Project Title:	Development of an Automatic Image Collection and Analysis System for Improving Onsite Construction Productivity
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Subject Area:	Construction Productivity

Objective

- To develop techniques of efficient summary and storage of construction videos from onsite monitoring system;
- To develop techniques for obtaining macro project progress using images from onsite surveillance cameras or ad hoc images from hand-held devices;
- To develop techniques for obtaining micro project progress in a construction task using images obtained at workface; and
- To develop techniques for trajectory-based activities analysis using videos from far-field surveillance cameras.

Background

Images and videos are the most useful information to assist construction management and they are ubiquitous and inexpensive. Existing studies on productivity improvement in construction management using videos and images focus on three aspects: at workface, on-site but away from the workface, and off-site. Traditionally, construction managers collect construction videos and images at workface and analyse these data manually but the closed-circuit television (CCTV) systems are widely used on the construction sites in recent years. The collected videos and images can be used for off-site information analysis. Some computer vision techniques have been used to automatically generate essential project information, measure, and visualize project progress, and analyse construction activities. Some researchers find that using automatic image and video processing will save up to 60% human effort in construction documentation. After reviewing and comparing the existing work, this research focused on four applications: construction project information management, macro and micro progress tracking, and activity tracking to maximize the utilization of construction videos and images collected from various sources and to indirectly improve future productivity.

Methodology

Video summary

First, effective image features were extracted from frames after analyzing the content of each frame. Then, scene boundary detection was accomplished by locating the abrupt changes in frames after measuring the difference of a single feature or multiple features of two successive frames. The operation was based on the principle that the contents in two successive scenes largely differ from each other. Finally, key frames were detected in each scene. The key frames can be used to form a concise project image/video dataset for easy storage, browsing and query.

Macro project progress detection

First, key points were detected from each image after analyzing its content. Then, the correspondences between two images were established by matching features which were calculated to describe the extracted key points. Finally, homography between two images was estimated using the obtained

correspondences. The differences (progress information) between two images could be visualized by aligning two images by using the estimated homography.

Micro project progress detection

The images/videos of major construction tasks at workface could be used to tracking micro project progress of the construction tasks. Comparing with macro project progress, micro project progress focused on measuring the substantial output of one construction task. According to the different characteristics (shape, colour, and texture) of image regions, which display completed work, three micro-progress measurement methods were adopted (Fig I). Using these three methods, the completed work regions were extracted by using flat image region detection, line segment detection and edge-based patch detection algorithms, respectively. The micro project progress could be measured in different construction tasks using a suitable method.

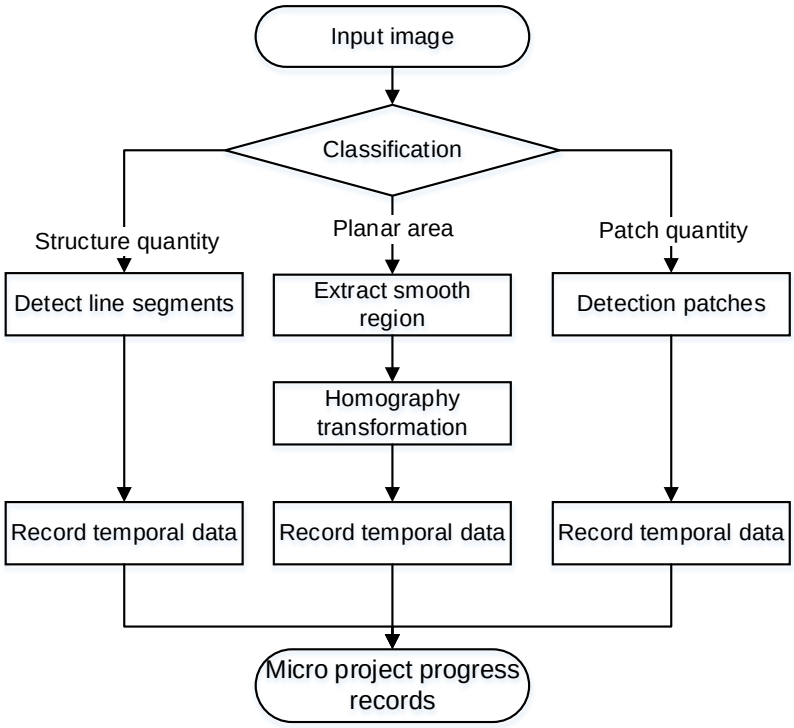

Fig. I Flowchart of micro project progress measurement

Work activity tracking at jobsite

Computer techniques could be used to detect and track the moving subjects at the jobsite from the input videos. The tracking results, i.e., the spatial and temporal information of working entities, are stored. By working with object recognition method, some on-site static entities could be detected when the clear profiles of on-site entities could be obtained from videos. Finally, the trajectories could be clustered based on the site space knowledge. Time utilization of entities and spatial utilization information (e.g., working spots) were analyzed to obtain the activity information. This resulting information could provide a guide for the future productivity analysis.

Results and Findings

- The developed new video summary method in this research performs well in video content condensing. The condensed video content could be effectively browsed in different displays.
- The developed macro project process could identify the major project components (e.g. steel structure and concrete structure) between two days using modified image registration method.
- The developed micro project process in this study could provide acceptable progress measurement results, which show that the methods were effective in assisting on-site quantity surveyors.
- The trajectories of multiple objects tracking were used for activity classification and site utilization analysis, specifically for work hot spots analysis in a selected case. According to the trajectories and hot spots detection results, two activities existed in the test site. The time utilization of each activity can be analyzed as well. This application can assist temporal site and resource utilization when the activities are not executed.

Recommendations

The preliminary case studies show that the prototype of the construction activity analysis system may be further developed for detailed micro-level productivity study. The system may be used in automatic construction activity sampling and generate detailed information about work time utilization of the selected target. This would benefit the evaluation of the efficiency of individual construction elements and the analysis of collaboration of different construction elements, and identify the factors that affect construction productivity. The system can also be used in monitoring spatial and temporal utilization of a construction site by tracking the activities on a construction site. This would benefit the optimization of site layout for temporary resources.

The proposed research components are currently standalone applications and focus on the research gaps of existing studies. Therefore, the future work is to integrate the results of these components and other research work to provide a more comprehensive construction video analysis system, which will facilitate construction communication and management.