Impervious Surface Mapping with High Resolution Satellite Imagery

There is a growing demand for environmentally friendly storm water management practices. Relatively recent federal mandates, outlined in the Clean Water Act (1999) and enforced through the EPA's National Pollutant Discharge Elimination System (NPDES), compel states to adopt comprehensive municipal storm water management rules by 2003! Because impervious surface maps are an essential input layer to all storm water analysis models, methods for accurately mapping and measuring the extent and quantity of impervious surfaces are of critical importance.

Beginning in the spring of 2003, researchers at the Center for Advanced Spatial Technologies (CAST) were investigating the feasibility of using DigitalGlobe Quickbird for the mapping of urban surfaces. Funding from a U.S.G.S./AmericaView grant supported this research, and the imagery used in the investigation was a donation to AmericaView states from DigitalGlobe, Inc.

In the summer of 2003, engineers with the City of Fayetteville, Arkansas identified a need to rapidly and inexpensively generate an accurate, up-to-date map of impermeable surfaces within the city's utility service area. (The municipal utility planning area covers approximately 170 square miles in and around Fayetteville, Arkansas.) The map was regarded as a critical component for modeling storm water runoff. The city, however, did not have the manpower or funds to conduct the traditional, time-intensive methods for mapping these features from aerial photographs. When City of Fayetteville representatives approached CAST researchers most of the methodology for completing the project using high spatial resolution satellite imagery was in place. After discussions with CAST researchers, the city decided to provide limited support for a research project to investigate the use of high resolution, multi-spectral, satellite imagery for mapping impermeable surfaces.

Phenomena such as exposed soil and water are easily identified with sensors gathering data from multiple wavelengths of the infrared portion of the electromagnetic spectrum (i.e. Landsat). Data from the four-band QuickBird sensor, however, was not found to be suitable for separating exposed soils from paving materials or clear water from building shadows using traditional image processing techniques alone. For this reason CAST researchers utilized Definiens eCognition software to take advantage of more advanced techniques such as multi-resolution image segmentation and object-oriented classification. The segments of final impervious surface map were classified using a customized nearest-neighbor algorithm that also took a number of spatial characteristics into account: spectral values in the raw data, land-use information derived from Landsat 7 imagery, proximity to known buildings and roads (imported and rasterized vector data), as well as object size and border information. To obtain the high spatial/positional accuracies, the impervious

surface maps were extracted from high resolution, ortho-corrected satellite imagery. These ortho-images were derived from DigitalGlobe's Quickbird Standard OrthoReady image product. The "standard" Quickbird product was augmented using existing control point monumentation supplemented with additional sub-meter GPS observations, and a 10 foot DEM provided by City of Fayetteville.

The final map product was in the form of a five category map suitable for storm water management modeling. The categories are: Impervious Surface, Forest/Wooded, Grasses/Herbaceous, Exposed Soils, and Water. Accuracies were determined based upon ground-truth points collected at times roughly corresponding to the image acquisition. The overall accuracy for the map was 84.21%.

■ Impervious Surface   ■ Exposed Soils
■ Forest & Woodland   ■ Water Bodies
□ Grasses & Pastureland

This research effort indicates that this methodology can be productively used to impermeable surface identification and efforts are now underway to transfer the results of the research to interested private sector engineering firms and others that are considering using the same approach in their future work.

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