Team Name : **Binary Broomsticks**

Team Leader Name : Survi Mukherjee

Problem Statement : **Mentis Mirror** "A Cognitive Digital Twin for Real-Time Emotion & Stress Detection" Combining IoT + AI for Human-Centric Wellness, Safety & Productivity

Team Members

Team Member-1:

Name: **Survi Mukherjee**
College: *Bachelor Of Technology (b.tech) at Dr. B.C. Roy Engineering College, Durgapur*

Team Member-2:

Name: **Joy Mukherjee**
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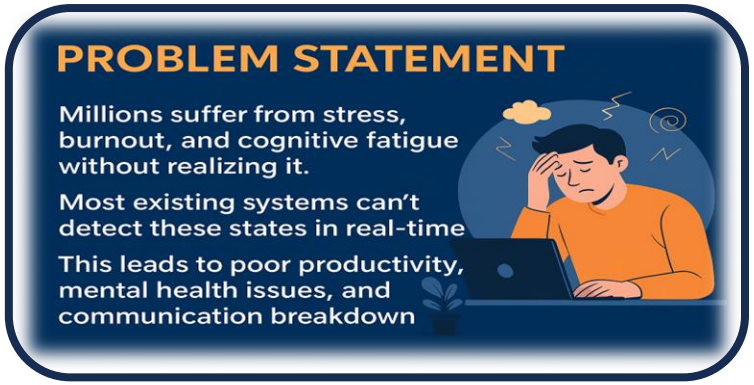
PROBLEM STATEMENT

🧩 **The Core Problem:** Modern individuals — especially students, developers, drivers, factory workers, and healthcare professionals — often suffer from **hidden cognitive fatigue**, **stress**, and **emotional burnout**, without clear external signs.



A student under exam pressure doesn't realize. rising cognitive stress until their performance drops.

💥 Why It Matters

🧍 **Invisible Decline in Mental Health**
People don't realize when their cognitive load becomes dangerous until performance drops, mistakes happen, or health suffers.

🕵️ **Lack of Real-Time Monitoring**
Current solutions (like wearables or wellness apps) are mostly reactive, not real-time, and focus only on physical vitals — not emotional well-being.

🔒 **No Integration into Daily Life or Digital Ecosystems**
Even if mood is tracked, there's no seamless way to make apps, calendars, or smart devices adapt to the user's cognitive state.

⚠️ Consequences

⏰ **Missed productivity opportunities** due to unrecognized mental fatigue

💬 **Poor communication** in remote teams due to unnoticed stress

🚑 **Burnout-related health issues** go undetected until it's too late

🔁 **Non-personalized digital experiences** — no tech understands how you actually *feel*

PROPOSED SOLUTION

🔍 **Overview:** **Mentis Mirror** is a **Neuro-AI powered IoT system** that creates a **digital twin of your emotional and cognitive state** in real-time by continuously analyzing **bio-signals**, **facial expressions**, **voice tone**, and **environmental factors**. It's a complete **emotion-aware platform** designed to enhance **well-being**, **productivity**, and **human-computer interaction**.

🧠 Key Capabilities

1. Multimodal Sensing

- **Facial micro-expression detection** using DeepFace/Azure Face API
- **Voice tone analysis** to understand emotional intensity (calm, tense, angry, etc.)
- **Heart rate variability (HRV)** and **GSR (sweat)** analysis to detect stress
- **Skin and ambient temperature sensing** for physiological context

2. Cognitive State Estimation

- Fuses data into a **time-series model** to understand:
  - Mood
  - Focus
  - Fatigue
  - Stress
- Generates a **real-time cognitive state vector**, e.g.: Mood: Low | Focus: Medium | Stress: High | Suggestion: Take a Break

3. Real-Time Feedback Loop

- Smart alerts via:
  - App notifications
  - Buzzer/vibration module
  - Dashboard suggestions
- Responds with **adaptive actions**:
  - Reschedules meetings via Microsoft Graph API
  - Suggests music, break, lighting changes
  - Logs behavior for long-term patterns

Azure-Powered Cloud Integration

- Data synced through **Azure IoT Hub**
- Emotional state modeled with **Azure Digital Twins**
- **Azure ML** optionally handles large-scale inference
- Connects to **Microsoft Graph API** to interact with the user's digital ecosystem (e.g., Outlook, Teams)

🧠 What Makes SynapSync Different?

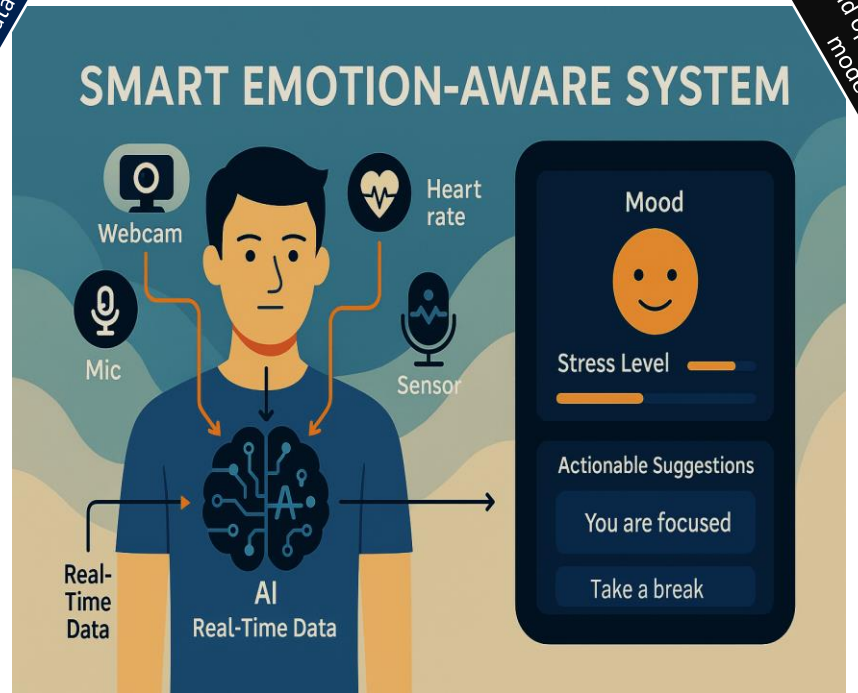
Personalized Digital Twin: Tracks your evolving mental state like a mirror of your mind

Real-Time Responsiveness: Alerts and adjusts environments instantly

Microsoft Integration: Graph API and Azure ecosystem compatibility

Multimodal AI Fusion: Combines physiological + emotional + contextual data

Non-invasive + Low Cost: Uses affordable sensors and open-source models



KEY COMPONENTS

Mentis Mirror *(Latin: Mirror of the Mind)*:- Reflects your cognitive state instead of desires. “Gaze into it, and it gazes into you.”

