Floating Maze

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Overall Concept

The heart of our project is the circular "Floating Maze" that seems to levitate mid-air. This illusion of suspension is realized using four ultra-high-strength, fine wires anchored firmly at the maze's four endpoints. These wires are connected to servos that are held aloft by four vertical rods, supplemented with a jointed wooden structure for stability and precision. This intricate setup facilitates the subtle tilt of the maze in all cardinal directions, guiding the ball's movement within.

Our choice of wood as the material, shaped meticulously with laser-cutting techniques, not only ensures precision but also lends an organic touch to the design. Enhancing its visual appeal, we spray-painted the wooden surface with a gradient that transitions from pure white to varying shades of blue. This evokes the imagery of a cloud-filled sky, reinforcing the concept of the maze floating amidst the clouds.

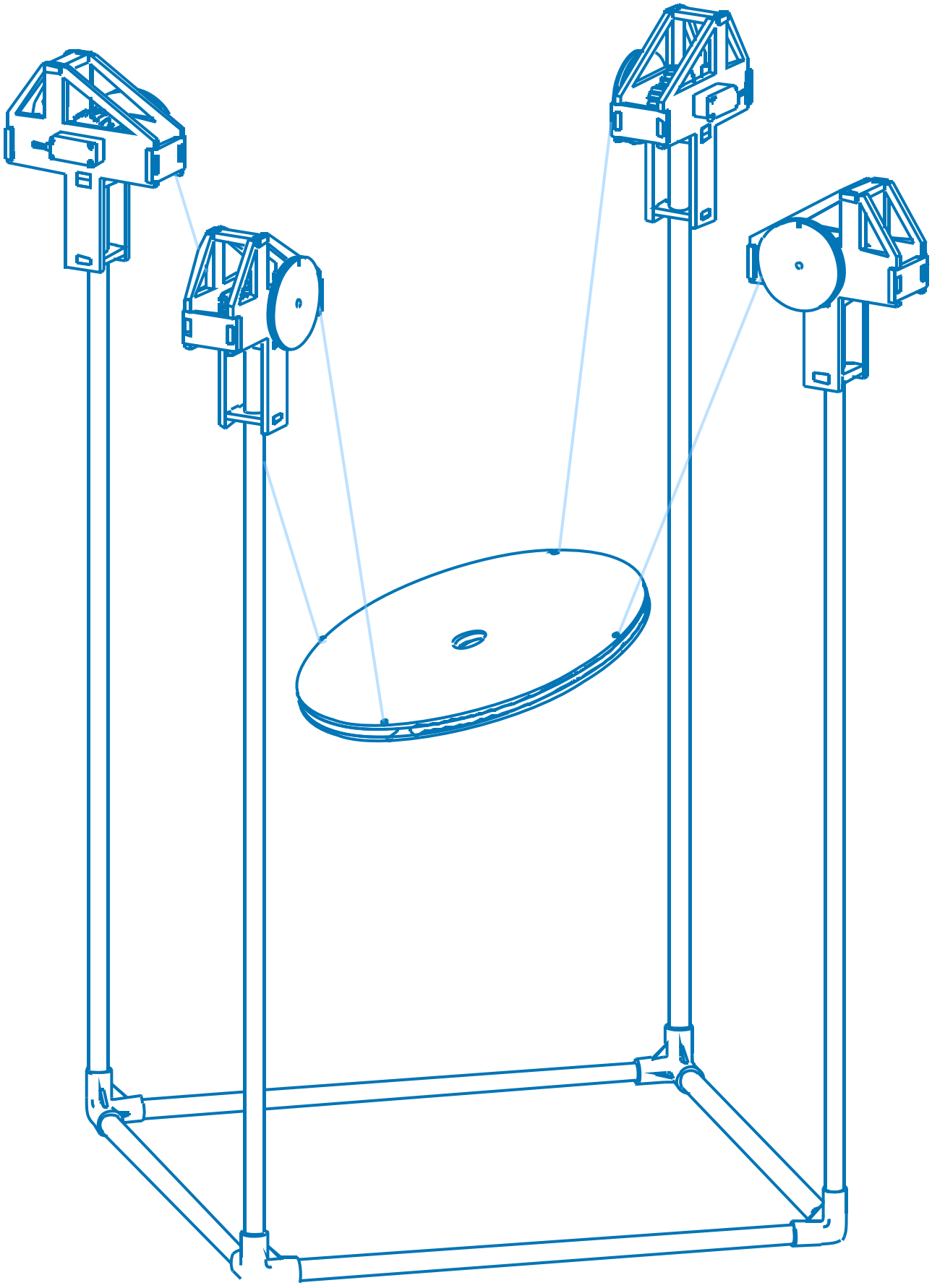
Central to the interactivity of the maze is the Leap Motion sensor, a device adept at capturing the intricate positioning of a player's fingers in real-time. By analyzing these positions, the system is able to deduce the overall vector orientation of the hand.

This orientation is translated into one of the general movement directions: forward, backward, left, or right. This hand orientation data is processed within the software environment, Processing, and then relayed to Wekinator, a machine learning tool. Wekinator refines this data, interpreting the player's intended hand gesture from the captured fingertip vectors. Once this interpretation is complete, the data is sent back to Processing, which in turn actuates the four servos to induce the desired tilt and movement in the maze.

Adding another layer of interactivity is a special mechanism situated at the maze's base. This mechanism is activated when the ball finds its way to the center of the maze. On activation, the ball is propelled outside the maze, signifying the conclusion of that round and paving the way for the commencement of the next.

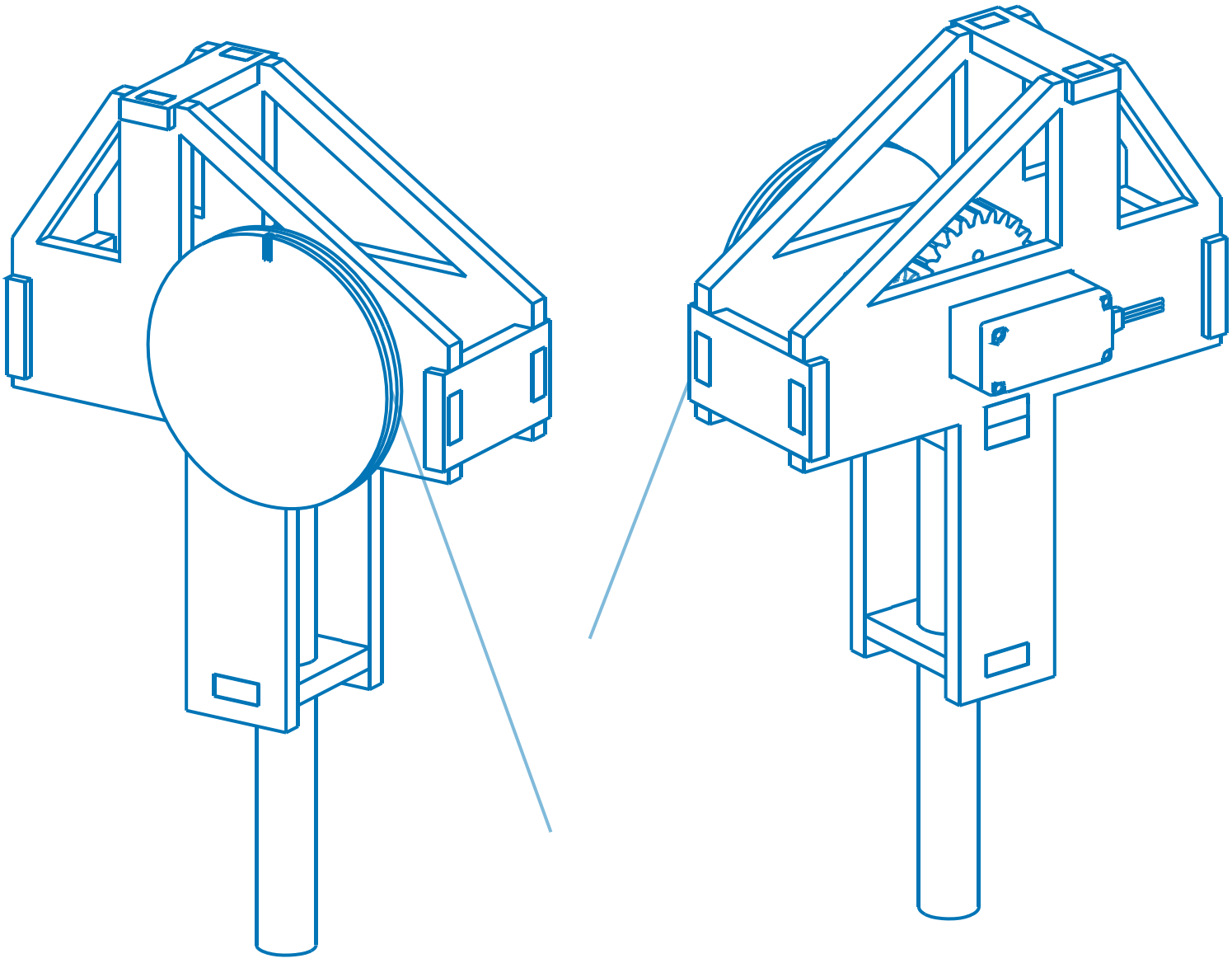
In essence, the "Floating Maze" is a harmonious blend of design and technology. It offers an environment wherein player actions directly influence gameplay. Every design element has been thoughtfully integrated to heighten the user experience, with technology seamlessly bridging the player's intentions with tangible game responses.

