Multi-view feature extraction based on slow feature analysis

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ARTICLE INFO

ABSTRACT

In this paper, we proposed to apply IncSFA to represent the feature of 3D model and employed graph matching to handle similarity measure problem between two different 3D model. First, we built the input data in order to guarantee it suitable for SFA mode according to structure information of 3D model. Second, SFA method utilizes iterations learning method to extract slow feature for each 2D views recorded from 3D model. Finally, weighted bipartite graph matching is leveraged to compute the similarity between query model and candidate model. Extensive comparison experiments were on the popular ETH dataset. The results demonstrate the superiority of the proposed method.

1. Introduction

In recent years, a rapidly growing technologies of 3D models have been widely used in diverse fields. Such as industrial product design, teleconference, human–computer interaction interactive, 3D games, education, film and television animation. Because of the large number of 3D models, the technology of 3D model retrieval is becoming a hot topic in computer vision. An excellent 3D model retrieval can effectively improve the utilization of 3D models and save human cost. Many methods have been proposed to handle 3D model retrieval problem. In general, these methods can be divided into two categories: model-based retrieval and view-based retrieval.

Model based 3D retrieval technology [31] is the new research field in recent years, the thought of retrieval technology originated from the content-based image retrieval [24,25]. Many countries have been engaged in this field of research, and they put forward a number of new search technologies and developed many model based 3D models retrieval experimental systems which made 3D models retrieval a more active area of research. However, in general, the current 3D models retrieval technology research is still in its infancy, and many issues remain to be further research and to be solved [7]. The another thought of the 3D models retrieval makes 3D model convert to two-dimensional images, by using 2D image to 3D model retrieval, we called the view based 3D retrieval.

View-based methods can effectively utilize many mature compute vision technologies to extract visual feature for model retrieval. However, it is hard to guarantee the solid of visual

feature according to the changes of light and recorded angles and the discrimination of feature from different images [17,32]. In order to handle these problems, we proposed to utilized Slow Feature Analysis (SFA) to generate robust feature for each view to handle the representation problem of model. SFA is a unsupervised learning framework for learning invariant or slowly varying features from a vectorial input signal. According to our problem, we converted each 3D model into a set of 2D RGB images from different angles. We see the model that are present in the image, rather than the color of the individual pixels and difference between each other. We need to find the statistical regularities from the set of 2D images for representing the 3D model. SFA is very suitable for this work. Fig. 1 can demonstrate our motivation. Slow feature can effectively increased the degree of differentiation with traditional feature. In this study, firstly, the representation views are selected from multi-views of 3D model. Secondly, Zerniker moment is extracted from each 2D image and IncSFA is utilized to compute the transfer function for each query 3D model, which is used to extract SFA feature for each candidate 3D model in retrieval process. Finally, WBGM is leveraged to compute the similarity between query model and candidate model to find the best retrieval result.

The advantages of the proposed method are threefold:

- SFA model is utilized to extract robustness feature for each 3D model, which can guarantee the accurate of similarity between query model and candidate model.
- WBGM is leveraged to handle similarity measure problem, which can effectively handle multiple object matching problem to guarantee the accuracy of similarity.
- A new dataset named Multi-view RGB-D Object Dataset (MV-RED) is used in this study, which was recorded by Kinect

