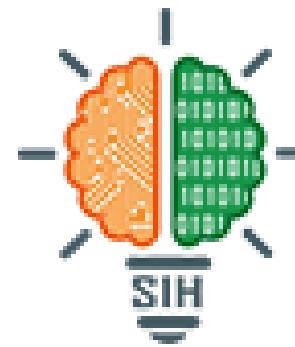
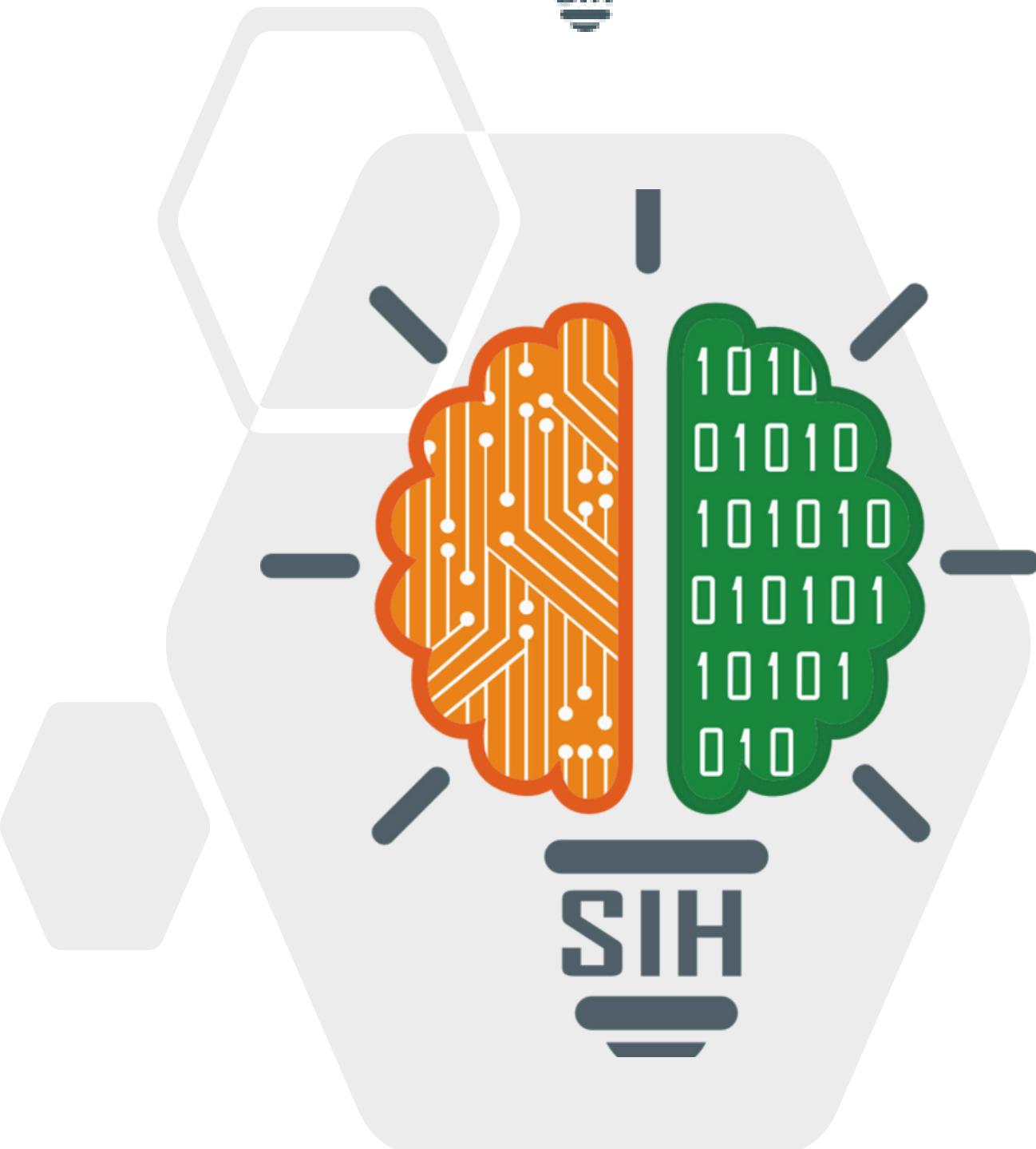


SMART INDIA HACKATHON 2025



SMART INDIA
HACKATHON
2025

- Problem Statement ID – **SIH25113**
- Problem Statement Title -
- **Cultural Sentinel – Integrated Protection Network**
- Theme – **Student Innovation**
- PS Category - **Hardware**
- Team ID - **63148**
- Team Name - **Team Elevare**



Aligned with UN Sustainable Development Goals
9, 11 & 13 to safeguard heritage and build climate-resilient communities



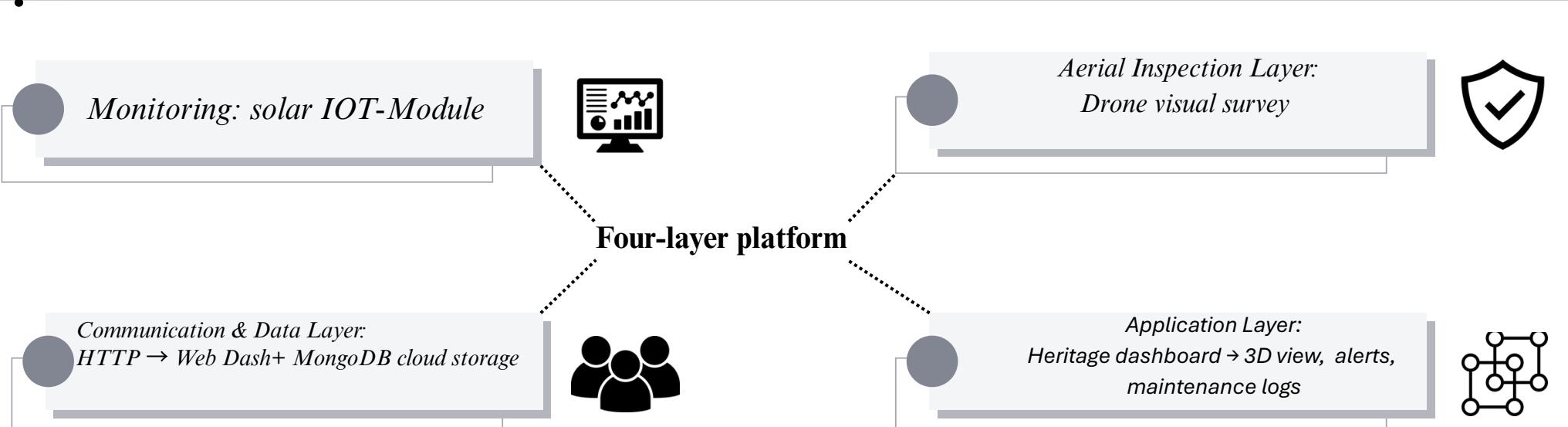
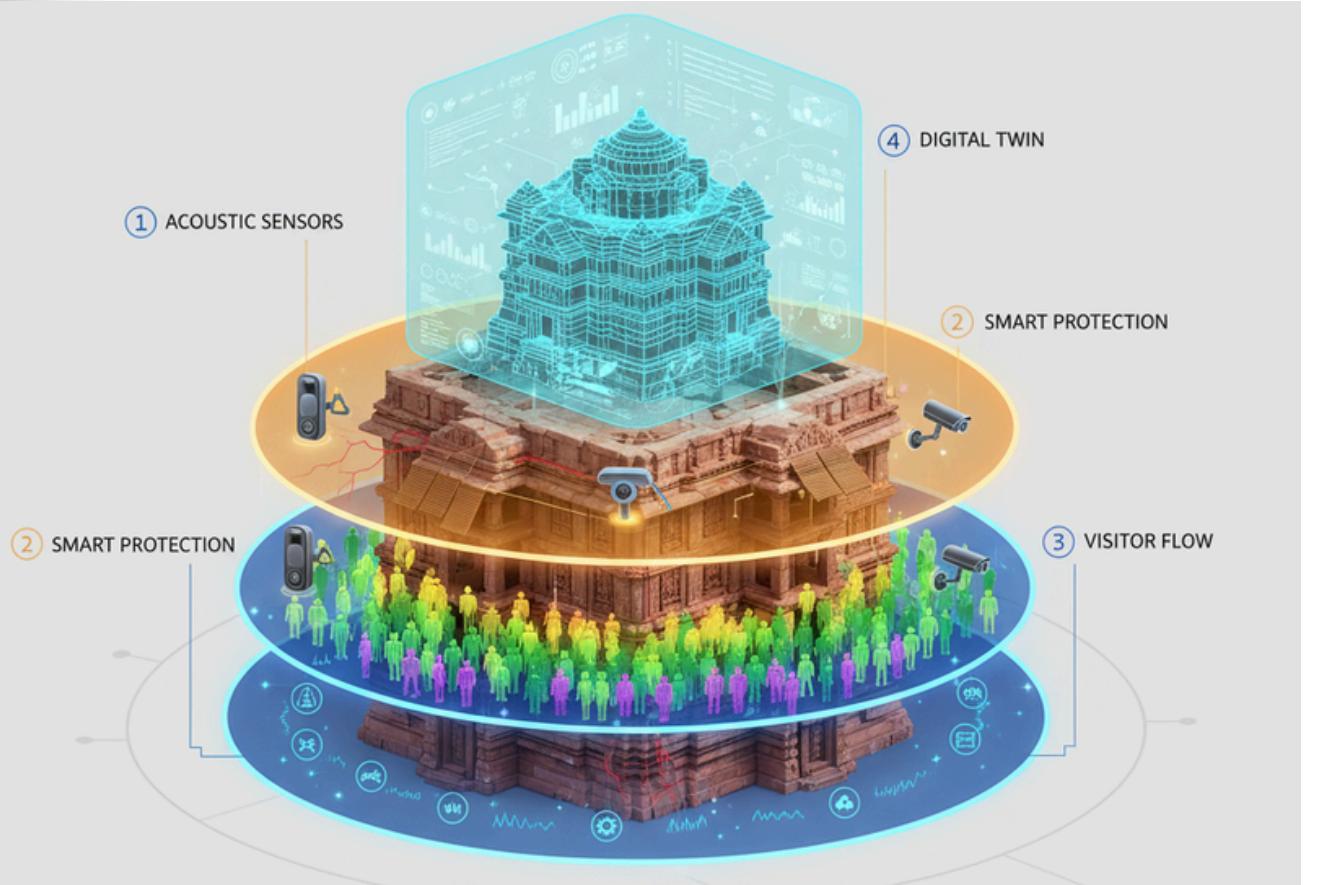
Cultural Sentinel



"Out of ~3,693 centrally protected monuments, only ~45% have been physically verified, while 50 monuments are missing or untraceable and 18 are officially described as not in a good state of preservation."

Problem

- Heritage sites suffer invisible damage: moisture, pollutants, micro-vibrations, and light/UV — these start as micro-cracks.
- Manual inspection is episodic, slow, and costly — damage found late.
- Need: a continuous, low-cost monitoring system for early warning and preventive maintenance.



