Automated Concrete Crack Detection Using Deep Learning for Enhanced Structural Monitoring

ABSTRACT

Concrete structures, such as bridges, roads, and buildings, are essential components of modern infrastructure but are often subject to degradation over time due to factors like temperature fluctuations, overloading, and long-term fatigue. Concrete, as a widely used building material, consists of a mixture of broken stones, gravel, and sand bound together by cement and water, with the proportions of these ingredients determined either by a nominal mix for standard construction or a design mix, based on laboratory tests to achieve desired compressive strength. However, despite its widespread use, concrete is susceptible to cracking, one of the most significant and fundamental indicators of a structure's condition. Cracks can severely compromise the structural integrity and safety of these infrastructures, leading to potential failures if left undetected. Timely detection and assessment of cracks are crucial to ensuring the safety and longevity of concrete structures. Traditional crack detection methods, which rely on manual inspection or basic image processing techniques, have limitations in terms of accuracy, efficiency, and scalability. To address these challenges, this research will propose a novel deep learning-based framework for the automated detection of cracks in concrete. The framework will utilize a dataset of concrete images sourced from publicly available repositories such as Kaggle. The dataset will be pre-processed to handle noise, normalize images, and ensure consistency in data quality. Key steps such as data augmentation, feature extraction, and model optimization will be implemented to enhance the model's robustness and accuracy. Performance evaluation metrics, such as accuracy, precision, recall, and F1-score, will be utilized to assess the effectiveness of the model in detecting cracks. The framework aims to significantly improve the efficiency and accuracy of crack detection, enabling early intervention and reducing the risk of structural failures. By automating the process of crack detection, this research will contribute to the development of more efficient, scalable, and reliable monitoring systems for concrete infrastructure, ultimately enhancing the safety and longevity of critical infrastructure.