

Online Monitoring of Unauthorized Construction Across the City

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Abstract—Urbanization has accelerated across the globe, bringing with it the challenge of regulating and managing land use effectively. Unauthorized construction activities not only violate municipal planning norms but also pose significant risks to public safety, environmental sustainability, and the equitable distribution of city resources. Traditional approaches to monitoring such developments—such as physical inspections by municipal staff, drone-based surveillance, or remote sensing using satellite data—often suffer from high operational costs, limited coverage, slow response times, and an overreliance on manual validation. These limitations create opportunities for undetected and unregulated construction to persist. To address these critical issues, this project introduces a comprehensive, AI-powered web-based monitoring system that automates the detection of unauthorized constructions throughout a city. The system harnesses deep learning algorithms—primarily a lightweight and efficient MobileNetV2-based Convolutional Neural Network (CNN)—to analyze and compare satellite imagery captured at different time intervals. By detecting structural differences between historical and current images of urban plots, the system can effectively identify changes that may signify illegal building activity. The architecture of the solution is modular and scalable. The process begins with image acquisition, wherein satellite images are retrieved from sources such as Google Earth Engine. These images undergo preprocessing steps such as noise reduction and contrast enhancement to improve clarity and usability. The images are then segmented into discrete land parcels for focused analysis. Users—including homeowners, builders, or real estate developers—can register on the platform and submit property details and construction plans for approval. Administrators have access to a dedicated review dashboard, where they can verify submissions, view satellite imagery comparisons, and oversee flagged discrepancies. The

system also integrates location services through Google Maps APIs and offers visual geo-mapping of detected violations. Technologically, the solution is built using Python for backend logic, incorporating TensorFlow for AI model training and OpenCV for image processing. Geographic Information Systems (GIS) tools such as ArcGIS and QGIS support spatial data analysis, while a web interface is developed using frameworks like Flask or Django. The database layer is supported by PostgreSQL with PostGIS extensions for managing geo-spatial queries and storage. This AI-driven platform offers a paradigm shift from reactive to proactive governance in urban development monitoring. It not only minimizes human error and reduces surveillance costs but also improves the transparency and accountability of municipal operations. By bridging the gap between AI technologies and urban governance, this system stands as a model for smart city applications, enabling authorities to maintain regulatory compliance, protect public infrastructure, and promote sustainable city growth.

I. INTRODUCTION

Urban development is an essential aspect of societal progress, but its rapid and often unregulated expansion poses significant challenges to city planning and governance. Unauthorized construction—whether in the form of unapproved extensions, illegal buildings, or violation of zoning regulations—has become a widespread issue in many growing cities. These illicit developments not only compromise the integrity of urban planning frameworks but also strain public infrastructure, increase safety hazards, and lead to environmental degradation. Traditional monitoring methods, such as periodic site inspections by municipal staff or the use

of aerial drones and satellite imaging, are often hindered by several limitations. These include high operational costs, lack of real-time detection, manual validation processes, and limited spatial-temporal resolution. Consequently, unauthorized constructions may go unnoticed for extended periods, making enforcement difficult and allowing regulatory violations to proliferate. In response to these challenges, this project proposes an AI-powered, web-based system designed to monitor and detect unauthorized construction activities in urban areas. By leveraging satellite imagery, deep learning algorithms, and geospatial data integration, the system automates the detection of structural changes in land plots over time. A MobileNetV2-based Convolutional Neural Network (CNN) model serves as the core engine for analyzing and comparing current and historical images to identify deviations from approved building plans. The platform supports a dual-role interface: end-users (such as residents or developers) can submit property details and request approvals, while administrative users (typically municipal authorities) can review these submissions, monitor construction activities, and respond to violations. The integration of Google Maps APIs and GIS tools allows for real-time geo-mapping of flagged constructions, while automated alert generation ensures prompt action by the relevant authorities. Through this system, we aim to bridge the gap between urban governance and emerging AI technologies, promoting transparency, efficiency, and sustainability in construction monitoring. Ultimately, this project supports smart city initiatives by providing a scalable solution for maintaining regulatory compliance and enhancing the quality of urban development.

