Developing a Digital Library of 3D Spatial Data

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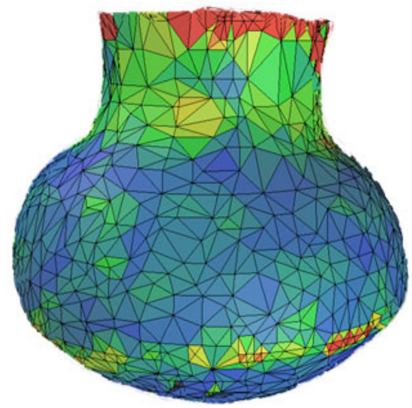
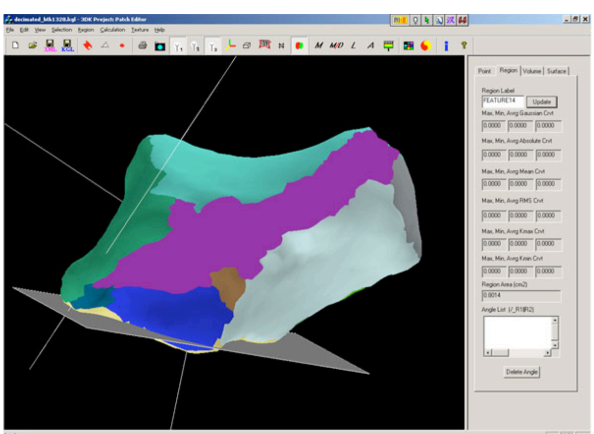


Polygonal Mesh model of Native American Ceramic Vessel with regions of curvature identified by color

This presentation provides an example of a digital library that includes geometric and topological data about 3D objects. Responding to the limitations of image-based two-dimensional (2D) data representations such as QuickTime perceived by discipline scientists, the Partnership for Research in Spatial Modeling (PRISM) project at Arizona State University (ASU) developed modeling and analytic tools that raise the level of abstraction and add semantic value to 3D data. The session will present differences between image based 2D and QuickTime presentation and presentation of modeled 3D representations, the challenges identified in developing a 3D digital library, and the importance of discussions to begin development of standards issues and conventions. Initial digital library efforts to display images of surface models using QuickTime and plug-ins have significantly expanded research and science education as complex natural objects become approachable through such visualization. Adding modeling and analytic tools based on surface and volume that permit objective quantification and analysis of 3D data has the potential to further extend research in virtually every discipline studying 3D objects.

The tools simplify analysis of surface and volume using curvature and topology to help researchers understand and interact with 3D data. The tools produced automatically extract information about features and regions of interest to researchers, calculate quantifiable, replicable metric data, and generate metadata about the object being studied. To make this information useful to researchers, the project developed prototype interactive, sketch-based interfaces that permit researchers to remotely search, identify and interact with the detailed, highly accurate 3D models of the objects.



Prototype bone joint surface tool interface

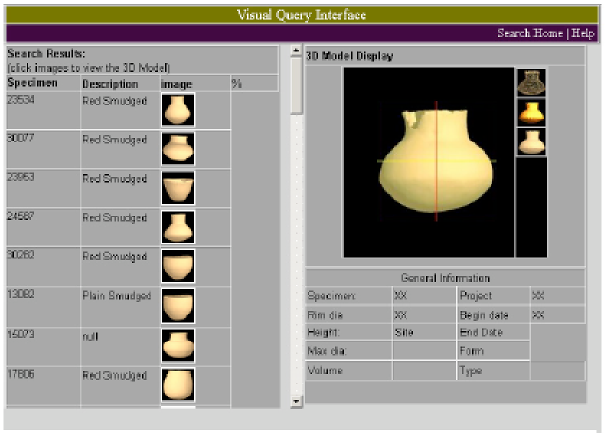
A number of 3D modeling and analytic algorithms have been combined, and new techniques developed to segment the geometric structure into regions, and to identify meaningful features. PRISM researchers developed two key tools: a watershed-based hybrid feature extraction and segmentation scheme to work with the triangular meshes automatically segments the surface into regions of similarity based on curvature; and a region editor that calculates more complex information about the object and its component features such as total object volume, absolute object symmetry, the area of surfaces identified, and the average angle at which surfaces intersect.

Use of 3D data also makes possible new measures based on topology and global or local changes in curvature that define the shape and meaningful features of the original object. The results support comparative analysis of contextual and spatial information, and extend research about asymmetric man-made and natural objects.

Components of the processes include development of:

1. Development of Metadata Schema and Organizational Structure
2. 3D Data Acquisition - Scanning
3. Feature Extraction and Region Identification–Tool development & application
4. Query Interface – Design and Development
5. Evaluation

The visual query process was developed to permit researchers to interact with the data using both contextual (text and numeric descriptive data) and spatial (shape and topological attribute) data. The PRISM team chose to design separate contextual and spatial input areas in the interface screen. Textual data was input or selected from pull down menus to query existing descriptive catalogs or databases. A sketch-based interface was developed that permits users to input both context and sketches to visually describe the object to initiate the search. Several text and spatial matching algorithms are used to identify and rank order objects within the database that math the search criteria.



Example of ceramics query interface results

During search and analysis of potential matches, intelligent filtering techniques are used limit the search pool. Initially simple text, metric, or gross spatial classification criteria are used to identify possible matches from the database and reduce the search domain. As the search progresses, increasingly more complex algorithms are applied to the shrinking pool of potential matches.

Standards are needed for data description, storage, interchange, and searching. Understanding of this complex multidimensional data will be essential as records managers begin to interact with collections of 3D data, and as it begins to reach archives. Conventions for display and organizing research tools are essential to effective preservation and access.

Evaluation and continued research into learning styles, communication preferences, and visual communication and display are needed to guide interface design. Clearly, development of simple, elegant, easy to use interfaces to accommodate the range of tools and user preferences for spatial data and modeling will be a significant challenge now and in the future.

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