SpotNFix: Smart Pothole Reporting & Severity Detection System

Submitted in partial fulfilment of the requirements of the degree of

BACHELOR OF ENGINEERING

by

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(2025-2026)

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CERTIFICATE

This is to certify that the project entitled **“SpotNFix: Smart Pothole Reporting & Severity Detection System”** is a bonafide work of **Aditya Sawant (22106084), Jay Yadav (23206007), Pranal Vernekar (23206008), Manas Jagtap (23206011)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of **Bachelor of Engineering** in **Computer Science & Engineering (Artificial Intelligence & Machine Learning).**

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Project Report Approval for B.E.

This project report entitled ***"SpotNFix: Smart Pothole Reporting & Severity Detection System"*** by ***"Dr. Rahul Ambekar"*** is approved for the degree of ***Bachelor of Engineering*** in ***Computer Science & Engineering (Artificial Intelligence & Machine Learning), 2025-26***.

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Date:

Place:

Declaration

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Potholes are one of the most common issues in road infrastructure, causing accidents, traffic delays, and vehicle damage. Existing reporting methods are mostly manual and inefficient, as they lack automated verification, severity assessment, and accountability in the repair process. To overcome these challenges, this project presents SpotNFix: Smart Pothole Reporting & Severity Detection System, a web-based platform that uses Artificial Intelligence (AI), Machine Learning (ML), and geolocation services to automate pothole reporting and management. In this system, users can capture and upload pothole images through the web application, where the location is automatically fetched. A trained ML model then verifies whether the image contains a real pothole and classifies its severity. Verified potholes are listed on the platform, prioritized by severity, and made available for government authorities and contractors. Repair work is assigned through a transparent bidding process, and contractors are held accountable by a warranty mechanism requiring free repair if the pothole reappears within a year. This solution ensures efficiency, transparency, and cost-effectiveness while supporting safer and smarter urban infrastructure.

UN SDG #9: Industry, Innovation and Infrastructure

UN SDG #11: Sustainable Cities and Communities

Keywords: Pothole Detection, Machine Learning, Smart City, Sustainable Infrastructure, Road Safety, Geolocation, Web Application, Urban Innovation, UN SDG, SpotNFix

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Introduction

Road infrastructure plays a crucial role in the overall growth, connectivity, and economic development of any country. Well-maintained roads not only ensure smooth transportation but also contribute to trade efficiency, public safety, and reduced fuel consumption. However, a persistent challenge faced by almost all urban and rural regions is the occurrence of potholes—depressions or cavities on road surfaces caused by factors such as waterlogging, heavy traffic, temperature variation, and poor construction quality. Over time, these potholes worsen due to continuous vehicle movement and neglect, posing serious risks to commuters. They can cause vehicle damage, traffic congestion, and, more critically, road accidents that endanger human lives.

Traditionally, the process of pothole identification and reporting has been largely manual and inefficient. Citizens report damaged roads through helplines, email complaints, or municipal web portals. While these channels are well-intentioned, they often suffer from several limitations—complaints may be vague, lack photographic evidence, contain inaccurate locations, or remain unverified for long periods. Moreover, due to the absence of an integrated system for tracking, prioritization, and feedback, authorities often struggle to manage a large number of reports efficiently. This leads to delays in repair work, repeated complaints, and a lack of accountability from contractors and civic authorities. The absence of automation and data-driven prioritization further reduces transparency in the overall repair workflow.

To address these limitations, this project introduces SpotNFix: Smart Pothole Reporting & Severity Detection System, an AI-driven solution that automates the process of pothole reporting, verification, and repair management. The system combines Artificial Intelligence (AI), Machine Learning (ML), and Geolocation Services to create a seamless, transparent platform for all stakeholders—citizens, government authorities, and contractors. Users can simply click and upload a photo of a pothole using the web application. The system automatically captures the geographical location of the image using EXIF-based GPS metadata and validates whether the photo genuinely represents a pothole using a trained YOLOv12 object detection model. Once verified, the Gemini AI service further classifies the pothole based on its severity and type, enabling prioritization of repair tasks.

What sets SpotNFix apart is its integrated workflow between citizens, authorities, and contractors. Verified potholes are displayed in a centralized dashboard accessible to municipal officials, who can either assign a repair task directly or open it for bidding among registered contractors. The contractor quoting the lowest amount is selected for repair work under a contract-based system, ensuring transparency and cost-efficiency. Upon completion, contractors are required to upload proof-of-repair images for verification, and the system allows penalization or rework if the same pothole reappears within a year.

Beyond automation, SpotNFix introduces a data-driven governance model. The system aggregates statistics on reported, verified, and repaired potholes to generate real-time analytics dashboards for monitoring urban infrastructure quality. This promotes accountability, helps optimize resource allocation, and supports decision-making for local governments. In essence, SpotNFix transforms the conventional, reactive process of road maintenance into a proactive, AI-assisted infrastructure management system that ensures transparency, efficiency, and public participation.

Chapter 2

Literature Survey

Year	Title	Domain	Algorithm	Dataset	Gap
2025	A Real-Time Pothole Detection System for Road Damage Detection and Classification — Anchuri Manaswiprasad et al.	Road damage / pothole detection and classification	Custom-trained Deep Neural Network (real-time, from mobile/vehicle cameras)	Custom dataset from road images (size not given).	Earlier studies mostly offline or sensor-based; this work enables real-time detection & classification for faster repair prioritization.
2024	Road Damage Detection and Reporting System Using YOLOv7: Enhancing Public Participation in Infrastructure Maintenance — Nizamiyati et al.	Road dama-ge detection & reporting	YOLOv7 (real-time object detection)	Custom Lampung road damage dataset (images of cracks, potholes with geotags). Size not specified.	Limited dataset diversity, lack of model comparison, and minimal real-world evaluation.
2021	A Modern Pothole Detection Technique using Deep Learning — Chakrapani et al. 2nd International Conference on Data, Engg & applications	Pothole / road surface defect detection	Deep Learning (Faster R-CNN + Inception-V2)	Image / video dataset (not specified in preview).	Missing details on dataset and exact performance; gap in robustness (lighting, conditions).

2021	Severity Estimation of Potholes in Imagery Using Convolutional Neural Networks — Vernon Kok, Nontokozo Mpofu & Micheal Olusanya	Pothole detection & severity estimation	Two-stage deep learning pipeline: 1. Pretrained object detection model (Faster R-CNN with ResNet50 backbone) for ROI extraction 2. CNN models (VGG16, VGG19, ResNet50 bases) for estimating depth (severity). Hyperparameters tuned via Random Search.	Detection: 399 labeled images from web Severity Estimation: Custom dataset (images from Johannesburg with ground-truth depth)	Most existing methods detect potholes but do not estimate their severity/depth from images
2016	Pothole Reporting System --- Eliza-beth Hammell et. al.	Pothole detection / reporting	Prototype sensing system (accele-rometer + Android app, cloud logging). Algorithm not clearly specified.	Sensor data from vehicles (details not prov-ided)	No genera-lization to varied roads, no CV-based detection, limited validation.

Chapter 3

Limitations of Existing Systems

Delayed action – Even after reporting, potholes may take weeks/months to be fixed.

Low accountability – Complaints are sometimes marked “resolved” without actual repair; no stringent measures for pothole resolution.

Poor coverage – Some apps work only in certain cities/states, not nationwide.

No automated ML integration – False pothole reports may get assigned; no automated model to verify authenticity.

Technical glitches – Apps often crash, have GPS/photo upload issues, or don’t send proper updates.

Lack of communication – Weak coordination between citizens, government officials, and contractors; no democratized or gamified feedback feature.

No contractor penalties – Contractors are rarely penalized for poor or temporary repair work.

No bidding system – Lack of transparent bidding among contractors for efficient and cost-effective pothole repair.

No severity-based reward system – Repairs are not prioritized or incentivized based on pothole severity.

No fund crowdsourcing feature – No mechanism for local communities, NGOs, or philanthropists to contribute funds for quicker pothole fixes.

Chapter 4

Problem Statement

Potholes remain a persistent challenge in road infrastructure, leading to increased road accidents, vehicle damage, and traffic congestion. Existing reporting mechanisms rely largely on manual submissions by citizens through helplines, emails, or municipal portals, which are often inefficient, unverified, and prone to duplication. These traditional systems lack automated validation, resulting in false reports and incomplete data that hinder effective decision-making. Furthermore, there is no structured method to assess or prioritize potholes based on severity, causing critical road damages to be neglected while minor issues receive attention. The absence of an integrated digital framework also limits coordination between citizens, government officials, and contractors, leading to poor accountability and delayed repairs. In many cases, repaired potholes reappear within weeks due to substandard work or lack of monitoring, wasting public resources and eroding citizen trust. Therefore, there is a pressing need for a smart, AI-driven pothole management system that can automatically verify reports, detect and classify severity through image analysis, and establish a transparent, trackable workflow for repair and contractor accountability.

Objectives of the Project

The main objective of the SpotNFix: Smart Pothole Reporting and Severity Detection System is to develop an intelligent, automated platform for efficient pothole detection, reporting, and management. The system aims to use Artificial Intelligence (AI) and Machine Learning (ML) techniques to automatically verify whether an uploaded image contains a pothole and classify its severity level for prioritized repair. It seeks to eliminate the inefficiencies of manual reporting by integrating geolocation tracking, AI-based verification, and real-time analytics into a single ecosystem. Another key objective is to build a transparent workflow that connects citizens, government authorities, and contractors, enabling efficient bidding, repair tracking, and accountability. The platform also focuses on promoting data-driven decision-making for urban infrastructure maintenance through detailed dashboards and performance metrics. Overall, the project strives to create a scalable, transparent, and technology-driven solution that enhances road safety, reduces repair delays, and fosters public trust in civic management systems.

