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Drones and LiDAR

As I write this article (early January 2015) the Federal Aviation Administration (FAA) has yet to release rules for the commercial use of small Unmanned Aerial Systems (sUAS) in the USA airspace. Meanwhile, hobby versions (technically identical to the commercial versions, in many cases) are flying off the shelf as more and more casual users realize the fun of flying and photographing.

In reality, commercial drones are not sitting in darkened hangers, waiting on rules. Hundreds, if not thousands of serious projects are being carried out on a daily basis with sUAS, predominantly carrying cameras. As discussed in several previous issues of *LiDAR News*, point clouds from dense image matching (DIM) is the enabling technology (along with the drone itself, of course) that has made all of this possible. Note that I use the term DIM to mean both the process and the product. Thus a DIM is a point cloud derived from the dense image matching process.

Drones are not so much taking away business from manned aerial survey missions as they are enabling aerial surveying where it was either not possible due to the site location, or simply was not economically feasible (the usual case). An example of a stockpile (modeled as a Triangulated Irregular Network, TIN) with an overhanging material conveyor (modeled as points) is depicted in **Figure 1**. These data were collected with a sUAS carrying a prosumer Sony NEX-5 camera.

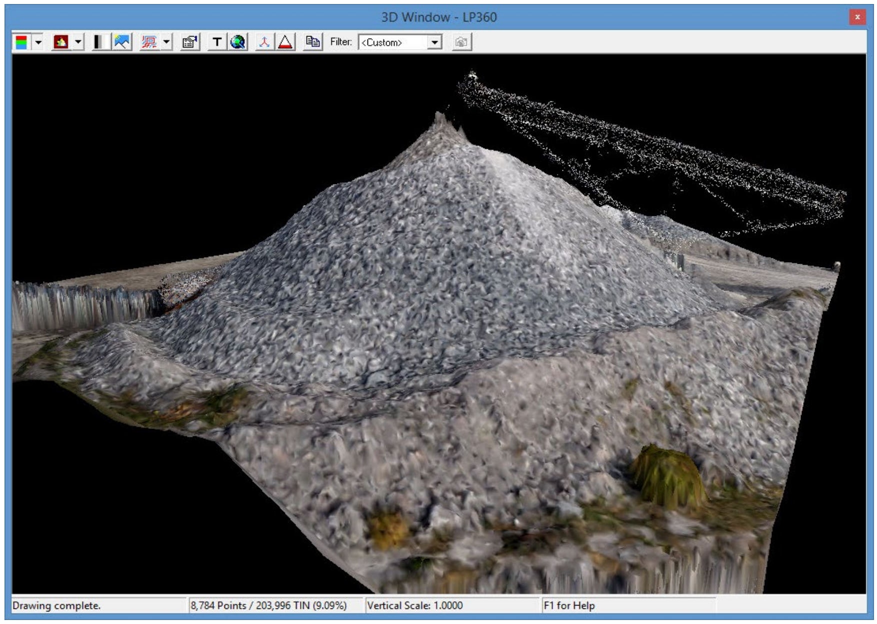

Figure 1: A 3D Stockpile model from dense image matching.

Obviously these data are extremely valuable, not only for visualization but also for quantitative analysis such as volumetric computations. A close analysis of data from dense image matching (DIM), however, will reveal defects that may render some types of analysis inaccurate. For example, note in **Figure 1** the general poor definition of the conveyor system (noise points, general "fuzziness"). For lack of a standard term, I refer to the degree of fidelity of a DIM to the true surface structure as "conformance." A low conformance DIM is significantly deviating from the true surface whereas a high conformance DIM is closely representing the surface. There are examples in a DIM where there is simply no conformance at all, such as overhead wires.

One of the primary reasons that LIDAR displaced photogrammetry 20 years ago as the preferred method of extracting elevation information is its very high conformance. The laser beam is a single source, active probe and thus no matching at all is required. Since this is the case, why don't we see LIDAR as the preferred sensor for drones when 3D modeling is a required product?

Recall that a LIDAR comprises a laser rangefinder and a precise positioning system (used to deduce where the range-finding laser is impacting the target). For short range applications such as a low altitude sUAS, the rangefinder itself is relatively inexpensive to produce. However, the positioning equipment is another story. There are two components to consider; sensing orientation (pitch, yaw and roll) and position (x, y and z). Orientation errors scale approximately linearly with sensor altitude. For example, when in the nadir position (pointing straight down) the linear error on the ground is approximately the Above Ground Level (AGL) altitude times the sine of the angular error. Thus reducing the AGL reduces the effect of angular error. Positional error, on the other hand, is constant regardless of altitude. This means that for any metric use of laser scanning, carrier phase global navigation satellite system (GNSS) technology is required (often referred to as Real Time Kinematic, RTK). Accurate inertial measurement units and RTK GNSS are still relatively expensive. In my most recent survey of equipment, I reckoned about thirty thousand US dollars for the GPS/IMU components. Add in the laser rangefinder and the sensor package is approaching 40 to 50 thousand US dollars. Of course, this is also a fairly heavy set of equipment, driving up the size of the sUAS and its energy requirements (e.g. battery size).

Well, in the big scheme of surveying equipment cost, this is not prohibitive. After all, a good Trimble dual station RTK GNSS will be in this same price range. However, the risk of equipment loss due to a crash is still very high with a sUAS in a typical scanning environment. Dropping this expensive payload into a water-filled pit in a quarry will most definitely ruin your day!

So what is the solution? Well, certainly equipment cost will continue to dramatically fall. We have already seen an announcement by Velodyne of a $7,999 laser range finder (be aware that this does not include the 30-40 thousand of position equipment that will be required!). Swift Navigation is trying to revolutionize the price of RTK with its 2 station Piksi system priced at US $1,000. These activities point to a potential order of magnitude reduction in the price of close range laser scanning within the next 18 months or so.

In the longer term, the real solution is going to be focal plane array (FPA) LIDARs (see "Quantum Cameras" in LIDAR News Vol 3, No 6)). These LIDAR arrays will allow us to dispense with the need for expensive positioning equipment, just as Dense Image Matching has done. In fact, the same basic algorithms will be applicable. While FPA LIDARs today are essentially still in the laboratory, the need for high speed range finding in the automotive industry will rapidly drive the cost of these devices down to the commodity level. I am looking forward to this with great excitement—it will truly revolutionize the use of drone technology for precision 3D data collection.

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