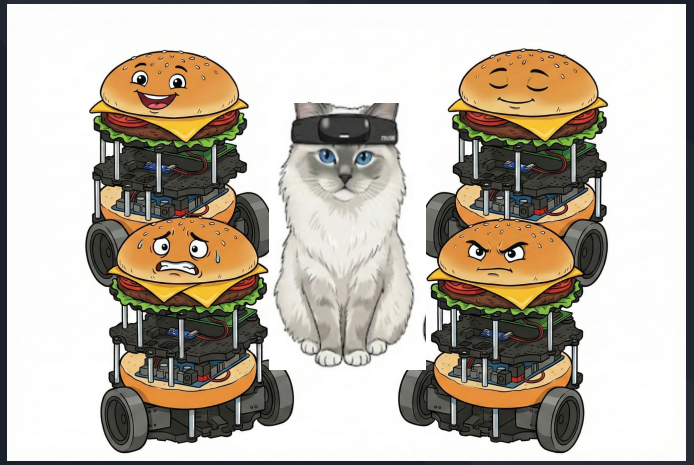
NeuroBot



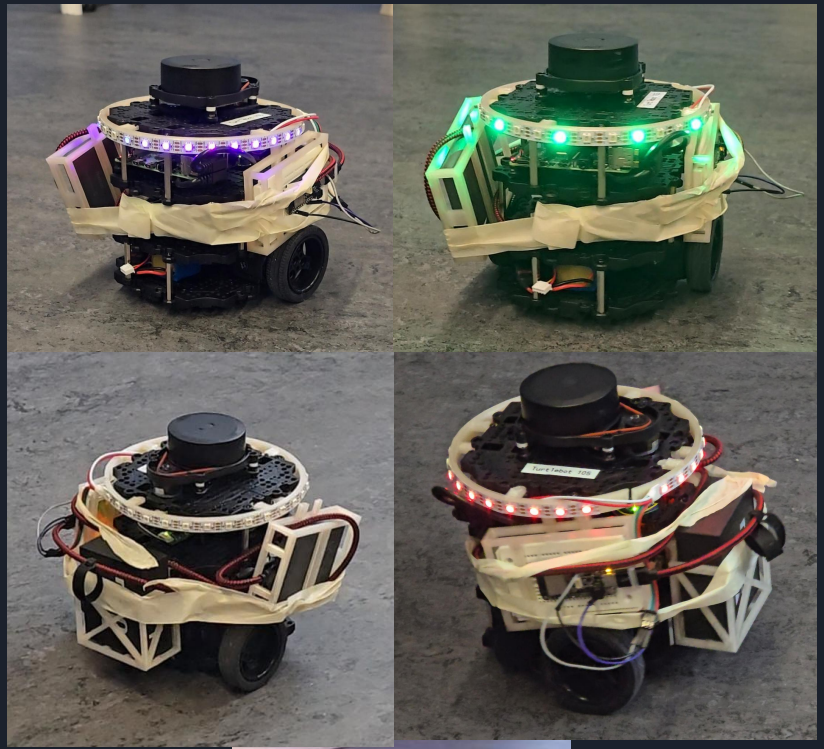
Ana Bog & Yannick Künzli

Concept

- Objective: Create an autonomous robotic avatar that physically embodies human psychological states in real-time.