Scope of the Projects

The SpotNFix project encompasses the complete lifecycle of pothole detection, verification, and resolution through the integration of AI, ML, and geolocation technologies. The system allows citizens to easily report potholes by uploading images, which are automatically analyzed to confirm authenticity and assess severity using a trained YOLOv12 object detection model and Gemini AI for classification. Verified reports are stored in a centralized database and displayed on an interactive dashboard accessible to government officials and contractors. The platform supports a bidding-based repair mechanism, where contractors can submit bids for verified potholes, and authorities can assign or approve repair work directly. In addition to automation, the system includes analytics dashboards for tracking key performance indicators such as the number of potholes reported, verified, repaired, and reappeared. The scope also extends to community features that enable citizen engagement and transparent communication with authorities. Designed as a **s**calable web-based solution, SpotNFix can be expanded to other civic infrastructure issues such as waste management or streetlight maintenance, making it a versatile and future-ready smart city application.

Chapter 5

Proposed System

Data Flow Diagram:

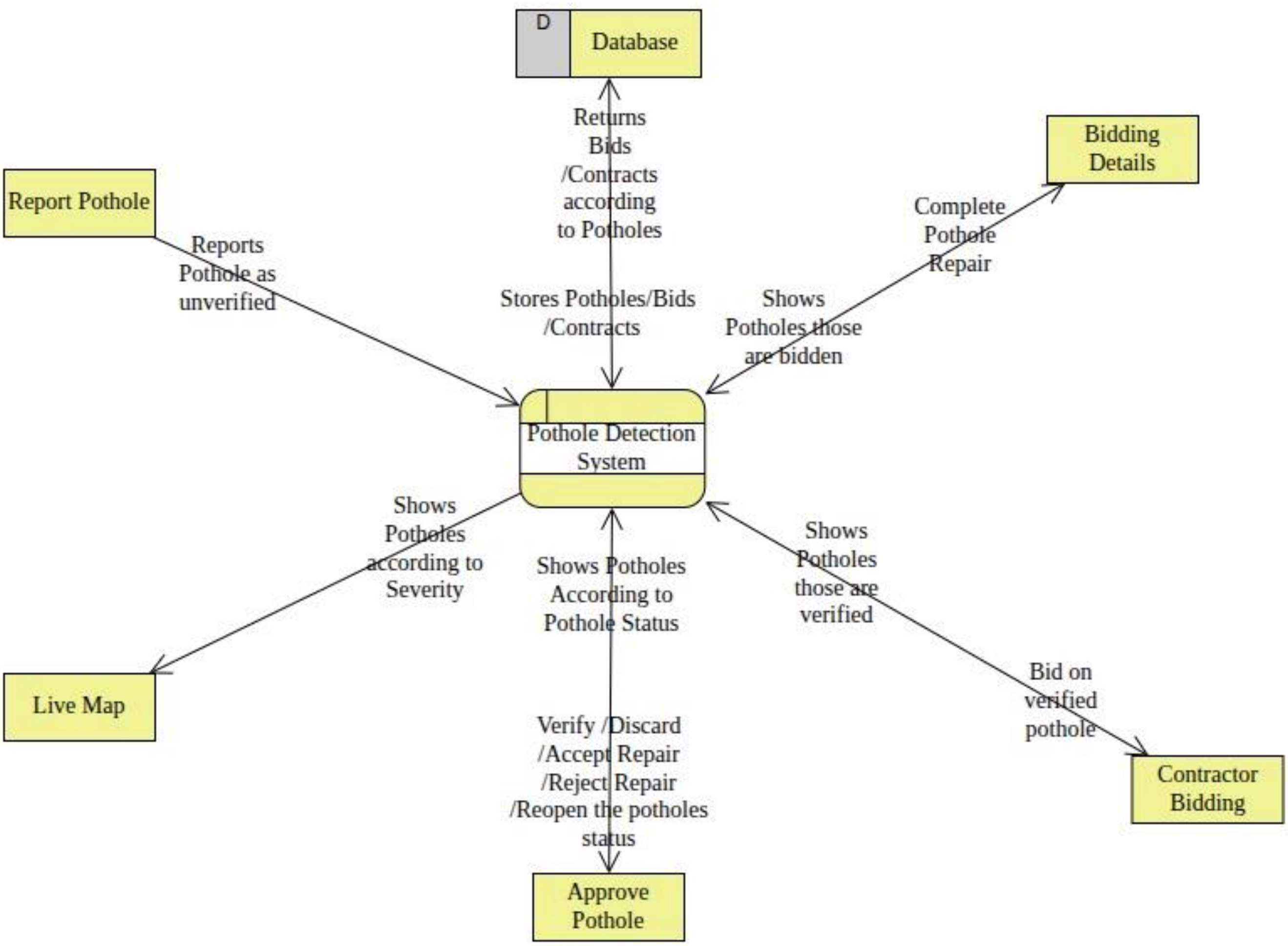


Figure 5.1 DFD Level0

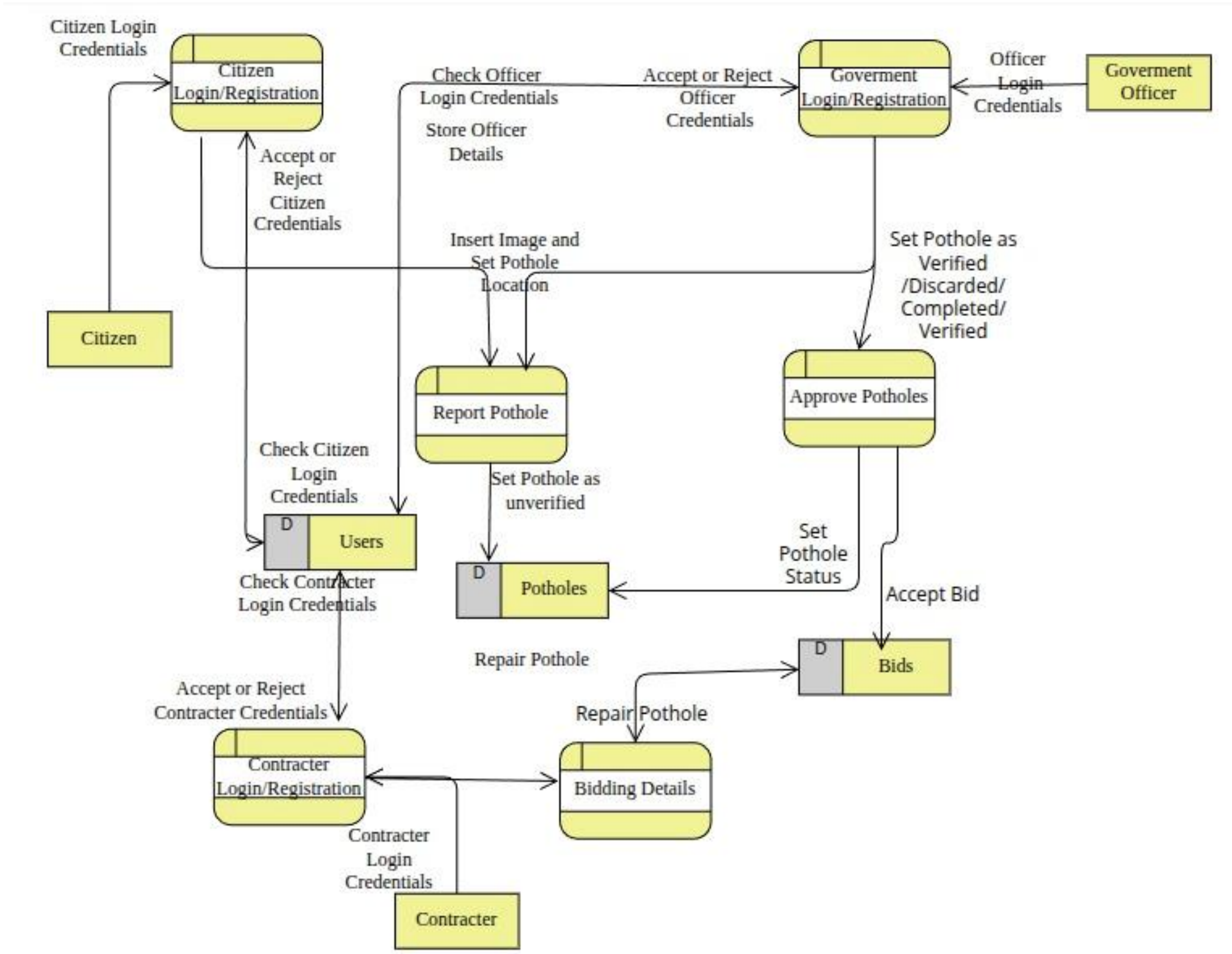


Figure 5.2 DFD level1

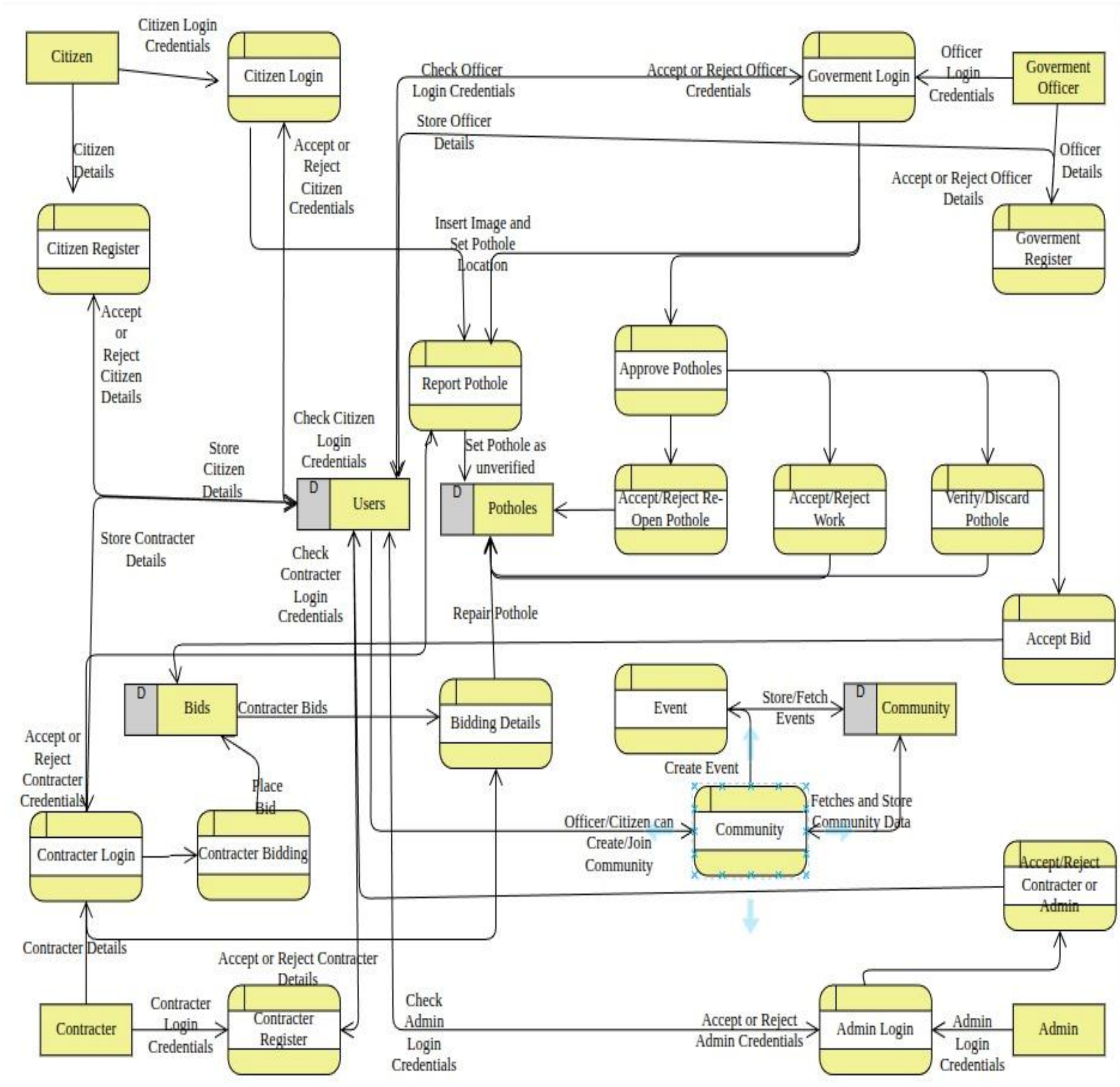


Figure 5.3 DFD Level2

Use Case Diagram:

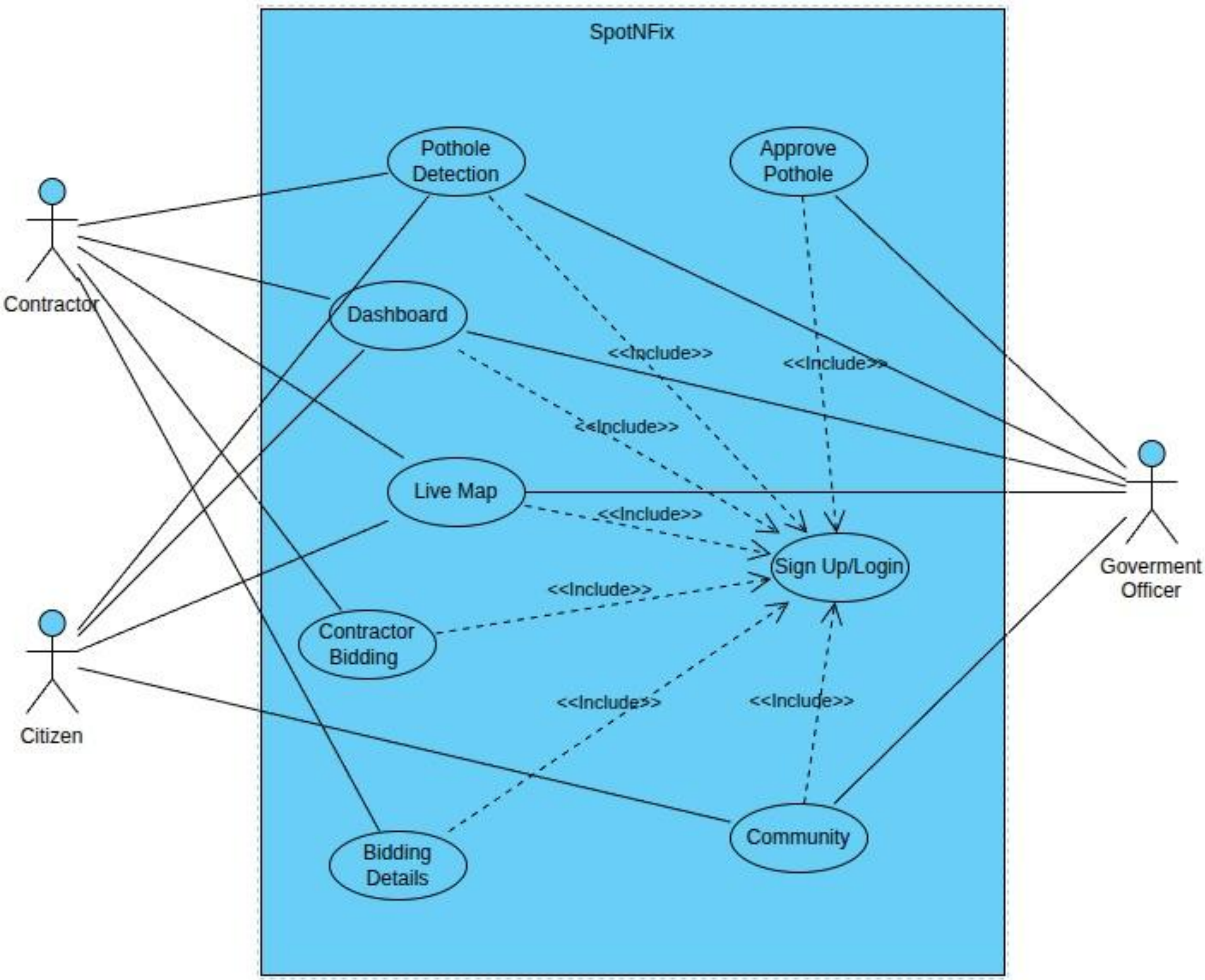


Figure 5.4 Use Case Diagram

System Architecture Diagram:

