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A fast twin modelling method for earthquake AR scenes with multi-sensor perceptual enhancement

Jigang You [a,b], Jun Zhu [a,*], Emmanuel Stefanakis [b], Pei Dang [a]

[a] *Faculty of Geosciences and Engineering, Southwest Jiaotong University, Chengdu 611756, China, Jigang You – jigang.you@ucalgary.ca, Jun Zhu - zhujun@swjtu.edu.cn, Pei Dang - dangpei@my.swjtu.edu.cn*
[b] *Department of Geomatics Engineering, Schulich School of Engineering, University of Calgary, Calgary, AB T2N 1N4, Canada, Emmanuel Stefanakis - emmanuel.stefanakis@ucalgary.ca*

* Corresponding author

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Abstract:

Rapid, accurate, and comprehensive perception of disaster site environments is essential for supporting scientific decision-making in disaster assessment, rescue planning, and the deployment and command of rescue forces. However, the dynamic and complex conditions of earthquake sites, including cloud cover, rain, fog, nighttime, and spatial occlusion, pose significant challenges for single-sensor modalities. These factors often result in incomplete information, reduced modeling accuracy, low efficiency, and limited perception capabilities.

To address these challenges, this study proposes a multi-source perception-enhanced twin modeling method for earthquake AR scenes. It begins with a comprehensive analysis of the complementarity, consistency, and heterogeneous correlations among multiple data sources, such as visible light, thermal infrared, and depth information. A perception data coordination framework is constructed, featuring time-pose-driven matching, structured representation of multimodal keyframe groups, and efficient multi-dimensional indexing-based scheduling. In addition, a spatiotemporal-semantic-constrained method is proposed for rapid modeling of dynamic AR scenes. An intelligent rescue terminal prototype is developed by integrating voice interaction and mixed reality technologies, and the prototype system is applied in a case study at an earthquake drill center.

Experimental results demonstrate that the proposed method significantly improves the efficiency of AR dynamic scene modeling while maintaining high registration accuracy. It overcomes spatiotemporal limitations in earthquake site perception and enhances the depth, coverage, and responsiveness of disaster scene understanding.

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