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Feature-Preserved 3D Canonical Form

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Abstract Measuring the dissimilarity between non-rigid objects is a challenging problem in 3D shape retrieval. One potential solution is to construct the models' 3D canonical forms (i.e., isometry-invariant representations in 3D Euclidean space) on which any rigid shape matching algorithm can be applied. However, existing methods, which are typically based on embedding procedures, result in greatly distorted canonical forms, and thus could not provide satisfactory performance to distinguish non-rigid models.

In this paper, we present a feature-preserved canonical form for non-rigid 3D watertight meshes. The basic idea is to naturally deform original models against corresponding initial canonical forms calculated by Multidimensional Scaling (MDS). Specifically, objects are first segmented into near-rigid subparts, and then, through properly-designed rotations and translations, original subparts are transformed into poses that correspond well with their positions and directions on MDS canonical forms. Final results are obtained by solving nonlinear minimization problems for optimal alignments and smoothing boundaries between subparts. Experiments on two non-rigid 3D shape benchmarks not only clearly verify the advantages of our algorithm against existing approaches, but also demonstrate that, with the help of the proposed canonical form, we can obtain significantly better retrieval accuracy compared to the state of the art.

Keywords Canonical form · Multidimensional scaling · 3D shape retrieval · Non-rigid

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1 Introduction

With the ever increasing accumulation of 3D models, how to accurately and efficiently retrieve these data has become an important problem in computer vision, pattern recognition, computer graphics, mechanic CAD, and many other fields (Shilane et al. 2004; Tangelder and Veltkamp 2008). One of most challenging issues in this problem is the calculation of dissimilarity between non-rigid objects that are commonly seen in our surroundings. Take Fig. 1(a) for an example, a man appears in three distinctive poses, but these models represent the same object in despite of having different appearances. In order to compare non-rigid 3D models quickly and effectively, it is often desired that the shapes can be represented by some discriminative signatures which are invariant or approximately invariant under various isometric transformations (i.e., rigid-body transformations, non-rigid bending and articulation).

While a large number of retrieval methods for rigid 3D shapes have been proposed in the last few years, there has been considerably less work for non-rigid models. In general, existing non-rigid 3D shape retrieval methods can be roughly classified into algorithms using local features, topological structures, isometry-invariant global geometric properties, direct shape matching, or canonical forms. Although these algorithms are all guaranteed to be isometry-invariant, they are still not well suited for practical applications in