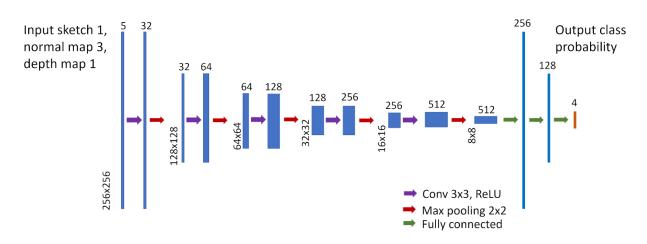# Supplementary document for "Sketch2CAD: Sequential CAD Modeling by Sketching in Context"

In this document, we provide additional data supplementing the main paper submission, in the following three aspects:

1. Detailed network structures.
2. Detailed user evaluation data.
3. Protocol instruction sequences for models shown in the paper.

Network Structures

Figure 1. **The network structure for operation classification.** The input contains the sketch and context maps, and the output is the vector of probabilities for 4 types of operations.

The networks structures for the operation classification task and the segmentation task for operation regression are shown in Figs. 1 and 2.

The five networks, including one for operator classification and four for segmentation of each operator, are trained separately on their synthetically generated data samples, but are combined into a large network graph during inference, to avoid switching overhead.
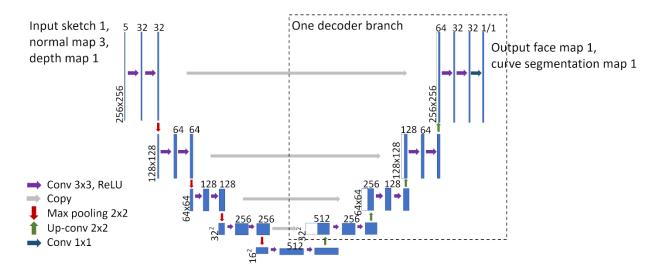
Figure 2. **The segmentation network structure for each operator regression.** The input contains the sketch and context maps, and the output contains the base face map and the stroke segmentation label. The network is a U-Net structure with one encoder and two decoders for the two output maps, respectively.

User Evaluation Data

We provide the complete data of the 6 participants evaluating our Sketch2CAD system here.

Participant. The participants include 4 postgraduate students, 1 master student, and 1 researcher in industrial research lab, all of CS discipline. We also take note of their background experiences with sketching and CAD modeling.

Procedure. Each evaluation consists of three parts:

a. Training session. We communicate with the participant the basic idea of Sketch2CAD, show some examples of how to model by sketching with the system, and then let the participant try the tool by casual modeling and exploration.
b. Modeling session. We ask the participant to try to create shapes similar to those shown in Fig. 3. During the modeling session, we only answer questions about UI usage.
c. Discussion session. We ask feedback from the participant, by going through the following 4 questions.
    Q1: Is the modeling sequence easy to conceive? (Rating: 0-5)
    Q2: Is the sketching intuitive and properly translated to the intended operations and parameters? (Rating: 0-5)
    Q3: Does the result quality match CAD level models? (Rating: 0-5)
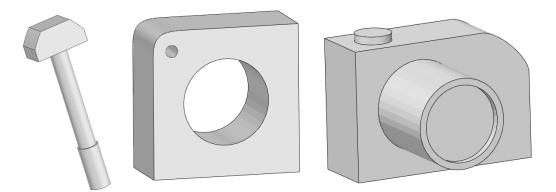   Q4: Overall rating, with comments on positive and negative aspects.

Figure 3. **The three images showing target models for user evaluation.**

User evaluation data divided by participant

Participant #1

Background:

Sketching: knows basic concept, has no training in drawing.

CAD: watched demo videos before, but never tried to model by itself.

Session duration:

Training session: 30 mins

Modeling session: task 1: 10 mins, task 2: 12 mins, task 3: 20 mins.

Ratings:

Q1: 5, Q2: 5, Q3: 5, Q4: 4.5

Comments:

Negative:

- There is no explicit ruler available in the interface, so the offset distance cannot be known directly when drawing
- Stroke pre-processing is needed, e.g., assist drawing regular ellipses
- Mouse-based drawing is less accurate than pen-based
- Cannot draw shape on the curved surfaces

Positive:

- The strokes are intuitive and effective once users know the basics of view projection
- The sequential modeling makes a lot sense
- The result quality is high

Participant #2

Background:

No sketching or CAD modeling experience.

Session duration:

Training session: 40 mins

Modeling session: task 1: 8 min, task 2: 14 min, task 3: 23 min.

Ratings:

Q1: 5, Q2: 4.5, Q3: 5, Q4: 4.8

Comments:

Negative:

- Must consider view projection distortion to draw proper strokes.

Positive:

- The strokes are intuitive to express the modeling expectation
- The interaction is easy, and the UI provides some assistant functions (regularization, snapping) which are effective to use
- The result quality is high

Participant #3

Background:

No prior experiences with sketching or CAD modeling.

Session duration:

Training session: 20 mins

Modeling session: task 1: 14 min, task 2: 10 min, task 3: 15 min.

Ratings:

Q1: 5, Q2: 5, Q3: 5, Q4: 5

Comments:

Negative:

- Pre-processing of the user strokes would help the drawing

Positive:

- The results are good; desired shapes can be obtained from the sketching

Participant #4

Background:

No prior experiences with either sketching or CAD modeling.

Session duration:

Training session: 30 mins

Modeling session: task 1: 10 min, task 2: 10 min, task 3: 10 min.

Ratings:

Q1: 5, Q2: 4, Q3: 5, Q4: 4.5

Comments:

Negative:

- View projection is essential for proper sketching.

