Rapid city modeling from precisely georeferenced LiDAR/HSI data using closed-feedback error loop

PI: Dorota A. Grejner-Brzezinska, **Co-PI:** Charles K. Toth
Sponsor: National Geospatial-Intelligence Agency (NGA)

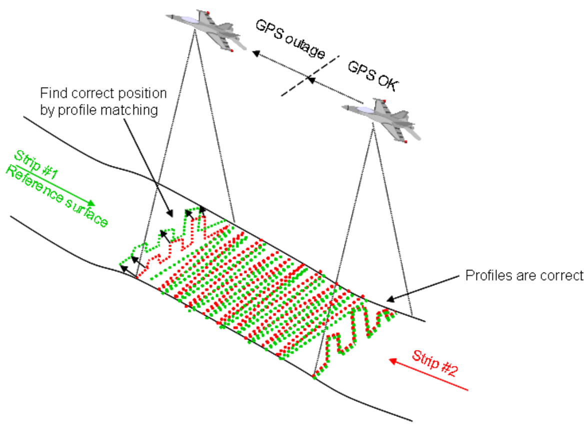

Figure 1. The concept of profile/surface matching (Strip 2) to a reference (existing) surface (Strip 1) to improve direct georeferencing under no GPS conditions. Strip 1 can be a part of the earlier collected surface data during the current mission, if no reference surface is available.

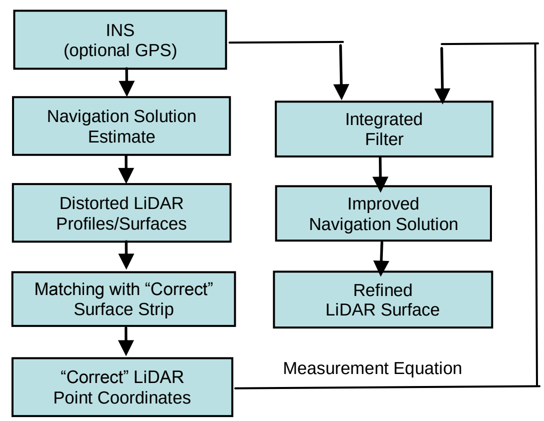

Figure 2. Conceptual information flow in the closed-feedback error loop.

The primary goal of this research project is to develop better automated capabilities in the analyst environment, where vast amounts of sensory data must be converted into useful and actionable information and intelligence. The application focus will be on a fast and fully automated technique for city/terrain model extraction from airborne LiDAR (Light Detection and Ranging) and HIS (hyper-spectral imagery) data using an efficient iterative/adaptive technique derived from linear and planar surface extraction methods, including PCA (principal component analysis) and Hough transforms in 3D. In addition, an intelligent closed-feedback error loop between the imaging and georegistration (GPS/INS) modules will be implemented. This design will ensure continuity, reliability, integrity and high accuracy of the georegistration solution – critical to extracting reliable object information from large volumes of image data. The motivation to include robust georeferencing as a part of this research is to address environments where GPS jamming may reduce the quality of the georeferencing performance, which seriously jeopardizes the quality of information extracted from LiDAR/HSI imagery. The selected demonstration application, i.e., fast, accurate and reliable city and terrain modeling is crucial for mission rehearsals, targeting, and guidance of smart weapons, personnel navigation and other warfare functions, such as analysis of Line of Sight to assess vulnerability to gunfire. Aside from national defense and combat missions, any broader scope emergency response, such as flooding or evacuation also require reliable terrain and urban area models that reflect any recent changes due to natural disasters or terrorist action.

The closed-feedback error loop has been implemented as an extension of the conventional Extended Kalman Filter-based navigation solution. From the imaging sensors, both relative position and relative attitude measurements, in any combinations, can provide fixes to the filter. The conceptual design is shown in Figure 1.