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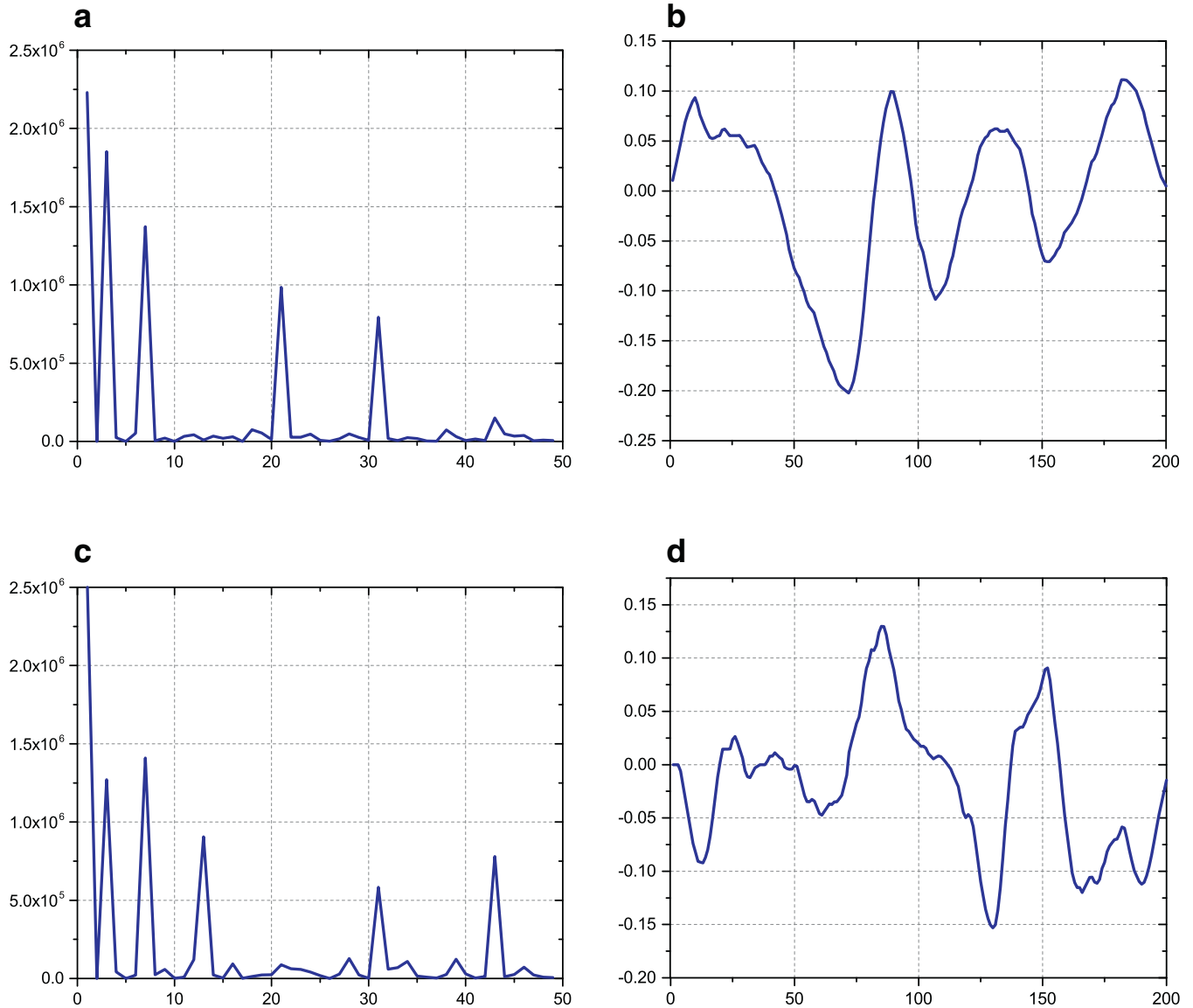
Fig. 1. The feature changes after learning Zernike and SFA respectively. (a) and (c), respectively, denote the Zernike feature of the apple and tomato. (b) and (d), respectively, denote the SFA feature of the apple and tomato.

cameras from different angles. The details will be introduced in next section.

The remainder of this paper is organized as follows: Section 2 reviews related work on 3D models retrieval. Section 3 introduces IncSFA. WBGM method in 3D models retrieval algorithm is proposed in Section 4. Experiments and results are introduced in Section 5. Section 6 gives the conclusion of this article.

2. Related work

Slow Feature Analysis (SFA) raised by Berkes and Wiskott refers to extract slowly varying characteristic from the rapid changing input signal and it is applied in 3D models retrieval [4,34]. It cannot only ensure to get the global optimal solution, but also simultaneously obtain a series of features of the change rate in ascending order. IncSFA is the first online algorithm for slow feature analysis, constructed via a combination of incremental PCA and MCA. We explain why using IncSFA and how it resists the curse of di-

mensionality. IncSFA was successfully compared with batch SFA. To deal with the high nonlinearity involved in extracting slow features from images, a hierarchical IncSFA network was built. It performed well on high dimensional video. IncSFA represents an important step forward, as it opens up the potential of SFA on unsupervised pre-processing of large sets of high-dimensional and nonstationary data, such as EEG signals, sensory input streams of autonomous robots, etc. SFA makes it use in unsupervised preprocessor for autonomous learning agents generally.

Now, many retrieval methods have been put forward to deal with the problem of 3D models retrieval [8,16]. The methods of the Hausdorff distance and the nearest neighbor are straightforward technique to directly employ these existing many-to-many matching methods [3,5]. Although these methods are designed for many-to-many matching, the comparison between two groups of multiple views is different from existing many-to-many matching tasks because of the complex relationship among these multiple views [13]. Papadakis et al. presented an unsupervised 3D object retrieval method based on the panoramic views that are obtained by projecting a 3D object to the lateral surface of a cylinder