AI-Enabled Smart Sensor Deployment & Damage Detection System for Post-Disaster Management

1. Problem Motivation

Natural disasters such as floods, earthquakes, and cyclones result in severe damage to infrastructure and human life. Rescue teams require fast and accurate information for decision-making. In real scenarios:

- Sensors are limited in number
- Random and inefficient placement
- Some critical areas remain unmonitored
- Overlapping coverage causes resource wastage

Therefore, an intelligent system is needed to ensure optimal monitoring with minimal resources.

2. Core Idea

This project introduces an **AI-based approach** to deploy and adjust sensors intelligently based on:

- Damage severity
- Population vulnerability
- Accessibility and risk levels

The system continuously updates itself as the disaster spreads, ensuring **real-time monitoring**.

3. Step-by-Step Technical Workflow

Step 1: Area Grid Division

The affected area is divided into equal-sized grid segments. Each segment stores risk-related information such as population density and infrastructure status.

Step 2: Hotspot Detection using K-Means Clustering

K-Means identifies clusters with the highest damage severity. Sensors are deployed at the **cluster centers** to cover the most critical zones.

Step 3: Sensor Range Optimization

The sensing radius is dynamically optimized to:

- Avoid redundant overlap
- Reduce blind spots
- Maximize monitored area

Step 4: Coverage Simulation

Performance is validated using coverage percentage and blind region analysis. Positions are adjusted if any regions remain unmonitored.

4. Vision-Based Damage Assessment

Satellite/drone images captured before and after the disaster are compared using AI-based image processing. The model automatically detects:

- Collapsed structures
- Blocked road networks
- Environmental hazards

A **Damage Severity Score (0–100%)** is generated for each region. Sensors are prioritized toward areas with higher scores.

Region	Buildings Before	Buildings After	Damage Score
A	150	90	60% (High)
B	120	115	4% (Low)

5. Novel Research Contribution

A. Dynamic Sensor Repositioning

Sensors dynamically shift toward newly identified high-risk zones detected by drones.

B. Proposed Priority Score Model

The following formula determines sensor deployment priority:

$$\text{Priority} = 0.5 \cdot \text{DamageScore} + 0.3 \cdot \text{PopulationRisk} + 0.2 \cdot \text{RoadBlockScore}$$

Higher priority regions receive immediate monitoring.

C. Intelligent Self-Updating Network

Continuous feedback loop ensures adaptiveness:

- Drone image updates
- Risk map regeneration
- Clustering update
- Sensor reallocation

6. Complete System Flow

Workflow:

`Disaster occurs → Image data collected → Damage detection → Risk mapping → Sensor clustering → Coverage optimization → Live monitoring → Dynamic repositioning if new risk appears`

Ensures uninterrupted situational awareness during relief operations.

7. Real-World Example

In an earthquake-affected urban area:

- Hospital collapses (High severity zone)
- Major road blocked (Medium severity zone)
- Playground unaffected (Low severity zone)

Sensors automatically reposition toward hospitals and critical infrastructures, improving rescue support.

8. Expected Research Results

- Blind spot reduction: 40–60% improvement
- Resource utilization efficiency: +50%
- Damage detection accuracy: 85–95%
- Faster response time: 30–45% improvement

9. Conclusion

This AI-enabled system improves disaster surveillance efficiency while minimizing cost and sensor requirements. It enables rescue teams to respond faster, cover larger areas, and access critical information in real time. The solution is practical, intelligent, and highly significant for post-disaster management.