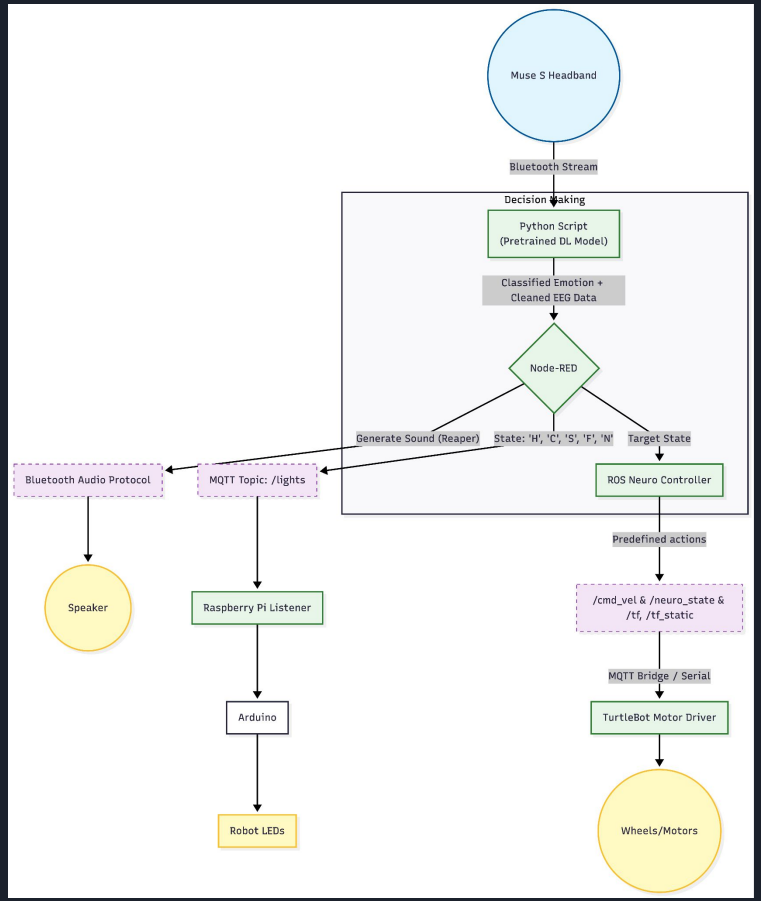
- Core idea: a bio-feedback loop where the performer can see the emotional state of the public during the play.

- The Metaphor: the emotional display goes well with the co-dependency theme of the scene.



Architecture

- Muse S Headband (4 Channel EEG)
  - Bluetooth
- Node-Red
  - Streams processed EEG signals to reaper for generative audio
  - Routes the states to lights and movement controllers
  - Integrates a small dashboard
- Communication
  - MQTT: sends and receives the states, the clean EEG and lights. Sends movements to a ROS node
  - ROS Bridge: Web sockets connecting Node-Red to ROS
- Compute
  - Laptop, runs python model and MQTT, ROS server, node-red, reaper and movement controller
  - Raspberry Pi listens to topics for MQTT and ROS
  - Arduino, handles the light changes.



Movement Logic

Orbit Controller

- The robot uses odometry and AMCL corrected localization to maintain it's circular trajectory

Dynamic Behavior Parameters

- Neutral: 0.6m orbit, moderate speed (0.15 m/s)
- Happy: Wobbly 0.55-0.75m orbit with sinusoidal modulation
- Calm: 0.7m wide orbit, slow drift (0.08 m/s)
- Stressed: Chaotic rotation with random noise
- Focused: Stationary angular tracking

State based behavior

- Robot switches between 5 distinct behaviors based on emotional state

Virtual Leash (Geofencing)

- 1.5m safety radius enforced across all states
- Motor override if boundary breached

