Supplementary Material for "Modeling by Drawing with Shadow Guidance"

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1 Database

We create a database consisting of 249 3D models with five categories collected from the Princeton Shape Benchmark (PSB) [SMKF04], COSEG [WAvK*12], and [vKXZ*13]. The five categories are vases and teapots (52 models), airplanes and birds (62 models), tables (40 models), chairs (75 models), and bicycles (20 models) Each category contains semantically similar models. The collections of 3D models in our database are shown in Figure 1.

2 User Studies

We conducted four user studies: *reference-oriented modeling*, *free modeling*, *modeling with/without shadow guidance*, and *comparison with other system*.

We recruited 19 participants (8 women and 11 men), who are all college students, to join in the studies. Eight of them have experience on 3D modeling with commercial packages. 11 participants have computer graphics background, and the rest are novice users who are interested in 3D modeling. Before the experiments, the participants were encouraged to spend no more than 15 minutes getting familiar with the system under our instructions. At the end of studies, they were also asked to fill in a short questionnaire (see Appendix).

Reference-oriented modeling. In the first study, the participants were asked to design models as similar as possible to reference models (i.e., vase, airplane, table, and chair), which were created by a professional using our system. After they

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finished the task, the modeling results were cross-rated among the participants. Figure 2 shows the modeling results and the corresponding similarity scores.

Free modeling. In this study, the participants were asked to freely create models given the name of category. The names of categories were given in random order. The models created by users are shown in Figure 3. Figure 4 shows several modeling sessions using our systems.

Modeling with/without shadow guidance. Given two reference models (airplane and bicycle), we invited eight participants to reconstruct the models with and without shadow guidance. To eliminate the learning effect, the participants were asked to finish the four sub-tasks randomly. Figure 5 left shows average time spent on each task, and the right chart shows average number of times the eraser operations applied.
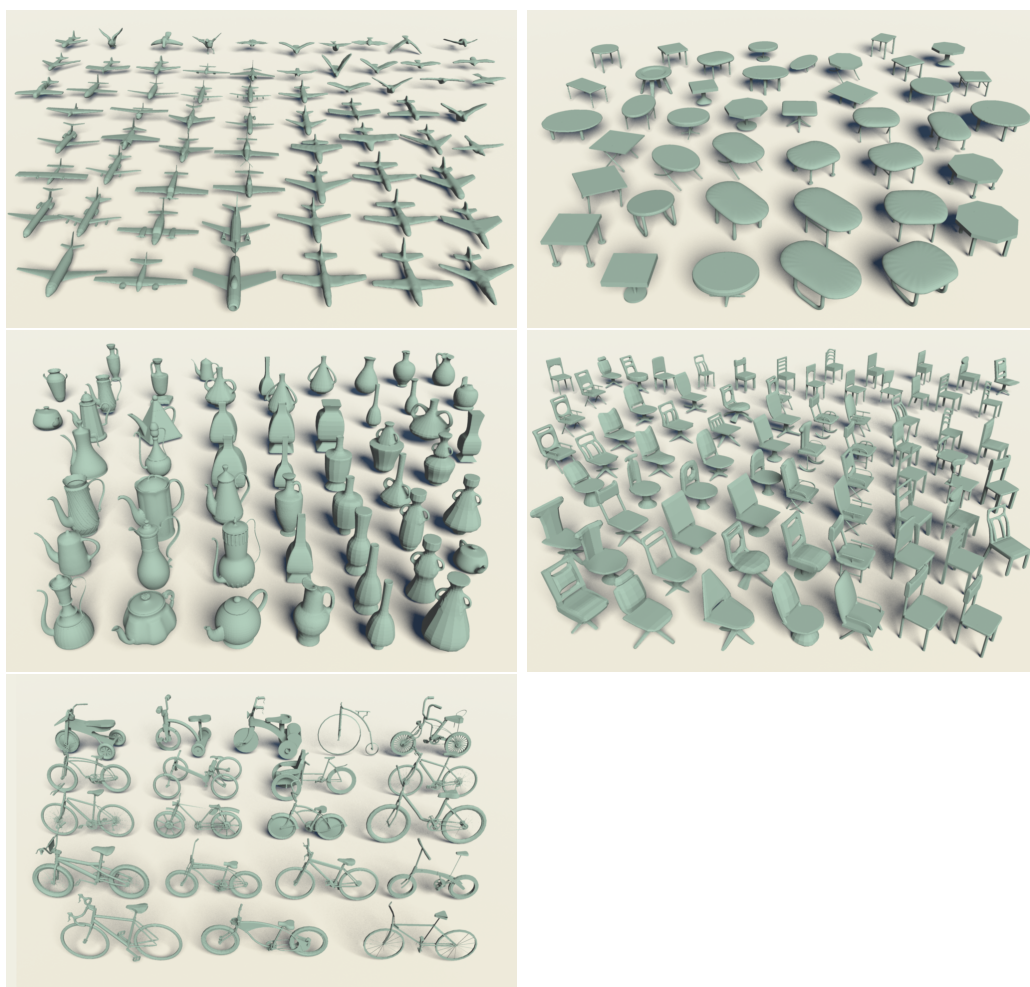

