Activity-Level Construction Progress Monitoring and Worker Productivity Assessment Using Visual Data

Monitoring construction progress and productivity is critical for successful project delivery, yet current practices remain labour-intensive and often provide limited insight at the activity and crew levels. This research presents an computer-vision-based approach that automates both activity-level progress monitoring and crew productivity analysis using images, videos, and Building Information Modeling (BIM).

The first contribution introduces the Activity Level Progress Monitoring System (ALPMS), which enables automated monitoring of construction progress at the schedule-activity level (e.g., formwork, reinforcement, concreting). The system integrates site imagery with four-dimensional BIM to create a Digital Twin environment. As-built point clouds are generated from images and compared with as-planned BIM models, while deep-learning-based semantic segmentation enables activity-wise progress reasoning. This approach produces detailed completion percentages rather than binary built/not-built outputs and supports three-dimensional visualization of progress. Additionally, a schedule-alignment method automatically maps reality models to project schedules by combining 3D alignment, point-cloud segmentation, and natural-language processing to extract and match task, location, and element information. Validation on real construction projects demonstrates less than 6% mean absolute error in activity-level progress estimation and promising performance in automatic schedule updating.

The second contribution focuses on improving labour productivity analysis through a Computer Vision-based Crew Balance Chart (CV-CBC) generation. The framework automates CBC generation from construction site videos via activity definition, dataset preparation, activity recognition model development, inference, and validation. Activity predictions are aggregated into Crew-Based Work Sampling metrics and categorized into Value-Adding, Non-Value-Adding, and Necessary Non-Value-Adding work. Evaluation on masonry operations shows a macro-F1 score of 0.54 across four activity classes and 60% CBC accuracy when compared with manually prepared charts, demonstrating the feasibility of scalable crew-level monitoring.

These contributions provide vision-based solutions for automated progress tracking and productivity assessment at both activity and crew levels. The proposed methods enhance schedule management, enable data-driven decision-making, and offer a scalable pathway toward improved efficiency and performance in construction projects.

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Dr. Aritra Pal is an assistant professor in the Department of Civil Engineering at the Indian Institute of Technology Madras. He holds a Ph.D. in Civil Engineering, specializing in Construction Automation, from National Taiwan University, where he was honored with the Dean's Award for exceptional academic achievement. Before joining IIT Madras, Dr. Pal worked as a postdoctoral research fellow at the University of Cambridge and National Taiwan University. His research focuses on harnessing advanced technologies such as Artificial Intelligence (AI), Machine Learning (ML), digital twin, and building information management to address complex challenges in construction engineering. Through his work, he strives to enhance the efficiency of construction projects and promote sustainability in the built environment. Dr. Pal also brings valuable industry experience, having managed large-scale construction projects across India and the Middle East. In addition, he actively contributes to his field by publishing his research in prestigious journals and conferences and serving as a reviewer for renowned publications.

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