Object Recognition in Noisy RGB-D Data

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Abstract. The object recognition task on 3D scenes is a growing research field that faces some problems relative to the use of 3D point clouds. In this work, we focus on dealing with noisy clouds through the use of the Growing Neural Gas (GNG) network filtering algorithm. Another challenge is the selection of the right keypoints detection method, that allows to identify a model into a scene cloud. The GNG method is able to represent the input data with a desired resolution while preserving the topology of the input space. Experiments show how the introduction of the GNG method yields better recognitions results than others filtering algorithms when noise is present.

Keywords: Growing neural gas · 3D object recognition · Keypoints detection

1 Introduction

3D object recognition is a growing research line which has been impulsed by the notorious advantages that offers the use of 3D sensors against the 2D based recognition methods. However, it is a topic that presents difficulties to achieve an effective recognition. Some of these difficulties are: noise, occlusions, rotations, translations, scaling and holes that are present in the 3D raw point clouds provided by the nowadays RGB-D sensors like Microsoft Kinect. Therefore, new algorithms are required to handle these problems and perform a correct object recognition process.

There exist several works in the field of 3D object recognition, some of these make a survey, review or evaluation of the existing 3D object recognition methods while other works focus on the proposal of new methods and approaches for the recognition process. In [5] a survey of 3D object recognition methods based on local surface features is presented. They divided the recognition process in three basic phases: 3D keypoint detection, feature description, and surface matching. It also describes existing datasets and the algorithms used by every phase of the whole process. Other studies like [13] focus on the evaluation of stereo algorithms. It makes an evaluation in terms of the recognition ability of this kind of algorithms. Using a different approach, [2] evaluates the different 3D shape descriptors for object recognition to study the feasibility of such descriptors in 3D object recognition.

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There are some works that propose novel object recognition pipelines, like [6], where using depth maps and images it achieves good recognition results on heavy cluttered scenes. Using a different approach, [12] proposes a novel Hough voting algorithm to detect free-form shape in a 3D space, which produces good recognition rates. [8] describes a general purpose 3D object recognition framework that combines machine learning procedures with 3D local features, without a requirement for a priori object segmentation. This method detects 3D objects in several 3D point cloud scenes, including street and engineering scenes. [1] proposes a new method called Global Hypothesis Verification (Global HV). This work adds the Global HV algorithm to the final phase of the recognition process to discard false positives. Our approach is based in the pipeline presented in this work, introducing noise into the original point cloud to test the effect of that noise in the recognition process.

In this paper we propose the use of a Growing Neural Gas (GNG) to represent and reduce the raw point clouds. These self-organizing maps learn the distribution of the input points and adapting their to topology. This feature allows to get a compact and reduced representation of the input space in a set of 3D neurons and their connections. In addition, we test different keypoints detectors to determine which obtain betters recognition results. Other papers like[17] use a GNG algorithm to filter and reduce single frontal point clouds. This GNG reduction improves the recognition process and reduces noisy 3D values. We will also compare our proposal against other reduction/filtering methods like Voxel Grid. Hence we present experiments that test a 3D object recognition pipeline with both the raw point cloud, the GNG and Voxel Grid filtered point clouds. Besides, we describe the selected dataset for the experiments and show the results.

The rest of this work is organized as follows. First, we introduce and describe in Section 2 the GNG and Voxel Grid methods that we will use in the experimentation. Then, in Section 3 the pipeline is explained. Next, Section 4 describes the dataset and how the recognition experiments are carried out. After that, in Section 5 we present the results and discussion of our experiments and, finally, conclusions are drawn.

2 3D Filtering Methods

One way of selecting points of interest in 3D point clouds is to use a topographic mapping where a low dimensional map is fitted to the high dimensional manifold of the model, whilst preserving the topographic structure of the data. In this section, we review some typical methods to represent and reduce 3D data. First, we describe the Growing Neural Gas algorithm and how it works. Then, we briefly describe the Voxel Grid method, which is other commonly used data structure, in order to compare our proposal method.