🧠 Facial Emotion Detection (Webcam + DeepFace)

- Captures micro-expressions, stress cues
- Runs locally or via Azure Face API
- Outputs emotions like Happy, Sad, Angry
- 🎯 Real-time emotion sensing from face

❤️ Heart Rate Sensor (MAX30102)

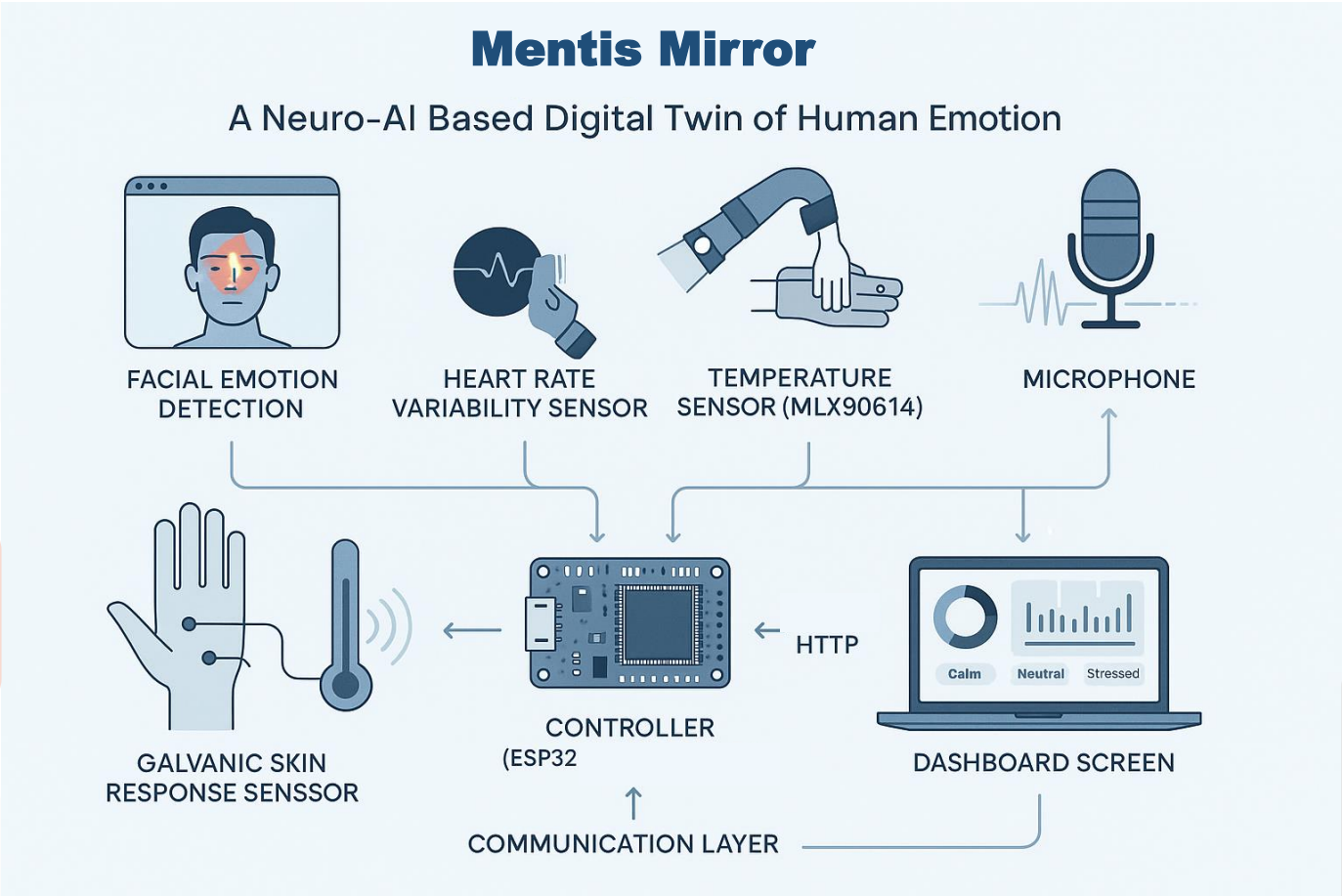
- Measures HR + HRV
- Detects hidden stress/cognitive load
- 🎯 Internal stress indicator

GSR Sensor

- Tracks sweat gland activity
- High GSR = high emotional arousal
- 🎯 Validates stress state

🌡️ Temp Sensor (MLX90614)

- Monitors ambient & skin temp
- Adds comfort/fatigue context
- 🎯 Often overlooked but vital input



🎙️ Voice Sentiment (Mic)

- Detects mood from tone, pitch, tempo
- Works even without camera
- 🎯 Passive emotion recognition

ESP32

- Collects sensor data
- Sends to API / processes locally
- 🎯 Real-time embedded processing

Data Layer (Flask)

- Aggregates signals
- Generates live Digital Twin (JSON)
- 🎯 Central logic + model host

Dashboard (Streamlit)

- Live mood/focus/stress view
- Logs trends + gives smart suggestions
- 🎯 User-facing insights & feedback

SYSTEM ARCHITECTURE

Detailed Flow

Provides a clear breakdown of each layer:

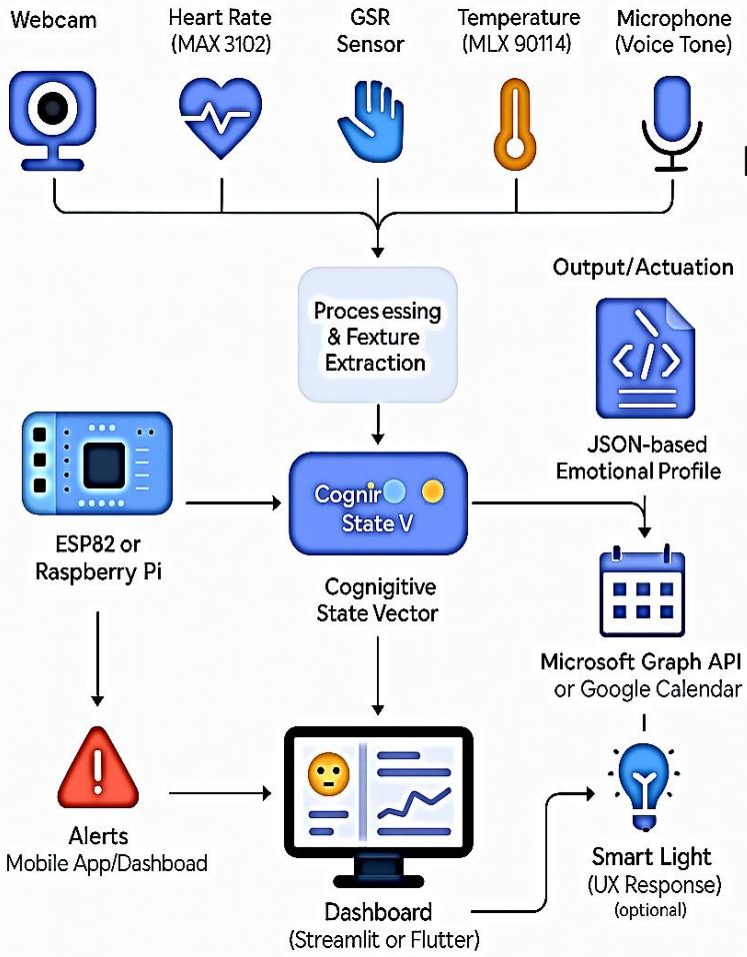
Data Acquisition – webcam, MAX30102, GSR, MLX90614, microphone