Figure 1: Our database consists of 249 3D models which are grouped into five categories, i.e., vases and teapots, airplanes and birds, tables, chairs, and bicycles.
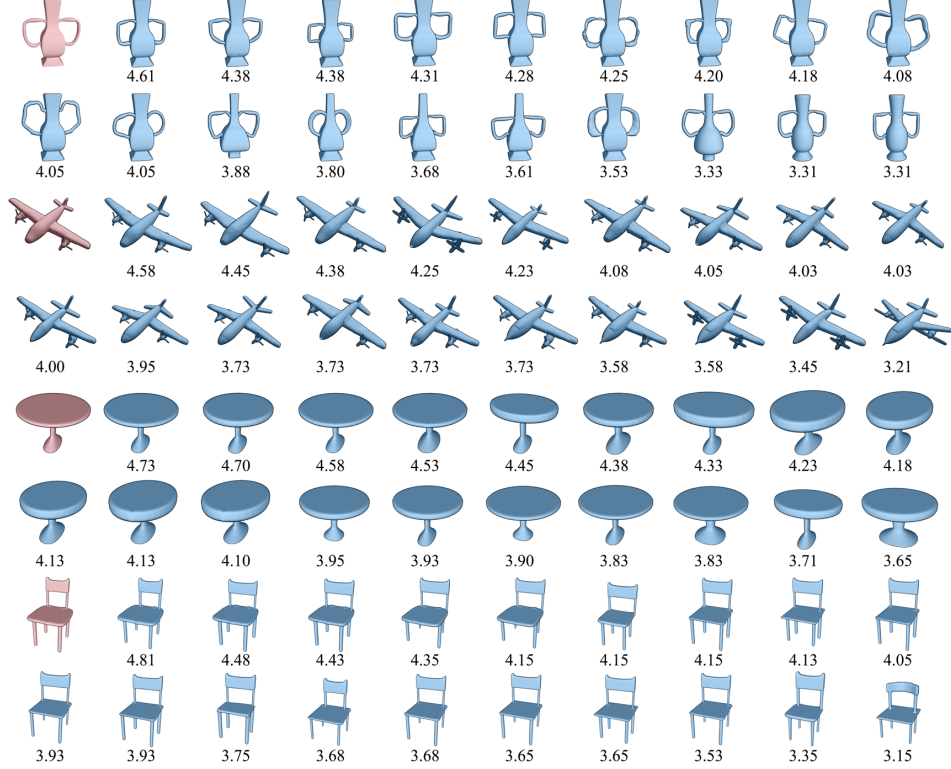
Figure 2: The modeling results of *reference-oriented modeling* task. The reference models are shown in red. The generated models (blue) are sorted by the average of similarity scores given by all the other participants (number below each model, 1 as "totally different" and 5 as "exactly the same").

Comparison with *Sketch-to-design*. We conducted a simple subjective comparison between *Sketch-to-design* [XXM*12] and our system as the dataset of chair models provided by *Sketch-to-design* is relatively small and not suitable for our system. In this study, we asked each participant to create chair models using *Sketch-to-design* and our system separately. Then they were asked three questions:

Q1. Which system is easier to use?

