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MB-Slam: A Slam Framework for Construction Monitoring

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Abstract : Simultaneous Localization and Mapping (SLAM) technology has recently attracted the attention of construction companies for real-time performance monitoring. To effectively use SLAM for construction performance monitoring, SLAM results should be registered to a Building Information Models (BIM). Registring SLAM and BIM can provide essential insights for construction managers to identify construction deficiencies in real-time and ultimately reduce rework. Also, registering SLAM to BIM in real-time can boost the accuracy of SLAM since SLAM can use features from both images and 3d models. However, registering SLAM with the BIM in real-time is a challenge. In this study, a novel SLAM platform named Model-Based SLAM (MB-SLAM) is proposed, which not only provides automated registration of SLAM and BIM but also improves the localization accuracy of the SLAM system in real-time. This framework improves the accuracy of SLAM by aligning perspective features such as depth, vanishing points, and vanishing lines from the BIM to the SLAM system. This framework extracts depth features from a monocular camera's image and improves the localization accuracy of the SLAM system through a real-time iterative process. Initially, SLAM can be used to calculate a rough camera pose for each keyframe. In the next step, each SLAM video sequence keyframe is registered to the BIM in real-time by aligning the keyframe's perspective with the equivalent BIM view. The alignment method is based on perspective detection that estimates vanishing lines and points by detecting straight edges on images. This process will generate the associated BIM views from the keyframes' views. The calculated poses are later improved during a real-time gradient descent-based iteration method. Two case studies were presented to validate MB-SLAM. The validation process demonstrated promising results and accurately registered SLAM to BIM and significantly improved the SLAM's localization accuracy. Besides, MB-SLAM achieved real-time performance in both indoor and outdoor environments. The proposed method can fully automate past studies and generate as-built models that are aligned with BIM. The main contribution of this study is a SLAM framework for both research and commercial usage, which aims to monitor construction progress and performance in a unified framework. Through this platform, users can improve the accuracy of the SLAM by providing a rough 3D model of the environment. MB-SLAM further boosts the application to practical usage of the SLAM.

Keywords : perspective alignment, progress monitoring, slam, stereo matching.
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