KinectSBR: A Kinect-Assisted 3D Sketch-Based 3D Model Retrieval System

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ABSTRACT

How to draw 3D sketches and how to search 3D models based on a hand-drawn 3D sketch are interesting but challenging questions. In this demonstration, we try to answer them by developing a novel Kinect-assisted 3D sketch-based 3D model retrieval system which also allows users to freely draw 3D sketches in a 3D space. We demonstrate its promising potentials in both collecting 3D sketch data and conducting 3D sketch-based 3D model retrieval.

Categories and Subject Descriptors

H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval; I.3.8 [**Computer Graphics**]: Applications

Keywords

Sketch-based 3D model retrieval; 3D sketch; Kinect

1. INTRODUCTION

A 2D sketch lacks the 3D shape information of the object it represents, which generates a large semantic gap between the iconic representation of the 2D sketch and the accurate representation of the 3D model behind. It is this gap that makes 2D sketch-based 3D modeling retrieval a very challenging task [3]. Motivated by this, we consider whether using 3D sketches for 3D model retrieval poses a viable alternative, one that would completely bypass the formidable semantic gap. If an interface is available to allow users to draw a 3D sketch of an object in free space (e.g., in the air), users would have the ability to encode the object's 3D information while expressing its features with salient 3D lines, just as the information stored in the counterpart 3D model.

In this demonstration, a virtual 3D sketching drawing "board" is first developed and then a novel 3D sketch-based 3D model retrieval system is created based on the board. By retrieving 3D models from a large scale sketch-based 3D shape retrieval benchmark (target dataset only) for 300 human sketches collected from seventeen users by utilizing the 3D sketching board, we demonstrate the promising retrieval performance of the system. According to our knowledge, we are the first that explores 3D sketching in a 3D space and develops an innovative retrieval system that enables users to search 3D models using hand-drawn 3D sketches.

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2. SYSTEM OVERVIEW

2.1 3D Sketching

We begin by developing a virtual 3D sketching "board" (see Fig. 1 (a)) with the Microsoft Kinect, which we designed to track the location of a user's hand in a 3D space. To enable a mode of hands-free interaction with the GUI, we implement a voice-activated interface that supports a list of voice commands (e.g. start, left, right, pause, resume, search, and reset). We also integrate a Kalman filter, which reduces background noise and predicts smoother sketches.

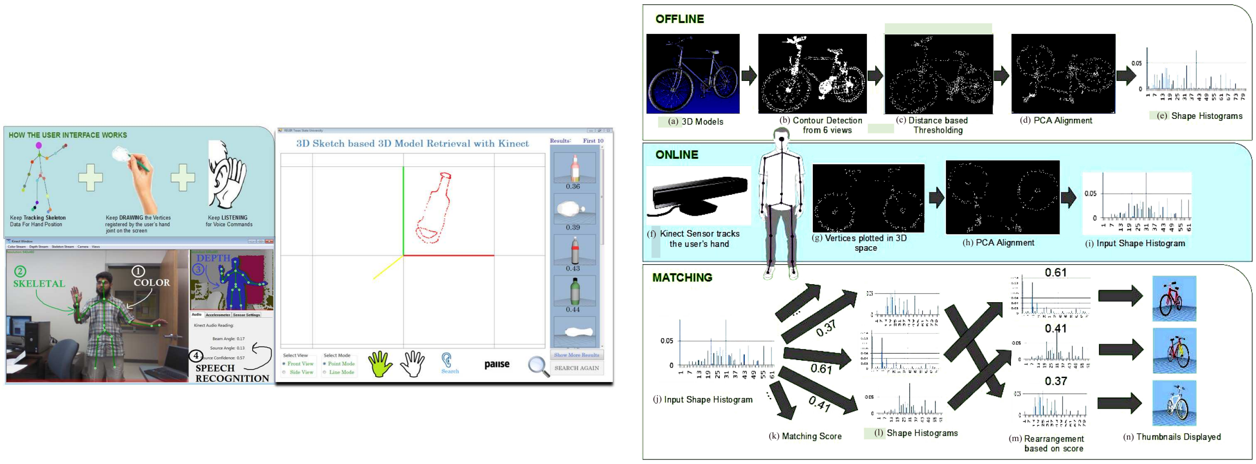
2.2 Retrieval System

An efficient **K**inect-assisted 3D **S**ketch-**B**ased 3D model **R**etrieval system (**KinectSBR**, see Fig. 1 (b)) is built based on the above 3D sketching platform. It has both online and offline processes and consists of three major components.

