchless control and IoT connectivity is increasingly common to improve usability and hygiene

Robot strategies

Our robot was designed with one main goal: to encourage people to refill their water bottles instead of buying new plastic bottles, thus promoting environmental sustainability and healthy water consumption. To achieve this objective, the robot adopts various interactive and engaging strategies, in particular the robot makes use of rewards in order to encourage users to perform those actions more.

The objective is to encourage users to return to the water dispenser more frequently, thus improving their behaviour towards the environment and their own health through a gesture of appreciation or recognition, or a "reward". The rewards offered include direct rewards for users, a leaderboard, or games to make the wait more pleasant. Furthermore, the possibility of interacting with the robot via touch sensors or the movements of the robot itself could arouse greater interest and involvement from users.

Functionalities

Location detection

We carried out a location detection inside building B2 of the Bovisa Polytechnic campus, in particular focusing on the places near the vending machines/dispensers, where the water dispensers were present, alternating in different times on different floors and for different times, in both, more or less frequented moments, to better understand the difficulties, problems and opportunities.

After our detection and analysis, we think the most intuitive location for our robot would be next to the machines/dispenser, where the current water dispensers are actually located, but we noticed that the number available is too low for the number of students present on campus, especially during break times from lessons, which are very similar among all courses, and main gathering moments of students, which causes large queues and waits, mostly due to the slow filling of the water dispenser on each floor of the campus. Furthermore, not only to use our penguin robot, but also to increase the number of water dispensers instead of having just one on each floor, but at least two, even if with our water dispenser the refill time will be drastically reduced, avoiding long queues.

The purpose of this positioning is to convince the user to fill the bottle, intrigued by the robot and enticed, instead of buying a new plastic bottle and that it is worth using the dispenser, obviously through the use of rewards and interaction , which make the queue to fill the bottle and the wait pleasant and less boring, also allowing students not to miss the start of lessons after the break by having to wait to fill the water bottle, but above all also doing a good deed, both for themselves, but in particular for the planet.

Predation mechanism

Thanks to the research carried out we have highlighted the fundamental innovative points that could improve our competitive advantages of our water dispenser:

1. *Interactive Design*: The playful penguin shape and interactive features make it stand out from traditional water dispensers. It creates a memorable experience for users, increasing product recognition and customer loyalty.

2. *Automatic Refill System:* The automatic and fast refill system ensures that water is always available without any waiting time. This convenience sets it apart from other dispensers that may require manual refilling or have slower refill rates.

3. *Personalised Interaction*: Incorporating features that allow the penguin dispenser to interact with users in a personalised manner enhances the user experience. Whether it's greeting users with friendly messages or responding to petting/interacting commands, this personalised touch adds a fun and engaging element.

4. *Gamification:* Introducing playful ranking systems or competitions among users can further increase engagement. For example, users could earn points or badges based on their water consumption or participation in certain activities, fostering a sense of competition.

5. *Dynamic Movement*: The ability for the penguin dispenser to move its body adds an element of charm and whimsy. It could greet or perform playful gestures to entertain users while they wait for their water, creating a unique and memorable experience.

By combining these features, your water dispenser not only provides a practical solution for hydration but above all, it encourages people to come back to fill their water bottle, to remember to always carry it with them, instead of always having to buy a new plastic one, its helping against pollution but also offers a fun and interactive experience that sets it apart from competitors. This unique combination of functionality and entertainment can help solidify your competitive advantage in the market.

Phase 2: Define

In this phase we start to go deeper into the analysis, studying the space and the user and starting to think about possible more definitive ideas.

Strategy

After extensive initial research, we began to define specific goals for our project. One of the crucial aspects was understanding the style and the character that our robot should embody. We therefore created a moodboard that expressed concepts of minimalism, simplicity and advanced technology, using neutral and cold colours to give a contemporary and sophisticated atmosphere.

Getting closer and closer to the definition of our robot, we began to develop sketches to outline the design, trying to find a harmonious balance between the theme of the project and its physical form. Next, we proceeded to build prototypes using raw materials, in order to gain a better understanding of the dimensions and components needed.

During this phase, we paid particular attention to the internal architectural structure of the robot, carefully studying where to position the components to ensure correct functioning. Furthermore, it was essential to start considering all the electronic elements necessary for the functioning of the robot, therefore drawing up a Bill of Materials (BOM) file which listed in detail all the electronic components necessary for the realisation of the project: these elements were defined following the choice of interactions, interface and robot movements.

We also tried to review the robot strategy and rewards by interacting with students through more specific surveys and questionnaires

This research and definition phase was crucial to developing a clear vision of our robot and to plan the next phases of the project effectively and efficiently.

Interviews

Semi-structured in-person interviews 1 (12.03.2024)

1. Do you think the issue of not refilling water bottles and relying on plastic bottles is a problem?
    a. Yes, I do believe it's a problem. Relying on plastic bottles contributes to environmental pollution, and not refilling water bottles exacerbates this issue.
    b. Yes, but if every now and then you don't have the bottle nothing happens, I sometimes forget it and have to buy one from the vending machines.

2. Is it a problem for you or others?
    a. It's a problem for both me and others. Personally, I'm concerned about the environmental impact of plastic waste, but it also affects others as it contributes to pollution and environmental degradation.

    b. For both of us, but I don't think my behaviour alone will change the world.

3. Why do you have/not have that behaviour? OR Why do you think others have/not have that behaviour?
    a. I try to avoid using plastic bottles because I'm aware of the environmental consequences and prefer more sustainable alternatives. However, others may not prioritise sustainability or may find it more convenient to purchase plastic bottles due to factors like accessibility or habit.
    b. Obviously I try to bring the water bottle, if I forget it every now and then I buy the bottle, I know it's wrong, but some people aren't interested, I don't know, maybe they aren't encouraged or interested enough

4. What would help you/others change that?
    a. For me, we should find a way to make the queue less long. it's boring to wait all the time, then the jet is very slow and you often have to wait for the whole break.
    b. There's too much queue, I don't feel like doing it.
    c. To entice people, maybe we should make the wait more pleasant or less slow, I don't know, for the games perhaps? but it is right to use the water bottle and not the plastic bottle

Semi-structured in-person interviews 2 (20.03.2024)

1. How often do they use the water dispensers on campus?
2. What are the main factors that influence your decision to use a water dispenser instead of buying plastic bottles?
3. What do you think about the current experience of using water dispensers on campus? Are there aspects that you think can be improved?
4. Have you ever considered the environmental impact of consuming plastic bottles compared to using water dispensers? To what extent does this influence your choices?
5. What would most incentivize you to use water dispensers? For example, specific rewards or incentives?
6. Have you noticed if there are any differences between the different water dispensers on campus in terms of ease of use, speed or quality of water dispensed?
7. Do you believe that adding interactive elements, such as games or prizes, can influence your behaviour in using water dispensers? How?
8. What suggestions would you have to improve the overall experience of using water dispensers on campus?

Most common answers

1. Frequency of use: "I use water dispensers at least once a day, especially during breaks between classes."

2. Decision factors: "Convenience and economic savings are the main reasons that push me to use water dispensers instead of buying plastic bottles, but I spend a lot of time during the break."
3. Current experience: "The overall experience is quite good, but could be improved with more dispensers, because there are not enough, there is always a very long queue and it is boring waiting."
4. Environmental impact: "Yes, I consider the environmental impact of consuming plastic bottles, and it is one of the main reasons why I prefer to use water dispensers." "Yes, but many times I forgot my bottle at home, so I have to buy a new one."
5. Incentives: "I would definitely be more incentivized to use water dispensers if there were rewards or incentives, such as discounts on other services or rewards for frequent use."
6. Differences between dispensers: "No, but at a certain point during the day the refill becomes really slow, especially when a lot of people use it."
7. Interactive elements: "I think adding games or prizes could make the experience more fun and engaging, encouraging me to use the water dispensers more often."
8. Suggestions for improvement: "It would be helpful to improve the numbers of dispensers, are not enough, really slow, maybe can be faster, because I spent all my break there, and dirty, so more maintenance."

Functionalities

During this phase it was necessary to further analyse and define the robot's strategies, as after the interviews and user analysis, data and problems emerged which allowed us to more precisely define the rewards, interaction and interface of the robot with the user, previously generic, obviously always with the intention of improving environmental impact behaviour, preferring to fill the water bottles rather than reappearing plastic bottles every time, and drinking even more.

Expression of Emotions and Movements:
The robot is equipped with an LED matrix that allows it to express a wide range of emotions, from the most joyful to the most encouraging, up to the sad ones, in order to emotionally involve users. In certain circumstances, such as when a user fills his water bottle, the robot can show happiness or enthusiasm, thus encouraging the desired behaviour, or vice versa incentivize him to fill the water bottle by appearing sad. Furthermore, some components of the robot are designed to make movements that attract users' attention, increasing interaction and engagement, especially in empty moments.

Creation of a Leaderboard and Challenges between Students:
Using NFC technology, the robot tracks the number of times users refill their water bottles. Based on this data, the robot creates a ranking of the most active users in filling water bottles. This creates healthy competition among students to reach the top of the rankings, acting as a further incentive to fill water bottles and reduce the use of plastic bottles.

‘Save the Planet’ message:
Every time a user fills a certain number of water bottles, the robot emits a message of encouragement and gratitude, underlining the user's positive contribution to protecting the

environment. This message not only recognizes the user's commitment, but also motivates them to continue the sustainable behaviour.

Our robot not only serves as a water dispenser and entertainer, but plays an active role in promoting healthy and sustainable behaviours. Through emotional interaction, friendly competition and messages of appreciation, the robot creates an encouraging and motivating environment that pushes users to drink more, reduce plastic pollution and do their part to protect the planet.

First ideas

The journey towards conceptualising our automatic water dispenser with the shape of a penguin involved several critical steps that encouraged individual creativity and the emergence of diverse ideas.
Our process began with a detailed briefing from our teachers, where we were introduced to the project requirements and objectives. This initial guidance provided a clear framework for what we needed to achieve, setting the stage for our creative exploration.

Brief

This year's project brief challenges us to craft robots capable of persuasion. These robots are envisioned not merely as mechanical entities but as charismatic motivators, adept at engaging and influencing human behaviour positively.

The key objectives are:

- *Motivational Capability:* We aim to design robots with the innate ability to motivate individuals. These robots will employ various techniques to encourage and inspire action, fostering positive behavioural changes for societal benefit.

- *Non-Verbal Communication:* Our robots will communicate primarily through non-verbal means, utilising sounds and gestures to convey intentions persuasively. This mode of communication enhances the robots' effectiveness in connecting with humans on a deeper, more intuitive level.

Costrains:

- Volume - trolley size
- Movement
- Interaction
- Fixed location - no wheels

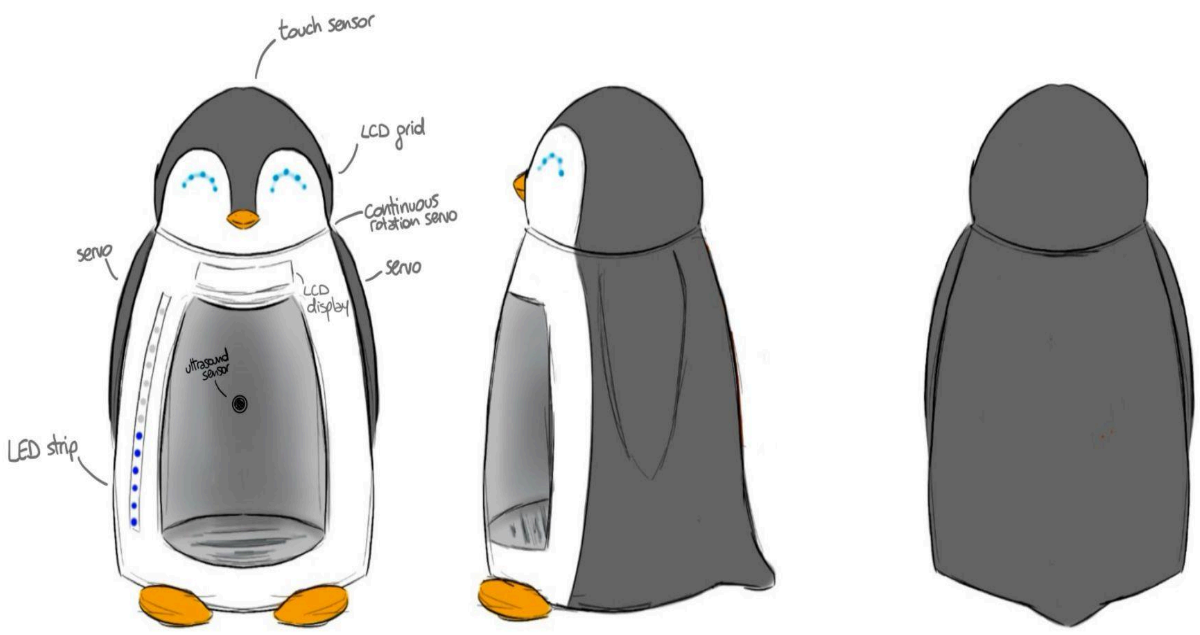
Brainstorming & Sketches

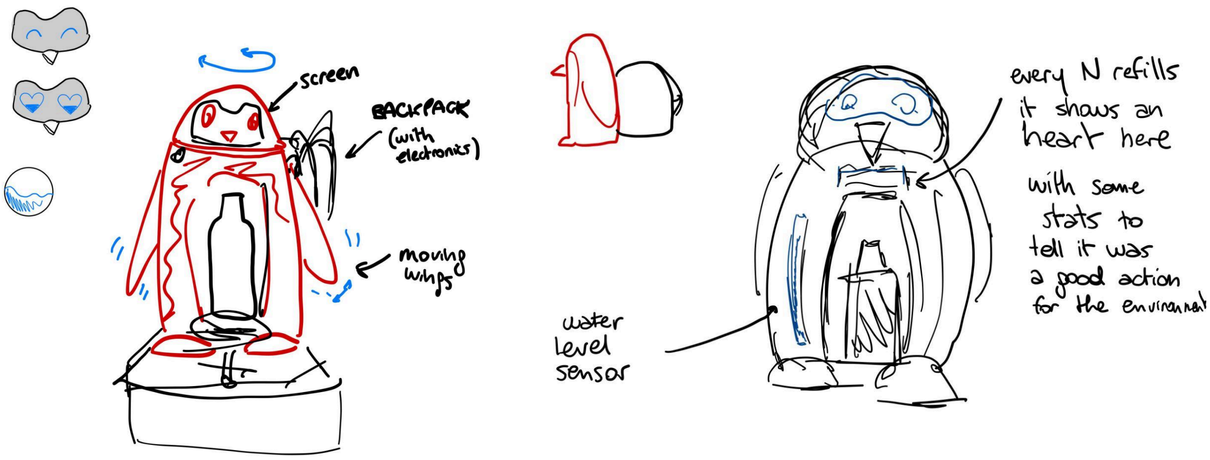
Following the briefing, the on-site inspection of the intended location for the water dispenser, the Interviews to gain deeper insights and the creation of the moodboard, all these conversations and all these datas provided valuable perspectives on user needs, preferences, and expectations. The feedback we received helped us identify key features and functionalities that the water dispenser should incorporate.

