Supplementary Materials (ID: 0290)

Section 1: Auxilary Variables and Constraints

Section 2: Thumbnails of Database Models

Section 3: Labeling and Accuracy of Each Sketch

Section 1: Auxiliary Variables and Constraints

In this section, we precisely define the variables that are not in the decision variables, but appear as we define the structure cost (Eq. 1), and we also describe the additional constraints required for the selected nodes and edges to form a connected graph.

In Mixed Integer Programming, some auxiliary variables are defined to capture certain events (i.e., a particular assignment to all decision variables), and are called indicator variables. An indicator variable takes the value of 1 when certain event is detected. Several indicator variables are used to define Eq. 1:

Stroke Segment Coverage Indicator. $u_i = 1$ if and only if the stroke segment g_i is covered, which means that g_i is assigned to some local interpretation. So, we have $u_i = v_{i,1} \vee v_{i,2} \vee v_{i,3} ... v_{i,|C|}$. The equivalent linear constraints are $u_i \leq \sum_j v_{i,j}$ and $u_i \geq v_{i,j} (j = 1...|C|)$.

Stroke Segment Overlap Indicator. $r_{k,i} = 1$ if and only if stroke segment g_k is simultaneously assigned to the local interpretation c_i and another local interpretation. The indicator is defined as follows: 1) $r_{k,i}$ should be 0 if it is not assigned to c_i, i.e., $r_{k,i} \leq v_{k,i}$; 2) it should also be 0 if it is not overlapped, i.e., $r_{k,i} \leq o_k$, where o_k is the number of times g_k is overlapped (Section 4.3.2); 3) it should be 1 otherwise, enforced by $r_{k,i} \geq v_{k,i} + o_k/N - 1$, where N is a constant always greater than o_k.

Stroke Segment Label Assignment. A stroke segment g_i is said to be assigned a label l_j if it is assigned to a local interpretation with a component of label l_j (e.g., chair seat and back). The indicator $h_{i,j}$ indicates such an assignment, i.e., $h_{i,j} = 1$ if g_i is assigned the label l_j. To define $h_{i,j}$, we find all local interpretations with components labeled as l_j and check if g_i is assigned to any of them. That is, let $c_k (k = 1...n)$ be all the local interpretations with components of label l_j; then $h_{i,j} = v_{i,1} \vee v_{i,2} \vee v_{i,3} ... \vee v_{i,n}$. The equivalent linear constraints are $h_{i,j} \leq \sum_k v_{i,k}$ and $h_{i,j} \geq v_{i,k} (k = 1...n)$.

Stroke Segment Group Activation. A stroke segment group $G_i = \{g_k\} (k = 1...n)$ is said to be activated by a label l_j, if one of its members g_k is assigned the label l_j. The indicator $t_{i,j}$ indicates such an assignment by $t_{i,j} = h_{1,j} \vee h_{2,j} \vee h_{3,j} ... h_{n,j}$, where $h_{k,j}$ is the stroke segment label assignment indicator mentioned above. The equivalent linear constraints are $t_{i,j} \leq \sum_k h_{k,j}$ and $t_{i,j} \geq h_{k,j} (k = 1...n)$.

Stroke Segment Inconsistent Labeling Indicator. If a segment g_k belongs to a stroke segment group G_i activated by label l_j, but g_k is not assigned the label l_j, then g_k is said to be inconsistently labeled. Such an event is indicated by $b_{k,j}$, where $b_{k,j} = t_{i,j} - h_{k,j}$. By such a definition, $b_{k,j} = 1$ only when $t_{i,j} = 1$ and $h_{k,j} = 0$, corresponding to the group being activated but the stroke segment is not properly assigned.

Apart from the indicator variables, we have one more continuous auxiliary variable defined as follows:

Stroke Segment Overlap Counter. If a stroke segment g_i is assigned to n local interpretations, it is said to be overlapped by $n - 1$ times. (Note that when $n = 0$, it is overlapped by 0 times.) This count is captured by a continuous variable o_i, defined as $o_i = \sum_j v_{i,j} - u_i$, where u_i is the stroke segment coverage indicator. Such a definition properly sets o_i even when $n = 0$.

The constraints listed in Section 4.3.2 are not enough to ensure the selected nodes and edges to form a connected graph. Here we list additional constraints for that purpose.

Graph Validity Constraint. An edge can be selected only when both of its end points (nodes) are selected, defined as $y_{i,j} \leq x_i$ and $y_{i,j} \leq x_j$.

Graph Connectedness Constraint. The selected graph must be a connected graph, and such a constraint is formulated using flow balance, given by `http://orinanobworld.blogspot.hk/2013/07/extracting-connected-graph.html?m=1`.

Section 2: Thumbnails of Database Models

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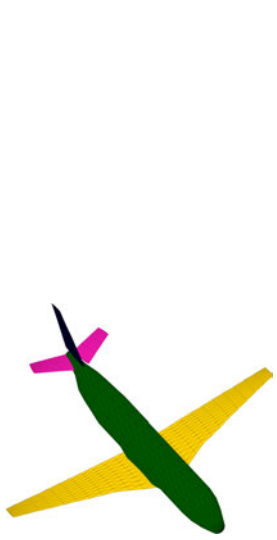