1 Mechanism Design



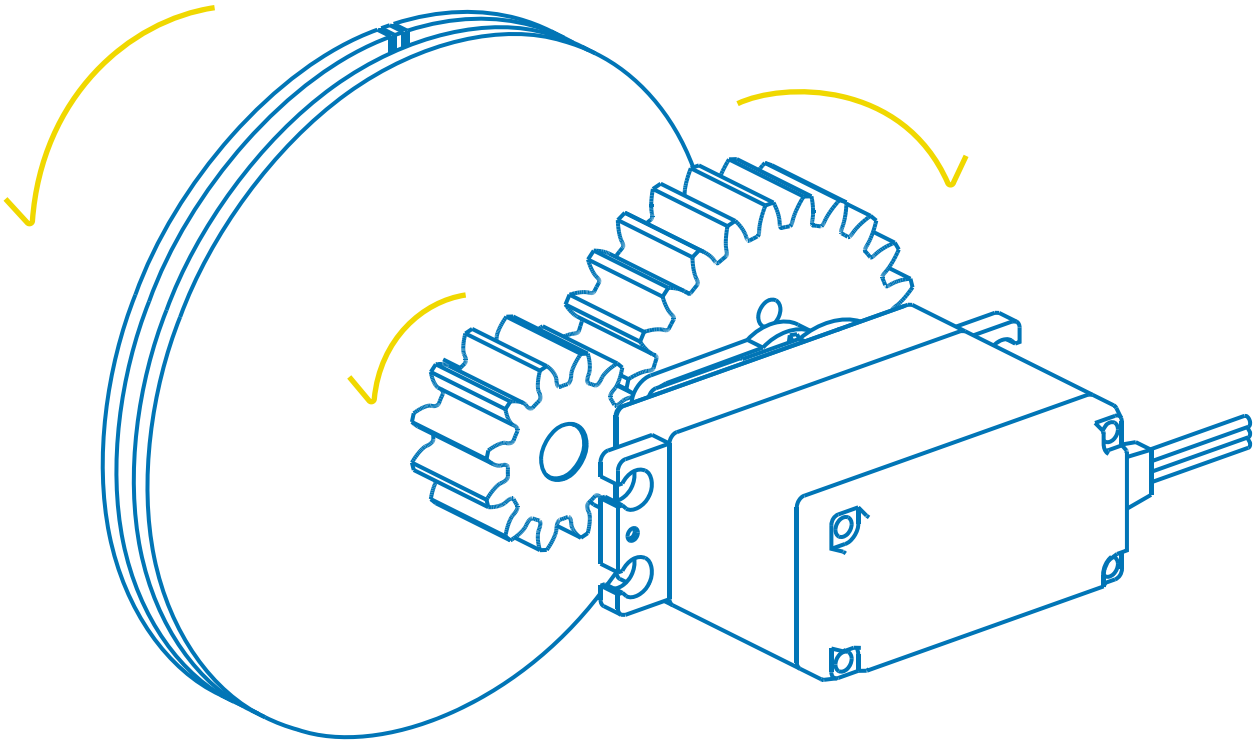
Gear Box

The appearance comes from the tower crane. We wanted to create a dreamy scene of a floating maze driven by towering cranes.