Participant #5

Background:

No sketching experiences. Knows a little about modeling in Blender.

Session duration:

Training session: 25 mins

Modeling session: task 1: 8 min, task 2: 6 min, task 3: 10 min.

Ratings:

Q1: 5, Q2: 5, Q3: 4.5, Q4: 4.8

Comments:

Negative:

- Over-sketching is desirable to support.

Participant #6

Background:

No sketching or CAD modeling experiences.

Session duration:

Training session: 20 mins

Modeling session: task 1: 10 min, task 2: 8 min, task 3: 4 min.

Ratings:

Q1: 5, Q2: 5, Q3: 4, Q4: 4.5

Comments:

Negative:

- Subtraction operation: the first drawn circle should always be anchored to base face.
- Fine-scale and complex models need fine-tuning than straightforward sketching.

Positive:

- After quick training and intuitive exploration, it is easy to draw targets.
- Intuitive for users without background experience. Easy creation of simple CAD shapes.

Summary

As observed in the paper, while not every user is proficient with sketching in perspective and there are comments for more complete UI features, the users seem to be naturally good at finding out the modeling sequences and our system allows them to sketch very roughly but still obtain high quality CAD models.

Protocol Sequences

We provide the protocols presenting the operation sequences in text, for the models shown in Fig. 12, result gallery, of the paper.

a. Mechanical piece 1:

DRAW: a cylinder on the ground

AddSweepShape: <plane 1, length 0.59>

SubtractPolyhedron: <plane 0, length 0.04>

b. Mechanical piece 2:

DRAW: a cylinder on the ground

SubtractSweepShape: <plane 1, length 0.17>

c. Lamp 1:

DRAW: a cylinder on the ground

AddSweepShape: <plane 1, length 0.67>

AddSweepShape: <plane 2, length 0.39>

d. Lamp 2:

AddSweepShape: <plane 1, length 0.69>

AddSweepShape: <plane 6, length 0.49>

e. Hammer:

DRAW: a cylinder on the ground

SubtractPolyhedron: <plane 1, length 0.48>

AddSweepShape: <plane 2, length 1.02>

f. RadioBox:

SubtractPolyhedron: <plane 3, length 0.36>

SubtractPolyhedron: <plane 3, length 0.36>

SubtractSweepShape: <plane 1, length 0.04>

SubtractSweepShape: <plane 1, length 0.04>

SubtractPolyhedron: <plane 1, length 0.40>

SubtractPolyhedron: <plane 1, length 0.40>

BevelCorner: <plane 1, corner 11>

BevelCorner: <plane 1, corner 4>

g. Camera:

AddSweepShape: <plane 3, length 0.40>

SubtractPolyhedron: <plane 0, length 0.40>

SubtractSweepShape: <plane 6, length 0.03>

AddSweepShape: <plane 7, length 0.03>

SubtractSweepShape: <plane 7, length 0.52>

h. Kettle 1:

BevelCorner: <plane 3, corner 0>

BevelCorner: <plane 3, corner 1>

AddPolyhedron: <plane 4, length 0.24>

AddPolyhedron: <plane 2, length 0.13>

AddSweepShape: <plane 1, length 0.02>

BevelCorner: <plane 3, corner 24>

BevelCorner: <plane 3, corner 23>

SubtractPolyhedron: <plane 5, length 0.13>

SubtractPolyhedron: <plane 16, length 0.16>

i. Kettle 2:

SubtractPolyhedron: <plane 3, length 0.18>

BevelCorner: <plane 5, corner 2>

AddSweepShape: <plane 6, length 0.07>

SubtractPolyhedron: <plane 0, length 0.57>

SubtractPolyhedron: <plane 0, length 0.57>

AddSweepShape: <plane 20, length 0.36>

AddSweepShape: <plane 20, length 0.36>

BevelCorner: <plane 0, corner 3>

BevelCorner: <plane 0, corner 2>

j. Mixer:

AddPolyhedron: <plane 1, length 0.37>

BevelCorner: <plane 3, corner 2>

BevelCorner: <plane 3, corner 2>

AddPolyhedron: <plane 2, length 0.22>

AddSweepShape: <plane 1, length 0.22>

ExtrudePlane: <plane 7, offset 0.46>

BevelCorner: <plane 11, corner 2>

BevelCorner: <plane 11, corner 1>

AddSweepShape: <plane 6, length 0.10>

k. Mechanical piece 3:

AddSweepShape: <plane 3, length 0.23>

SubtractSweepShape: <plane 6, length 0.50>

SubtractSweepShape: <plane 4, length 0.34>

SubtractSweepShape: <plane 4, length 0.34>

SubtractSweepShape: <plane 4, length 0.34>

SubtractSweepShape: <plane 4, length 0.34>

BevelCorner: <plane 4, corner 3>

BevelCorner: <plane 4, corner 2>

BevelCorner: <plane 4, corner 0>

BevelCorner: <plane 4, corner 1>

l. Guitar:

BevelCorner: <plane 3, corner 1>

BevelCorner: <plane 3, corner 2>

BevelCorner: <plane 5, corner 8>

BevelCorner: <plane 5, corner 9>

SubtractSweepShape: <plane 5, length 0.27>

SubtractSweepShape: <plane 5, length 0.27>

SubtractSweepShape: <plane 5, length 0.08>

AddPolyhedron: <plane 5, length 0.06>

ExtrudePlane: <plane 10, offset 0.69>

AddPolyhedron: <plane 13, length 0.25>

BevelCorner: <plane 21, corner 0>

BevelCorner: <plane 21, corner 1>

AddSweepShape: <plane 21, length 0.05>

AddSweepShape: <plane 21, length 0.05>

AddSweepShape: <plane 23, length 0.05>