Multi-Layer Safety

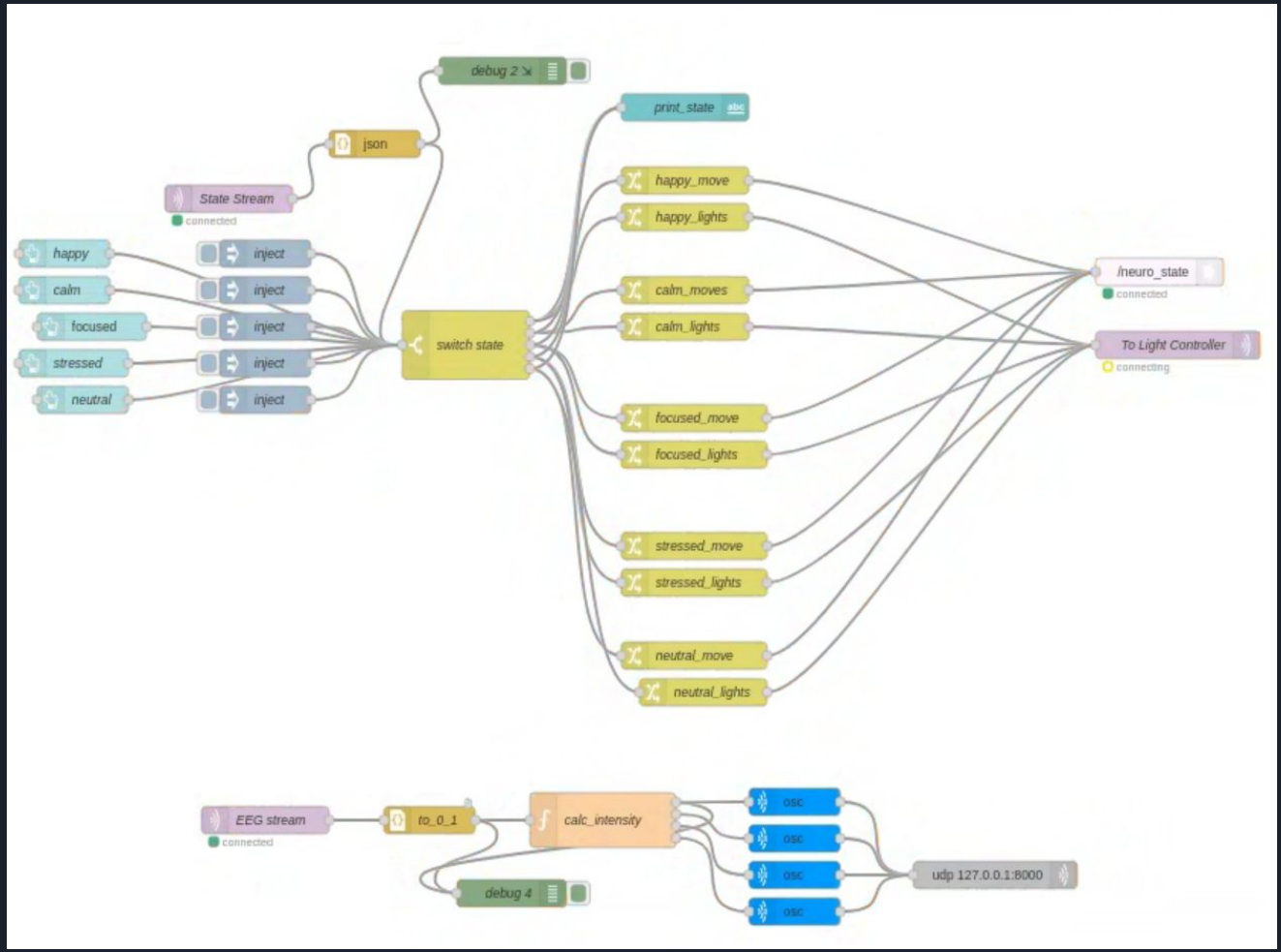
- LIDAR obstacle detection (<20cm) overrides all behaviors
- Geofence boundary enforcement
- Graceful state transitions