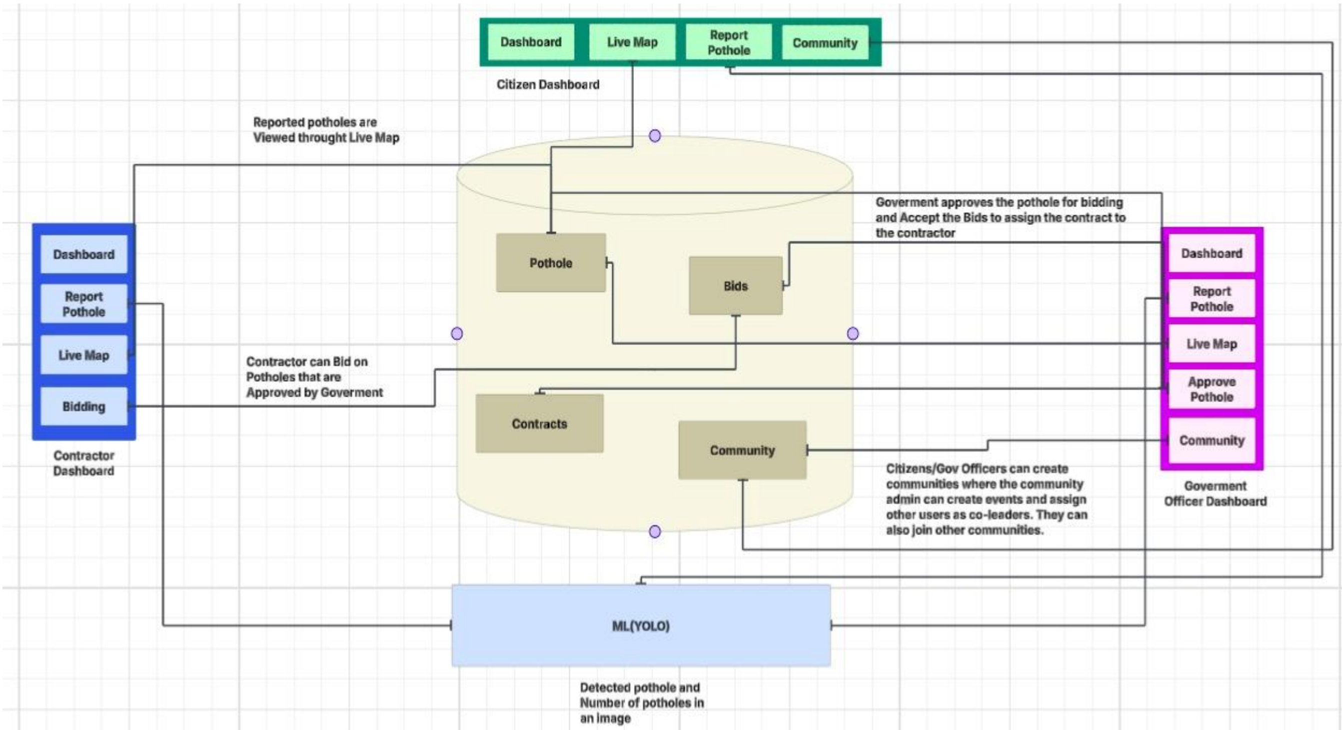


Figure 5.5 System Design Diagram

Chapter 6

Experimental Setup

6.1 Software Requirements

- Frontend: React 19, Vite, Tailwind CSS
- Backend: Node.js (Express 5)
- Database & Storage: Supabase (PostgreSQL + Storage + Realtime)
- Machine Learning Model: YOLOv12 (Ultralytics, ONNX export)
- AI Integration: Google Gemini API (severity & type detection)
- APIs / Services:
    - Google OAuth – user authentication
    - Mapbox GL / Leaflet – maps & geolocation
    - Supabase Realtime – live updates
    - Nodemailer – OTP & email notifications

6.2 Hardware Requirements

- Client Devices: Smartphone, tablet, or desktop with camera, GPS, and internet
- Server:
    - Minimum: 4-core CPU, 8 GB RAM
    - Optional: GPU for YOLOv12 acceleration
    - Storage: 10 GB minimum
- Deployment: Cloud or on-prem Linux environment

6.3 Operating Environment

- Web-based application accessible via browsers on Windows, Linux, macOS, Android, iOS
- Supports camera-based pothole uploads and GPS location tracking
- Authorities and contractors access via standard browsers
- Requires stable internet for AI/ML and Supabase integration

6.4 Development Environment

- Frontend: React + Vite (fast build, modular UI)
- Backend: Node.js + Express (API handling & business logic)
- Database: Supabase (data + file storage + realtime)
- ML Microservice: Flask + ONNX Runtime (YOLOv12 inference)
- AI Service: Google Gemini (severity classification)
- Version Control: GitHub
- Config: Environment variables & Vite proxy setup

6.5 Machine Learning & AI Libraries

- Ultralytics YOLO (v12) – Model training/export
- ONNX, ONNX Runtime – Model inference
- Flask – ML API hosting
- Roboflow SDK – Dataset import
- NumPy, OpenCV – Image processing
- PyTorch – YOLOv12 training backend
- Gemini API – Severity/type classification

Chapter 7

Project Planning

Gantt Chart:

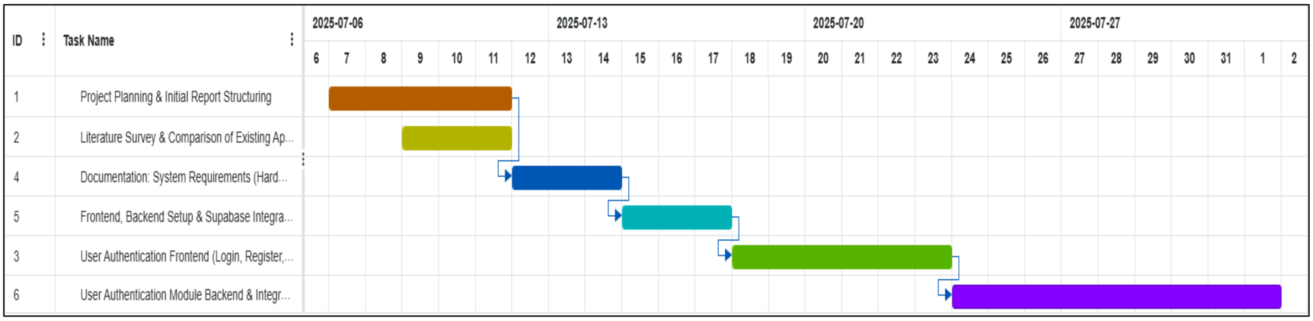


Figure 7.1 July (Gantt Chart)

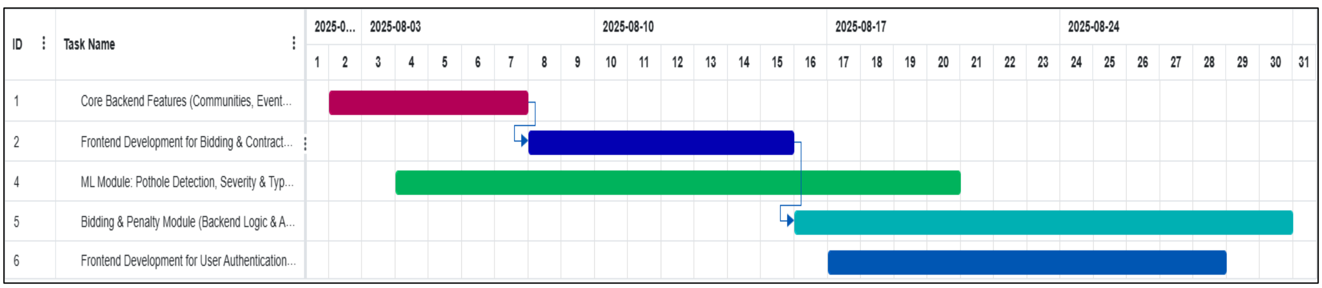


Figure 7.2 August (Gantt Chart)

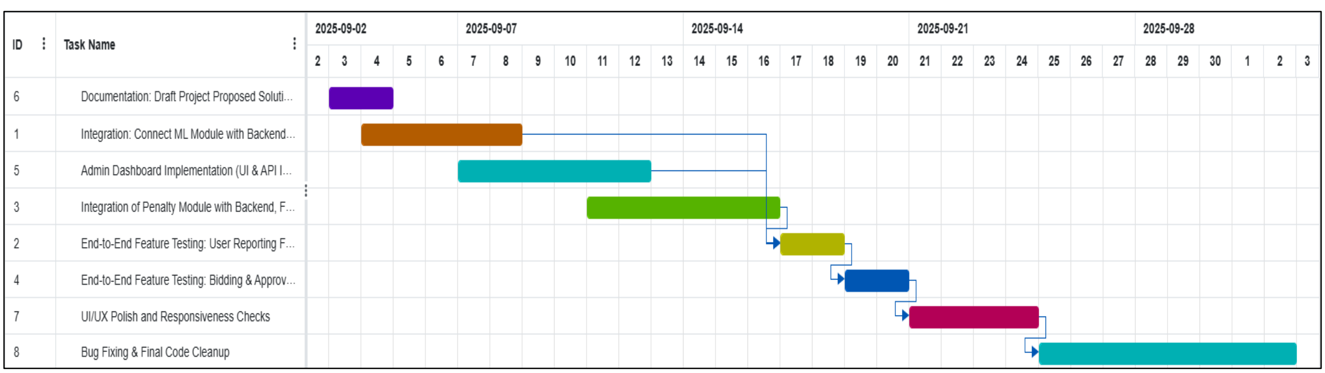


Figure 7.3 September (Gantt Chart)

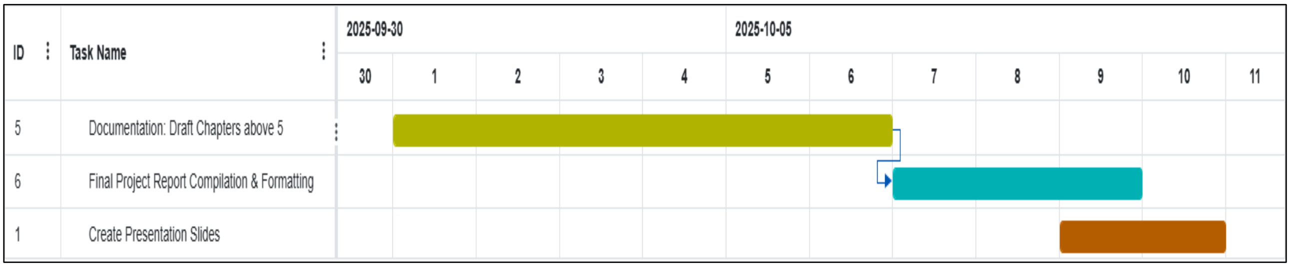


Figure 7.4 October (Gantt Chart)

