



Crack Detection System Using Drone-Captured Images

Mr. B. Muthu Krishna Vinayagam, M.E.,¹, Jaflet Evangeline I², Bhava Akshaya M³, Shalini S⁴

¹ Assistant Professor, Dept. of CSE, Kamaraj College of Engineering and Technology, Virudhunagar, Tamil Nadu, India

^{2,3,4} UG Scholar, Dept. of CSE, Kamaraj College of Engineering and Technology, Virudhunagar, Tamil Nadu, India

Emails: muthukrishnavinayagamcse@kamarajengg.edu.in¹, joeljaflet3905@gmail.com², bhavaakshaya2006@gmail.com³, shaluantomable@gmail.com⁴

Abstract

Structural cracks in concrete infrastructures such as buildings, bridges, and pavements pose significant safety and durability risks if not detected at an early stage. Conventional crack inspection methods rely heavily on manual visual assessment, which is time-consuming, subjective, and unsafe for large-scale or hard-to-reach structures. To address these limitations, this project presents a Drone-Based Concrete Crack Detection System using Machine Learning, integrated with an interactive Streamlit web application. The system utilizes drone-captured images as input and employs a Convolutional Neural Network (CNN) to automatically detect the presence of cracks. In addition, image processing techniques such as grayscale conversion, thresholding, and pixel analysis are applied to estimate crack severity quantitatively. The developed web-based interface allows users to upload multiple images, visualize detected cracks through overlay highlighting, and receive automated decision outputs. The system also generates downloadable CSV and PDF reports and provides audio-based result announcements to enhance usability. The proposed solution offers an efficient, scalable, and non-invasive approach for automated structural health monitoring and early crack detection.

Keywords: Concrete Crack Detection, Drone-Captured Images, Machine Learning, Convolutional Neural Network, Image Processing Techniques, Crack Severity Analysis, Streamlit Web Application.

1. Introduction

Structural cracks in buildings, bridges, roads, and other infrastructures pose serious risks to public safety and long-term structural stability. Despite advancements in construction materials and monitoring techniques, crack detection is still largely dependent on manual visual inspection methods. These traditional approaches are time-consuming, labor-intensive, subjective, and often unsafe when structures are located at heights or in hazardous environments. As infrastructure ages and urban development increases, the need for an efficient, accurate, and automated crack detection mechanism has become increasingly important. Recent research highlights that modern web-based applications combined with Artificial Intelligence provide real-time processing, scalability, and improved decision-making capabilities, making them suitable for infrastructure monitoring solutions (Zhang, L et al., 2016; Dorafshan, S et al., 2018; Cha, Y.-J et al.,

2017). Similarly, drone-based inspection systems integrated with deep learning techniques have been identified as effective tools for detecting structural damages, offering high-resolution image capture, reduced human risk, and enhanced detection accuracy through convolutional neural networks and image processing methods (Li, X et al., 2022; Kumar, R et al., 2023). In this context, the proposed Crack Detection System using Drone Captured Images introduces a reliable, automated, and scalable solution for infrastructure inspection. The system utilizes drone technology to capture high-quality images of structures and applies machine learning algorithms to identify and classify cracks with precision. The platform ensures faster assessment, minimizes manual intervention, and supports timely maintenance decisions. The originality of this work lies in integrating drone-based image acquisition with AI-powered crack detection and an interactive web-



based monitoring interface, contributing to improved structural safety, reduced maintenance costs, and sustainable infrastructure management.

1.1. Current Issues in Structural Crack Inspection

In today's rapidly developing world, aging infrastructure such as buildings, bridges, pavements, and dams is increasingly vulnerable to structural deterioration. Cracks in concrete structures often go unnoticed due to the lack of efficient monitoring systems and dependence on manual inspection methods. Traditional inspection approaches are time-consuming, labor-intensive, subjective, and sometimes unsafe, especially for large-scale or elevated structures. As a result, minor cracks may remain undetected until they develop into severe structural damage, leading to safety risks and high repair costs (Zhang, L et al., 2016; Dorafshan, S et al., 2018;). Therefore, there is a critical need for a reliable and technology-driven solution that enables accurate crack detection, ensures timely maintenance decisions, and promotes long-term structural safety (Cha, Y.-J et al., 2017; Li, X et al., 2022;).

1.2. Purpose and Major Target of the Project

The Crack Detection System using Drone Captured Images is important because it addresses the limitations of conventional inspection methods through an innovative technology-enabled approach. By utilizing drones for high-resolution image acquisition and applying machine learning algorithms for automated crack detection, the system ensures accurate identification and assessment of structural damages. This supports infrastructure safety, reduces manual effort, and minimizes risks associated with physical inspections (Kumar, R et al., 2023; Singh, P et al., 2024;). The project aims to detect cracks efficiently, estimate crack severity, provide real-time visualization through a web-based interface, generate detailed inspection reports, and support preventive maintenance planning. Ultimately, the system contributes to improved structural reliability, reduced maintenance costs, and sustainable infrastructure management.

2. Method

The Crack Detection System was developed using a drone-assisted and machine learning-based

methodology to enable automated identification of structural cracks in concrete infrastructures. The system captures high-resolution images of buildings, bridges, pavements, and other structures using unmanned aerial vehicles (UAVs). These drone-captured images are then processed and analyzed using image preprocessing techniques and deep learning models to detect crack patterns accurately. The workflow follows a structured process that includes image acquisition, preprocessing (noise removal and grayscale conversion), crack detection using a trained Convolutional Neural Network (CNN) model, crack severity estimation through pixel-level analysis, and result visualization. The detected crack regions are highlighted using visual overlays for better interpretation. The system is integrated with a Streamlit-based web interface that allows users to upload images, view detection results, generate CSV and PDF reports, and access audio-based result announcements. The development approach combines drone technology, machine learning algorithms, and modern web technologies to ensure scalability, accuracy, and efficient structural monitoring.

