Efficient Surface and Feature Estimation in RGBD

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***Abstract*— Extracting useful information of RGBD images at high frame-rates requires fast algorithms that are more than just individual steps in a pipeline. Ideally, they should be doing as much as possible in a single step, and re-use information from previous computations. We will present our first experiences with such a pipeline, consisting of open-source algorithms from the Point Cloud Library (PCL) of ROS, and detail the modifications and parameters used for easy reproduction and extension.**

I. Motivation

Our approach for efficient object classification is based on a database of object scans using the kinect sensor. We perform smoothing, normal estimation, surface radius estimation and feature extraction using PCL, sped up by the use of voxelization. The locally labeled voxels are then used to calculate two features in parallel for each object hypotheses, and classified using SVM. While groups of points can be formed in an organized dataset by extracting pixel neighborhoods as well, using voxelization ensures spacial closeness and similar volume.

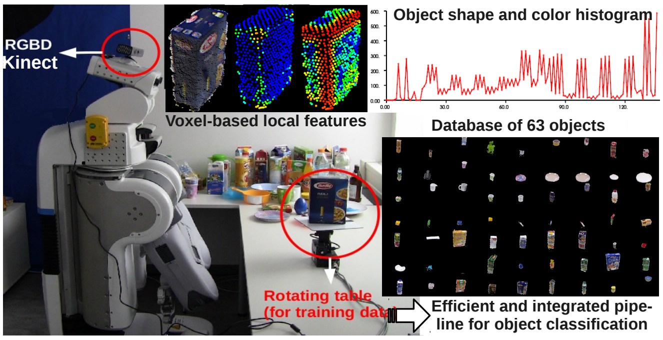

Fig. 1: We perform object classification based on RGBD data, and present the efficient processing algorithms that are used to achieve it, as well as our freely available object database.

A. Smoothing and Normal Estimation

In each voxel, the surface defined by the points can be estimated robustly using an MLS approach [1], and the cross product of two tangents of the fitted polynomial in a given point define the normal. Computing the points and normals once per voxel (by sampling multiple points on the surface) avoids nearest neighbor searches for each point and provides enough data to estimate the geometry, as detailed below.

B. Descriptive Local Geometric Features

The radius of the curves with the minimum and maximum curvature can be estimated as in [2], but based on the sampled points for each voxel. As these are metric values, they can be used intuitively to categorize the surfaces in the cells, which can be further used to build object-level features [3].

C. RGBD Feature For Object Classification

Having voxels with both RGB and geometric features enables the simultaneous use of two features operating on voxel neighborhoods: GRSD [3] and Color-CHLAC [4]. The former computes transitions between the surface types, while the latter color correlations. The features can be computed at once, on average in 0.26 s per object (consisting of 4632 points on average). Initial classification results on 63 objects using SVM show 76.4% accuracy, with a classification time of 0.05 s per object. This can be improved further by marking each view as a separate class during training, but considering only the object type when interpreting the results. Initial tests using the less accurate Hokuyo improved the success rate by 12%.

There are other features in PCL that can be used as well, and some of them can be even adapted to work on voxels to achieve a speed-up and to combine them with the above two.

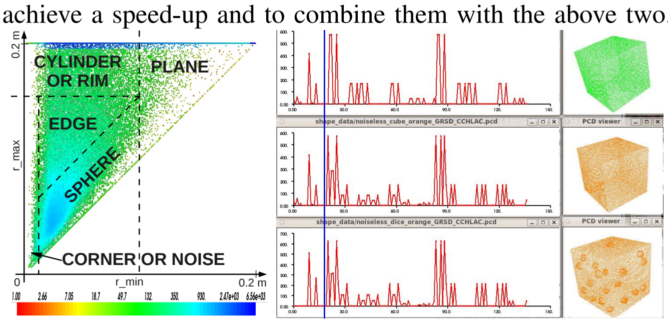

Fig. 2: Left: surface curve radius log-distribution for objects and main surface type associated with local feature ranges. Right: GRSD can not differentiate colors (identical histogram bins on the left), while ColorCHLAC can not differentiate the die from the cube (bins on the right). Their combination produces distinct signatures for them.

II. Results

Our results will be presented in a demo and the object database released for free use. The unreleased parts of the code will be published as part of PCL (`pointclouds.org`).

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