

FROM THE TOOLSHED

Extracting infrastructure assets from point clouds



VirtuSurv scans in planar view

The Challenge

For those new to working with point clouds, or for those a bit overwhelmed with the myriad of solutions marketed by software companies, I would like to offer some insight into what I've learned over the years in the industry: particularly, converting point clouds into useable and modifiable computer-aided drafting (CAD) vector formats. This process is also known as 'geometry extraction.'

As a general rule, point cloud modeling/geometry extraction is not a fully automated process with any software platform to date. There are varying levels of sophistication with geometry extraction software and selecting the best solution for firms is dependent upon the goals of the project as well as the budget available.

CAD software and 3rd party plug-in's to CAD are the most common methods for point cloud modeling. To create a

full model extraction from point clouds however, requires a healthy knowledge-base of modeling workflows within the native CAD software of choice. Most 3rd party software provides basic tools to create key geometric primitive features such as lines, surfaces, and basic solids. Anything beyond this complexity is typically handled manually with traditional 3D modeling in the CAD environment.

Further, some of these 3rd party software platforms include a few

BY PAUL TICE

advanced features for creating walls, finding datum, or connecting piping. These platforms may also include a BIM library of pre-modeled components that can be inserted in a semi-automated fashion, depending on the geometry detected in the point clouds by the software algorithms. It is worth noting that while the inclusion of BIM libraries can be extremely useful for the BIM designer/modeler, the accuracy and performance of these advanced vector-creation tools are highly dependent on the quality of the scans (low noise, good resolution, etc.), and will frequently fail if conditions of the point clouds

viewer which can visualize point clouds photorealistically. Coupling these platforms with Bentley Descartes and Pointools Edit software provides users with classification tools, on-the-fly point cloud modeling, and among the best dynamic clipping boxes for point clouds on the market. Bentley CAD systems now include the unique capability for visualizing 2D drawings with 3D models and point clouds simultaneously; a feature called 'Hypermodeling'. Bentley is known for CAD innovation, platform stability and is capable of handling numerous point clouds in one session.

to handle point clouds directly to date, Graphisoft has partnered with CadImage which in recent history, has been developing a solution for point cloud integration. Presently, users can import orthophotos into ArchiCAD generated from point clouds allowing for geometry extraction by tracing scaled images. This capability holds true for most CAD packages on the market as a lightweight, point cloud modeling alternative.

PointCab

Compatible with most CAD platforms on the market. Utilizes orthophoto technology to quickly create 3D models from raster images. PointCab is an interesting innovation and worth a look on YouTube.

“...geometry extraction is not a fully automated process with any software platform to date.”

aren't optimal. A user's familiarity with manual modeling methods in their chosen CAD platform will help compensate for these tool limitations.

Extraction Tools on the Market

There are a wide variety of tools out there that tackle different point cloud modeling problems and cater to various CAD platforms. Here are a few relevant CAD and 3rd party combos that work well with geometry extraction from point clouds, including:

Bentley Systems

MicroStation V8i suites and AECOSim Building Designer: These packages include the Pointools point cloud

Autodesk

Several 3rd party software solutions for point cloud modeling are available for Autodesk products including Scan-to-BIM by IMAGINiT for Revit, and Kubit for both Revit and AutoCAD. These provide users with tools to create orthophotos, model by tracing the planar view of scans, access BIM component libraries, and other functionality. Autodesk has integrated point cloud usage into most of their platforms creating a one-stop-shop for CAD firms.