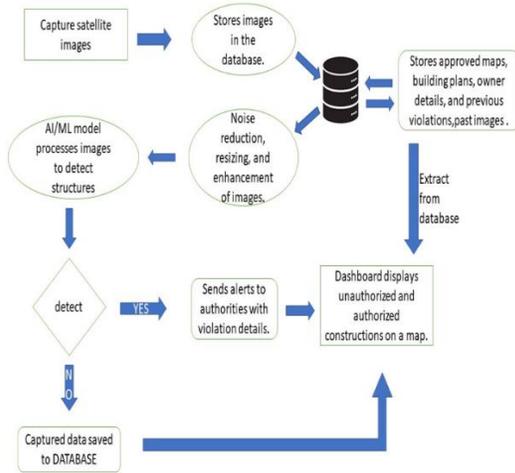
II. LITERATURE REVIEW

The rapid pace of urbanization has necessitated the development of effective methods for monitoring unauthorized constructions in cities. Traditional approaches such as manual site inspections and citizen complaints, though historically relied upon, are often inefficient, labor-intensive, and vulnerable to human error or corruption. Remote sensing techniques using satellite imagery have improved the spatial scale of monitoring, employing image differencing and change detection algorithms to

identify structural transformations over time. However, these methods typically lack real-time capabilities and require expert interpretation, limiting their practical application in fast-growing urban areas. Geographic Information Systems (GIS) have further enhanced spatial analysis by enabling the integration of multiple urban datasets, yet they still depend heavily on manual data updating and analysis. More recently, drone-based surveillance has gained popularity due to its ability to provide high-resolution imagery and frequent monitoring. Despite their benefits, drones present logistical challenges including high operational costs, regulatory constraints, and limited area coverage. In contrast, the integration of Artificial Intelligence (AI), particularly Convolutional Neural Networks (CNNs), into urban monitoring systems has shown considerable promise. Deep learning models such as MobileNetV2 offer efficient and accurate image classification and change detection, even with limited computational resources. Studies have demonstrated that when coupled with web-based dashboards and GIS tools, AI-driven platforms can automate the identification and flagging of unauthorized developments, thereby facilitating faster and more transparent decision-making by municipal authorities. Nevertheless, the literature reveals a gap in fully automated, scalable systems that integrate citizen input, satellite data, AI-based detection, and real-time administrative response. This project seeks to address these gaps by developing a comprehensive, AI-powered web platform for the continuous monitoring of unauthorized construction activities across the city.

III. RESEARCH METHODOLOGY

Needs Assessment: This project adopts a systematic and multi-phase research methodology combining remote sensing, artificial intelligence, and geospatial technologies to develop an automated web-based system for monitoring unauthorized constructions in urban areas. The methodology encompasses data acquisition, image processing, deep learning model deployment, spatial mapping, user interaction modules, and administrative workflows. Each phase is designed to ensure accuracy, scalability, and real-time responsiveness, enabling effective detection and management of illegal developments.



Here's an explanation of the DFD components:

1. **Capture Satellite Images:** The system begins by capturing satellite imagery of the area under surveillance.
2. **Store Images in Database:** These captured images are stored in a database for processing and analysis.
3. **Image Preprocessing:** The images go through noise reduction, resizing, and enhancement to improve quality and make them suitable for AI/ML analysis.
4. **AI/ML Model Analysis:** The preprocessed images are fed into an AI/ML model that detects structures (buildings, roads, etc.).
5. **Detection Decision:** The system checks whether there are any unauthorized constructions detected by comparing detected structures against approved maps and plans stored in the database.
6. **If Unauthorized Construction is Detected:** Sends alerts to authorities with detailed violation information. This information is also displayed on a dashboard that shows authorized and unauthorized constructions on a map.
7. **If No Unauthorized Construction is Detected:** The data is saved to the database for future reference.

1. **Data Acquisition:** The first phase involves the collection of high-resolution satellite imagery over selected urban regions. These images are sourced through publicly available platforms like Google Earth Engine and supplemented by historical imagery archives to enable temporal comparison. Both current

and past images are retrieved at fixed intervals to identify structural changes. Alongside, user-submitted property images and details (e.g., approved construction plans, GPS coordinates, building permits) are collected through the system's web interface.

2. Image Preprocessing:

The raw satellite images are often affected by atmospheric noise, varying lighting conditions, and spatial distortions. To enhance image quality and ensure consistency, the images undergo preprocessing operations such as:

- **Noise Reduction using Gaussian Filtering:** Smooths the image by removing random noise while preserving edges, making it clearer for analysis.
- **Contrast Enhancement through Histogram Equalization:** Improves image clarity by adjusting brightness levels, making hidden details more visible.
- **Georeferencing to Align Imagery with GPS Coordinates:** Maps image pixels to real-world locations using GPS, enabling accurate spatial analysis.
- **Image Resizing and Normalization:** Standardizes image size and scales pixel values for compatibility and better performance in deep learning models.

