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Automated Measurement of Bridge Expansion Joint Gaps Using a Zero-shot Segmentation Framework with Prompt Model

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ABSTRACT

Bridge expansion joints are essential components for preserving structural integrity and ensuring traffic safety by accommodating displacements induced by thermal fluctuations and vehicular loads. However, conventional inspection practices are labor-intensive, time-consuming, subjective, and often require traffic control, emphasizing the need for a more efficient and automated solution. This study introduces an image-based monitoring framework that integrates zero-shot models with a few-shot prompt model to automatically measure expansion joint gap widths using road surface images captured by vehicles equipped with line-scan cameras. Specifically, the zero-shot detection model, Grounding DINO, localizes expansion joints without the need for task-specific training data. A minimally trained semantic segmentation model is then used to provide prompt points, which guide the Segment Anything Model v2 (SAM2) in accurately segmenting the gap regions. Field applications on highways operated by the Korea Expressway Corporation confirmed the method's effectiveness, achieving a mean absolute error of approximately 2.50 mm compared to manual measurements—closely matching the camera's spatial resolution of 2 mm/pixel. These findings demonstrate the practicality and scalability of the proposed framework, enabling reliable and continuous bridge monitoring while significantly reducing human effort and operational costs.

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