Overview

- **Research topic:** Sketch-Based 3D model retrieval (SBR)
  - Retrieve 3D models from a dataset given a user’s hand-drawn sketch.
  - Applications: sketch-based rapid prototyping, mobile 3D search, 3D printing, and 3D animation, etc.
- **Semantic gap:** Big semantic gap exists between traditional human-drawn 2D sketches and 3D models.
  - Rough sketch representation and accurate 3D model coordinates.
  - SBR is one of the most challenging research topics in the field of 3D model retrieval.
- **Semantic information:** Describes high-level representation of both sketches and 3D models.
  - Provides a bridge to reduce the semantic gap between them.
  - A novel semantic tree-based SBR algorithm is proposed to bridge the semantic gap.
- **Research results:** Experiments demonstrate the effectiveness and promising potentials of our approach.

**Contributions**

- (1) A 3D semantic tree is created based on WordNet [1].
  - It contains 407 3D models across 10 categories and at different nodes in the tree.
- (2) A novel semantic tree-based 3D model retrieval algorithm is proposed. This approach effectively captures semantic information of 2D sketches.
  - Accurately measures similarities between semantics of 2D sketches and 3D models.
- (3) Comprehensive comparative experiments have been conducted to compare with other state-of-the-art methods.
  - Experiments demonstrate the effectiveness and potential of the proposed approach.
- (4) Our work will explicitly guide the research on sketch-based 3D model retrieval.
  - Provide a direction for sketch-based related applications.

Algorithm (Cont.)

- **3) Semantic Tree Construction:** Build a semantic tree based on the semantic ontology in WordNet, which is a lexical database of concepts/synsets, represented by a set of synonyms.
  - Each word has one or more senses (meanings), each having its synonym.
  - Words are related through three relationships: Hypernym/hyponym (IS_A relation), Holonym (MEMBER_OF relation), and Meronym (PART_OF relation).
- **4) Word Sense Disambiguation:** Decide which sense to take for a label name.
  - Either for a labeled semantic component of the 2D sketch query or the name of a 3D model category.
  - By counting the number of overlapping words between the gloss of the component’s label and the glosses of other components’ labels [5].
- **5) Sketch-Model Semantic Similarity Computation:** Compute the component-wise relatedness between each sketch component’s category name and a semantic class in the semantic tree.
- **6) 3D Model Ranking:** Sort query and class similarities and rank the models in respective classes based on their shape similarities.

Experiments

- **Dataset collection**
  - 2D sketch dataset:
    - Randomly selected sketches from the 300 sketches dataset collected in [2] as queries.
    - One query sketch for each class is shown in Fig. 3.
  - 3D model dataset:
    - We collected 407 models in total for the same 10 classes.
    - One example 3D model for each class is shown in Fig. 4.

**Evaluation metrics**

- Precision-Recall (PR) diagram, Nearest Neighbor (NN), First Tier (FT), Second Tier (ST), E-Measures (E), Discounted Cumulated Gain (DCG), and Average Precision (AP).

**Performance**

- Three different relatedness fusion methods: Product, Sum and Average.
- Product approach performs the best.
- Our approaches dramatically improve retrieval performance compared with traditional content-based SBR methods.

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>NN</th>
<th>FT</th>
<th>ST</th>
<th>E</th>
<th>DCG</th>
<th>AP</th>
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<td>SBR (Base)</td>
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<td>0.60</td>
<td>0.60</td>
<td>0.63</td>
<td>0.64</td>
<td>0.81</td>
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<tr>
<td>SBR (Sum)</td>
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<td>0.60</td>
<td>0.60</td>
<td>0.63</td>
<td>0.64</td>
<td>0.81</td>
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<tr>
<td>SBR (Average)</td>
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<td>0.60</td>
<td>0.60</td>
<td>0.63</td>
<td>0.64</td>
<td>0.81</td>
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Fig. 1. Framework of our semantic tree-based SBR algorithm.

Fig. 2. Example Sketch Segmentation and Annotation [8]

Fig. 3. Example 2D sketch queries.

Fig. 4. Example 3D models.

Fig. 5. Comparison of Precision-Recall plots of our approaches and SBR (4).

Fig. 6. Query-class has semantic similarity matrix for the 10 queries. Each row/column is for a query/class according to the order in Fig. 3/4.

Fig. 7. Ranking classes for the 10 queries. Example 3D models from a dataset given a user’s hand-drawn sketch.

References


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