

Voice of the Street: Integrated Smart City Infrastructure Monitoring and Reporting System (ISCIMRS)

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Abstract - Maintaining urban infrastructure presents ongoing difficulties for contemporary metropolitan areas, as conventional oversight methods frequently lack real-time problem identification capabilities. This research introduces Voice of the Street, a community-focused mobile platform enabling city dwellers to contribute actively to infrastructure oversight through photographic documentation of concerns including malfunctioning street illumination, roadway damage, deteriorated walkways, and additional municipal challenges. The platform combines location-based mapping with community-sourced information gathering to establish a dynamic comprehensive record of urban infrastructure status. Our methodology incorporates GPS positioning for accurate location identification and implements alert mechanisms that immediately notify appropriate city departments. The platform operates on contemporary technological infrastructure featuring Node.js server architecture paired with Supabase database management (PostgreSQL foundation), guaranteeing expandability and instantaneous information updating. Initial evaluation involving 300 participant users distributed across two municipal zones revealed a 67% enhancement in issue recognition and decreased resolution duration from 11 days to 4.2 days, confirming that community-powered documentation substantially enhances municipal effectiveness and establishes clear responsibility frameworks connecting residents with governmental services.

Keywords: metropolitan infrastructure, community participation, collective data gathering, smartphone platform, instantaneous documentation

1. Introduction

Metropolitan inhabitants regularly encounter infrastructure deficiencies including malfunctioning street illumination, dangerous pavement deterioration, and damaged walkways that jeopardize safety and reduce quality of life. Although residents are frequently the first to observe these issues, notifying municipal authorities remains challenging. Traditional reporting methods involving phone calls, online forms, or in-person visits create barriers discouraging citizen participation, leaving many problems unreported until they become serious hazards. Modern urban development extends beyond installing sensors and surveillance systems—it requires empowering citizens to actively contribute to city management. Despite residents possessing superior neighbourhood knowledge compared to automated systems, most cities lack simple, effective reporting mechanisms. This disconnect leaves valuable information

unshared and infrastructure problems unresolved for extended periods.

"Voice of the Street" was developed to bridge this gap. Our mobile application streamlines infrastructure reporting through simple photograph capture. The system automatically records GPS coordinates and timestamps, then transmits reports directly to relevant departments. Built on Node.js and Supabase, it creates dynamic city-wide infrastructure condition maps, helping authorities prioritize repairs and allocate resources efficiently. Users simply photograph issues, select categories, and submit—the system handles routing, tracking, and notification automatically, creating accountability between residents and government while encouraging continued participation..

2. Literature Review

2.1 Advanced Detection Technologies

Contemporary investigations demonstrate that machine learning frameworks, specifically YOLO variants and convolutional networks, successfully identify infrastructure deficiencies through camera imagery. An extensive examination of 95 investigations (2015-2024) documented YOLOv8 reaching complete accuracy on standardized datasets. These frameworks balance identification velocity and precision for real-time implementations. However, such systems generally demand specialized apparatus and technical proficiency, constraining widespread public utilization.

2.2 Smart City Citizen Participation

Effective metropolitan initiatives merge resident input platforms with technical infrastructure. European municipalities prioritize democratic engagement through mobile applications, with all evaluated cities providing electronic participation capabilities. South Korea's nationwide initiative exemplifies extensive integration by merging telecommunications infrastructure with reporting applications throughout six operational categories. Despite effectiveness, these comprehensive systems require considerable financial commitment and intricate coordination, potentially restricting implementation in resource-limited settings.

2.3 Mobile and IoT-Based Monitoring

Infrastructure oversight methodologies differ in sophistication and availability. Investigations indicate vibration-detection systems utilizing connected sensors reach 80-90% identification accuracy for roadway damage. Mobile alternatives provide

superior availability but encounter difficulties with user engagement variability. Camera-equipped smartphone approaches deliver dependable evaluation while maintaining citizen accessibility, though they introduce privacy and computational considerations.

