A 2D Sketch Interface for a 3D Model Search Engine *

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1 Introduction

This sketch describes our experiences with creating query interfaces for an online search engine for 3D models. With the advent of affordable powerful 3D graphics hardware, and the improvement of model acquisition methods, an increasing number of 3D models is available on the web, creating a need for a 3D model search engine [Paquet and Rioux 2000; Suzuki 2001]. An important problem that arises for such an application is how to create an effective query interface. To investigate this issue, we created several different query interfaces, and tested them both in controlled experiments as well as in a publicly available 3D model search engine.

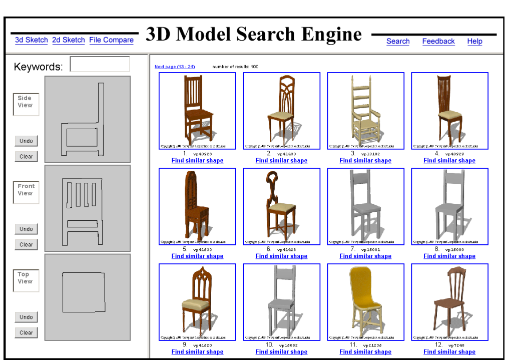
Perhaps the simplest approach to search for 3D models is to match keywords in filenames, captions, or referring webpages. However, trying to find 3D models just using text-based search techniques is not always effective: model files may be insufficiently annotated (e.g. `pr122.dxf`, `john.wrl`, misspellings, foreign languages), or ambiguously annotated (e.g. `plane.wrl`). In these cases and others, we hypothesize that shape-based queries will be helpful for finding 3D objects. For instance, shape can combine with function to define classes of objects (e.g. *round* tables).

In this sketch, we report our experiences with shape-based queries based on matching 3D models, 3D sketches, and 2D sketches.

The most straight-forward shape-based query interface is to provide the search engine with an existing 3D model and ask it to retrieve similar ones. Our search engine supports this strategy in two ways: the user may upload a 3D model file, or specifiy a 3D model returned in a previous search. However, a suitable 3D model may not be available to the user, in which case one has to be created from scratch. We support this by using Teddy, a simple 3D sketching tool (by T. Igarashi). Unfortunately, we found that even such a simple tool is too difficult to use for the average user. Moreover, only certain types of shapes can be created with Teddy (blobby objects with topological genus zero).

2 A 2D Sketch Interface

We therefore also created a 2D sketching interface that allows the user to supply up to three outline sketches as a query (see figure).



*`http://shape.cs.princeton.edu`

This creates the problem of how to match 2D sketches to 3D objects, which is significantly different from classical problems in computer vision: the 2D input is hand-drawn rather than photographic and the interface is interactive. We must consider several new questions: How do people draw shapes? Which viewpoints do they select? How should the interface guide the user's input? What algorithms are robust enough to recognize human-drawn sketches?

To investigate these questions, we ran a pilot study in which 32 students were asked to draw three views of 8 different objects, with a time limit of 15 seconds per object. We found that people tend to sketch objects with fragmented boundary contours and few other lines, they are not very geometrically accurate, and they use a remarkably consistent set of view directions. Interestingly, the most frequently chosen views were *not* the characteristic views predicted by perceptual psychology, but instead ones that were simpler to draw (i.e. front, side and top views).

We match the n user sketches with projected 2D images of each 3D model in the database rendered from m different viewpoints ($m > n$). A model's similarity score is the minimal sum of n pairwise sketch-to-image similary scores, subject to the constraint that no image can be matched to more than one sketch. These pairwise scores are computed by comparing their shape signatures. These signatures are based on the amplitudes of the Fourier coefficients of a set of functions obtained by intersecting the 2D Euclidian distance transform of the image with a set of concentric circles. By taking the amplitude of each coefficient, we discard phase information, thereby making the signature rotation invariant. Starting from the distance transform of the image helps make our method robust to small variations in the positions of lines.

3 Results

To investigate how 2D sketches can combine with text in interactive searches, we ran a user study with 43 students from an introductory computer science class. Each subject wrote up to five text keywords, and drew three simple outline sketches of 5 target objects (a chair, table, cannon, bunkbed and an elf), within a time limit of 2 minutes per object. Afterwards, we scanned their sketches and logged their keywords so that we could enter them as input to our search engine, searching in a database of 1890 household objects.

The results suggest that text and shape can be complementary in the information they provide a search engine. For example, for the chair, text keywords were not discriminating enough to differentiate it from the hundreds of other chairs and related furniture in the database: the median rank of the target chair in the text-only results was 216. Yet very simple sketches were able to describe it fairly precisely: the sketch-only median rank was 17. On the other hand, simple text keywords picked out the four bunk beds in the database (median rank 3), while the box-like sketches were not very discriminating (median rank 64). A similar effect was seen for the elf and cannon. Combining the text- and sketch scores improved the median rank to 2 for these three objects. Generally speaking, the text was effective at identifying classes of objects, while the sketches were helpful at selecting the best matches from within a class. The net result was that the combination of sketches and text usually produced a better match than either one alone.

To conclude, we believe that a 2D sketch interface is a useful query interface for a 3D model search engine. Text and shape provide different kinds of information, so used together they can be more specific.

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SUZUKI, M. T. 2001. A web-based retrieval system for 3d polygonal models. *Joint 9th IFSA World Congress and 20th NAFIPS International Conference (IFSA/NAFIPS2001)* (July), 2271–2276.