Automated progress measurement and management in construction: variables for theory and implementation

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Cost, schedule, and quality are the three major performance indicators for construction organizations and projects. Monitoring these three indicators provides the managers with valuable information in terms of 'current status', 'corrective countermeasure', and 'forecast of future risks'. Among the three indicators, the cost and schedule functions are closely interrelated as they share common data in their controlling processes, and the progress serves as a common basis for analyzing the performances. However, the managerial effort (or workload) required to acquire and maintain detailed progress data has been the major barrier to practical implementation.

Although recent advances in data acquisition technologies (DATs) provide solutions to this barrier, to date, there has been no research addressing a comprehensive framework to implement effective automated progress measurement and management (APMM). Previous research in this area has mainly focused on limited construction tasks or limited functions, and still in the initial stage requiring further development. In this context, this paper aims to propose a comprehensive APMM framework that will enhance the practicability by automating throughout progress planning, controlling and reusing processes.

One of the key issues of performance measurement in construction is the perspective whether it is measured from a project level or an organization level. Based on an extensive literature review, thirteen construction performance measures (with various sub-measures) categorized within three different perspectives (with sub-perspectives) are identified and summarized in this paper. It is inferred that cost, schedule, quality, and value are most often used measures and contributes as an information bridge to all other construction performance measures. Again, among these four measures, the cost and schedule are closely inter-related and share a lot of common data. The progress (earned value, or budgeted cost for work performed, BCWP) is used as a baseline to which the planned schedule and the actual cost are compared in order to measure the schedule performance and cost performance, respectively. This fact supports the rationale behind choosing the progress as being the most promising area for the automated construction performance measurement systems.

Variables for automated progress measurement can be identified by the major processes across the management cycle including planning (C1), controlling (C2), and reusing (C3). The processes for APMM along with this cycle consist of formulating measurement packages (M1), choosing measurement methods for each package (M2), applying appropriate measurement algorithm (M3), and utilizing measurement DAT for each package (M4) as fully discussed in Jung and Kang (2007).
To reuse the historical database for future projects, an automated adjustment (Jung 2008) mechanism (M5) needs to be incorporated within the processes. These five APMM mechanisms (M1 through M5) allocated onto the management cycle (C1 through C3) are then viewed from three levels of perspective (P1 through P3). This comprehensive framework illustrates the components of APMM as well as the full usage of APMM results within a broader managerial value chain in the construction industry. One additional perspective of advanced cost and schedule control (E1 through E7) is investigated as well in order to explore detail topics for the five mechanisms (M1 through M5) of APMM.

Thorough literature review was performed in order to examine current research efforts for every single variable. It is found that previous research in relation to APMM has been mostly focused on the algorithms and DATs (M3 & M4) only for limited construction tasks or DATs. No research was performed in the areas of automated measurement methods (M2) (e.g. automated earned value). Automated planning (C1:M1) and reusing (C3:M5) were investigated in limited studies, therefore these are the necessary areas for future APMM research. Comprehensiveness encompassing all construction tasks is recommended in order to effectively enhance the practicability of APMM. Incorporating semi-automation would also be required to boost the economic feasibility of APMM.

Research team of the authors now actively participates in the packages and adjustment areas (M1 & M5) for real-world projects and recognizes the significant importance of practical algorithms and DATs (M3 & M4) for better integrated progress management systems. It is strongly believed that this integration would mutually foster the APMM theory and implementation.

References