Q2. Which kind of suggestion is more intuitive?

Q3. Which system do you prefer?

Figure 6 shows the results. For Q1 and Q2, about 42% of participants thought our system was easier to use than *Sketch-to-design*, and 57% of them thought shadow guidance was more intuitive. For Q3, 52% of the participants preferred our system.

Statistics. During the studies, we recorded the sequence of strokes (both drawing and erasing) and time spent on each task. On average the participants took 3
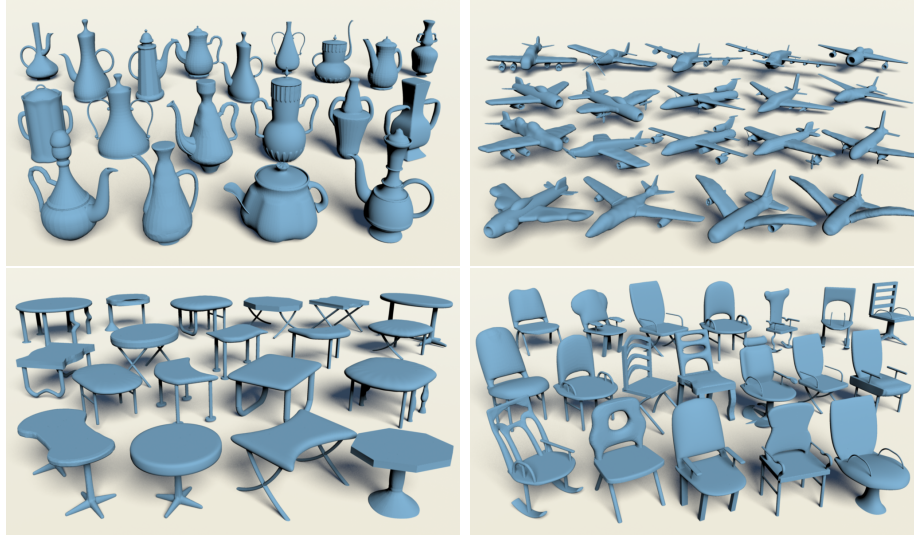
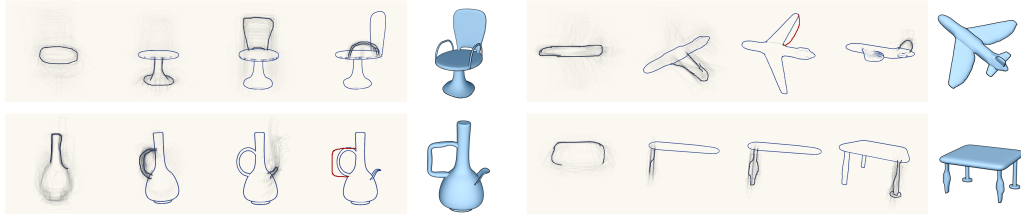Figure 3: 3D models created by users using our system.

Figure 4: Various modeling sessions using our system.