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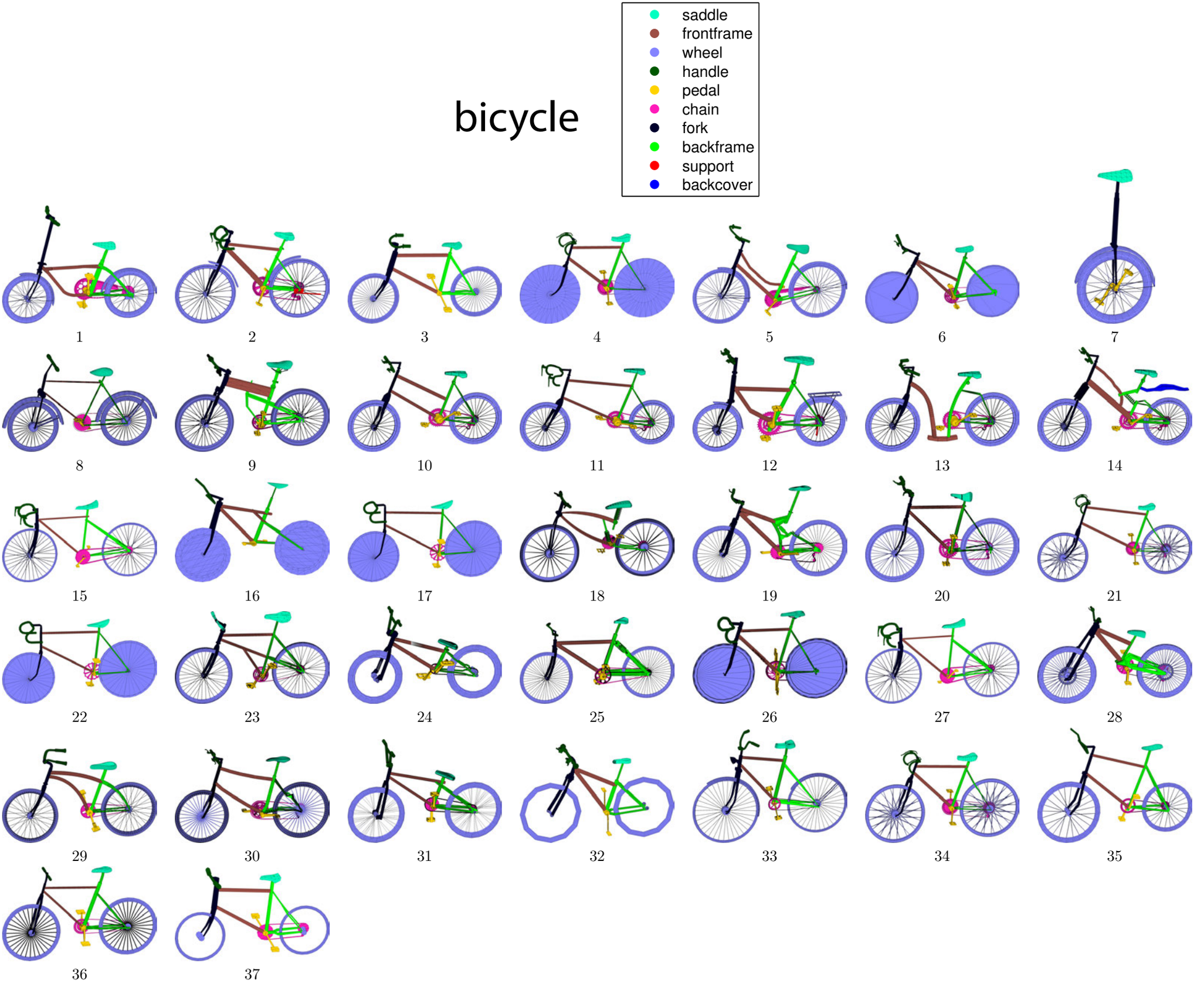
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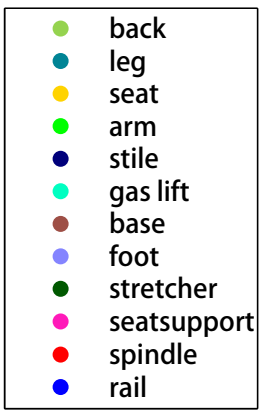
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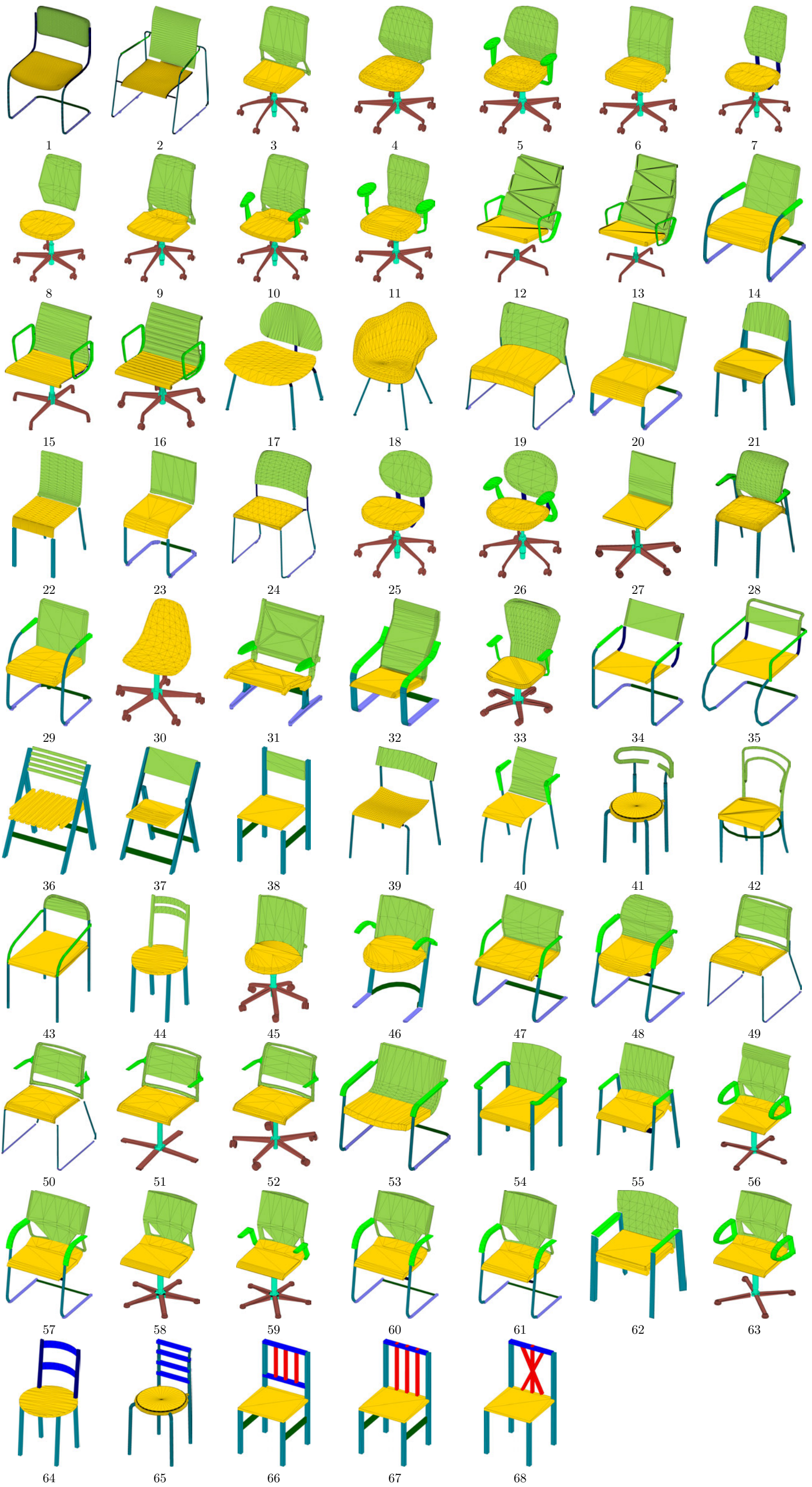
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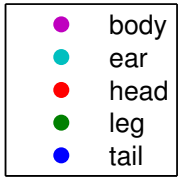