2.4 Geospatial Systems for Urban Management

Successful infrastructure administration necessitates spatial information organization. Grid-based positioning systems facilitate rapid information retrieval and representation. Merging spatial and chronological information aids understanding of infrastructure degradation sequences, enabling anticipatory maintenance where authorities can predict failures preceding occurrence.

Infrastructure Monitoring Approaches Comparison

Method	Accuracy	Real-time	Accessibility	Cost
Manual Inspection	High	Low	N/A	High
Laser Scanning	Very High	Medium	Low	Very High
Machine Vision	High (95–100%)	High	Low	High
Vibration Sensors	Medium (80–90%)	Very High	Low	Medium
Our System	User-driven	High	Very High	Low

3. PROPOSED SYSTEM ARCHITECTURE



3.1 System Overview

Voice of the Street functions through three interconnected operational tiers. The resident interface tier manages information collection through an accessible mobile application.

The server processing tier administers information storage, identity verification, and instantaneous synchronization employing Node.js and Supabase technologies. The municipal coordination tier supplies administrative tools for concern management and resolution. Our architectural approach emphasizes availability and expandability, guaranteeing infrastructure dependability regardless of participant technical capabilities, network conditions, or documentation volume.

3.2 Mobile Application Interface

Our mobile platform emphasizes operational simplicity. Participants photograph concerns, triggering automatic GPS position recording, temporal stamping, and equipment identification. Users designate from established classifications (roadway damage, illumination failures, walkway deterioration, drainage concerns) and optionally supplement brief explanations.

The platform displays participants' historical submissions and present status—awaiting review, designated, undergoing resolution, or completed. Upon authorities designating problems resolved, reporters obtain alerts featuring comparative imagery. Throughout evaluation, 67% of participants receiving completion notifications submitted supplementary reports compared to 31% without resolution visibility. Participants control identity disclosure to authorities or maintain anonymous submission.

3.3 Backend Architecture

Our server infrastructure operates on Node.js for rapid and expandable management of API requests, identity verification, and operational procedures. Supabase functions as our principal database platform, delivering:

- Instantaneous capabilities: Database modifications immediately synchronize throughout all connected clients
- Integrated authentication: Manages participant registration, access, and session administration securely
- Row-level security: Guarantees participants access exclusively their submissions while administrators maintain elevated authorizations
- PostGIS extension: Manages geographic inquiries and spatial calculations efficiently
- Storage repositories: Archives uploaded imagery with automatic distribution network integration

Our database incorporates essential tables for submissions (featuring location, classification, status, imagery), participants, classifications, designations, and status chronology. Database indexing on regularly queried attributes guarantees swift performance despite hundreds of thousands of records.

3.4 Geospatial Intelligence

ISCIMRS utilizes PostgreSQL with PostGIS for location-based capabilities. Each submission preserves precise latitude and longitude coordinates, facilitating efficient inquiries including identifying submissions within specified radius, locating submissions within district perimeters, grouping proximate submissions, and producing frequency heat representations of problem distribution.

The infrastructure automatically identifies appropriate department responsibility for each concern and determines which maintenance personnel operate within that region. When numerous submissions reference identical locations within brief timeframes, spatial grouping recognizes them as potentially identical concerns, preventing redundant work assignments. Heat representations displaying problem frequency assist identifying infrastructure requiring systematic attention, while monitoring response durations reveals workflow inefficiencies.

3.5 Municipal Dashboard

City administrators access documented concerns through web-based dashboard featuring map and catalog perspectives. Color-designated markers specify problem positions, categories, and status. Administrators can allocate submissions to particular teams, modify priority levels, or consolidate duplicates. Field personnel access designated responsibilities through mobile dashboard, examining problem specifications, site navigation, and updating status with completion imagery.

Supabase's instantaneous subscriptions automatically refresh the dashboard upon new submission arrival or status modifications, eliminating manual updating. Analytics display response durations, completion proportions, and problem allocation across classifications and communities, supporting equitable considerations in resource distribution.

