Extracting Meta-Information From 3-Dimensional Shapes With Protege

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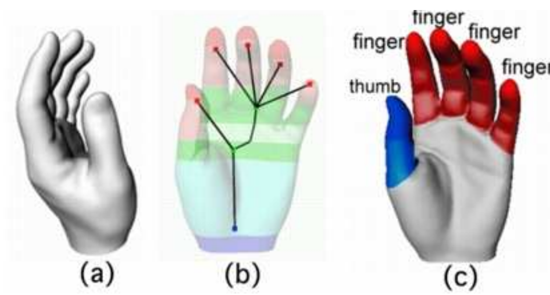

Figure 1: Image Courtesy of the AIM@SHAPE project.

The multimedia world can be classified into one-dimensional media like text and sound, and multi-dimensional media. Among the latter, those that are characterized by a visual appearance in a space of 2, 3, or more dimensions are called shapes. Examples of shapes are pictures, sketches, images, 3D models of solid objects, videos (disregarding the sound track), 4D (=3D+Time) animations, etc. Shapes are expected to take a central role in the Semantic Web in the next years, with high potential impact in several key areas. Consumer PCs are now all equipped with high-performance 3D graphics hardware. Considering that most of these PCs are connected to the Internet, it seems clear that in the near future 3D data will represent a huge amount of traffic and data stored in the Internet. It has been predicted that geometry is poised to become the fourth wave of digital multimedia communication, where the first three waves were sound in the 1970s, images in the ’80s, and video in the ’90s. So if the principal use of PCs is currently related to 2D image processing and visualization (if one restricts to multimedia content), the next step is to add new dimensions (3D geometry, 4D, i.e. time-dependent, geometry) to this information content and endow it with knowledge (semantics). While the technological advances in terms of hardware and software have made available plenty of tools for using and interacting with the geometry of shapes, the interaction with the semantic content of digital shapes is still far from being satisfactory. While we have tools for viewing digital shapes even in much unspecialized web contexts (e.g. browser plug-ins like SVG or VRML for 3D shapes), we miss tools for interacting with the semantics of digital shapes. It is not possible, for example, to search digital shapes by their semantic meaning. This is partly due to the lack of methods for the automatic extraction of the semantic content of digital shapes (semantic annotation) and partly to the evolution of research on shape modelling which had to be highly focused, in the past years, on the geometric aspects of shapes.

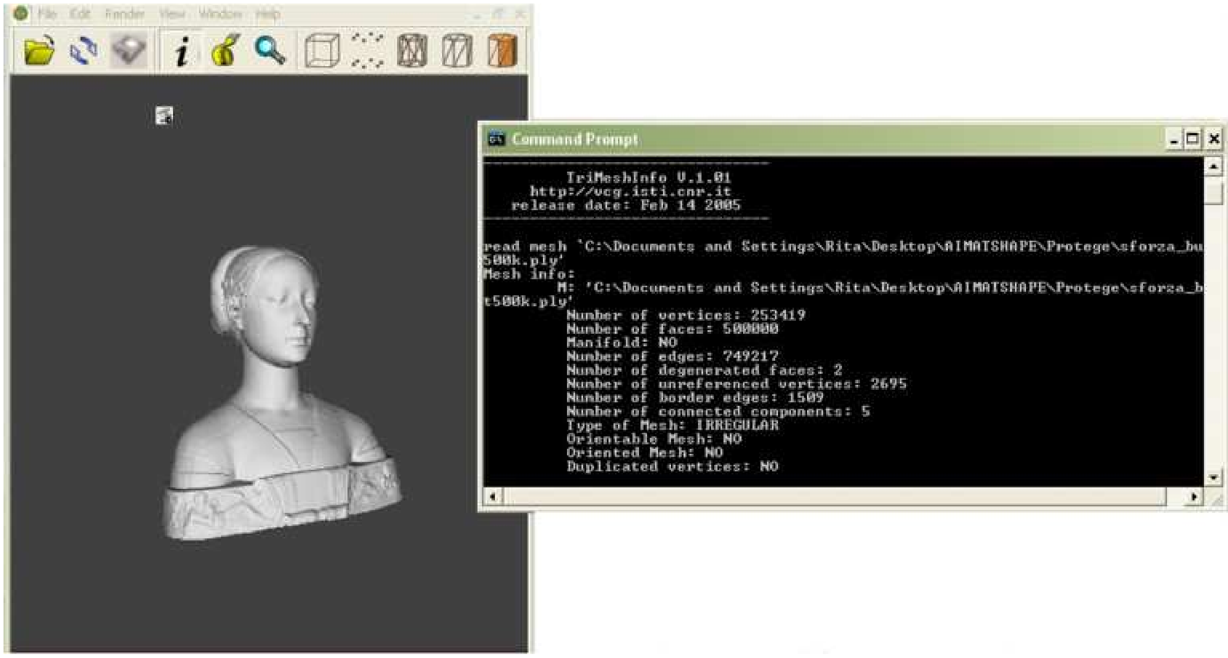

Figure 2: TriMeshInfo Interface. Information collected for the Ippolita Sforza Bust 500K triangular faces.