Two phases followed after the brainstorming, one of generation of ideas, creating sketches that allow you to best express your ideas and the second of convergence of ideas to create a single and defined concept.

- *Individual Idea Generation:* After these collaborative steps, we decided to work independently to ensure that each team member could develop ideas without being influenced by others. This period of solitary brainstorming allowed us to explore our unique perspectives and creativity. Each of us started making sketches and conceptual drawings of possible designs for the automatic water dispenser, inspired by the shape and form of a penguin.

- *Emergence of Diverse Concepts:* By working individually, we ended up with a variety of innovative ideas. Each sketch reflected a different interpretation of the project brief and the insights we had gathered. The diversity of concepts ranged from varying functionalities and aesthetic details to unique approaches in addressing user needs and environmental considerations.

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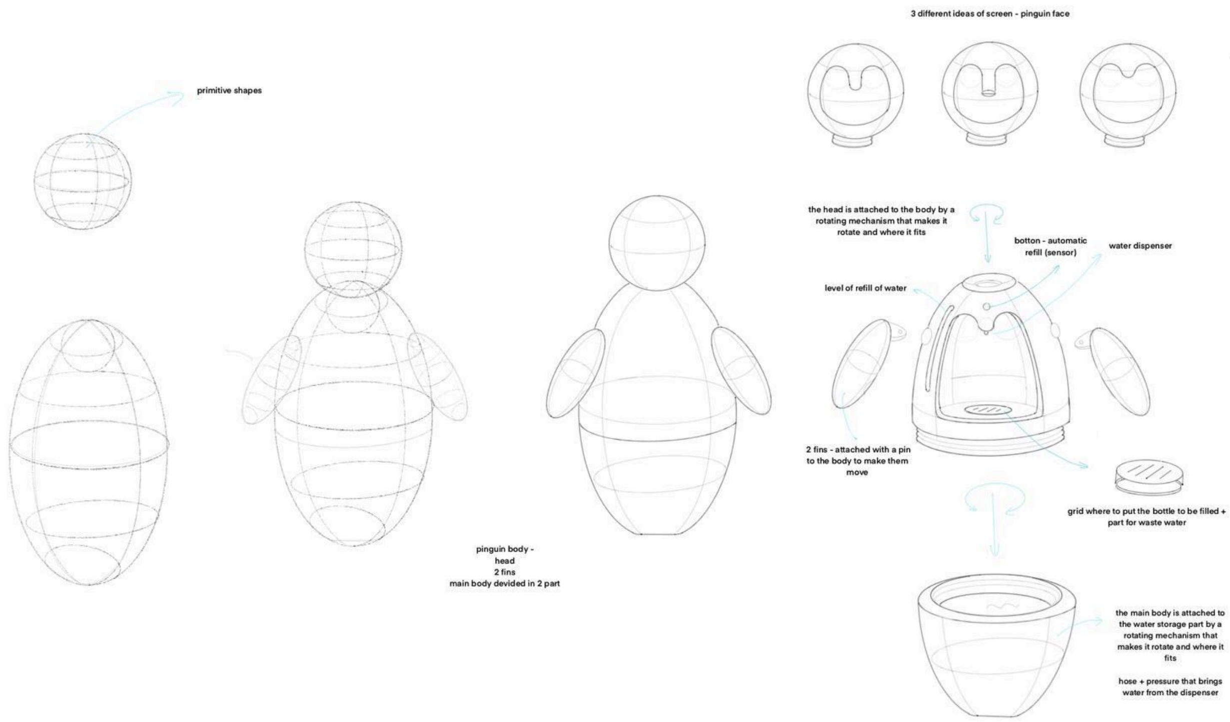

primitive shapes
pinguin body -
head
2 fins
main body devided in 2 part
3 different ideas of screen - pinguin face
the head is attached to the body by a rotating mechanism that makes it rotate and where it fits
botton - automatic refill (sensor)
water dispenser
level of refill of water
2 fins - attached with a pin to the body to make them move
grid where to put the bottle to be filled + part for waste water
the main body is attached to the water storage part by a rotating mechanism that makes it rotate and where it fits
hose + pressure that brings water from the dispenser

Moodboard

Our moodboard is a visual representation of the themes and inspirations guiding our design project. It reflects a cohesive aesthetic direction grounded in cold colours and elements inspired by penguins, ice, and water.

- *Cold Colours:*
  The dominant colour palette of our moodboard features cold hues such as icy blues, grey, frosty whites, and deep navy tones. These colours evoke a sense of coolness and tranquillity, setting the overall mood and atmosphere of the design. The cold colours not only reflect the icy environment but also symbolise the urgency and seriousness of the environmental issues we aim to address.

- *Penguin, Ice, and Water Inspiration:*
  Penguins, ice, and water are central motifs in our moodboard. Penguins represent the general shape of our product structure because of the resilience and adaptability in harsh environments, serving as a metaphor for our project’s commitment to sustainability and environmental consciousness. The water imagery further emphasises the water dispenser that we are gonna develop and the connection between the shape and the theme.

- *Minimal Shapes and Rounded Forms*:
  The design elements on our moodboard are characterised by minimal shapes and rounded forms, inspired by the natural contours of a penguin's body. This minimalist approach ensures a clean and modern aesthetic, while the rounded shapes evoke a sense of friendliness and approachability. The simplicity of these forms also enhances the visual clarity and impact of the design, making it easy to convey our message effectively.

Electronics

AUTOMATIC REFILLING

The challenge

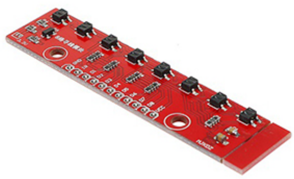
The automatic refill system was an important feature that we wanted to implement.
From our experience and from the several interviews we had with students of Politecnico, it is very annoying to push a hard button for the whole filling time.
This is a very challenging goal since every bottle of water is different in height, diameter, overall shape, weight and material.
Moreover, we thought about a problematic situation: the bottle might not be fully empty.
So, even if we could evaluate the volume of a bottle, we would need to know how much water is already inside before starting the refill.

The three main evaluation we studied were:

- bottle height evaluation
- bottle presence evaluation inside the refilling area
- water level evaluation

Bottle height evaluation

A moving laser sensor (as the rotating LIDARs) was the first idea, but after some discussion we decided to avoid the usage of a moving sensor, to have a simpler structure.
A good solution was to use an IR array sensor. This type of sensor, placed vertically on the inside wall of the refilling area, could sense the presence of the bottle at different heights and give an approximate height of the bottle.
In the end, since the level water inside the bottle couldn't be detected, it was useless to have an height evaluation.



Bottle presence evaluation

At this point we only had to detect the presence of the bottle inside the refilling area.
We thought about a laser or IR, to continue the work flow of the previous step.
But after some research of sensors and material, we noticed that a round and sometimes irregular shape was bad to have a good reflection of the light beam.
It was also a problem if someone would have wanted to use a transparent bottle (plastic or glass), so it was not a good solution: it could have worked, but not every time and not for every user.

Another solution we thought about was to use a micro switch to sense the presence mechanically, but it assumed that the user has to place the bottle perfectly against the wall.
It could have been placed under the bottle, but we decided that we didn't want any electronics on the floor of the refilling area, since it could get wet and break.

The best option was to use an ultrasonic sensor placed on the wall, since it works with almost all the materials.

In the prototype it was placed horizontally, but for the final product, since the bottle surface is round, we thought that placing it vertically was better for having a better and more perpendicular reflection of the sound wave.

Water level evaluation
We get now to the most difficult and unsolved problem we had: the detection of the water level inside the bottle.
This is important to make the water pump stop at the right time, and not spill out the water.

As it will be said we had plenty of solutions, but for each of them there was an associated problem that made the sensor not suitable for EVERY water bottle type.

The first sensor considered was a laser or IR sensor placed near the nozzle, pointing the inside of the bottle.
The study revealed that the light would not be reflected well by the water, passing the surface of the water and continuing until the bottom of the bottle, giving a wrong measurement of the distance.

The second option was to use a sonar placed near the nozzle, pointing the inside of the bottle.
The problems were that the water flowing from the nozzle interfered with the measurements, and the sensor was too big: the sound wave could hit the neck of the bottle giving the distance from the bottle and not the one from the water surface.

There were online different options for floating sensors or strip sensors that needed contact with the fluid, but for hygienic reasons we decided to avoid contact sensors.

Since detecting the water level from the inside was not possible, we tried it from the outside: the next option was a capacitive sensor.
It is a sensor that is able to detect the presence of water behind a wall of solid material.
So what we would have needed to do was to sense the height of the bottle and move the capacitive sensor to the neck of the bottle, so that when the water reached the neck the pump would have stopped.
After some further research we found out that this sensor would have not worked with metal bottles, which is the case for most of them.

In a last attempt we noticed that while refilling our bottles they made a sound more high pitched the more the level increased.
So we studied the physics of the resonance of bodies.
It ended up being very complex to achieve, because the shape of the resonance body changes as the water fills the inside, the volume of the sound is very low in some kinds of bottles, and the type of sound changes with respect to different shapes and materials.

Final compromise
Our final choice was to have a semi-automatic refill system.
Since the user knows the size of his bottle and how much bottle he has still inside the bottle, we let the user set the amount of water needed by simply turning a knob (a potentiometer),

that allows to set for instance from 200mL to 1L (the actual range will be chosen in the final steps).

From now on the refilling is automatic:

- it starts when the bottle is placed and detected inside the refilling area
- it stops when the selected amount of water is poured or when the bottle is removed from the refilling area, so that as little water as possible is wasted

To have a better measurement of how much water flows from the water and not rely just on a time of filling measurement, we decided to add a flow sensor that gives us a better evaluation of the litres poured and allows us to stop the pump in a more precise way.

ELECTRONICS POSITIONING

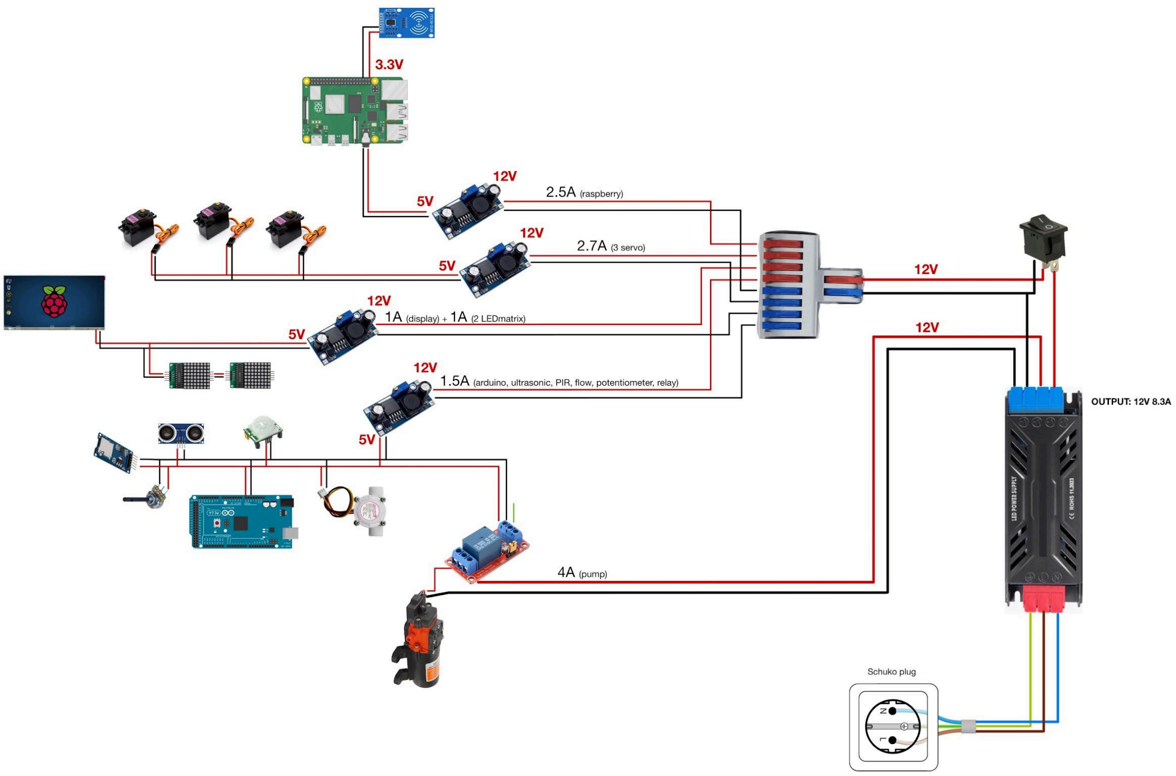
Constrained position electronics:

- 1x RFID sensor (NFC reader): in the front
- 1x Screen: on the chest (between head and refilling area)
- 2x LED matrix: in the head
- 1x servo: centred under the head
- 2x servo: near the two wings
- 1x ultrasonic: vertical on the wall of the refilling area (height of the bottom hole should be low enough for a glass, but not too low that the sound beam hits the floor of the refilling area: the width of the sound wave is 30 degrees under the horizon) (distance of the sensor from the bottle should be of about 5 cm)
- 1x PIR sensor (motion): on the front to detect people
- 1x pump: uses water, needs to be separated from other electronics (water pipes should go out not from the bottom, but from the back)
- 1x flow sensor: uses water, needs to be separated from other electronics
- 1x ON/OFF switch: on the back
- 1x power supply: near the on/off switch

Other electronics to be placed

- 1x Raspberry: take in consideration it is connected to RFID sensor and Screen
- 1x Arduino: take in consideration it is connected to LED matrices, servos, ultrasonic, PIR, flow sensor, potentiometer, relay
- 1x potentiometer (knob)
- 1x SD module

ALL THE POSITIONING MUST CONSIDER THE POWER SUPPLY WIRING (see figure below, but it will be updated and changed in next chapter) AND DATA WIRING WITH RASPBERRY AND ARDUINO



The POWER SUPPLY considering plug, on/off switch, transformator, step downs has to be considered as a single block since the cables are soldered or intertwined and taped together for safety reasons.

