EYE-LINK

Hybrid Assistive System for Quadriplegia & ALS Patients

Elsewedy University of Technology (SUT)

Department of Computer Science | Team G26

THE MISSION

Problem: "Locked-in Syndrome" leaves patients cognitively intact but physically paralyzed, unable to speak or control their environment, stripping them of autonomy.

Solution: A modular hybrid system combining **Computer Vision** and **Embedded Systems** to bridge the gap between intent and action using only eye movements.

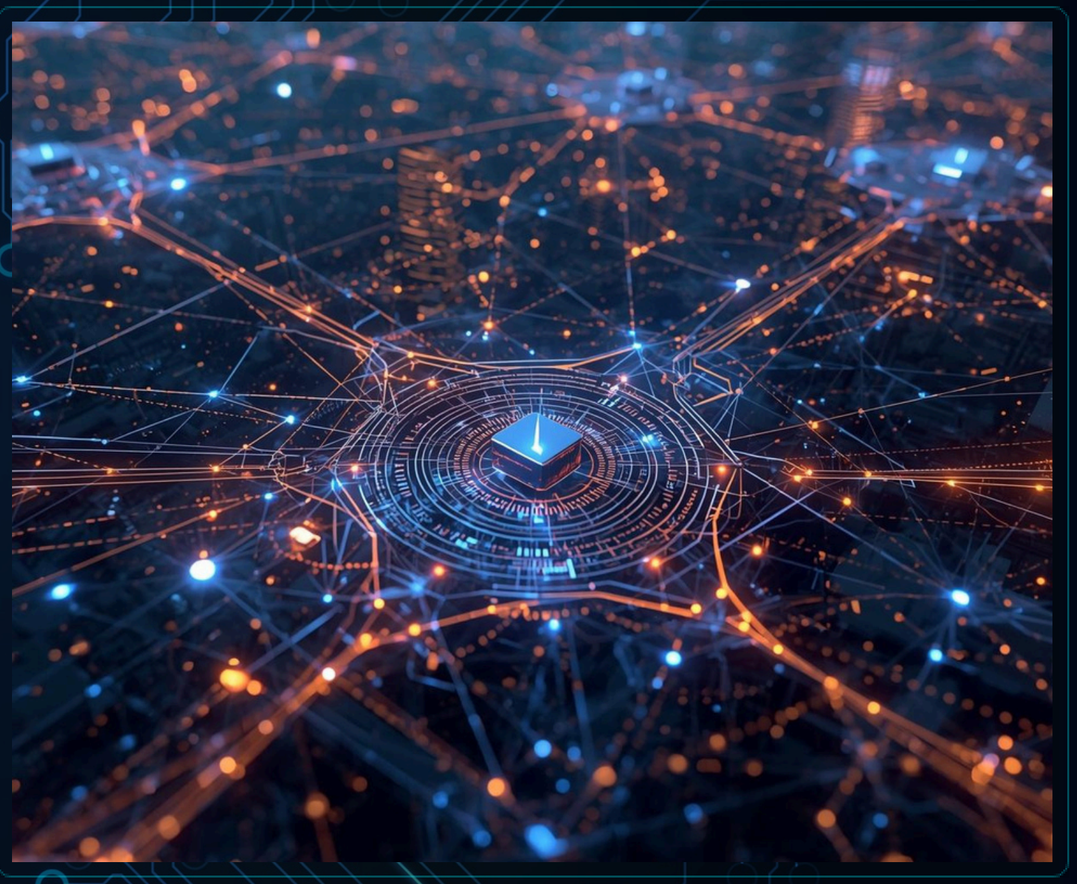
SYSTEM ARCHITECTURE

THE HYBRID BRIDGE

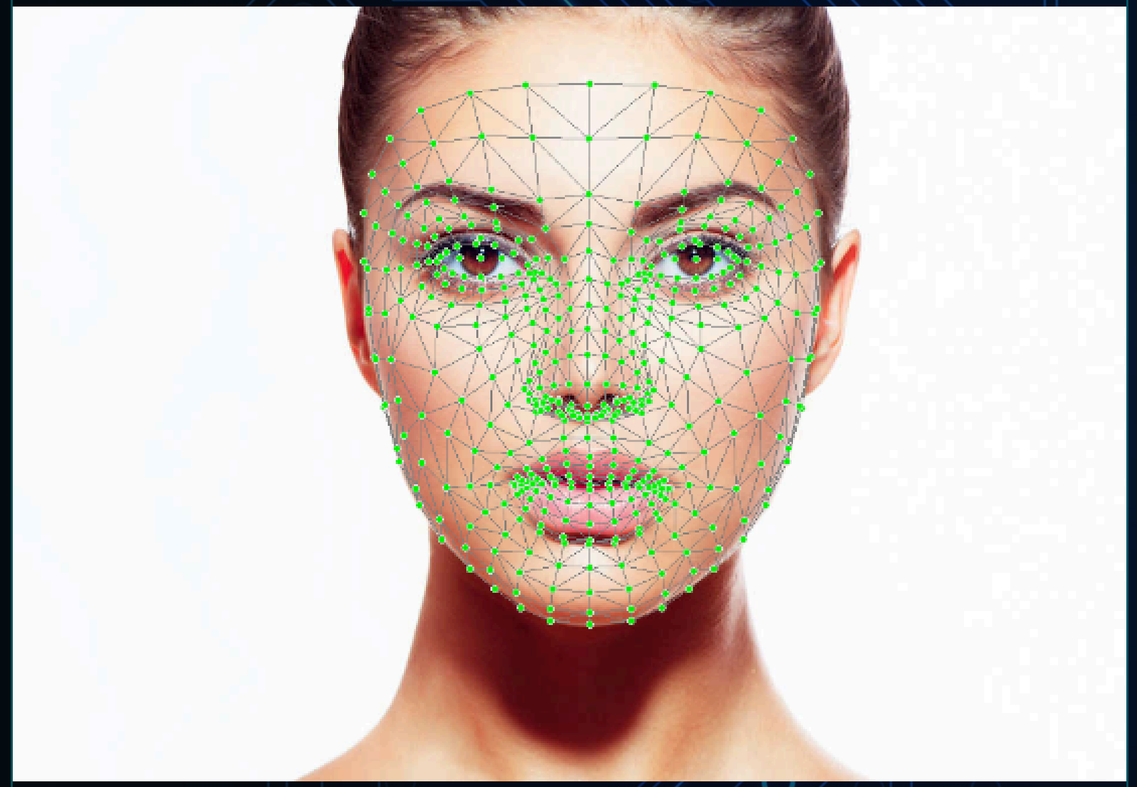
main.py

Eye-Link operates on a unidirectional control flow from visual input to physical output, orchestrated by .

- **Input Layer:** Webcam (30fps) capturing raw frames.
- **Processing Layer:** Python (MediaPipe + OpenCV) for gaze & blink logic.
- **Output Layer:**
  1. *Digital:* TTS Engine (pyttsx3)
  2. *Physical:* Arduino Serial Command (Relays)



