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Project 1: Photogrammetry from images to 3D point clouds

The topic consist of computer visions, imaging and optical science. Specifically, the problem is that industry has made use of a fairly complex pipeline to turn images into 3D point clouds for 3D modeling. These models are useful for architects in construction, restoration projects, and manufacturing of tools. On a large scale, the archiects can use these 3D models to figure out the exact area one has on top of a building for example. On a smaller scale, laser tech can create cloud points of tools which can be imported into CAD for nuanced editing of dimensions.

The problem is that the process to create 3D models from images is arduous. Useful images are gathered using drones. From there, photogrammetry algotherms map points to objects from one image to the next creating vector data that can be used in 3D modeling. From there the point clouds are then arranged in a 3D space to create a 3D model. The points create edges, then faces, then finally polygons. ("What are Point Clouds, And How Are They Used?" youtube video linked below)

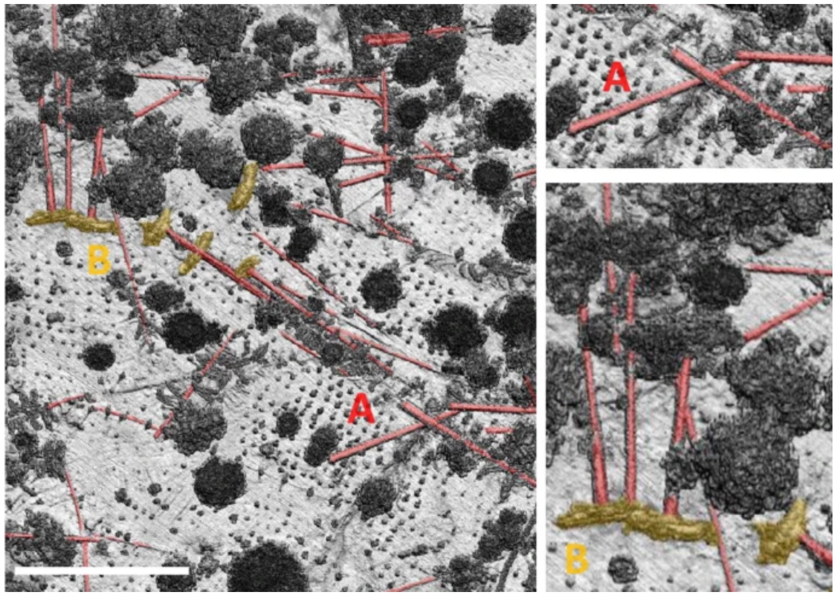
Personally, I find this topic very interesting as an enthusiast of Iot devices. Finding methods to speed up the photogrammetry process would allow embedded systems on the edge to complete these tasks on the fly. Having these 3D models ready to go would give an edge to the manufacturing process in evaluating tolerances of their products. Better yet, on a larger scale this would introduce a method to 3D model large cities . Having 3D models would be hugely beneficial in shortest path problems that plague our society.

The first paper I came across during my research in photogrammetry is called "Comparing tree attributes derived from quantitative structure models based on drone and mobile laser scanning point clouds across varying canopy cover conditions". This paper introduces an interesting problem about differentiating similar looking objects in photogrammetry. In the paper it specifies that despite modern advancements in DLS (drone laser scanning) and MLS (mobile laser scanning) camera technology, "data can be limited by occlusions and environmental complexities (Comparing tree attributes derived from quantitative structure models based on drone and mobile laser scanning point clouds across varying canopy cover conditions, Abstract)".

To combat the problem of bad data, the researches suggest using a probablistic modeling technique which combines data from both DLS and MLS. The researches compared the accuracy of seven tree attributes that can be measured using 4 types of QSM (quantitatve structure models). The first being using DLS alone, then MLS alone, combined DLS and MLS, and finally introducing point cloud modeling under different canopy levels. On average, the accuracy increased by around 20 percent. "Overall, the fusion of DLS and MLS point clouds allowed the retrieval of comprehensive tree-level information (Comparing tree attributes derived from quantitative structure models based on drone and mobile laser scanning point clouds across varying canopy cover conditions, Abstract)". Whats most interesting to me in this paper is that the researches combated the introduction of bad data by purely mixing up their data retrieval techniques. This goes to show that in photogrammetry one of the most important parts is having a good data set. With the probabl introduction of deep learning to the area of photogrammetry, having a good data set will be even more important to have.