The complete bill of materials relating to the electronic components we will need [including links to the e-commerce sites that sell them] is in BOM

In short, the main components needed will be:

- POWER SUPPLY
- ON/OFF SWITCH
- STEP DOWN (x4)
- ARDUINO
- RASPBERRY
- RFID SENSOR
- SCREEN
- LED MATRIX (x2)
- SERVO MOTORS(x3)
- MICRO SD MODULE
- ULTRASONIC SENSOR

- PIR SENSOR
- POTENTIOMETER.
- TOUCH SENSOR
- RELAY
- FLOW SENSOR
- WATER PUMP

In the delivery section we will go more into detail for each component.

DIFFERENT VERSIONS: “WATER PUMP OR VALVE?”

We decided to have the water pump separated from the robot for several reasons:
the size is such that it takes up lot of of space intended for the electronic components
leakage of water inside the robot must be avoided as much as possible
periodic maintenance and hygienic operations requires the pump to be easily accessible without having to open the robot each time

To these reasons we add the main one: the robot is designed to be used in different situations. By placing the pump outside the robot we can maintain the robot inside structure the same even if we are using a pressurised water network: the pump is replaced by a valve still controlled by the relay.

Coding

In this initial part, a careful selection of the computing hardware has been made. The first task was to decide whether to use a Raspberry Pi-based system to control the entirety of the robot or to use an Arduino alongside it. This selection was crucial since it would drastically shape our ability to implement certain features (e.g., driving a screen that runs a GUI (graphical user interface) requires a Raspberry Pi), and it would significantly influence our electronic schematics and the coding structure of our project. After careful thought and discussion, we decided to divide the project into two main subsystems:

- An Arduino that runs the core functionality of the robot, including the refilling process (handling of the pump) and the animations (both rendered through motors and LED matrices)

- A Raspberry Pi system that runs a GUI and a database.

This layout offers several advantages:

1. *Ease of development:* The Arduino is more oriented towards microelectronics control compared to Raspbian systems. It offers thousands of libraries needed to control different types of hardware and provides a reliable toolchain in the Arduino IDE for development on such platforms. On the other hand, the Raspberry Pi, given its multi core structure, is capable of running full-fledged desktop applications (with some performance limitations, which are acceptable for this project).

2. *Fault tolerance:* The Arduino drives all the core functionality of the robot. This means that only a bug in the Arduino would result in a non-functional robot. However, since Arduino is an embedded system (ES), the predictability of such a system is higher compared to a full-fledged OS upon which the application would run if developed on the Raspberry Pi itself.

3. *Modularity:* A change in one core part of the project does not necessarily influence the other part hosted on a different board.

4. *Expandability:* More features could be added later given the presence of the Raspbian system.

5. *Time constraint elasticity:* In case of critical last-minute errors, the system will perform just fine without the Raspberry Pi. A drawback of this approach is that we are limited by the lower performance bounds of the Arduino system, meaning that some potential features possible with a Raspbian-only system are not feasible in this context.

After defining the initial layout of the system, we proceeded with hardware selection. We chose:

- *An Arduino Mega:* This is due to the need for a powerful and capable system to run the entirety of the robot. The Arduino itself controls the state of the robot, requiring the most responsive Arduino board possible with substantial RAM (random access memory) and program memory. Moreover, given the number of sensors, a considerable number of pins is needed.

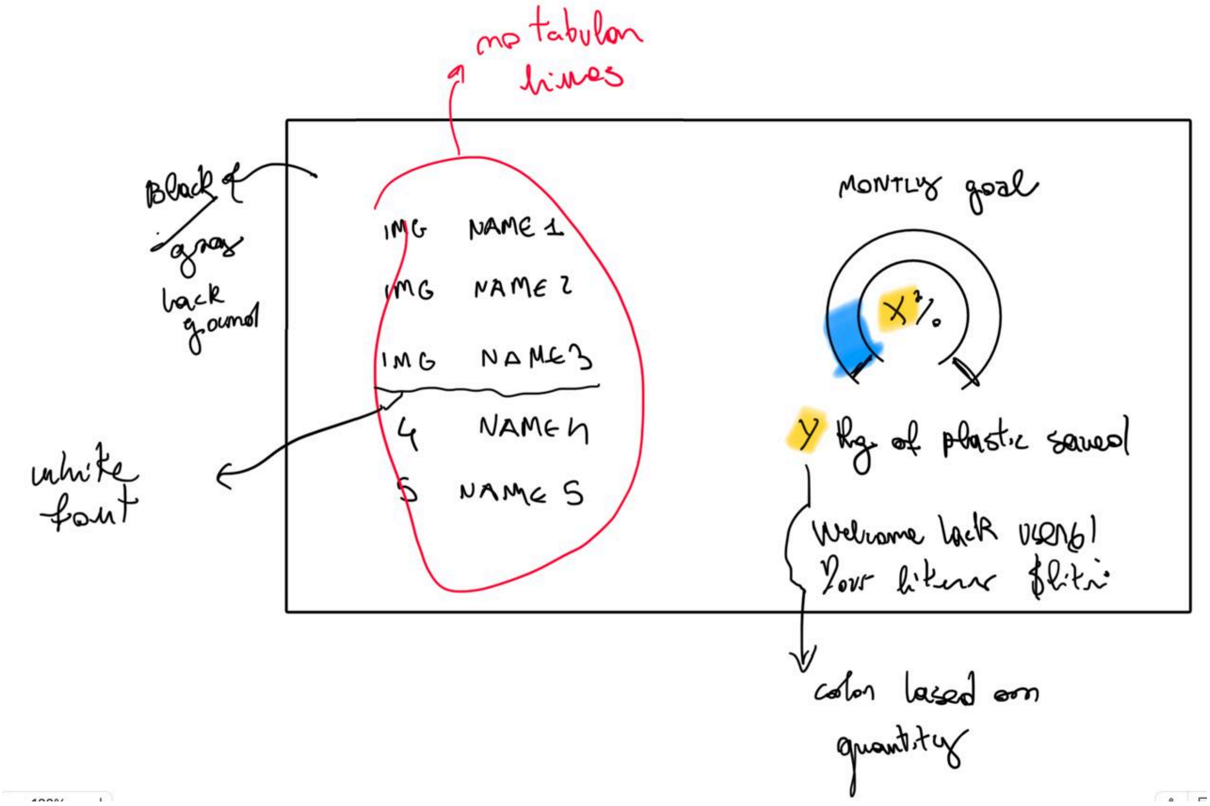
- *A Raspberry Pi 3 Model B v2:* We did not have any particular constraints on this system aside from the ability to run a database (performance here was negligible as we planned to make six queries per second at peak load in a small database) and a simple (low power) GUI.

For programming languages, we chose the standard Arduino code (a slightly modified version of C++) and Python for the Raspbian system. We selected Python because it allowed us to easily perform database queries and create simple GUIs using external libraries. For the database, we chose a simple SQL-compliant database, specifically MariaDB.

GUI - Graphical User Interface

THE IDEA

At first we decided the elements we wanted in our GUI:



We decided to display on the screen a ranking showing the best water drinkers, the global stats of SPLASHY and the stats of the current user.

The ranking is important because it is a way to encourage people to drink more, as a challenge between friends.

The global stats are useful to understand the impact of not using plastic bottles from the vending machines: the more people drink the more plastic we save!

We didn't want only numbers since they are difficult to look at and you get easily lost on the screen.
For this reason we added a progress bar that shows how much water has been poured by SPLASHy with respect to a certain weekly/monthly goal.

The current user stats are a crucial element also for the interaction, since it is the only feedback the user has to know that his NFC tag has been read and recognised.
So that SPLASHY can greet the user with a "***Welcome back UserName!***".

Structure

The first idea about the robot structure is to divide the entire body in 2 main parts: the body and the base.

The body has a large main structure, the "belly", inside which there are the main electronic components, such as the Arduino, LCD for information and sensors for detecting the height of the bottle and the water and finally separated: the nozzle and the water hose connected to the gallon of the base. Attached to this there will be the fins, one on the right and one on the left, inside which there are two servo motors for movement, and finally there is the head at the top, inside which there is a servo motor for rotation , the touch sensor and the LCD matrices for the eyes, all connected to the "belly" through channels.

In the base that is under the body, there is storage space for the gallon of water, with the water pump. Another possible idea to hide the gallon of water is to create a backpack for the penguin robot to hide it.

Shape

During the in-depth research phase on the topic of plastic pollution and its impacts on the environment, we focused on observing the main causes of this phenomenon, noting in particular the devastating effect it has on the melting of ice. To stay true to this environmental and natural theme, we made the decision to design our robot with a penguin-inspired shape.

As highlighted in our moodboard, we opted for the adoption of cold and soft colours, such as blue and light blue for the plastic cover of the body which recall the glacial environment of the polar regions. The shapes of the robot will be characterised by simple and sinuous lines, which recall the elegance and naturalness of the marine world.

The body of the robot will be composed of a hollow round belly, inside which the refill bottle will be placed, two side fins and a rounded head, which will give the robot the distinctive appearance of a penguin. Furthermore, under the body of the robot, there will be two containers similar to ice cubes, which will act as tanks for the water to be dispensed, or a backpack in plastic to hide the gallon of water and make the look more playful.

This choice of shape and design not only remains consistent with the environmental and natural theme of our project, but also helps to create an engaging and memorable visual experience for users, encouraging them to actively interact with the robot and adopt more sustainable behaviours.

First Prototype:

We created a first prototype with simple materials, such as polystyrene, which best represented our idea and the dimensions of the product, this allowed us to begin to better define the project and understand where to start working and what to focus on most.

Phase 3: Develop

In this phase we describe the development process, departing from the first prototype to the final improvements regarding the coding and electronics component and the 3D model.

Strategy

During this phase of our project, after exploring and evaluating numerous ideas for the design of our penguin through drawings and prototypes made from waste materials, we finally came to a definitive conclusion regarding the shape and structure of the penguin. This allowed us to concretely define the final design and organise the work in a more structured and targeted way.

Division of Duties: Designers and Engineers

- Designer: The designers' task was focused on creating a detailed 3D model of the penguin and on the aesthetic and functional design of the product. During this phase, the designers had to work closely with the engineers to ensure that the final design could meet the mechanical and engineering needs of the product. This involved a continuous exchange of feedback and numerous design iterations to resolve feasibility and optimization issues.
- Engineers: The engineers focused on the functioning of the penguin, dealing with the part of code and programming necessary to make the prototype operational. They worked on developing the electronic components and control systems, ensuring that every part of the penguin works as intended. This included the integration of sensors, motors and other components essential for the proper functioning of the penguin.

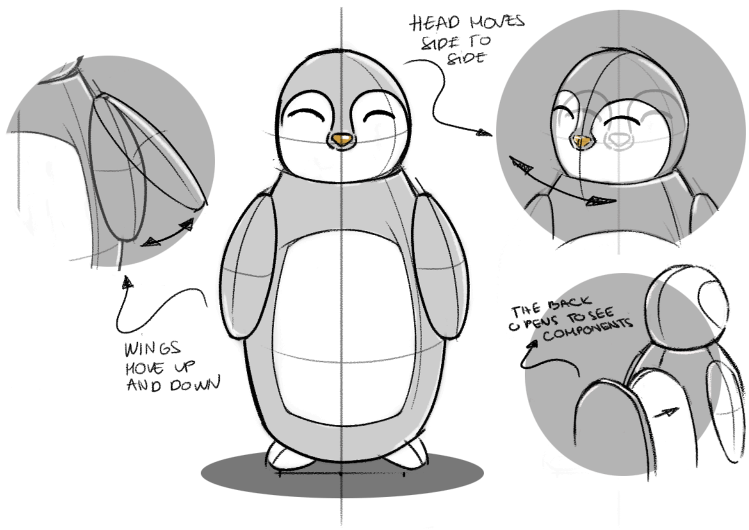
Thanks to the work of both parties, we managed to produce the first working prototype. This allowed us to test the various features of the penguin and identify areas for improvement. During this phase, we faced numerous issues, including:

- Mismatches between design and functionality: Some elements of the initial design were not compatible with mechanical needs, requiring significant modifications to accommodate them.
- Technical issues: Some electronic components did not work as expected, requiring further debugging and redesign.
- Code Optimization: The initial code needed to be optimised to improve the efficiency and responsiveness of Penguin.

These issues were resolved through an iterative process of testing and review, which allowed us to make necessary changes and constantly improve the prototype.
This development phase was crucial to transform the initial ideas into a working prototype ready for further improvements. The work between designers and engineers was fundamental to overcoming the challenges encountered and ensuring that the final product satisfied both aesthetic and functional needs.

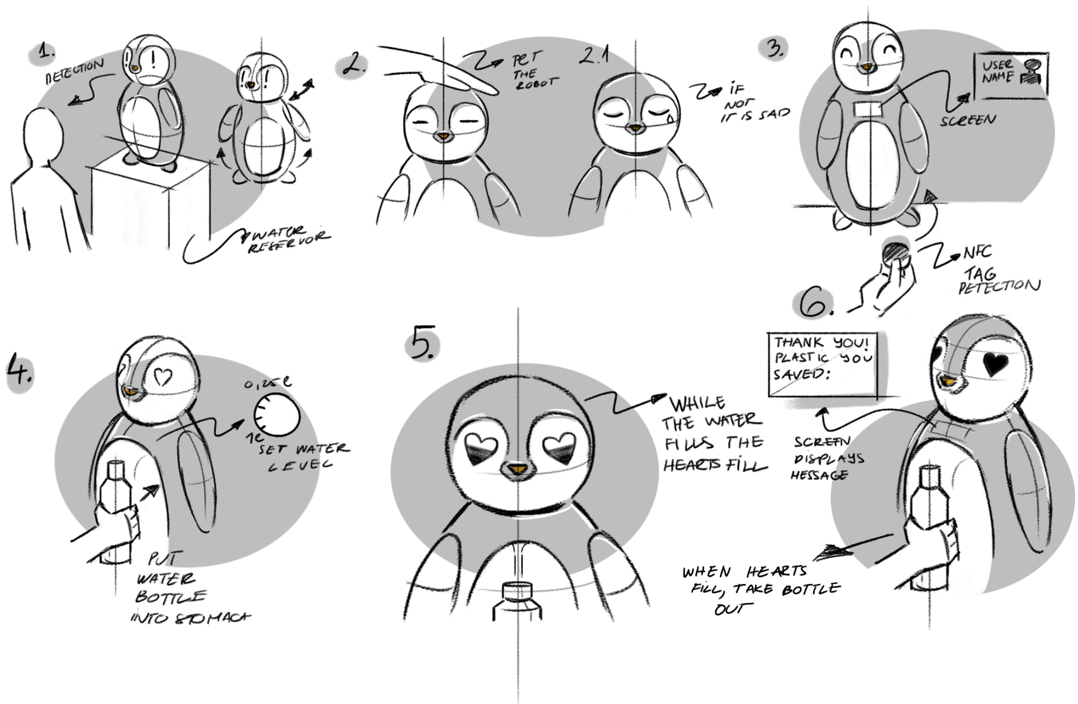
Concept

After carefully evaluating all the ideas that emerged, we looked for a solution that was common to all proposals, reflected the ideas of all group members and was liked by the entire team. We therefore decided to maintain the shape of the penguin, working to obtain a sinuous and continuous silhouette between body and head. The design includes parts that can be assembled and disassembled, to facilitate control of the components via a rear door dedicated to managing the electronics. Furthermore, our design includes moving parts such as wings and head, to add dynamism and functionality to the model and greater interaction with the user.