THE VISION ENGINE



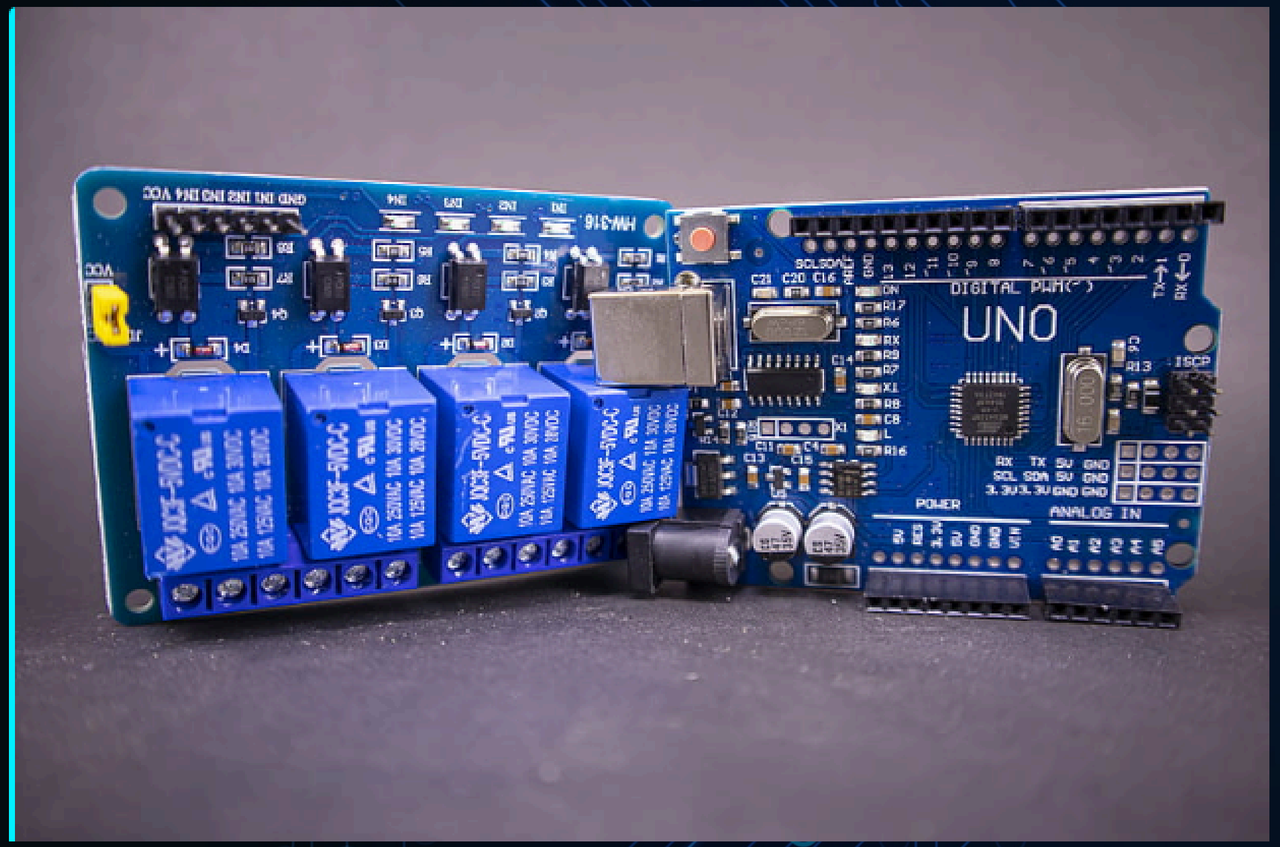
PRECISE TRACKING LOGIC

Developed by **Hisham**, the vision core uses MediaPipe Face Mesh to track 468 landmarks.

We calculate the **Eye Aspect Ratio (EAR)** using Euclidean Geometry to distinguish intentional blinks from noise.

$$EAR = \frac{\| P_2 - P_6 \| + \| P_3 - P_5 \|}{2 \| P_1 - P_4 \|}$$

HARDWARE INTEGRATION



ROLE: ADAM SAID

Safety-Critical Design: We utilize an **Optocoupler-Isolated 4-Channel Relay** module. This ensures the 220V AC mains load is electrically separated from the 5V logic of the Arduino/Laptop.

- **Microcontroller:** Arduino Uno/Nano running C++ Firmware.
- **Protocol:** Custom Serial API (e.g.,). `LIGHT_ON\n`
- **Actuation:** Real-time switching of Lights, Fans, and Heaters.

CORE LOGIC & INTELLIGENCE

MULTI-BLINK STATE MACHINE

Youssef Mahmoud **(Team Leader)** implemented a smart state machine in `main.py`.

- 1 Blink: Navigate Down
- 2 Blinks: Select / Confirm
- 3 Blink: Navigate Up

SYSTEM ARCHITECTURE

Mohamed Walaa ensured modularity.

Designed with automatic fallback to "Simulation Mode" if physical hardware is disconnected.

`hardware.py`

ZERO LATENCY

Optimized integration between OpenCV frame capture and Serial transmission to achieve < 300ms response time for critical actions.

USER INTERFACE & DATA

HIGH-CONTRAST ACCESSIBILITY

Madonna Khaled designed the GUI using high-contrast colors (/) to reduce eye strain for patients.

Cyan Black Dark Gold

gui_interface.py

SCALABLE DATA

Marez Rafaat structured using nested dictionaries. This allows adding new languages or commands without modifying the source code.

menu_data.py

MAINTAINABILITY STRATEGY

CONFIGURATION CENTER

Ramy Sameh implemented to centralize all constants (Thresholds, Ports, Colors). This adheres to the "Separation of Concerns" principle, making the system adaptable to different patients instantly.

`config.py`

ERROR HANDLING

The system is built to fail safely. If the internet cuts out, local libraries take over. If the camera is occluded, the system enters a "Safety Pause" to prevent accidental triggers.

THE TEAM BEHIND EYE-LINK

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LIVE DEMONSTRATION

Bridging Ability and Technology