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Geometric and Topological Signatures for 3D Retrieval [1]

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Abstract

This paper examines the problem of retrieving from a database of three-dimensional objects the most similar objects to a given object. We present two novel geometric signatures for 3D retrieval. We also show how to enrich these signatures with a topological signature. Finally, we describe an experimental study comparing the quality of various signatures using several estimation measures, and draw conclusions.

CR Descriptors: I.3.5 [**Computer Graphics**]: Computational Geometry and Object Modeling; I.3.8 [**Computer Graphics**]: Applications; H.3.3 [**Information Systems**]: Information Search and Retrieval

1 Introduction

Large repositories of digital 3D objects have become increasingly common in many fields, including e-commerce, medicine, entertainment, molecular biology, CAD and manufacturing. The existence of large databases creates a need for efficient techniques of shape-based retrieval of 3D models.

Shape-based retrieval is usually done in two steps. First, each object in the database is compactly represented by a *signature*. Second, a *retrieval algorithm* compares signatures and ranks objects according to the similarity of their signatures. In this paper we focus on developing representative signatures.

In the last few years, several papers dealing with 3D object retrieval appeared. In [4] a vector of preset order shape moments is used as a signature. In [12] an object is represented by a probability distribution sampled from a shape function measuring global geometric properties, such as the distribution of Euclidean distances between pairs of randomly selected surface points. In [6], a topological matching method is proposed, where a multi-resolution Reeb Graph is computed and considered a signature. In [13] descriptors based on cords, moments and wavelets are described. In [16] spherical harmonics are used, where a spherical function is sampled in many points, yet the map is characterized by a few parameters. In [9] a shape descriptor that represents a measure of reflective symmetry for an arbitrary 3D voxel model for all planes through the model's center of mass, is proposed.

This paper proposes two novel geometric signatures: a *sphere projection* signature and an *Octree* signature. The sphere projection signature attempts to capture the global characteristics of a 3D object by computing the amount of "energy" required to deform it into a pre-defined shape. The Octree signature provides a hierarchical representation of an object. The paper also shows how to enrich the above geometric signatures with a topological signature.

An important issue is how to assess the quality of signatures. Typically, each technique is tested on different databases using different criteria, which makes it hard to compare signatures. In this paper we discuss a few general measures for evaluating signatures. These measures are based on the work done in the field of information retrieval [1, 2, 8, 15].

Finally, we describe a comparative study we conducted. We collected from the Internet a database containing 1850 objects. Our proposed signatures were compared to other signatures discussed in the literature [4, 12] using various estimation measures.

The rest of this paper is organized as follows. Section 2 introduces our novel signatures and shows how to enrich them with topological properties. Section 3 describes methods for achieving invariances to resampling, simplification and rigid deformations. Section 4 presents retrieval performance evaluation techniques. Section 5 presents our experimental study. Finally, Section 6 concludes this paper.

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