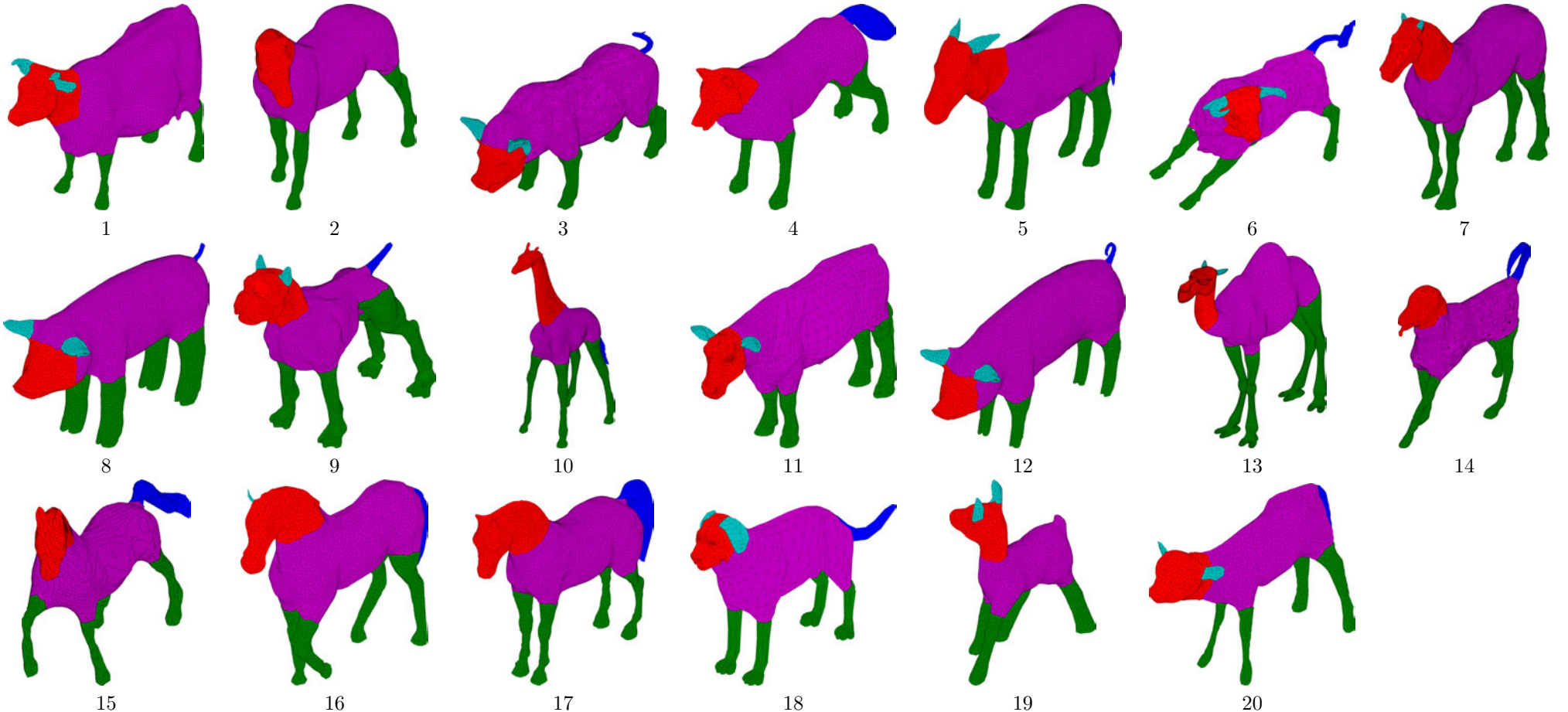

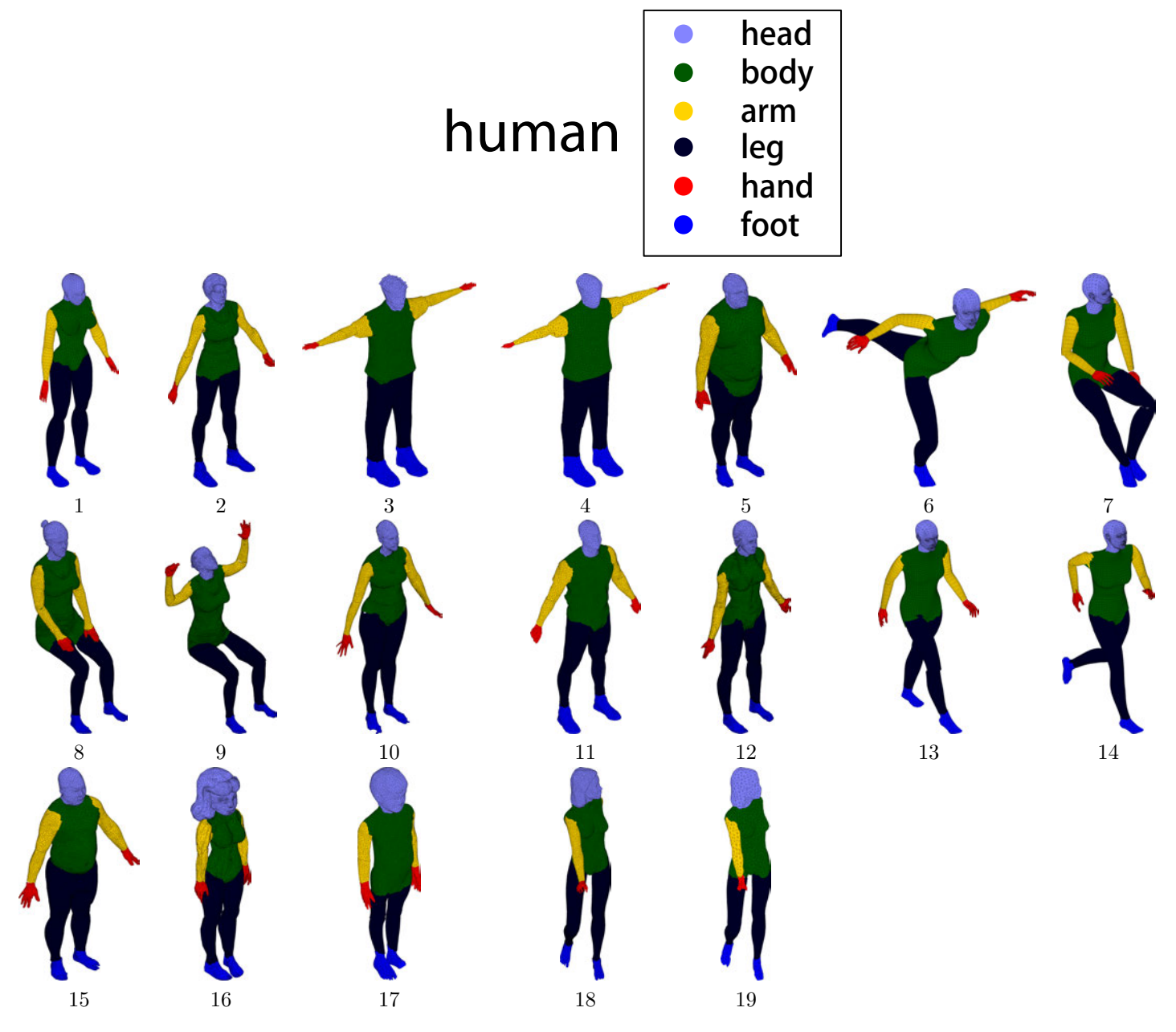
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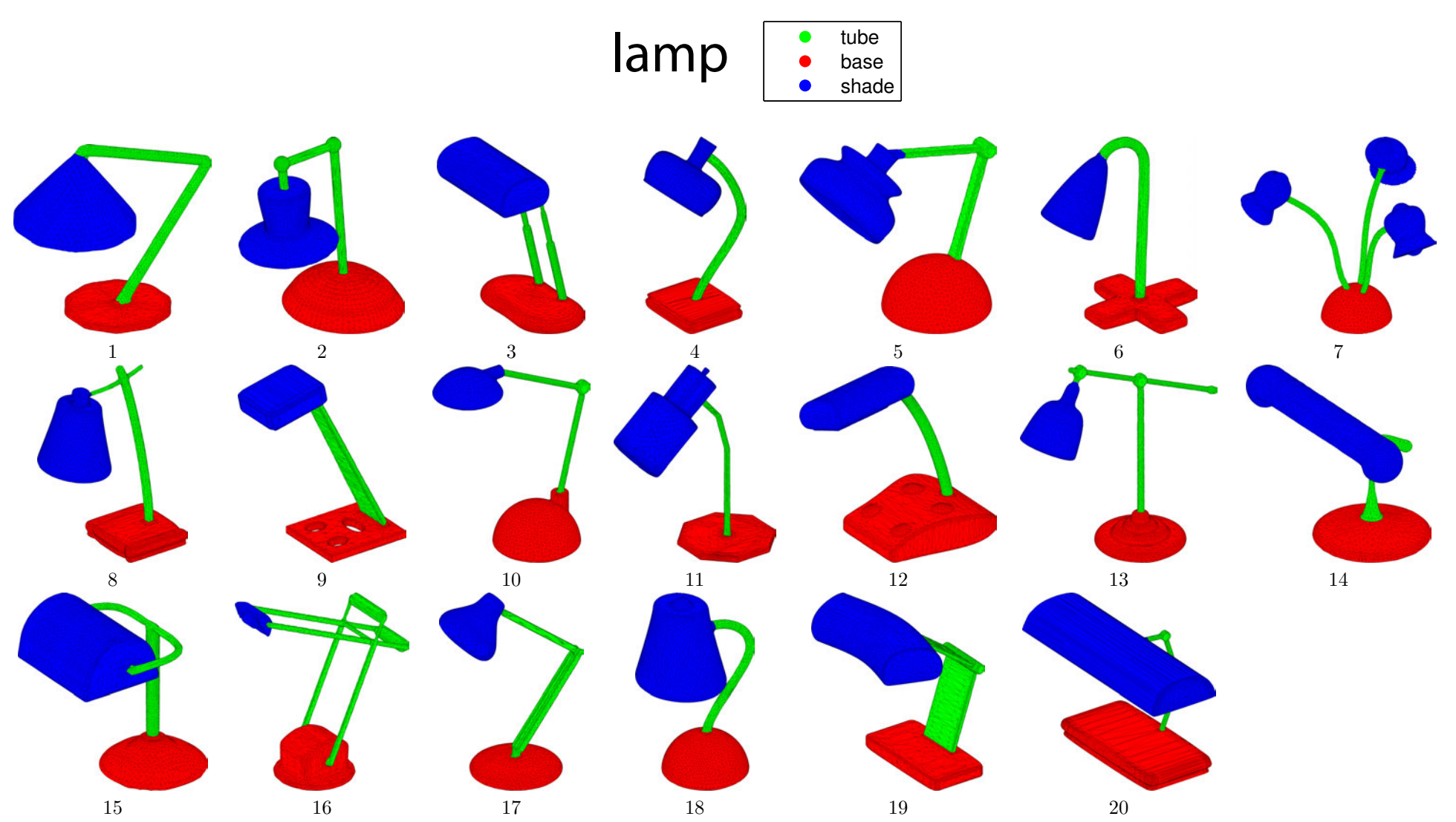
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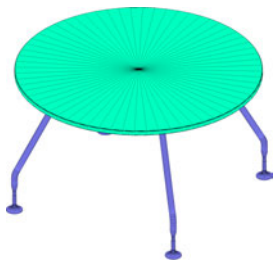
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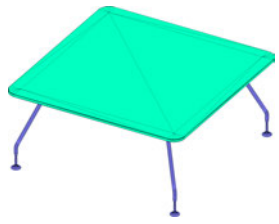
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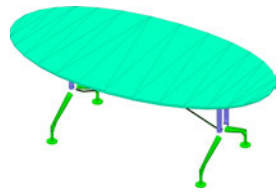
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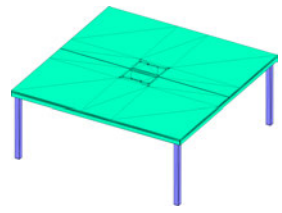
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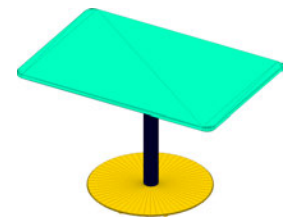
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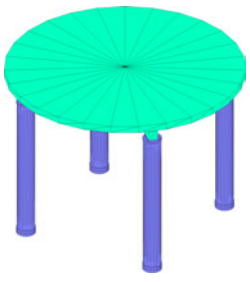
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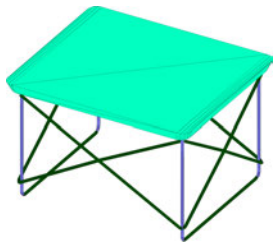
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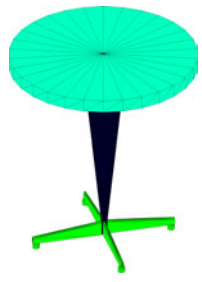
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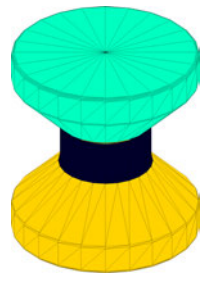