Processing & Fusion – ESP32/Pi → Flask/FastAPI → ML

Digital Twin – JSON-based emotional profile with optional cloud sync

Output & Actuation – Alerts, calendar/smart environment integration

Visualization – Real-time dashboard with mood/stress/focus analytics



Simplified View

High-impact version for this architecture:

Sensors collect multimodal data

ESP32/Pi sends it to ML backend

ML produces a JSON “cognitive twin”

Dashboard shows live trends & alerts

Optional calendar sync and smart adaptation

The **Mentis Mirror** system architecture consists of sensor modules (facial, heart rate, GSR, temperature, voice) connected to an ESP32 or Raspberry Pi, which transmits data to a backend for processing and emotion classification. A machine learning model fuses these signals into a real-time cognitive state, which is visualized through a dashboard and triggers smart alerts or adaptive actions.

ML & AI MODELS – THE BRAIN BEHIND MENTIS MIRROR

1. Facial Emotion Classification

- DeepFace or CNN detects expressions like Happy, Sad, Angry, etc.
- Real-time emotion detection from webcam feed.

2. Voice Tone Analysis

- Uses Whisper + sentiment classifier (e.g., SVM/LSTM).
- Extracts emotion from pitch, tone, tempo of speech.

3. Physiological Stress Detection

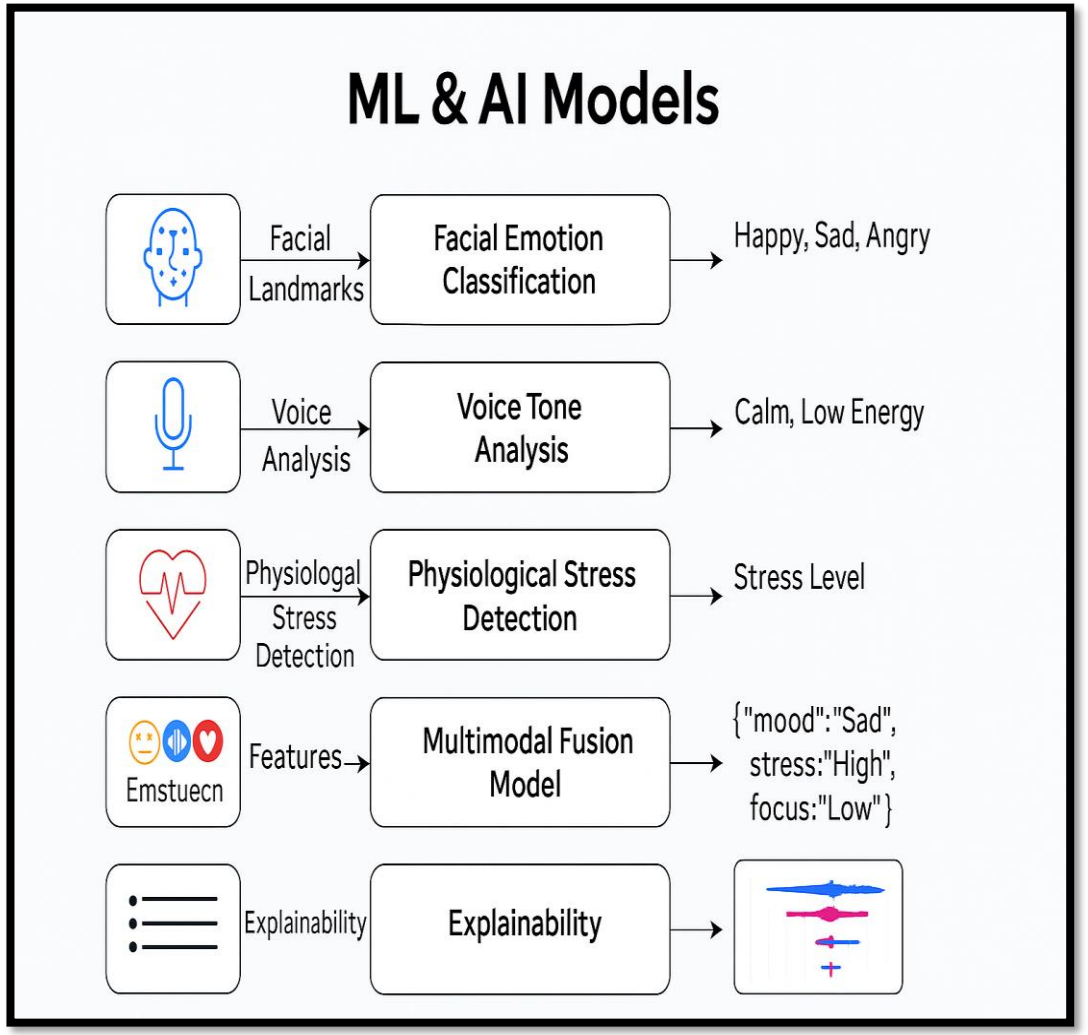
- HRV (heart rate variability), GSR, and temperature analyzed.
- ML model (Random Forest / LSTM) classifies stress levels.

4. Multimodal Fusion

- Combines all data streams into a Cognitive State Vector.
- Generates a JSON-based digital twin of emotional state.