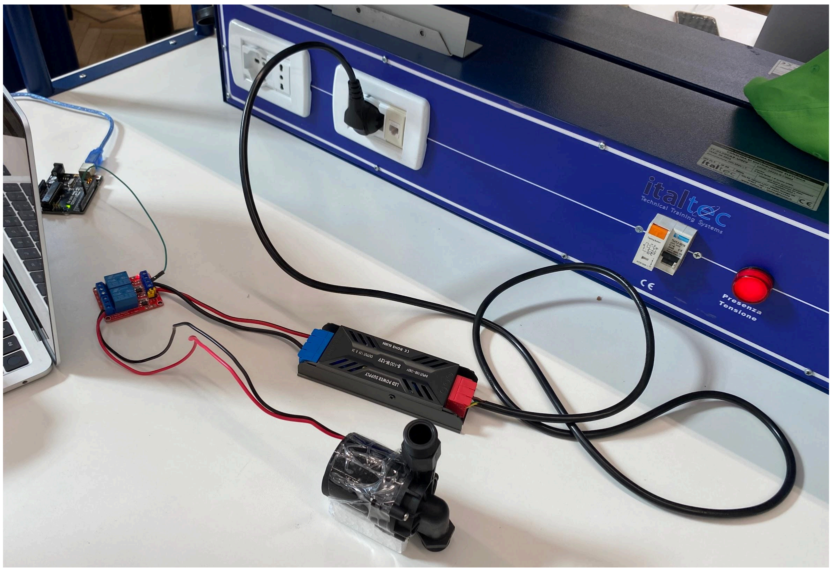
Storyboard

After various analyses and assumptions, and through surveys conducted with users, we tried to extrapolate the most important considerations regarding the possible interactions that our robot penguin could have and carry out to best satisfy user needs. This gave us insights into what users want and expect from an interactive robot. Subsequently, we created a storyboard that illustrated in detail how the user interacts with our robot and highlights the main features of the latter, guaranteeing an intuitive and satisfying user experience.



Electronics

POWER SUPPLY



In our first testing the power supply for the electronics was from the 5V pin of Arduino, but the more electronics we started to add, the more current we needed.
For this reason in the first prototype the Arduino was powered by both the jack (connected to the electric plug) and the USB (connected to our computers for serial communication).

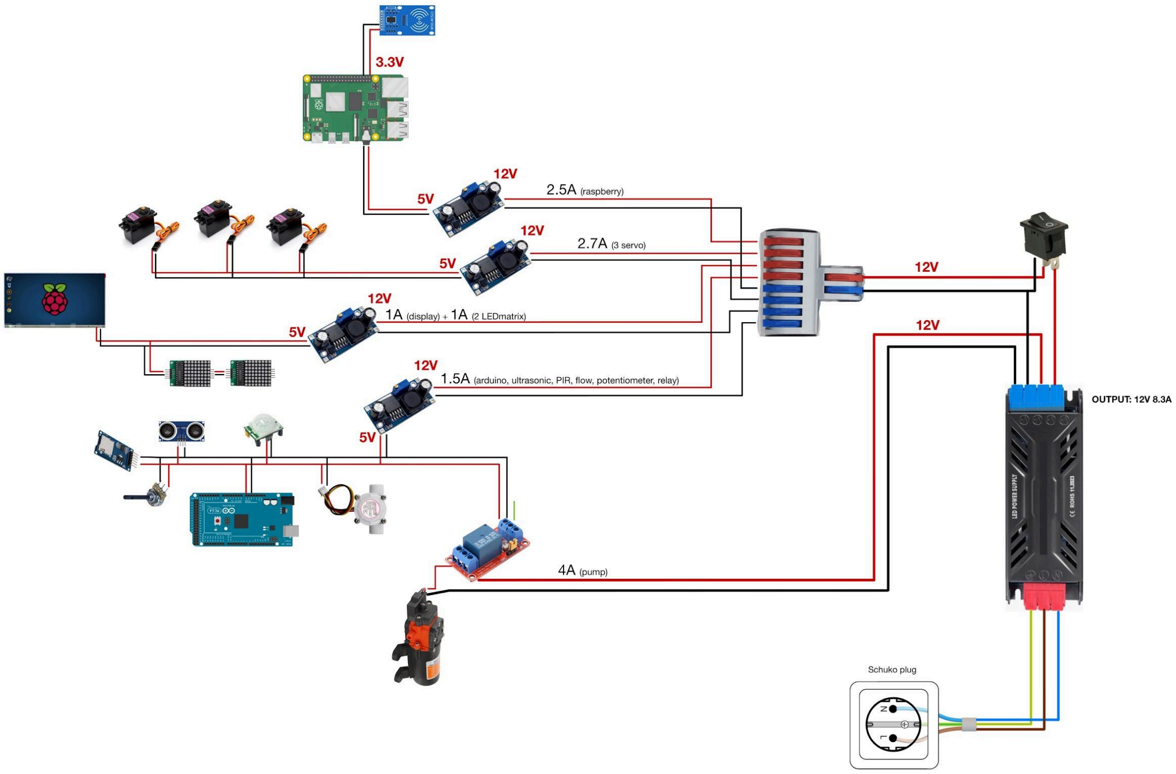
For the final product, however, we decided to not use the Arduino as a power supply, since more components were about to be added: instead, we opted for a more solid solution.

The current flows from a Schuko plug towards a 100W transformer.
The transformer output is 12V, so it is perfect to power the pump which works at 12V.

For all the other components we need a step down from 12V to 5V.
Since one step down can't hold all the current required, after some studies, we figured out that we needed four step downs in order to split the current in a manageable way.
The components are clustered in the following groups:

- Raspberry + RFID sensor (powered by the 3.3V pin of the Raspberry)
- 3x servos
- 2x LED matrix + screen
- Arduino + all the remaining sensors + relay

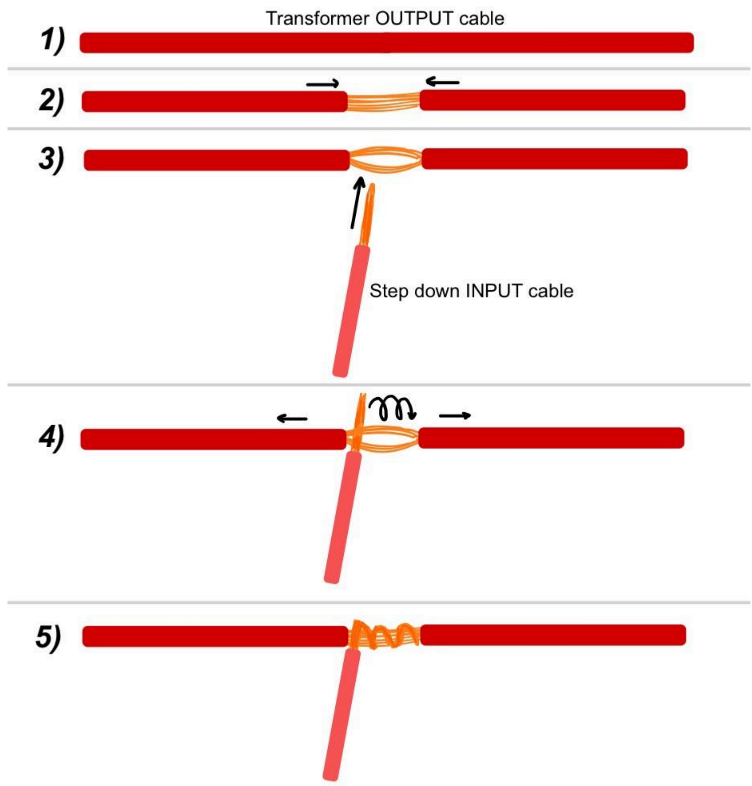
In this way we can guarantee a continuous powering for the Raspberry and Arduino, avoiding current lack when all the servos and LED matrices are turned on. Between the power supply and the step downs has been placed an ON/OFF switch to be able to shut down the product even without having to unplug it.

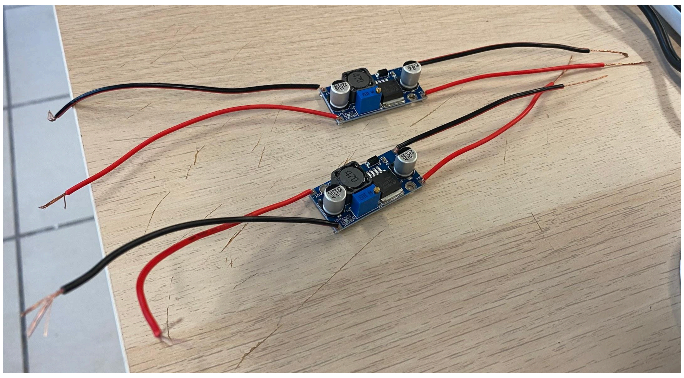


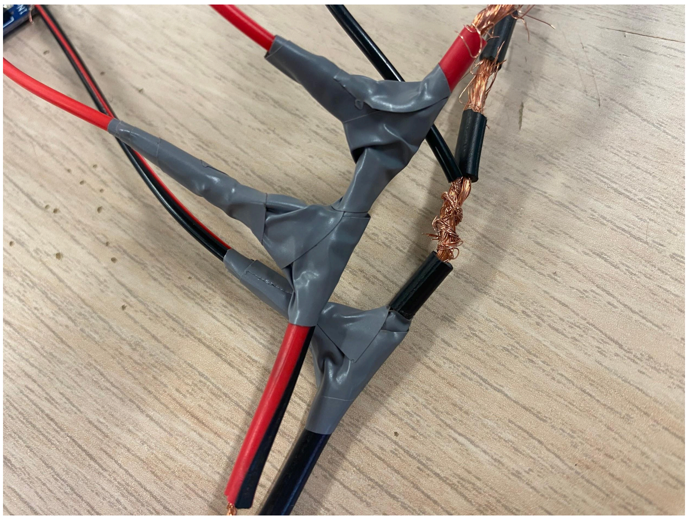
All the step downs are soldered to two cables for the output, and to two for the input. The soldering was done by us, except for the step down soldered also on top, which was taken from a previous robot.

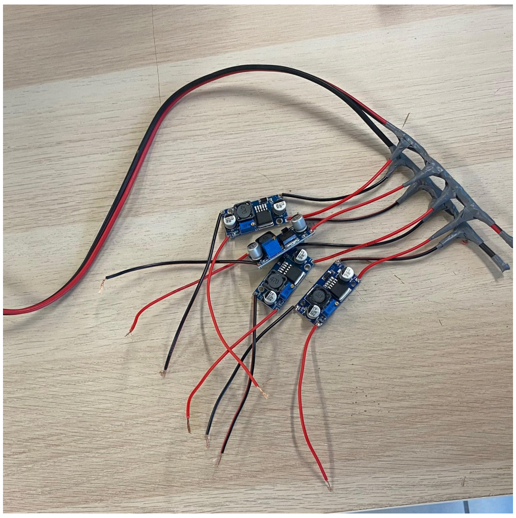
The cables of the input side are connected to the 12V cable from the transformer output.

Instead of soldering it we decided to use a technique still very structurally solid, but that allows future replacements of the step downs in case of breakage.
The technique consists in intertwining the cables together and taping them to confer rigidity, electrical isolation and safety.









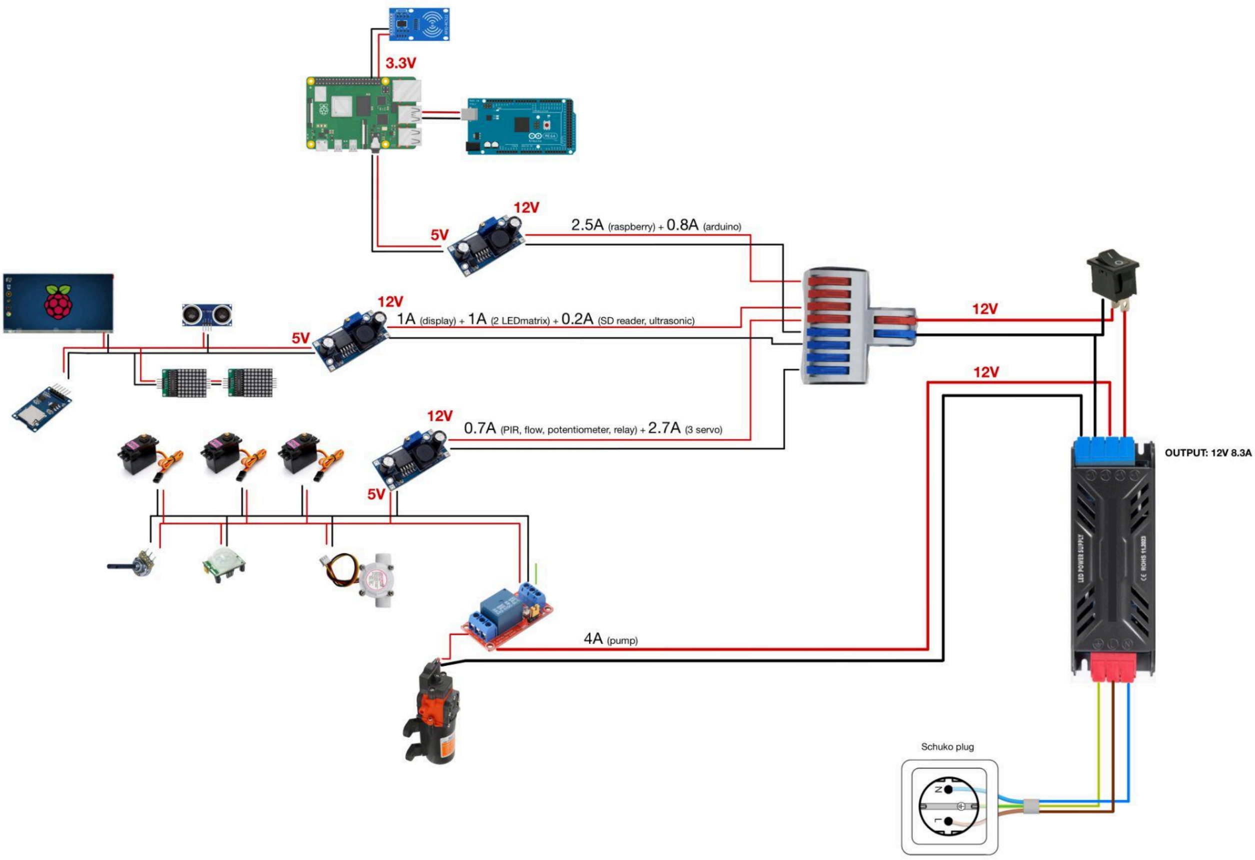
As you can see in the powering schematic on top, this splitting can be also obtained by using a “rapid” type of connector with 2 input slots and 8 output slots.
For reasons of time and cost we decided not to use it, but it could be easily added to upgrade the circuit in cleanliness and beauty.