4. IMPLEMENTATION AND TECHNICAL DETAILS

4.1 Technology Stack

Frontend:

- React Native (cross-platform iOS & Android compatibility)
- Native camera and GPS modules
- Offline storage with automatic synchronization

Backend:

- Node.js with Express.js for RESTful APIs
- Supabase (PostgreSQL) with PostGIS
- Cloud-hosted with CDN integration

4.2 Key Features

Performance Metrics:

- Image compression: 200–500 KB per photograph
- Query response: <100 ms with 50,000+ records
- Real-time updates: 100–300 ms latency
- Offline capability: 18% reports queued successfully

Security Implementation:

- JWT token authentication
- Rate limiting: 20 reports/hour per user
- TLS 1.3 encryption for all data transmission

5. EXPERIMENTAL RESULTS AND EVALUATION

5.1 System Performance

Load evaluation demonstrated substantial expandability with the infrastructure managing 200 simultaneous uploads while preserving API response durations between 600-950ms. Database inquiries functioned efficiently with proximity investigations completing in 50-150ms and heat representation production in 300-500ms, despite exceeding 50,000 records. Instantaneous updates contacted dashboard clients within 100-300ms.

5.2 User Engagement Study

Initial deployment featuring 300 participants throughout three months displayed substantial user acceptance. Primary discoveries:

- 89% assessed the application "extremely accessible" or "accessible" to operate
- 67% of participants receiving completion alerts submitted supplementary submissions versus 31% without response
- 473 aggregate submissions documented, featuring 312 previously unidentified to authorities

Report Distribution: Roadway damage (38%), Street illumination (24%), Drainage (15%), Walkways (12%), Additional (11%)

5.3 Municipal Impact

The infrastructure substantially enhanced infrastructure administration efficiency. Response durations decreased from 11 days to 4.2 days—a 62% enhancement. Heat representations identified three problem "concentration zones" requiring systematic attention.

6. CHALLENGES AND FUTURE WORK

6.1 Current Challenges

Image Quality Variability: Users occasionally submit blurry photos from moving vehicles or poorly lit conditions. Future versions could implement blur detection and brightness analysis with resubmission prompts.

Category Misclassification: Approximately 15% of reports required reclassification. Solutions include visual guides, location-based suggestions, and user tutorials.

Geographic Coverage Bias: Technology-engaged areas generated 3.2x more reports per capita. Addressing this requires multilingual support, community outreach, and partnerships with local organizations.

6.2 Future Enhancements

Planned improvements include predictive analytics for infrastructure deterioration patterns, augmented reality features showing existing reports at locations, gamification with recognition badges and leaderboards, and emergency service integration for critical failures.

7. Conclusion

Voice of the Street demonstrates that effective urban infrastructure monitoring doesn't require expensive sensors or complex deployments. By providing citizens with simple smartphone reporting tools, cities can leverage distributed observer networks. Our pilot with 300 users identified 312 previously unknown problems and reduced response times from 11 to 4.2 days—a 62% improvement.

Built on Node.js and Supabase, the system provides scalable infrastructure with real-time synchronization and geospatial analysis. At \$280 monthly operational cost, it's financially viable for resource-constrained municipalities. With 89% user satisfaction and proven impact, the system offers a replicable model for cities worldwide. Future enhancements including predictive analytics and AR features will further transform urban infrastructure management.

8. Acknowledgment

We convey appreciation to municipal departments that engaged in our initial evaluation program and supplied beneficial response on infrastructure functionality. Particular recognition to the 300 participant users whose dedicated engagement assisted us in refining the application and confirming its effectiveness. We recognize the open-source computer vision community whose resources and pre-trained frameworks expedited our development substantially. We additionally acknowledge our project supervisor and the academic personnel of Sinhgad Academy of Engineering for their continuous assistance and direction throughout this investigation.

9. References

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