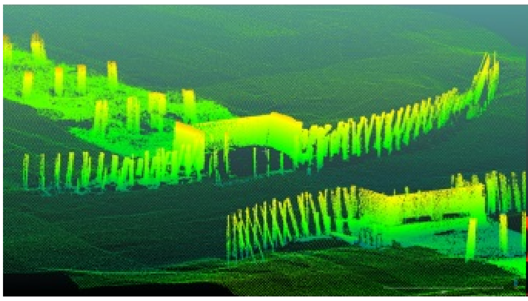
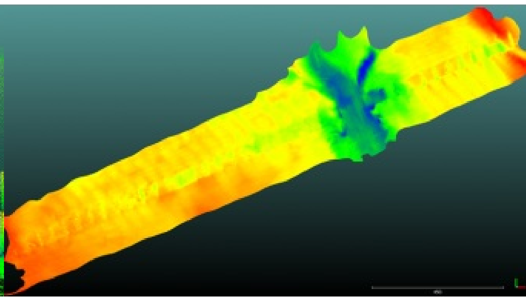
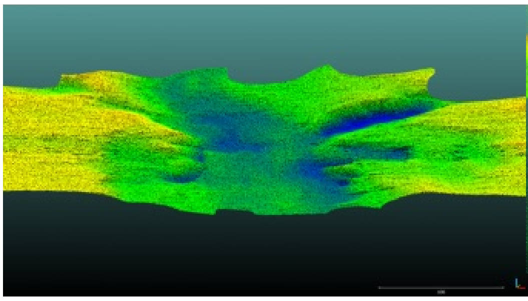
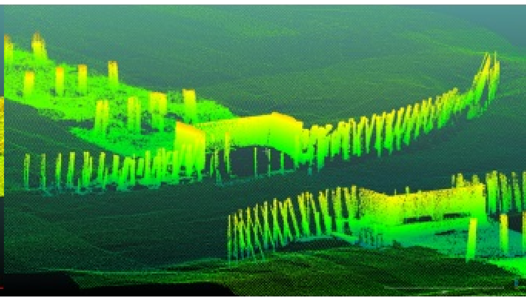
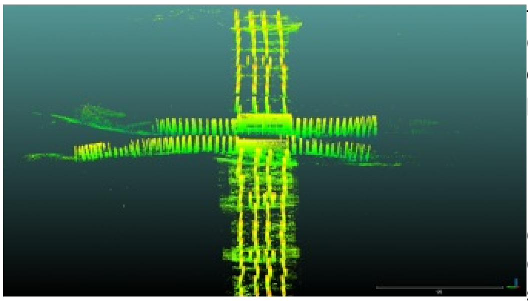
3D POINT CLOUD EDITING FOR QUICK SEAFLOOR EXTRACTION ANALYSIS AND VISUALIZATIONS

Open source software and hydrographic survey data

Hydrographers and data processors are expected to produce high-quality deliverables with a swift turnaround in this present age of data collection and technological refinement. However, the cost of proprietary commercial software processing programmes has excluded many in the past. Such programmes incorporate finely tuned tools suites and nested algorithms that have been polished and distilled over the years. Happily, the financial hurdles are not as high as the passion and love that these individuals carry for this explorative industry, and open source resources and collective intelligence are changing the game.

Processors are often given large datasets with requests for end product fly throughs or refined visualizations of smoothed and processed bathymetry, accompanied by the traditional short deadline and restricted budget. Open Source software suites such as Cloud Compare and their plug-in extension the Cloth Simulation Filter help to fulfil such expectations. This gives smaller firms the ability to process data similar to that of the powerhouses in this industry with unrestricted budgets.

File formats

Originally designed to perform swift cloud and mesh comparisons on large datasets, Cloud Compare currently exists as an open source 3D point cloud editing and processing software. It boasts a suite of tools for extraction, analysis and end product creation. Accompanied by a multitude of users, an active forum, github, online tutorials and plenty of documentation, navigation is effortless. Integrating this tool into an already existing workflow is simple since it can ingest and export a heap of file formats with drag and drop functionality, such as .csv, .ascii, .pts, .txt, .vtk, .dxf, .las, .laz, raster grids, ESRI’s .shp and image files. The programme saves each project and the associated files in a proprietary file format of a .bin file. Users see it as a best use case for the visualization of scenes, the creation of aesthetically pleasing presentations, and quick fixes to an already existing workflow when it comes to bathymetric processing. The cross-section functionality after running the point cloud through the Cloth Simulation Filter is also a useful tool for insight.

A plug-in designed by Wuming Zhang et al. from Beijing Normal University, CN, the Cloth Simulation Filter (CSF), quickly extracts ground points from a point cloud. Originally used for separating ground and non-ground measurements from Lidar (light detection and ranging), this tool can be just as applicable for quick seafloor extraction analysis and visualizations.

