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Deep Learning on 3D Point Clouds

Project Goal

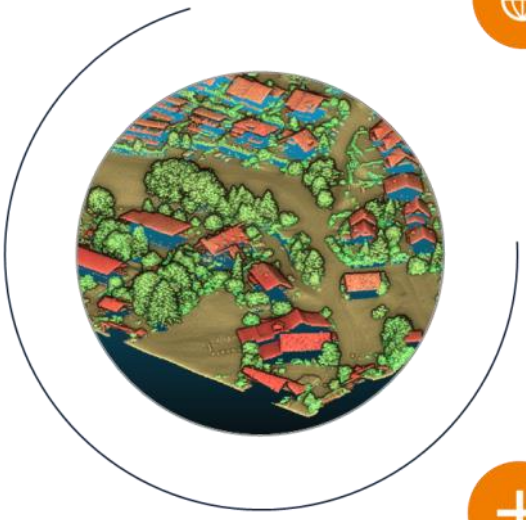
3D point clouds are an enabling technology in the digitalization of many industries. Point clouds allow to precisely represent real world objects and sceneries in a georeferenced digital format. Unlocking the information-richness of 3D point clouds requires additional analysis. Many industries can benefit from automated detection and analysis of specific objects in large 3D scans.

This use case presents a scalable approach that successfully applies neural networks to 3D point clouds to generate an instance segmentation of large scenic point clouds. Detected objects can then be analyzed regarding positions, volumes, sizes, distances, and more.

Dataset Used

For this use case we worked with photogrammetric point clouds generated by our drone flight partner FairFleet. Photogrammetric point clouds are 3D reconstructions from multiple 2D images. Improvements in scanning and drone technology have made them a viable alternative to LiDAR generated point clouds.

The point clouds we analyzed were scans from urban and semi-urban environments, often containing construction sites. Each scan had up to ten million points. The point clouds where labeled for general object classes such as ground, vegetation, and buildings but also for specific objects of interest such as construction machinery, traffic signs and roof surfaces.



State-of-the-art 3D scene segmentation
Input scan is automatically clustered into distinct objects which are classified by AI

Deep Learning from RGB & 3D
Neural Network learns to reliably recognize objects based on color, geometry and surrounding

Scalability of scan size
Allows processing large scans (~25 ha) with variable size and complex content

Scalability of detectable objects
New objects can be added and labeled efficiently with the help of clustering tool

Challenges

Training neural networks on 3D data is a new frontier in AI research that was only recently made accessible with breakthrough architectures such as PointNet. Most applications so far are limited to classifying single point clouds, for example 3D scans of individual objects. But in order to properly make use of point clouds in for example construction and planning, it is necessary to segment large scenic scans with tens of millions of points.

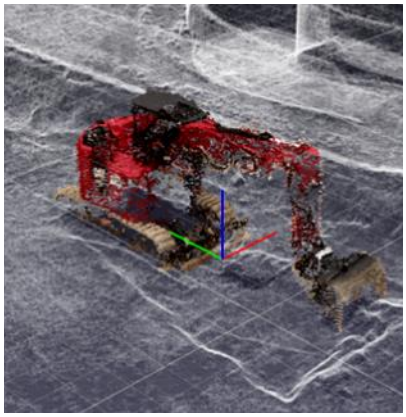
Applied Methods

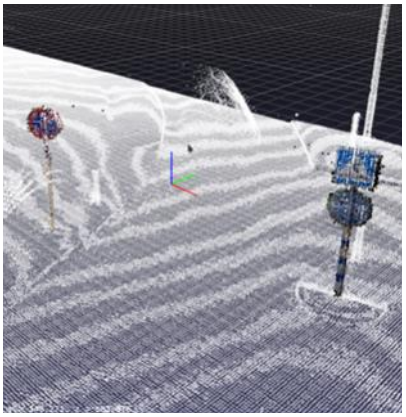
To segment large scenic 3D point clouds, we used a combination of unsupervised clustering and supervised neural network training. Making use of local geometric features, we are able to cluster a large scan into a set of homogenous geometric primitives. Complex objects then can be modelled as a combination of such components. The neural network we trained encodes both the geometry of individual components as well as their spatial relationships to another. The network then learns to associate this highly abstract but information-rich encoding of an entire scene with a respective set of labels.

Project Outcome

We were able achieve accuracy scores of up to 93% for individual object classes, depending on the available labeled examples. In many cases already 50 labeled examples where enough to achieve a class recall of more than 80%. In comparison to deep learning on images, where several thousand training examples are usually required, this makes AI applications on point clouds already feasible at a smaller scale.

The output of our network constitutes a so called “instance segmentation” of the input point cloud. That means it is not only possible to assign a label to each 3D point (“segmentation”), one can also isolate individual instances of each label class. This additional step enables further analyses such as automatically counting and locating individual objects of a certain type.





Supper & Supper Geo AI solutions allows you to automatically locate specific objects, take inventory, isolate components and much more.

Potential Applications

Our technology can turn point cloud data into valuable information, enabling you to successfully implement your digitalization strategy.

In terms of 3D spatial intelligence, instance segmentations of point clouds are only the beginning. They open up a whole range of possible solutions and automated analyses.

Such exemplary applications include urban infrastructure inventories, solar suitability analyses, construction site monitoring and 3D model generation.

Our 3D AI solutions can be adapted to your custom requirements and can be integrated into end-to-end solutions that feed results back into geodatabases, map layers, and AutoCAD models.