Focus Digital 3D models

Digging in progress: Underground structural elements can now be recorded digitally for documentation purposes.

Our AI-based system generates georeferenced data required for documenting underground infrastructure.

Excavators have been let loose on the streets of Germany, with roads and pavements everywhere being dug up so that fiber-optic cables can be installed and pipelines can be upgraded. Once the job has been done, the ground is covered back over and nobody has any idea what has been installed where or how deep in the ground it is. What are the potential consequences? Regular power outages, disrupted internet connections and even gas explosions in the worst case scenario – and all because cables and pipelines are accidentally damaged by excavators at work. None of this would be a problem if the underground infrastructure were documented with careful precision. To this day, the location of structural elements underground tends to be roughly sketched by hand and entered manually into a geographic information system (GIS). This whole process is time-consuming and the information is often incomplete because details on depth in particular are not documented in full.

Mobile data collection with low-cost sensors

Fraunhofer IPM has worked in partnership with grid operator Bayernwerk Netz GmbH to develop a tool for creating a 3D digital picture of excavated areas, ensuring that all the information can be documented accurately and efficiently. A standard tablet is used to collect data and the TrenchLog software developed internally at the institute takes care of automated data analysis. The whole process is straightforward and doesn't require any specialist knowledge. The person conducting the survey holds the tablet and takes photos as he or she walks along the excavated area. Those images will later be used to generate a 3D point cloud. Equipped with a commercially available stereo camera system and an inertial sensor, the device accurately records data with a tolerance of 20 centimeters over a distance of 50 meters. A visual SLAM (simultaneous localization and mapping) algorithm is used for 3D reconstruction, ensuring that all data streams can be used in combination as effectively as possible. During the development phase, the team tested out the system in an excavated area on the institute's own site.

Control points for georeferencing

The measurement data is linked to the global navigation satellite system (GNSS). When it comes to georeferencing, the fact that the surfaces of cables and pipes are more or less all the same makes it difficult to identify individual reference points. With that problem in mind, the team relies on their own weather-resistant control points, which they temporarily attach to building walls and junction boxes. These reference points are included in the measurements, meaning that position measurement can be accurate to within a few centimeters. And they serve another purpose. Pipelines are often installed in long stretches, but it's not always possible to measure excavated areas spanning meters and meters in one go. Measuring in installments can be confusing, but sections can be overlapped when being documented if additional control points are put in place. The measurement data can then be collated to create one continuous image at a later stage.

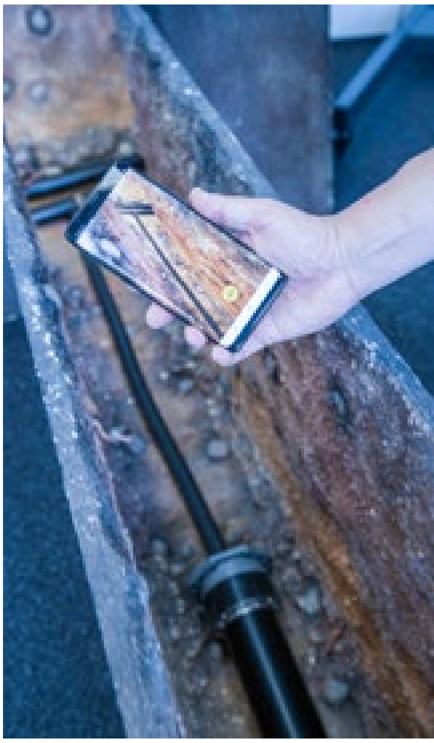
Automatic detection of typical structural elements

If structural elements are to be documented properly, the type and quantity needs to be recorded alongside the location of cables, pipes and connectors underground. The TrenchLog software tool can pick these objects out of the measurement data and count them as soon as the data has been collected. This is possible because a deep learning algorithm was trained with previously defined types of objects, including pipelines and cables with different diameters and all kinds of connectors. The algorithm is part of an artificial neural network that has been trained with a comprehensive data set featuring relevant images. New elements can be added to that data set, depending on what needs to be documented.

A set of heuristics is applied to the data to reduce the number of image recognition errors. Data storage also needs to be optimized for the collection and analysis processes to run smoothly. For example, the point cloud is reduced to a fixed minimum distance between points to reduce the volume of data. Areas that overlap in images are not analyzed to speed up the process.

Visualization and image correction

The fact that the tool is easy to use also comes down to the clear presentation of the measurement data. The team developed a visualization component to ensure an undistorted 3D reconstruction based on the point cloud. The intuitive user interface allows for plausibility checks, manual corrections and data uploads to the cloud. This system is designed to cover stretches of up to 50 meters. And every meter counts on the journey to fully document thousands upon thousands of kilometers of trenches containing underground pipelines and cables that are excavated and covered over again through the years.



As simple as that: Data is collected using a standard mobile device. No specific prior knowledge is required to get the job done.

> "We're seeing power and fiber-optic networks being expanded up a lot at the moment. Our tool helps by making 3D mapping efficient."

Dr. Christoph Werner, Group Manager