The cables on the output side of the step downs are connected with other electronics not with a direct soldering, but with connectors: this is to guarantee an easier maintenance of the product and an easier replacement of the components.

POWER SUPPLY UPDATE

During the assembling of the final product, the step-down taken from a previous robot turned out to be defective, making the powering of the associated component impossible.

Since we didn't have one to replace we decided to rearrange the powering according to the following schematic:



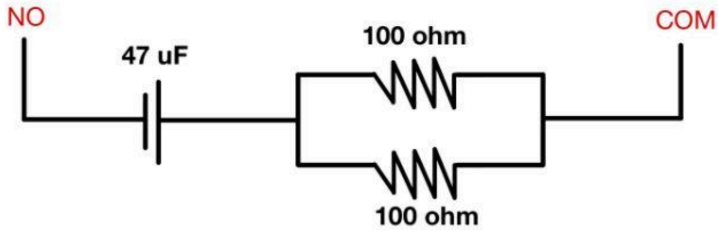
The big main change is that the Arduino is powered by the Raspberry: this is because the Arduino (when powered from its step-down) didn't receive enough power to stay on when the LED matrices and servo motors turned on and caused the Arduino to restart itself at random moments, especially when the pump was in action.

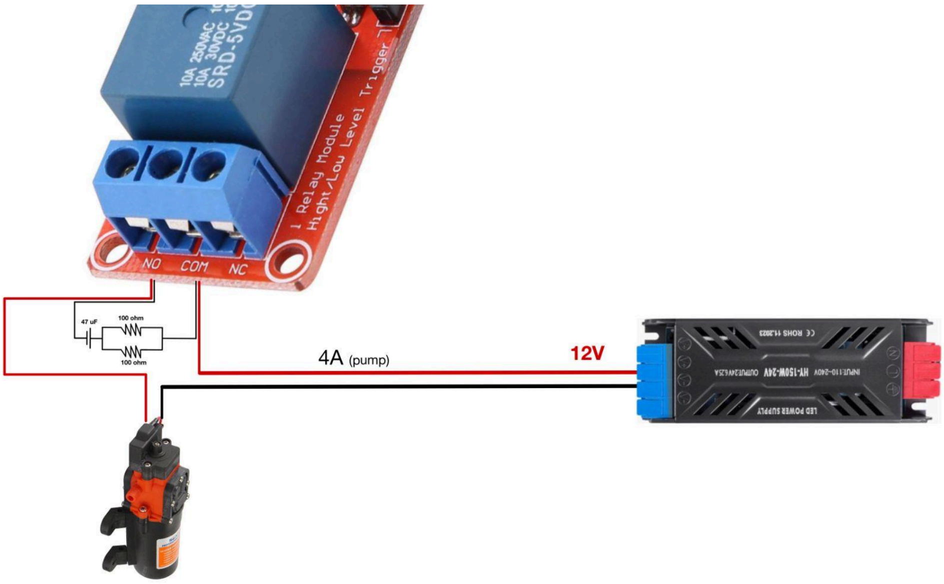
Solved this problem, the powering was perfectly balanced in every state except for the refilling one: at the end of the refilling, the Arduino restarted itself every time we selected an amount of water greater than 0.75l.
We thought at first that the pump after a certain time was requiring too much power, creating a lack in the Arduino, but at this moment we knew that the Arduino was powered by the Raspberry, which didn't have any restarting problem.

Studying the problem deeply and searching in which line the code was interrupted, we noticed that the Arduino restarted itself every time after it gave the command to the relay to turn off the pump.

In practice every time that the relay turned off the pump, a current peak was generated in the circuit and it caused the Arduino to restart.

To solve this issue and remove this peak of current, we utilised a snubber circuit. We added a capacitor of 47uF in series with two resistance of 100 ohm in parallel between the NO and the COM of the relay as shown in the in the adjacent scheme. This addition made it possible to avoid the restart of the Arduino after the refilling is finished, solving the power issue we had.





Coding

Arduino

During the development phase the effort has been initially directed towards the creation of the core system: the Arduino.

In this phase the challenge of managing multiple sensors and actuators alongside multiple states has arisen.

The solution to the problem was:

- creating a sort of scheduler that allowed us to execute different jobs on different sensor and actuators
- creating a finite state machine that would control the behaviour of the robot. This would act as an observer on the sensor and as a controller on the actuators. In this

manner we achieved a system where sensor and actuators were effectively decoupled from the control logic itself. The control system (the finite state machine previously mentioned above) reacts on the input given by the sensor, effectively changing the state of the robot by performing action through the actuators

Deep dive into Arduino system

During the Arduino development phase several sub-challenges were found:

1. Storing led matrix and servo motors animation: Since the Arduino is an ES this means limited ram capabilities. This implies that it's not possible to store directly in ram memory both led matrix and servo motor animations. In order to solve this problem we implement a system where all the animations are represented by a file that is loaded from SD memory at required time.
2. Pump calibration: Since the water flow may not be always optimal or even the pump pressure could change over time a reliable method to ensure the required water quantity is delivered is needed. In order to ensure this a flow sensor has been utilised. The flow sensor produces a pulse every time water passes by. An Arduino interrupt is able to capture such a pulse.
3. Water bottle revelation: As stated before, during the initial discovery phase many ways to completely automating the process of refilling was discussed. Since none of them were feasible we ended up using a sonar sensor. This introduced another problem which was the delay caused by the reading, and its own associated error. In order to resolve the letter a sliding-window filter style was developed. Meanwhile, in order to reduce delay on sonar calls, we used the NewPing library that allows us to cap sonar recognition to a certain distance.
4. Touch sensor: It was not possible to find a suitable pre-made touch sensor. This is because we need a non-rigid plate that must be able to adapt to the surface of the robot (in our case the head which is rounded). So we had to build one by ourselves by grabbing out a copper thin foil and using 3MΩ resistance. By creating such a circuit and using CapacitiveSensor library we were able to effectively detect a touch even if the copper shield has not been directly touched by the user. Another problem arose with the circuit itself: relaying it on the calculation of the capacity (in order to detect a touch) a minor current peak derived by a non-linear power consumption of the system could cause the sensor to trigger itself resulting in a false-positive actuation. This has been solved using a sliding-window filter (like in the case of the ultrasonic sensor).
5. Tasks, Scheduler and FSM (Finite State Machine): Aside from minor bugs during development, no major problem or challenge was encountered during this development phase (it turned out that the original idea of the scheduler produced during the define phase was excellent).
6. Motor setup: to ensure correct movement of the wings of the robot several steps have been made. The first goal has been to create servo motor animation that could express the emotions of the penguin in a rightful and expressive manner. To solve the problems of limited ram capabilities of the Arduino, the same approach used with led matrices has been utilised. Files with placeholders representing servos angles have been created and stored in the SD card of the robot.

Later, when the body and the wings of the robot have been 3D printed the following steps have been done in order to find the effective servo motors angle:

- Find the angle limits for each servo motor in order to avoid smashing of the wings with the body of the robot.
- Carefully setting the angle limit (accounting for inertia forces produced by the mass of the wings accelerating) for homing position.
- Replacing the placeholders with the actual angles values for each servo of the robot.

Build flags for Arduino

The Arduino code has 4 different types of build flags all of them activate using #define BUIL_FLAG_NAME in the appropriate spaces:

1. DEBUG flag: this is the core flag that enables all the subsequently listed flags and enables only general system error capture using serial. This flag should be situated in the root of the project (Splashy.ino file).
2. WARN flag: this flag enables logging of potentially unwanted behaviour in the system. It's useful to show boundary case limits in the code. This flag should be situated in the root of the project.
3. TEST flag: this flag enables simulation behaviour for some components that are not present in the simulator PICSimLab. This flag should be situated in the root of the project.
4. ${LIBRARY_NAME}_DEBUG: this is a debug specific flag that should be specified for each library you want to test. This flag should be situated in the header (.h file) of the library you want to inspect. It produces a serial output N.B. : it's not possible to use any of these flags when connecting it to a Raspberry. This is because the Arduino and the Raspberry communicate using the serial communication protocol that would otherwise be flooded by debug messages.

Raspberry

Once this Arduino development phase has ended a brief, but still important, test phase has taken place to ensure both software and hardware components where ok. The software side of the Arduino has also been tested with a tool called PICSimLab, a software able to simulate Arduino's architecture and some other components. After a successful sub-system test the Raspberry development phase has started.

In this phase we focused primarily on:

- creating a database that should hold information for statistics and competition between users.

- setting up an RFID reader such that the user could get recognized by the robot The GUI is then being displayed using a 3.5' monitor connected with the raspberry using HDMI.

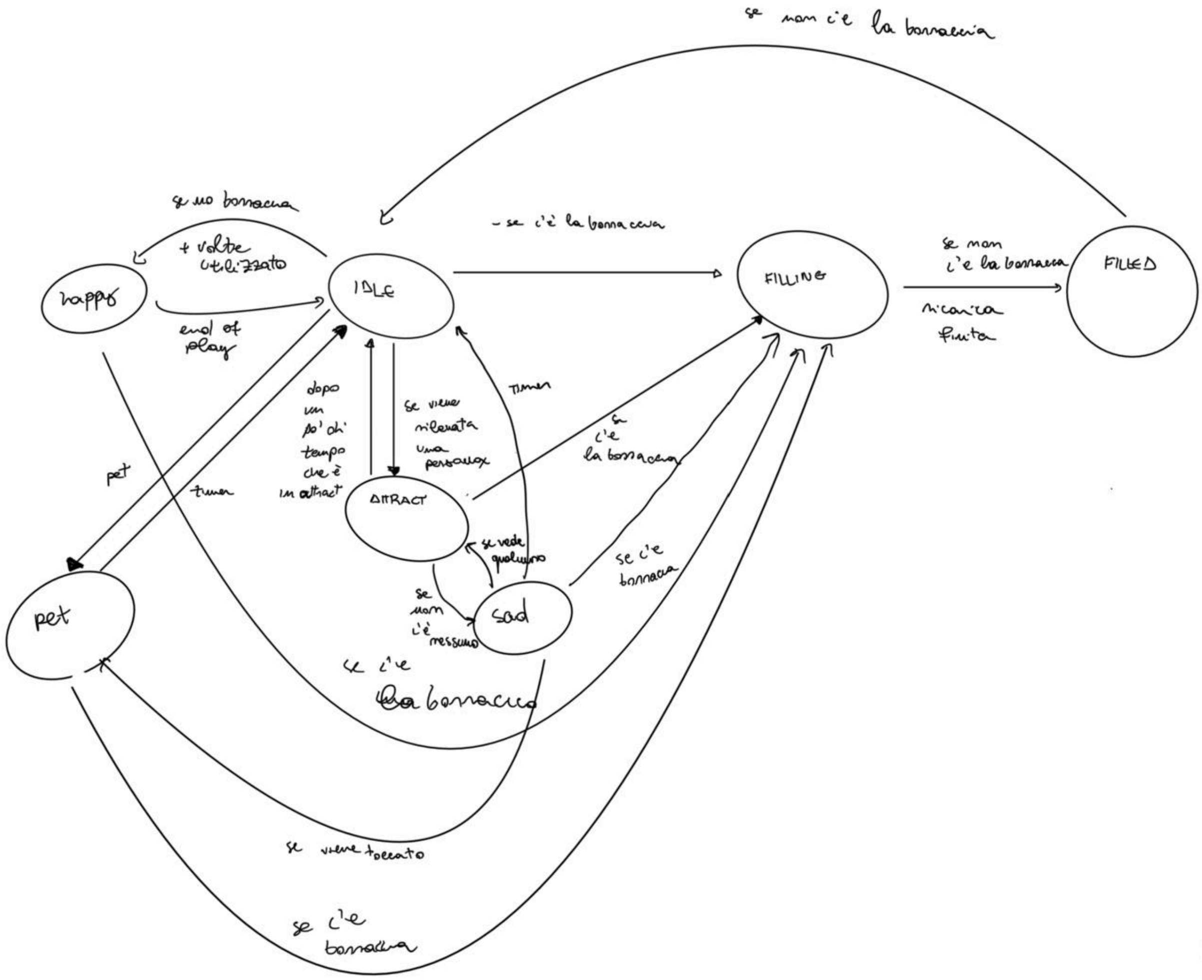
Deep dive in Raspberry
In this phase major challenges were encountered, especially due to incompatibility problems with display driver and the RFID reader:

1. RFID & monitor: The RFID reader (model id RC522) and the screen (model id MPI3508) communicates using Raspberry's SPI protocol. While for the RC522 it's clear the usage of such protocol (to communicate NFC tag data), for the MPI3508 the motivation relies on the fact that it's also touch screen capable. This latter fact implies that the default driver for this monitor will also install such drivers that will completely reserve the SPI interface for the screen, effectively cutting off the ability of the RFID reader to communicate with the Raspberry. On top of that, the drivers of the screen (at time of writing, 23/05/2024) seems to be broken for the current version of Raspbian (we suspect this is due to the changes made on the system to port from X11 display server to the newer Wayland protocol). In order to solve this issue we modify /boot/firmware/config.txt with the force_hdmi_hotplug=1 flag in order to make the system post on such a screen without touching the SPI configuration. This process comes with the downside of not having the possibility to enable the default screen resolution for this monitor which is 480x320 (this is not a standard resolution, so careful and very complex modification of the XORG server and GPU drivers is needed). We came as close as correctly modifying the XORG configuration, but we fell short on the GPU drivers configuration. We had to pick 720 x 480 which has the same 2:1 ratio as the original screen resolution, and it was default supported by GPU drivers.
2. Database setup: The database setup comprehends the installation and configuration of MariaDB, alongside phpMyAdmin packages that enable database control over the web interface. For this project an SQL database with 3 columns representing id (varchar 255), name (varchar 255), and quantity (float) was created.
3. In order to start up our GUI application at boot we relied on the Systemd daemon manager. In order to do so a custom splashy.service and splashy.timer files were created and placed under /etc/systemd/system/ directory. In this manner it's possible to enable such service at boot. To do so just systemctl enable splashy.timer.

