BSP-Net: Generating Compact Meshes via Binary Space Partitioning

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Motivation

How to generate meshes?

3DN
Wang et al, CVPR 2019

AtlasNet
Groueix et al, CVPR 2018

Pixel2mesh
Wang et al, ECCV 2018

3D-R2N2
Choy et al, ECCV 2016

IM-NET
Chen & Zhang, CVPR 2019

OccNet
Mescheder et al, CVPR 2019

Warping template meshes

Voxels / implicit field → marching cubes
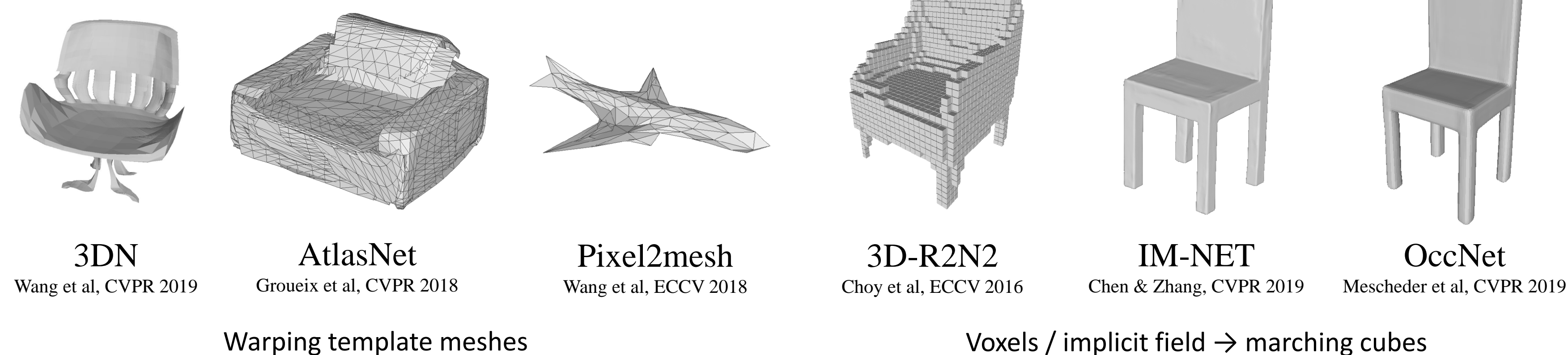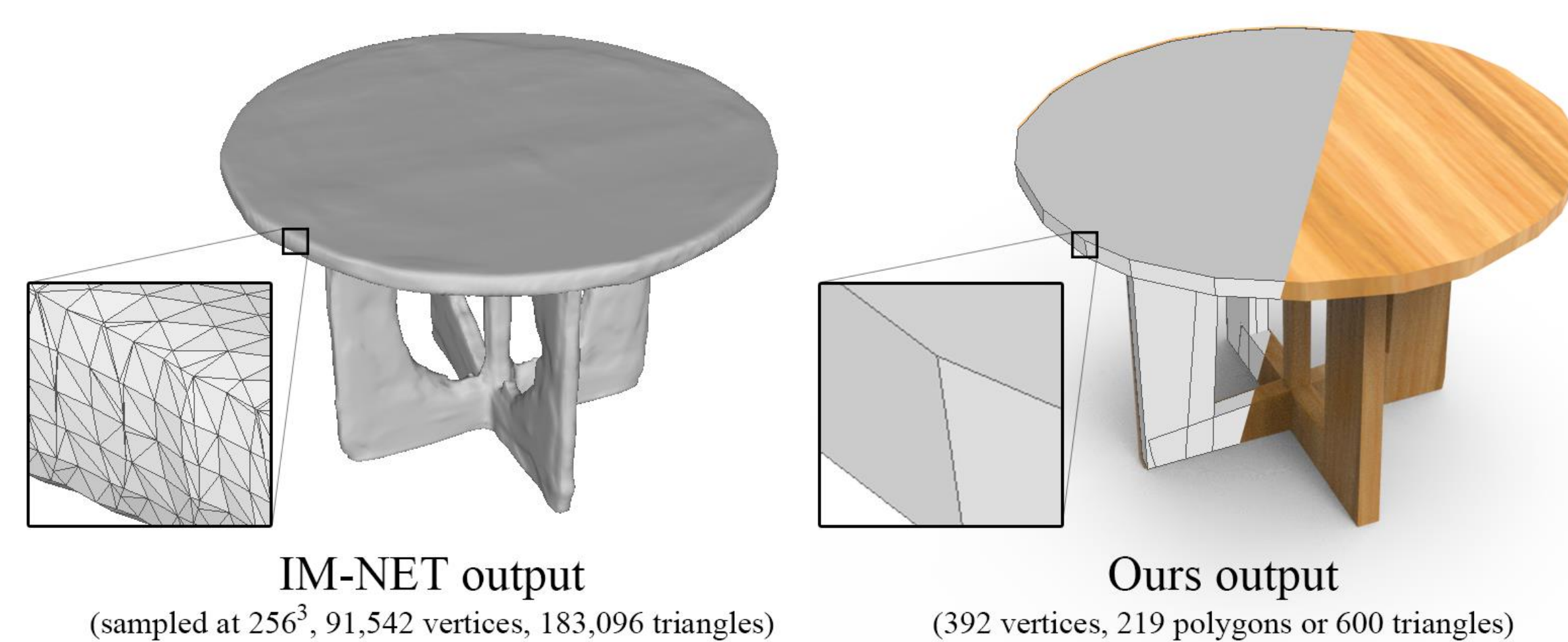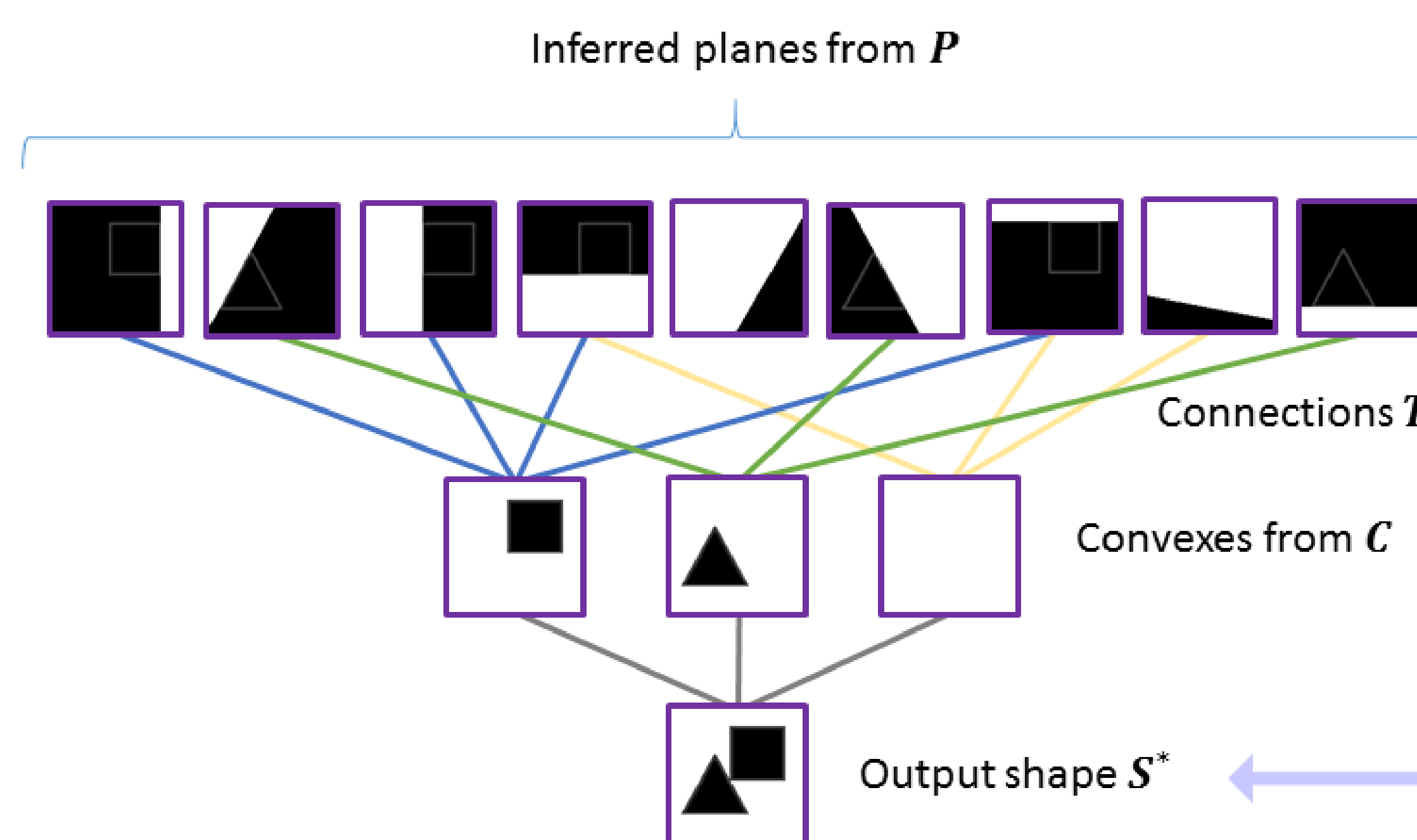
Compactness