Table 1 Key Modules and Technologies Used in Crack Detection System

Table with 2 columns: Component and Technology. Rows include Frontend Interface (Streamlit), Backend Processing (Python), Machine Learning Model (Convolutional Neural Network (CNN)), Image Processing (OpenCV, NumPy), and Alert System (Audio Notification / Result Announcement).

3. Results and Discussion

3.1. Results

The Drone-Based Crack Detection System was successfully designed and implemented as a web-based platform integrated with machine learning for automated structural inspection. The system enables users to upload drone-captured images of buildings, bridges, pavements, and other concrete structures through a Streamlit-based interface. The uploaded

images are processed using image preprocessing techniques and analyzed using a trained CNN model to detect cracks accurately.

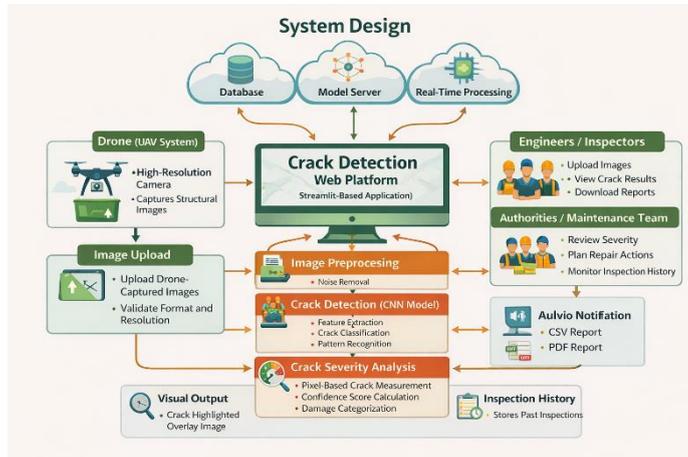


Figure 1 System Design of Crack Detection System

The system highlights detected crack regions with visual overlays and estimates crack severity using pixel-level analysis and confidence scoring. It also generates structured inspection reports in CSV and PDF formats and provides optional audio-based result announcements. The results demonstrate that the system improves detection accuracy, reduces manual inspection time, and enables safer evaluation of hard-to-reach structures. Overall, the proposed system provides an efficient and organized digital approach for automated structural crack detection and monitoring.

3.2. Discussion

The results of the Crack Detection System indicate that integrating drone technology with deep learning significantly enhances the efficiency and reliability of structural inspection processes. Unlike traditional manual methods, the proposed system offers automated crack detection with consistent and objective results, minimizing human error and inspection risks. The use of UAVs ensures safe image acquisition from elevated or hazardous locations, while the CNN model enables accurate pattern recognition of cracks. The inclusion of report generation, severity estimation, and inspection history tracking improves transparency and supports informed maintenance planning. Furthermore, the

system promotes preventive maintenance by enabling early detection of minor cracks before they escalate into severe structural damage. These findings highlight that a scalable, AI-driven inspection workflow can improve infrastructure safety, reduce maintenance costs, and contribute to sustainable infrastructure management.

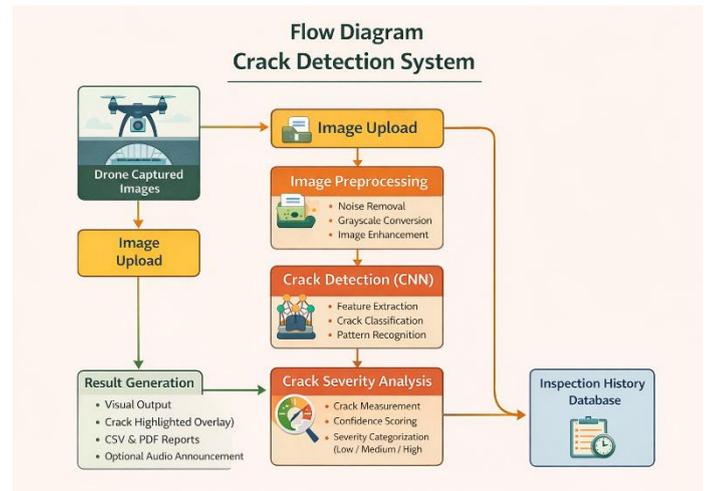


Figure 2 Flow Diagram for Crack Detection System

Conclusion

The Crack Detection System using Drone Captured Images confirms that structural crack identification can be significantly improved through the integration of drone technology and machine learning. The system successfully captures high-resolution images of concrete structures and applies a Convolutional Neural Network (CNN) model to automatically detect and analyze crack patterns. The results and discussion demonstrate that the proposed system enhances inspection accuracy, reduces manual effort, and improves safety by minimizing the need for physical inspection in hazardous or hard-to-reach areas. Furthermore, the integration of severity analysis, visual overlays, and automated report generation ensures transparency and supports timely maintenance decisions. Therefore, the proposed system serves as a reliable and scalable solution for automated structural monitoring, contributing to improved infrastructure safety, cost-effective maintenance, and sustainable asset management through digital innovation.



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References

The Previous studies have focused on automated crack detection using deep learning and image processing techniques. Zhang et al. [1] demonstrated the effectiveness of Convolutional Neural Networks (CNNs) for road crack detection. Dorafshan et al. [2] compared traditional edge detection methods with deep learning approaches and highlighted the improved accuracy of CNN-based models. Cha et al. [3] emphasized the use of deep learning for vision-based structural damage detection, while Li et al. [4] discussed the role of UAVs in safe and efficient infrastructure inspection. These studies support the integration of drone technology and machine learning for automated structural crack detection.

Journal reference style:

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