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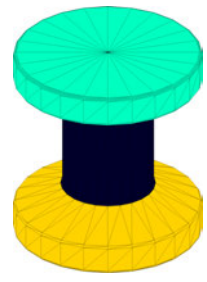
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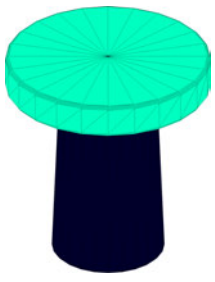
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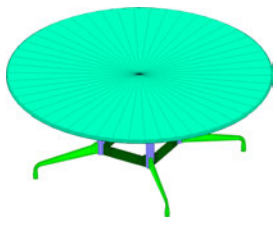
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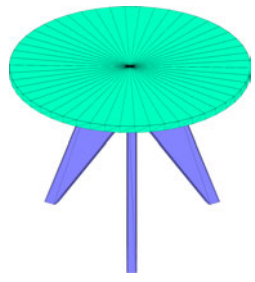
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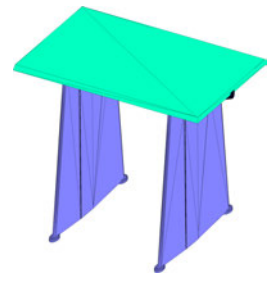
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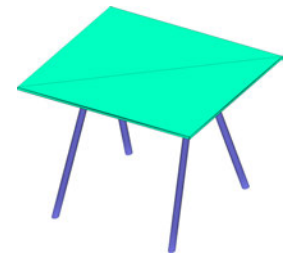
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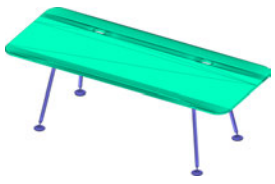
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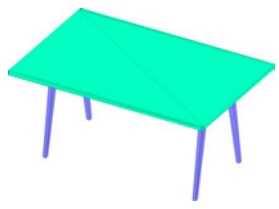
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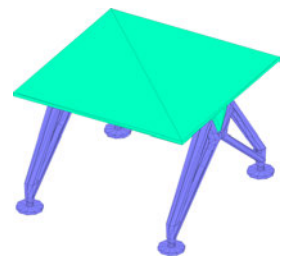
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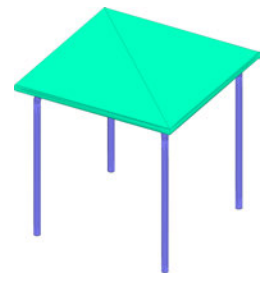
