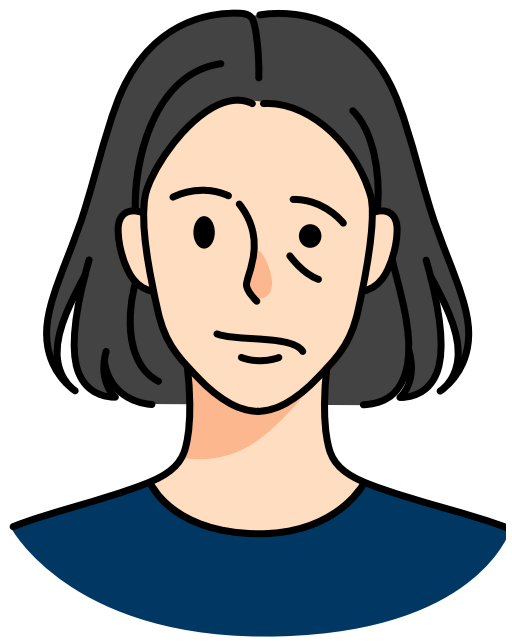


# Can We Smile Without Muscles?

## Stabilization Control System for Dielectric Elastomer Actuators (DEA)

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### THE PROBLEM



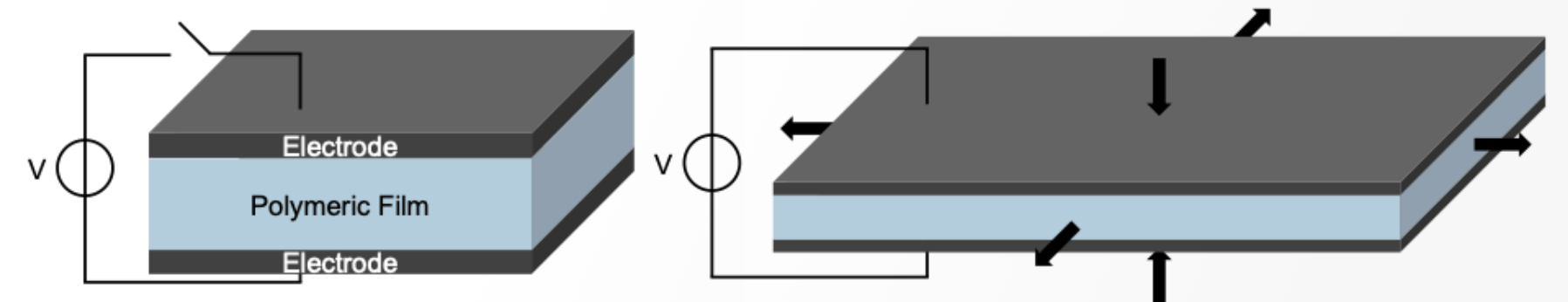
Facial paralysis

- Facial paralysis is a health condition that affects thousands of people.
- It impacts the ability to **express emotions** (smiling)
- Traditional treatments are **invasive** and often fall short in restoring natural movement.

### THE SOLUTION

#### Dielectric Elastomer Actuators

- Promising soft actuator for **artificial muscles**
- Under **high voltage**, it can **mimic** the natural movement of muscles