State Diagram - Behaviour and Interaction

The behaviour will be described in a technical way through a state diagram, and in a more user friendly way with a storyboard and user manual.

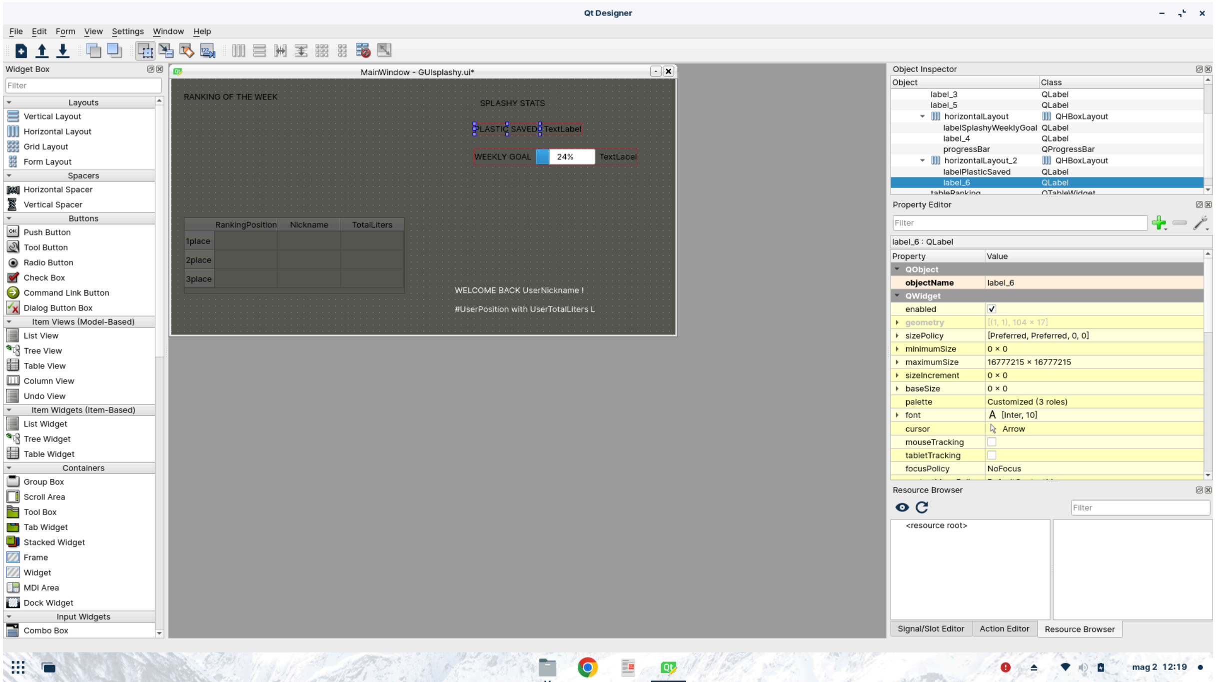
This is the initial sketch of the State Machine diagram:



GUI - Graphical User Interface

INSTALLING PYSIDE2 AND QT DESIGNER

The first step was to install Qt Designer.

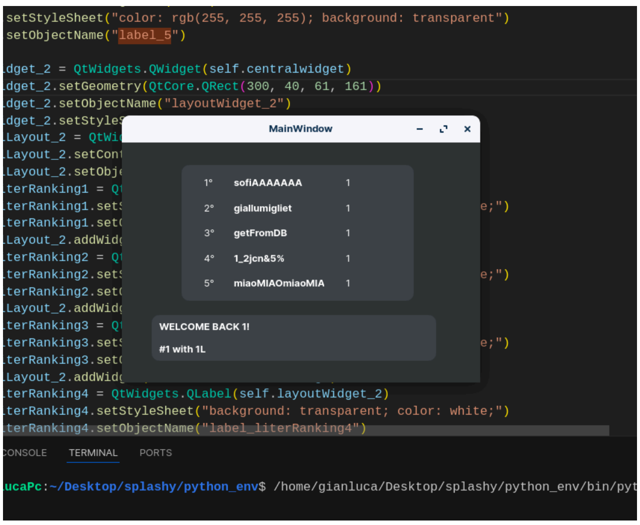


It is a very intuitive drag&place designing program, where you can set different styles and formats to each element.
With it we can create a .ui file that can be then converted into a .py file through the command
`pyuic5 GUIname.ui  -o GUIname.py`
Around this file we can create the actual working GUI.

UPDATING THE DESIGN

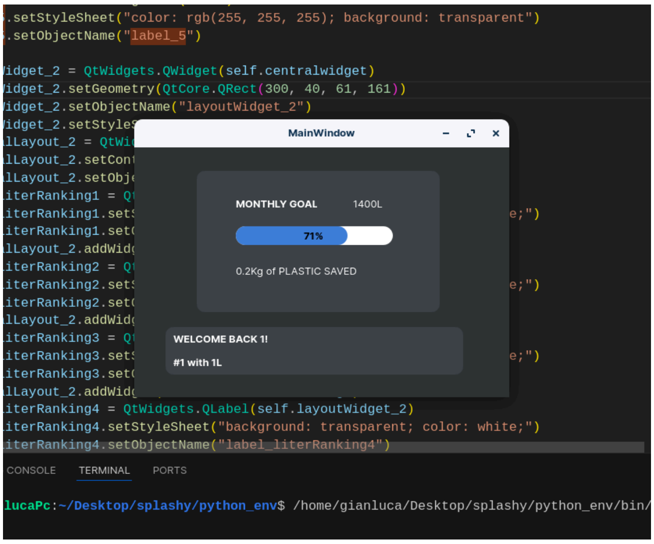
To have an easier reading of the information, we decided to separate the ranking and the global stats, by showing only one of them at a time, alternating them every few seconds.

Moreover, the overall look has been changed to something more minimal and modern, to better fit the robot mood.



In the end another thing we wanted to implement was that the greeting to the current user, appeared only when an NFC tag is scanned.

So if UserName is not an empty string it shows the greeting, else it greets. The UserName is associated with the NFC tag scanned, and it is set to empty when the refill has finished.
Here you can see a DEMO: [DEMO]



DATABASE CONNECTION

The elements of the GUI need to read the value to display from an associated database that contains all the needed user information.
This informations are not sensible data, the database contains information such as:

- tag NFC ID
- nickname
- litres

And so on.. This part is explained more in detail in the database coding section.

SCREEN REFRESH AND VALUES UPDATE

All the values got from the database are updated several times per second. To ensure that the GUI actually changes dynamically, we tested it with a common increasing value ***self.getFromDB***.

Here you can see the result of the test: [Update TEST]

PROGRESS BAR BUG

From the previous final step of the design we noticed a bug in the progress bar from Qt Designer: for low percentages (less than 10%) the left side is not rounded as it should be.

Unluckily this is not a fixable bug, since it belongs to Qt Designer.

Here you can see test with a bug: [Bug TEST]

Structure

During the development process, our team aimed to create an innovative 3D model by integrating diverse ideas and perspectives. We envisioned a vertically oriented structure combining functionality with aesthetic appeal. The initial design focused on two key segments: the rear section for housing electronics and the front section for accommodating a water bottle. Our primary goal was to balance stability and functionality.

Upon completing the initial prototype, we identified issues with static balance and the impracticality of the water dispensing mechanism. Additionally, the wings, intended as dynamic components, lacked the desired range of motion and were unused.

To address these challenges, we leveraged the penguin's anatomy to rectify the balance issues. By repurposing the tail and rear fin as a dual support system, we achieved structural equilibrium. The wings were redesigned to house an interactive LED screen, adopting a spherical joint mechanism that allows up to 90 degrees of movement and we are still working to obtain a 30 degrees of inclination. We also integrated an NFC reader into one of the wings to enhance user engagement by facilitating access to ranking information.

For the water dispensing mechanism, we introduced a user-friendly knob for automated water quantity selection, positioned atop the penguin's belly. This intuitive interface streamlined the user experience and enhanced the design's aesthetic.

We redesigned the rear door for easier access to the electronic components. Initially, makeshift solutions like tape were used to secure the components, but we later incorporated shelves and hooks into the 3D model for the electronic components. This strategic redesign not only simplified the internal layout but also rendered it more manageable and organised.

Espressions

The characteristic feature of the interaction with the user of our robot penguin is the innovative interface of the LED matrices in the eyes, which allows the penguin to express different emotions depending on the moment. This feature makes interacting with the penguin more intuitive and engaging.

- Attracting Phase: When the penguin wants to attract attention, its eyes take the shape of a bright exclamation mark, capturing users' interest.

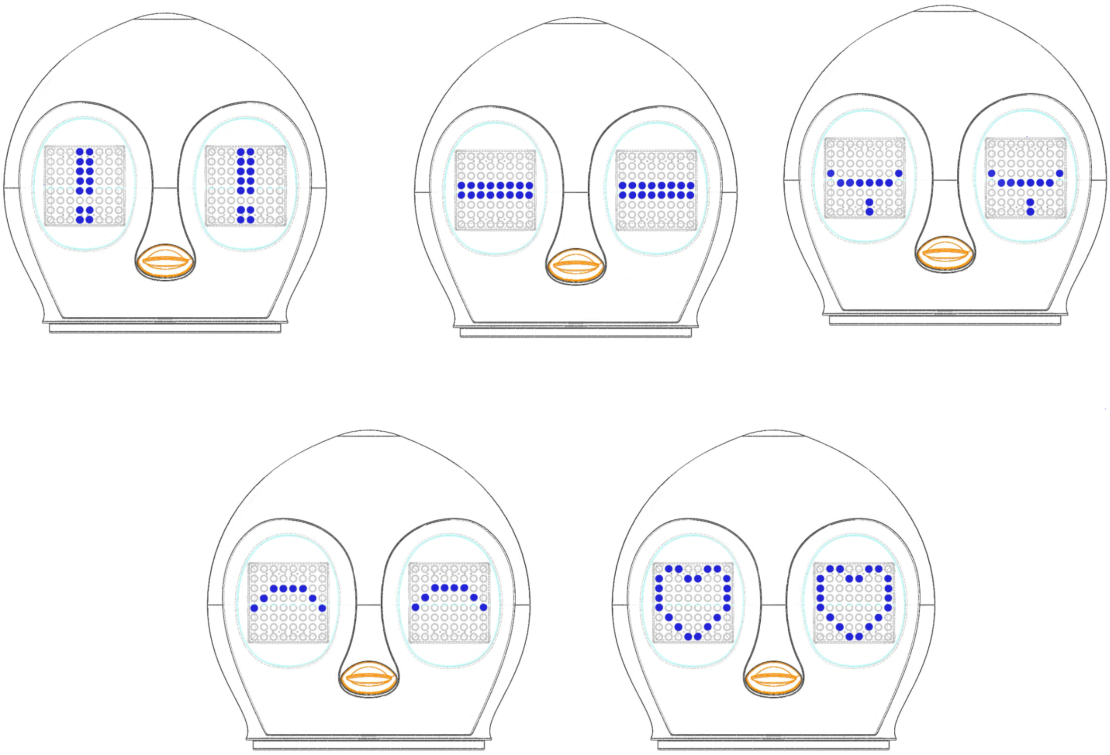
- Happiness phase: When someone approaches/is detected or fills the bottle with water, the penguin expresses happiness through a joyful expression.

- Sad phase: If no one approaches for a while, the penguin becomes sad and its eyes show tears, expressing a sense of loneliness and drawing the user's attention.

- Petting phase: When the penguin is petted, it expresses satisfaction with eyes that turn into a straight line.

- Refill phase: During the water filling phase, the eyes transform into hearts, which progressively fill, showing the progress of the refill.

In summary, the interface of the LED matrices in the eyes of our robot penguin is not just an aesthetic element, but a fundamental component that transforms interaction with the user into an engaging experience.



Logo

This logo is the visual identity of our project, featuring our penguin water dispenser, Splashy The design intricately blends the image of a penguin with the dynamic movement of water, encapsulating our core values and mission.

The upper part of the logo illustrates a penguin, symbolising the main shape of our product, and our dedication to environmental protection, as said in the first part of research.

The lower part of the logo transitions into stylized water droplets, signifying the seamless flow and refilling process provided by our dispenser machine. This element emphasises our focus on sustainability, highlighting the easy access to clean water, reducing the resilience on single-use plastic bottles. The colour palette of blue and white reinforces the themes of cleanliness and freshness, as in the mood board, and with the splash of orange for the penguin's beak, it bursts out with a detachment from the monochromatic rest, suggesting innovation.

Overall, this logo effectively communicates the essence of our project: delivering a practical, eco-friendly solution for water consumption while fostering a deeper connection to the natural world through the symbolic use of the penguin and water imagery.

Shape

The initial design concept began with a rough sketch featuring sinuous, spherical contours. However, we soon identified disproportionate elements between the head and body, needing a refinement of our approach. To achieve authenticity, we meticulously adjusted the penguin's head to harmonise with the overall body structure, ensuring visual cohesion. We incorporated a rounded, hollow belly to serve as a practical location for the lost water reservoir, on which the bottle is positioned by the user, in correspondence with the nozzle, while this entire body all in all highlig the penguin's distinctive physique.

To evoke the essence of a penguin, we carefully crafted fins and wings to closely resemble their real-life counterparts and added a delicate beak to enhance the robot's character and authenticity. We paid close attention to surface finishes and colour palettes, the colours have gone from light blue/blue to black/grey, selecting them to mirror the nuances of a genuine penguin's appearance, thus imbuing our robot with a sense of realism and relevance.

First working prototype:

We created our first true prototype, 3D printed, after carefully modelling all the parts. This process allowed us to better understand the internal spaces of the design, precisely identifying what to fix and where to place the electronics. Creating the prototype also enabled us to evaluate whether the shape and size of the product were suitable in reality.

Having the physical prototype was fundamental to our work. It provided us with a concrete opportunity to observe and improve the design, highlighting areas that needed modifications. Additionally, the prototype was used as a 'guinea pig' for the first practical tests.
During these tests, we made several adjustments, worked intensively on it, and inevitably, damaged some parts. This iterative process was essential to refine our project, leading us to a deeper understanding of the needs and challenges of our design.

In conclusion, creating the prototype provided us with valuable insights and played a crucial role in improving our final product, both functionally and aesthetically.