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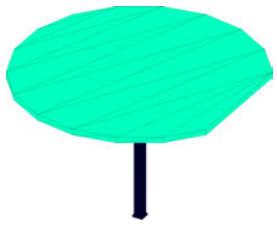
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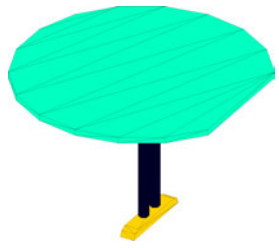
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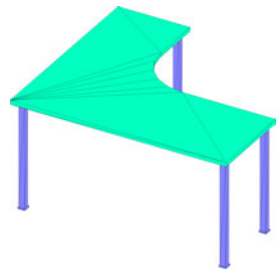
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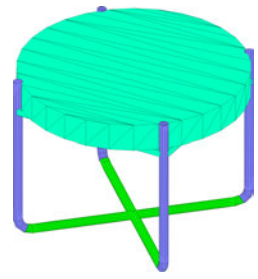
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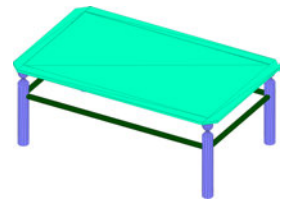
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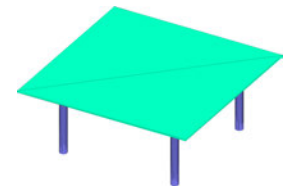
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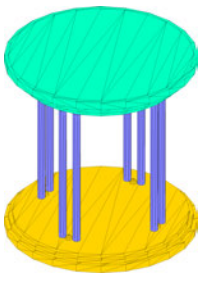
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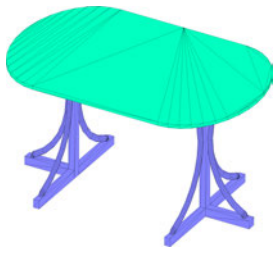
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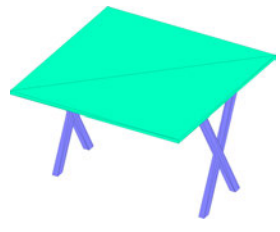
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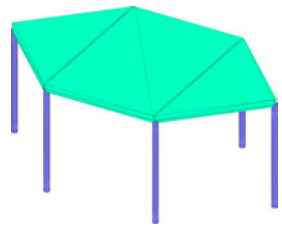
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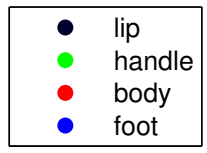