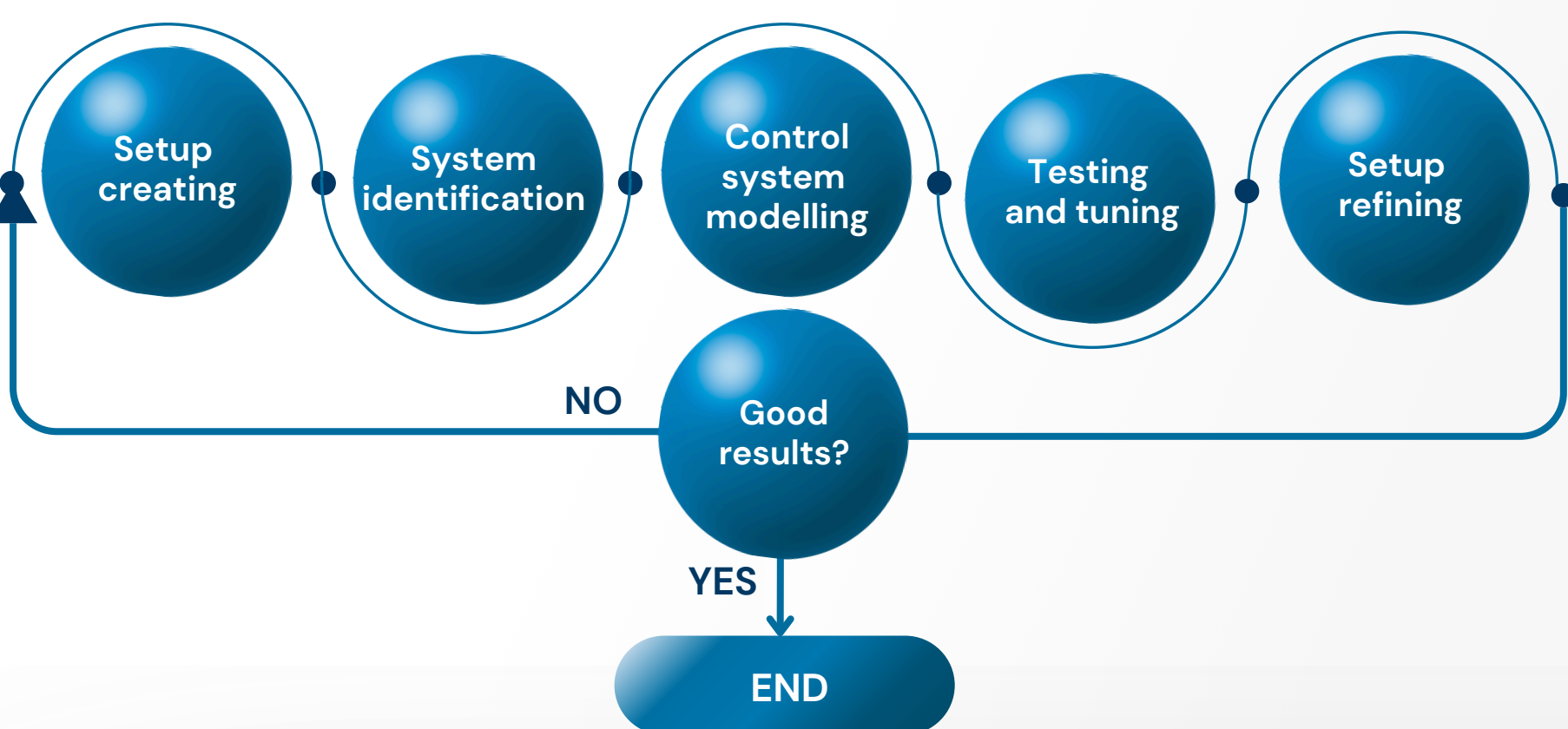


Schematic Representation of a DEA Structure and Function

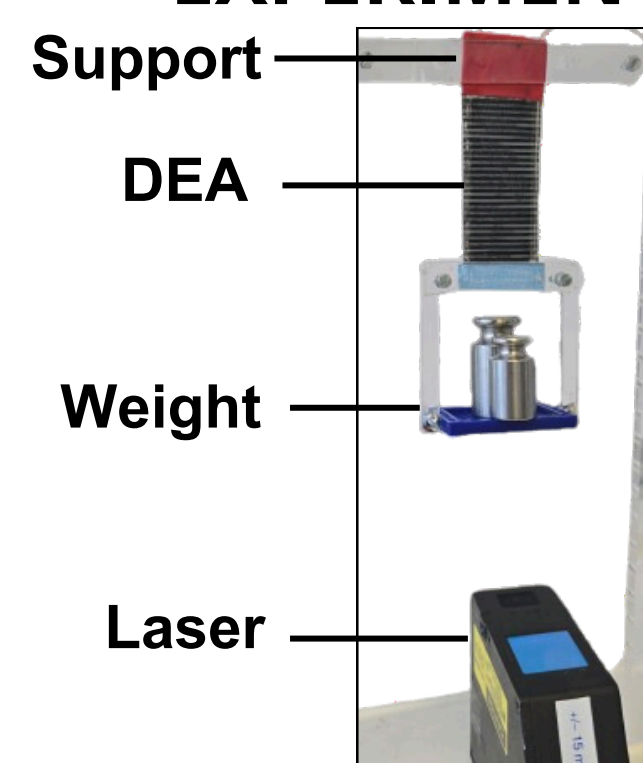
To achieve smooth movements is challenging due to mechanical constraints

