

Abstract

Heritage structures represent invaluable cultural legacies but face progressive deterioration from environmental exposure, aging, and human-induced stresses. Traditional visual inspection methods for their health assessment are often subjective, time-consuming, and limited in scope, underscoring the need for automated and reliable approaches. This research explores a deep learning (DL)-driven image-based framework for damage detection, segmentation, and crack quantification in concrete and masonry structures, with emphasis on brick masonry heritage monuments such as Darbhanga Fort (Bihar) and Hooghly Imambara (West Bengal). Leveraging the YOLOv8 detection and segmentation models, the study establishes curated high-resolution image datasets and applies advanced training strategies, including hyperparameter tuning and data augmentation, to enhance performance. The developed models achieved high precision, recall, and mean Average Precision (mAP) across single- and multi-class tasks, demonstrating robust detection of cracks, spalling, discoloration, and vegetation. Furthermore, a novel crack quantification method based on segmentation masks enables accurate estimation of crack length and width, even in complex masonry geometries. The findings confirm the suitability of YOLOv8 for real-time, non-invasive structural health assessment and monitoring (SHM), offering a scalable and practical solution for heritage conservation. This work contributes curated datasets, fine-tuned model weights, and an automated framework that can transform heritage preservation practices through technology-enabled, data-driven decision-making.

Keywords: Heritage structure; Brick masonry; Darbhanga Fort; Hooghly Imambara; Image-based technique; Deep learning; YOLOv8; Structural health assessment; Crack quantification; Unmanned aerial vehicle.