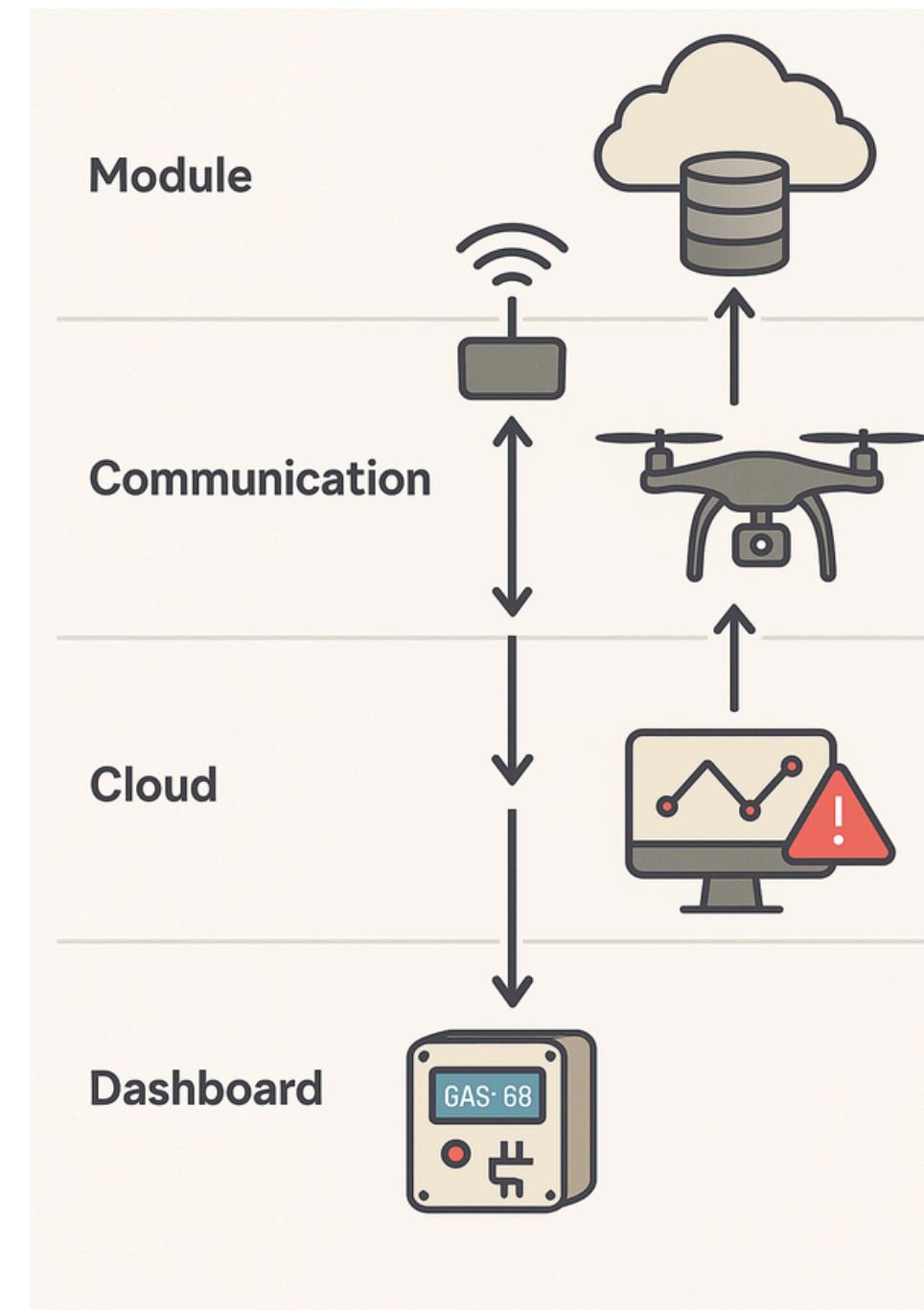
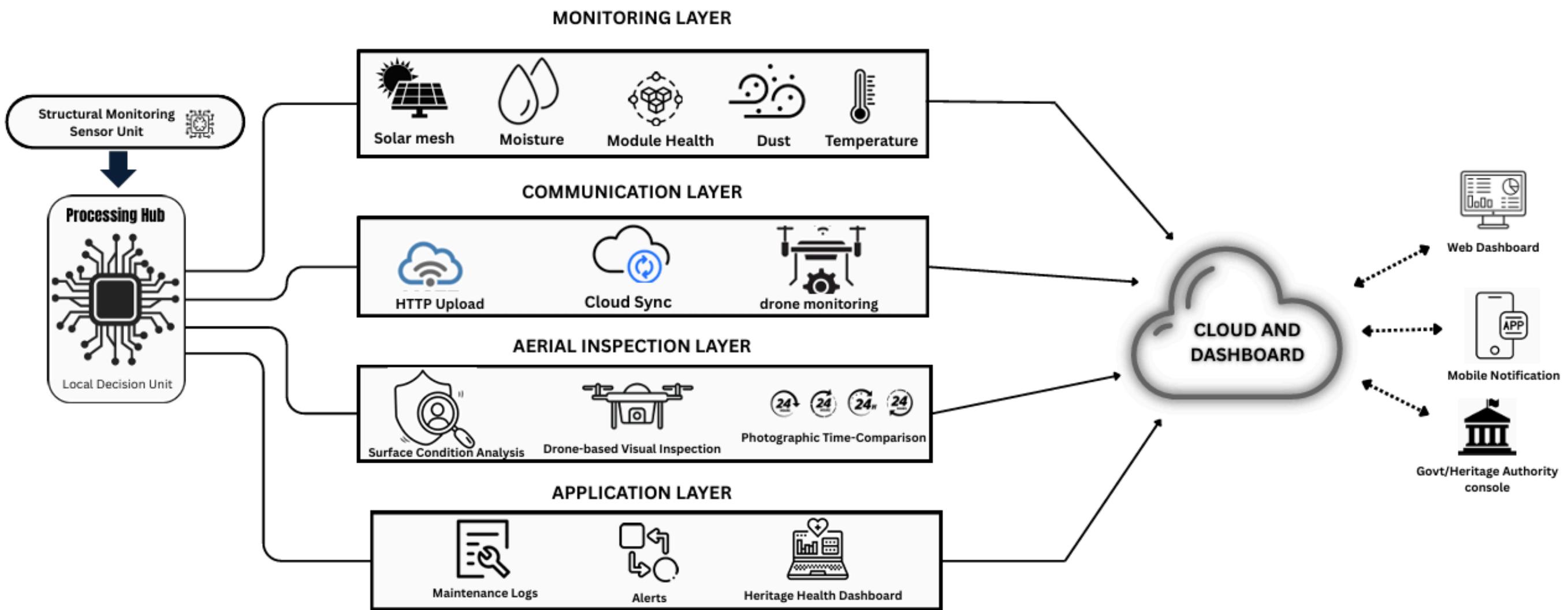
Why It Matters / Urgency:

- Heritage loss is irreversible; preserving monuments is preserving identity and cultural heritage.
- Enhances visitor safety by enabling early detection of structural vulnerabilities.
- Once micro-cracks propagate, restoration costs become huge, sometimes irreversible.

Our Solution

A hybrid monitoring system using a solar-powered IoT module ,cloud dashboard,drone imaging to detect early structural and environmental risks in heritage sites and support proactive conservation.

- *Integrated system: On-field IoT modules (LCD + LED for immediate status) + drone imaging (manual photo archival) + dashboard.*
- *Deployed 4 tested modules: gas; sound+PIR; soil moisture+water; color+light.*
- *Low-cost, modular, battery/solar compatible — designed for retrofit to existing sites.*



TECHNICAL APPROACH

IoT Layer:

ESP32 firmware (C/Arduino), multi-sensor interface, WiFi HTTP communication, solar-powered operations.

Communication & Cloud Layer:

ThingSpeak for live feeds, MongoDB Atlas for long-term storage, broker for lightweight messaging.

Backend / Data Layer:

Node.js + Express API, MongoDB database, time-series logging.

Aerial Inspection Layer:

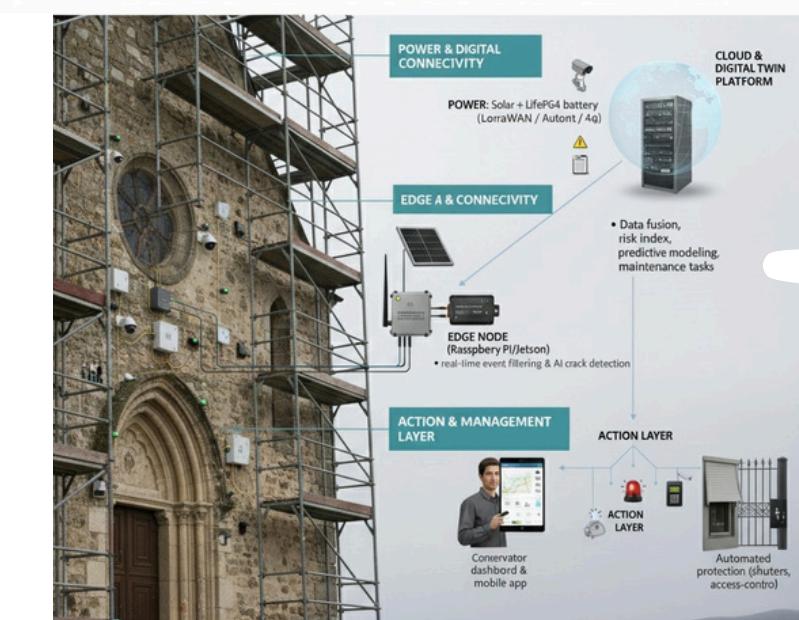
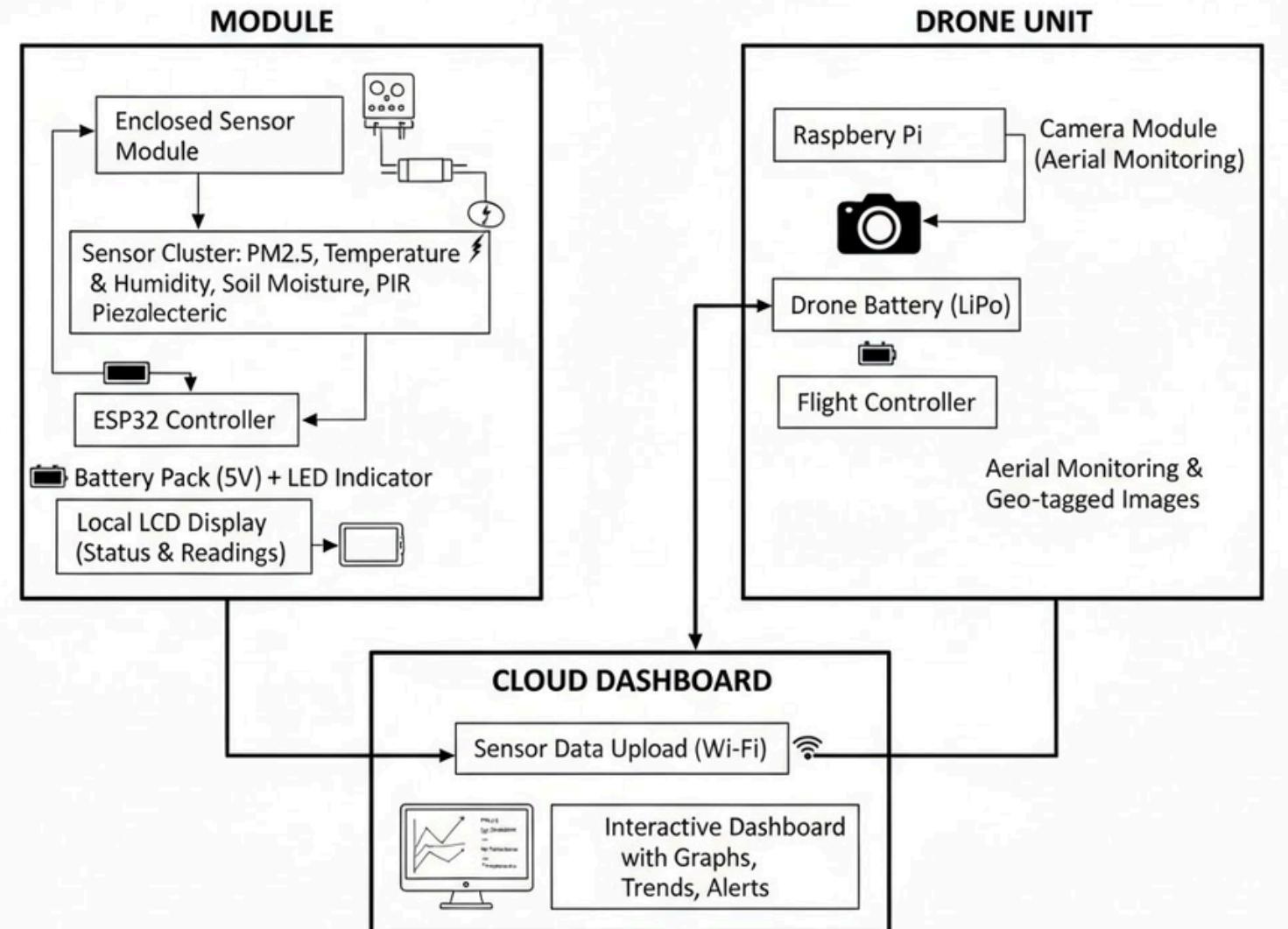
Drone-based visual capture, Python + OpenCV for basic mapping.

