Database Issues in Digital Mapping

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Extended Abstract

Although databases for geographic information systems (GIS) have been developed to manage digital map data, the integration of aerial imagery and collateral information is rarely performed. For the most part, the use of sophisticated intelligent spatial databases, in which a user can query interactively about map, terrain, or associated imagery, is unknown in the cartographic community. In standard GIS systems, the ability to formulate complex queries requiring dynamic computation of factual and geometric properties is severely limited, often reflecting its origin as collections of thematic map overlays. Spatial database research requires the integration of ideas and techniques from many areas within computer science such as computer graphics, image processing, artificial intelligence, and database methodology as well as from the traditional area of photogrammetry. The problem is complex along many dimensions.

First, digital cartography requires a massive amount of raw data: image, map, textual, and collateral data. Recently, various estimates of the amount of data associated with cartographic production[1] have been revealed by the three major users of remote sensing and aerial imagery in the United States: the U.S Geological Survey (USGS) estimates 10^{12} to 10^{14} bits, the National Aeronautics and Space Administration (NASA) estimates 10^{16} bits; and the Defense Mapping Agency (DMA) 10^{19} bits. In a further projection, DMA estimates that by 1995 they will require support for 1000 on-line users, each having a local database context of 10^{12} bits.

Second, the number and variety of spatial entities, their description, attributes, and the rich set of spatial relationships between entities can not be handled by precomputed tables of relationships. The extraction of man-made and natural features from source imagery using automated image analysis tools will require a map database as a source of knowledge to guide the extraction and interpret the processing results. Thus, in order to perform image analysis using knowledge-based techniques[2, 3], we must have some *a priori* information that allows us to constrain computation and search to reasonable levels. This is a chicken-and-egg problem of grand proportions.

The development of intelligent spatial databases addresses two problems in digital mapping. First, from a database perspective, the explosive increase in the availability of imagery and image related information makes finding some small piece of relevant information increasingly difficult On-line storage of tens of thousands of images does not help unless the user can quickly locate a feature or landmark of interest in many

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different images simultaneously.

Second, the same underlying problem exists from an automatic image interpretation standpoint; symbolic indexing and addressing of images for automated analysis requires many of the same techniques as in interactive analysis, except that the human image analyst provides the guidance. Facilities such as on-line image/map databases, signal and symbolic indexing of natural and man-made features, and spatial reasoning can be viewed in the short term as an semi-automated tool for increasing productivity of human photo interpreters and analysts, and in the long term, as the knowledge base for automated systems capable of detailed analysis including change detection and automatic update of map descriptions.

This paper gives a brief overview of current research at Carnegie-Mellon University in the area of spatial database systems for digital cartography and aerial photo interpretation. A brief overview of MAPS, the Map Assisted Photo Interpretation System, is presented[4]. MAPS is a large integrated database system containing high resolution aerial photographs, digitized maps, and other cartographic products, combined with detailed 3D descriptions of man-made and natural features in the Washington, D. C. area.

In this system, the user can formulate queries into the spatial database using high resolution imagery to specify an area of interest for spatial indexing, or to specify a generic type of feature. If an appropriate user interface is provided and explicite image-to-map correspondence is performed, the image can act as a map for a user unfamiliar with an area of interest. Further, the ability to represent and index spatial knowledge allows us to begin to develop image processing techiques to recover roads, buildings, and terrain features used to update or refine existing maps[5].

1. References

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