Model based tracking of rigid curved objects using sparse polygonal meshes

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Abstract

In this paper a framework to improve model based tracking of rigid curved objects using polygonal meshes is presented. Previous approaches deal with curved objects treating them as polyhedral objects but requiring the use of dense meshes which may be computationally inefficient. Furthermore, when considering, for instance, applications targeting mobile devices, the data size of this model can become an inconvenience to the final user. However, reducing the quality of the object mesh creates a trade-off between the computational time and tracking accuracy. In order to solve this problem, we suggest the use of quadrics calculated for each patch in the mesh to give local approximations of the object shape. Then, curves representing the quadrics projection in the current viewpoint are used for distance evaluation. This representation allowed us to considerably reduce the level of detail of the polygonal mesh and keep an accurate tracking.

Keywords: Apparent contour, quadrics, model-based tracking, camera pose estimation, sparse polygonal meshes.

1 Introduction

Tracking the 3D pose of a known object is a common task in computer vision and many approaches to achieve real-time tracking have been developed in order to attend different applications and scenarios as can be seen in the crescent number of systems in Augmented Reality (AR).

This work focus on model-based tracking that considers the object edges while doing tracking, similar to the approaches presented in [3] and [2]. A polygonal mesh of the target object is used for matching with the edge information found on the video image. Given an initial estimation of the pose, edge normal search of projected edges in the image is performed and the final pose is obtained after an optimization process. However, the approaches mentioned above are applied mainly to polyhedral objects with flat faces.

When dealing with curved objects, the tracking becomes more challenging because dense meshes are required to accurately recover the object shape, creating a trade-off between the computational time and tracking accuracy as exemplified in Fig.1(a): the number of patches in the mesh was reduced in order to improve the system efficiency, but a larger distance *d* between projected and detected edges is used for error evaluation, affecting accuracy.

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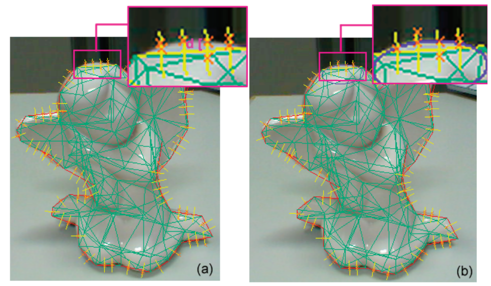

Figure 1: A sparse polygonal mesh is overlaid on the target object and a comparison between the distance evaluation of (a) the standard tracking and (b) our proposed approach using conics is showed.

2 Proposed Framework

In our framework, a general quadric equation is calculated for each patch in the mesh and curves representing the quadrics projection in the current viewpoint are used for matching with detected edge points in the video image (conics represented by the blue lines). In Fig.1(b), it is possible to notice it approximates better the object contour and the error is clearly smaller when compared to Fig.1(a) - part of the ellipse passes exactly on the detected edges.

Quadrics were chosen because they have simple contour generators and their apparent contour can be easily obtained by using the theory provided by differential geometry [1]. They are represented by conics and using them instead of the original edges from the mesh makes the tracking more robust when dealing with sparse meshes because more correct point correspondences can be found and more accurate because it is able to approximate better the local shape of the object.

Our main contribution is the creation of a simple representation that can be easily constructed and at the same time efficient when dealing with curved objects having different shapes. This representation also allowed to considerably reduce the data size of the polygonal mesh (in some cases, the number of patches can be reduced to 10% of the number of patches from the dense mesh), making it a good option for AR applications in mobile devices, for instance. Experimental results comparing the use of dense and sparse meshes will be presented using both simulated and real image data.

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