Application Layer:

React web dashboard, alerts & maintenance workflow.

Security Layer:

HTTPS, JWT authentication, role-based access for authorities and maintenance teams.

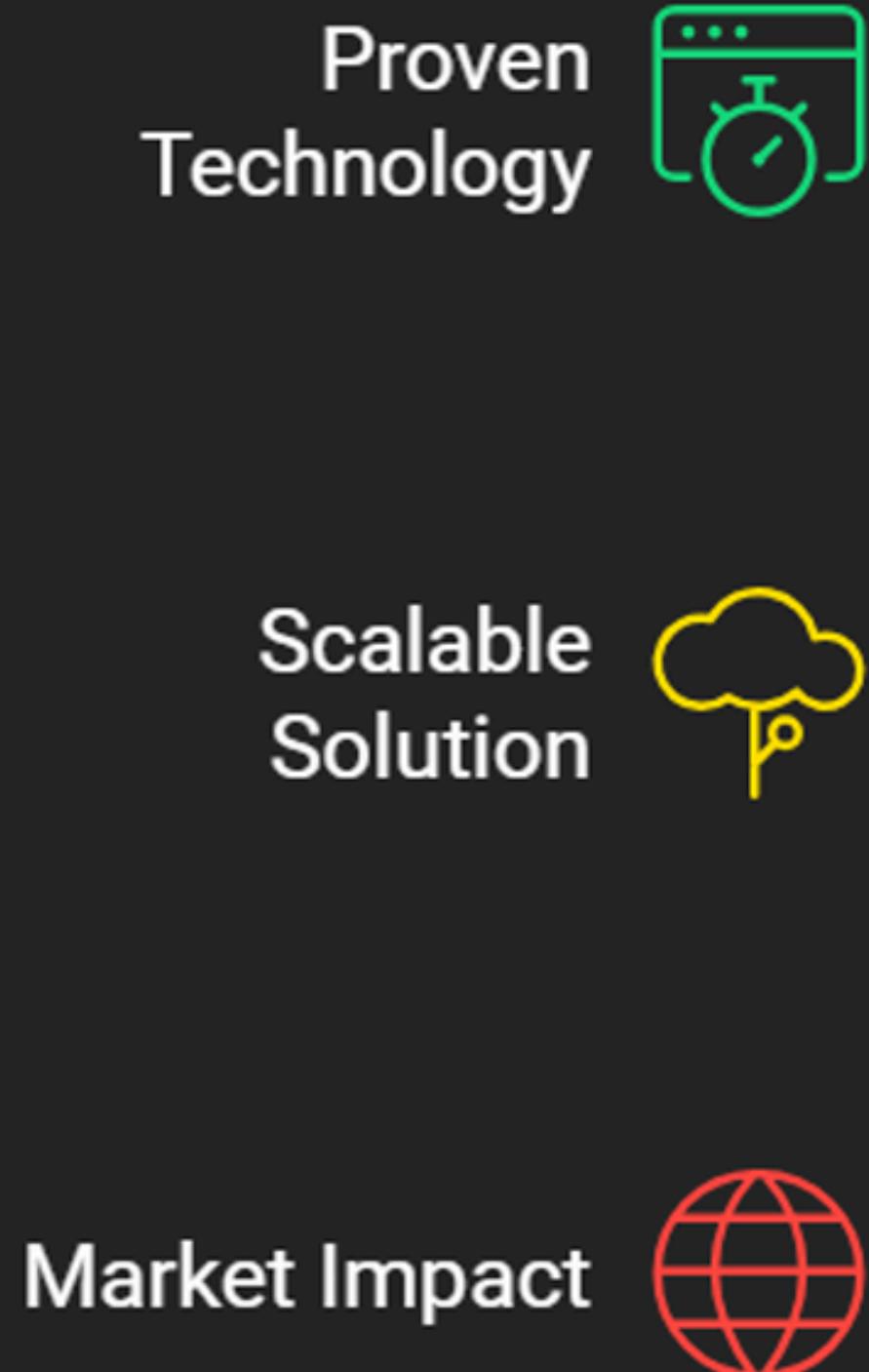


System Architecture

- *Modules gather and pre-process data, display via LCD + LED.*
- **Communication:** WiFi to gateway → Realtime DB.
- **Drone:** Periodic manual flights to capture high-resolution photos (archival & manual inspection).
- **Dashboard:** Live readings, trend graphs, color-coded alerts, and module status.

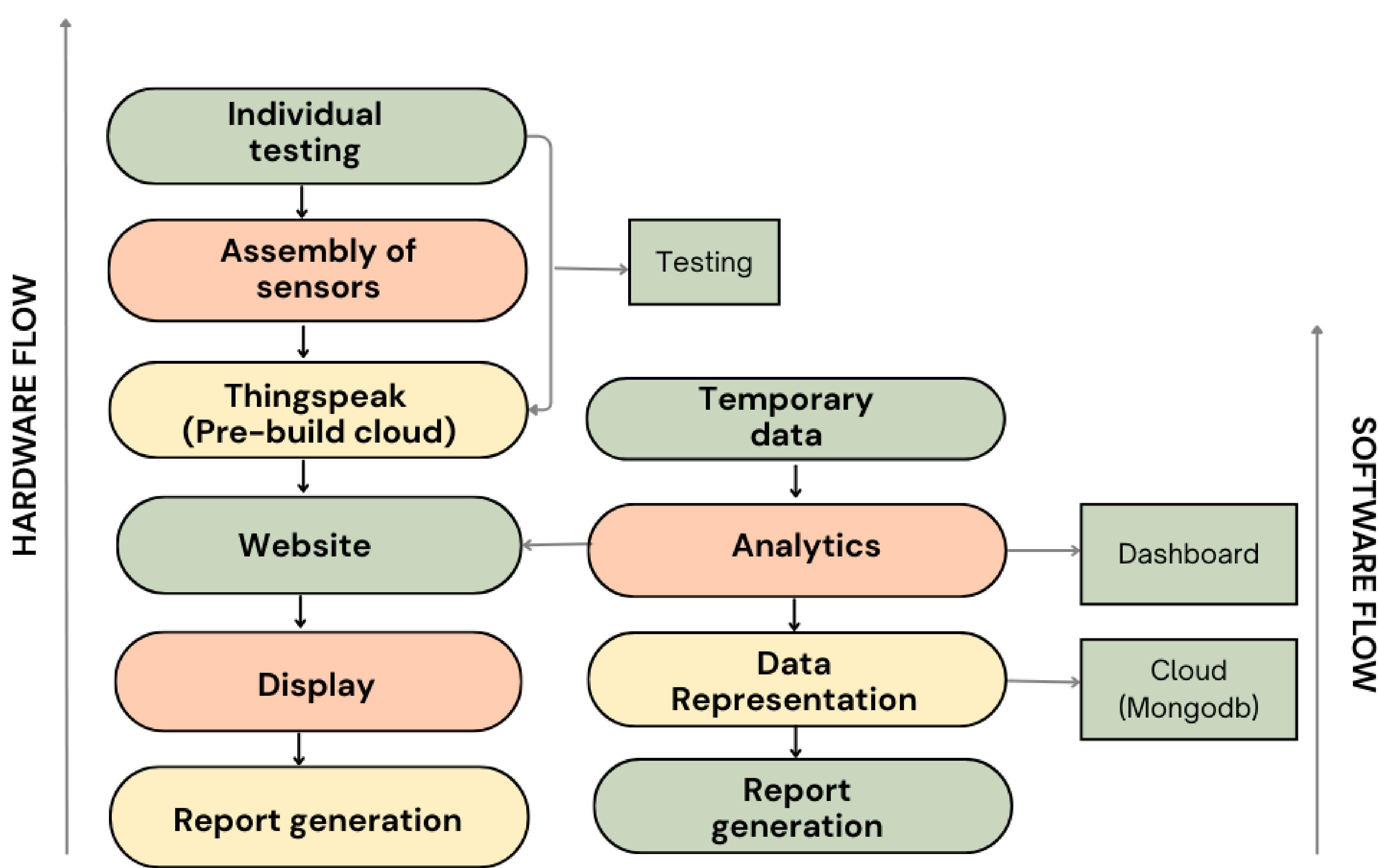
"Preserving the past,
powered by present-
ready technology!"

Market Readiness and Impact



Validated
System

Cost-Efficient



DAY WISE PROGRESS



- Module Development (1 - 4) & Website Front end

- Module Development (5 - 8) & Website Back end

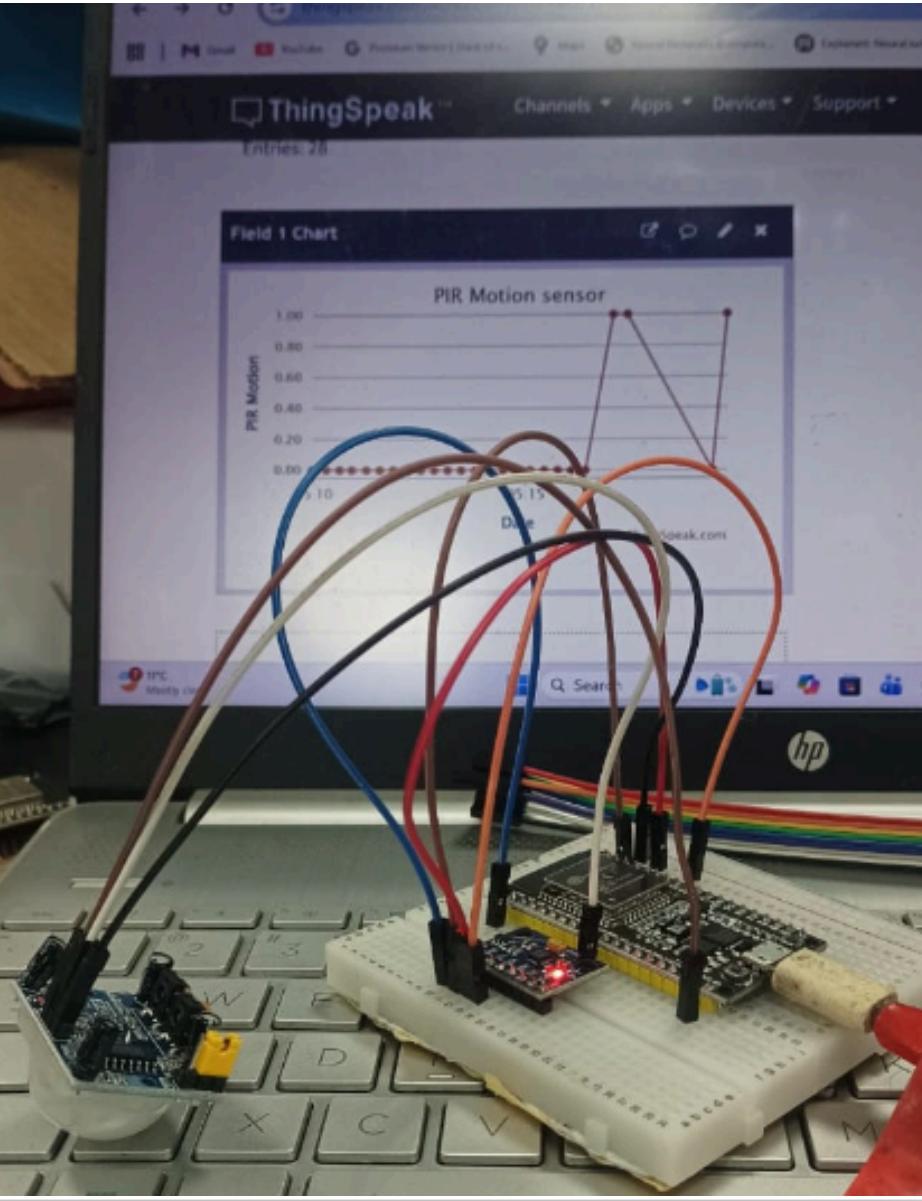
- Integration of two sensors with solar panel & battery in an enclosure
- Completion of sample testing, Demo of web app
- Drone initial configuration & 3D Model Printing

