How to Create Sophisticated 3D Outputs

Explore the Infinite Possibilities of Your Point Cloud Data

Dr. Alexander Christ, Oberursel

In the course of digitalization transformation, 3D scanning and point cloud technologies enable the application of powerful solutions for engineering. They are key-enablers for the successful progress of initiatives like Industrie 4.0 and the digitalization of existing factories and plants, especially when no 2D drawings or CAD models are available. Users can work remotely with the digital representation anywhere and anytime in front of a computer. Modern 3D scanning hardware and software tools allow accurate data processing and accelerate the utilization of point cloud data. The digital twin of existing factories and plants can be used to perform detailed 3D analyses, like collision detection for the removal of old equipment or the installation of new machines. Validation capabilities allow the comparison of scanned facilities (as is) against the original 3D models (as planned). Innovative solutions enable the advanced utilization of point cloud data and the creation of sophisticated 3D outputs.

Point Cloud Handling as Key-enabler for Digitalization

Point clouds describe a discrete amount of three-dimensional sample points of a vector space [2]. The term cloud references the unorganized spatial structure. Point clouds are broadly used in engineering workflows and applications today, e.g., for prototyping or reverse engineering. The initial step for creating point cloud data is to digitize a physical object in the real world. The quality of the resulting point cloud depends on the used digitalization system and its achievable accuracy and tolerances [3]. For the digitalization of mid to large scale objects like buildings, plants, production lines etc., 3D laser scanners are prevalent. The current 3D scanning technology enables the fast capture of physical objects and the creation of precise digital representations.

The integration of metadata allows the specification of plant equipment, pipes, steelwork etc. and the usage in further downstream processes. Sophisticated software tools enable the efficient processing of point cloud data. 3D models can be imported into point clouds to perform 3D simulations or validation and exported from point clouds as collaborative outputs that are used in CAD or BIM (Building Information Modeling) workflows. For the creation of high quality digital twins (see Figure 1), a sufficient point cloud utilization process is required.

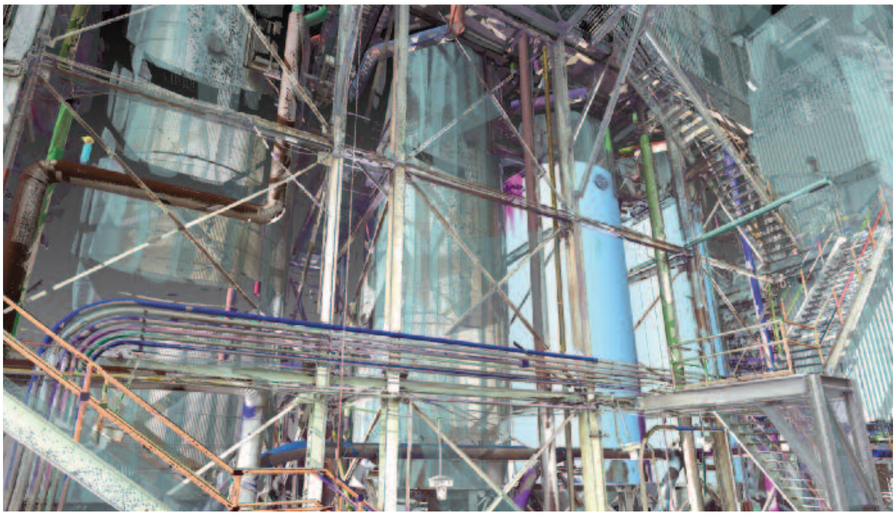

Figure 1: *Digital Twin of an Existing Plant*

Point Cloud Utilization Process

The process of point cloud utilization consists of five steps: data import, data pre-processing, 3D analyses, 3D modeling and the creation of sophisticated outputs.