Phase 4: Deliver

In this phase we describe the final robot and decisions we took.

Final Robot description

Strategy

This last phase represents a crucial moment in the development cycle of a technological product, with the first prototype already created, the main objective is to test, improve and finalise the product so that it can function correctly and autonomously, as well as being aesthetically attractive. This process involves close collaboration between teams of designers and engineers, who work together to perfect every detail of the product.

During this phase there were sub-phases that allowed us to arrive at the final result, in fact we exploited the maximum potential of the first prototype, which was subjected to a series of tests to evaluate its performance, functionality and reliability, including whose technical checks (for example, tests of circuits and mechanical components) and practical use tests. This allowed us to understand the areas for improvement, in fact the engineers analysed the data collected during the tests to identify the critical problems that need to be solved including malfunctions, energy inefficiencies, compatibility problems and more, while the designers evaluate the aesthetics and ergonomics of the prototype and this phase can lead to changes in the design to improve the visual appeal and usability of the product. This then allowed us to make the necessary changes to the 3D model and software code, to finally create the new prototype incorporating the changes.

During this phase, we had numerous unforeseen events, which required us to find quick and creative solutions to address problems that could compromise the delivery of the product on schedule, requiring close collaboration and effective communication between all team members.

Shape

During this delivery phase, we analysed the errors and problems present in the 3D model of the robot, thanks to the tests carried out. As a result, we finalised and improved the 3D model.

- Starting from the body, we decided to divide it into three parts instead of two, since it was difficult to attach the electronic components inside. Now, the structure includes:

    1. The black outer shell: 3D printed in PLA, this part wraps around the entire robot, providing strength and a uniform appearance.
    2. The front belly 3D printed in white PLA: This component has been rounded in the upper part compared to the previous one, and has two holes for the sonar, now arranged vertically rather than horizontally, to improve the detection of the water bottle.

3. The central black internal body in 3D printed PLA: this part is fundamental for anchoring the electronic components, facilitating internal order thanks to specific attachments for the various components, given the numerous cables present.

- The water tank was 3D printed in white PLA, with a circular recess on the grid to correctly position the water bottle under the nozzle, avoiding positioning errors.

- On the back, a black PLA door has been 3D printed, fixed with two screws and equipped with a finger hole for easy opening, this closes the structure hiding the electronics.

- The head was designed following the body to maintain a harmonious silhouette. It is made with a 3D printer in black PLA and has two internal square recesses for the LED matrices.

- The white eye mask is made of interlocking and 3D printed in white PLA, on which 'covers' for the LED matrices are applied, initially in transparent resin, but it did not reflect the LED designs well. Therefore, it was manually thermoformed in PVC starting from the printed models.

- The feet and tail, also 3D printed in black PLA, contribute to the stability of the structure. A proximity sensor is mounted on the left foot to detect the presence of people.

- On the back of the body there are: the ON-OFF button, two holes for the water pump and the power socket.

- On the front there is a knob, 3D printed and made of black PLA, which covers the potentiometer, to select the quantity of water, labelled with laser-printed stickers on vinyl sheets, located to the right of the front screen.

- On the left, however, there is the NFC tag reader, under the body shell, highlighted by a white label laser-printed on a vinyl sheet.

- The front screen is inserted into a specially made recess, with an external mask to improve the general aesthetics, also in 3D printed black PLA.

- The 3D printed black PLA wings were designed to follow the shape of the body, being thin and light to allow agile movements. They are fixed to the structure via a specially designed mechanical mechanism.

Support base

To ensure that nothing was left to chance for our final presentation, we meticulously crafted the support base for our robot. The process began with the procurement of all necessary materials, including plywood of 8mm. We carefully measured and cut the pieces to precise specifications, then assembled them into a sturdy box structure.

Next, we constructed a dedicated shelf to securely hold the pump, ensuring it would function optimally during the presentation. We also integrated two strategically placed holes to accommodate the water pipes, facilitating smooth and efficient operation.

Once the structural components were complete, we turned our attention to the finishing touches. The entire assembly was primed with cementite to create a smooth, durable surface. This was followed by a coat of white paint, giving the base a professional and polished appearance and after a final second coat of paint again.

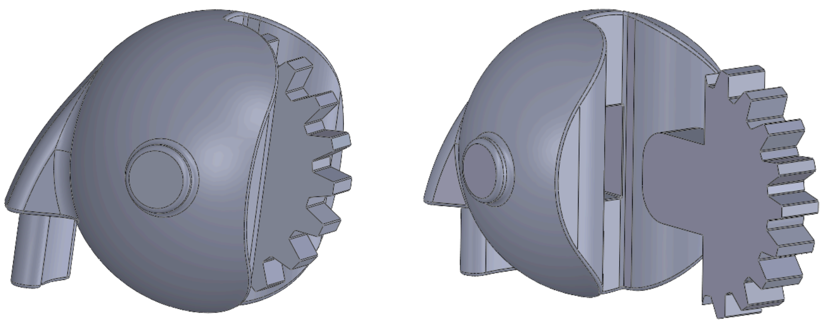
To add a final touch of professionalism, we designed and applied a front-facing graphic that prominently featured our logo. This graphic also included detailed course information, presenting a comprehensive and visually appealing overview of our project.

Inside the box there was a gallon of water which brought the water inside the robot to the nozzle with the pressure of the pump, it was hidden inside to make the aesthetic appearance even more pleasant.

Mechanics

In designing our robot, the most complex mechanical part was that concerning the mechanisms of the wings and the head. Initially, the idea was to attach the wings directly to the mechanism, but this would have compromised the aesthetics of the robot. We therefore thought about how to hide the mechanisms, especially after the *Development* phase in which we decided to no longer include the LED screen on the wings, instead keeping it on the front of the penguin together with the NFC tag reader.

For the movement of the wings, we had previously thought of using two servo motors: one to open the wings with respect to the vertical axis of the body and another to tilt the wings by 30 degrees. However, we have reconsidered and redesigned the entire system to be able to use only one servo motor for the movement of each individual wing, thus hiding the mechanism from view.



We created a "ball joint" mechanism, consisting of two parts: a ball that attaches to the rest of the wing on the outside and a gear that fits inside the ball. This gear connects to a second gear attached to the servo motor mount located on the inside of the body. This system allows the two toothed gears to slide over each other, connecting the servo motor and the wing, allowing angular movement of the wings from 30 to 70 degrees, regulated by the code. During the final test we realised that the toothed gears had too small teeth and were slipping over each other, so we had to remodel in 3D and reprint the toothed gears having made them larger, fewer in number and more spaced between them.

For the movement of the head, we created a cylinder that connects the head to the servo motor mount located in the body of the robot. This cylinder allows, based on the angles generated by the code, to easily rotate the head 180 degrees, 90 degrees to the right and 90 degrees to the left with respect to the central axis.

These mechanical solutions not only improved the aesthetics of the robot, but also optimised the functioning of the movements, making them more fluid.

In the link below, you can see the technical drawings to better understand the model: [Technical drawing Splashy]

Electronics

In this section each component is shown with his:

- *model name/code*
- max current and voltage needed
- *data connection (**pinout**)*
- usage, description, problems, solutions

POWER SUPPLY

SUCIKORIO trasformatore 12V 100W

INPUT: 220V AC; OUTPUT: 8.3A - 12V

We chose a 12V power supply to be able to power the water pump.
With a computation of the max total current draw in each state, we decided to have 100W of power in order to have a safe margin.
The dimensions had to be as slim as possible in order to fit inside the robot.

ON/OFF SWITCH

ON/OFF Switch DC 12V 20A LED

supporting max 20A DC - 12V

At first we wanted to turn off the whole apparatus, even the power supply, by putting the switch between the Schuko plug and the power supply.
But we realised that the switch was designed to be used with DC current.
So, by placing the switch before all the step downs, we can turn off all the components.
And, since the water pump is turned on from the relay, by turning off the relay we also turn off the pump.

STEP DOWN (x4)

LM2596

supporting max 3A on load - conversion from 12V to 5V

With a computation of the max total current draw of each component, we decided to have 4 step downs in order to have a safe margin.
The components are grouped under the same step down in a way such that we stay below the 3A.

ARDUINO

ARDUINO MEGA 2560

0.8A - 5V

We chose the MEGA 2560 due to the need for a powerful and capable system to run the entirety of the robot.
The Arduino itself controls the state of the robot, requiring the most responsive Arduino board possible with substantial RAM (random access memory) and program memory. Moreover, given the number of sensors, a considerable number of pins is needed.

RASPBERRY

RASPBERRY PI 3 Model B v2

2.5A - 5V

This component is needed because the arduino does not have the required computational power to manage a database, and with the HDMI output we can easily connect the screen.

It controls the RFID sensor and the screen. All the other components are controlled by the Arduino.

We did not have any particular constraints on this system aside from the ability to run a database (performance here was negligible as we planned to make six queries per second at peak load in a small database) and a simple (low power) GUI.

RFID SENSOR

RFID-RC522

26mA - 3.3V

*// SDA connects to Pin **24***

*// SCK connects to Pin **23***

*// MOSI connects to Pin **19***

*// MISO connects to Pin **21***

*// GND connects to Pin **6***

*// RST connects to Pin **22***

The sensor is needed to recognise the user and add his stats of the current refill to the database.

Since the data collected by this sensor are used by the database and the screen it was an easy choice to let it be controlled by the Raspberry.

SCREEN

MPI3508

0.5A - 5V

*//data connection through **HDMI***

The main requirements for the screen were an HDMI input, and really slim and small dimensions.

We decided to buy a 3.5 inch screen, so that it can fit well on the robot surface (not being too bulky), but at the same time not too small that the displayed information was not visible.

It is used to show a ranking of the best water drinkers, the global stats of the robot and the current user stats.

LED MATRIX (x2)

MAX7219 LED matrix

0.3A - 5V

*#define LED_MATRIX_DATA_PIN **2***

*#define LED_MATRIX_CLK_PIN **4***

*#define LED_MATRIX_CS_PIN **3***

They are used as the eyes of the robot, to give a visible feedback of the interactions with the robot.

At first we had red led matrices, but we changed them with blue ones.

SERVO MG996R (x3)

MG996R

0.9A - 5V

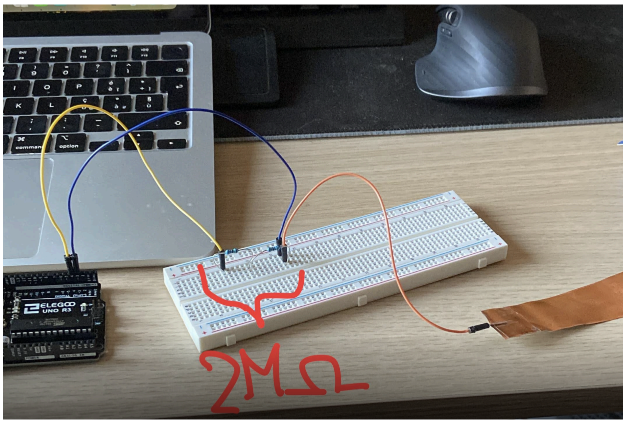
#define LEFT_WING_SERVO_PIN ***13***
#define RIGHT_WING_SERVO_PIN ***12***
#define HEAD_SERVO_PIN ***11***
They are used to move the head and the wings of the robot, to give a visible feedback of the interactions with the robot.

MICRO SD MODULE
MicroSD Card Adapter
200mA - 5V
#define SD_CSPIN ***7***
// MISO ***50***
// MOSI ***51***
// SCK ***52***
In order to store the files in which are written the animations for the LED matrices and the servo motors we decided to use an external microSD.
By doing this we ensure to have more free space in the internal memory of the Arduino.

ULTRASONIC SENSOR
HC-SR04
15mA - 5V
#define ULTRASONIC_SENSOR_TRIGGER_PIN ***26***
#define ULTRASONIC_SENSOR_ECHO_PIN ***27***
This sensor is used to detect the presence of the bottle inside the refilling area.

PIR SENSOR
HC-SR501
1mA - 5V
#define PROXIMITY_SENSOR_PIN ***25***
This sensor is used to detect the presence of people around the robot, so that it can draw attention.
POTENTIOMETER
B1M
negligible - 5V
#define POTENTIOMETER_PIN ***A3***
In order to choose the amount of water to be poured we have a knob, which is mounted onto the potentiometer.

TOUCH SENSOR
negligible - 5V
#define TOUCH_SENSOR_PIN_SEND ***30*** *// digital pin*
#define TOUCH_SENSOR_PIN_RECIVE ***9*** *// PWM pin*
To increase the interactions with the robot we added a touch sensor on the top of the head: in this way the user can also pet the robot.



The touch sensor is made following this tutorial, provided by the teacher:
https://www.aranacorp.com/en/create-a-capacitive-sensor-with-arduino/
Until we didn't have a complete power supply scheme, we had some current spikes that triggered the sensor, even if not touched.
But when we set and finished it, the sensor became stable.

RELAY

2 Channels Relay Module High/Low Level Trigger
supporting max 10A - 12V, trigger current 5mA
#define PUMP_PIN ***29***
Here we have a 2 channel relay, but we needed only one.
Since it was provided and it didn't change current consumption or performances we decided to use it anyway.
We can select which channel to use and if the relay is NO (normally-open) or NC (normally-closed).
The selection of the channel is unconstrained.
We selected the NO, so, when it is triggered, the circuit closes and the current flows into the water pump.

FLOW SENSOR

YF-S402
15mA - 5V
#define FLOW_SENSOR_PIN ***19***
We could avoid using this component and tune the refilling stop with respect to the time needed.
But in order to be more precise and not spill water, it is very useful.

WATER PUMP

SEAFLO pompa 12V 4.3LMP
4A - 12V
The pump needed to be sufficiently powerful to have a fast refill, but not too powerful that is too noisy and requires too much current.
At first we had a pump which was not self-priming, which is an important characteristic our pump must have to suck water from a container.
We changed it into a new one.

Informatics

In this section we briefly list all the external libraries used for both the Arduino and the Raspberry systems.
All detailed code structure is available in the next link: CODE STRUCTURE, but you can also find it in the appendix. Such documentation was generated using Doxigen.

1. Arduino
    - Servo 1.2.1
    - CapacitiveSensor 0.5.1
    - LedControl 1.0.6

- NewPing 1.9.7

2. Raspberry
    - pyserial 3.5
    - mfrc522 0.0.7
    - mysql-connector-python 8.4
    - Pyside2 5.12
    - Pyside2extn 1.0.0 (git build)

Important Note: Due to last-minute problems the **touch sensor** has been **disabled** in the build uploaded to the Arduino board. This is due to the technological nature of the touch sensor and the power-supply system.