3. Image Segmentation and Plot Division:

The processed satellite images are divided into segmented plots or tiles that correspond to cadastral maps or predefined land parcels. This spatial segmentation is crucial for localizing analysis and comparing image regions to specific user-submitted property boundaries. Techniques such as edge detection, watershed segmentation, and k-means clustering may be applied to isolate buildings and features within each tile.

4. Feature Extraction and Deep Learning Classification:

At the core of the system lies a Convolutional Neural Network (CNN) model based on MobileNetV2 architecture. This model is trained to extract and classify visual features that indicate construction

activity. The CNN performs the following tasks:

- Extracts structural patterns, such as roof outlines, wall geometry, and shadows
- Detects changes in building density or new construction footprints
- Compares past and present images to identify discrepancies

MobileNetV2 is chosen for its lightweight architecture, allowing fast and accurate classification even on limited hardware or cloud-based deployments.

5. Change Detection and Violation Identification:

Once features are extracted, the system compares historical and current imagery of each plot. If new structures or modifications are detected that do not match the approved construction plans submitted by the user, the system flags them as potential violations. This phase includes:

- Binary image differencing to highlight added or removed structures.
- Change thresholding to filter minor or non-relevant alterations.
- Violation tagging where suspected unauthorized changes are marked for review.

6.Alert Generation and Notification:

Upon identifying a potential unauthorized construction, the system automatically:

- Sends alerts to municipal authorities via email or dashboard notifications.
- Marks the affected location on an interactive map.
- Generates a report summarizing the detected changes, user-submitted details, and satellite image evidence.

7. Geospatial Visualization and Dashboard Integration:

The detection results are visualized through a web dashboard developed using frameworks like Flask or Django, integrated with Google Maps API and GIS libraries (ArcGIS, QGIS). The dashboard enables:

- Real-time visualization of flagged sites.
- Access to historical construction data.
- Filtering of alerts by region, severity, or date.
- Administrative review and approval workflows.

8. User Interaction Modules:

The system includes role-based modules:

- User Module: Allows users to register, upload property details, and track the approval status of their constructions.
- Admin Module: Enables administrators to review flagged constructions, approve or reject user submissions, and oversee citywide monitoring metrics.

9. System Testing and Validation:

The methodology concludes with extensive testing phases:

- Model validation using labeled datasets with known construction changes
- Accuracy and precision measurement of the CNN model
- Performance benchmarking for image processing speed, detection latency, and alert delivery
- User acceptance testing (UAT) to evaluate the system's usability, interface design, and reliability from both user and administrator perspectives.

IV. FUTURE ENHANCEMENT

While the current system offers a robust AI-powered platform for detecting unauthorized constructions using satellite imagery and deep learning, there are several potential improvements and expansions that can further enhance its effectiveness, scalability, and adaptability in real-world urban environments. The future enhancements may include:

Integration with Real-Time Drone Feeds: Incorporating drone surveillance into the system will allow higher-resolution, real-time imagery for areas where satellite data is insufficient or delayed. This can enhance detection accuracy and provide ground-level context to suspected violations.

Mobile Application for Field Inspection: Developing a mobile app for municipal officers and field engineers can support on-the-ground validation of flagged sites. The app could include live GPS tracking, camera integration, and violation reporting features.

Machine Learning Model Upgrades: Improving the AI model by experimenting with more advanced architectures like ResNet, EfficientNet, or transformer-based vision models could increase detection precision and reduce false positives.

3D Construction Analysis:
Using LiDAR or stereo satellite images, the system can evolve to detect not just horizontal expansion but also vertical growth, helping detect unauthorized high-rise developments.

Citizen Reporting and Crowdsourcing:
Adding a citizen engagement module would allow the public to report suspicious construction activities, enhancing transparency and community participation.

Automated Legal Compliance Checker:
A future version could cross-reference detected changes with local zoning laws, building codes, and approved permits to automatically determine the nature and severity of the violation.

Cross-City and National Deployment:
With scalable cloud infrastructure, the platform can be extended to monitor multiple cities or states, enabling a centralized system for government authorities.

Predictive Analytics and Risk Forecasting:
Incorporating AI-driven trend analysis can help authorities predict areas at high risk for illegal construction based on historical patterns, urban growth rates, and socioeconomic data. services by identifying trends and anticipating needs.

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V.CONCLUSION

This project introduces an AI-powered system for monitoring unauthorized construction using satellite imagery and deep learning. By automating image comparison and integrating geospatial tools, the system enables real-time detection, alerting, and

efficient oversight by authorities. It offers a cost-effective, scalable, and transparent solution that supports smart urban planning and strengthens regulatory enforcement in rapidly growing cities.

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