

U.S. Army's S&T on Spatial Data Integration

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U.S. geospatial intelligence community has moved over the past 10+ years from a "MONO- to MULTI-" environment. This "multi-" environment includes multi-sensors, multi-sources, multi-producers, multi-representation, and multi-answer. However, tools to support this transition have been lagging behind in development. There are few robust automated tools to integrate and validate Features, Imagery, and Elevation, and other spatial-temporal referenced data sources.

Traditionally, the U.S. DOD and Intelligence geospatial communities have relied on space-based sensor platforms that support the generation of relatively static geospatial data. These communities are now moving toward continuously refining and improving geospatial databases by exploiting tactical sensors, air and ground-based sensors, and humans in the field. However, the current focus of a proliferation of sensors that will provide a plethora of raw sensor feeds is not supported by a complementary level of effort to integrate/fuse all these sensors, analyze this data, and provide the commander/soldier with actionable information about the battlespace environment where he/she will operate.

To address this shortfall the U.S. Army Engineer Research and Development Center's Topographic Engineering Center has initiated an applied research program in FY03 entitled: Geospatial Information Integration and Generation Tools (GIIGT). The objective of the R&D program is to deliver tools to integrate, manage, and exploit multi-source imagery, features, and elevation data in order to present only the 'best set' of relevant geospatial information. GIIGT has established an overall guiding philosophy that applies to differing types and representations of spatial information and is the following:

1. Multi-source information is an emerging reality
2. There is no perfect sensor – positionally or informationally
3. Assume the data or derived data are partial answers – maybe right, maybe wrong
4. Store, correlate, examine and improve data in a continuous update cycle i.e.,
 - Store partial answers in object database
 - Examine, reinforce, refute, and mine
 - Assemble and disseminate coherent answers
 - Improve the original data
5. Generate Additional Data (as required)

This guiding view governs our research and development in the following technical areas:

Geospatial Feature Fusion (Feature Linking)

Feature Linking is developing software tools that will automatically match and link vector feature representations across multiple data sets to provide the user with the "best spatial and attribute information" available from multiple sources.

Spatial Data Mining

Spatial Data Mining is developing software tools which learn about our spatial physical world through the non-trivial extraction of implicit, previously unknown, and potentially useful knowledge from widely

differing sources of data and then extract this knowledge in such a way that it may be employed in areas such as spatial prediction, forecasting, estimation, and decision support. These approaches must use specific spatial information such as x-y coordinates and/or elevation in addition to semantic information.

Cross-Sensor Image Registration

Different sensors and sensor types have different spatial accuracies, sensor acquisition parameters, and phenomenology. The objective of cross-sensor registration is to develop a software capability to automatically correct for these absolute and relative spatial inaccuracies so that image positions can be accurately and quickly geolocated to a common uniform reference.

Digital Elevation Model Fusion

Digital Elevation Model Fusion is developing automated techniques that fuse elevation data from diverse sources into a single, coherent digital elevation model. Fusion issues being addressed involve: hole filling, adjacent/overlapping DEMs, differing quality & resolution DEMs, bare earth versus reflective surface issues.

Spatial Database Management

Efforts are underway to examine issues of storing and accessing very large spatial databases and develop object-based spatial data models.

Feature Extraction Algorithms

Feature extraction methods are combining statistical pixel classification with learning, rule-based, and geometrical relationship to generate more robust features. Further work is focusing on the direct or indirect collection of features from GPS-enabled devices in the field.

The GIIGT program is supported by contracts, small business innovative research (SBIR) initiatives, and in-house research.

From a broader perspective the U.S. Army's Terrestrial Science Basic Research Program has recently defined a geographic information science research focus area that addresses fusion of data and information at a higher cognitive level to support understanding of the impact of the battlespace environment on military operation. This geospatial research focuses on increasing knowledge about the terrain effects on modern warfare through cognitive understanding of map/digital terrain information, analysis/reasoning, modeling of geospatial data, and knowledge discovery from spatially and temporally referenced data. Relationships within geospatial data are extremely complex because it usually exhibits strong temporal and spatial correlations. Understanding shared spatial complexity within the military operating environment demands a comprehensive problem-solving approach that facilitates correlation of information across spatial and temporal scales, across multiple levels of organization, and across technology areas. New concepts and methods for acquiring and representing geospatial information can be combined with Battlespace Environment (BE) related cognitive and behavioral processes to advance fundamental understanding of the spatial dimensions of human (warfighter) and social (military echelon) dynamics. This research seeks to answer the following questions such as: How is shared, spatial information cognitively fused and assimilated for maximum understanding by the user? How does shared spatial information move within and across levels of physical and social systems?; How do humans influence shared spatial information and respond to complexity in BE systems?; What new knowledge can be gained from scientific

examination of correlation, patterns, and relationships in spatial information?; and What knowledge and relationships can be found in spatio-temporal data (e.g. cycles, trends) that might be exploited in predicting the future state of the battlespace.

The payoff for this research and development on geospatial data integration and management in concert with other related efforts within DOD, industry, and universities is the ability to provide superior battlespace environment awareness, assured mobility and survivability by providing the commander/soldier/decision-maker with the “best set” of relevant geospatial data. This ability to provide the best geospatial information contributes to providing ground commanders/soldier with a superior understanding of the environment as she/he responds to a disaster/crisis at home and plans for and responds to missions in foreign lands.