Chapter 8

Expected Outcome

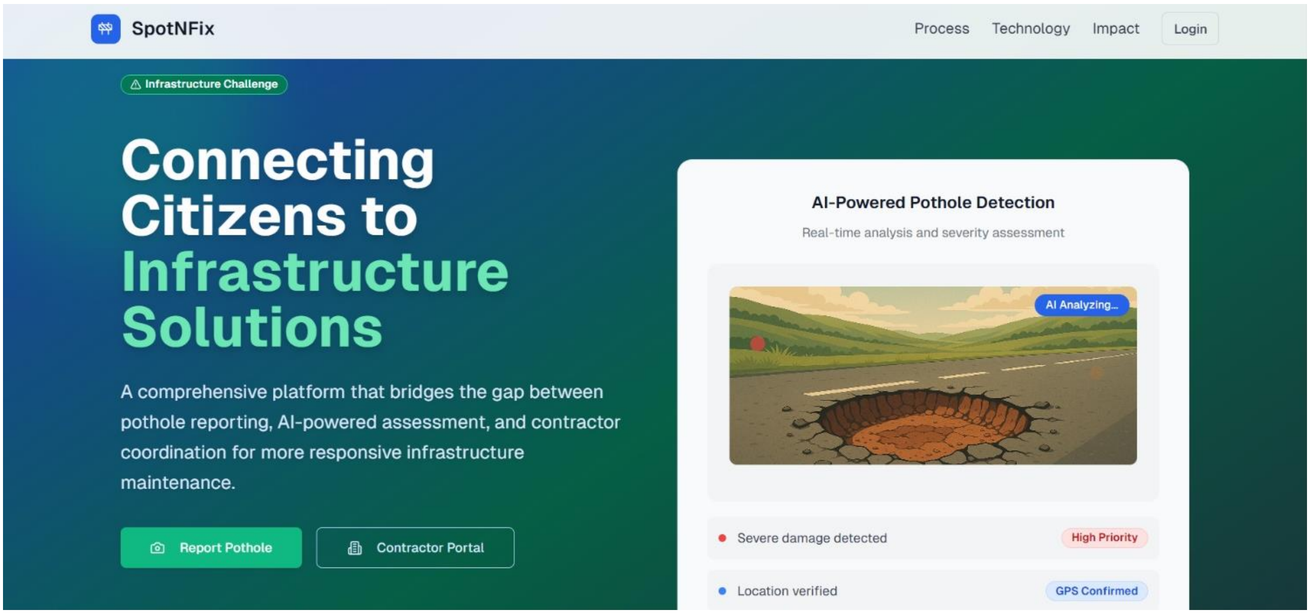


Figure 8.1 Landing Page

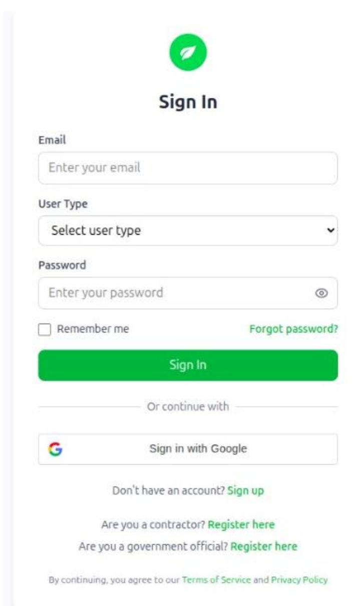


Figure 8.2 Login Page

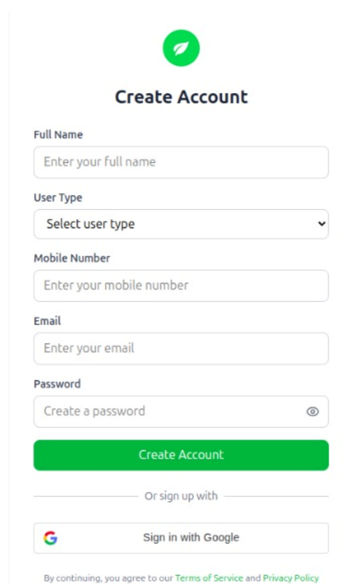
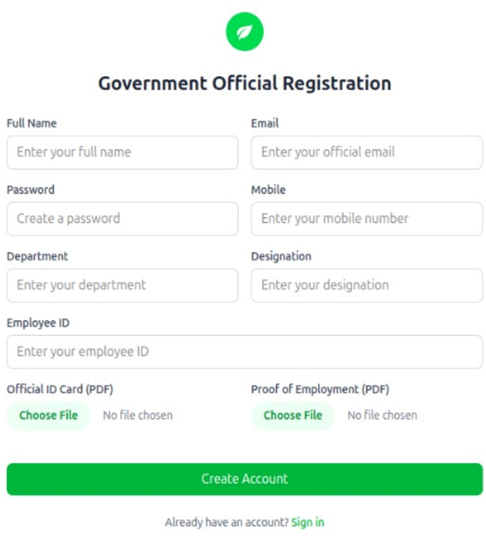


