Modeling and enhancement of LiDAR point clouds from natural scenarios

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PROBLEM

The generation of realistic natural scenarios is a longstanding and ongoing challenge in Computer Graphics. A common source of real-environmental scenarios is open point cloud datasets acquired by LiDAR (Laser Imaging Detection and Ranging) devices. However, these data have low density and are not able to provide sufficiently detailed environments.

Procedural generation has been solved by modelling each semantic layer individually. Realistic ground surfaces are either approached using Digital Elevation Models (DEM) or noise images transformed accordingly to real-world processes, e.g. erosion [GGP*19]. Also, vegetation is modeled through the simulation of ecosystems [MHS*19]. Thus, the spatial distribution and growth of vegetation are the main challenges for the 3D modeling of natural environments. Therefore, the 3D reconstruction from real-world data arises as an alternative to classical procedural modelling methods [COB*18].

OVERVIEW

In this study, we propose a method to reconstruct real-world environments based on LiDAR data, thus overcoming density limitations and generating rich environments with ground and high vegetation.

Additionally, our proposal segments the original data to distinguish among different kinds of trees. The results show that the method is capable of generating realistic environments with the chosen density and including specimens of the identified tree types.

CONCLUSIONS

We have presented a preliminary study regarding the reconstruction of real-world environments to output either realistic scenarios or dense point clouds. Therefore, we can generate virtual scenes similar to the original source. Accordingly, the results can be used to refine the starting dataset for forestry research, Deep Learning applications, etc.

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METHOD

Our approach is based on guided procedural modeling of real-world point clouds using scanned data in order to generate synthetic scenarios in natural environments. To this end, we use open LiDAR data to model vegetation and ground layers.

Ground modeling: As a first step, the ground is uniformly split using a regular grid. For each voxel, relevant point data is aggregated, such as their color and elevation.

Figure 1. Overview of our method.

Next, a NURBS (non-uniform rational B-spline) surface is automatically built using the prior voxel discretization. To resample the reconstructed ground, we use a spatial probability distribution function for each voxel. Hence, voxels are populated with new points as long as a given density goal is not achieved. As a result, we represent the ground as a 3D spline that allows both to reconstruct the scene as a triangle mesh or as a dense point cloud. Figure 2b represents the reconstructed surface achieved with this method.

Vegetation modeling: Points labeled as high vegetation are then processed to reconstruct forestry areas. To this end, these points are clustered to differentiate tree specimens. We solved this using a clustering method based on a threshold distance and color similarity. Once clusters are built, we generate a regular grid for each one. Hence, tree roots are considered to be located in voxels whose density is significantly higher than the ground density. The vertical position (Y) of each tree will be determined by the NURBS created in the ground process, whereas their size is computed considering non-empty voxels of the area around the XZ position.

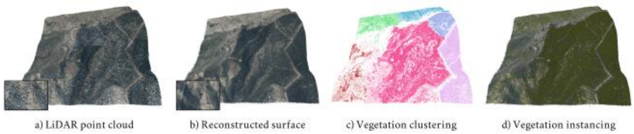

Figure 2. Partial results of the proposed method, in comparison with the original point cloud (a).

RESULTS

With the proposed method, we generate point clouds with a user-defined increase of point density. Figure 3 compares the input and the resulting point cloud with 10x more density.

Furthermore, we reconstruct vegetation that is poorly acquired with a LiDAR sensor by instancing and sampling tree triangle meshes. As depicted in Figure 3, the first image barely shows tree canopy returns. However, our result fills the ground areas not reached by LiDAR with dense vegetation. Also, we managed to replicate 254417 different trees within the obtained clusters.

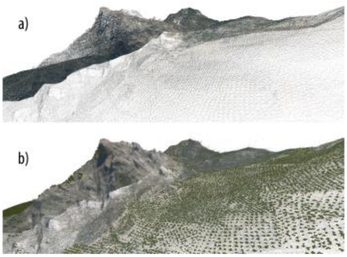

Figure 3. Comparison of publicly available LiDAR point cloud and enhanced environment.