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Localization and Dimensional Measurement of Prefabricated Elements in Accelerated Bridge Construction using Neural Radiance Field and Zero-shot Segmentation Model

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ABSTRACT

Accelerated bridge construction (ABC) requires precise alignment of prefabricated bridge structural components to ensure constructability and prevent assembly failure. Conventional methods to localize and measure prefabricated bridge elements in ABC from the point cloud data (PCD) using structure-from-motion (SfM) struggle due to their sparsity and low resolution, leading to inaccuracies in localization and dimensional evaluation especially in complex ABC environment. Furthermore, effectiveness of employing supervised deep learning-based 2D segmentation models with PCD processing techniques for automatic localization and dimensional evaluation of prefabricated components heavily relies on the prepared labeled dataset and requires additional training, which limits their generalization capabilities in diverse ABC scenarios. To address these limitations, this study presented an automated and robust method for localizing and assessing the dimensions of prefabricated elements in ABC by integrating neural radiance fields (NeRF) with zero-shot segmentation model. NeRF reconstructs dense PCD to capture detailed as-built conditions in ABC, while zero-shot segmentation model enables data-efficient segmentation of prefabricated elements without additional training to segregate the region of interest PCD for localization and dimensional assessment. The performance of the proposed method is demonstrated and validated using a prefabricated girder testbed for ABC, emphasizing the strong robustness and generalization capabilities for the localization and dimensional measurement of prefabricated bridge structural elements.

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