Figure 8.3 Citizen Register Page



Figur8.4 Govt. Register Page

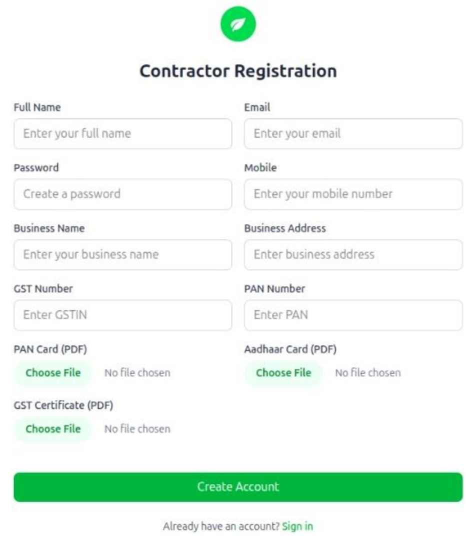


Figure 8.5 Contractor Register Page

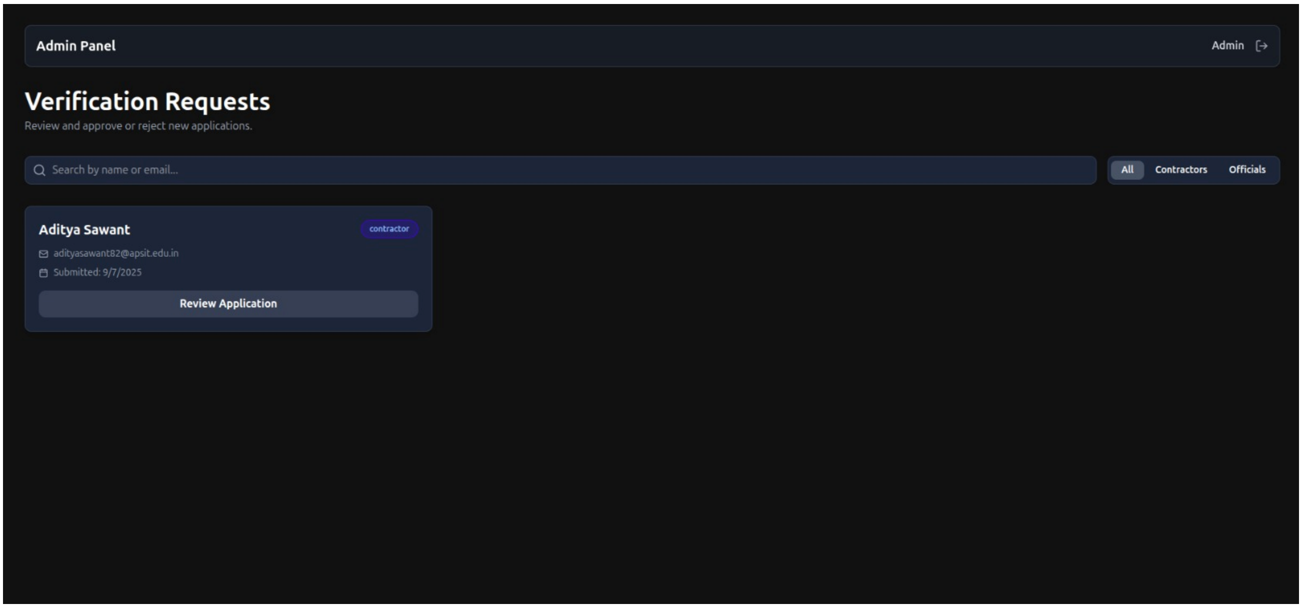


Figure 8.6 Super Admin Panel

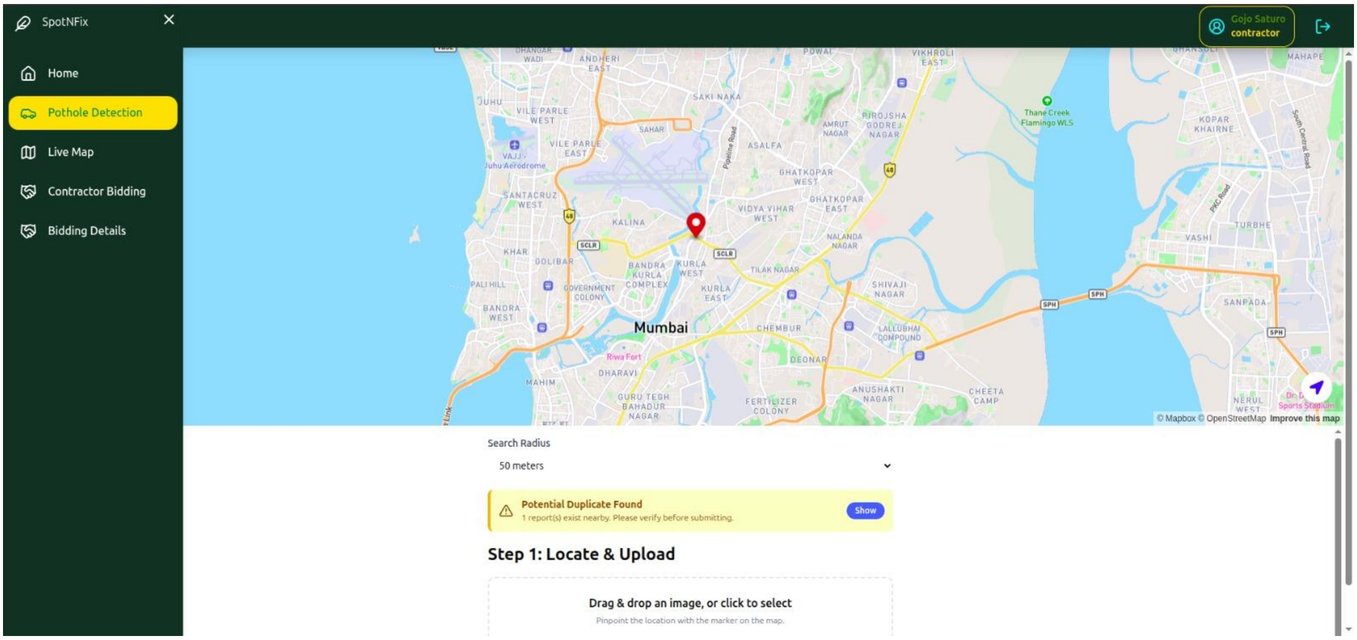


Figure 8.7 Pothole Detection Page

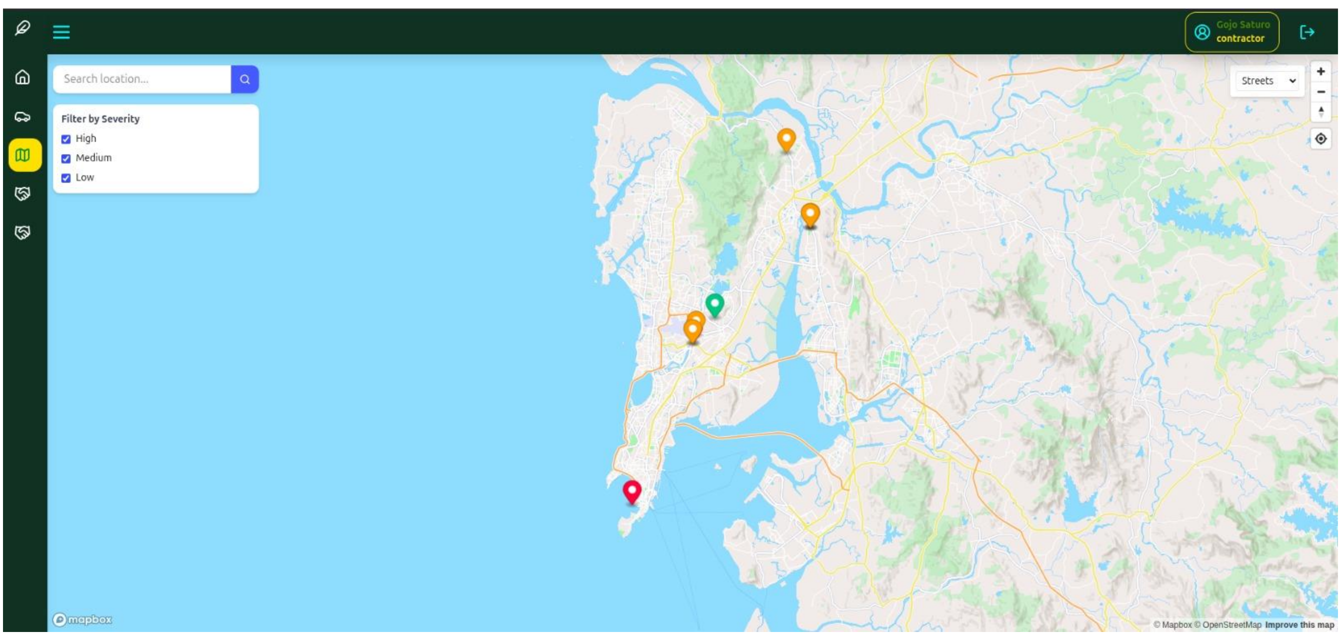


Figure 8.8 Live Map Page

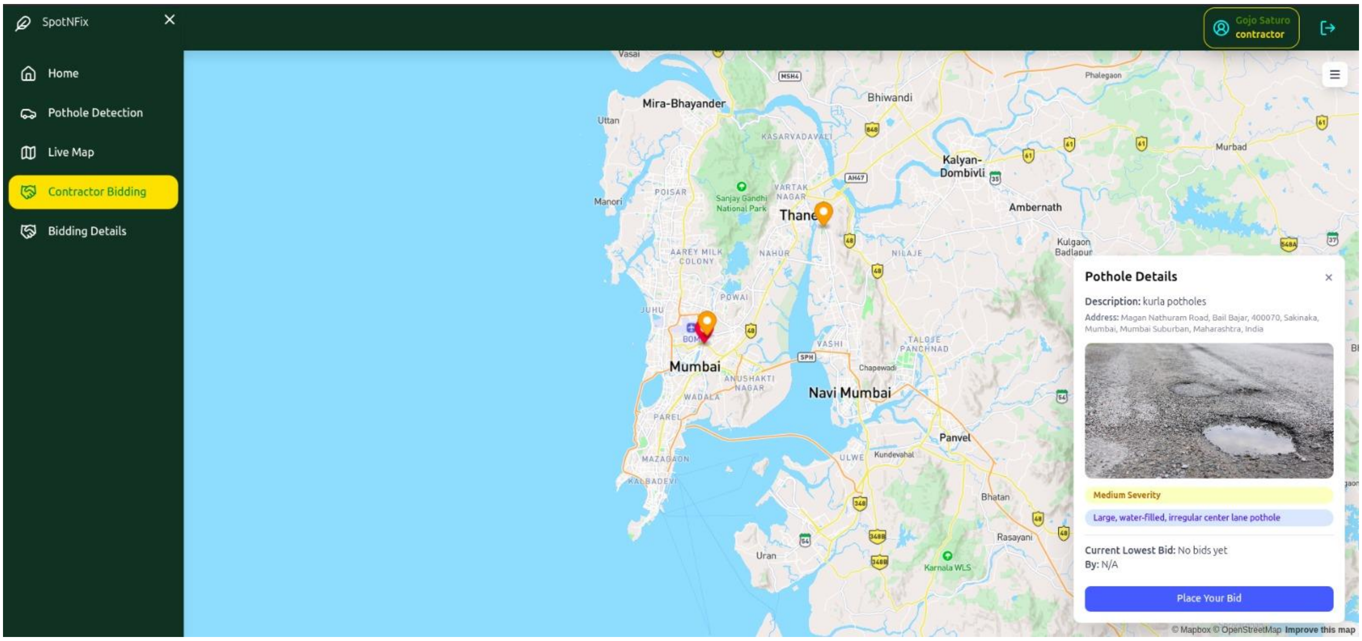


Figure 8.9 Contractor Bidding Page

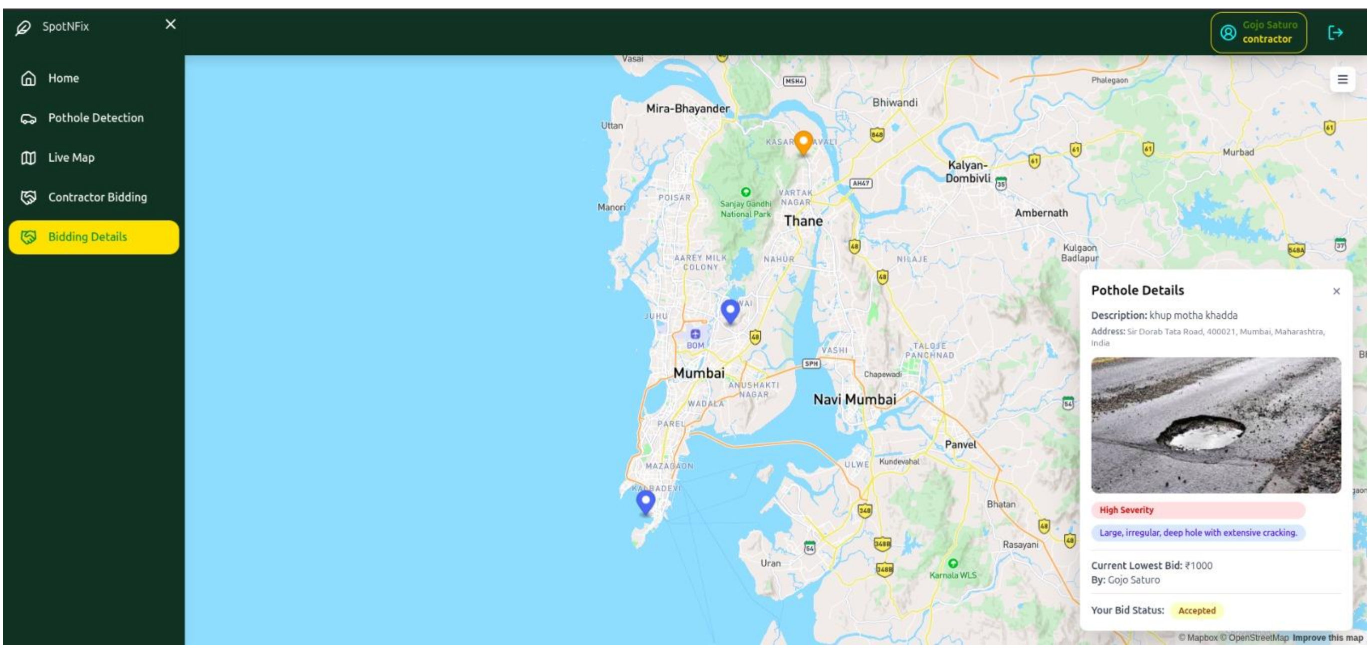


Figure 8.10 Contractor Bidding Details Page

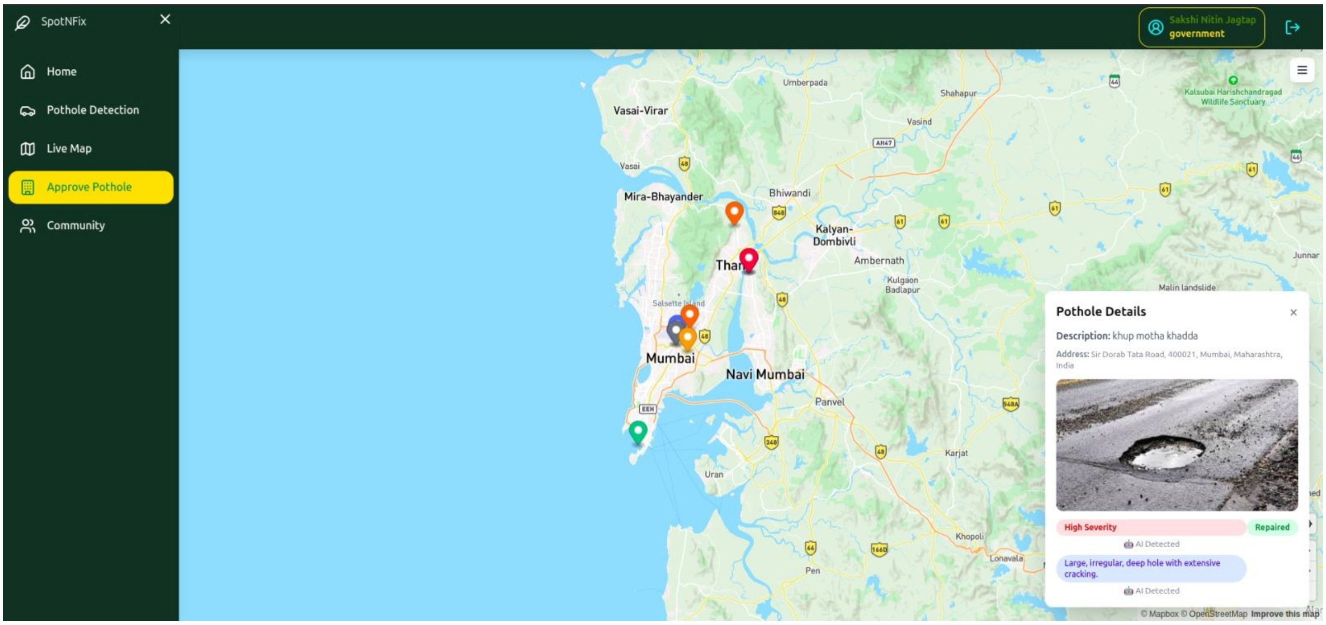


Figure 8.11 Govt. Approve Pothole Page

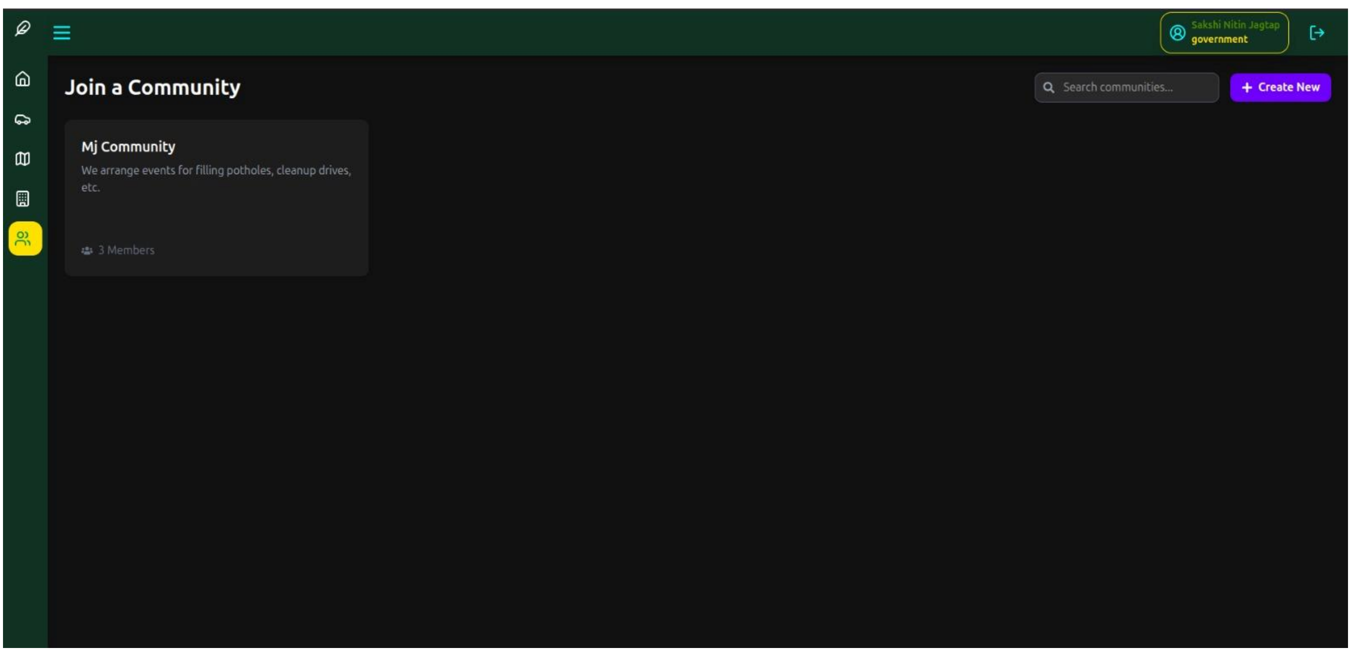


Figure 8.12 Communities Page

