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**Project 1: From image to 3D point clouds**

## Overview

A point cloud is a set of data points in space, which can represent a 3D shape or object. Each point position has its Cartesian coordinate set. Point clouds are typically generated by 3D scanners or photogrammetric software that measures many points on the surface of surrounding objects. Compared with CAD models and even simple Mesh, point clouds have many advantages -- point clouds are simple, uniform structures that are easier to learn. Using data from 3D point clouds, we can quickly reconstruct the exact shape and true color of objects.

However, 3D data is hard and expensive to collect while taking pictures is a quick and easy way to record 2D information. On this basis, we can combine our familiar prior knowledge of shape Geometry to reconstruct 3D object, and record its 3D coordinates, reflection intensity and color information of 3D objects in the way of point clouds. In this topic, people are mainly devoted to making model and algorithm more accurate, efficient, applicable to multiple objects and even reconstruct the entire scene.

## Related research and implements

This method has been proved to be feasible, and in recent years there have been a lot of researches and applications on 3D image reconstruction. Taking my personal experience as an example, the tenants could see the 3D scene of the room online through the reconstruction of the camera, which saved me a lot of time to go to the field. Moreover, the UAV is used for data acquisition to construct point clouds for real scene 3D reconstruction, so as to realize auxiliary planning and design, dynamic maintenance and other functions.

At present, both industrial and academic methods focus on neural networks. Take [2] as an example, which uses neural networks to generate point clouds. In this paper, the author try to solve the uncertainty problem in the restoration of a single projection image with 3D structure by using some prior knowledge. They use Chamfer Distance and Earth Mover's distance to construct loss functions, and later show that these two functions are differentiable almost everywhere. Finally, the experiment is built on the ShapeNet dataset, which contains a large number of artificial 3D object models, of which they uses 220K models in 2000 classes for training. In the final experimental results, the authors compare their model with the 3D-R2N2 model, which is a deep model that performs 3D image reconstruction by inputting multi-scale images. Finally, the authors compared the algorithm with human 3D reconstruction ability, and found that it outperformed human imagination on some objects.

Here [3] is another open source point cloud generation application. In this application, an ordinary camera is used to take pictures from different angles around the target object with BCH code background. Then input to a visual structure from motion system to complete 3D model reconstruction. Furthermore, this article [4] shows a very mature application. The

algorithm has been packaged and deployed on the drone. While taking photos by the camera on the drone, the software would automatically generate point cloud basing on the image and location information.

On the whole, most of the 3D reconstruction algorithms in the last two years are based on deep learning. Personally, I believe deep learning still has great potential in the combination with hardware devices, and I look forward to the application of this 3D reconstruction algorithm in more scenes.

**Reference**


[1] Xian-Feng Han, Hamid Laga, Mohammed Bennamoun, Image-based 3D Object Reconstruction: State-of-the-Art and Trends in the Deep Learning Era, arXiv:1906.06543.

[2] Haoqiang Fan, Hao Su, Leonidas J. Guibas; Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017, pp. 605-613

[3] http://ccwu.me/vsfm/index.html

[4] https://www.sema-soft.de/aktuelles/news/details/news/detail/News/from-photo-to-3d-point-cloud/