- Module Integration with Web App
- Drone configuration

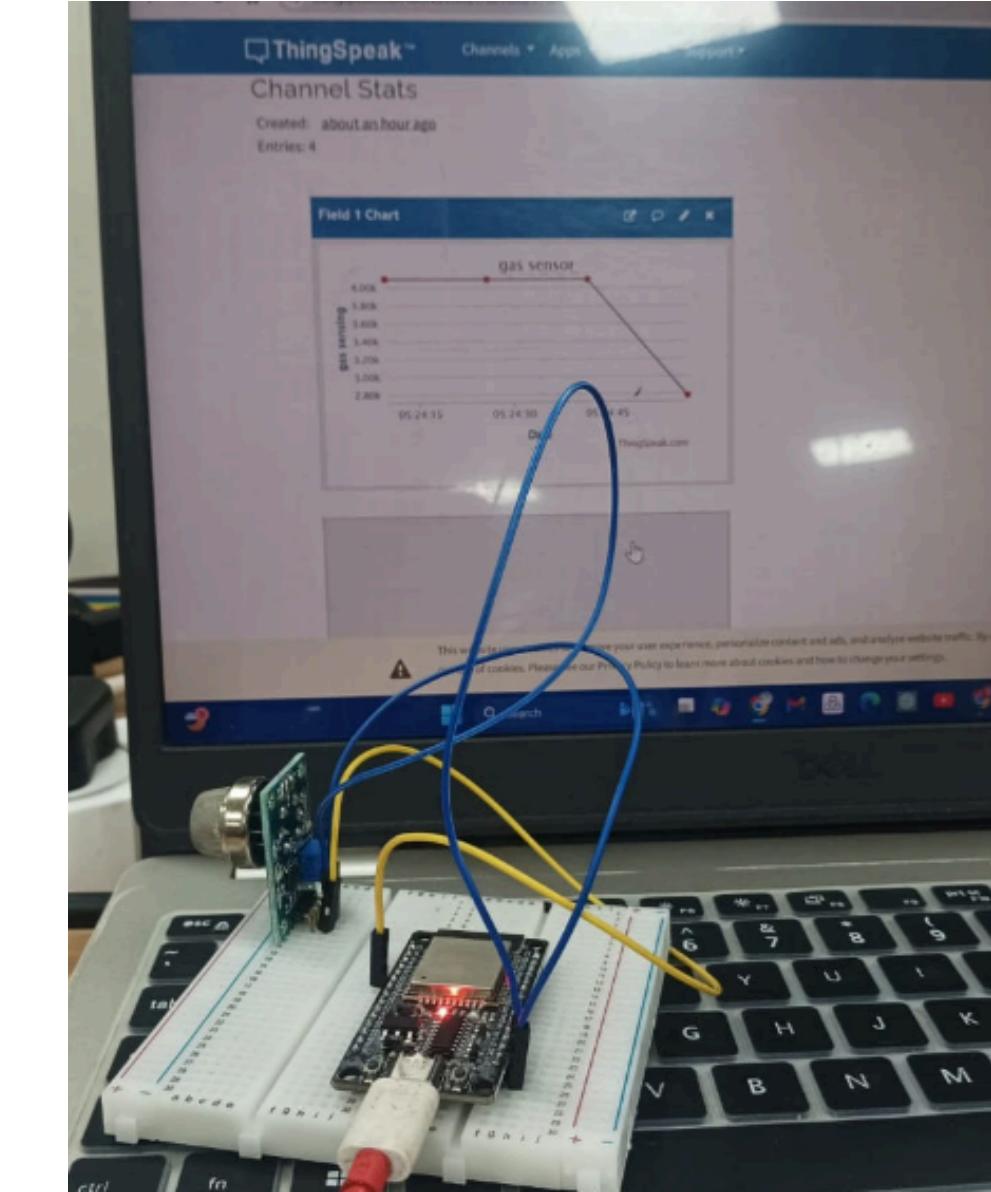
- Final Demonstration

Ground Module Development – Progress Update (Day 1)

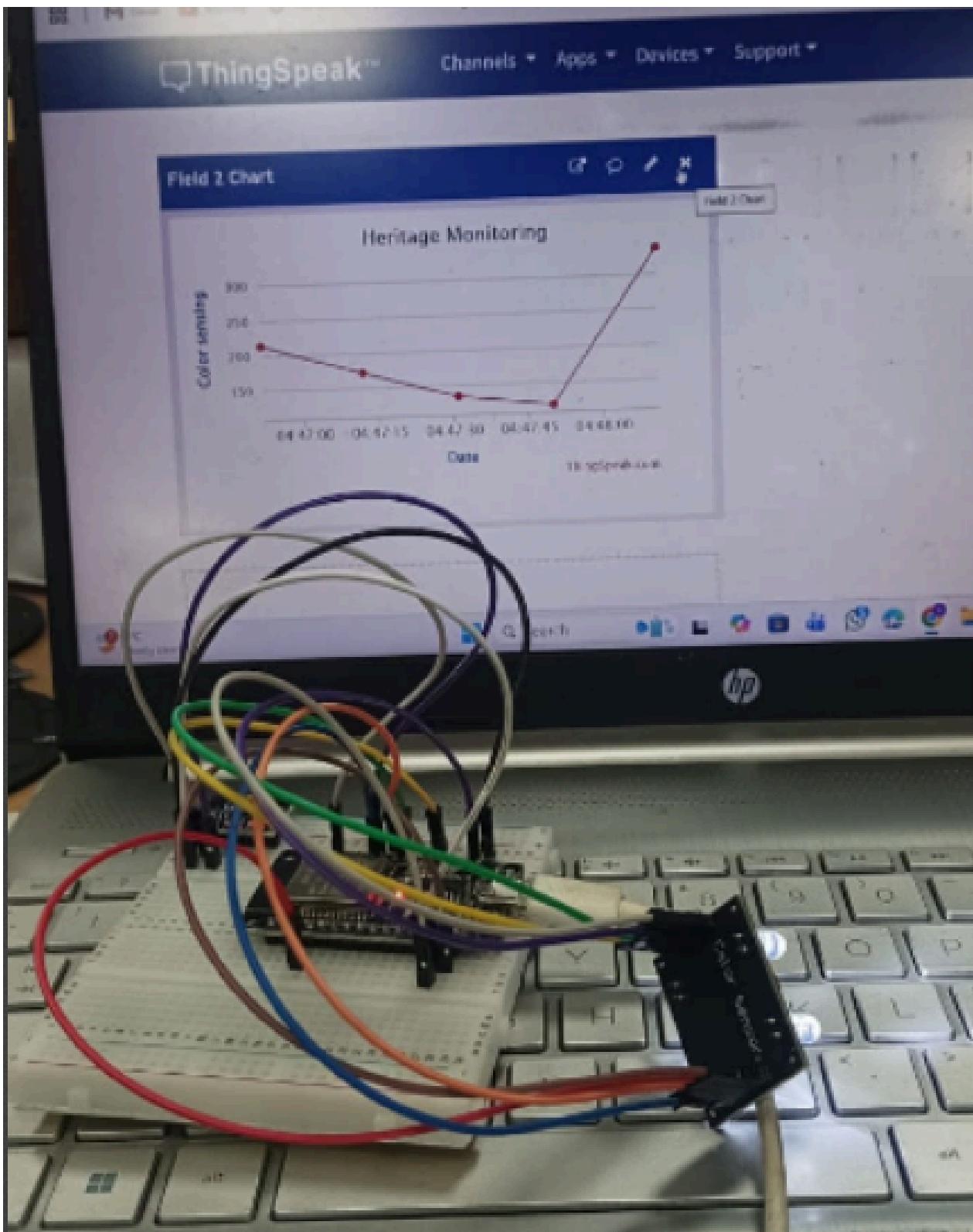
- Individual sensor validation and cloud integration for all environmental & structural parameters.
- Each sensor was tested with ESP32 and successfully uploaded data to ThingSpeak dashboards.”



PIR Motion Detection
– Proximity Detection
– Live motion spikes on server

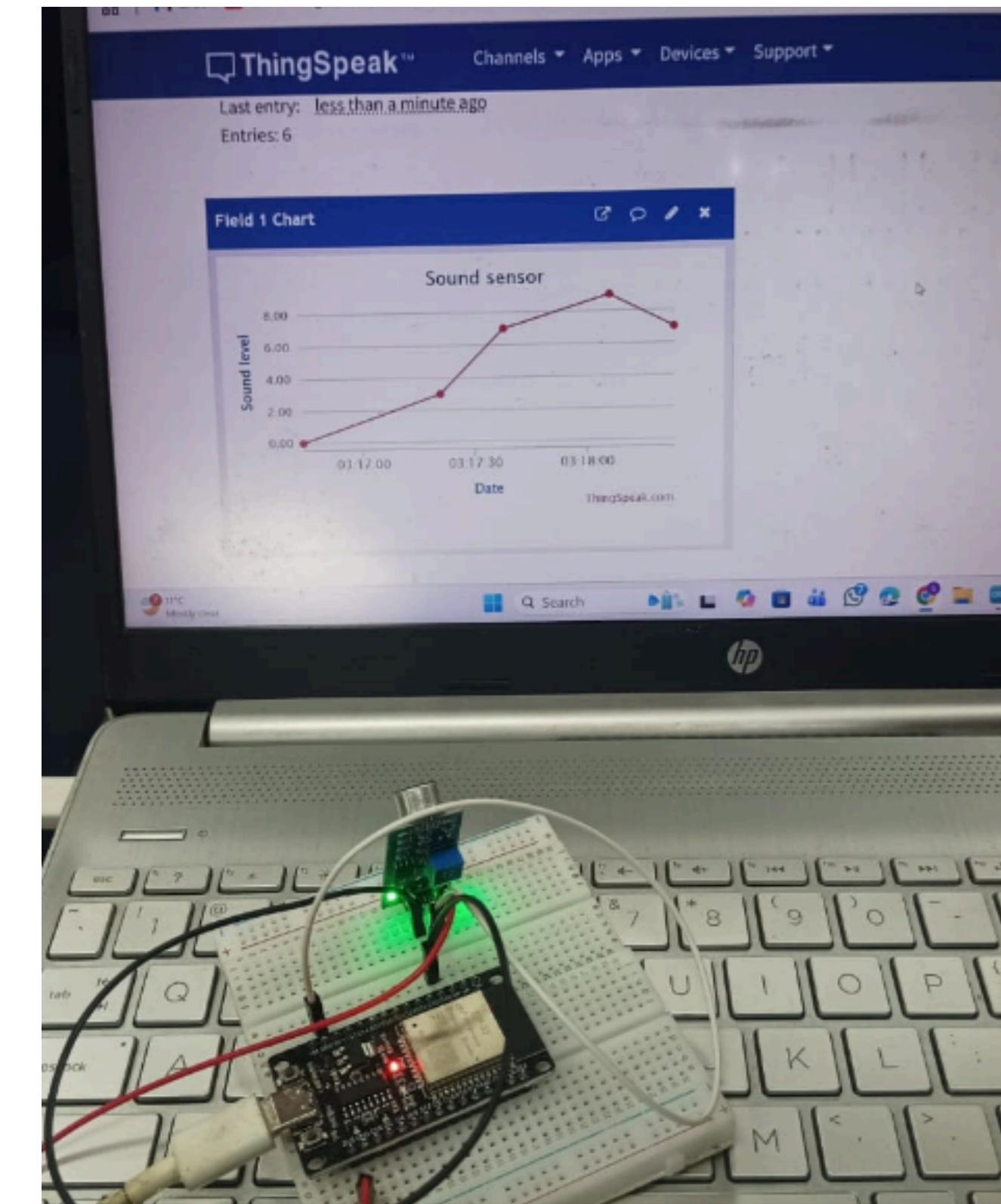


MQ135 – Air Quality / Gas Sensor
• Air quality detection & atmospheric deterioration
• Successfully real time data readings