→ My mission: Develop a control system for the DEA that regulates the behavior of the DEA to the desired output

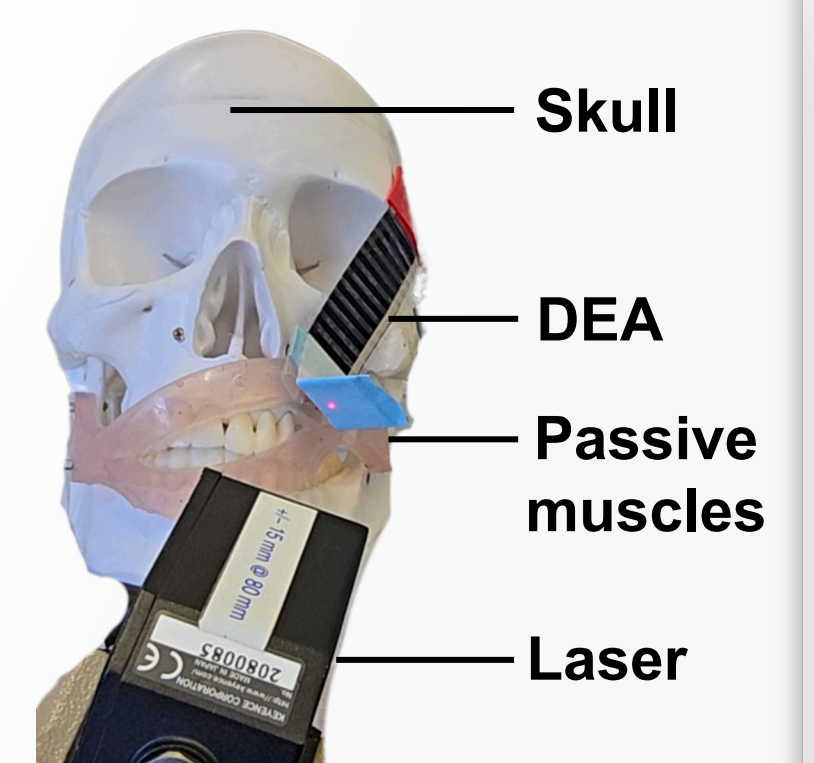
### METHODOLOGY



### EXPERIMENTAL SETUP



Vertical setup



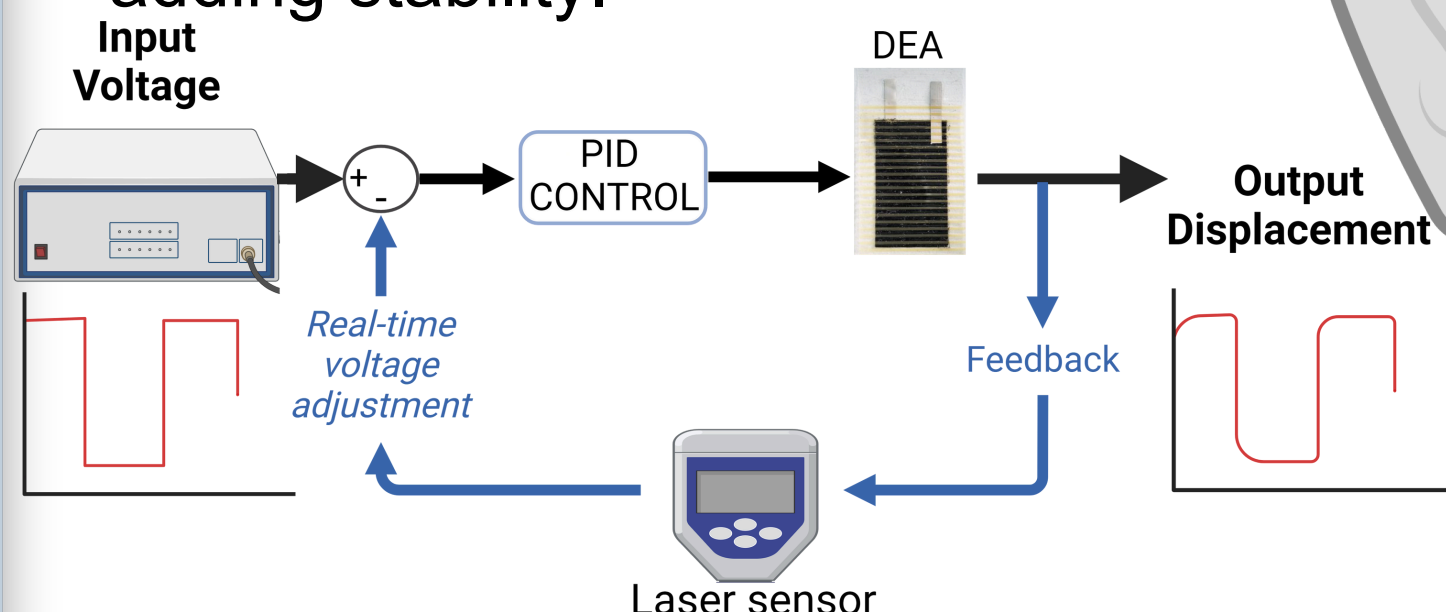
Skull setup

### CONTROL SYSTEM

- **Adjust** performance with real-time feedback.
- Manages **inputs** (voltage) to achieve **desired outputs** (DEA movement).
- Continuously monitors feedback to maintain **stability** and **precision**.

