< Monitoring large construction sites from the air with cameras and laser scanners supports optimal planning and documentation of construction projects.

GROUP **LASER SCANNING**

Construction progress: Aerial capture and automated analysis

Major construction sites have a lot going on, with large quantities of materials and objects moved around daily. A laser scanner developed by Fraunhofer IPM for STRABAG AG captures road construction sites from the air to document these changes. The 3D data obtained are automatically analyzed with specially designed software.

Monitoring and documenting project progress at major construction sites is important for providers of construction services such as STRABAG AG. Project managers in the construction industry are increasingly using digital data and special software for this purpose. These form the basis for what is known as Building Information Modeling (BIM), which helps with the optimal planning and implementation of construction projects.

Drones equipped with cameras have been in use for quite some time at major construction sites, such as traffic route construction, to document the status of the project. They fly over the area every few days and deliver a wealth of information including the position and size of asphalt and gravel surfaces, guardrails, curbs, manhole covers or trees as well as the stock and storage location of construction materials and equipment. At present, the 3D data computed from camera images is »manually« analyzed, that is, through visual inspection. A joint project of STRABAG and Fraunhofer IPM is aimed at making this process more efficient.

The challenge: Accurate recognition of objects in 3D point clouds

A measurement system developed by Fraunhofer IPM, which uses a laser scanner in addition to cameras, is installed on a UAV (unmanned aerial vehicle) platform and directly delivers a georeferenced 3D point cloud as well as camera data. The eye-safe measurement system weighs only two kilograms and can capture an area of several hundred square meters in less than ten minutes. The laser scanner generates up to 60 profiles per second with 1000 measuring points each perpendicular to the flight path. The precision of a single point measurement is approximately 1 cm.

The 3D data generated by the scanner offers two major advantages. Unlike camera images, the measuring beams penetrate vegetation, so that even ground points under trees or shrubs can be captured. In addition, this approach eliminates unwanted shadow effects, which are unavoidable with camera-only systems. Moreover, the 3D point clouds generated by the scanner with RGB information from the images provide the best basis for an automated analysis of the measured data. Until now, this process has been akin to that of »paint by numbers«: the 3D point cloud is analyzed by manually extracting objects. In the future, the process of data interpretation is expected to be taken over by specially designed learning algorithms that work on the principle of »deep learning« based on artificial neural networks (ANN). In its basic state, such an ANN resembles a crude network of artificial neural connections. The ANN is prepared for the eventual task of classification with a specially generated training dataset, as only known objects can be reliably identified.

TRAINING DATASET FOR ARTIFICIAL NEURAL NETWORKS (ANN): To create a training dataset, thousands of datasets containing the prototypical elements of a construction site scenario are manually annotated. All the border areas of a relevant object, a streetlight or a tree for instance, are marked down to the pixel. This creates prototypical polygon faces that are assigned to predefined object classes. These annotated faces serve as input patterns for the ANN and later recognize geometry, color and other descriptive parameters to create the associated output pattern, i.e. a specific object class. Fraunhofer IPM has developed a software tool for data annotation, which makes this process efficient.

Classified 3D model of the construction site

Apart from training the ANN, the other prerequisite for automated data analysis is the appropriate preparation of input data. The intelligent fusion of camera and scanner data forms the ideal data pool. The camera data plug any gaps in the 3D point cloud and provide additional color information, while depth information from the 3D point cloud enables, for example, better differentiation of overlapping objects than would have been possible with the help of camera data alone. A framework developed by Fraunhofer IPM projects the scanner data accurately and precisely onto the images of the color camera. This way each RGB image of the scene is assigned a corresponding depth channel. The RGB-D(epth) data prepared in this manner along with a trained network make the data analysis very robust to object variations and changes in view angles and light conditions. And that is critical, as no two construction sites are alike and no measurements are made in a controlled environment. Project partner STRABAG will get an executable software package that creates classified datasets in the industry-standard LAS format, which, if required, can be linked to other data such as BIM or CAD data. This creates the digital data that form the basis for the efficient management of large construction projects.

Ready for take-off: A STRABAG employee gets the drone ready to go. The data recorded are later automatically analyzed.

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