minutes to model an object in User Study I task and 4.5 minutes to create a new model in the second task. Table 1 shows the average response time of our system on each category. Figure 7–14 show the statistics of the questionnaires. All the participants confirmed that the generated model preserved the structure properties (Question 10 in questionnaire).
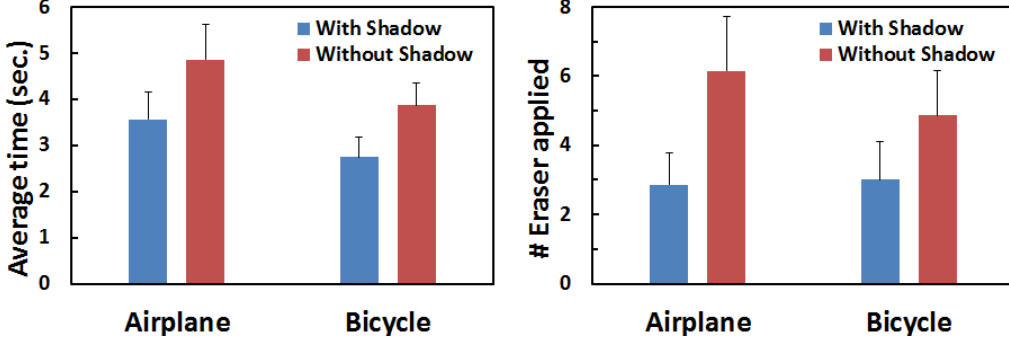
Figure 5: Statistics of modeling with/without shadow guidance. Left: average time spent on each task. Right: average number of times the eraser operation applied.
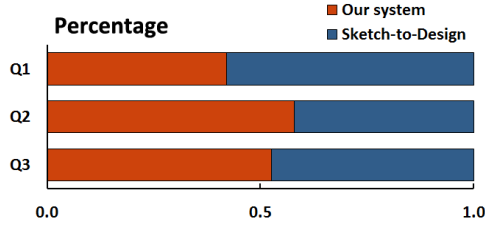

Figure 6: Subjective comparison with *Sketch-to-Design* [XXM*12].

Database	#Models	#Parts	T_R	T_S	T_C
Chairs	75	485	110	86	22
Tables	40	185	139	93	33
Airplanes+Birds	62	271	76	105	38
Vases+Teapots	52	170	129	62	15
Bicycles	20	86	83	83	17

Table 1: Response time (in milliseconds) of each stage of our system on various categories. T_R, T_S, and T_C denote average response time of view-dependent retrieval, shadow composition and part conjoining, respectively.
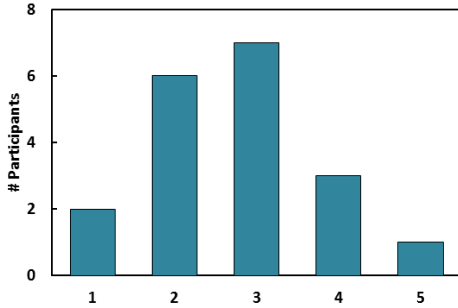

Figure 7: Question 4 "Please rate your drawing skills (1 as 'bad' and 5 as 'great') ".
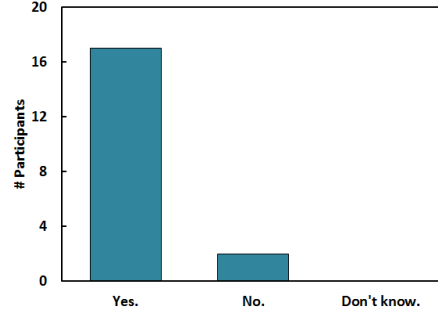

Figure 8: Question 5 "Is our system easy to use?". About 89% of subjects thought our system were easy to use.
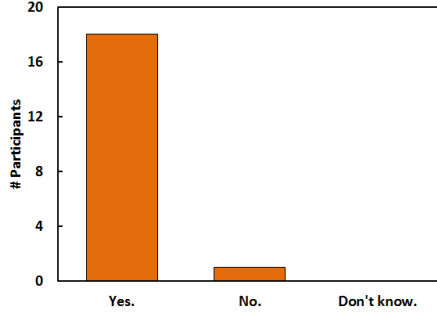
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Figure 9: Question 6 "Is the interface of our system intuitive?". More than 94% of subjects thought the user interface was intuitive.
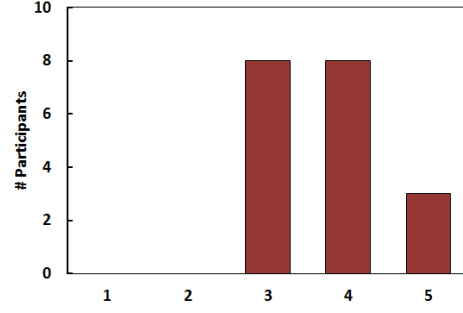

