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Development of a Machine Learning-Enabled Augmented Reality Tool for Indoor Structural Defect Inspection on iOS Devices

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ABSTRACT

Visual inspection is a fundamental approach to assessing the condition of building structures; however, conventional methods remain highly dependent on manual labor, are time-consuming, and often result in inconsistent or inaccurate evaluations. These issues are exacerbated by the reliance on qualified engineers, leading to potential scheduling conflicts, increased operational costs, and delays in damage assessment, which may compromise public safety. Despite advances in sensing and automation technologies, integrating real-time 3D spatial awareness with automated defect detection remains underexplored in practical indoor inspection workflows. To address this gap, this study aims to develop an integrated inspection tool that combines augmented reality and machine learning to enhance the precision, speed, and usability of indoor structural damage detection. The proposed tool incorporates Apple's ARKit and RoomPlan APIs to conduct real-time spatial mapping and localization, generating accurate 3D reconstructions of interior environments. For defect detection, the YOLOv8 object detection model is implemented to identify structural deficiencies such as surface cracks and spalling in real-time. These two modules are seamlessly integrated into a unified AR environment, enabling inspectors to interactively document defects by raycasting their positions within the 3D space and anchoring them onto a 2D-floor plan derived from the reconstructed model. Field tests are conducted across various room sizes to validate the tool's performance under realistic conditions. Results show that the system significantly improves measurement accuracy, reduces inspection time by 30% to 50%, and minimizes the personnel required for on-site assessments. Moreover, all collected data, including defect images, floor plans, and 3D models, are automatically consolidated into a single structured output, promoting efficient documentation and streamlined data management.

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