Color Sensor (Surface Variation Check)

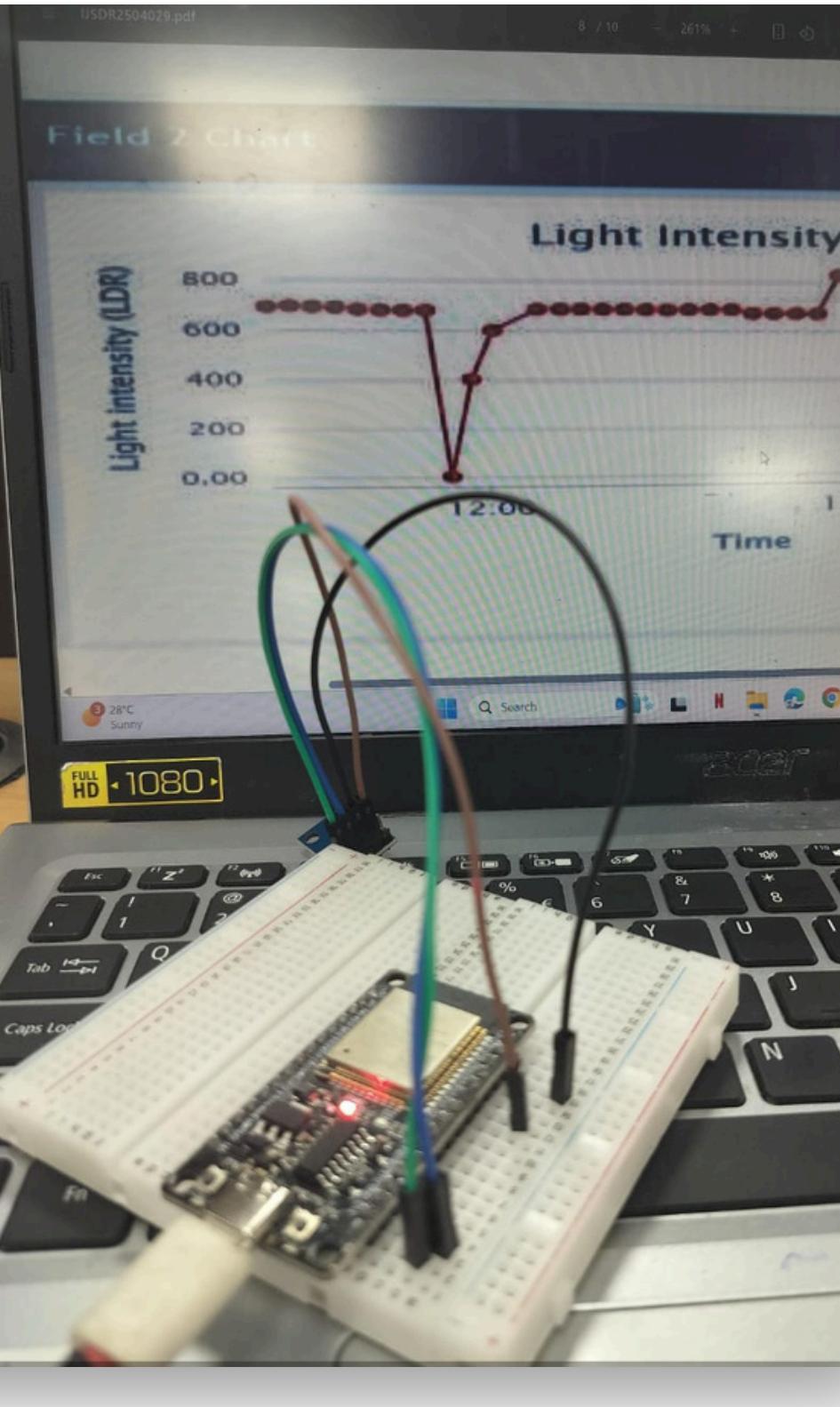
- Early test for stone color shifts
- Preliminary experiment for surface reflectance



Sound Sensor

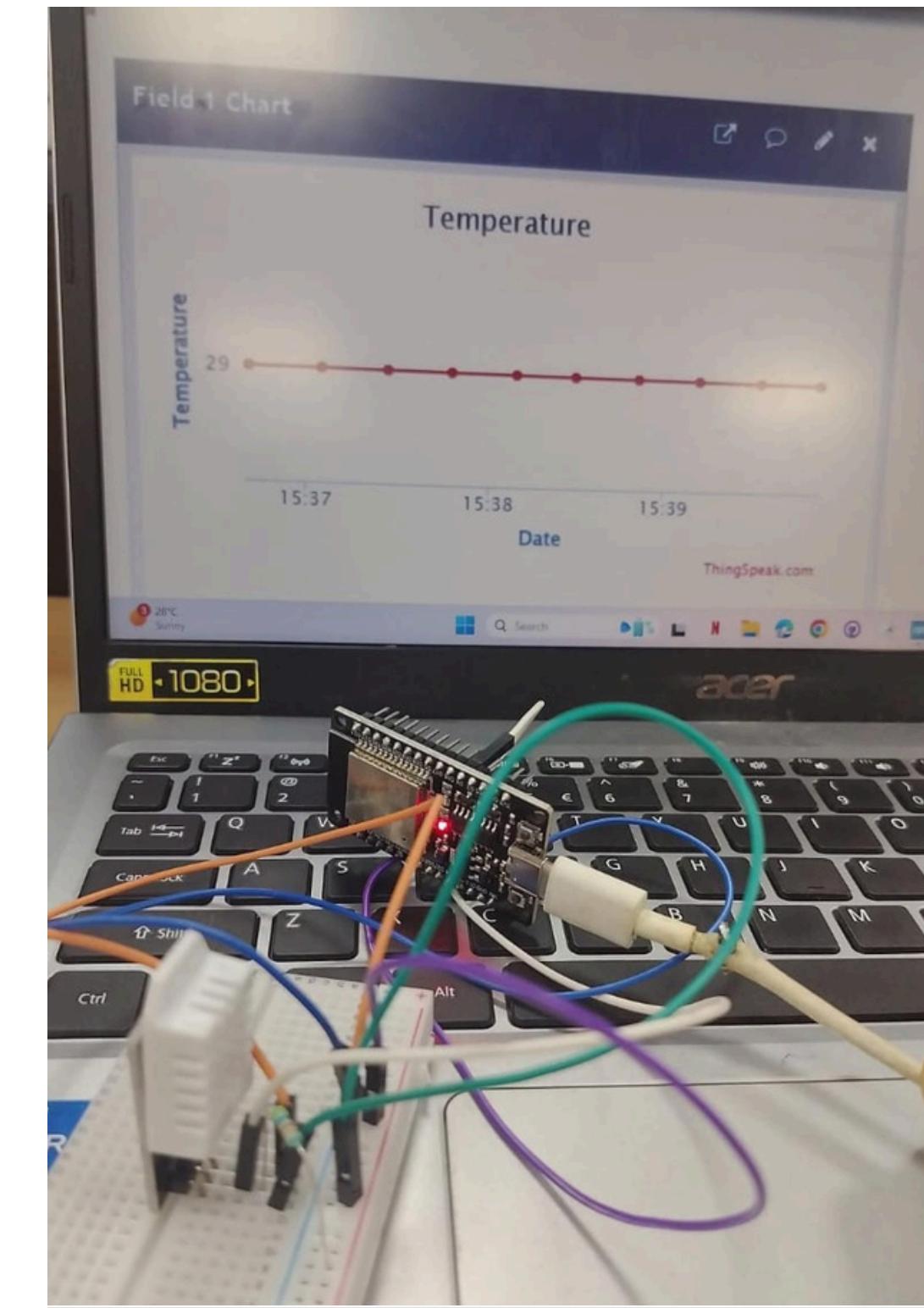
- Tracks high-impact noise & abnormal events
- Data correctly logged on cloud

DAY-2



BH1750 – Light Intensity / UV Exposure

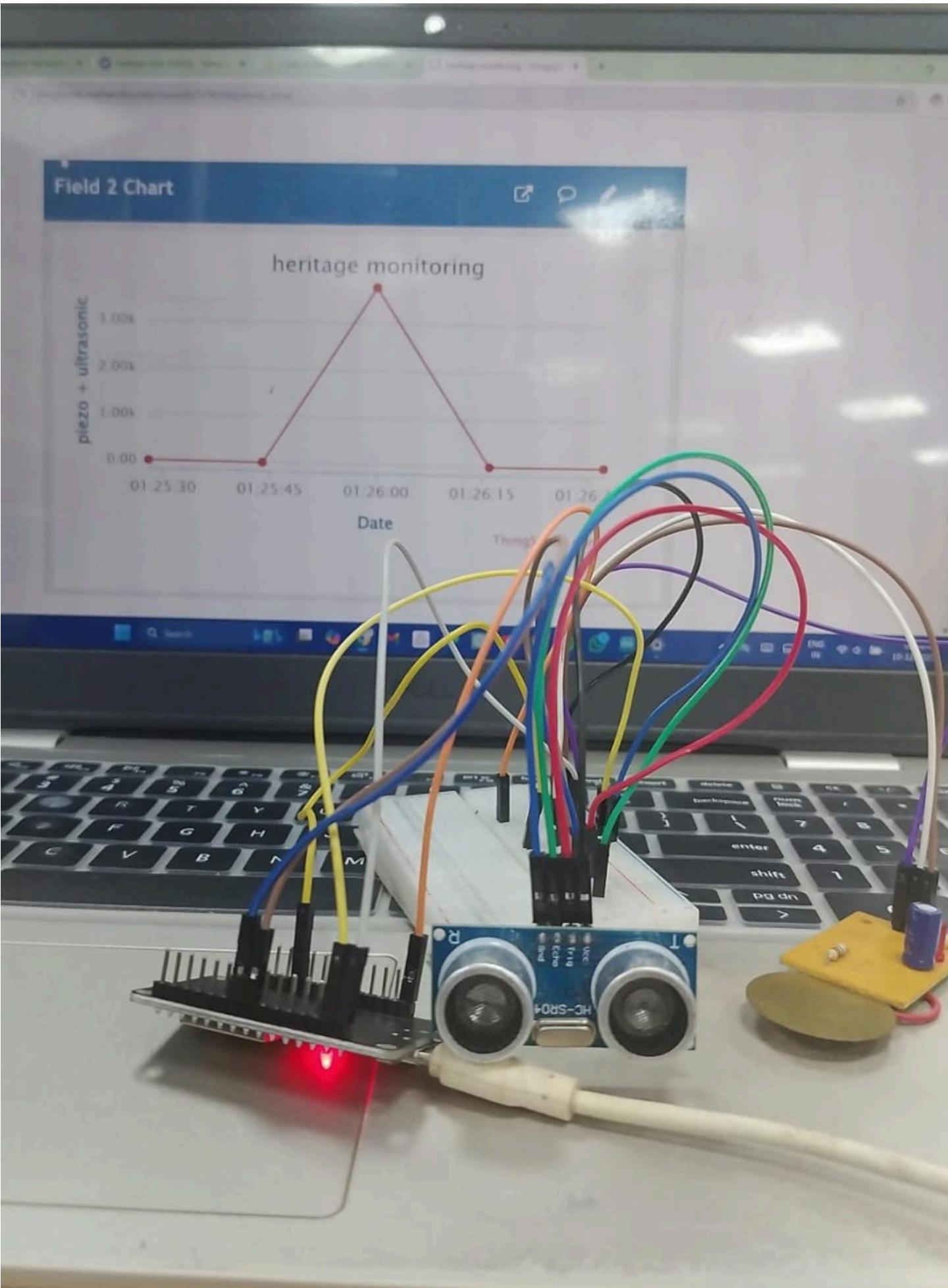
- Detects UV/sunlight impact on sandstone
- Sensor calibrated and functioning



DHT22 – Temperature & Humidity

- Measures thermal fluctuations affecting stone stress
- Tested stable, accurate readings

