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AI-BASED 3D VIRTUAL BRIDGE PIER DAMAGE EVALUATION USING NERF AND 3D GAUSSIAN SPLATTING WITH UAV

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Abstract

In 1995 Kobe earthquake, 2011 Tohoku Earthquake and 2016 Kumamoto Earthquake, and recent 2024 Noto Peninsula Earthquakes, damage to bridge piers poses a significant risk to the safety and serviceability of highway viaducts, particularly in densely populated urban regions of Japan. Conventional inspection practices depend largely on close-range visual surveys, which are time-consuming, subjective, and difficult to conduct immediately after disasters. This study proposes a non-contact pier damage assessment framework that integrates three-dimensional (3D) model generation using Neural Radiance Fields (NeRF) and 3D Gaussian Splatting (3DGS) with artificial intelligence–based damage detection using the You Only Look Once (YOLO) object detection algorithm. Multi-view images captured by unmanned aerial vehicles (UAVs) and smartphones were employed to reconstruct high-fidelity 3D models of bridge piers exhibiting representative damage patterns, including cracking, spalling, surface deformation, and section loss. The reconstructed NeRF and 3DGS models were used to generate dense point clouds and synthesized multi-view images, which served as inputs for YOLO-based damage detection and localization. The performance of the proposed framework was evaluated in terms of reconstruction quality, detection accuracy, and practical applicability for field inspection. The results demonstrate that the combination of neural 3D representations and YOLO-based damage detection enables efficient and reliable identification of pier damage, highlighting the potential of this approach for rapid post-disaster assessment and digital inspection of bridge infrastructure.

Keywords*: Bridge damage detection, Neural Radiance Fields (NeRF), 3D Gaussian Splatting*