5. Explainability

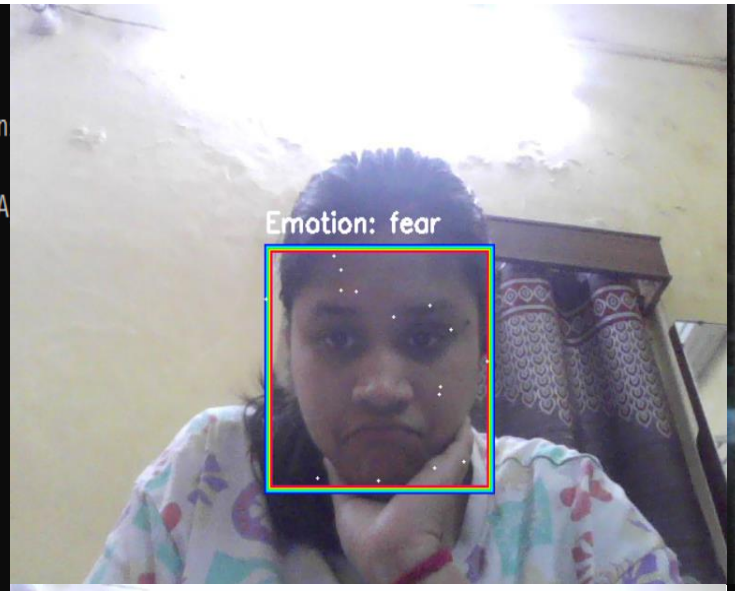
- SHAP (SHapley Additive) explains feature importance.
- Builds trust and interpretability into emotional predictions.

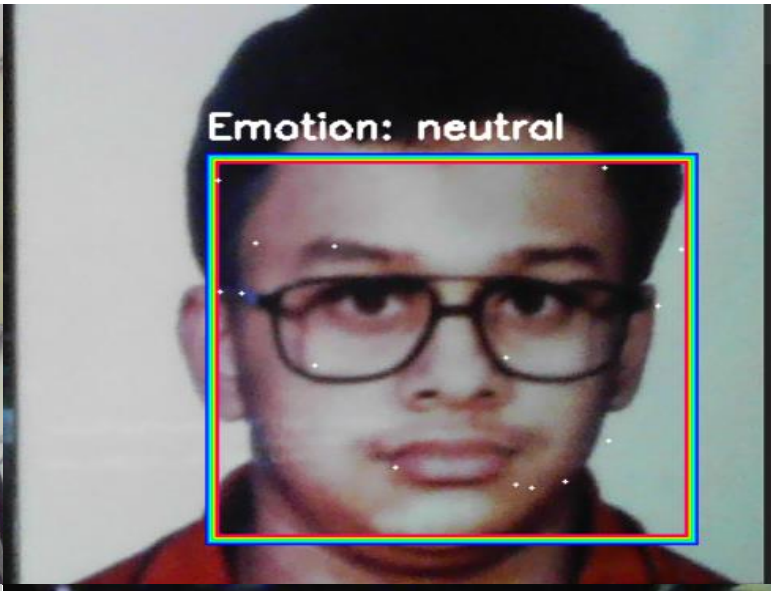


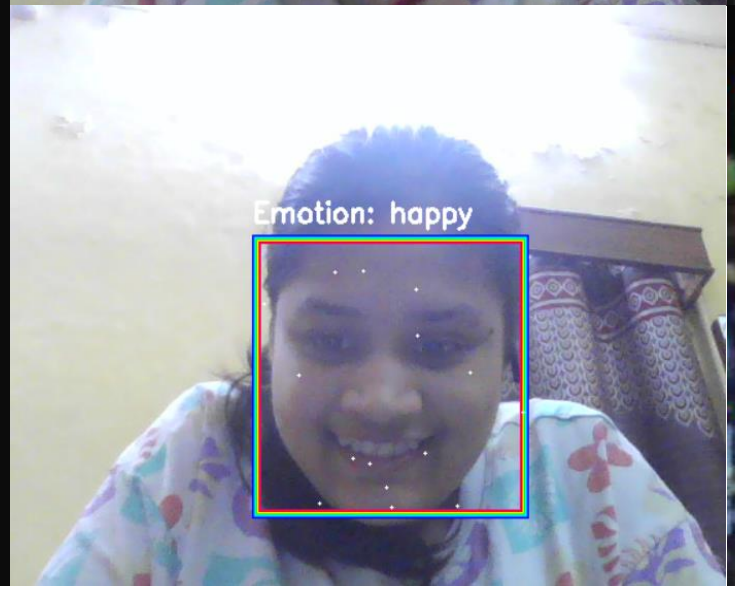
FACIAL EMOTION CLASSIFICATION

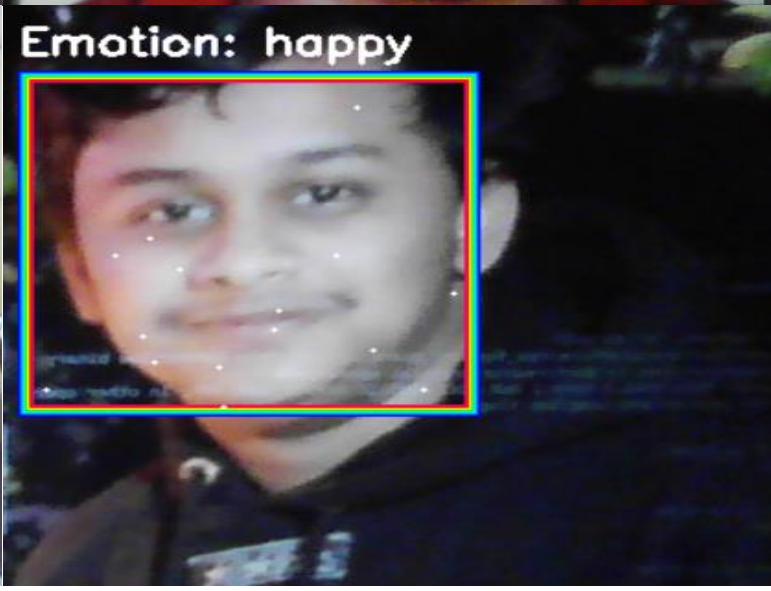
✨ Mentis Mirror uses DeepFace to detect real-time facial emotions from webcam input. 🐟 To enhance user experience, magical glowing lines dynamically appear above and below the face while displaying the detected mood with confidence.