DAY-3

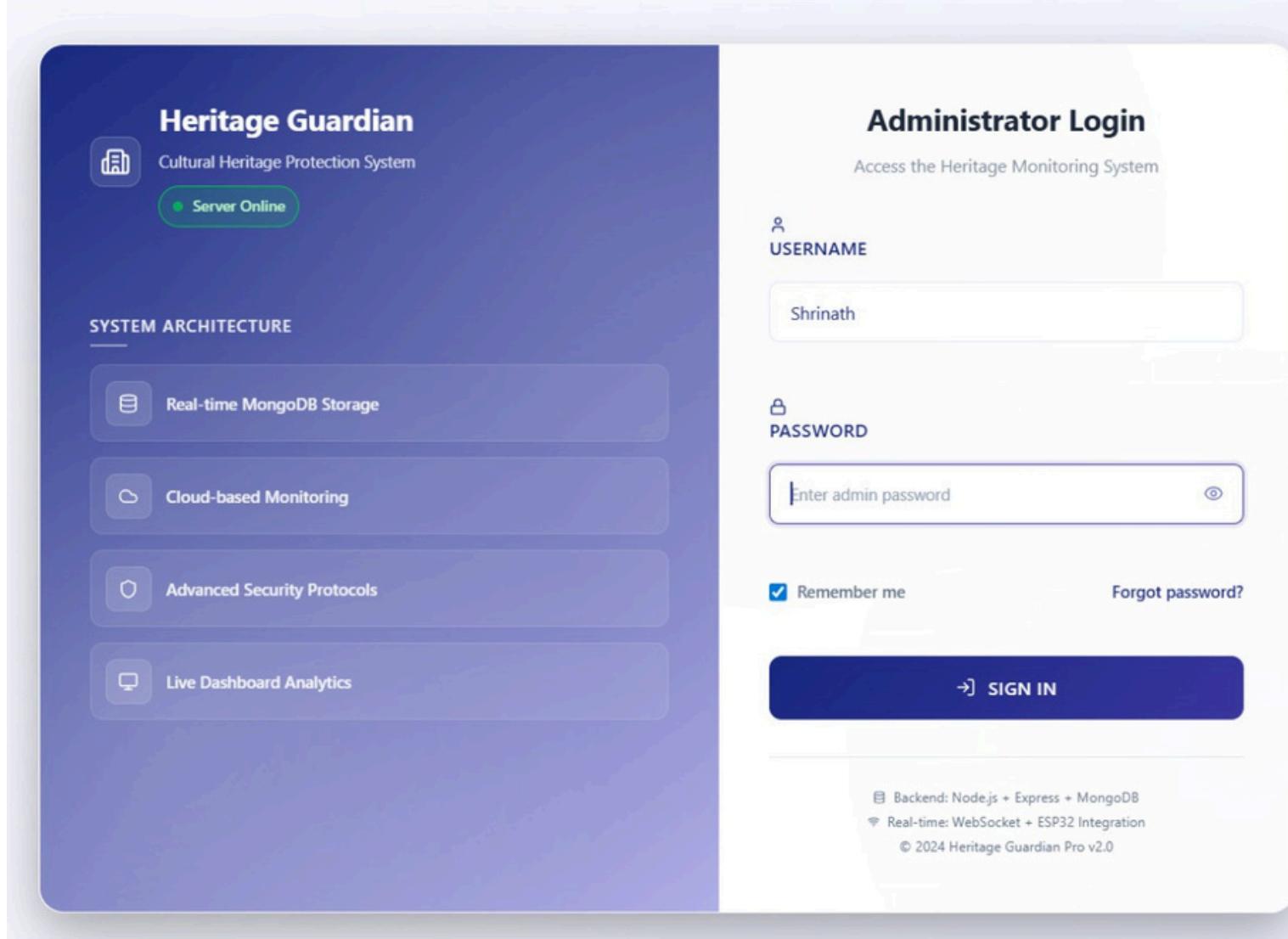


Piezo + Ultrasonic – Human proximity / Micro-Vibration Detection

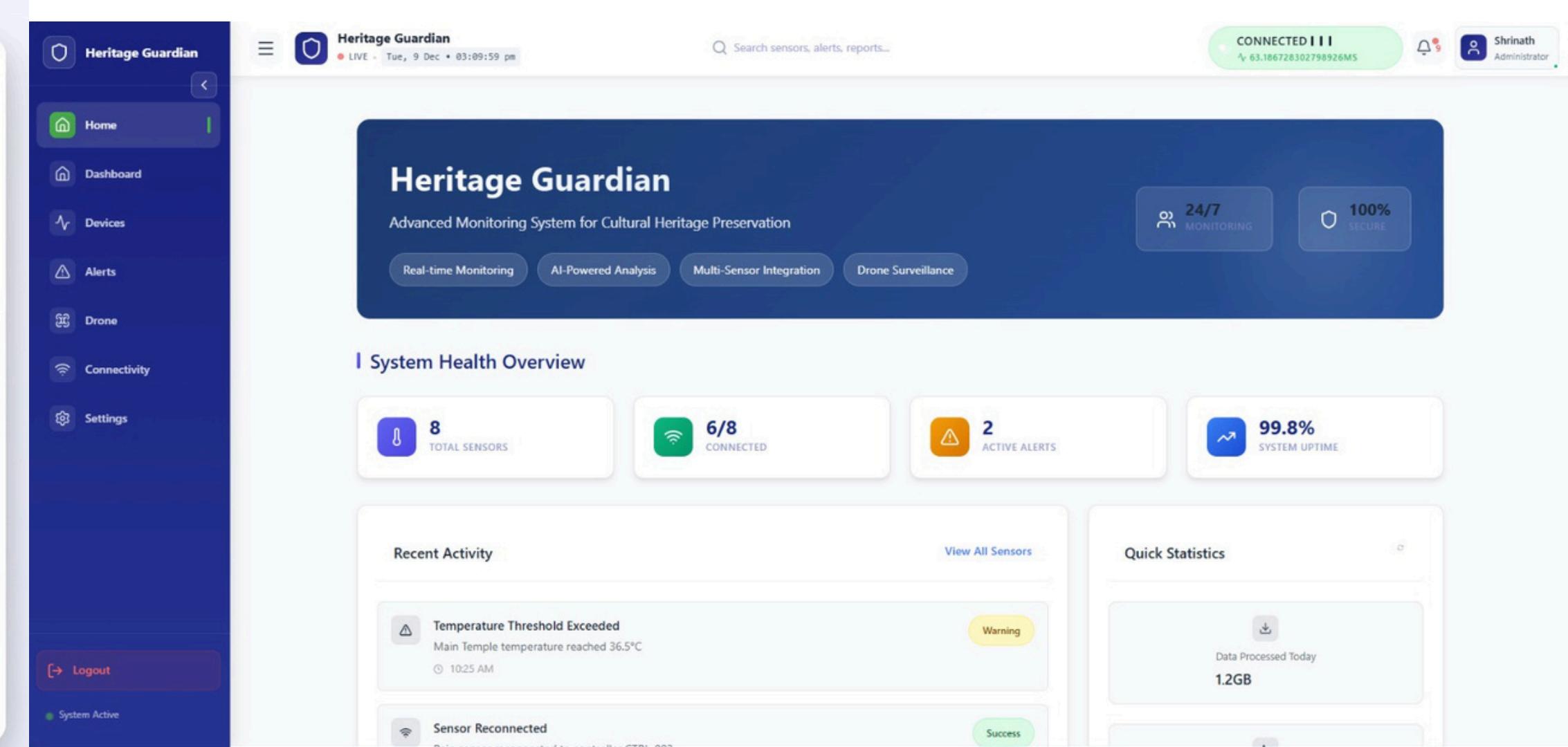
- Detects human standing time, wall interaction, and tiny vibrations indicating strain on heritage structures.
- Helps identify unauthorized touching/scribbling on walls.
- Sensor tested, calibrated, and sending live data to dashboard.

Heritage Monitoring Dashboard (Prototype v1.0)

Administrator Login Page



Home Dashboard

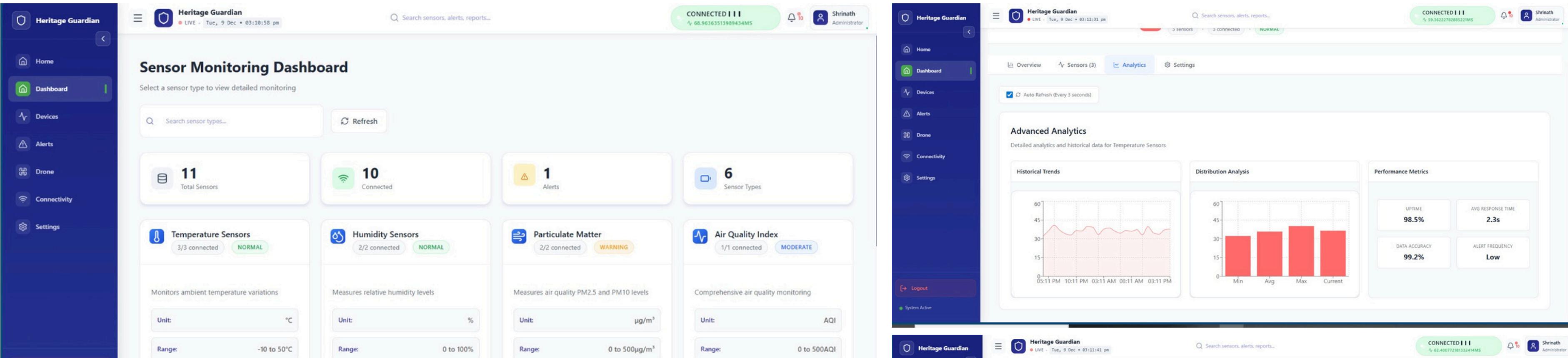


The main dashboard view includes:

- System Health Overview
- Recent Activity Feed
- Quick Statistics Section
- Sidebar Navigation

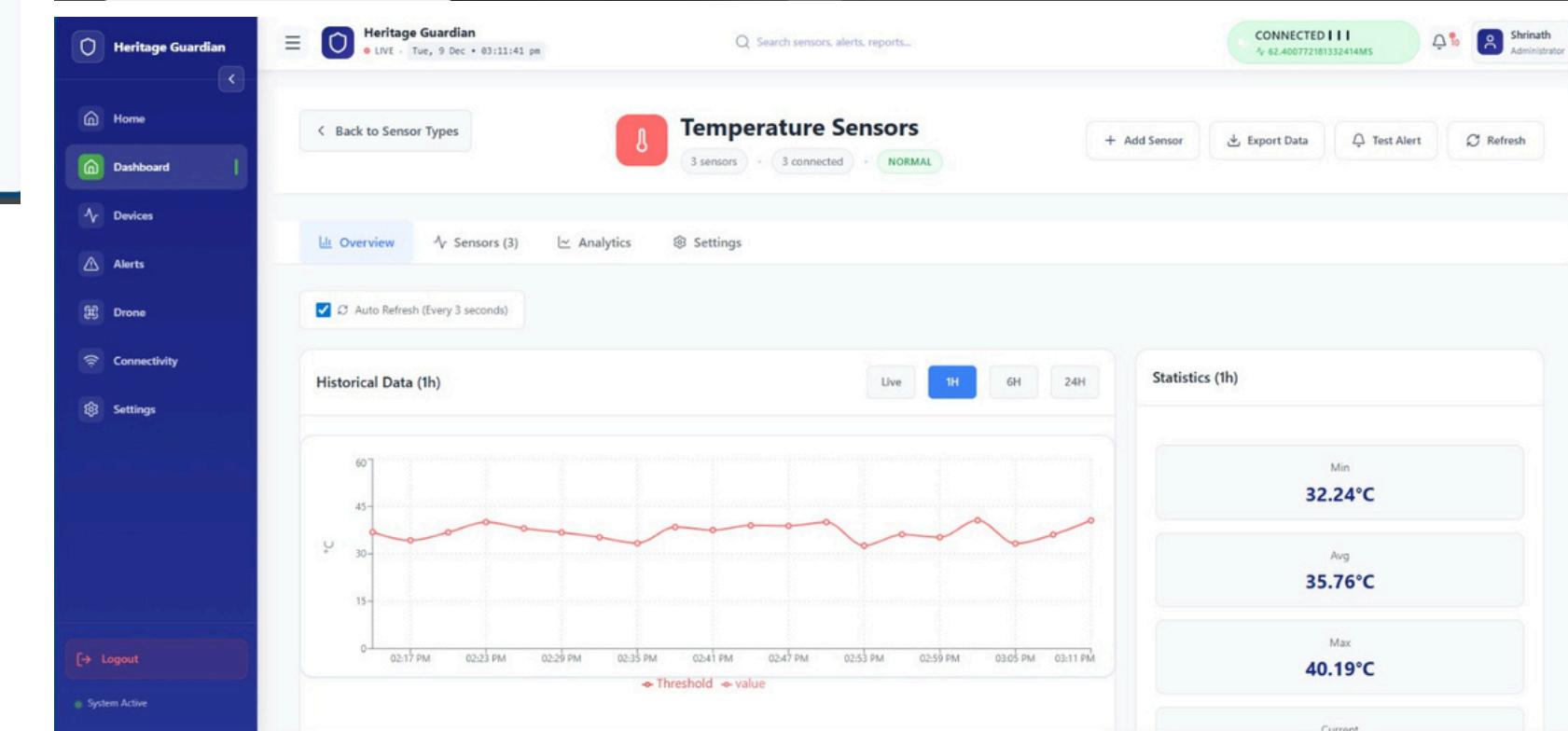
SENSOR DASHBOARD & ANALYTICS INTEGRATION (DAY-2)

A fully functional multi-sensor dashboard and integrating real-time analytics. The platform now provides detailed monitoring for every sensor deployed in the heritage site.