Flow

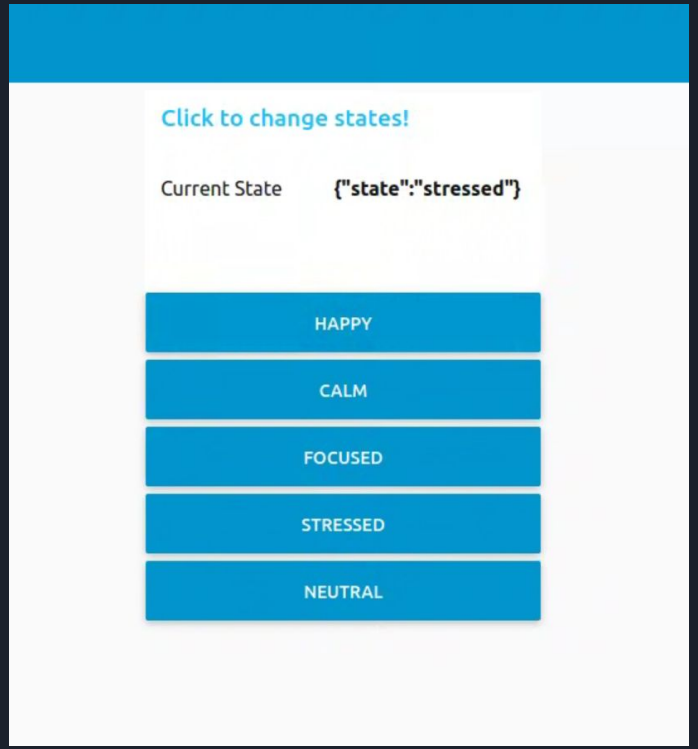
UI, states, lights and

movements —>

sound —>



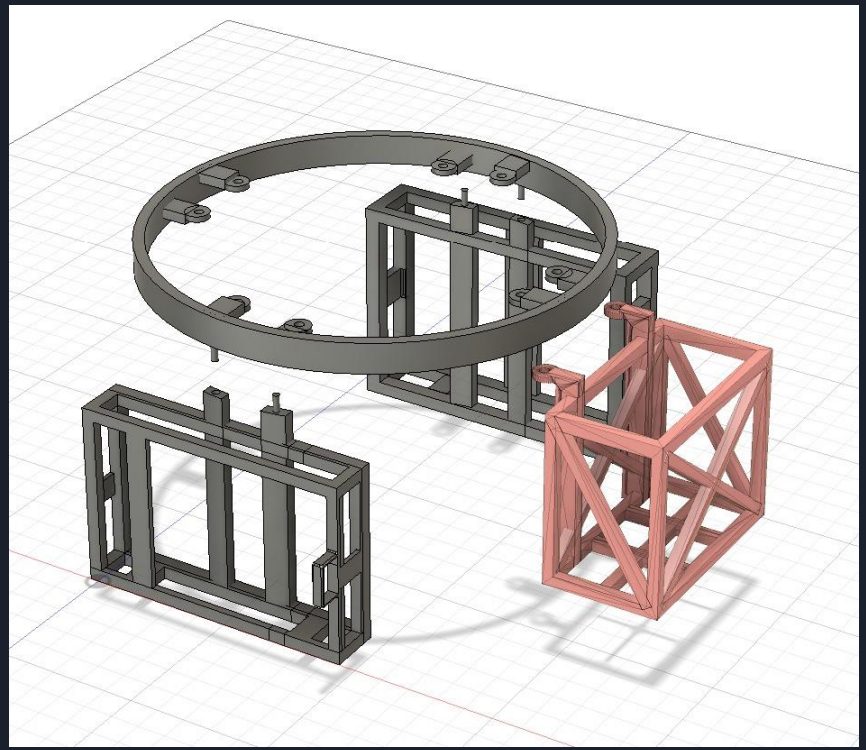
GUI


Click to change states!
Current State
{"state":"stressed"}
HAPPY
CALM
FOCUSED
STRESSED
NEUTRAL