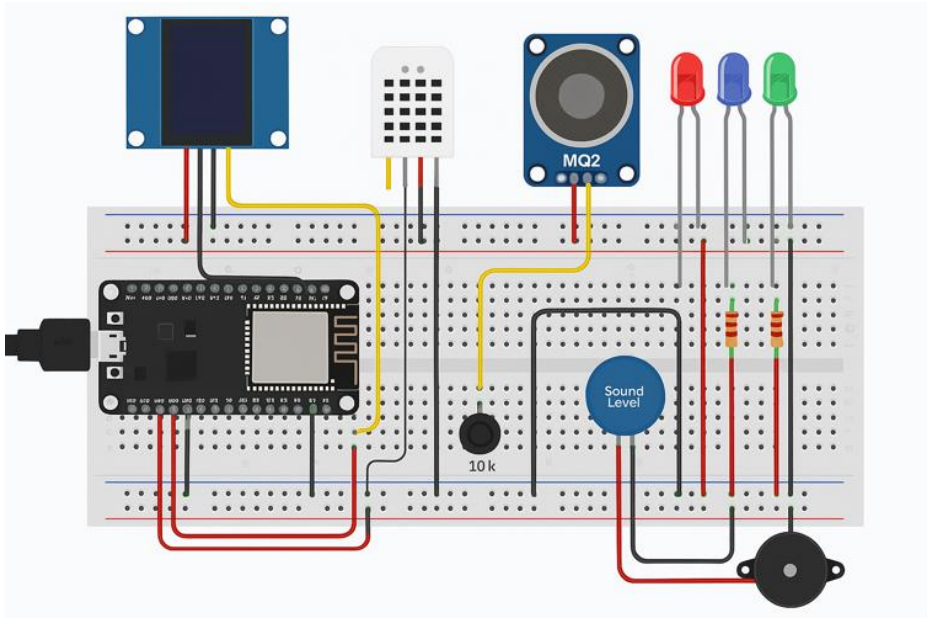
```
 Logged to MySQL successfully!
  Webcam is running. Press 'c' to capture, 'q' to quit.
2025-07-23 12:14:38.229598: I tensorflow/core/platform/cpu_feature_guard.cc:210] This Ten
is optimized to use available CPU instructions in performance-critical operations.
To enable the following instructions: SSE3 SSE4.1 SSE4.2 AVX AVX2 AVX512F AVX512_VNNI FMA
ations, rebuild TensorFlow with the appropriate compiler flags.

  Capturing image 1...
 NEUTRAL (58.95%) at 2025-07-23 12:19:01
 Logged to MySQL successfully!

  Capturing image 2...
 NEUTRAL (74.28%) at 2025-07-23 12:19:05
 Logged to MySQL successfully!

  Capturing image 3...
 NEUTRAL (53.87%) at 2025-07-23 12:19:08
 Logged to MySQL successfully!

  Capturing image 4...
 FEAR (68.08%) at 2025-07-23 12:19:41
 Logged to MySQL successfully!

  Capturing image 5...
 HAPPY (90.15%) at 2025-07-23 12:19:46
 Logged to MySQL successfully!

  Emotion logs saved to emotion_logs.csv
```











SENSOR SYSTEM ARCHITECTURE - FOR PHYSIOLOGICAL STRESS DETECTION

- Central Controller
  - ESP32 Dev Board
  - Reads sensors, controls outputs
- Input Sensors
  - DHT11 → GPIO2
  - MQ2 → GPIO34
    - Sound Sensor → GPIO35
    - Button → GPIO15
- Output Components
  - OLED → GPIO21(SDA), GPIO22(SCL)
  - LEDs → GPIO13/12/14
  - Buzzer → GPIO27
- Power Supply
  - USB 5V Power
    - Red → VCC, Black → GND
- Communication Flow
  - Sensors → ESP32 → OLED/LEDs/Buzzer

EXPLAINABILITY

Why SHAP?

SHAP (SHapley Additive exPlanations) helps us understand *why* a particular emotion was detected by explaining each feature's impact on the model's output.

Feature Contribution Visuals

SHAP values highlight how factors like facial expressions (e.g., mouth openness, brow raise, eye squint) influence the emotion prediction.

Transparent Predictions

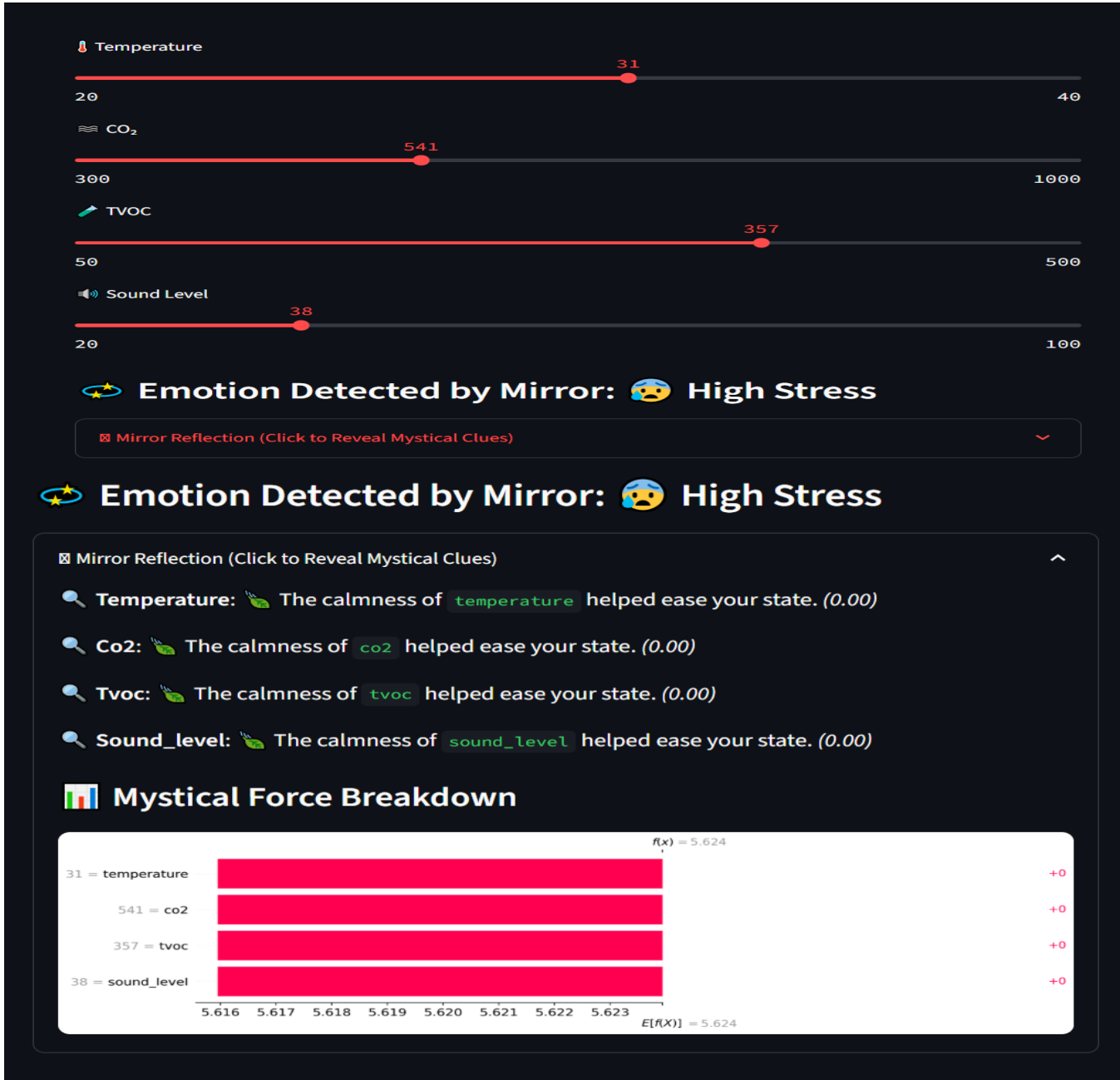
Provides per-frame visual justification for the detected emotion — building trust in the AI system.

