Mapping Matters

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

Your Questions Answered

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

Question: When computing Circular Map Accuracy Standard (CMAS) and Linear Map Accuracy Standard (LMAS) from RMSE positional values, I use the formula described below but I don't know if these are valid for computing angles (omega, phi and kappa). Should angles be treated the same way as positions when computing the 90% confidence interval?

1) **CMAS AND LMAS CALCULATIONS Mapping Accuracy Calculation Methods and Requirements**
Horizontal Vertical
Circular Map Accuracy Standard = CMAS
2) ***= 2.1460 * sigma Linear Map Accuracy Standard = LMAS = 1.6449 * sigma***
Standard Circular Error = sigma
3) sigma = .7071 * square root(stdev(X)2 + stdev(Y)2) stdev(Z) = sigma
CMAS Statistical Confidence level = 90% LMAS Statistical Confidence level = 90%

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> *"In the past, photogrammetrists believed that the aerial triangulation should result in attitude angles determination with an accuracy of 10 arcseconds or better."*

Dr. Abdullah: In surveying practice, angles are part of the network and are seldom evaluated by themselves, as the network closure accuracy is what counts. However, in photogrammetric practice the position and orientation angles of the exterior orientation parameters, X, Y, X, Omega, Phi, and Kappa are dealt with separately despite the fact that their effects on the mapping process are correlated.

Your question takes an interesting look at the problem of evaluating an aerial triangulation performance by paying attention to the accuracy of the exterior orientation parameters. Users typically focus on the final results of the mapping process and care less about the camera position and orientation. However, with the introduction of the Inertial Measurement Unit (IMU) to the mapping process initiated our quest for ways and means to evaluate the IMU's ability in determining the sensor attitude. During the current debates on the new mapping standard in America, the question was raised as to whether the new standard should include a measure for the sensor position and attitude. This is especially important when we deal with an image-based mapping process that relies solely on direct sensor orientation using an IMU (no aerial triangulation to be performed) or when a non-imaging sensor such as lidar is concerned.

So far, we only have scattered thoughts on this concept and no concrete strategy on how to deal with the subject of quantifying the performance of an IMU, and even an aerial triangulation for that matter, in determining the sensor attitude. As far as I know, to date no one has included accuracy criteria for the exterior orientation of the sensor in a request for proposal (RFP). As for your question on whether you can use the same statistical measure used for the coordinate's evaluation, IMU manufacturers quantify their instrument's performance using root mean squares error (RMSE) for the roll, pitch and heading individually. However if you instead prefer the 90% confidence level, then you need to use the linear criteria of 1.6449 sigma (or RMSE) as you are dealing with one-dimensional measurements (one for each of the roll, pitch and heading or omega, phi and kappa).

In my opinion, the challenging part is to come up with threshold values for the sigma or the RMSE of the attitude angles. In the past, photogrammetrists believed that the aerial triangulation should result in attitude angles determination with an accuracy of 10 arcseconds or better. No statistical measure (confidence level) is assigned to the above figure, but for the sake of discussions I will assume it is an RMSE. The number 10 arcsecond became a goal for the IMU manufacturers to meet when manufacturing their instruments. Again, most if not all aerial triangulation operators and users do not pay attention to the accuracy of these angles during the bundle block adjustment. As a matter of fact, some of the aerial triangulation packages do not provide a measure to quantify such figures, while some of the packages provide detailed Covariance matrix analysis where all errors in the adjustment are quantified.

As for the lidar processing, the story is little different as operators pay great attention to the accuracy of the sensor orientation angles during the boresighting process.

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