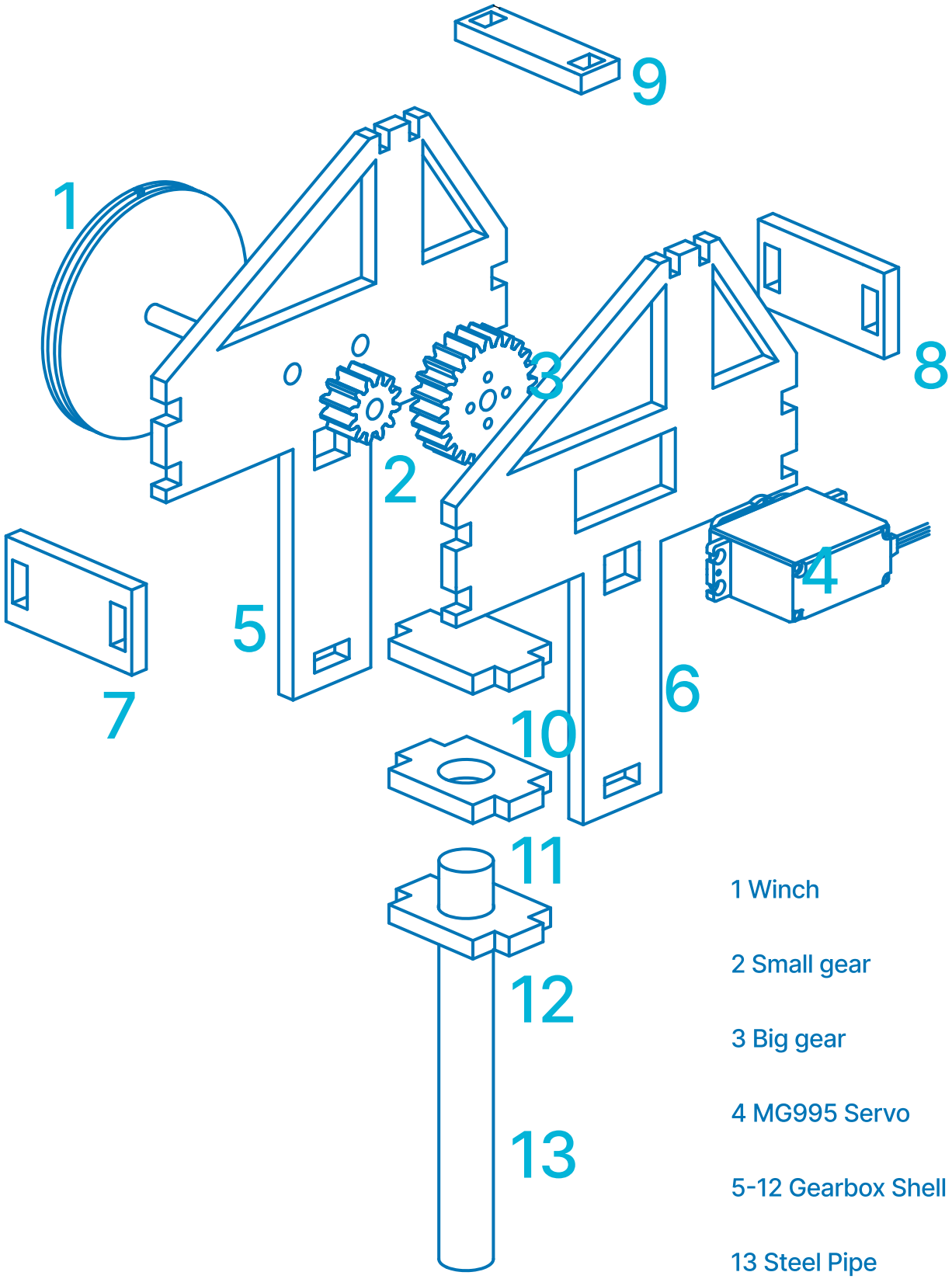


Mechanism

We used the MG995 servo because it has more torque. The gears are made of density board cut by laser, and the big gear is fixed to the servo, which is twice the diameter of the pinion gear, so that if the big gear turns half a turn, the small gear can turn once, and thus the small gear drives the fixed external winch (3D printing) to turn once, which collects and releases the wires, and thus turns the maze.



Exploded View



1 Winch

2 Small gear

3 Big gear

4 MG995 Servo

5-12 Gearbox Shell

13 Steel Pipe

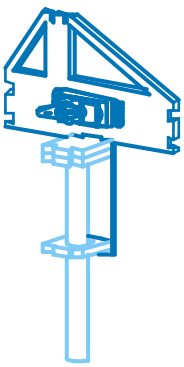
Assembly Processes

1

2

3

4



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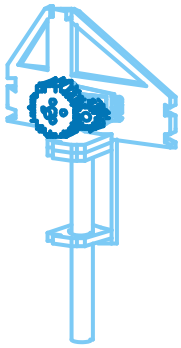

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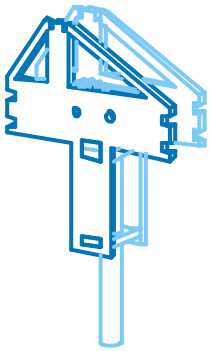

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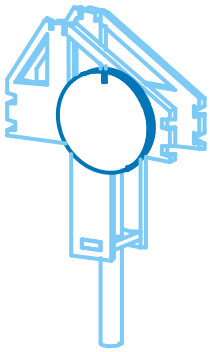

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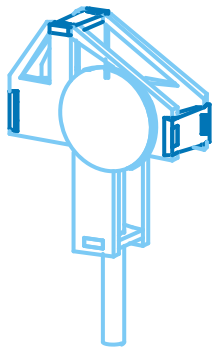
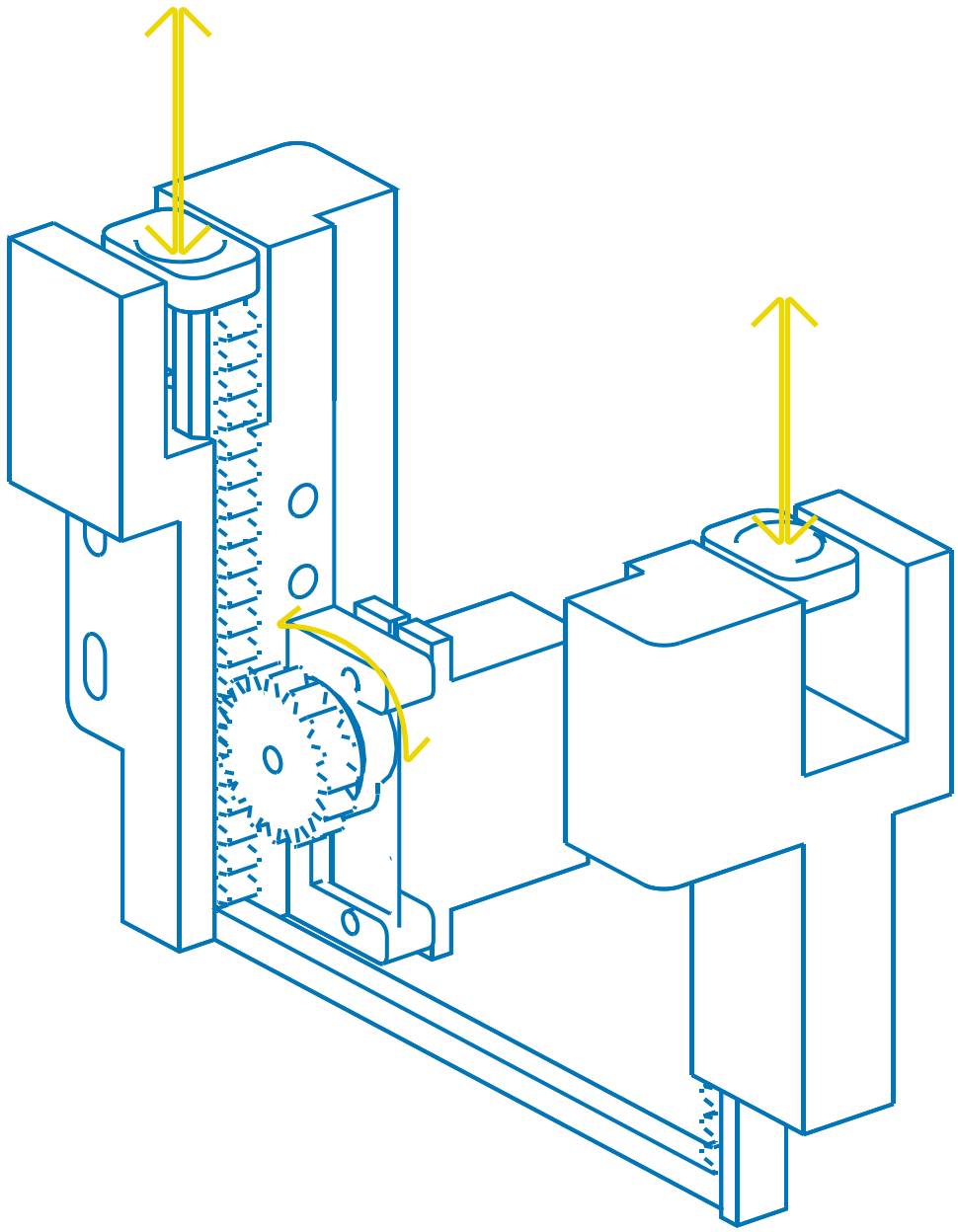


