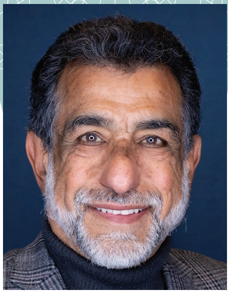

MAPPINGMATTERS

YOUR QUESTIONS ANSWERED

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

BY Qassim A. Abdullah, Ph.D., PLS, CP**

QUESTION:

Questions: What would you recommend to quantify the relative accuracy for area and distance measurements, from imagery? The new ASPRS Positional Accuracy Standards for Digital Geospatial Data has the section on "Data Internal Precision (Relative Accuracy) of Lidar and IFSAR Data," but would this be the best approach for a 2D orthomosaic as well? The new standard is important, and we want to educate our user community on its concepts and the importance of accuracy, as well as current methods for measuring data. As you know, most drone projects cover small geographic areas, and 30 independent checkpoints for accuracy assessment may not be feasible. A common drone application is measuring changes in the volume of stockpiles, such as a project monitoring a dynamic construction site, where much of the content in the imagery changes daily. Users in this case would need to ensure the accuracy (precision/repeatability) of their 2D and 3D measurements, but may be less concerned about absolute positional accuracy. What advice would you give to these users?

Cody Benkelman, Product Manager for Imagery at Esri (www.esri.com)

Relative accuracy versus data internal precision: First, I would like to bring readers' attention to the fact that in Edition 2 of the ASPRS standard, we changed the term "relative accuracy" to "data internal precision," as many industry professionals do not consider the repeatability in measurements as a standard accuracy measure. Therefore, I will apply the term "data internal precision" when discussing "relative accuracy" in this article.

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Is there such a term as "relative accuracy" for an orthomosaic? As for your first part of the question, I do not believe that there is a meaningful term for a 2D map's data internal precision. Data internal precision is about repeatability and the internal precision of a dataset or an instrument. Measuring distance or area once on one set of an orthomosaic does not effectively evaluate data internal precision. You can repeat the measurement of the same distance or area multiple times on the same orthomosaic to come up with a data internal precision figure, but this does not represent the map's data internal precision as much as it represents the accuracy of the tool being used to conduct these measurements—ruler, tape, etc.—or the ability of the person to repeat this measurement.

How do you determine data internal precision for a map? To determine the data internal precision of a map, you will need to fly the same area over and over, using the same sensor, same ground controls, same processing software, and same skills of data technician. Once multiple sets of an orthomosaic are produced, the data internal precision of a distance or an area measurement can be established by measuring the same distance or area on different sets of the orthomosaic. But even with that, the many variables in the process make it difficult to relate data internal precision solely to the orthomosaic itself.

"The subject of determining data internal precision can be better understood and reached for lidar, where data internal precision defines the ability of the lidar ranging to measure the same elevation multiple times by different pulses—i.e., a point cloud."

Determining data internal precision for lidar is easier to understand: The subject of determining data internal precision can be better understood and reached for lidar, where data internal precision defines the ability of the lidar ranging to measure the same elevation multiple times by different pulses—i.e., a point cloud. We estimate the data internal precision of lidar by comparing the elevation of a flat, smooth surface from different point clouds or laser pulses. All these pulses or point clouds should result in the same value for the elevation of that horizontal, flat, and smooth surface. However, due to the biases in laser ranging, those elevations will never have the same values. The variation in the elevation values for that surface represents the repeatability or data internal precision of the lidar data.

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> ***"the best measure to represent data internal precision is to statistically measure the variance or the standard deviation."***

What is the best measure to represent data internal precision? In my opinion, the best measure to represent data internal precision is to statistically measure the variance or the standard deviation. Standard deviation is a statistical measure for the fluctuation or dispersion of individual errors around the mean value of all errors in a dataset.

Checkpoints for a drone project; is there a way around it? As for the second part of the question on drone users and the use of independent checkpoints in measuring relative change, I agree that applications such as stockpile monitoring do not need checkpoints to measure every time a volume is computed. However, it is crucial to these operations to make sure that the photogrammetric process that precedes the volume, or the point cloud, generation is repeated from one day to another with the same level of accuracy and precision. To guarantee a repeated level of accuracy for the aerial triangulation and therefore the entire photogrammetric process, one will need to use reliable ground control points and a set of additional independent checkpoints during the aerial triangulation process. The purpose of checkpoints in the aerial triangulation process is to provide evidence of the accuracy of the solution. Relying on the fit to the ground controls in the solution alone is not acceptable because it is a biased measure. That said, although it removes the requirements for independent checkpoints necessary to verify the accuracy of the final volume computations, you still need those checkpoints upfront to assess the accuracy of the aerial triangulation. As you will see, if the user wants to do it right, there is no benefit to eliminating checkpoints from the process; it is a matter of moving it from one phase of production to another. Without assuring that the different volumes generated from one day to another were produced and computed with the same level of accuracy, estimating the changes in the stockpile will neither be accurate nor reliable, and you will never be sure that the 5,000-cubic-yard change in the stockpile (for example) was due to the accuracy of the photogrammetric process or what was actually hauled away.

> ***"To guarantee a repeated level of accuracy for the aerial triangulation and therefore the entire photogrammetric process, one will need to use reliable ground control points and a set of additional independent checkpoints during the aerial triangulation process."***

Number of checkpoints and the ASPRS Accuracy Standard: Now I would like to elaborate on the number of checkpoints and how the drone community looks at the requirement of at least 30 checkpoints. The ASPRS standard requirement for this number is modeled after the well-known central limit theorem. According to the central limit theorem, regardless of the distribution of the population, if the sample size is sufficiently large ($n \geq 30$), then the sample mean is approximately normally distributed, and the normal probability model can be used to quantify uncertainty when making inferences about a population based on the sample mean. With that declaration, no one can justify performing a statistically and scientifically valid accuracy assessment with fewer than 30 checkpoints. However, I understand the business environment surrounding drone operations and the size of these projects. If users cannot afford 30 checkpoints, then my advice is to perform the assessment with the maximum number of checkpoints you can afford—but do not skip the assessment. Although it is not a valid statistical sample, fewer checkpoints are better than no checkpoints. Fewer checkpoints at least provide an idea about the data accuracy at the location of those checkpoints. Edition 2 of the standard provides the following accuracy reporting statement for such cases:

> ***If users cannot afford 30 checkpoints, then my advice is to perform the assessment with the maximum number of checkpoints you can afford—but do not skip the assessment."***

"This data set was tested as required by ASPRS Positional Accuracy Standards for Digital Geospatial Data, Edition 2, v2 (2024). Although the Standards call for a minimum of thirty (30) checkpoints, this test was performed using ONLY __ checkpoints. This data set was produced to meet a ___(cm) $RMSE_H$ Horizontal Positional Accuracy Class. The tested horizontal positional accuracy was found to be $RMSE_H$ = ___(cm) using the reduced number of checkpoints."

The statement clearly declares the test as not meeting the ASPRS standard, but it reports the number of checkpoints used in the assessment. This statement encourages truth in reporting and at the same time makes users aware of the importance of using a minimum of 30 checkpoints for accuracy assessment.

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