3D Prototypes

LEDs circle →

breadboard container →



← battery container

← JBL container

Music/Sounds

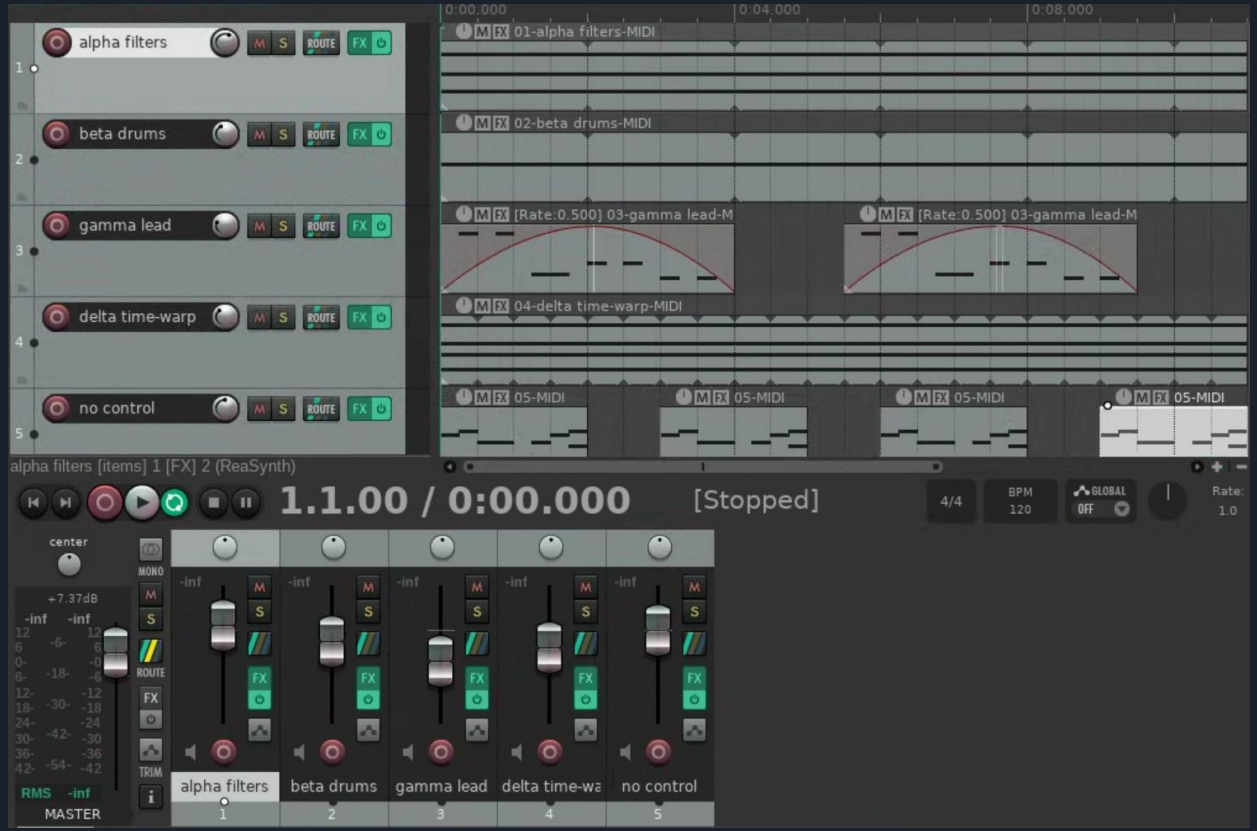
alpha controls filter→

beta controls drums →

gamma controls lead →

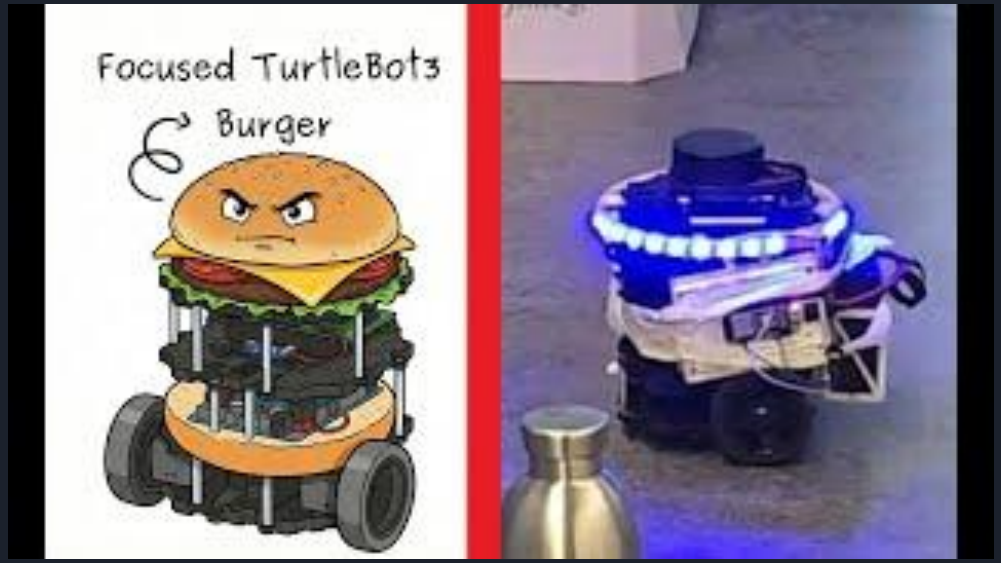
delta controls time-warp →

un-tuned background melody →



DEMO

States



Reaper demo

Sounds

Limitations and Challenges

Limitations:

1. Mapping the states with a 4-channel consumer-grade EEG hardware is not ideal
2. Recording a dataset takes a long time and differs for each participant
3. Noise and body movement impact the results greatly

Challenges:

1. Robot shifting with odometer
2. Reliable emotional state changes
3. Recording 25x30s CSVs for each state
4. Connecting all the components

Future Work

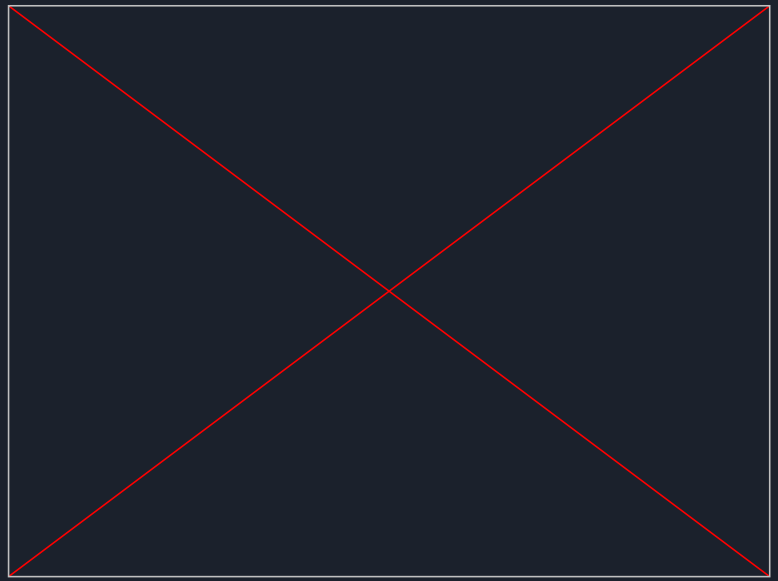
- More emotional states
- Better model accuracy
- Improved music
- Better movements
- Dynamic tracking: using a camera to track the performer
- More complete UI
- Rethought 3D models

Questions ?

Demos (1)

- Neutral: circling around the performer, lights off
- Happy: faster movement, wobbly, green lights
- Stressed: no velocity but rapidly rotating left and right, flashing red lights
- Calm: circling but slower, blue lights
- Focused: stops moving, turns towards the performer and lights turn to purple
- Sound based on incoming EEG signal

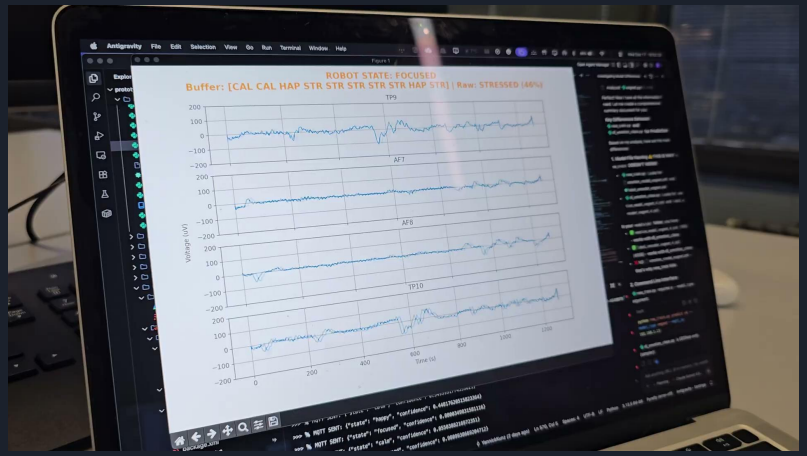
Neutral



Demos (2)

Focused to Happy

Stressed



Demos (3)

Calm

Reaper Music