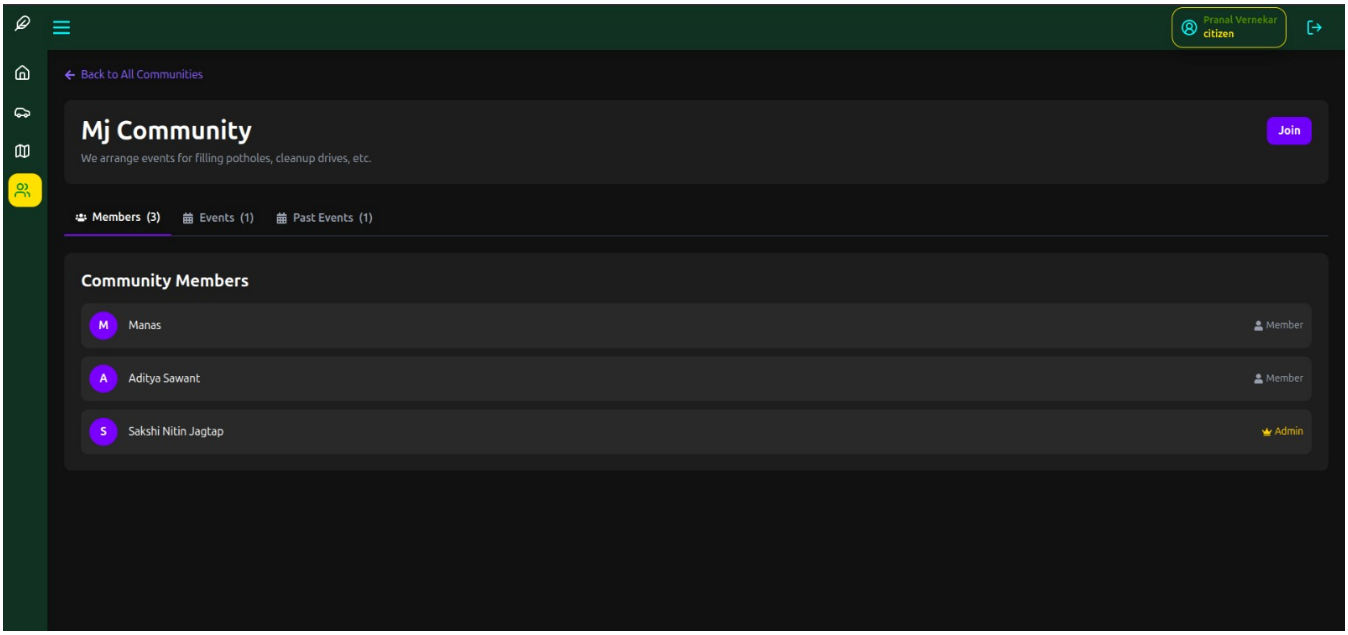


Figure 8.13 Community Members Page

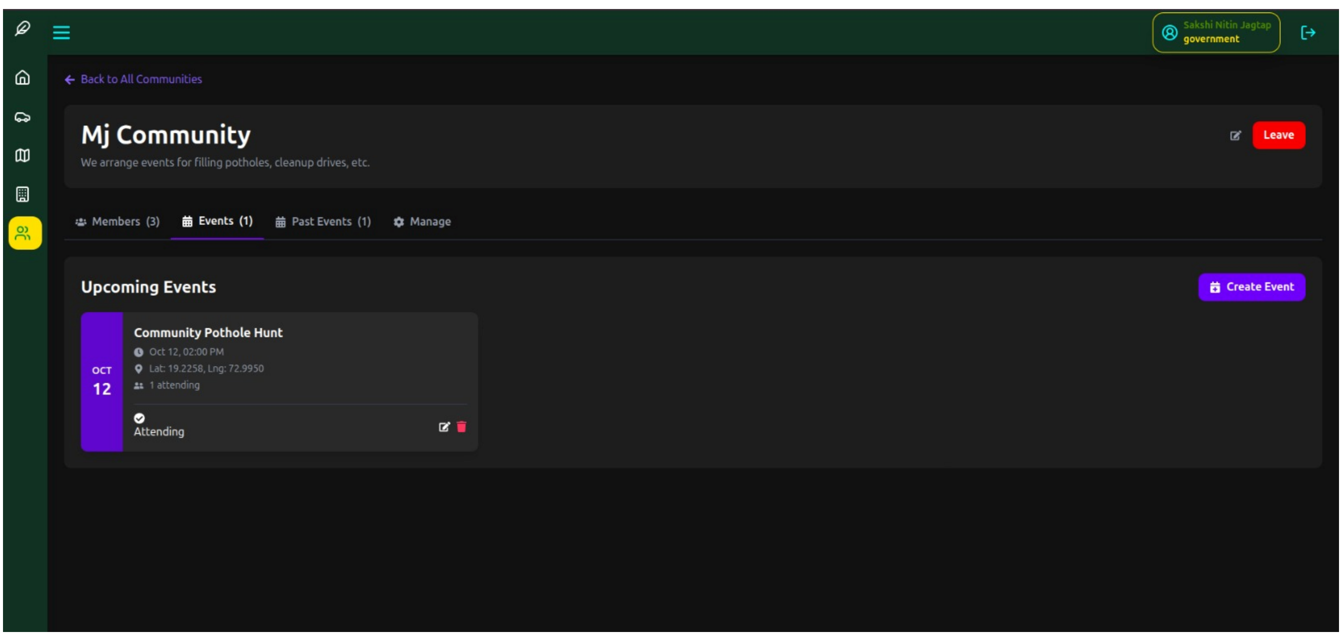


Figure 8.14 Community Events Page

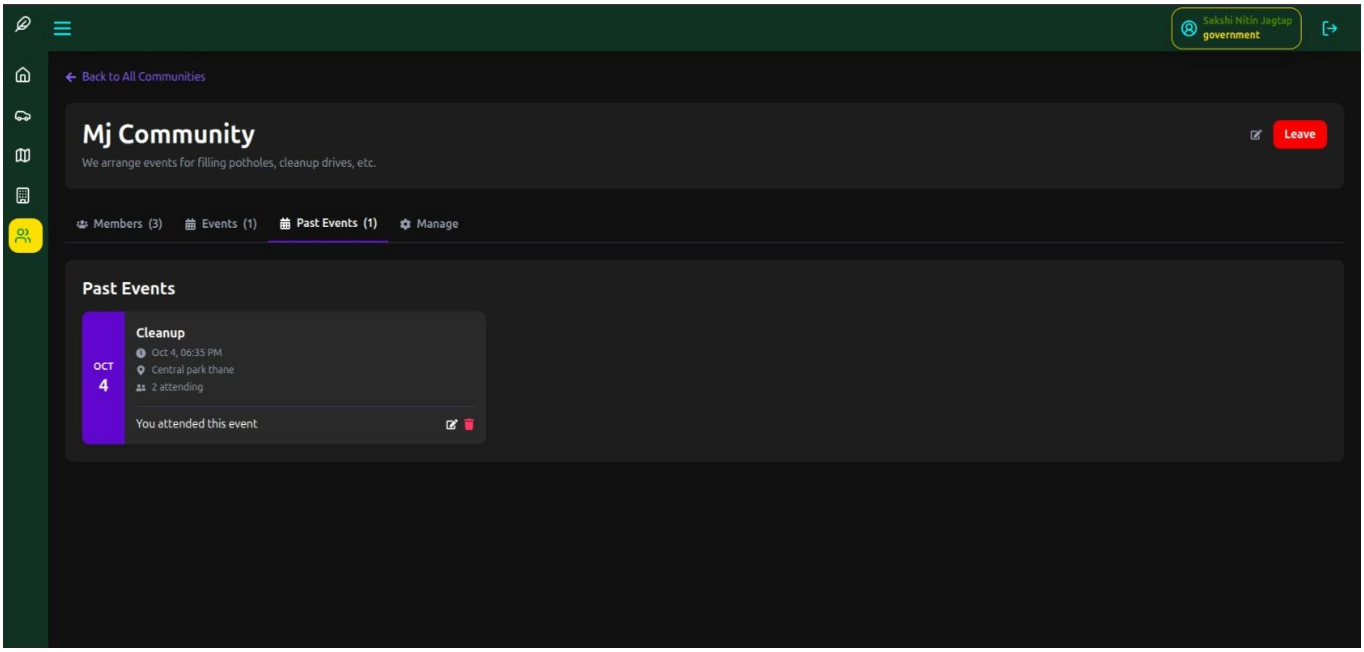


Figure 8.15 Community Past Events Page

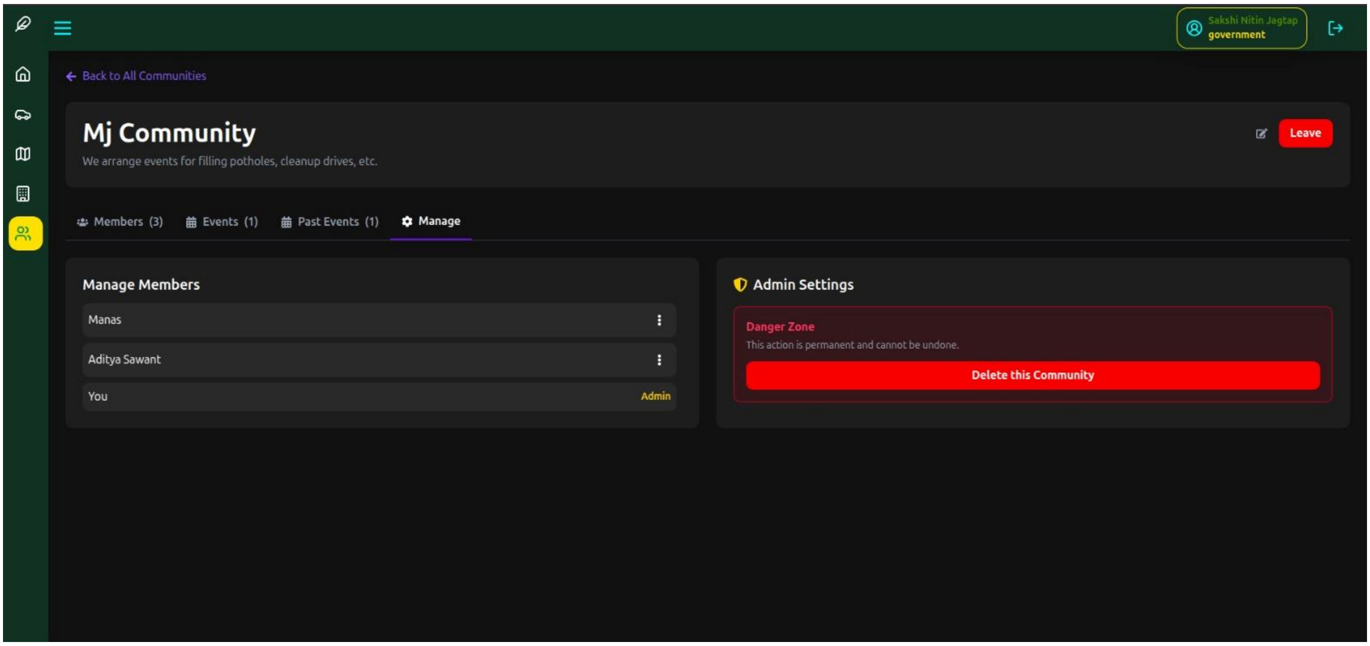


Figure 8.16 Community Manage Page

Chapter 9

Conclusion

In conclusion, SpotNFix represents a comprehensive and intelligent approach to modern road maintenance by integrating Artificial Intelligence, Machine Learning, and geolocation technologies for automated pothole detection, severity classification, and reporting. The system effectively bridges the communication gap between citizens, authorities, and contractors, enabling a transparent and efficient repair workflow through its bidding and accountability mechanisms. By leveraging YOLOv12 for object detection and Gemini AI for severity analysis, SpotNFix ensures accurate identification and prioritization of critical road damages. Furthermore, the inclusion of real-time dashboards and analytics promotes data-driven decision-making, enhancing transparency and operational efficiency. Overall, SpotNFix contributes toward building smart, sustainable, and citizen-centric urban infrastructure, transforming the conventional approach to road management into a proactive, technology-driven system.

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