Problem Definition & Design Thinking

Title: Structural Health monitoring System

Using IoT and Sensor Networks

Problem Statement:

Traditional structural inspections are time-consuming, costly, and sometimes miss early signs of damage. A continuous and automated SHM system is required to enhance safety and reduce maintenance costs

Target Audience:

- **Hospitals:** - To ensure the safety of patients and the seamless operation of these essential spaces, implementing structural health monitoring is crucial
- **Government Agencies:** They often oversee regulations for public health infrastructure and invest in monitoring technologies for compliance and disaster management.
- **Technological Developers and Providers:** Companies that develop monitoring devices, software, and services aimed at improving durability and safety of the healthcare infrastructure

Objective:

- Identifying cracks, stress points, or weaknesses before they escalate into major problems.
- Providing data-driven insights to prioritize and schedule maintenance activities efficiently reducing unnecessary costs.
- Reducing expenses associated with emergency repairs or replacement by addressing issues in their early stages
- Regular monitoring helps prevent degradation and ensures buildings and structures remain functional for longer periods.

Design Thinking Approach:

Empathize:

Relying on human inspectors requires significant time and effort, especially for large or complex structures. Inspectors may face difficulties accessing certain areas, such as high-rise buildings or confined spaces. Results can vary based on the skill and experience of the inspectors, leading to potential oversights.

Key User Concerns:

- Safety and reliability
- Cost efficient
- Real-Time Monitoring and Alerts
- Maintenance and Support

Define:

Use sensors like accelerometers, strain gauges, vibration sensors, and temperature sensors placed strategically on the structure. Wireless sensor networks (WSNs) will transmit the data to a central server. Use platforms like Thing Speak, Blynk, or Firebase to view real-time structural data. Trigger alerts if data crosses pre-set safety thresholds. Basic data analytics to identify unusual strain displacement, or vibrations.

Key Features Required:

- Sensors and IoT devices gather continuous data on structural integrity, such as stress, strain, vibrations, and temperature changes.
- AI and machine learning algorithms analyze data to detect patterns, anomalies, and potential failure points.
- Instant alerts for critical issues, such as cracks or material fatigue, sent via email, SMS, or mobile apps.

Ideate:

Some potential ideas for this solution include:

- Use advanced machine learning algorithms to predict structural weaknesses or failures based on patterns in collected data, enabling pre-emptive action.
- Develop energy-efficient or self-powered sensors (e.g., solar or piezoelectric) that can operate without frequent maintenance, reducing operational costs.
- Equip systems with features to account for climate-specific challenges, such as high humidity, extreme heat, or freezing temperatures, enhancing their resilience.

Brainstorming Results:

- Develop machine learning models that predict structural failures based on historical data environmental conditions, and material properties
- Design monitoring systems that cater specifically to regions prone to unique environmental conditions like earthquakes, floods, or extreme humidity.
- Offer intuitive dashboards that allow users to configure alert thresholds and prioritize monitoring areas.
- Create low-power devices that rely on renewable energy sources for long-term sustainability.

Prototype:

- Sensors: Use strain gauges, accelerometers, and temperature sensors to collect data.
- Connectivity: Deploy IoT devices with wireless communication (e.g., Wi-Fi).
- AI Analytics: Integrate machine learning to detect anomalies and predict failures. Dashboard:
- Create a user-friendly interface for data visualization and alerts.
- Testing: Test the prototype on a small building section. Alerts: Set up real-time notifications for critical issues.

Key Components of Prototype:

- Sensors: Strain gauges, accelerometers, temperature, and crack detection sensors.
- Processing Unit: Microcontrollers (e.g., Arduino) for data handling.
- Power Source: Renewable energy or long-lasting batteries.
- Data Storage: Cloud or blockchain for secure records.

Test:

The prototype will be tested by a focus group consisting of the target audience They will interact with the AI features and other key features of the prototype, and their feedback will be gathered to improve the system.

Testing Goals:

- Accuracy: Ensure sensors provide precise and reliable data about structural health parameters.
- Real-Time Functionality: Verify the system delivers data and alerts without delays.
- Integration: Test compatibility with other building systems (e.g., HVAC, security).
- Energy Efficiency: Measure the power consumption of sensors and devices.