To address this issue we developed a tool called TriMeshInfo[1] (Fig. 2) that aims at supporting the process of switching between the three basic levels of shape-knowledge representation: *geometric, structural and semantic*.

What is common to all shapes is that they all have a geometry (the spatial extent of the object), they can be described by structures (object features and part-whole decomposition), they have attributes (colors, textures, names, attached to an object, its parts and/or its features), they have a semantics (meaning, purpose), and they may also have interaction with time (e.g., history, shape morphing, animation, video). A purely geometry-based representation of a digital shape can be used to view the shape (Fig. 1a); a structural view can give hints and show how the shape components are linked together (Fig. 1b); a semantic view is able to propose an interpretation or meaning of the digital shape (Fig. 1c).
The structure of a shape is obtained by organizing the geometric information and by making explicit the association between parts or components of shape models or shape data. If the organization is geometry based we can cite as examples: multi-resolution models, multi-scale models, curvature based surface decompositions, topological decompositions, etc. If the approach is already semantic oriented, we can list: shape segmentations, pattern or cluster based structuring, form feature representations, etc. Shapes may enter the digital world either by digitalization or by design processes. In both cases, there might be a considerable amount of knowledge available about the shape, which is neither captured nor coded, in the digital representation of the shape. In our application we have started with the analysis of 2D and 3D

[1]TriMeshInfo has been developed as part of the tool repository of AIM@SHAPE EU Project

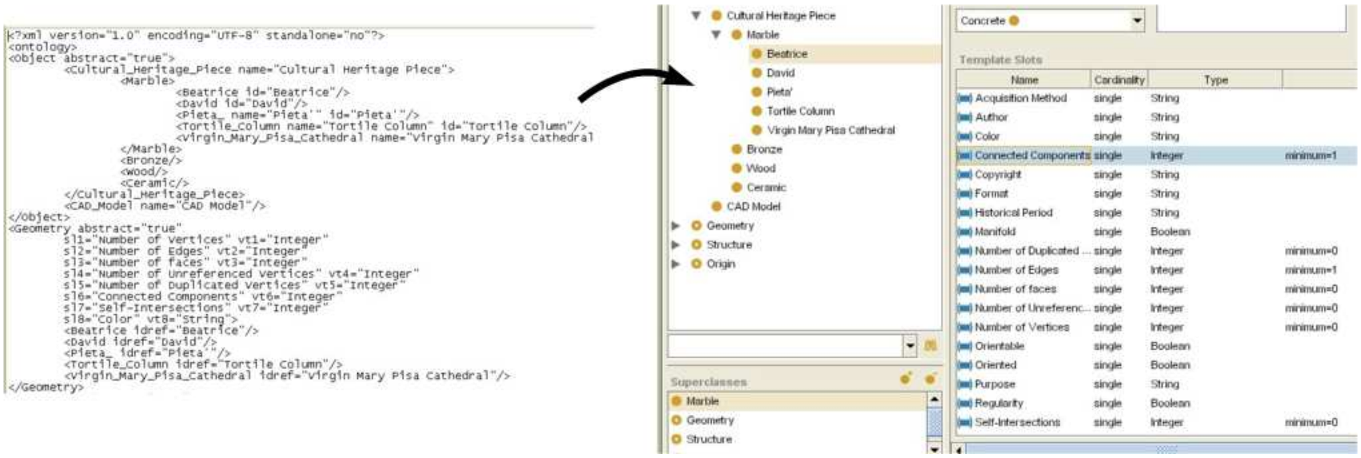

Figure 3: (a)TriMeshInfo XML File (b)Loaded in Protege.

shapes composed of triangular patches. For each analyzed dataset the following information are extracted:

- *Geometrical*: number of vertices, number of edges, number of faces, connected components, number of holes, number of isolated vertices, number of duplicated vertices, self-intersections, genus, color;
- *Structural*: manifold, regularity, orientability, scale, format;
- *Semantic*: origin, author, purpose, way of creation, copyright.

The first two are automatically generated through and inspection of the dataset topology. The Semantic information are instead provided as a separate .txt file associated to the model compiled by the creator of the model himself. To formalize the extracted information in terms of metadata, which describe shape models and shape processing tools, and ontologies, which provide the rules for linking semantics to shape or shape parts, we exploit the protege knowledge formalization mechanisms. We save all extracted data in a .xml file and import it into the protege environment. Following the XML-OWL format TriMeshInfo creates for each shape, a taxonomy and, for each level of knowledge, a class, each attribute becomes a slot for the class it belongs to (Fig. 3). With this process we avoid the manual data entry and once the .xml file, automatically produced by TriMeshInfo, is loaded we can start to populate our database of shape instances and develop queries and graph-chart. The ideal target would be to be able to make TriMeshInfo a plug-in of Protege. Current information systems may handle the geometric representation of digital shapes, but not their semantics (meaning or functionality) in a given context. Through a common formalization framework, it would be possible to build a shared conceptualization of a multi-layered architecture for shape models, where the simple geometry is organized in different levels of increasing abstraction (geometric, structural and semantic layers). Technological innovation would be high in terms of tools for the automated semantic annotation of digital shapes, as well as tools for accounting for the semantics while digitizing, modelling, and sharing shape data.