#### PID Control:

- **Proportional (P):** Immediately corrects based on **current** error
- **Integral (I):** Eliminates **accumulated past** errors for steady accuracy.
- **Derivative (D):** Responds to **error rate changes**, adding stability.



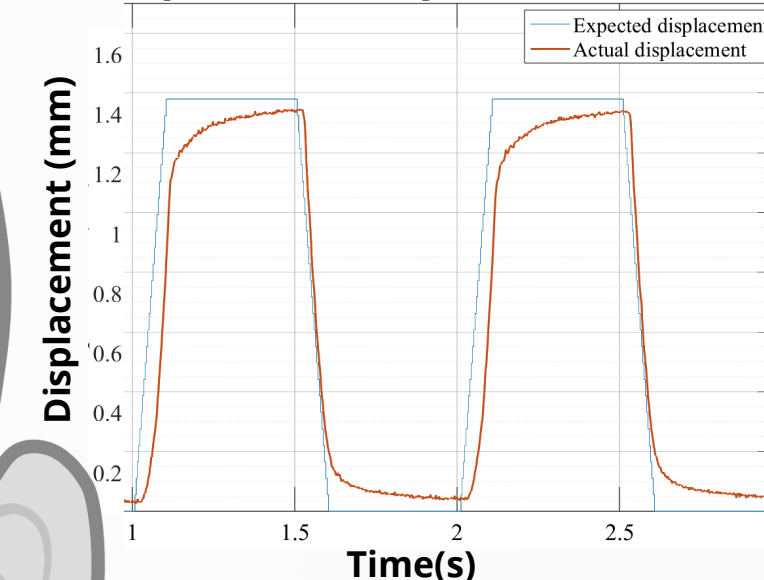
### RESULTS

**Vertical setup:** the output response follows the input trend but exhibits significant deviations, oscillations, delays... The PID corrected two types of errors:

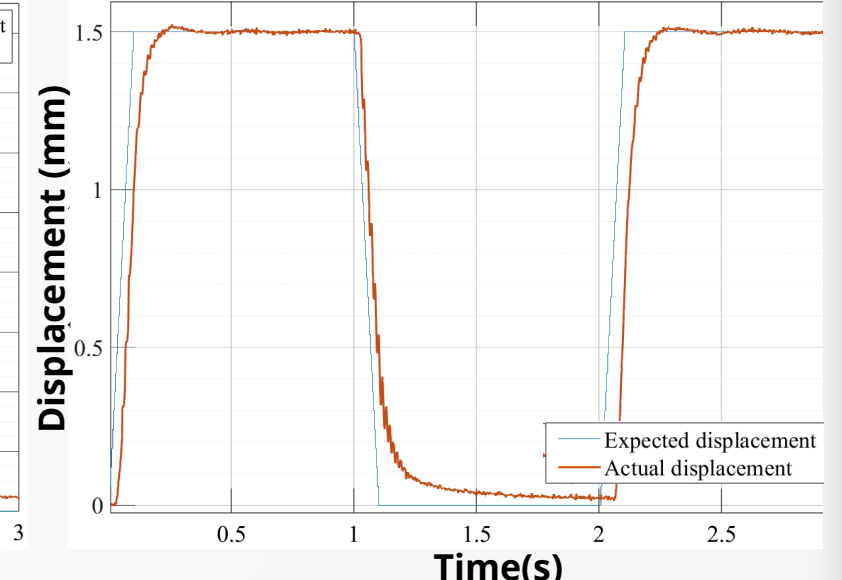
- **Overshoot error** (graph showing oscillations)
- **Steady-state error** (graph showing a constant offset from the target)

#### Skull setup:

Before PID (deviation+delay)

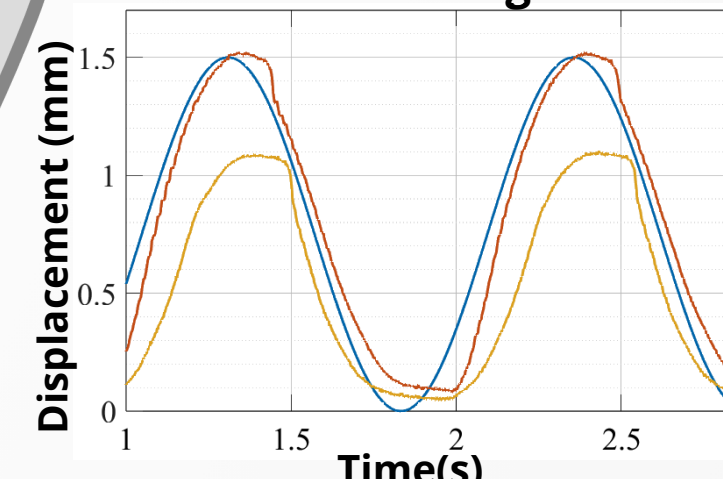


After PID (50 ms response time)

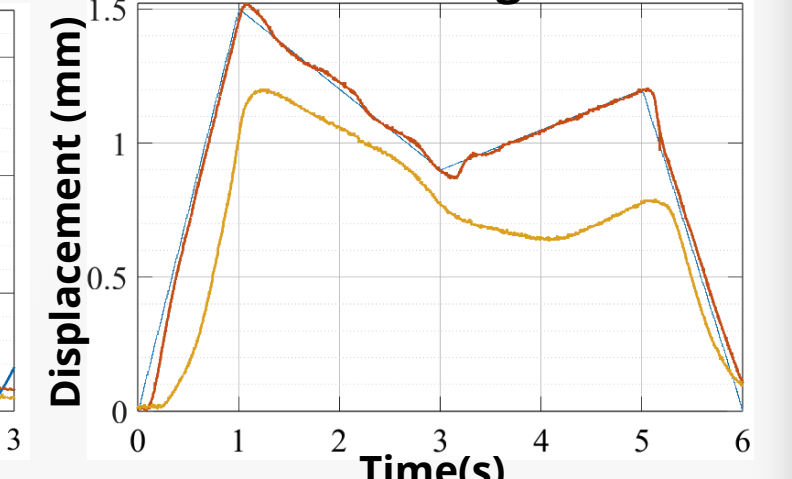


#### Response with different signals:

Sinusoidal signal:



Random signal:



RMSE	Before PID	0.3528	After PID	0.1445
	Before PID	0.3173	After PID	0.0494

### CONCLUSION

- DEAs demonstrated potential in facial muscle replication.
- Key to improve: Performance and Stability

• Future advancements in control models offer promising pathways for artificial muscles

### FUTURE CAPABILITIES

- Explore alternative control models for improved performance. (neural network)
- Investigate the use of alternative sensors that are easier to integrate with the human body. (Self-sensing DEA)