Graphisoft

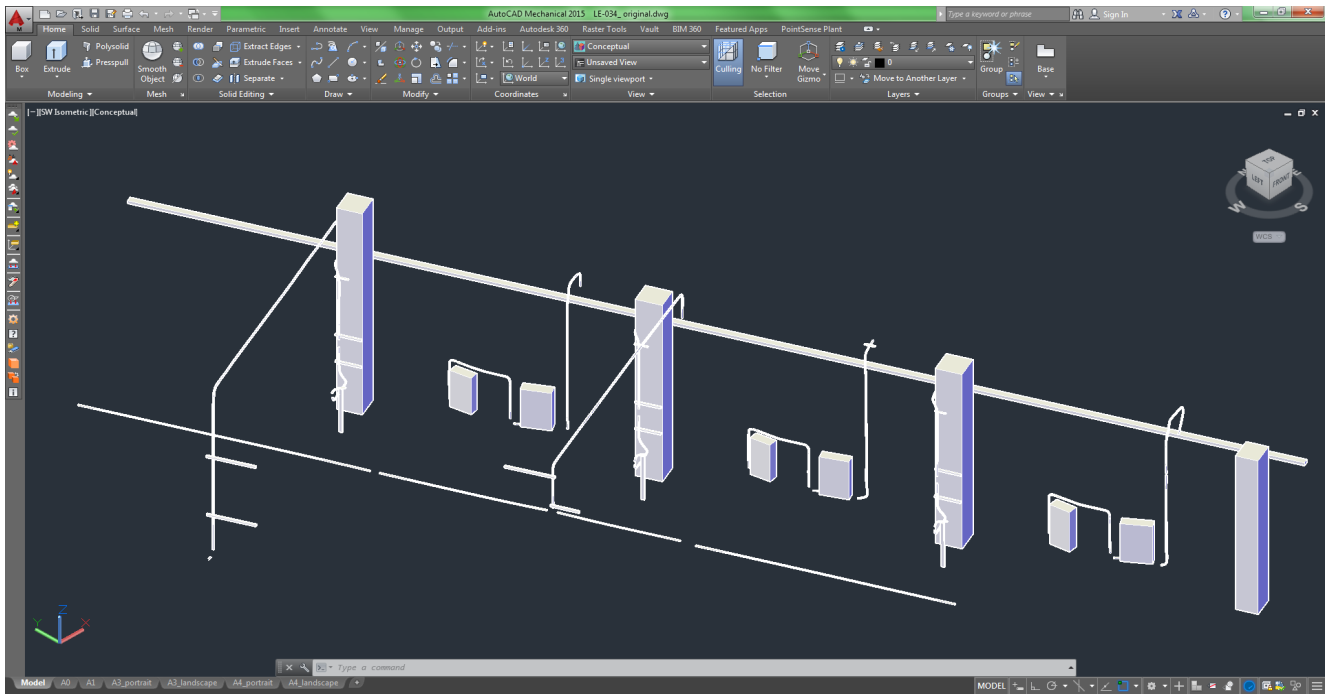
ArchiCAD—an incredibly robust BIM software platform with excellent visualization capabilities. While not yet able

3D Systems

Meshing and component modeling software. This more sophisticated geometry extraction software provides automated meshing capabilities and tools to seal the mesh in a 'watertight' fashion. This software is primarily used in the reverse engineering industry for machined parts, aerospace, entertainment, or with applications such as 3D printing. With a higher cost and learning curve than other geometry extraction solutions, it makes sense that entire companies have been built around this software. Modeling with point cloud meshing software excels in applications involving artifacts and other projects requiring a high level of detail/precision with irregular geometry.

ClearEdge 3D

Excellent pipe extraction algorithms with support for other types of primitive vector extraction such as architectural features. License is on a bucket contract. Users pay fees based on the number of point clouds processed.



AutoCAD 2015 point cloud derived 3D model.

Proprietary Laser Scanner Software

Each laser scanning instrument has accompanying software created by the manufacturer (Riegl, FARO, Leica, et.al.) which usually does a great job at registering, visualizing, and exporting scans to CAD, including some level of limited geometry extraction capabilities.

Open Source

Numerous point cloud extraction scripts—such as can be found on the Point Cloud Library (PCL) website—are available for free. Some of these take some programming skill in C++, Java, or other languages to implement, yet may be a great solution for innovative firms. Meshing software also is available on open source websites but may be somewhat limited to smaller point cloud data-sets.

