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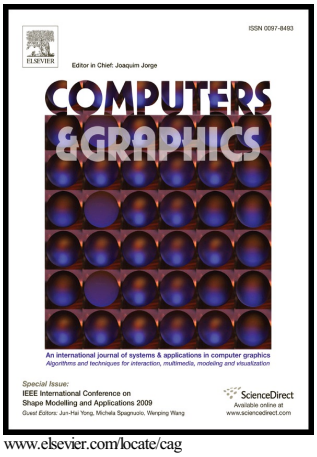

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Estimating affine-invariant structures on triangle meshes

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Abstract

Affine invariant measures are powerful tools to develop robust shape descriptors that can be applied, for example, to shape matching, shape retrieval, or symmetry detection problems. In this work we introduce estimators for the affine structure of surfaces represented by triangle meshes, i.e. affine co-normal and normal vectors, affine curvature tensors, affine mean and Gaussian curvatures, and affine principal directions and curvatures. The proposed method estimates the affine normal using a finite differences scheme together with a least-squares approximation, followed by a weighted average strategy to approach discrete affine curvature tensors. When compared to the exact geometric measures of analytic models, experiments on regular meshes obtain small error, which decreases for finer meshes, and outperforms a state-of-the-art method in some cases. Experiments to evaluate affine invariance show that the difference between measures before and after equi-affine transformations remains small even after large deformations.

Keywords: affine geometry, invariant measures, affine invariance, equi-affine transformations

1. Introduction

Triangle meshes have been widely adopted in the last decades to explicitly represent 3d shapes in many computer graphics and geometry processing applications [5]. An explosion in the number of 3d models available on the internet was observed in the last decade due to novel modeling and digitizing techniques and the popularization of depth sensors [32]. For this reason, topics ranging from 3d shape retrieval [19] to dynamic remeshing [14] have attracted the attention of researchers from different communities.

Shape similarity and retrieval of 3d discrete surfaces is currently an active topic of research with many open problems [4, 32]. While several rigid shape descriptors are available in the literature, the non-rigid shape correspondence problem lacks robust solutions [35].

Besides 3d shapes, computer vision researchers have been focused in developing and improving techniques related to the problem of matching and registration of other graphic objects. Recently, the development of more sophisticated invariant descriptors for images resulted in more reliable matching techniques. In particular, affine invariant measures have been successfully explored in that context [22, 23, 37].

As an alternative, affine differential geometry is the simplest one beyond Euclidean differential geometry, and can be studied using some tools of the latter [8]. It provides measures that are invariant under a class of transformations larger than the rigid motions, including shearing and non-uniform scaling. This allowed novel affine invariant applications to emerge in the last decade [25, 27, 11].

However, while many estimators for Euclidean differential geometry structures were proposed for triangle meshes [31], their analogues for discrete affine geometry structures have not been completely researched yet. This restricts the potential of affine invariant methods for triangle meshes. In this work we present estimators for equi-affine differential structures on triangle meshes, including the affine normal vector, affine shape operator, and consequently affine curvatures and principal directions (see Fig. 1). The potential applications of such invariant structures ranges from computer vision, as in affine invariant shape matching; to geometry process-

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