Interdisciplinary research leads to reduced construction costs and multiple awards

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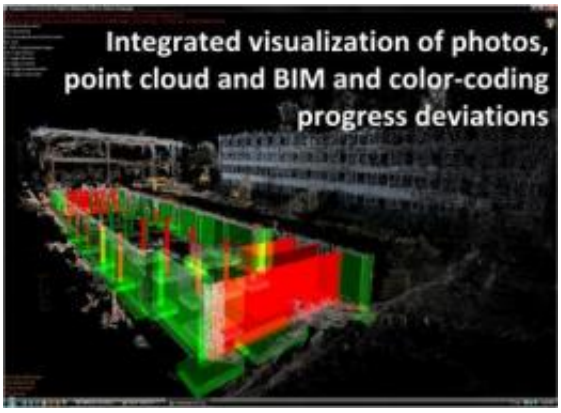

This image shows the integrated visualization of photos taken at the construction site, and the color coding allows someone monitoring the progress to understand where performance deviations may be occurring. Credit: Virginia Tech

Mani Golparvar-Fard, an assistant professor of civil and environmental engineering at Virginia Tech, has developed an augmented reality modeling system that automatically analyzes physical progress on large-scale construction projects. The system allows a contractor to determine whether a project is on, ahead, or behind schedule, leading to cost savings and reduction in project delivery time.

Without the need for a Global Positioning System (GPS) or any other location tracking technology, the modeling system, named the 4 Dimensional Augmented Reality or D4AR, is able to geo-spatially store

digital pictures of a building in 4D (3D plus time) and integrates the photos with Building Information Models (BIM) during any and all phases of construction.

With the widespread popularity of digital photography, on-site pictorial recordings of construction projects have become a daily part of the building process. Field engineers might take around 250 pictures per day providing a wealth of visual information.

However, the challenge remained as to how to automatically determine the three dimensional geometry of the construction site from the unordered and uncalibrated collection of images, Golparvar-Fard said. Furthermore the images needed to be accurately registered with BIM in a common three dimensional environment, allowing performance of the project in forms of physical progress, cost, and delivery time to be systematically analyzed.

Golparvar-Fard achieved this caching in his method by reconstructing as-built 4D point cloud models from the unordered daily site photographs, and comparing the reconstructed models with BIM using a new computer vision and machine learning based method.

The augmented reality system developed by Golparvar-Fard also gives the construction industry the ability to automate and remotely monitor the safety, quality, and site layout. His modeling environment allows the "integrated visualization of as-built and as-planned models," he explained.

With the D4AR models, any user is able to load their digital photo logs for a specific building, reconstruct a 3D scene, and navigate through the pictures by location and time. The D4AR models also provide users with the unique ability to organize and integrate their daily construction images with BIM and project schedule, and interactively browse through

the geospatial configuration, saving time and delivery time.

At the 2012 Construction Research Congress, Golparvar-Fard received the award for best journal paper from the American Society for Civil Engineers' *Journal of Construction Engineering and Management* for his work on D4AR. During the same event, Golparvar-Fard along with graduate student Andrey Dimitrov and Feniosky Peña-Mora, dean of engineering and applied science at Columbia University, received the Best Poster Award for their poster, "Robust Material Recognition for Automated Generation of Building Information Models from Unordered Site Image Collections."

Dimitrov is a computer science master's student and a Ph.D. candidate in civil engineering and engineering mechanics at Columbia University, under the supervision of Golparvar-Fard and Peña-Mora.

D4AR provides new possibilities for the construction industry, including evidence for dispute resolution, safety inspection measures, progress evaluation and analysis, and even faster, more accurate as-built versus as-planned evaluation.

Golparvar-Fard is commercializing the D4AR tool through a spinoff company he started with Peña-Mora and Silvio Savarese of the University of Michigan- Ann Arbor. The D4AR modeling system is currently being tested by Turner Construction with the World Trade Center and several other high profile construction projects. Turner and the National Science Foundation helped fund the research.

Golparvar-Fard is also expanding this modeling method to other areas of research from rapid energy performance modeling of existing buildings to structural stability analysis.

Golparvar-Fard began his work on the D4AR modeling as a graduate

student in 2007 at the University of Illinois at Urbana-Champaign when he superimpose a three dimensional building information model over time lapsed images and used a metaphor based on traffic light colors to represent performance deviations.

Provided by Virginia Tech