Magnetic Barriers and Centre Lift

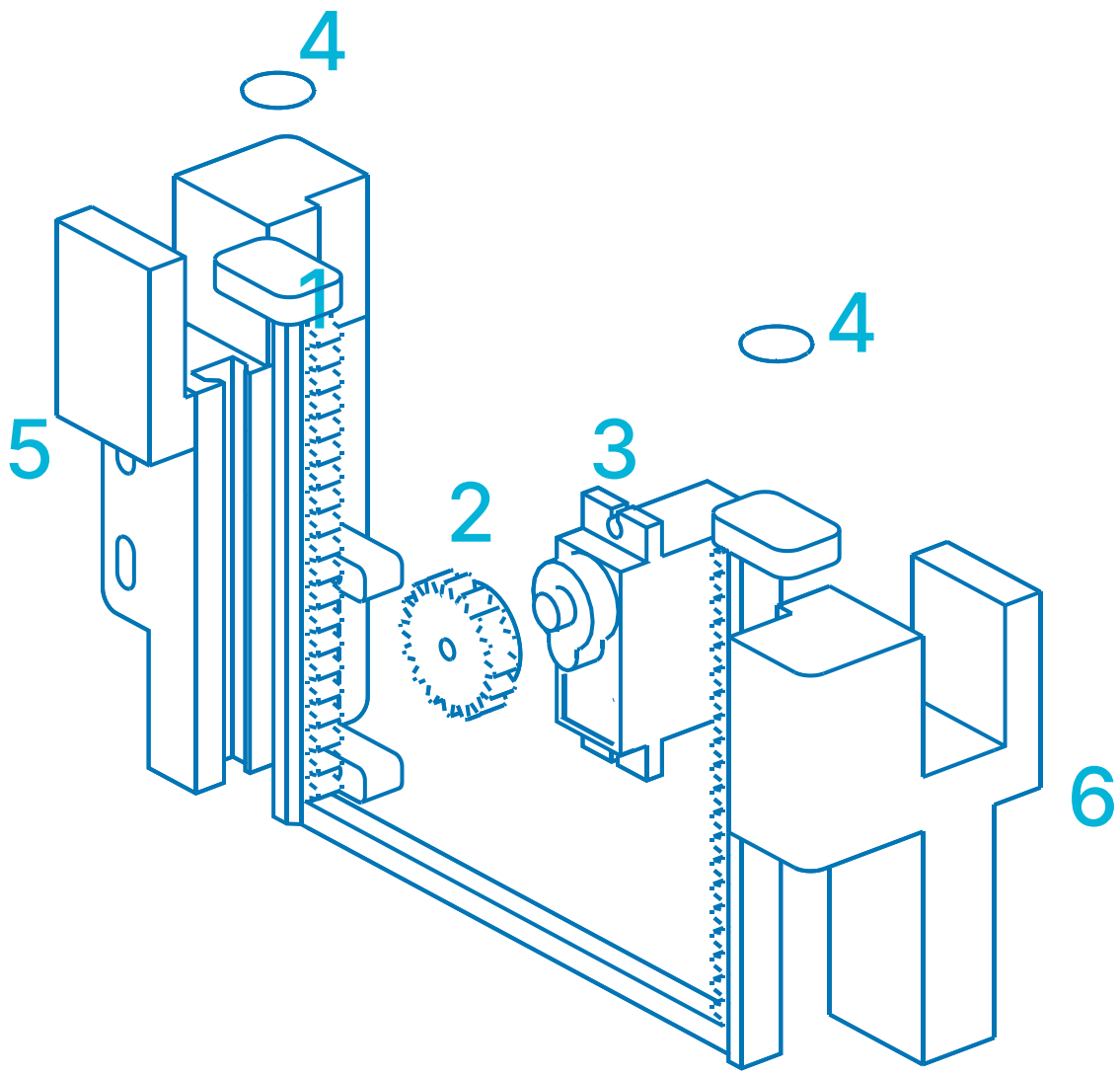


Four obstacles are distributed along the path of the maze and are controlled by the player's facial expressions. The player may frown at the difficulty of manoeuvring the maze with gestures, an expression that causes certain obstacles to rise and certain obstacles to fall, the rising obstacles attracting the ball via magnetism, which in turn affects the player's mood.

Located at the bottom of the maze, the structure is designed to magnetically create a "trap barrier" that attracts the balls. It is powered by a micro servo, a set of gears and racks that turn the rotation into vertical displacement, and a connection that moves a distant rack up and down at the same time.