Data set from the Fort Pierce Inlet, 2019. Delivered as one large point cloud to process, it was originally two merged points clouds from both a multibeam survey and Teledyne BlueView laser scan of the pilings and bridge structure.

Point cloud extraction

The plug-in is based on cloth simulation and modelling; derived from a 3D computer graphics algorithm used to simulate cloth in computer programmes. The point cloud is inverted and a rigid cloth is laid on the inverted surface. During the simulation, cloth is modelled as a grid that consists of particles with mass and interconnections, called a Mass-Spring Model. By analysing the interactions between the cloth nodes and the corresponding points, the locations of the cloth nodes can be determined to generate an approximation of the ground surface. The ground points are then extracted from the point cloud by comparing the original points and the generated surface.[1]

This filtering method only requires a few easy-to-set integer and Boolean parameters, and takes less than a couple of minutes to process. The accuracy stands up to other toolsets and functionality found in proprietary commercial software as well. Benchmark datasets provided by ISPRS (International Society for Photogrammetry and Remote Sensing) working Group III/3 were used to validate the proposed filtering method, and the experimental results yielded an average total error of 4.58%, which is comparable with most of the state-of-the-art filtering algorithms[2].

Fort Pierce Inlet, Florida. Inlet Mouth. View into the West.

Classifying point clouds

Parameters in the selection dialogue are split into general and advanced parameters. General parameters allow the user to specify whether the scene is relatively flat, containing associated relief, or steeply sloping, in which the rigidness of the cloth is determined. Note that, for steep slopes, this algorithm may yield relatively large errors as the simulated cloth is above the steep slopes and does not fit with such ground measurements well due to internal constraints among particles. This problem can be solved by selecting that option. If there are no steep slopes in the scene, neglect it.

Advanced parameter settings contain three constraints to assist with the level of detail and refinement. The integers shown when the filter dialogue is selected are standard and should be appropriate for most datasets. Cloth resolution is the grid size of cloth used to cover the terrain. The bigger the cloth resolution integer set, the coarser the DTM (Digital Terrain Model) produced. Max iterations refers to the maximum iteration times of terrain simulation. Classification threshold refers to a threshold to classify the point clouds into ground and non-ground parts, based on the distances between points and the simulated terrain.

This dataset is from the Fort Pierce Inlet, 2019. Given to us as one large point cloud to process, it was originally two merged points clouds from both a multibeam survey and a Teledyne BlueView laser scan of the pilings and bridge structure. Since the company was not given the separated bare earth and structure files, the CSF was ideal for this. The client was concerned about the scour around the pilings, and desired to see a quick visualization of the depth. Considering the point cloud is inverted during extraction, the depth of the scour was able to be shown in detail.

Full dataset, view into the North.

Open source and machine learning

The extraction or refinement of coral heads and boulder piles within scour would need to be manually performed with Cloud Compare's segmentation tool, or a separate tool process as the surface is produced from inversion. Retaining the same coordinate and height values, even through various tool processing techniques have been applied, is a bonus for data integrity. Another benefit of the CSF algorithm is that the simulated cloth can be directly treated as the final generated DTM for some circumstances, which avoids the interpolation of ground points, and can also recover areas of missing data[2]. The user can additionally check a box to have a separate meshed (Delaunay Triangulation 2.5D XY plane) surface export once the filter has extracted the ground points.

The use of insightful and synergistic programmes such as Cloud Compare, open source softwares, machine learning and automation will continue to gain traction as collaborative atmospheres continue to grow and influence niche industries, such as hydrographic ventures. This will allow for ease and interoperability in future scientific communities.

Pilings, view into the North. Post CSF application. Non ground points.

Acknowledgments

Cloud Compare, created by Daniel Girardeau-Montaut.

https://www.danielgm.net/cc/

Citations

1: http://www.cloudcompare.org/doc/wiki/index.php?title=CSF_(plugin)

2: Zhang W, Qi J, Wan P, Wang H, Xie D, Wang X, Yan G. An Easy-to-Use Airborne Lidar Data Filtering Method Based on Cloth Simulation. Remote Sensing. 2016; 8(6):501.

Wuming Zhang had the original idea that uses cloth simulation to filter Lidar data. Jianbo Qi refined and implemented this idea, and wrote this manuscript. Peng Wan helped to refine some parameters settings and developed the cloud compare plug-in. Hongtao Wang summarized some existing filtering algorithms and gave much useful advice to promote this method. Donghui Xie and Xiaoyan Wang helped to process some Lidar data, and tested this method with them. Guangjian Yan helped to review this article and give much advice.