Metric Tensor and Christoffel Symbols based 3D Object Categorization

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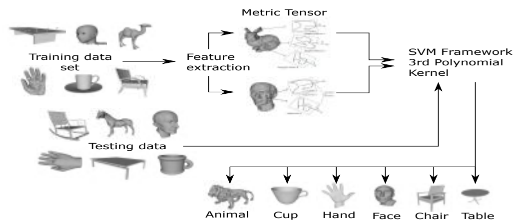

Figure 1: *Overview of the 3D object categorization Framework*

Abstract

In this paper we propose to address the problem of 3D object categorization. We model the 3D object as a 2D Riemannian manifold and propose metric tensor and Christoffel symbols as a novel set of features. The proposed set of features capture the local and global geometry of 3D objects by exploiting the positional dependence of the features. The categorization of 3D objects is carried out using polynomial kernel SVM classifier. The effectiveness of the proposed framework is demonstrated on 3D objects obtained from different datasets and achieve comparable results.

1 Introduction

3D object categorization is a much harder problem for computers than humans. To address this issue we propose a set of features based on metric tensor and Christoffel symbols. Metric tensor together with Christoffel symbols captures the unique set of geometric features that are inherent to the 3D object shapes. Most of the 3D categorization methods use shape, features and Bag-of-Words extracted from certain projections of the 3D objects [Toldo et al. 2009]. However, we propose to use features extracted from the geometry of 3D objects to categorize them and achieve comparable results.

2 Approach

The 3D objects under consideration are modeled as a set of 2-dimensional Riemannian manifolds [Weinberg 1972]. The global geometrical properties of a 3D object are usually different from the local geometrical properties due to non-uniformity in the geometrical properties throughout the surface. The local geometrical properties computed for a 3D object are unique as they exhibit positional dependence and hence can be used for 3D object categorization. Riemannian metric tensor and Christoffel symbols effectively portray the inherent geometrical properties for a 3D object and hence are selected as features for categorization of 3D objects. The metric tensor represents the geometrical signature of the manifold in the local patch, however this alone may not capture the global geometrical properties since variations in the local patches are not inherently captured in the metric tensor. The Christoffel symbols give the numerical measure for the deviations in the geometrical properties of the manifold in the neighborhood of a patch. The geometrical properties can quantitatively be represented using the combination of metric tensor and Christoffel symbols. The metric tensor and Christoffel symbols vary from point to point for a 3D object and hence can be modeled as a function of position. The categorization of the 3D objects into generic classes is carried out using a SVM framework with the proposed set of features and is shown in Figure 1. The proposed set of features are computed for a predifined set of models belonging to a particular class of objects and are fed to the SVM for learning. The testing data is fed to the SVM framework for categorization into the predefined class.

3 Implementation

The results for the 3D object categorization framework are carried out using known data set used by Roberto et al. [Toldo et al. 2009]. The 3D models are taken from Aim@shape project, TOSCA non rigid shape dataset and Stanford 3D scanning repository. The dataset includes 6 categories with 8-10 samples in each class. We compare our results with the results presented by Roberto et al. [Toldo et al. 2009] which uses a similar data set. We demonstrate the results for the categorization of the 3D objects using leave-one out cross validation testing with a success rate of 100% for 6 categories compared to 85.83% as presented by Roberto et al. [Toldo et al. 2009]. The limitation of proposed work is that, it cannot handle non-rigid transformation and deformation of objects.

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References

Toldo, R., Castellani, U., and Fusiello, A. 2009. A bag of words approach for 3d object categorization. In *Proceedings of the 4th International Conference on Computer Vision/Computer Graphics CollaborationTechniques*, Springer-Verlag, Berlin, Heidelberg, MIRAGE '09, 116–127.

Weinberg, S. 1972. *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*. Wiley, New York, NY.