3D Print; PLA; Micro Servo FS90MG

Exploded View



1 Rcak

2 Gear

3 Micro Servo FS90MG

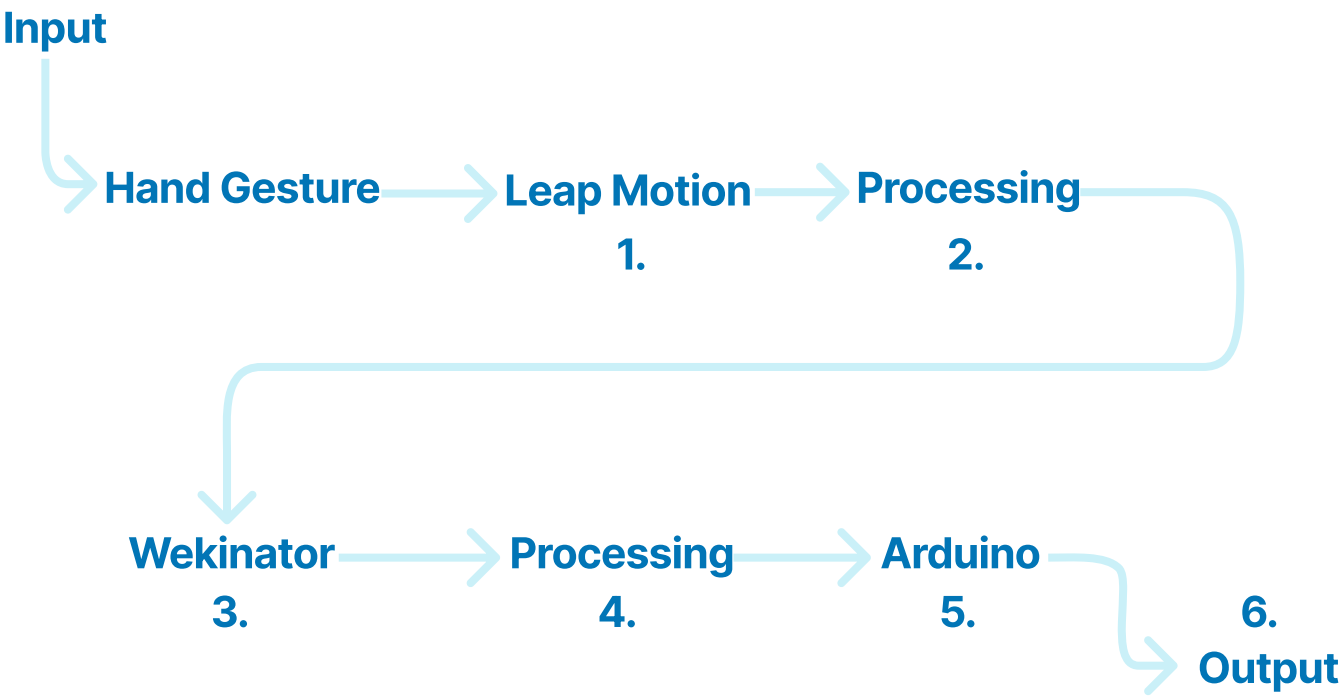
4 Magnetic disk

5 6 Support structure

2 Software Design & Machine Learning

Software Diagram & Machine Learning

Hand Gesture System



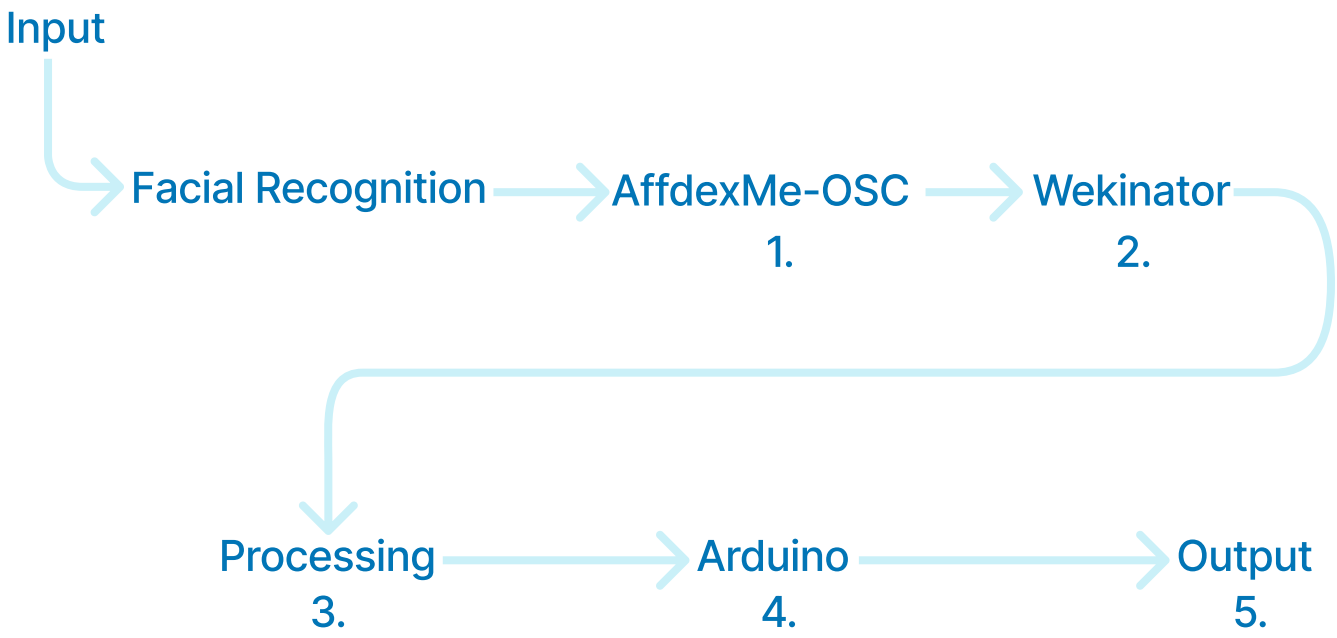
Machine Learning Model: Regression
Algorithm: Neural Network
Evaluation:
forward: 0.09RMS
backward: 0.05RMS
left: 0.02RMS
right: 0.07RMS

Process

1. **Leap motion get the coordinates of five fingertips and palm.**
2. **Processing transfer the coordinate data to vector data of the five fingertips pointing to the palm.**
3. **Wekinator map five vector data into 9 directions which includes middle and oblique to move maze smoothly.**
4. **Processing conduct secondary analysis and classification of direction data and transfer to Arduino.**
5. **Arduino controls four servos, which are respectively connected to one corner of the maze plate.**
6. **Output: The rotation of the servos drives the gearbox, and then drives the plate to tilt.**

Software Diagram & Machine Learning

Facial Recognition System



Machine Learning Model: Classifier
Algorithm: Decision Tree
Evaluation: 96% with 10 folds

Main Facial Expressions and Emotions:
Brow Furrow
Cheek Raise
Lip Stretch
Smile
Joy
Anger

Process

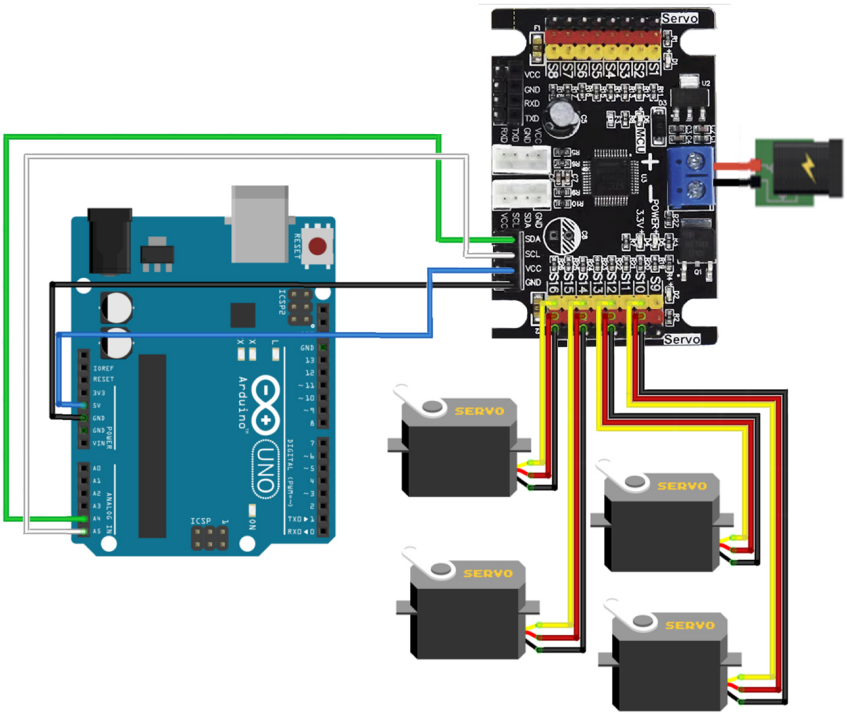
1. Setting up 32 facial expressions and emotions in AffdexMe-OSC which can recognise the expressions and emotions of poker-faced, angry and happy.
2. Connecting OSC to Wekinator where 32 features are divided into 3 categories, which are poker-face, brow wrinkle and smile.
3. Processing transfer these three categories data into 1, 2, 3.
4. The output three numbers are transferred to Arduino to control the rotation speed of servos.
5. Output: Servos drives four linkage structure that beneath the maze plate, raising and lowering obstacles in response to the brow wrinkle or smile expressions, thereby adjusting the level of difficulty.

3 Hardware Design

Circuit Diagrams

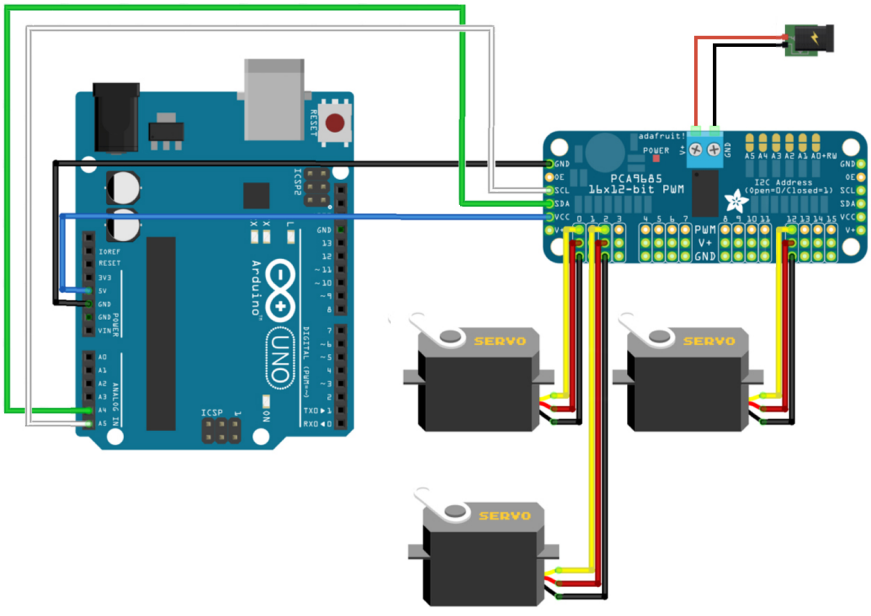
Maze Control

We use the CZ3457-16-channel servo driver board to control four servos. The reason why we use CZ3457 is because we use mg995 servo to control the tilt of the labyrinth disk. Since the labyrinth disk is heavy, mg995 needs to be connected to a 7.4V power supply. CZ3457 can be connected to a 5V-12V power supply to meet our requirements. need. At the same time, CZ3457 supports the <Wire.h> library, which can directly control the rotation of the servo by changing the angle.