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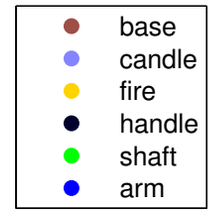

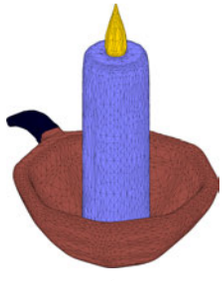
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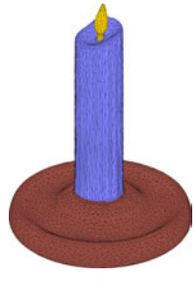
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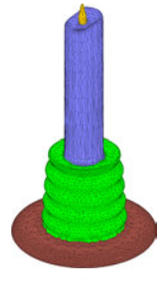
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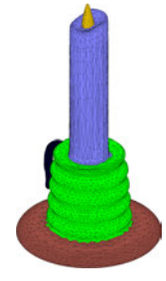
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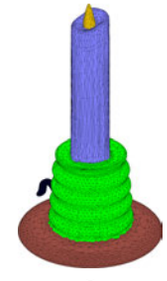
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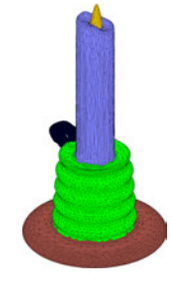
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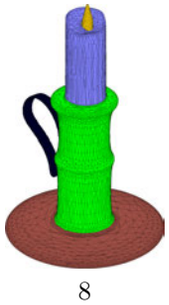
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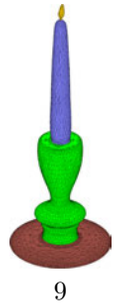
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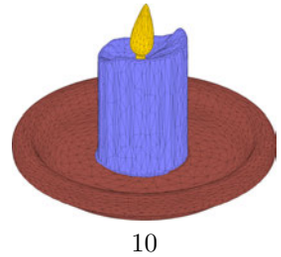
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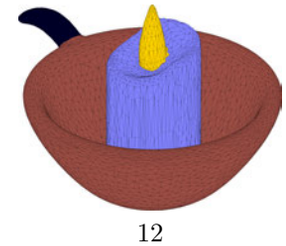
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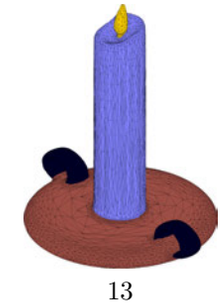
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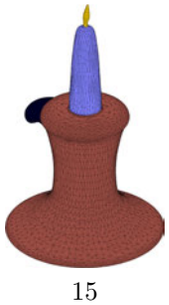
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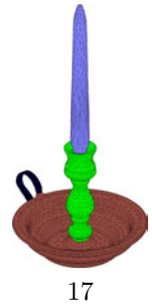
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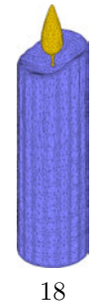
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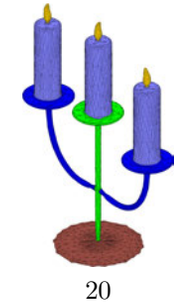
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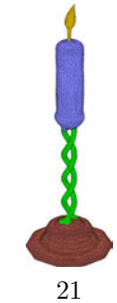
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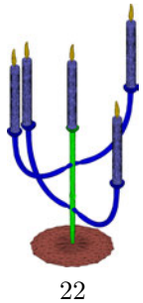
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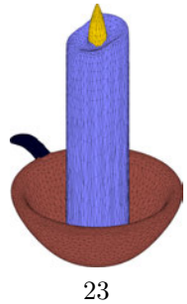
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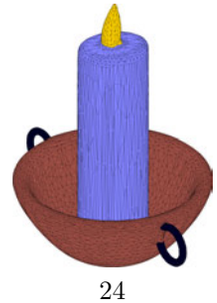
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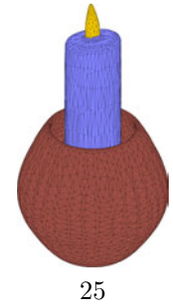
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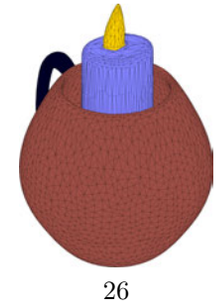
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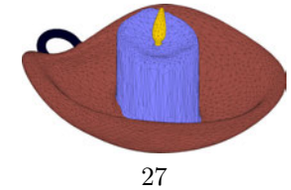
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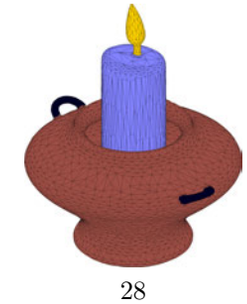
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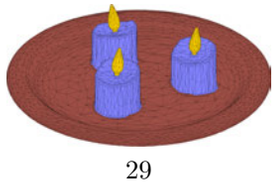
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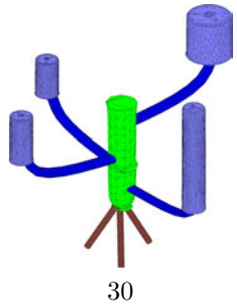
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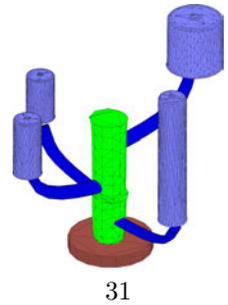
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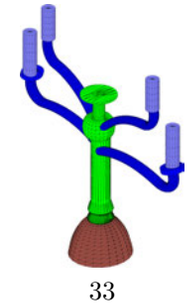
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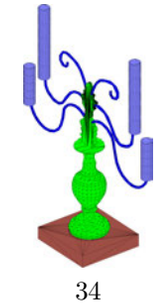
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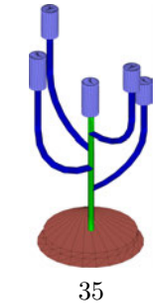
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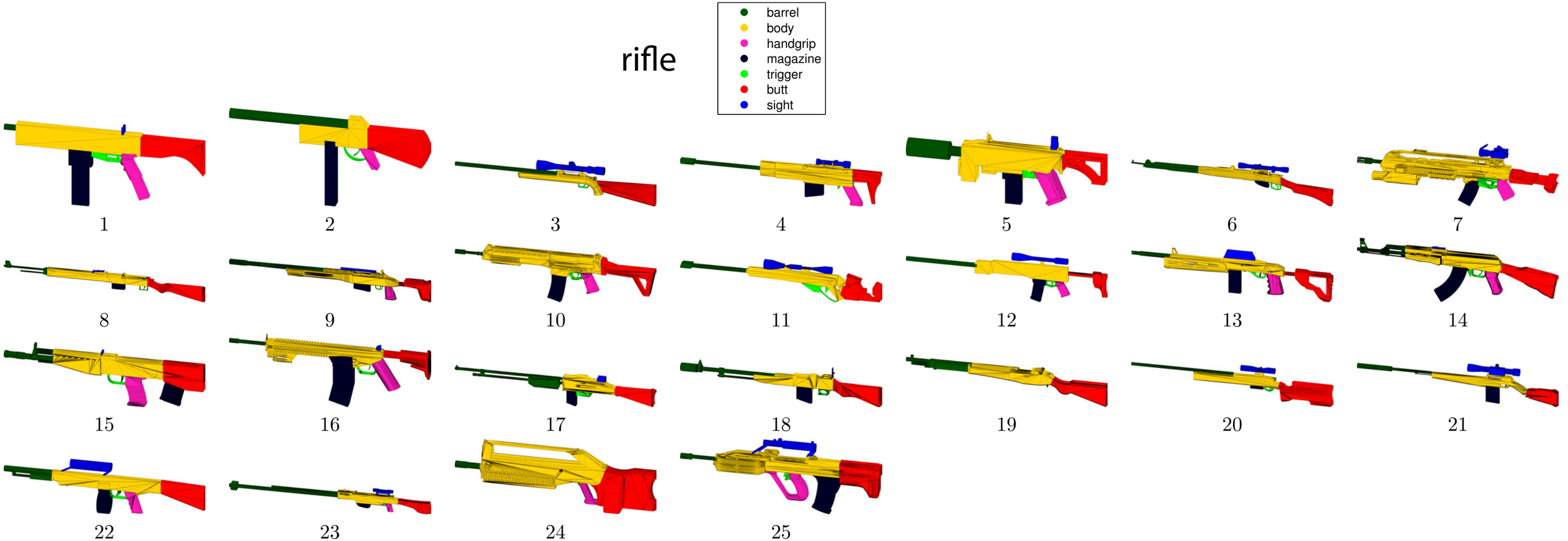
rifle