Sensor Monitoring Dashboard

- Displays all connected sensors (temperature, humidity, PM2.5, AQI, etc.)
- Shows active alerts, sensor types, connectivity count
- Added search, refresh, and sensor grouping
- Integrated sensor thresholds (e.g., PM warnings, humidity limits)



DAY-3

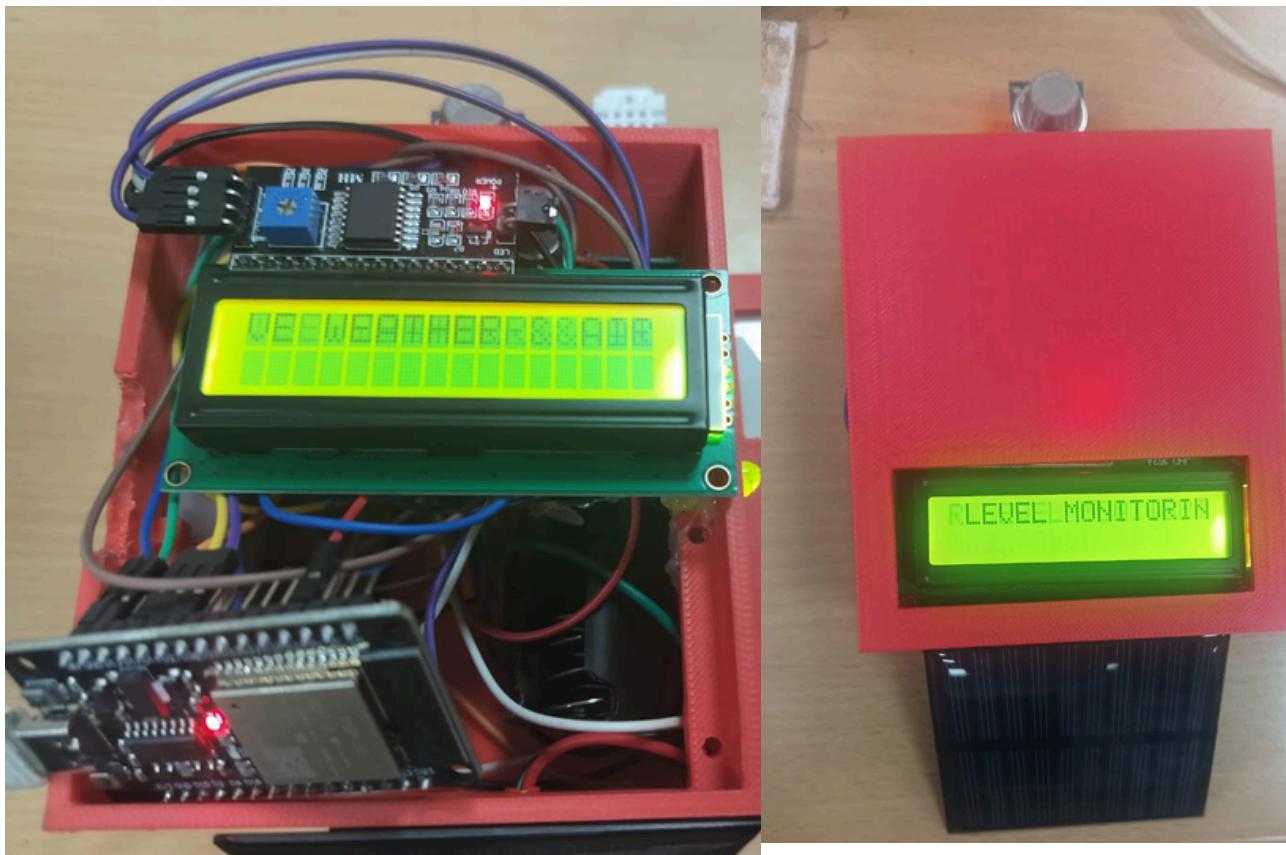
The image displays three separate screenshots of a software application titled "Heritage Guardian".

- Left Screenshot (Device Management):** Shows a dashboard with a search bar for "Search sensors, alerts, reports...", a "CONNECTED" status indicator, and a "Shrinath Administrator" user profile. The main area is titled "Device Management" with the sub-instruction "Manage controllers, sensors, and device configurations". It includes a search bar for "Search controllers...", buttons for "Refresh", "Export Data", and "+ Add Controller", and a checkbox for "Auto Refresh (Every 5 seconds)". Below this are sections for "Controllers" (4 total, 2 online, 1 offline), "All Sensors" (9 total), and "Device Logs" (50 total). A summary box shows "4 CONTROLLERS", "2 ONLINE", and "1 OFFLINE". Below these are cards for "Main Temple Controller" (Main Temple Hall), "Ancient Wall Controller" (Ancient Wall Section), "Storage Room Controller" (Storage Room), and "Roof Controller" (Temple Roof).
- Middle Screenshot (Device Status):** Shows a dashboard with a "CONNECTED" status indicator and a "Shrinath Administrator" user profile. The main area displays four cards for different controllers:
 - Main Temple Controller:** IP 192.168.1.101, Last Seen 2 minutes ago, Battery 85%, Signal 92%.
 - Ancient Wall Controller:** IP 192.168.1.110, Last Seen Just now, Battery 95%, Signal 88%.
 - Storage Room Controller:** IP 192.168.1.103, Last Seen 3 minutes ago, Battery 90%, Signal 45%.
 - Roof Controller:** IP 192.168.1.109, Last Seen 15 minutes ago, Battery 30%, Signal 0%.
- Right Screenshot (Sensors):** Shows a dashboard with a "CONNECTED" status indicator and a "Shrinath Administrator" user profile. The main area displays four cards for different sensors:
 - Main Temple Temp:** 39.43 °C, Falling Threshold: 38°C, Rising Threshold: 40°C, Min: 20°C, Max: 45°C.
 - Wall Vibration:** 0.13 g, Falling Threshold: 0.15g, Rising Threshold: 0.15g, Min: 0g, Max: 1g.
 - Storage Temp:** 26.22 °C, Falling Threshold: 30°C, Rising Threshold: 40°C, Min: 15°C, Max: 40°C.
 - Roof Rainfall:** 0 mm, Stable Threshold: 20mm, Min: 0mm, Max: 50mm.

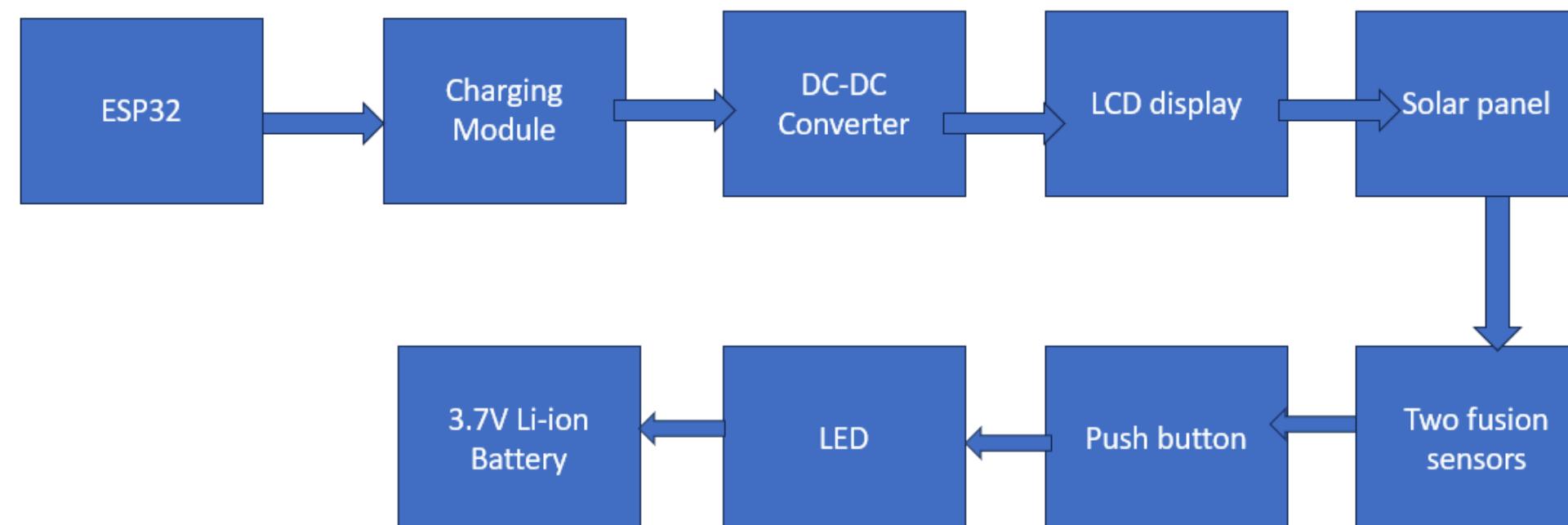
Provides a complete overview of all connected devices, allowing easy management, configuration, and status checks.

Provides a complete overview of all connected devices, allowing easy management, configuration, and status checks.

DAY 4 – System-Level Integration & Live Monitoring



Components in the Module enclosure



DAY - 5 FINAL DEMONSTRATION



Aerial Inspection Layer – Drone-Based Visual Monitoring

Second layer uses a custom-built quadcopter to perform periodic aerial inspection of heritage structures. This helps us capture angles and areas that ground sensors cannot reach — especially elevated surfaces, roof cracks, wall erosion, and moisture-affected patches.

- ◆ **High-Resolution Visual Monitoring**

Captures structural surfaces for crack patterns, discoloration, and erosion.

- ◆ **Hard-to-Reach Area Inspection**

Ideal for temple upper domes, wall carvings, roof edges, and inaccessible stone joints.

- ◆ **Periodic Time-Series Comparison**

Drone images/videos are compared over time to track structural deterioration.

- ◆ **Safe & Non-Intrusive**

No physical contact with the monument — protects fragile structures.