1. **Data Import**
   The first step after capturing the real, physical objects with 3D laser scanners is the import of the point cloud data into the desired software tool. Usually several scans are required to digitize a complex object and capture a full 360-degree scene. Tripod-type 3D scanners and handheld scanners or a combination of both can be used for the digitalization process. The software tool has to support the import of multiple scan data formats including raw scanner data and the viewing of large scale point clouds with billions of points.

2. **Data Pre-processing**
   The second step is the scan registration. Current solutions enable a markerless automatic registration of different scans and an automatic noise reduction. This allows a 3D scanning process during ongoing operation. Kinetic noise from moving objects like transportation vehicles or workers on shop floor level can automatically be identified in the point cloud, isolated and removed. Noise reduction also covers the removal of overlapping noise resulting from different capture views on the same object and reflections. For viewing scenarios and a better performance, a reduction of the total number of points and the size of the point cloud can be achieved.

3. **3D Analyses**
   3D analyses contain precise digital measurement, validation of CAD/BIM with point cloud data and real time collision detection. Extraction of planes and cylinders enables a precise measurement in a digital environment. Higher quality of measurement is achieved by using dedicated references, like center lines of pipes or averaged planes, instead of picking arbitrary points. This saves time as it allows to replace on-site measurements and reduces the risk of missing/wrong measurements in the real world by unexperienced staff as well as the risk of physical injuries. For validation purposes, CAD/BIM models can be overlaid with point cloud data to check the deviation against the concept design, degradation over the years etc. For installation and removal simulation, real time interference checks are applied. 3D CAD models of machines, equipment etc. are moved along a defined path through the point cloud and collisions are highlighted in real time (see Figure 2). The CAD model path movement can be saved as video and shared with stakeholders beyond engineering.

4. **3D Modeling**
   The most important capabilities for the creation of sophisticated outputs are provided within 3D modeling. It is the major step for creating precise and reliable digital twins that are utilized in further Industrie 4.0 processes. Similar to CAD systems, layers are used for isolation of scanned objects and classification of point cloud areas. Advanced software solutions allow the automated extraction of planes and cylinders, which can be used for 3D modeling of pipes, ducts and steel structure based on point clouds. The integration of standards including pipes and steel beams facilitates the usability.

5. **Collaborative Outputs**
   For engineering use cases, collaborative outputs focus on the export of polygon models and precise 3D B-rep models. 2D orthogonal images with reduced scale, but still high precision, are used for 2D CAD drawing creation reference. Standalone viewer files support the distribution of point cloud data to other departments and among stakeholders in project teams without an installation or the license of a point cloud software tool. External links allow even casual users to add notes, comments and hyperlinks on the point cloud to include documents, e.g., PDF, MS Office, XML etc. For marketing and after sales activities, fly-trough videos of the digital twin can be created.