barrel
body
handgrip
magazine
trigger
butt
sight
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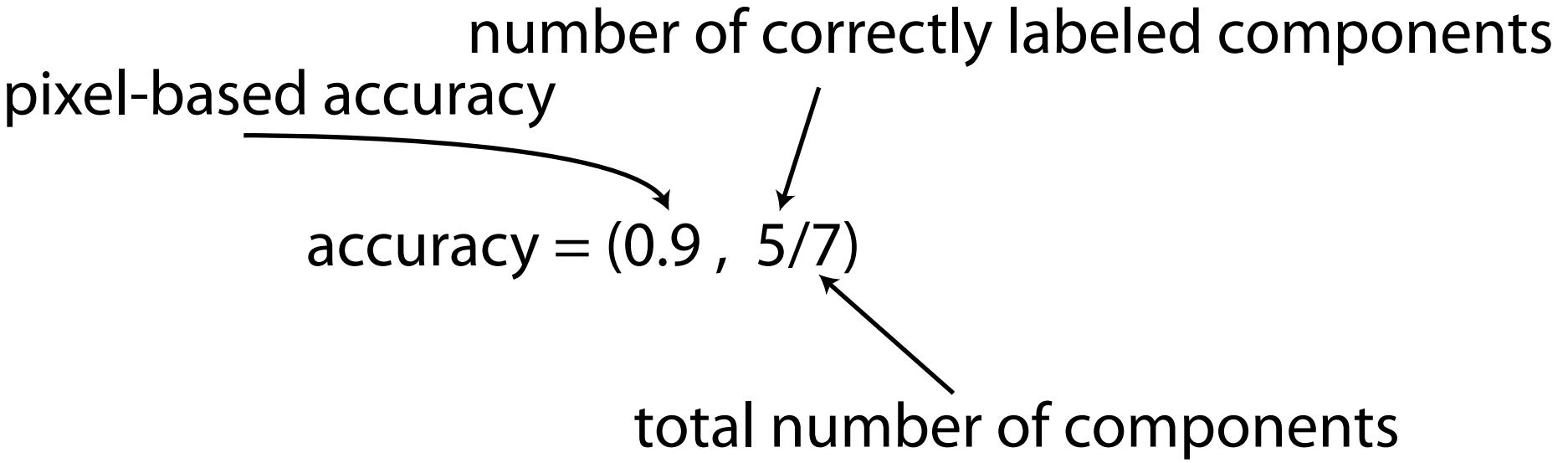
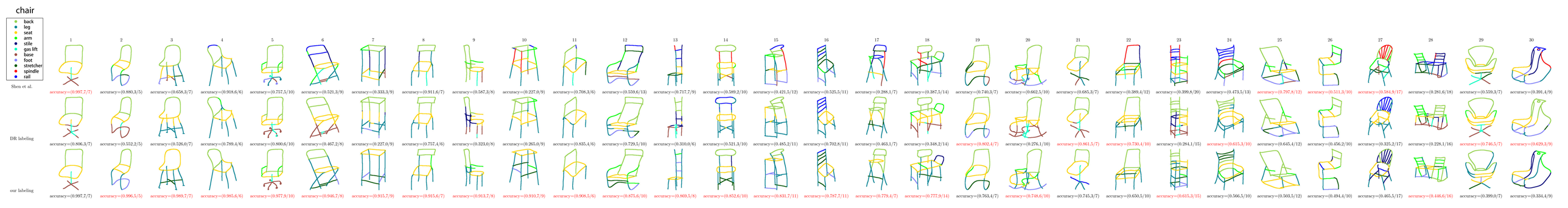
Section 3: Labeling and Accuracy of Each Sketch




chair
back
leg
seat
arm
stile
gas lift
base
foot
stretcher
spindle
rail
Shen et al.
DR labeling
our labeling
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accuracy=(0.880,3/5)
accuracy=(0.658,3/7)
accuracy=(0.918,6/6)
accuracy=(0.757,5/10)
accuracy=(0.521,3/9)
accuracy=(0.333,3/9)
accuracy=(0.911,6/7)
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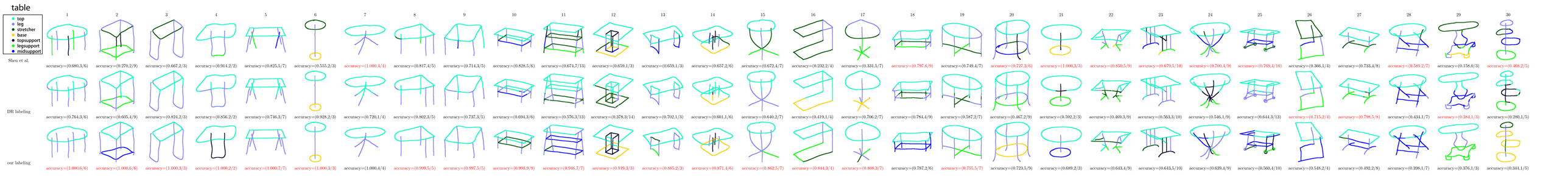
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top
leg
stretcher
base
topsupport
legsupport
midsupport
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Shen et al.
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DR labeling
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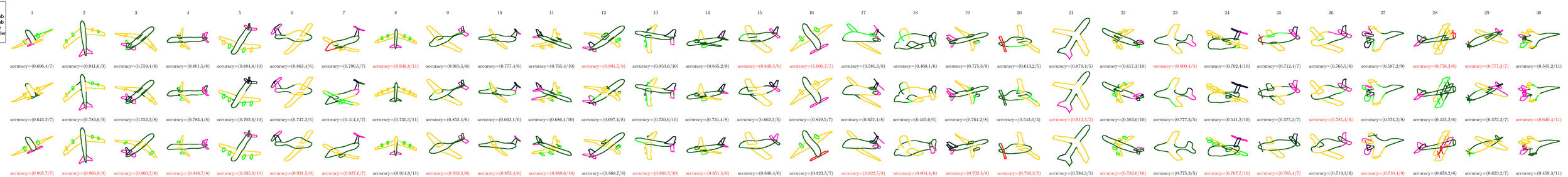
airplane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wing
horistab
vertstab
engine
propeller
tail
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Shen et al.
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accuracy=(0.459,3/11)