Barriers Control

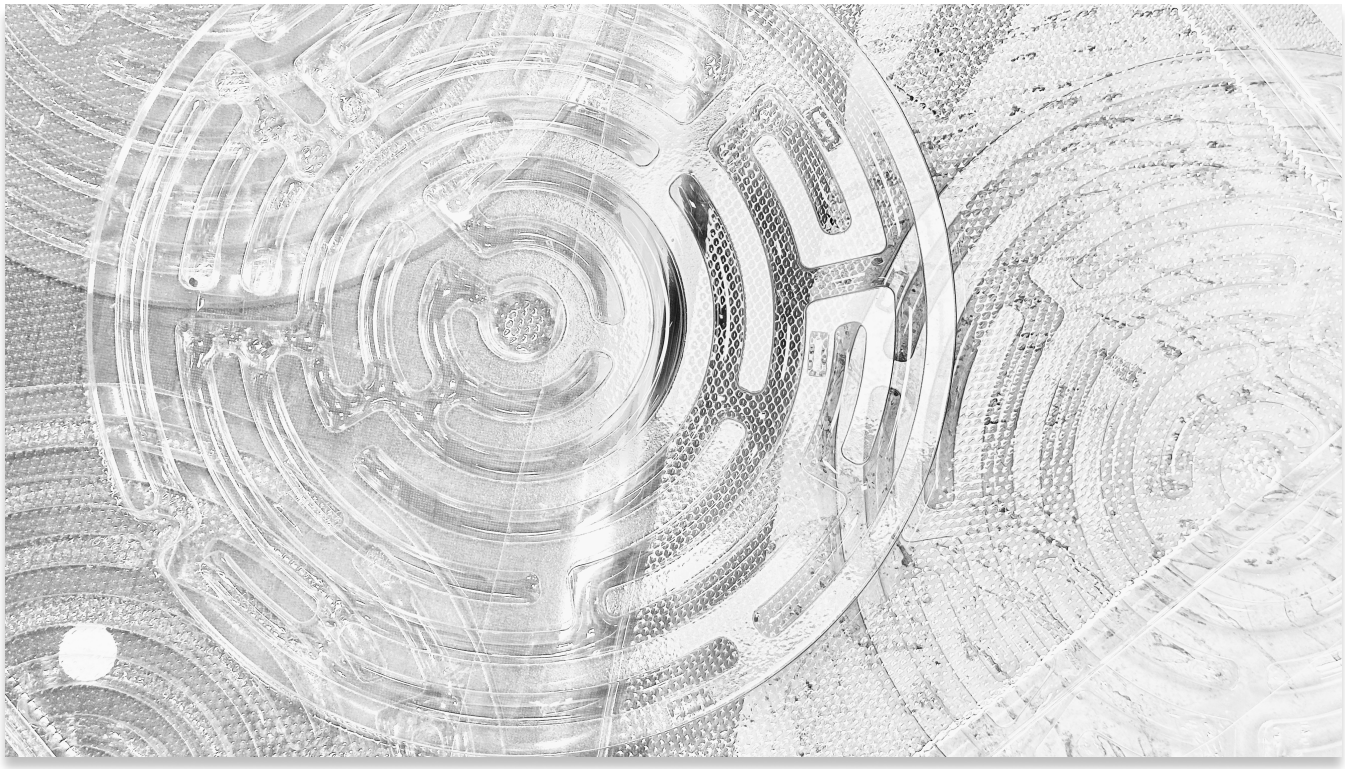
We use PCA9685-16-channel servo driver board to control four servos. The reason why we use PCA9685 is because we use sg90 servo to control the obstacles in the maze, which needs to be connected to a 5V power supply. We use the PWM signal to control the steering gear for angular positioning.

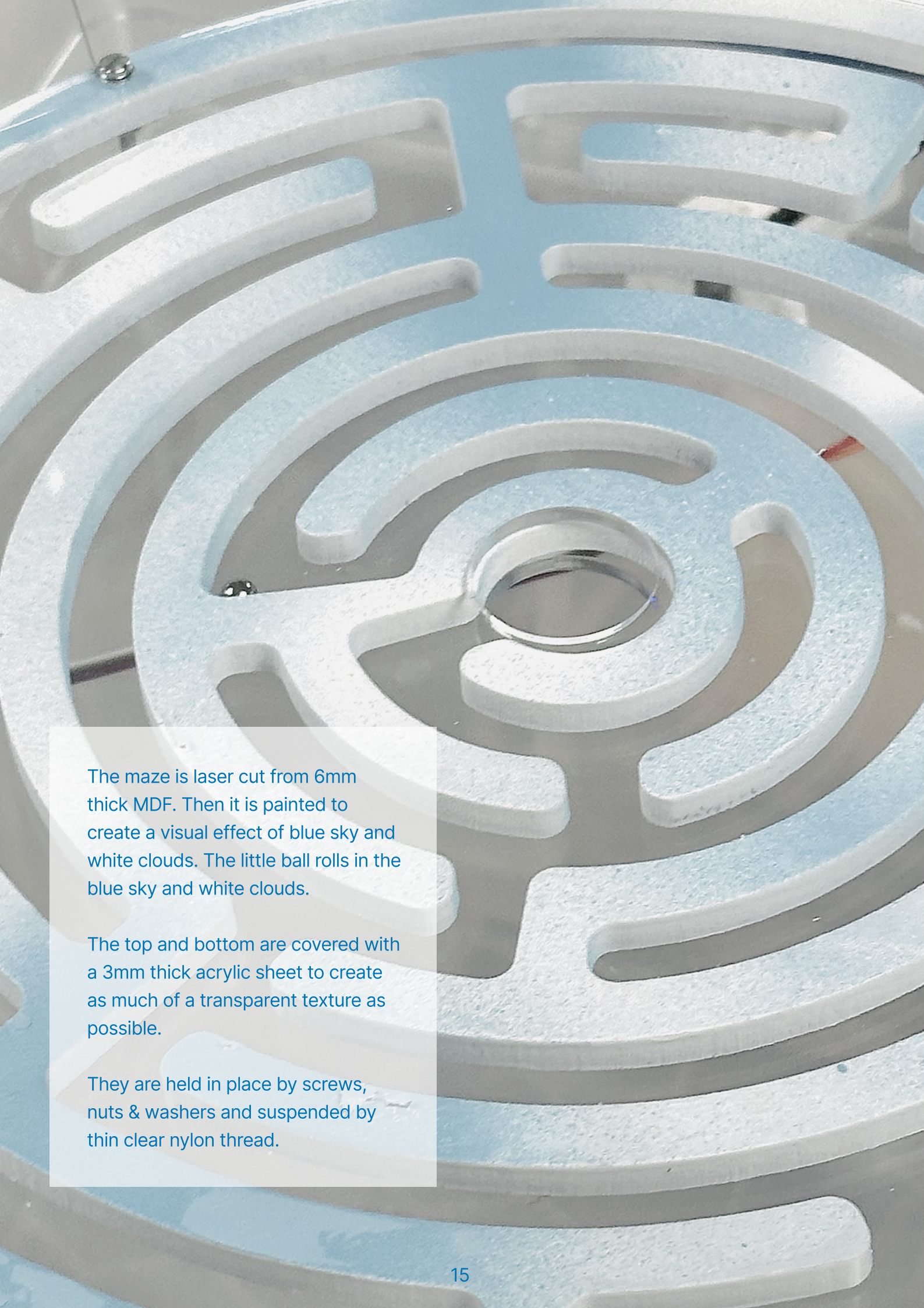


Maze

Attempt: vacuum moulding

The labyrinth was initially manufactured using vacuum blister moulding - because we wanted it to be transparent and lightweight. However, after several attempts at vacuum moulding, and during the creation of the functional model, it became clear that the lightweight mass would cause the model to be unstable; and that vacuum moulding did not allow us to create a perfect shape (design, as well as flaws in the moulding process) - so we finally decided to create the maze out of acrylic sheets and MDF with laser cutting.