- ◆ **Integrated With Dashboard**

Drone captures are uploaded to our cloud dashboard for:

- Surface condition maps

- Before/After comparisons

- Alert generation



Equivalent Professional Sensors & Deployment Plan

Parameter	Industry Sensor Type	Typical Use	Notes
Air Quality / Pollutants	Multi-gas AQI units (CO ₂ , VOC, PM)	Tracks harmful gases that accelerate stone decay	Used in environmental monitoring systems globally for heritage & urban sites (renkeer.com)
Humidity & Temperature	Weather-proof temp/humidity sensor	Controls micro-climate affecting salts, fungi growth	Standard in cultural sites & museums (renkeer.com)
Vibration / Structural Motion	MEMS accelerometers / vibration sensors	Detects dynamic excitation due to crowd or traffic	Common in structural health monitoring (SHM) of buildings (ResearchGate)
Moisture / Water Infiltration	TDR soil moisture probes / water level stations	Detects seepage and rising damp near foundations	Part of environmental monitoring stations (codasensor.com)
Light / UV Exposure	Calibrated light & UV sensors	Measures harmful radiation affecting surface materials	Used to assess light exposure risks (codasensor.com)

ESTIMATED COST (INDUSTRY SENSOR VERSION)

INDUSTRY SENSORS (APPROXIMATE MARKET PRICES):

Component	Est. Cost (₹)	Notes
Multi-gas air quality sensor	₹8,000 – ₹20,000	Depending on pollutant range & calibration
Weather-proof temp/humidity sensor	₹4,000 – ₹10,000	Outdoor ruggedity
MEMS Vibration sensor	₹3,000 – ₹8,000	Multi-axis for dynamic analysis
TDR soil moisture probe	₹6,000 – ₹12,000	Longer life, accurate moisture data
Calibrated light + UV sensor	₹5,000 – ₹12,000	Measures lux + UV index
Communication & processing node	₹5,000 – ₹12,000	Industrial IoT gateway or controller
Power & enclosure	₹3,000 – ₹8,000	Weatherproof, solar optional

◆ *Industry-ready module cost per sensor node: ₹15,000 – ₹40,000+*

FEASIBILITY AND VIABILITY

Over 50 ASI monuments reported missing (Indiatimes, 2023) shows risk of poor data accuracy & authenticity."

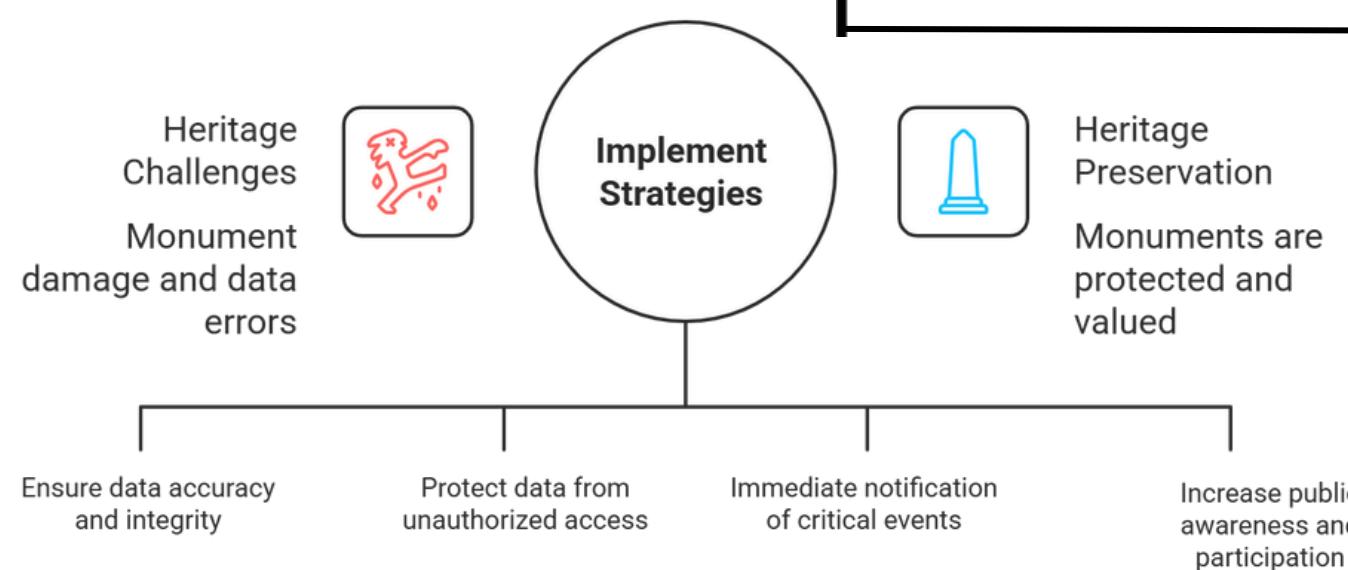
Potential Risk & Challenges

- ⚠ System risks → Sensor failure, power loss, hardware wear
- 📡 Network risks → Signal drops, slow data transfer, interference
- 🚁 Drone limits → Short battery life, weather impact, restricted zones
- 🌧 Environmental risks → Rain, heat, dust, and corrosion damage
- 🏛️ Site risks → Limited access, strict rules, installation challenges

"Project Heritage Guardian is not just feasible, but scalable, secure, and future-ready for protecting India's cultural legacy."

Feasibility Analysis

- ⚙️ Technology – IoT sensors, drone imaging, cloud storage → scalable, real-time monitoring
- 📊 Operations – Simple dashboards for easy site management and reporting
- 🏛️ Market – Heritage sites, museums, research institutes; growing interest in digital preservation
- 💰 Finance – Low infrastructure cost; cloud-based, minimal maintenance



Strategies to Overcome

- ✅ System stability → Regular sensor checks, backup power supply
- 📡 Network reliability → Signal boosters, offline data logging
- 🚁 Drone efficiency → Planned flight paths, spare batteries
- 🌧 Weather protection → Waterproof casing, dust protection layers
- 🏛️ Site coordination → Prior permissions, proper installation planning

Potential Impact

- **Preservation** – Safeguards heritage for future generations.
- **Accessibility** – Makes artifacts available for education, research.
- **Protection** – Reduces risk of physical damage.
- **Policy** – Supports informed heritage conservation decisions.

Benefits of the Solution

- **Monitoring** – Tracks heritage sites with real-time alerts..
- **Documentation** – Automates records for research and restoration.
- **Efficiency** – Reduces costs and manual maintenance efforts.
- **Engagement** – Boosts public awareness and community participation.

“Protecting heritage today is an investment in identity, culture, and knowledge for tomorrow.”

Why this is novel?

- *Manual inspections* → **Real-time monitoring**
- *Single-parameter systems* → **Multi-sensor module**
- *No on-site alerts* → **LCD + LED instant indication**
- *High deployment cost* → **Low-cost modular design**
- *No visual evidence* → **Drone-assisted documentation**
- *Scattered data* → **Unified cloud dashboard**

SCALABILITY

- Plug-and-play modules — easy to add more
- Covers entire monuments
- aLoRa/WiFi = long-range deployment
- Low cost = nationwide scaling

USER EXPERIENCE and AESTHETIC EXPERIENCE

✓ Simple to Use

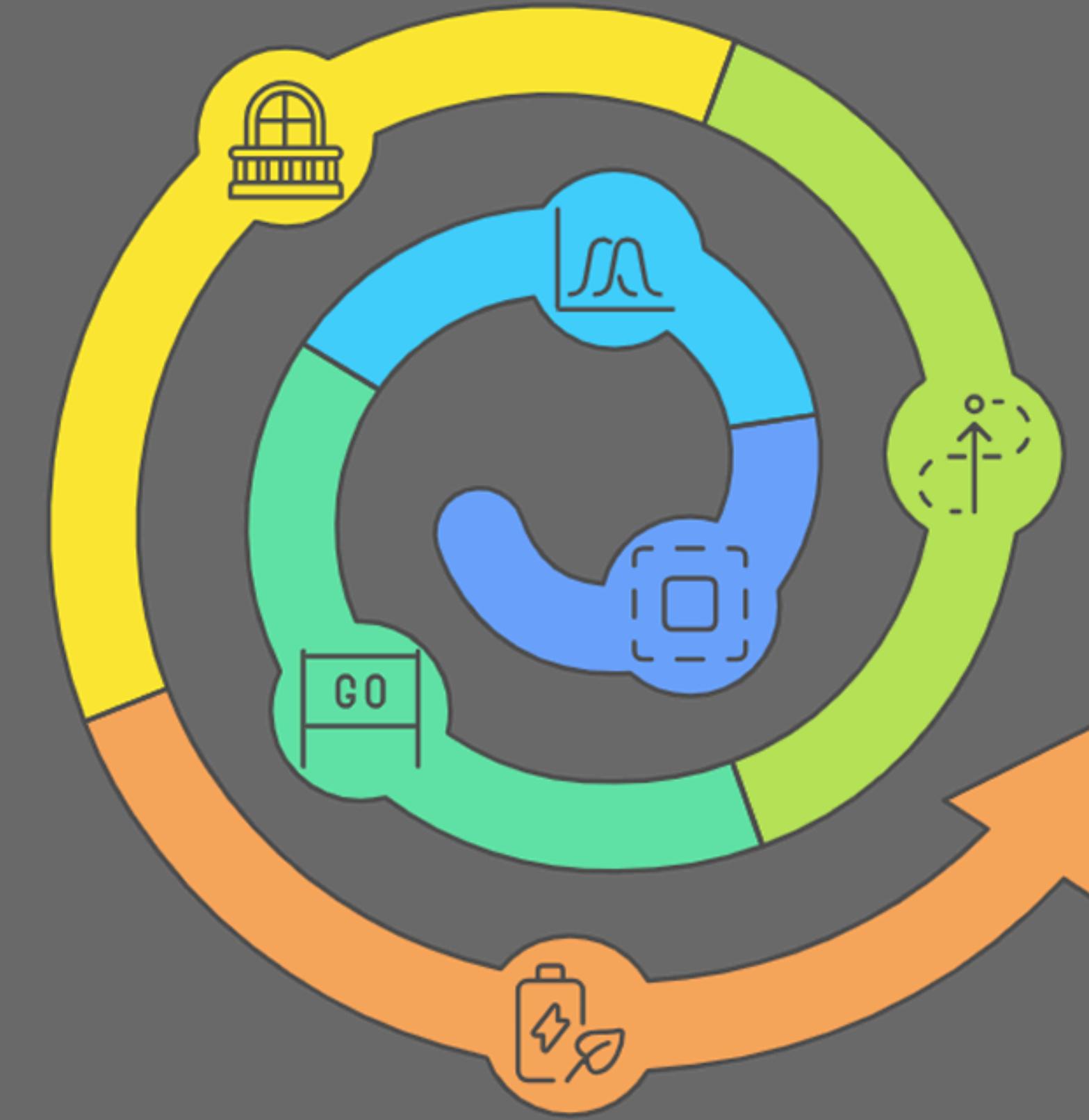
- Clear LCD readings
- LED alerts for instant understanding
- Easy, clean dashboard interface

✓ Aesthetic & Non-Intrusive

- Compact, neat module design
- Minimal wiring & tidy enclosure
- Blends with heritage environment without visual disturbance

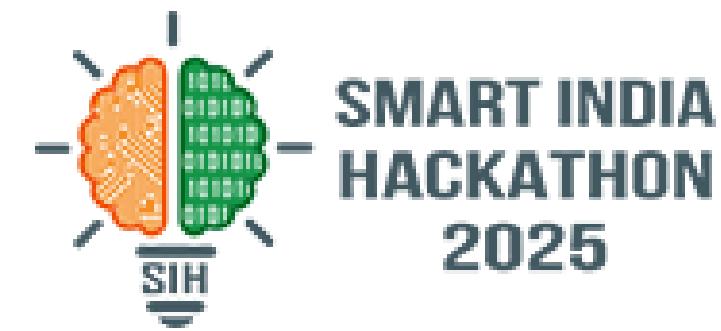
FUTURE ROADMAP

Heritage Site Monitoring System Roadmap



- 01 Scaling to New Sites
- 02 Advanced Analytics and Integration
- 03 Community and Visitor Engagement
- 04 Global Expansion
- 05 Diversified Use Case
- 06 Sustainability and Automation

RESEARCH AND REFERENCES



◆ **ACADEMIC PAPERS & JOURNALS**

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<https://www.mdpi.com/1424-8220/20/23/6558>

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<https://doi.org/10.1016/j.culher.2022.06.015>

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◆ **ARTICLES & TRUSTED SOURCES**

- UNESCO - Digital Innovation for Heritage Preservation, 2023.

<https://www.unesco.org/en/digital-heritage>

- World Economic Forum - How AI and IoT Can Safeguard Cultural Heritage, 2022.

<https://www.weforum.org/agenda/2022/07/ai-iot-protect-heritage>