Magic + Logic

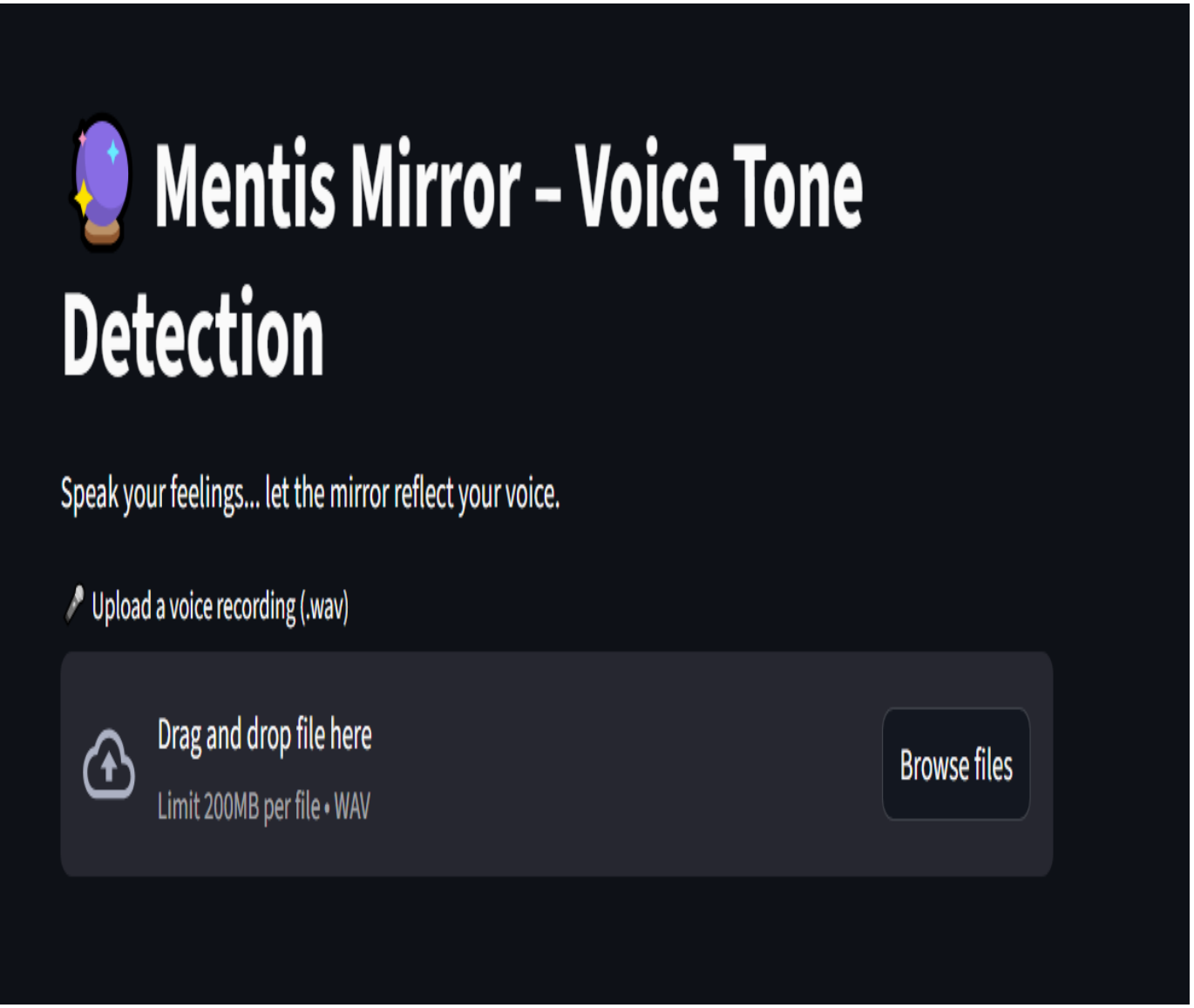
Blends the *magic of emotion detection* with the *logic of feature attribution*, reinforcing that Mentis Mirror is not just mystical, but also scientifically explainable.

User Benefit

Users can view which facial regions contributed most, making the system more interactive, educational, and emotionally intelligent.



Voice Tone Analysis



🎯 Purpose

- Identify emotional tone in voice recordings using AI
- Allow users to **speak their feelings** to the mirror
- A step toward **multi-modal emotion detection**