bicycle
saddle
frontframe
wheel
handle
pedal
chain
fork
backframe
support
backcover
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Shen et al.
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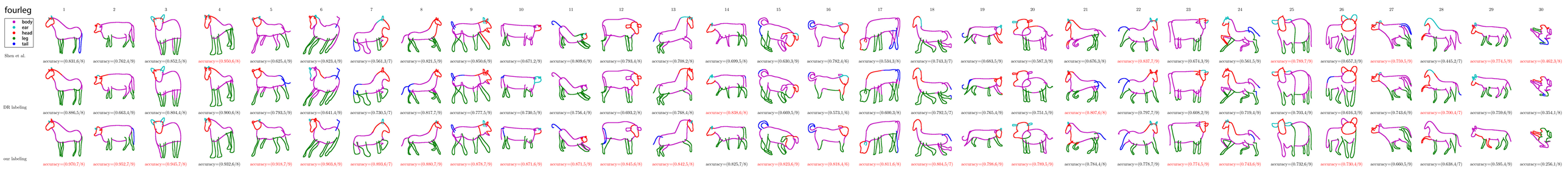
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Shen et al.
DR labeling
our labeling
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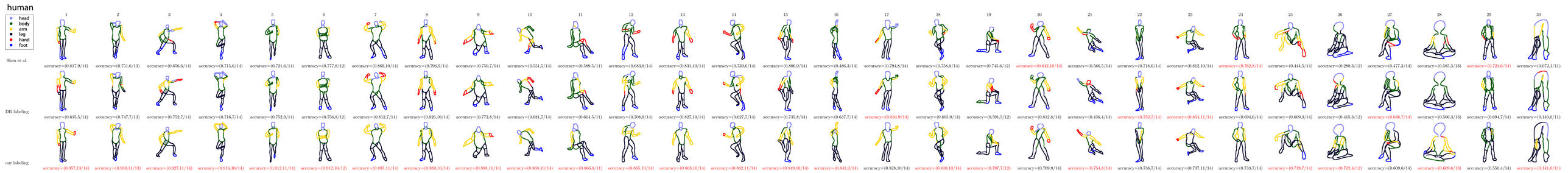
human
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Shen et al.
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DR labeling
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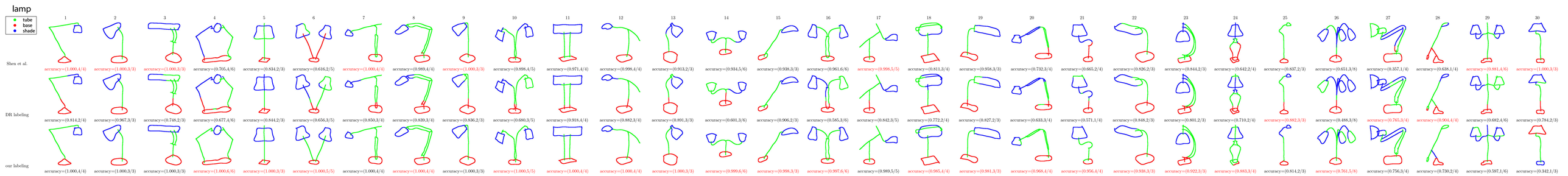
lamp
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Shen et al.
DR labeling
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2 accuracy=(1.000,3/3) accuracy=(1.000,3/3) accuracy=(1.000,3/3)
3 accuracy=(1.000,3/3) accuracy=(1.000,3/3) accuracy=(1.000,3/3)
4 accuracy=(0.705,4/6) accuracy=(0.677,4/6) accuracy=(1.000,6/6)
5 accuracy=(0.834,2/3) accuracy=(0.844,2/3) accuracy=(1.000,3/3)
6 accuracy=(0.616,2/5) accuracy=(0.656,3/5) accuracy=(1.000,5/5)
7 accuracy=(1.000,4/4) accuracy=(0.850,3/4) accuracy=(1.000,4/4)
8 accuracy=(0.989,4/4) accuracy=(0.839,3/4) accuracy=(1.000,4/4)
9 accuracy=(1.000,3/3) accuracy=(0.836,2/3) accuracy=(1.000,3/3)
10 accuracy=(0.898,4/5) accuracy=(0.680,3/5) accuracy=(1.000,5/5)
11 accuracy=(0.971,4/4) accuracy=(0.918,4/4) accuracy=(1.000,4/4)
12 accuracy=(0.998,4/4) accuracy=(0.882,3/4) accuracy=(1.000,4/4)
13 accuracy=(0.913,2/3) accuracy=(0.891,3/3) accuracy=(1.000,3/3)
14 accuracy=(0.934,5/6) accuracy=(0.601,3/6) accuracy=(0.999,6/6)
15 accuracy=(0.938,3/3) accuracy=(0.906,2/3) accuracy=(0.998,3/3)
16 accuracy=(0.961,6/6) accuracy=(0.585,3/6) accuracy=(0.997,6/6)
17 accuracy=(0.998,5/5) accuracy=(0.842,3/5) accuracy=(0.989,5/5)
18 accuracy=(0.811,3/4) accuracy=(0.772,2/4) accuracy=(0.985,4/4)
19 accuracy=(0.958,3/3) accuracy=(0.827,2/3) accuracy=(0.981,3/3)
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21 accuracy=(0.665,2/4) accuracy=(0.571,1/4) accuracy=(0.956,4/4)
22 accuracy=(0.826,2/3) accuracy=(0.848,2/3) accuracy=(0.938,3/3)
23 accuracy=(0.844,2/3) accuracy=(0.801,2/3) accuracy=(0.922,3/3)
24 accuracy=(0.642,2/4) accuracy=(0.710,2/4) accuracy=(0.883,3/4)
25 accuracy=(0.837,2/3) accuracy=(0.882,3/3) accuracy=(0.814,2/3)
26 accuracy=(0.651,3/8) accuracy=(0.488,3/8) accuracy=(0.761,5/8)
27 accuracy=(0.357,1/4) accuracy=(0.765,3/4) accuracy=(0.756,3/4)
28 accuracy=(0.638,1/4) accuracy=(0.904,4/4) accuracy=(0.730,2/4)
29 accuracy=(0.881,4/6) accuracy=(0.682,4/6) accuracy=(0.597,1/6)
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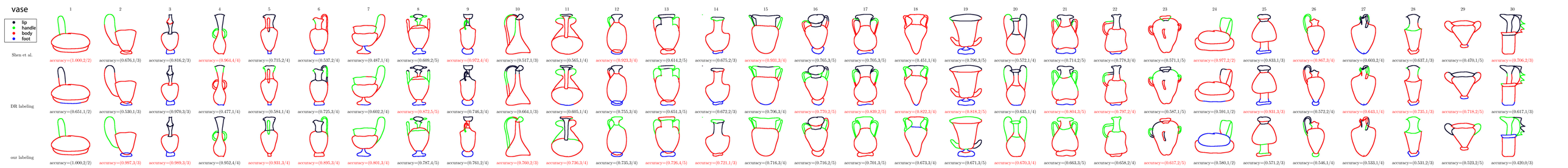
vase
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Shen et al.
accuracy=(1.000,2/2)
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DR labeling
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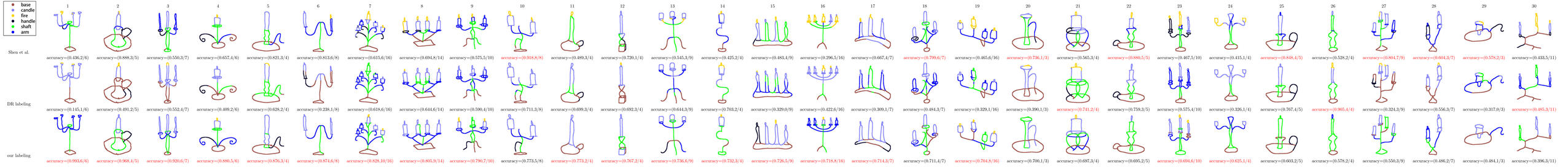

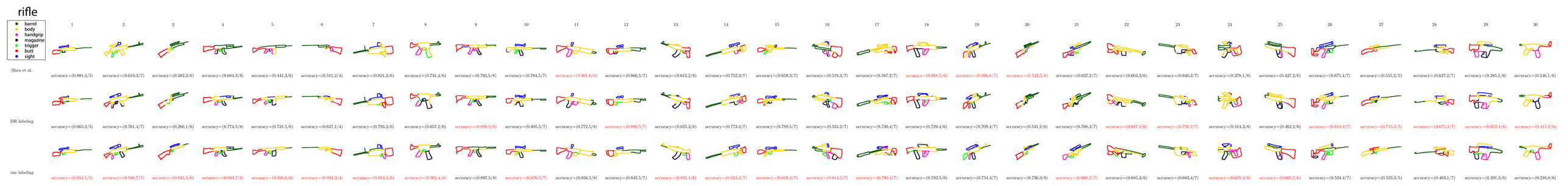
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Shen et al.
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DR labeling
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