Problem Definition & Design Thinking

TITLE: AI-EBPL Structural Health Monitoring

Problem Statement:

Aging and deteriorating infrastructure poses significant safety hazards. Traditional methods of structural monitoring are time-consuming, costly, and often reactive rather than preventive. With the rise in urban development and infrastructure load, there's a critical need for a real-time, intelligent solution that can assess and predict the health of structures to prevent catastrophic failures.

Target Audience:

- Civil and structural engineers
- Government infrastructure departments
- Maintenance teams for bridges, buildings, and industrial facilities
- Urban planners and smart city developers

Objectives:

- Develop an AI-powered system to monitor structural integrity in real time
- Use sensor data to predict possible structural failures
- Provide actionable insights to engineers and maintenance teams
- Enhance public safety through early warning systems

Design Thinking Approach

Empathize:

Stakeholders such as engineers and city planners are burdened by inefficient monitoring systems. They need reliable, real-time data to ensure public safety and minimize maintenance costs.

Key User Concerns:

- Accuracy of AI predictions

- Durability and reliability of sensor hardware
- Cost-effectiveness and ease of integration
- Real-time data accessibility and visualization

Define:

The system must be capable of detecting structural changes or stress patterns that indicate deterioration or potential failure. It should collect data from multiple sensors, analyze it using AI, and deliver clear, actionable insights through an intuitive interface.

Key Features Required:

- Wireless sensor network for strain, vibration, and temperature
- Real-time data analytics and anomaly detection
- AI model trained on structural data
- Cloud-based storage and dashboard access
- Alerting system for critical thresholds

Ideate:

Some potential ideas for this solution include: - A sensor-based system that monitors structures for cracks, stress, and vibrations - A mobile or web application that shows real-time structural health status - AI algorithms to predict future structural failures based on collected data

Brainstorming Results:

- Embedded IoT sensors in critical structural points
- AI algorithms to learn normal vs abnormal patterns
- Solar-powered modules for energy independence
- Mobile app/dashboard for engineers
- Data fusion from different types of sensors

Prototype:

Developing a basic monitoring system where:

- Sensors collect data on structural parameters
- An AI model processes this data to detect anomalies
- A dashboard displays the current health status and alerts users

Key Components of Prototype:

- ESP32 microcontroller with sensor modules (strain gauge, accelerometer)
- LoRa/Wi-Fi for data transmission
- Cloud platform for AI model and storage
- User interface displaying structural metrics, alerts, and predictions

Test:

The prototype will be tested by engineers and infrastructure teams on real or simulated structures.

Testing Goals:

- Validate accuracy of sensor readings in real conditions
- Measure the precision of AI anomaly detection
- Test system performance in varied environmental conditions
- Collect user feedback on dashboard usability
- Ensure reliable data transmission over long distances