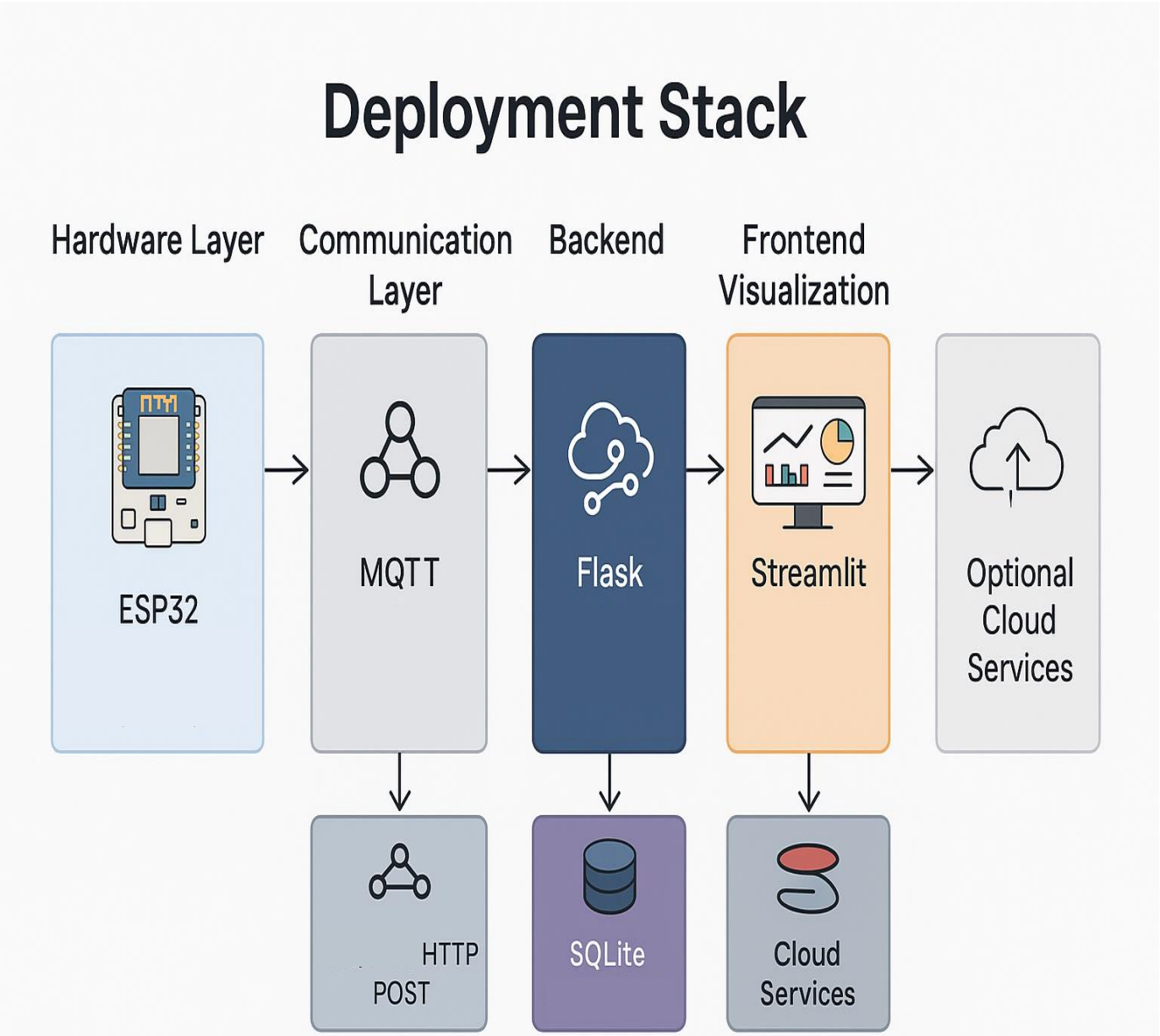
🛠️ How It Works

- Users upload a **.wav file** (max 200MB)
- Pre-trained ML model analyzes **pitch, intensity, tone**
- Emotion categories: Happy, Sad, Angry, Neutral, etc.
- Uses features like MFCC, Chroma, Zero-Crossing Rate

🔮 Future Scope

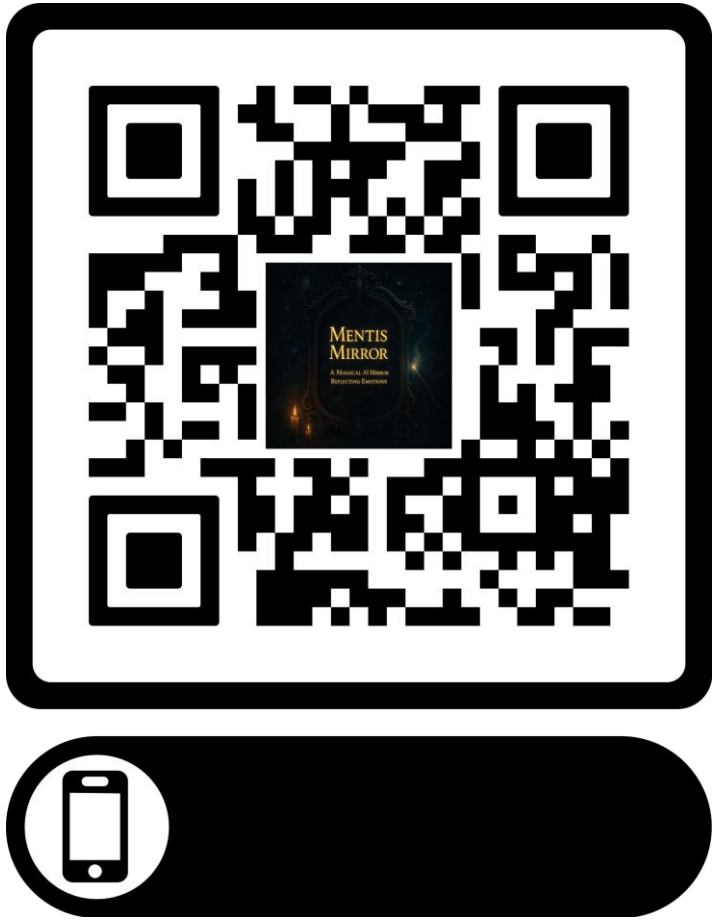
- Combine **voice tone + facial emotion** for accurate predictions
- Enable **real-time voice emotion feedback**
- Integrate with magical item triggers based on **voice mood**

DEPLOYMENT STACK



1. Hardware: ESP32 collects sensor data
2. Communication: HTTP POST sends data to backend
3. Backend: Flask handles data + ML inference
4. Database: SQLite logs emotional states
5. Frontend: Streamlit shows live cognitive insights
6. Cloud (Optional): Integrate with IoT Hub or Graph API

PLEASE SCAN TO QR. CODE TO SEE THE UI OF OUR PROJECT.



COST BREAKDOWN (PROTOTYPE)

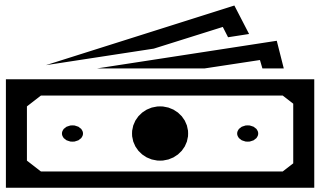
COST BREAKDOWN (PROTOTYPE)

Component	Unit Cost (INR)	Qty	Total Cost (INR)
ESP32 Dev Board	₹ 300	1	₹ 300
MAX30102 Heart Rate Sensor	₹ 250	1	₹ 250
GSR Sensor Module	₹ 150	1	₹ 150
MLX90614 IR Temp Sensor	₹ 400	1	₹ 600
USB Webcam Facial emotion detection (via DeepFace)	₹ 600	1	₹ 600
Microphone Module	₹ 150	1	₹ 150
Jumper Wires + Breadboard + Misc	₹ 200	1 set	₹ 200
Power Supply (Battery/Adapter)	₹ 250	1 set	₹ 250
TOTAL COST			₹ 2,300

Component	Unit Cost (INR)	Qty	Total Cost (INR)	Purpose
ESP32 Dev Board	₹300	1	₹300	Controller for sensors and communication
MAX30102 Heart Rate Sensor	₹250	1	₹250	HR & HRV detection
GSR Sensor Module	₹150	1	₹150	Stress detection via skin conductivity
MLX90614 IR Temp Sensor	₹400	1	₹400	Skin & ambient temperature sensing
USB Webcam	₹600	1	₹600	Facial emotion detection (via DeepFace)
Microphone Module	₹150	1	₹150	Voice tone/emotion input
Jumper Wires + Breadboard + Misc	₹200	1 set	₹200	Wiring & prototyping accessories
Power Supply (Battery/Adapter)	₹250	1	₹250	Powering ESP32 and sensors

🧠 **Software/Cloud Costs (₹0 – All Free/Open Source):**

- ❑ **DeepFace** : Open-source
- ❑ **Flask / Streamlit**: Free
- ❑ **Google Calendar API / Firebase (Free Tier)**: ₹0



KEY FEATURES & IMPACT

✅ **Key Features**

🧠 **Real-Time Emotion Detection**

Uses facial cues, voice tone, and physiological signals for live mood analysis.