Given the complexity and the high power needed to correctly feed the pump, the Raspberry and the screen (especially the pump can suck up to 54W) and being the touch sensor a capacitive sensor that has been built by us, some peaks of current could, during full load, lead to false positive reading from the touch sensor (the touch sensor registers a touch that has never happened). For this reason we decided to disable it via software (the sensor is actually present in the robot). To **enable** it just **uncomment line 155 to 157** of Splashy.ino file.

Possible fixes for this:

- build a better isolation in order to avoid electronic interference of other wires.
- reroute touch sensor cables to avoid electronic interference of other wires.

Better power isolation of the Arduino (which is the responsible for probing the touch sensor and hence reading it) is not a feasible, or at least practical, solution for this since the Arduino is being powered from the Raspberry-pi, so there is no direct control over power delivery from this source.

Google Drive Link:
https://drive.google.com/file/d/11vYEeH9QbJjPI5ycCLtsm3J3rB1rQKe3/view?usp=share_link

Github Link: https://github.com/d-graz/Splashy

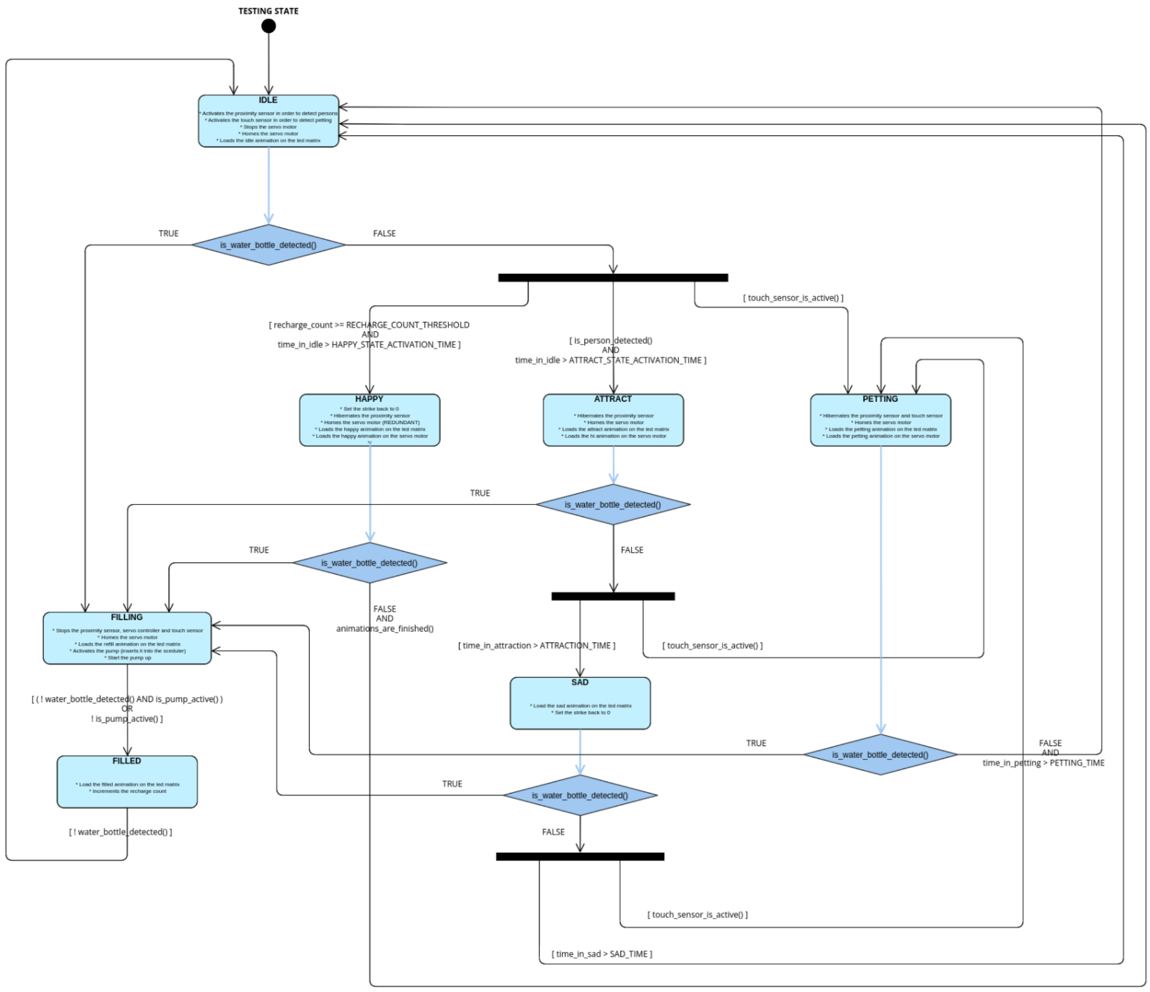
GUI - Graphical User Interface

After the last review with the teachers we apply some changes on the GUI to improve the interface.

Here you can see the last version: Final GUI

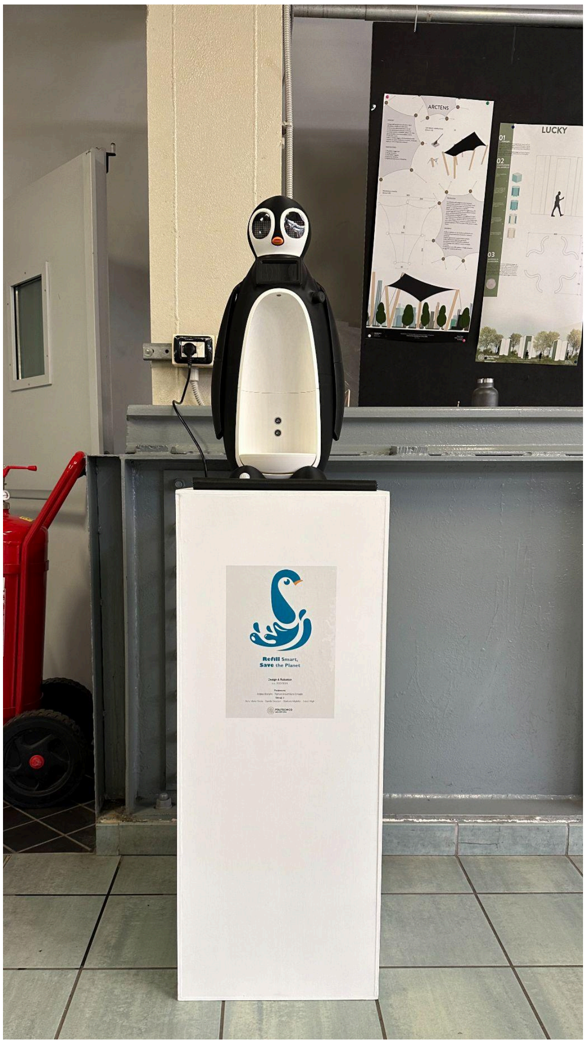
State Diagram - Behaviour and Interaction

In the last delivery phase, we definitively schematized the state diagram, updated with all the changes and improvements. The picture below show the final State Machine diagram:



Final product

After all the work done, the improvements made, these below are the photos of our robot finished and ready for use.



Conclusion

From this experience we learnt different aspects of product making, by working and absorbing knowledge from our teammates.
It is very satisfying to see a finished working robot, since we started from abstract ideas and drawings.

The journey was not always easy and we spent more time and effort than expected, in order to have the best results.

We are already thinking about some improvements, but due to the lack in time and budget, we leave them to posterity:

- more powerful power supply to ensure a more stable system
- better internal organisation in the placement of the electronics (for example the RFID for the NFC tag could be in the stomach of the robot, so that a NFC tag sticker attached to a bottle can be detected in one move by placing the bottle for the refill)
- more attacks for the electronics, so not to use velcro
- finer tuning of the sensors
- safer internal design, in order to physically separate the flow sensor and water pipes from the other electronics (avoiding spilling of water on them) and making room for the wires of the touch sensor
- replace the water pump with a valve in order to connect the robot to the pressurised water network of the campus
- creation of a hole for a drainpipe under the grid of the water tank, to connect it to the water network

APPENDIX

User Manual

At the link below you can download it: User Manual Splashy

Maintenance Manual

At the link below you can download it: Maintenance Manual Splashy

Minutes of the Meetings

Meeting 06/03/2024

Time: 6 h
Venue: Google Meet
Attendees: Enrico, Davide, Gianluca, Sofia

- we discussed about general design choices, types of interactions, shape of the robot and feedbacks (eyes, movement of the body).

Meeting 10/03/2024

Time: 5h
Venue: Google Meet
Attendees: Enrico, Sofia

- we discussed about the moodboard.
- we decided on the style of the moodboard and the colours, we selected the photos, created a layout that reflected the initial and group ideas.

Meeting 17/03/2024

Time: 2 h
Venue: Google Meet
Attendees: Davide, Gianluca

- we discussed about electronics parts, BOM.
- we decided to use an Arduino and a Raspberry for the control, and we selected the compatible hardware to achieve the correct behaviour of the robot discussed previously.

Meeting 18/03/2024

Time: 3 h
Venue: Google Meet
Attendees: Enrico, Davide, Gianluca, Sofia

- we discussed about interaction, water pump.
- Gianluca explained the different possibilities for the automatic refill mechanism.
- we chose the goals we wanted to achieve and how to differentiate the robot from already existing machines.

Meeting 21/03/2024

Time: 2 h
Venue: Google Meet
Attendees: Davide, Gianluca

- Davide explained to Gianluca the way the scheduler works, to have a better simultaneous work and understand what can and can’t be done.

Meeting 28/03/2024

Time: 2 h
Venue: Google Meet
Attendees: Davide, Gianluca

- we discussed about the feasibility of using different sensors for the automatic refilling.
- we decided which sensors to use and how to manage them, in the context of the Arduino integration.

Meeting 30/03/2024

Time: 4 h
Venue: Google Meet
Attendees: Enrico, Davide, Gianluca, Sofia

- general update between design, hardware and software.

Meeting 4/04/2024

Time: 2 h
Venue: Google Meet
Attendees: Davide, Gianluca

- we discussed about the animations of the led matrices and the positioning of the electronics.
- we chose a draft of the layout for the electronics and picked an online tool in order to draw the LED animations.

Meeting 09/04/2024

Time: 6 h
Venue: AIRlab
Attendees: Enrico, Davide, Gianluca, Sofia

- initial testing of hardware and starting of the prototype assembly.

Meeting 23/04/2024

Time: 7 h
Venue: AIRlab
Attendees: Davide, Gianluca, Sofia

- we completed the assembly and tested the prototype.

Meeting 27/04/2024

Time: 3h
Venue: Google Meet
Attendees: Enrico, Sofia

- we discussed about the adjustment to do on the 3d model

- we decided to remodel all the parts in 3D, and to divide the main body into 3 parts instead of two, so as to be able to have the central internal opening to attach all the electronics, and to create ball joints for the movement of the wings, that we also modified these, making them lighter and more sinuous, we decided to completely redo the head and create a mechanism that connected it to the body and allowed it to rotate: a shaft, finally we decided to model the feet and tail to have better stability of the structure and to divide the large parts into smaller ones to quickly print the pieces, we finally decided where and how to arrange the electronics inside

Meeting 30/04/2024

Time: 6 h
Venue: AIRlab
Attendees: Davide, Gianluca

- we tested the prototype and electronics optimising some behavioural aspects and tuning some hardware

Meeting 4/05/2024

Time: 1 h
Venue: Google Meet
Attendees: Davide, Gianluca

- we discussed about the pump and water pipes
- we decided to buy a new pump, since the previous one was not able to create the necessary sucking pressure

Meeting 13/05/2024

Time: 7 h
Venue: AIRlab
Attendees: Davide, Gianluca

- we completed the power supply
- We worked on the GUI, by choosing the layout of the information shown.

Meeting 14/05/2024

Time: 5 h
Venue: AIRlab
Attendees: Gianluca, Sofia

- we completed GUI design,
- we discussed about the storyboard, gantt and report, choice of fabrics, logo, 3d model.

Meeting 16/05/2024

Time: 4 h
Venue: Google Meet

Attendees: Enrico, Gianluca, Sofia

- we chose the hardware positioning in the final robot and defined the general guidelines and sensor position constraints in order to create the 3D model.

Meeting 22/05/2024

Time: 1 h
Venue: Google Meet
Attendees: Davide, Gianluca

- we decided the integration for the new pump alongside the water pipes and connectors to buy

Meeting 23/05/2024

Time: 3 h
Venue: Google Meet
Attendees: Davide, Gianluca

- last changes to GUI, LED animations and motor animations.

Meeting 25/05/2024

Time: 8 h
Venue: Politecnico Bovisa - B2
Attendees: Davide, Gianluca, Enrico, Sofia

- initial robot assembly

Meeting 27/05/2024

Time: 6 h
Venue: Politecnico Bovisa - B2
Attendees: Davide, Gianluca, Enrico, Sofia

- final robot assembly

Meeting 27/05/2024

Time: 4 h
Venue: Politecnico Bovisa - B2
Attendees: Davide, Gianluca

- final tests

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Attachments

This is the link to the Gantt: Gantt Splashy
This is the link to the BOM: BOM Splashy
This is the link to the 3D model: 3D model Splashy
This is the link to the code and libraries: Code&Libraries Splashy
This is the link to the detailed code structure: Code structure Splashy
This is the link to the Water Flow Sensor YF-S402 datasheet: Water Flow Sensor Splashy
This is the link to the Transformer datasheet: Transformer Splashy
This is the link to the RC522 RFID datasheet: RFID Splashy
This is the link to the Water Pump datasheet: Water Pump Splashy
This is the link to the Potentiometer RV24AF-10-15R1-B1M datasheet: Potentiometer Splashy
This is the link to the MicroSD Card Adapter datasheet: MicroSD Card Adapter Splashy
This is the link to the MG996R Servo Motor datasheet: Servo Motor Splashy
This is the link to the MAX7219 Based 8x8 LED Matrix datasheet: LED Matrix Splashy
This is the link to the LM2596 step-down datasheet: Step-down Splashy
This is the link to the HC-SR501 PIR motion sensor datasheet: Motion Sensor Splashy
This is the link to the HCSR04 Ultrasonic Sensor datasheet: Ultrasonic Sensor Splashy
This is the link to the Arduino® MEGA 2560 Rev3 datasheet: ArduinoMEGA Splashy
This is the link to the Raspberry Pi 3 Model B+ datasheet: Raspberry Splashy
This is the link to the Google Photo: Photo Splashy
This is the link to the technical drawing: Technical drawing Splashy
This is the link to the User Manual: User Manual Splashy
This is the link to the Maintenance Manual: Maintenance Manual Splashy