(1) Data processing. The process targets generating a normalized 3D outline for a 3D model. A Principle Component Analysis (PCA)-based 3D normalization process is first applied on the 3D model, followed by integrating the 3D contour points of its six standard views (Fig. 1 (b): (b)) to generate the complete 3D outline. Next, we perform an approximately uniform point sampling on the 3D outline based on a distance threshold between the 3D points (Fig. 1 (b): (c)). Finally, a PCA alignment is performed (Fig. 1 (b): (d)) on the 3D outline. The same normalization process is applied to hand-drawn 3D sketch queries.

(2) Feature extraction. Motivated by the inherent nature (point cloud) of 3D sketches and 3D outlines, we represent both with efficiently-extracted 3D shape histograms [1] (20 shells, 6 sectors, 120 bins in total) (see Fig. 1 (b): (e)).

(3) 3D sketch-3D model matching. Euclidean distances between the 3D shape histograms of the 3D sketch query and all the target 3D models are first computed (Fig. 1 (b): (k)) and then sorted ascendingly (Fig. 1 (b): (m)). Finally, we display the thumbnails of the top ten 3D models accordingly on the right of the GUI (Fig. 1 (b): (n)). Users have the option to access more results with the appropriate voice command (e.g. "more results").



(a) GUI (b) Framework

Figure 1: System Graphical User Interface (GUI) and framework.

3. DEMONSTRATIONS

We will demonstrate that our KinectSBR system enables users to perform: **(1) 3D sketching:** use one hand to sketch a 3D sketch in the air when standing within 5 meters in front of a Kinect; **(2) 3D sketch-based 3D model retrieval:** continue to conduct a search of 3D models based on the drawn 3D sketch from a large scale 3D model dataset. We demonstrate these via the two following experiments.

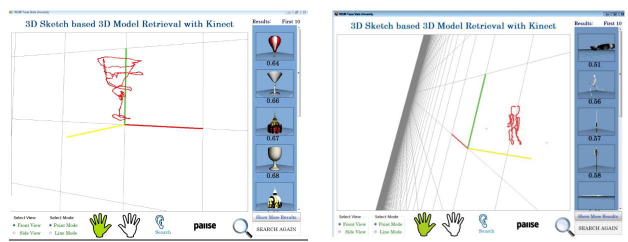
3.1 Kinect300 3D Sketch Dataset Collection

Considering objects' diversity, complexity and popularity, we construct the first 3D sketch dataset, the Kinect300, using our virtual 3D sketching "board" (Section 2.1). The Kinect300 consists of 300 sketches, uniformly divided into 30 categories. Seventeen users contributed to the 3D sketch data collection; each user was asked to draw a 3D sketch for several preselected categories.

Before the start of each user's data collection session, the user was allowed to sketch several unrecorded drawings to accustom themselves with the drawing rules of the application and with the practice of drawing in a three-dimensional space. After this brief training, the user was asked to sketch for each of a number of predefined categories.

3.2 3D Sketch-Based 3D Model Retrieval

Based on the retrieval system presented in Section 2.2 and the Kinect300 dataset collected above, we perform a 3D sketch-based 3D model retrieval experiment. The Kinect300 is used as the 3D query set, while the 3D target dataset is that of the SHREC'13 Sketch Track Benchmark [2], which contains 1258 3D models of 90 classes. Based on the five commonly-used evaluation metrics defined in [4], we achieved the following performance: Nearest Neighbor: 0.029, First Tier: 0.021, Second Tier: 0.038, E-Measure: 0.021, Discounted Cumulative Gain: 0.254. The retrieval performance reveals a nontrivial challenge existing in this type of 3D model retrieval: effectively matching an inaccurate hand-drawn 3D sketch with accurate 3D models. However, the good results we obtained with simple sketches demonstrates the potential of our approach. For example, good performance has been obtained in categories such as airplane, balloon, sword, and wineglass, though more complicated classes such as human, face and house produce inferior results. Figure 2 shows two example searches with sketches of different complexity. Finally, with the high efficiency of the 3D shape histogram and the Kalman filter, the above retrieval can be conducted in real-time: our algorithm completes a query in only 1.22 sec on a modern computer (Intel CPU @3.07 GHz).



(a) Simple (b) Complicated

Figure 2: Two example retrieval results for sketches of different complexity.

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