

Generation of Cost Effective Digital Elevation Models (DEMs) for Urban Applications

Digital Elevation Models (DEMs) are the digital representation of topographic and/or man-made features located on the surface of the earth. DEMs are widely used for hydrologic analyses, resource management, transportation planning, earth sciences, environmental assessment, and military applications. Increased use of DEMs in these wide-ranging applications has led to a greater need for higher resolution and higher accuracy digital elevation data. This is especially true for urban applications such as base map registration and generation, stormwater management, and flood-risk assessment because of the fine horizontal and vertical spatial scale of most urban features (streets, buildings, etc.).

The most widely available high-resolution DEMs in the U.S. are the 7.5-minute Level 1 DEMs available from the United States Geological Survey (USGS). The USGS 7.5-minute DEMs have a 30m horizontal (xy) resolution, a 7-15 m RMS vertical (z) accuracy, and are available for the entire continental U.S. However, the horizontal resolution and vertical accuracy of the USGS DEMs are not suitable for the vast majority of urban applications.

We have developed and demonstrated a methodology that uses digitally scanned 1:40,000-scale NAPP aerial photography to generate DEMs with horizontal resolutions of 1-3 m. This is ten-fold improvement in resolution compared to the 30-m USGS DEMs. The cost for acquiring the NAPP photographs and precision scanning is about \$30/photo and typically 8-12 NAPP photos are required for stereo-coverage of a medium-sized city (400 km²). Thus these are an extremely low-cost data source for DEM generation. Our methodology uses the digitized NAPP images, limited amounts of ground control (2-3 GCPs per image), and Commercial Off The Shelf (COTS) stereo-processing software to generate the high-resolution urban DEMs.

We have performed rigorous assessments of the vertical accuracies of the high-resolution DEMs at multiple test sites. The assessments utilized tens of thousands of check points derived from kinematic differential GPS surveys. Our results have shown that stereo-processing of the digitized NAPP images can routinely produce DEMs with 1-3 m horizontal resolutions and vertical elevation accuracy on the order of 2-3 m RMS. The DEMs reveal very fine-scale features in urban locations. The horizontal resolution of the DEMs is well suited for urban area applications including watershed basin delineation, transportation and sewer planning, stormwater runoff estimation, and flood area extent mapping.

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