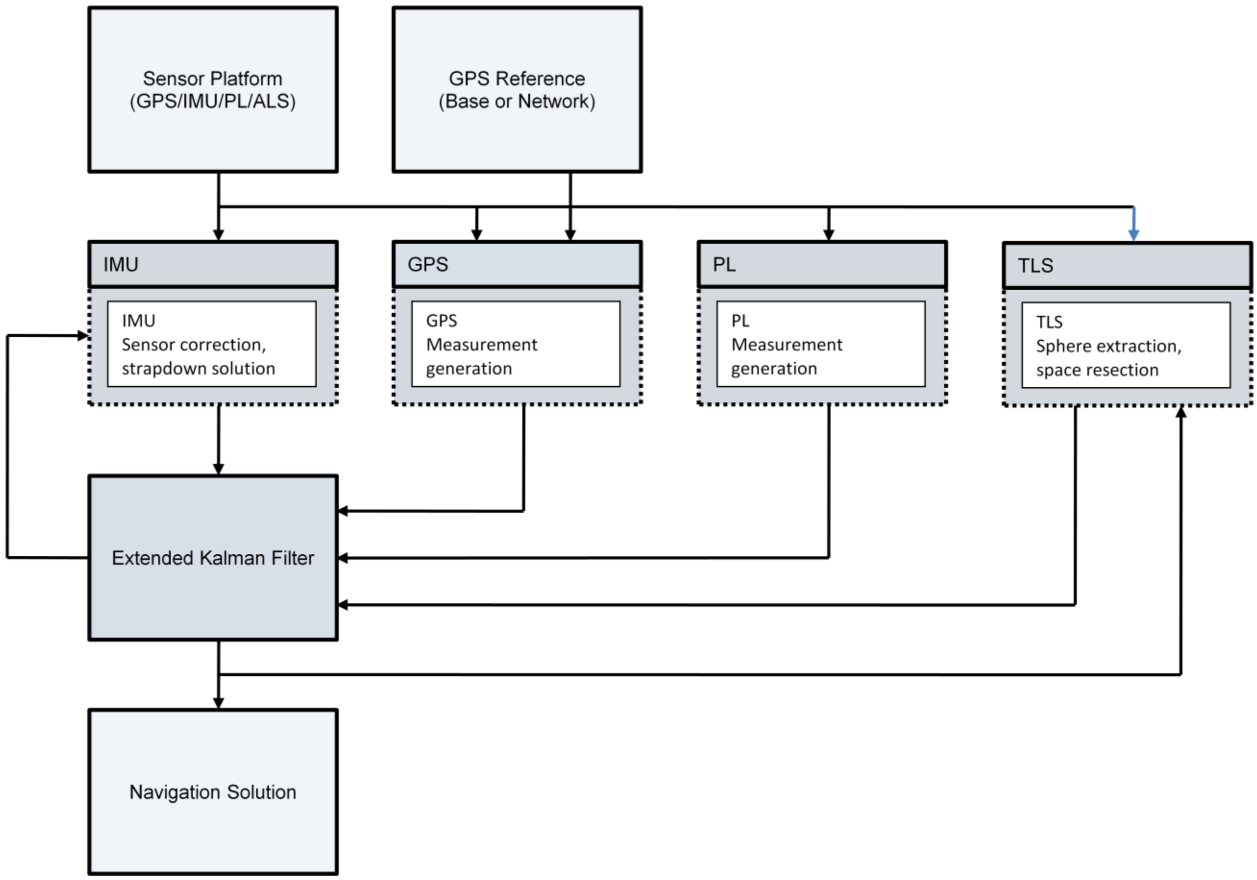

Figure 1. Closed-feedback error loop, based on measurements from LiDAR and HSI imagery.

To support navigation during GPS gaps, a surface matching method based on the ICP (Iterative Closest Point) algorithm has been developed. Initial results with simulated and real data show that the RMSE of x, y, z directions of LiDAR points could achieve ±0.52m, ±0.03m, ±0.06m, respectively, and the accuracy for trajectory reconstruction was ±1.05m, ±0.42m, ±0.60m, respectively. Sample results are shown in Figure 2, where an urban area of medium complexity was used.

Table 1. Surface matching and trajectory recovery performance.