❤️‍🔥 **Multimodal Stress Detection**

Combines heart rate variability, GSR, and temperature to improve accuracy.

📲 **Smart Cognitive Twin Modeling**

Creates a digital replica of emotional state using AI-powered fusion.

📊 **Intuitive Dashboard & Alerts**

Visualizes trends in stress, focus, and fatigue with real-time feedback.

🔌 **Edge + Cloud Ready**

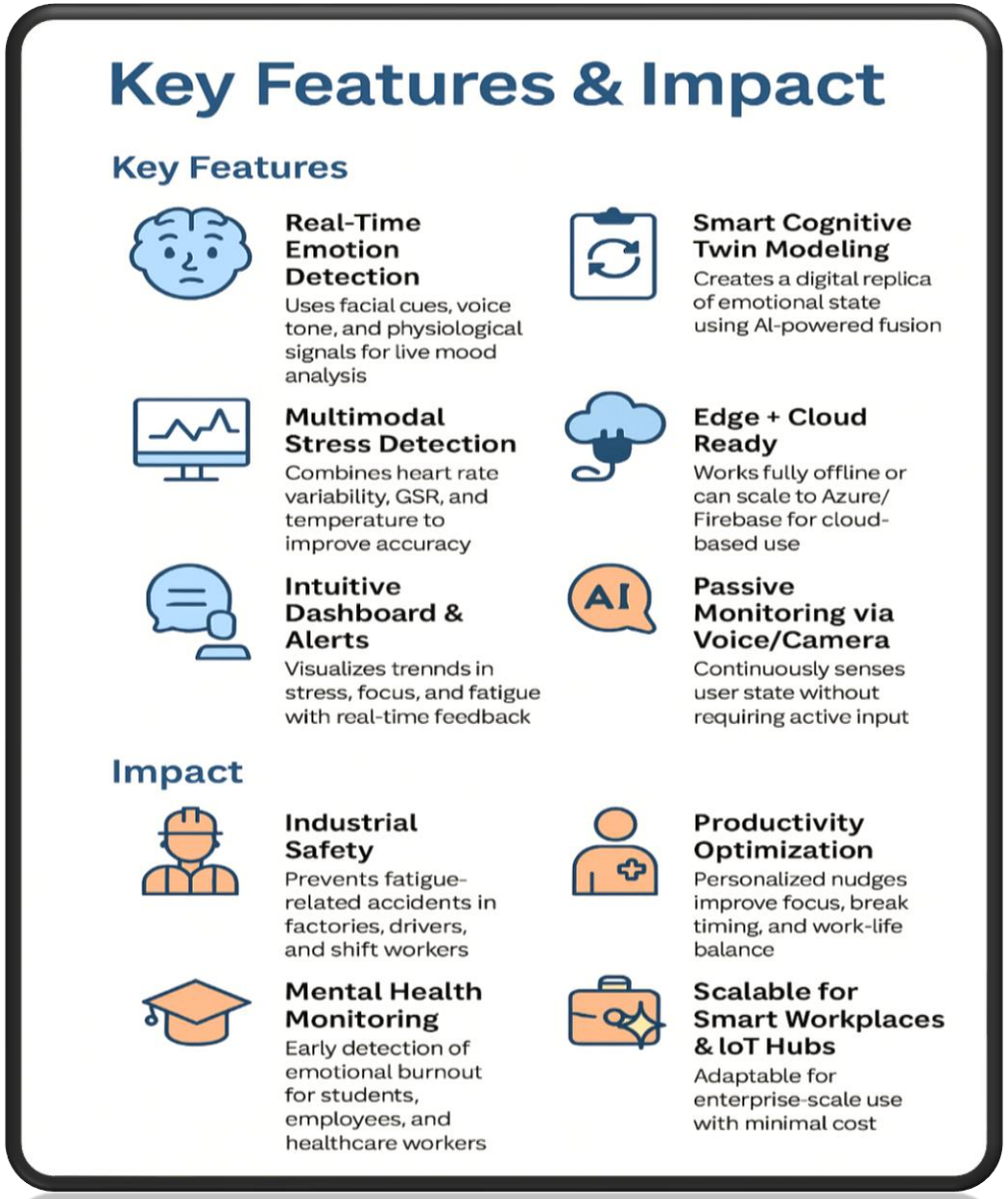
Works fully offline or can scale to Azure/Firebase for cloud-based use.

🎙️ **Passive Monitoring via Voice/Camera**

Continuously senses user state without requiring active input.

💬 **Explainable AI**

SHAP-based model transparency to build trust and accountability.



🌍 **Impact**

🏭 **Industrial Safety**

Prevents fatigue-related accidents in factories, drivers, and shift workers.

🧑‍⚕️ **Mental Health Monitoring**

Early detection of emotional burnout for students, employees, and healthcare workers.

🎓 **Educational Wellness**

Helps track cognitive load in students during learning or exams.

💼 **Productivity Optimization**

Personalized nudges improve focus, break timing, and work-life balance.

🌐 **Scalable for Smart Workplaces & IoT Hubs**

Adaptable for enterprise-scale use with minimal cost.

CONCLUSION

What is Mentis Mirror?	An AI-powered cognitive digital twin that detects emotional states in real time using facial expressions, voice tone, and physiological signals — enhancing safety, wellness, and productivity.
🔍 Core Features	Real-time facial, voice & stress-based emotion detection
	Multimodal AI fusion model with SHAP explainability
	Offline + cloud-ready architecture (ESP32, Pi, Flask, Streamlit)
	Smart alerts, trend visualizations & personalized insights
Impact Areas	**Industrial Safety:** Prevents fatigue-based accidents
	Mental Health: Early burnout detection for professionals/students
	Productivity: Data-driven nudges to optimize daily performance


Supported By
Microsoft Azure
Azure Developer
Community
Managed by
Reskill
TRIWIZARDAT HON 1.0

☺ THANK YOU ☺