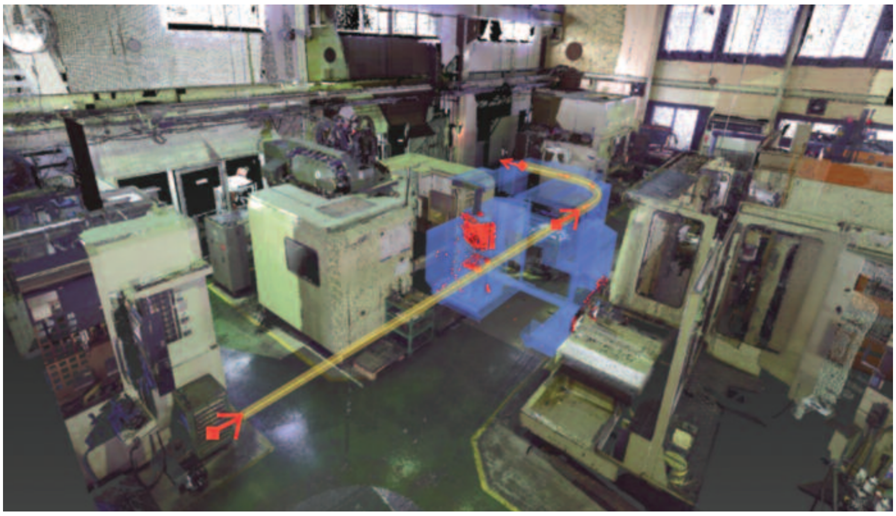

Figure 2: *Collision Detection for Carry-in Route Planning*

Challenges in Point Cloud Handling

Although the technology for point cloud handling has been advanced over the last years and a broad range of tools is available on the market, companies are still facing major challenges and inefficient processing of their point cloud data. In AEC (Architecture, Engineering and Construction) business, improvements from powerful CAD applications have not found entrance into the BIM world. The transition from 3D CAD expertise to BIM is essential to fulfill future engineering and business requirements as a major contribution to digital transformation.

Typical challenges for point cloud handling result from various applications used in individual workflows. Companies often have different workflows with different applications to create similar outputs. The deployment of multiple software packages to handle point cloud data leads to several imports and exports throughout the workflows, implying a high risk of media discontinuities and imposing restrictions on applications and

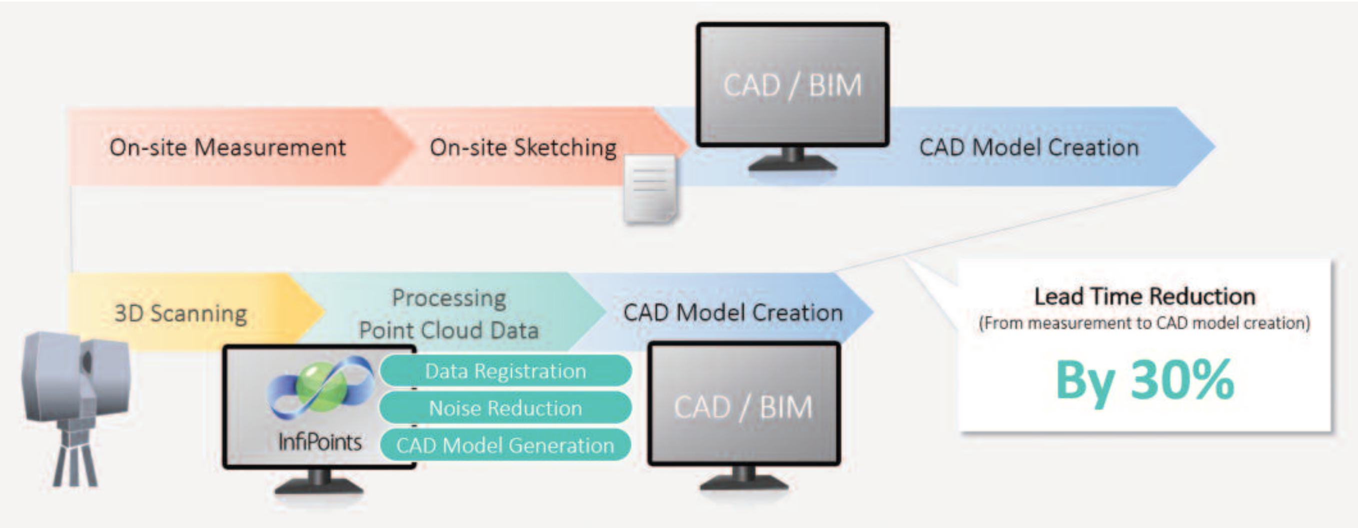

Figure 3: *: Lead Time Reduction through Digitalization*

formats. Today's workflows show high manual effort for registration, noise reduction, modeling etc., which is extremely time consuming and carries risk of human errors and quality issues. As point cloud data can easily exceed GBs of data, performance has always to be considered. Even basic viewing capabilities require appropriate hardware and software. Missing collaboration capabilities prevent the adoption of point cloud utilization by casual user.