Please note for the following case study Autodesk products were the standard for this particular contractor.

Electrical Asset Documentation—Case Study

Over the past several months, I have had the privilege to partner with two Oregon firms on a robust scan processing project at a silicon-wafer manufacturing complex. The primary electrical contractor, 'Quality Plus Services' (QPS) was awarded this project in which they were to install electrical systems throughout the complex and later document their installations with 3D laser scanning. These point clouds were then to be modeled in 'vanilla' AutoCAD format and integrated into a master 3D architectural model designed by the overall general building contractor's BIM team.

As their workload increased, QPS turned to tech-temp agency, [Aerotek](#)

to find help with processing (which included modeling) the some 1300+ scans that were coming in from their field technicians. [ToPa 3D](#) was among several contractors found by Aerotek through LinkedIn (social networking works!) and tasked to provide assistance with this project; primarily scan processing and 3D modeling led by QPS project coordinator, Garrett Gordon.

Our team faced a few challenges with this workflow including a learning curve for new technicians added to the team, finding a point cloud-to-model solution and finally, geospatially aligning the electrical system models to the master model.

Once the new recruits had scanning operations and data delivery workflows in place, tackling the geometry extraction was the next step. A modeling solution was required to extract ½" diameter

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conduit from the point clouds and stay within our overall 1" project tolerances. While it is 'possible' to model small conduits and other features directly in AutoCAD, or any other CAD platform for that matter from point clouds (a somewhat tricky chore in itself), it was determined from the project timeline standpoint to find 3rd party software to assist with this job.

Enter, **Kubit**.

Kubit is a robust, relatively inexpensive and easily implemented point cloud modeling solution for extracting basic 3D primitives. Another nice feature of Kubit is that it can also create pre-modeled BIM components with specific, predetermined standards.

Kubit became a great solution for this project in part because smaller conduits and supporting electrical strut features were often highly reflective or occluded by other machinery in the environment, leaving only a fraction of the feature needing to be modeled visible within the point clouds. Automated pipe extraction tools currently on the market would have a very difficult time with these. However, the VirtuSurv module that comes with Kubit's PointSense Plant package allows users to simply trace the planar view photo of the registered point clouds while its linking feature simultaneously creates the vector 3D model primitives in AutoCAD. The simplicity and speed at which accurate 3D models can be created in CAD with these tools are impressive.

As mentioned before, Kubit has a 3D component library feature that allows users to create the exact infrastructure standards to be modeled, allowing Kubit to intelligently place said BIM components based on feature recognition algorithms from the point clouds.

Therefore, users can specify a set diameter pipe or fixture type, simply click twice on the point cloud image in VirtuSurv's planar view, and (with a touch of algorithmic, fairy scan magic) the component feature appears in AutoCAD exactly where it should be.

It should be noted, however that these are tools, and with tools come margins for error. Over time, we have found some tools work really well for certain features to be extracted while others require a slightly different approach depending on the resolution of the scan, noise present and other factors that may confuse the extraction algorithms.

Placing the 3D vector models into the master was a process of rotating the hundreds of individual electrical system models to grid north and then adjusting to the rotation and true elevation of the master BIM model. Finally, the workflow was completed with quality control checks and tracing out the basic primitive models created by Kubit with AutoCAD MEP software and assigning metadata to each system.

With such a large scale coordination effort, it has been remarkable to watch the master model all come together in such a short period of time. This type of precision infrastructure documentation would have taken perhaps years without the tools at our disposal today, rather than the few months we've been on the project. Combining **FARO** products with Autodesk and Kubit tools has proved to be a winning combination from this toolshed; a place we most certainly will be returning to for future projects. ■

Paul Tice is the CEO of ToPa 3D, Inc., specializing in point cloud integration and 3D modeling with CAD systems for the AEC and preservationist industries.