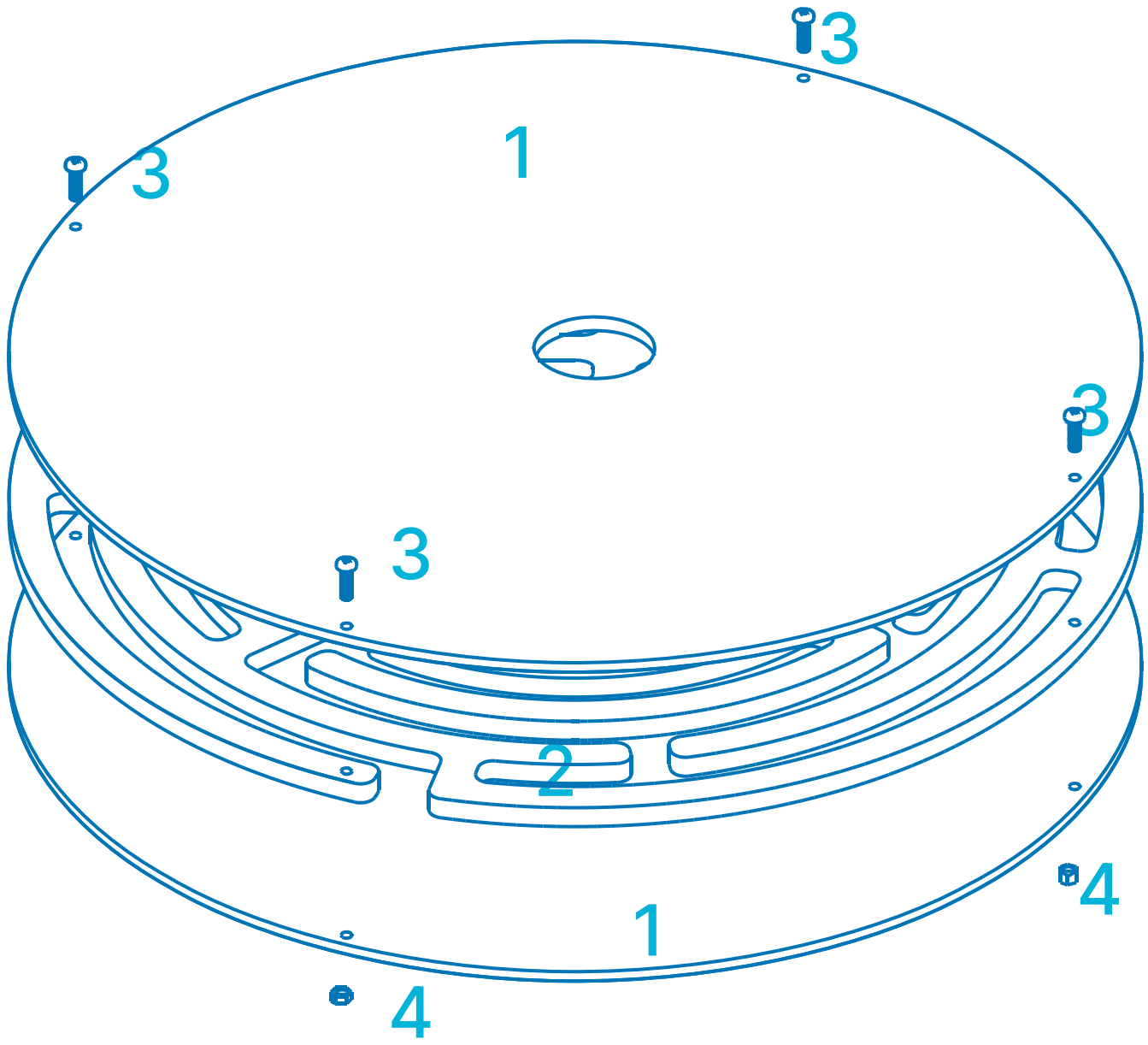


The maze is laser cut from 6mm thick MDF. Then it is painted to create a visual effect of blue sky and white clouds. The little ball rolls in the blue sky and white clouds.

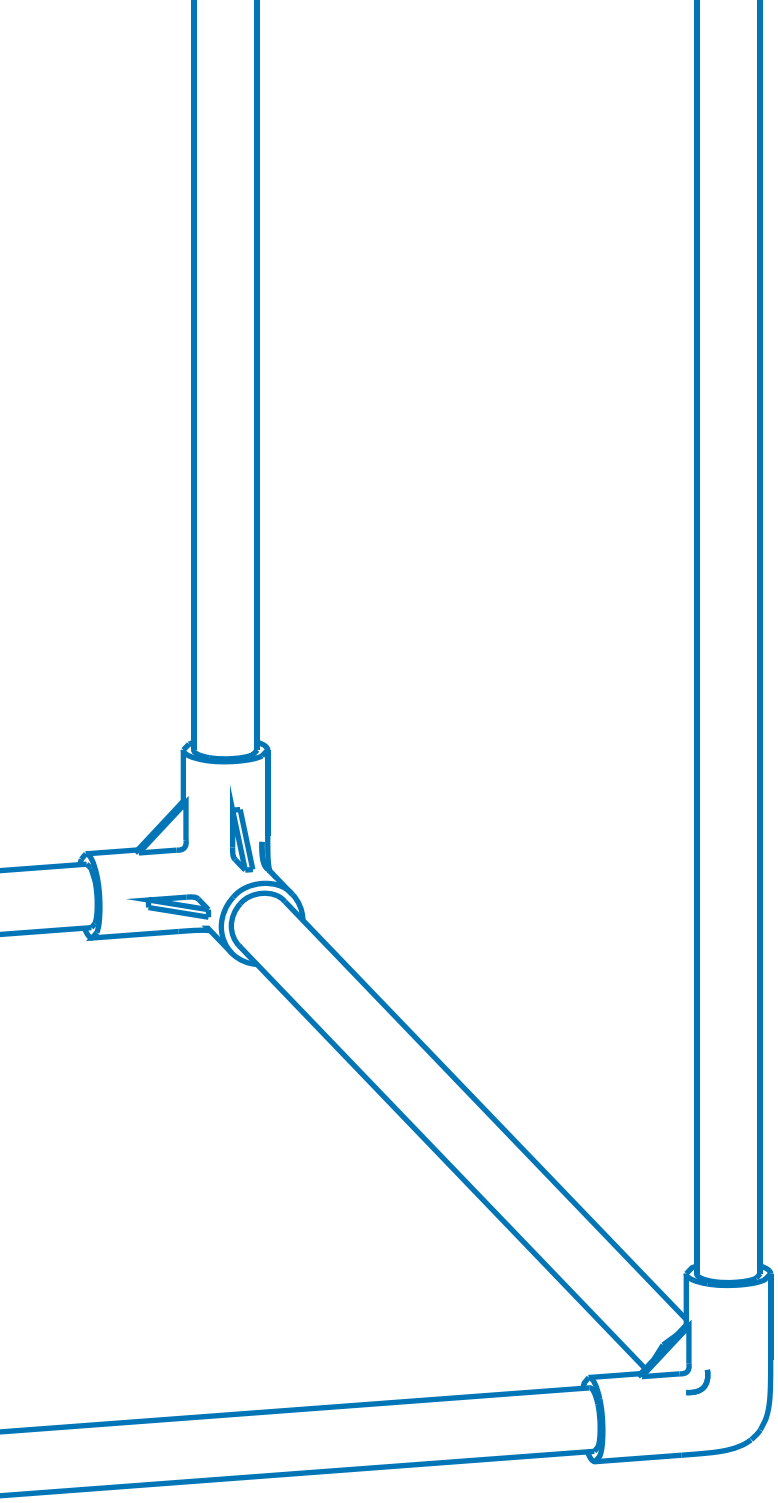
The top and bottom are covered with a 3mm thick acrylic sheet to create as much of a transparent texture as possible.

They are held in place by screws, nuts & washers and suspended by thin clear nylon thread.

