MAPPINGMATTERS

YOUR QUESTIONS ANSWERED

The layman's perspective on technical theory and practical applications of mapping and GIS

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QUESTION:

Question One: I was asked to provide services for surveyors, which of course means that absolute accuracy is key. The surveyors flew a sample project and provided me with a list of GCP coordinates. They also hired a company that specializes in processing images for surveyors to verify and compare data. The other company was able to process the data using a leading UAS data processing software and get the residuals down to under 0.01-0.02 ft. However, when I processed the same data using the same GCPs and the same software, I could not get the RMSE much lower than 0.07 ft. Digging into the problem further, I found that I needed to turn on the "rolling shutter" option in the software since the camera has a rolling shutter. Once I fixed that, my results matched the other company's results. Can you share your thoughts on that function? Also, in your article, "Harnessing Drones the Photogrammetric Way," you mentioned that the RMSE figures from aerial triangulation should not be used alone as proof of product accuracy. Can you elaborate?

Nathan Mangsen, Mangsen Mapping

Dr. Abdullah: I am glad you mentioned the issue of the rolling shutter, as it is important to the UAS mapping community. Shutter plays a vital role in camera operation as it is used to control the passage of light into the focal plane of a camera resulting in a perfectly exposed image. Digital cameras are manufactured with either mechanical shutters, electronic shutters or a combination of the two. Consumer-grade cameras, like those used with UAS, are designed according to two mechanisms, the leaf shutter (also known as the "dilatating aperture shutter") or the rolling shutter (also called "curtain" or "sliding shutter"). The leaf shutter, which is usually mechanical, is favored in the mapping community because it freezes the scene as it exposes the entire sensor array. On the other hand, the rolling shutter exposes one line of pixels at a time, creating a sliding curtain effect, until the entire image is exposed. When a rolling shutter is used on a camera mounted on a mobile platform like UAS, the imagery is distorted and can blur. This distortion is exaggerated by high aircraft speeds or low light conditions. Most image processing software that is designed for precision mapping provides an option to correct for rolling shutter distortion during data processing. For aerial mapping from a mobile platform, such as a UAS, leaf shutter is recommended because it minimizes or eliminates image blur due to aircraft motion. Unfortunately, many UAS users are not aware of this fact. For those who are aware, many do not know that some (not all, unfortunately) UAS data processing software provides the option to correct for the anomaly caused by rolling shutters. This option needs to be activated by the user during processing since the software does not automatically know whether the imagery was collected with a lens that has a rolling shutter. If the effect of the rolling shutter is not addressed during data processing, the positional accuracy of the product will be compromised. Your question brings up a good example of this problem. My suggestion for users of UAS data processing software is to first figure out whether the camera that will collect the data is equipped with a rolling shutter and if so, to figure out whether the software provides an option to correct for the rolling shutter effect.

"If the effect of the rolling shutter is not addressed during data processing, the positional accuracy of the product will be compromised."

Let me now address your question on basing final product accuracy on the quality of the results of aerial triangulation or, in more specific terms, the fit to the ground control points (GCPs) during the aerial triangulation process. There are several reasons why we should not use the estimated errors of aerial triangulation as final indicators for derived product accuracy. Among them are:

1. **Survey checkpoints should be independent from the production process:** The correct way to evaluate the positional accuracy of any geospatial product is to use an independent set of survey checkpoints that were

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not utilized during the product production process. This independent set can either be used during aerial triangulation as long as they are used as checkpoints and not as GCPs, which could influence the adjustment, or it can be used to evaluate the accuracy of the derived products, such as orthorectified imagery or a digital surface model (DSM).

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2. **Aerial triangulation can result in false accuracy:** During aerial triangulation, all terms and elements included in the photogrammetric model—such as image and camera parameters (lens focal length, lens distortion, focal plane geometry, etc.), atmospheric model, measurement quality, ground control accuracy, etc.—are considered to be adjustable observations. The mathematical model adjusts these parameters according to a priori accuracies that are defined for each of these parameters by the software users. Unfortunately, many users do not have enough knowledge about this photogrammetric mathematical model nor do they know how to assign the correct a priori weight for all these parameters. What makes the matter worse is some software companies tried hard to make this software, with its black-box concept, user friendly so people without a mapping background could process data using their software. Wrongfully assigned a priori weight on any of these parameters during aerial triangulation can exaggerate or minimize existing errors. For example, wrongfully adjusting parameters that include lens focal length, coordinates of the camera principal point, GPS coordinates for the image center, etc., will result in product errors. Many of these camera parameters are correlated with the coordinates of the GCPs. Therefore, an error in the survey GCPs can be mimicked or absorbed by the correction to one or more of the camera parameters or the image center coordinates during adjustment. Unless constrained correctly, this adjustment can result in smaller than usual, artificial errors in the GCPs and can lead users to believe that they produced accurate products when they did not.

> **Wrongfully assigned a priori weight on any of these parameters during aerial triangulation can exaggerate or minimize existing errors."**

3. **There can be additional sources of error introduced:** If you are producing orthorectified imagery, there is another layer of errors that can contribute to product accuracy besides aerial triangulation. The orthorectification process utilizes the exterior orientation parameters from aerial triangulation and a DSM. The accuracy of orthorectified imagery is greatly influenced by the quality of the DSM. The DSM source could be external, such as from lidar, or internal, created from the same processing software and using the same aerial triangulation. Even if the DSM is produced with software using the same imagery that was used for aerial triangulation, having high-quality aerial triangulation does not guarantee the production of a high-quality DSM. This is because the image matching used for the DSM is subject to noise due to shadow and poor surface definition.

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