Elysium's InfiPoints for Point Cloud Utilization

Elysium's InfiPoints solution covers the entire point cloud utilization process. It supports the import and export of all common point cloud and CAD/BIM formats. InfiPoints provides capabilities to automatically extract planes and cylinders from point clouds, which assists semi-automatic 3D modeling of pipes, ducts and steelwork. Generated CAD models can be exported maintaining parametric information such as length and diameters for further editing in CAD/BIM tools. Sophisticated 3D outputs are achieved by leading-edge technology and a deep mathematical understanding of real world engineering needs.

The performant processing of GBs of data, seamless handling of CAD, BIM and point cloud data in one solution as well as the functionality to structure and classify point clouds form the basis for the creation of digital twins of large scale objects like plants, ships and manufacturing facilities. The one stop solution approach of InfiPoints streamlines the point cloud utilization process. Main benefits are the reduction of manual effort and lead time (see Figure 3) through digitalization, while safeguarding the quality of desired outputs.

Time savings arise from advanced technologies for 3D modeling based on point cloud data. Most companies strive for a fully automated solution, since manua- workflows often take weeks or months. As a return of investment in new software, significant reduction of manual effort is integral. The implementation of industry standards streamlines the deployment of created 3D outputs in further processes. Capabilities to validate the registration accuracy guarantee the quality of generated digital twins, while collision detection allows user to conduct virtual simulation on layout and carry in/out route planning. With the attachment of external links to digitized 3D objects, the point cloud serves as collaboration platform by the provision of all relevant information.

Collaboration within the Digital Twin

For an efficient collaboration with stakeholders within a digital twin, virtual reality (VR) technology [4] is deployed. Elysium's InfiPoints for Oculus integration enables the usage of head-mounted display Oculus Rift [5] to explore digital twins remotely. Multiple users at different locations access the same virtual environment simultaneously to conduct a meeting inside the digital twin (see Figure 4). Main use cases are visualization, virtual inspection and maintenance. Rich functionalities like digital laser pointers and measuring tapes as well as the virtual application of mark ups inside the digital twin facilitate being "virtually on-site."

Contrary to the 2D visualization of 3D models on computer screens, the utilization of VR devices leads to an embracement of users by the point cloud data.

Figure 4: *Point Cloud VR for Collaboration*

Point cloud VR fills the gap between the numerical value and human's physical senses. On top of distance measurement between two objects, users can experience if they can access a dedicated area with their engineering tools. Even with the successful implementation of laser scanners and point cloud software InfiPoints, companies sometimes have been unable to reduce the rework. Intuition and usability provided by point cloud VR were the missing pieces to achieve the desired level of digitalization.

Conclusion

Powerful point cloud software is used in various industries, e.g., plant engineering, manufacturing or shipbuilding. Main benefits are significant reduction of lead time and cost as well as lower risk of duplicate work and improvement of safety. Elysium's one stop solution InfiPoints provides capabilities for data import, pre-processing, 3D analyses, 3D modeling and the creation of collaborative outputs that avoid media discontinuities and streamline the entire point cloud utilization process. Sophisticated 3D outputs bridge the gap between existing facilities and their digital twins. They enable the utilization of point clouds in further engineering processes and CAD/BIM applications. Standalone outputs like fly-through videos and viewer files facilitate point cloud data utilization beyond engineering without the need for licenses or software installations.

Future solutions will address the further utilization of point cloud VR through the enrichment with capabilities for collaboration. Collaboration can be improved by a point cloud server [6] for performant visualization of large point clouds. Point cloud data is stored, processed and rendered on server-site, while several users can access point clouds as clients via a Web service. The integration of sensor (e.g., thermography) and communication data in digital twins leverages collaboration and sharing in real time. A smart, connected factory can communicate an issue in the real world to its digital representation and automatically dispatch a notification to related persons to investigate in the digital twin [1]. Precise point cloud data may be used inside 3D maps to provide accurate position information for AR mobile sensors, contributing to mobility as another main driver for digitalization. ■

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Dr. Alexander Christ
Strategy & Business Development
Elysium Europe S.A.R.L.

E-Mail:
alexander.christ@elysiuminc.com

Contact