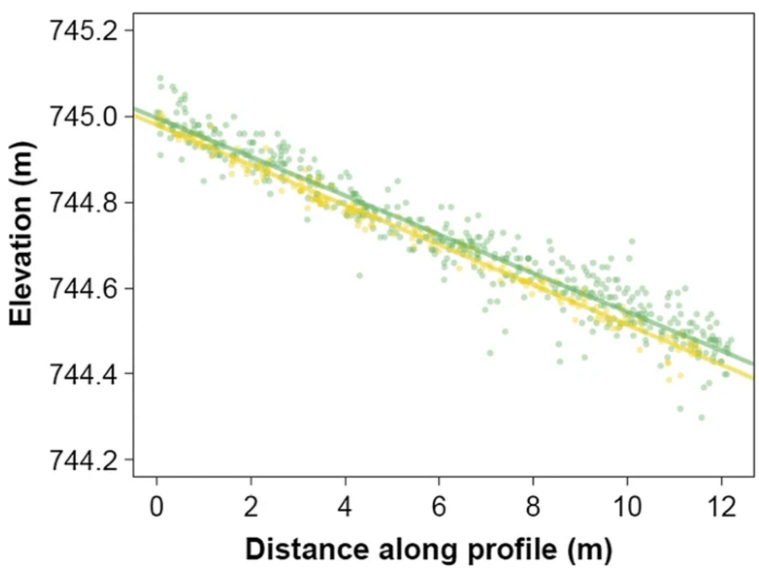
The second paper I came upon during my research is "New Opportunities for Forest Remote Sensing Through Ultra-High-Density Drone Lidar". This paper sparked my interest greatly because I have experience in the hardware level circuity involved in designing various sensors which this paper will specify a new type of sensor called Lidar. Lidar sensors measure distance by measuring the time it takes for the light in the laser to hit an object and come back. The sensor has an array of lasers to measure depth information. Lidar sensors can measure the most detailed depth information without using much resources in its algorithms to transform the depth information plus picture information to a 3D model. Now Lidar sensors come with some drawbacks. The maindraw back is distance. Lidar sensor in an iphone for example only can reach 5 meters max. However, the paper specifies that a forrest type settings can correct all the drawbacks of using a lidar scanner in mapping the area. The paper states that "A good rule of thumb is that flight altitude should not exceed 0.5 × EMR when scan angles up to 60° (New Opportunities for Forest Remote Sensing Through Ultra-High-Density Drone Lidar, Effective Measurement Range)". Because forested areas have a lot of objects in close proximity, the lidar sensor would hardly ever reach its maximum range.

The paper goes onto explain mundane technicals of retrofitting lidar sensors onto drones and very technical accuracy details of the lidar sensors themselves but what was interesting to me is the test trials.



Flight Campaign in the Czech Republic

In the above image we can see a very detailed image of a forested landscape captured using lidar sensors retrofitted onto a drone. The image is so detailed that the researches could identify recently fallen trees!

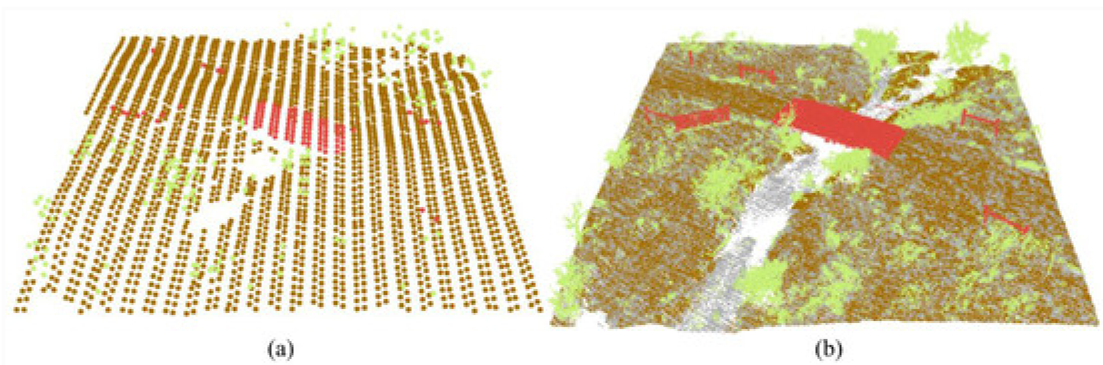


Comparison of lidar surface elevation profiles

This graph is also very interesting. The elevation of the forrest area is plotted against the distance along a given area or (profile). The scatter plot showcases all the points in a given profile are grouped together very closely. This data can be used to further explore the destruction of the forest by mapping new elevation points again a line regression plot!

Overall this paper showcases that not one approach to photogrammetry fits all environments. Depending on the characteristics of the environment, different sensors, different algorithms, and different methods to obtain data sets can all be fine tuned to get the best results.

Finally, the last research paper I came upon was "Drone Laser Scanning for Modeling Riverscape Topography and Vegetation: Comparison with Traditional Aerial Lidar". This paper goes into detail on comparing the different types of sensors used for scanning landscapes vs drone lidar or (DLS). Now what really stood out to me in this paper was the concrete evidence that showcase drones as the best method for large scale photogrammetry rather than ALS (aerial laser scanning) with airplanes.



ALS vs DLS on a river bank

(a) = ALS, (b) = DLS

"(Figure 9)"

As you can see in this figure, (b) looks a whole lot more detailed than (a). The main reason for this lack of detail using ALS is because of environmental obstacles like occlusion getting in the way of the lasers at such high distances from the land.

This paper brings up an interesting research question. Would the introduction of multiple drones scanning land at the same time increase the amount of good information one can extract from the area? If research was conducted to allow drones to divide and conquer a scanned area the time reduction would reduce tremendously! Overall, this paper brings to light innovate approaches to existing methods of photogrammetry and calls force the introduction of new approaches as drone technology naturally evolves.

To summarize, photogrammetry is such a large research area that we can see very different approaches work great in one area while struggle in another! Having a one track mind in trying to speed up the backend for photogrammetry algorithms might be short sighted when other methods can circumvent resource limitations.

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