Exploded View



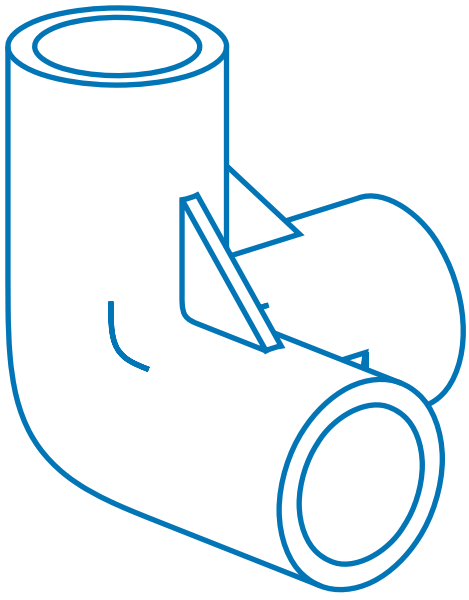
1 Aryclic sheets 2 Maze 3 Screws 4 Nuts



3-way Pipe Connector

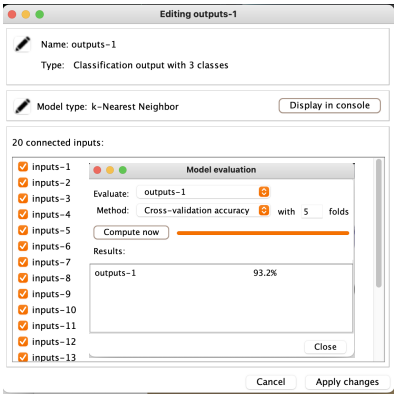
Pipes are connected together using the 3-way pipe connectors.

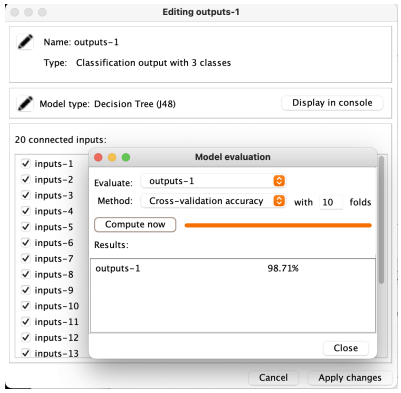
3D printing; PLA



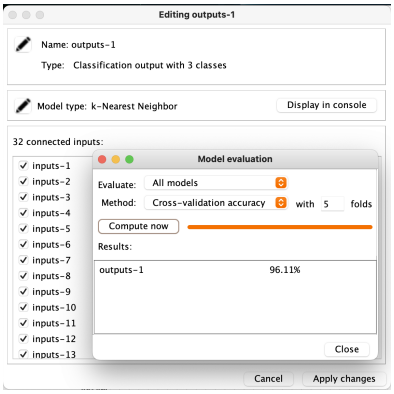
Algorithm Model Comparing

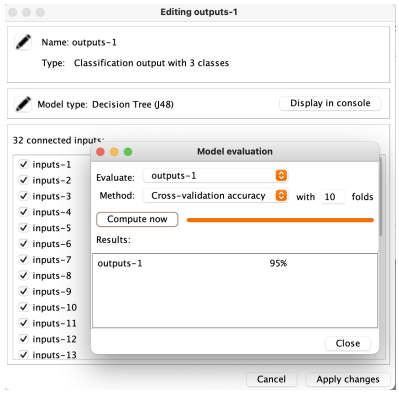
AffdexMe-OSC





Performance of 20 facial expressions and emotions

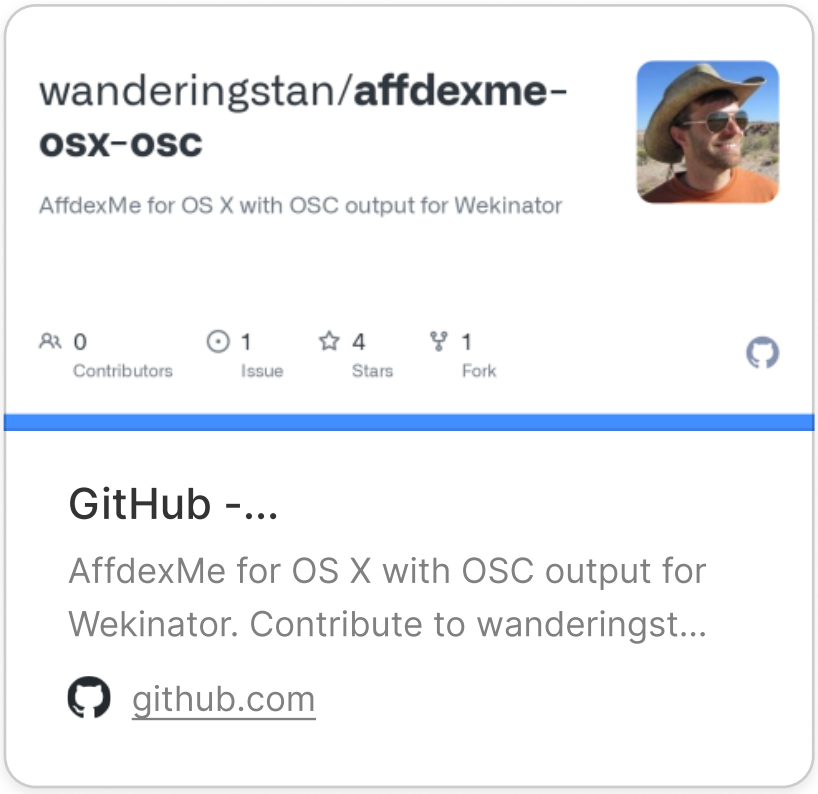




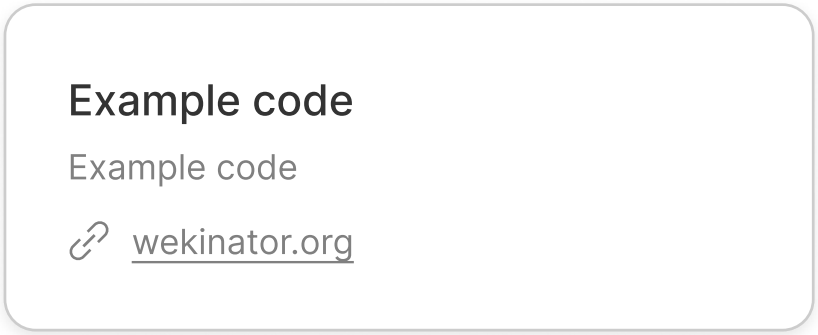
Performance of 32 facial expressions and emotions

There are two training models available for the classifier to analyse the data: K-NN and Decision Tree.
Upon comparing model evaluations and recognition precision, the Decision Tree model with 32 input features outperforms the K-NN model, which utilises only 20 features.

Links of Reference



AffdexMe-OSC download link



Wekinator Learning Example

https://grabcad.com/library/lego-technic-gears-1

Gear Example

https://www.thingiverse.com/thing:146289

https://drive.google.com/drive/my-drive

MG995 Servo Example

Files of 3D Modelling and Laser Cutting

https://drive.google.com/drive/my-drive

Gear Box Laser Cutting

Coding and Wekinator Reference

https://drive.google.com/drive/folders/1g97TO8TzK2fBkY8rKP3×8oY6AJMEAqoc?usp=drive_link

Maze Barrier Coding

https://drive.google.com/drive/folders/1QI5D1nuquxwY_nutQzT8wX5AZkjhXqRJ?usp=drive_link

Maze Tilt Coding

https://drive.google.com/drive/folders/1pqdc5xrFExdRony5TAHXjoTE41zmTZIo?usp=drive_link

Wekinator train
Leap Motion

https://drive.google.com/drive/folders/10DS6XzjZ27I482ywUKC2wXLWwWoP3Klg

Wekinator train
AffdexMe-OSC