A SPATIAL-TEMPORAL INFORMATION MODEL FOR CONSTRUCTION PLANNING

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Abstract

Construction site is a dynamic environment in which workspaces of construction activities, layout of temporary facilities, and material deployment continuously change in space and time throughout the entire life of a project. The dynamic objects on site interact with each other and site surroundings in a complex spatial-temporal manner. It is critical to consider spatial-temporal relationships between site objects at the pre-construction planning phase, otherwise conflicts or improper layout may frequently occur on site and influence the success of a project.

Four dimensional (3D+time) modeling technique has been proven to be useful and promising in pre-construction planning. It aims to augment and integrate traditional planning aids such as 2D/3D drawings and Critical Path Method (CPM) schedules. However, the current 4D modeling methods take great effort to create the model that mainly serves as a post-planning review tool, focusing on product visualization, predefined attribute analysis, and specific space conflict detection. They usually lack the capability to represent dynamic workspaces, conduct 4D analyses, and automate or facilitate the automation of model creation tasks.

This research aims at understanding the dynamic interaction between site objects by creating a Spatial Temporal Information Model (STIM) for construction planning with dynamic representation, analytical, and convenient modeling capabilities to address the above mentioned issues. Firstly, the newly created model employs a flexible workspace generating and adjustment method to represent the dynamic workspace for each activity, considering labor's comfortable working ranges and workspace evolvement. Secondly, a 4D construction topology framework is created to support 4D construction topological analysis considering the dynamic workspaces. It includes a generic representation to describe 4D topological relationships in general and a Topology Categorization Method (TCM) to facilitate 4D topological analysis for specific planning tasks. Lastly, a Spatial Temporal Referencing System (STRS) is created to implement the construction 4D topology framework and as a platform for inputting, indexing, and analyzing 4D information. The inputting method of STRS, a Graphical Planning Method (GPM), facilitates the 4D modeling process that synergizes 4D modeling into CPM scheduling and provides analytical assistance. The indexing method of STRS, an Octree-based Indexing Method (OIM), combined with the corresponding analyzing method, improve the efficiency of 4D topological analysis.

A prototype of STIM is developed and validated based on a case study. The prototype is tested in its capability of 4D modeling, dynamic workspace representation, and construction 4D analyses. The 4D analyses cover three typical construction planning tasks including space time conflict detection, crane position testing, and hazardous area management. It is validated that STIM can be implemented and assist

in construction planning tasks. The results demonstrated great potential of STIM to serve as an analytical 4D model for construction planning.

This study brings contributions in three aspects: a) it better captures and represents the construction site dynamics; b) it enhances the analytical capability by supporting 4D topological analysis; and c) it improves the 4D modeling process. With STIM, dynamic as-build drawings with both product and workspace information can be generated at any required time point to serve as an effective communication tool; and a 4D model is no longer just a post-planning review tool, but able to support the initial pre-construction planning with analytical capabilities.