An Advanced Methodological Optimization for Structural Integrity Assessment in High-Rise Buildings Using Integrated Sensor Data and Machine Learning Algorithms

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Abstract. The growing complexity of urban environments and the increasing demand for sustainable construction have amplified the necessity for advanced structural integrity assessments in high-rise buildings. This study introduces an innovative methodological optimization framework, integrating real-time sensor data with machine learning algorithms to enhance the predictive accuracy of structural assessments. Employing a case study of a prominent skyscraper, we demonstrate the effectiveness of our approach in identifying potential degradation points and optimizing maintenance schedules. The findings indicate significant improvements in assessment precision and resource allocation, paving the way for more resilient architectural practices and sustainable urban development. The proposed framework offers a transformative solution that bridges the gap between traditional assessment techniques and contemporary data analytics, ensuring the longevity and safety of high-rise structures.

Keywords: structural integrity, high-rise buildings, sensor data, machine learning, predictive analytics, sustainable architecture, urban development, real-time monitoring

Introduction

In an era marked by rapid urbanization, the structural integrity of high-rise buildings has become a paramount concern for architects and engineers worldwide. As cities expand vertically to accommodate growing populations and economic activity, ensuring the safety and resilience of these towering structures is critical. The present methodologies for assessing structural integrity often rely on periodic inspections and historical data, which may not provide a comprehensive view of a building's current state. This gap in real-time monitoring capabilities poses significant risks, not only to the occupants but also to the economic stability of urban centers. Furthermore, the shift towards more sustainable construction practices necessitates the integration of advanced technologies that can provide timely and accurate assessments of structural health. Recent advancements in sensor technologies and data analytics have opened new avenues for enhancing structural assessments. The integration of Internet of Things (IoT) devices enables real-time monitoring of critical parameters such as vibrations, strain, and temperature fluctuations. However, the challenge lies in effectively processing and interpreting the vast amounts of data generated by these sensors. Machine learning algorithms offer a promising solution to this challenge, allowing for sophisticated data analysis that can predict potential structural failures and optimize maintenance schedules. This paper aims to address the pressing need for a robust framework that incorporates both sensor data and advanced analytical techniques for assessing the structural integrity of high-rise buildings. By developing a methodological optimization framework, we seek to enhance the predictive capabilities of structural assessments, ultimately contributing to safer and more sustainable architectural practices. The structure of the paper is as follows: we first review the current landscape of structural integrity assessments in high-rise buildings, followed by a detailed explanation of our methodological approach, the case study, results, and discussion. Lastly, we conclude with implications for future research and practice in this vital area of architecture and engineering.

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