Chapter 2

Uniform Sampling of Rotations for Discrete and Continuous Learning of 2D Shape Models

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ABSTRACT

Different methodologies of uniform sampling over the rotation group, SO(3), for building unbiased 2D shape models from 3D objects are introduced and reviewed in this chapter. State-of-the-art non-uniform sampling approaches are discussed, and uniform sampling methods using Euler angles and quaternions are introduced. Moreover, since presented work is oriented to model building applications, it is not limited to general discrete methods to obtain uniform 3D rotations, but also from a continuous point of view in the case of Procrustes Analysis.

INTRODUCTION

Two-dimensional shape models are able to change their shape according to a labeled training set. A shape is composed by a finite set of landmarks whose geometrical information remains unchanged when the shape suffers from rigid transformations. Common 2D shape models (e.g. Point Distribution Models, Active Shape Models) have been successfully applied to solve several problems in Computer Vision, such as face tracking, object recognition, and image segmentation. Usually, these models are learned from a discrete set of 2D shapes once the rigid transformations are removed by aligning the training set, i.e., applying Procrustes Analysis (PA). However, PA is
sensible to incomplete and biased set of views of the objects in the training set. In order to solve this problem, examples of 3D objects can be used in two ways: on the one hand, 3D objects are used to extract uniform 2D views to be aligned by standard PA; on the other hand, Continuous Procrustes Analysis (CPA) is used to learn all 3D rigid transformations directly from the 3D examples. In the past, such techniques could only be applied to a limited number of objects, since the most part of databases were storing two-dimensional information. However, recently many 3D databases, as well as 2D databases with three-dimensional information, have become available because of the market release of low cost depth cameras. It is illustrated in Figure 1 how 2D data could be extracted from 3D information provided for this kind of cameras. Different approaches to achieve non biased 2D shape models from 3D data will be explained and discussed along this Chapter.

Uniform sampling of 3D objects is considered a key step when building unbiased 2D shape models. Frequently, Euler angles are used to define three dimensional rotations; however, Euler angles suffer from known problems like gimbal lock or non-uniform rotations (Kuffner, 2004). The main part of this Chapter will be devoted to discuss different configurations to parameterize 3D rotations: usual non-uniform rotations and uniform sampling alternatives using quaternions and Euler angles.

2D shape models are also able to modify their shape in a non-rigid mode, consistent with shape deformations in the training set. The extraction process for non-rigid variations is outlined in the next section; however, deformable models are not addressed in this research, though they could be a direct extension.

BACKGROUND

Building 2D shape models will be the main goal when generating and analyzing uniform rotations. From this perspective, construction of statistical models will be introduced and, specifically, the Procrustes Analysis (PA) technique is described. PA is an important step in model building, as well as it is closely related with the continuous approach of uniform sampling.

2D Shape Models

Two-dimensional shape models are statistical models which are able to modify their shape according to the different transformations present.

Figure 1. (left) Image sequence obtained from a depth camera; (middle) 3D skeletons extracted using Kinect© for Windows SDK; (right) 5 cameras, randomly distributed around the 3D skeleton, are displayed.
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