Figure 10: Question 7 "Please rate the effectiveness of the 'shadow' during the modeling process (1 as 'absolutely helpless' and 5 as 'very useful')". The average score is 3.7.
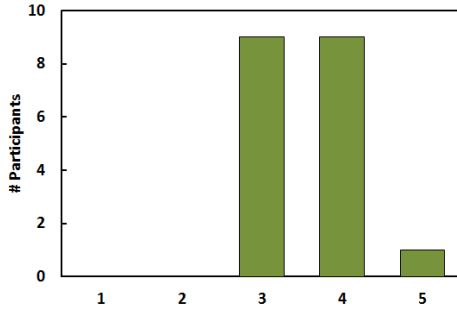

Figure 11: Question 8 "Please rate the quality of the shadow guidance (1 as 'bad' and 5 as 'great')". The average score is 3.6.
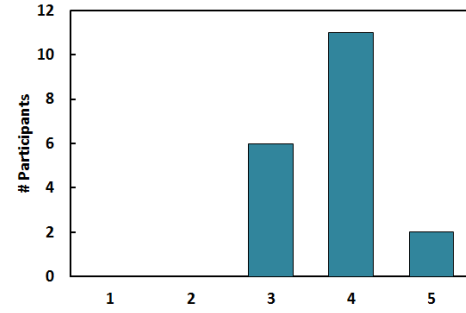

Figure 12: Question 9 "Please rate the retrieval results (1 as 'bad' and 5 as 'great')". The average score is 3.8.
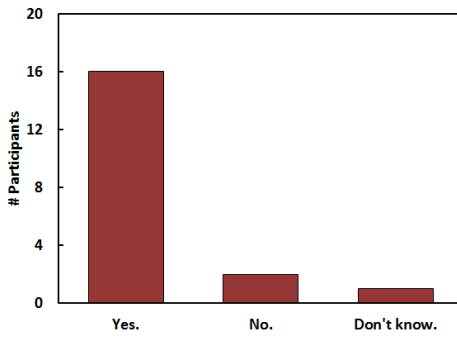

Figure 13: Question 11 "Can you easily use the editing tool to edit the model?". About 84% of subjects thought the editing tool of our system was easy to use.
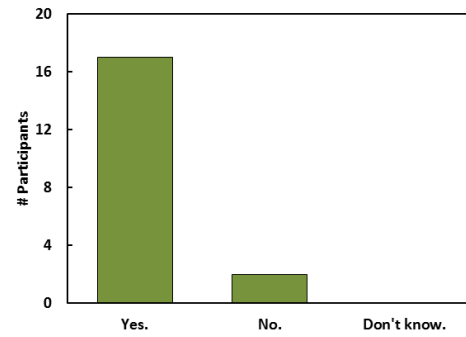

Figure 14: Question 12 "Do you like this system?". More than 89% of subjects said they like our system.

Appendix

Questionnaire

The questionnaire is divided into 2 sections

- **SECTION A** asks about your personal information.
- **SECTION B** is about your experience of using our system.

SECTION A

1. Your gender: Male. / Female.

2. Do you have computer graphics background?   Yes. / No.

3. Have you ever used any professional modeling
   packages before?   Yes. / No.
   (e.g., 3ds Max, Maya, or ZBrush.)

4. Please rate your drawing skills   1. / 2. / 3. / 4. / 5.
   (1 as "bad" and 5 as "great"):

SECTION B

5. Is our system easy to use?   Yes. / No. / Don't know.

6. Is the interface of our system intuitive?   Yes. / No. / Don't know.

7. Please rate the effectiveness of the "shadow" during
   the modeling process   1. / 2. / 3. / 4. / 5.
   (1 as "absolutely helpless" and 5 as "very useful"):

8. Please rate the quality of the shadow guidance
   (1 as "bad" and 5 as "great"):   1. / 2. / 3. / 4. / 5.

9. Please rate the retrieval results
   (1 as "bad" and 5 as "great"):   1. / 2. / 3. / 4. / 5.

10. Does the generated model preserve the structural
    properties (i.e., symmetry and connection   Yes. / No. / Don't know.
    relationship) well?

11. Can you easily use the editing tool to edit the   Yes. / No. / Don't know.
    model?

12. Do you like this system?   Yes. / No. / Don't know.

You have finished the questionnaire – Thank you!