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Normal Estimation via Shifted Neighborhood for Point Cloud

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Abstract

For accurately estimating the normal of a point, the structure of its neighborhood has to be analyzed. All the previous methods use some neighborhood centering at the point, which is prone to be sampled from different surface patches when the point is near sharp features. Then more inaccurate normals or higher computation cost may be unavoidable. To conquer this problem, we present a fast and quality normal estimator based on neighborhood shift. Instead of using the neighborhood centered at the point, we wish to locate a neighborhood containing the point but clear of sharp features, which is usually not centering at the point. Two specific neighborhood shift techniques are designed in view of the complex structure of sharp features and the characteristic of raw point clouds. The experiments show that our method out-performs previous normal estimators in either quality or running time, even in the presence of noise and anisotropic sampling.

Keywords: normal estimation, point cloud, neighborhood shift

1. Introduction

Estimating surface normals in a point cloud is a crucial preprocessing operation. High quality normals benefit numerous point clouds processing algorithms, such as surface reconstruction [1], geometric primitive extraction [2], anisotropic smoothing [3] and point based rendering [4]. Although it has been extensively studied, accurate computation near various features in the presence of noise and non-uniform sampling is always a recurrent issue.

The normal of a point is approximated by analyzing the geometry structure of its local neighborhood. The methods [1, 5, 6, 7] use the whole neighborhood centered at the point on the assumption that the surface is smooth everywhere. Even when different weights are assigned to all its neighbor points according to positions and initial normals, blurred edges are unavoidable since points belonging to different surface regions are taken into consideration. To alleviate the problem, different voting techniques are employed, such as RNE [8] and HF [9]. However, some inaccurate normals may still exist in the vicinity of sharp features with anisotropic sampling or large dihedral angels. There are also segmentation based approaches [10, 11], who explicitly segment the anisotropic neighborhood into several isotropic sub-neighborhoods to avoid using points of different surface regions. Higher performance are ensured with the cost of longer runtime.

In this paper, we present a brand novel approach to construct the neighborhood for fast normal estimation. Instead of using the neighborhood centering at the current point, a set of neighborhoods containing the current point are evaluated and the one with the most consistent normals is selected as the neighborhood of the current point. Thus the selected neighborhood have more possibility to be isotropic, i.e. excluding points from different regions, which will lead to more faithful normal estimation. In the above core idea, the construction of the set of candidate neighborhoods is vital. In view of the characteristic of point clouds and corner features, specific candidate neighborhoods construction methods are designed. We also introduce a criteria considering both flatness and distance to evaluate the normals' consistency of a neighborhood. Thus our method can estimate normals accurately and fast even in the presence of noise and anisotropic sampling, while preserving sharp features. The experiments illustrate the effectiveness of the proposed method. The contributions of this paper are twofold:

- A novel perspective of constructing a neighbor-