Image-based As-Built Site Documentation and Analysis - Applications and Challenges

Stefan Kluckner, Juergen Hatzl, Manfred Klopschitz, Jean-Séverin Morard
Christof Hoppe, Stefanie Zollmann, Horst Bischof, Gerhard Reitmayr

Siemens Corporate Technology, Video Analytics, Austria, Graz
Institute for Computer Graphics and Vision, Graz University of Technology, Austria

Abstract. Documenting and analyzing the progress made at a site of interest like rapidly changing construction sites, automatically comparing the current status with the corresponding as-planned status and automatically controlling affected supply chains has long been a dream for developers and planners. Due to recent developments in digital sensor technology and computer vision, image-based data can be massively exploited to make this dream come true. In particular the maturity of deriving 3D information from overlapping image material supports the highly automated understanding and analysis of observed sites. In the context of construction site monitoring we present an entire processing chain that considers an optimal image acquisition strategy, 3D+time data generation as well as interactive analysis and visualization techniques. We will discuss mature parts of our image-based processing chain, but also highlight the challenges of applications using highly-automated as-built documentation.

Overview

To get towards highly automated image-based site documentation and analysis there is first of all a need to acquire every relevant spot at the site of interest. Flexible remote-controlled sensor platforms, like UAVs, cameras mounted on cranes or permanently installed camera networks, enable the acquisition of raw image data that can be used to create and enrich site information. In particular, overlapping imagery enables the accurate computation of 3D scene information by means of stereoscopic approaches. Relating this 3D data over time yields 4D observations, composed of color, texture, geometry over time, and largely supports automated methods towards full scene understanding and the acquisition of both the change and the construction site's progress. Four-dimensional information usually consists of time-dependent 3D reconstructions that are aligned within a canonical coordinate system, whereas the relevant timestamps could be defined milestones within a workflow project management, but also of dates that are sampled on a regular basis.

Having the models aligned within a common coordinate system further helps to overlay construction site plans and available geo-data, enabling the detection of significant deviations as the work on the site is progressing but also to enrich

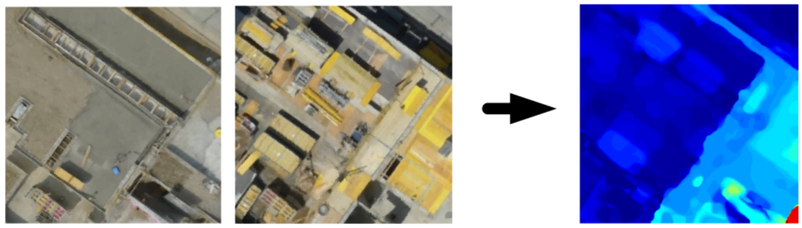

Fig. 1. Automated detection of change from deviant geometry within virtual orthographic views. The views are derived from 3D models generated at two different timestamps. Warm colors denote high progress made over time.

the collected raw data with semantics at different levels of detail or to precisely superimposes the plans on the current images with augmented reality technology. Figure 1 demonstrates a derived virtual orthographic view onto one of our showcase construction sites located in Graz. For each timestamp a number of approximately 250 images were collected and automatically processed with our photogrammetric workflow. The models are aligned within a common coordinate system and the deviations in geometry describe the progress made over time. Having such knowledge about the observed site helps to improve the supervision of contractor achievements, detection of schedule derivations and supports the search of sources of defects and parties in charge. Reliable progress documentation methods then support developers to monitoring sites easier, understanding underlying processes better and managing logistics and resource planning more efficiently.

In the presentation we discuss the core parts of our processing chain for highly-automated site documentation and analysis by taking into account acquired image-based data as well as the requirements defined by costumers. We first highlight the issues of an optimal flight management that is necessary to provide a set of images with sufficient overlap for efficient and reliable 3D model generation. Further, we elaborate on accurate, but highly automated model alignment within a defined coordinate system and the overlay of additional input sources like vector-based data. We present implemented techniques for analysis such as efficient change detection, augmentation and visualization. Finally, we summarize the challenges and future scenarios.

Acknowledgements This work is supported by Siemens AG Austria and the Austrian Research Promotion Agency (FFG) FIT-IT project Construct (830035).

Contact

Siemens AG Austria, Corporate Technology
Dr. Stefan Kluckner, stefan.kluckner@siemens.com
Strassgangerstrasse 315, 8054 Graz