Our BSP-Net generates compact, i.e., **low-poly** meshes. The outputs can reproduce sharp edges, yet still approximate smooth geometry.

Implicit models such as IM-NET need to be iso-surfaced, resulting in over-tessellated meshes which only approximate sharp details with smooth surfaces.
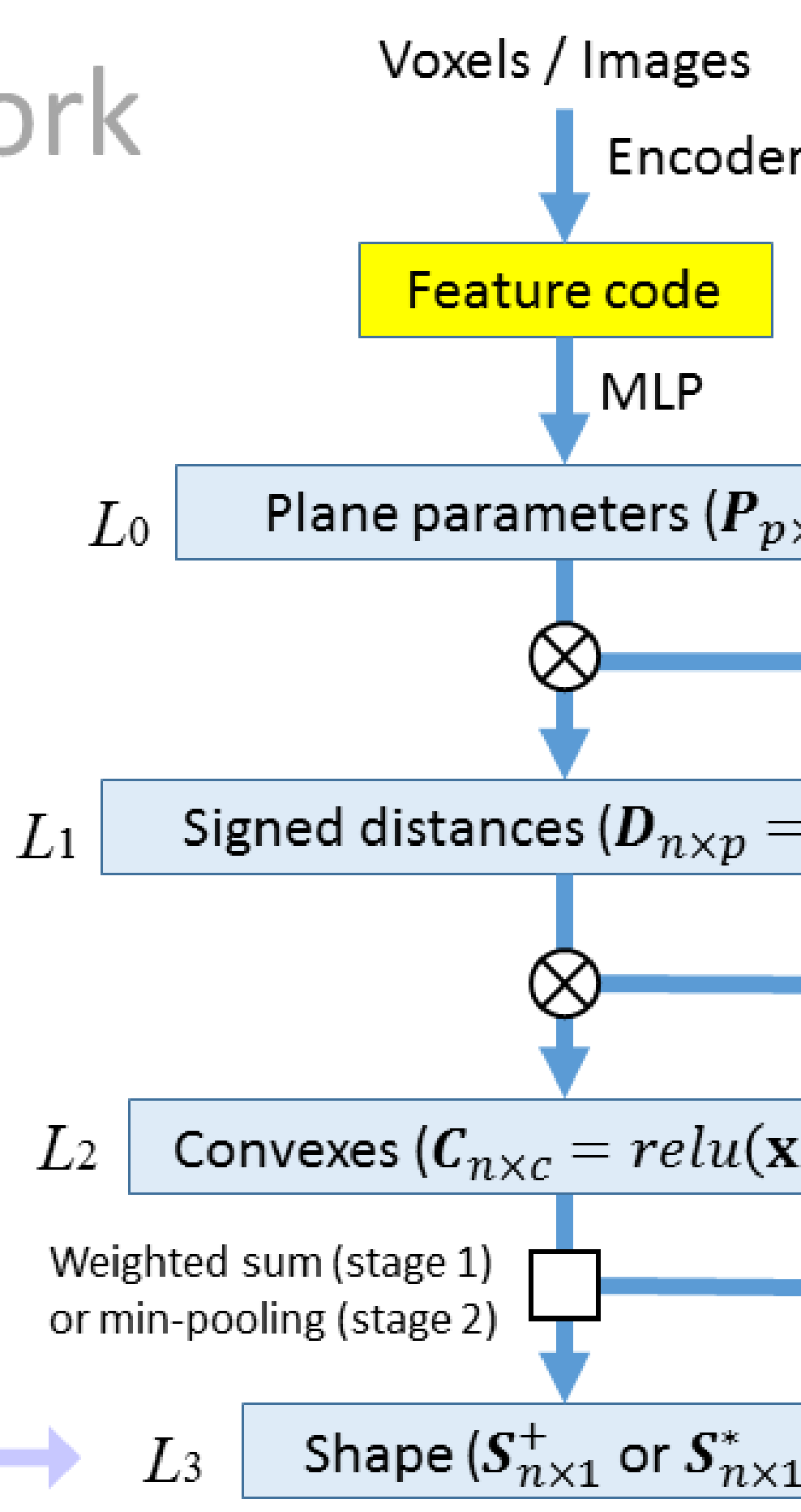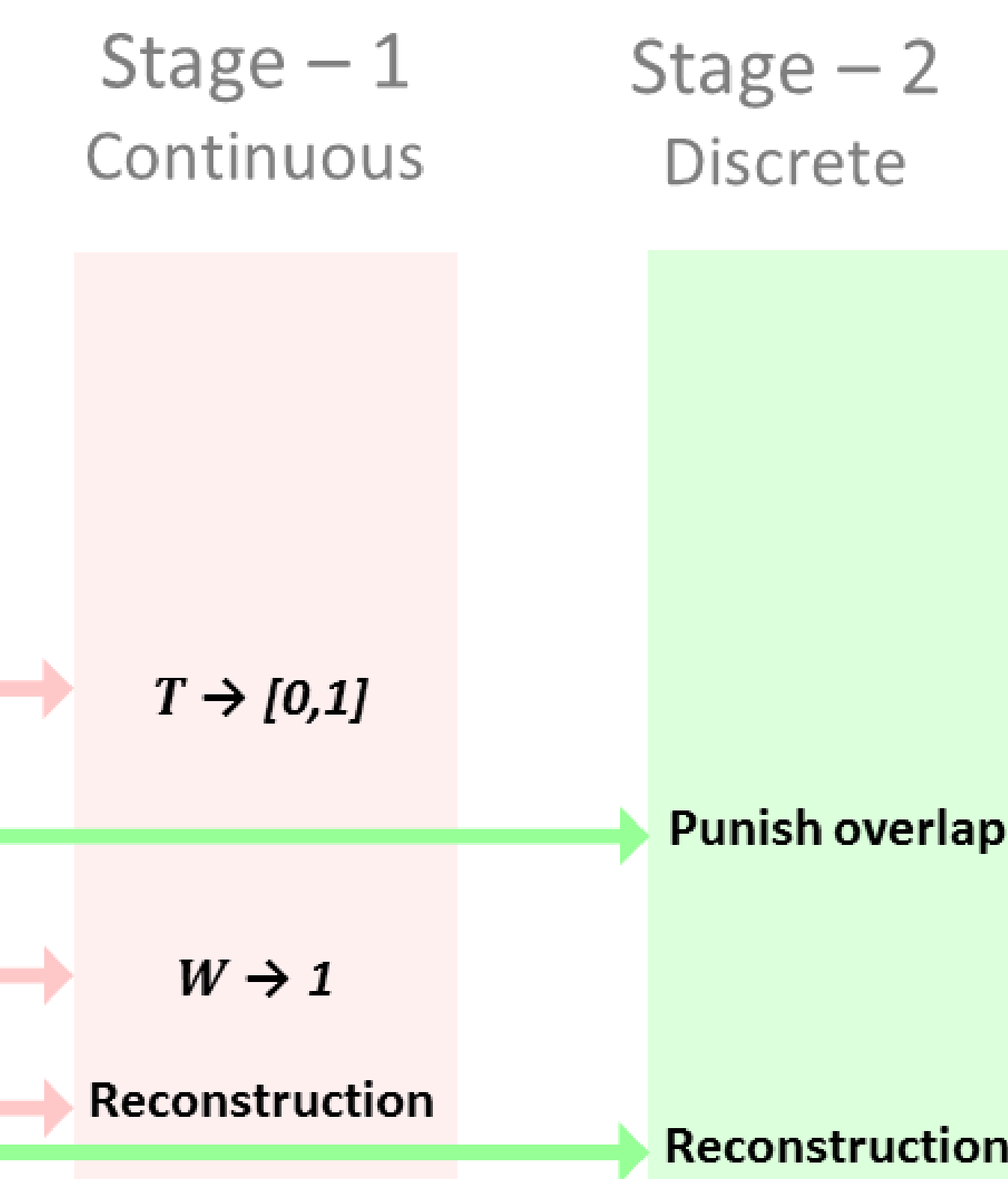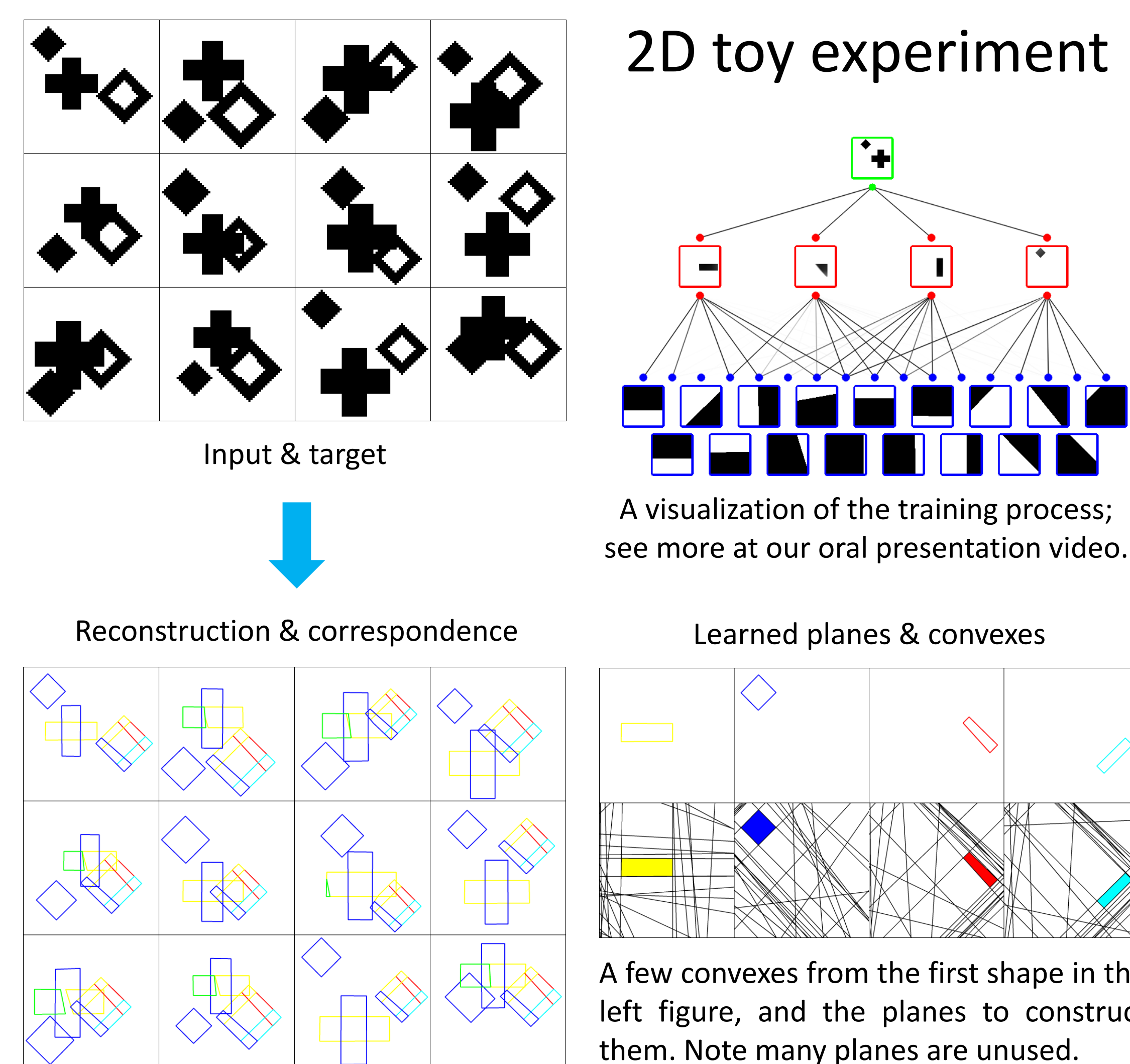

IM-NET output
(sampled at 256^3, 91,542 vertices, 183,096 triangles)

Ours output
(392 vertices, 219 polygons or 600 triangles)

Method

BSP-tree

Network

Loss function

Voxels / Images

Encoder

Feature code

MLP

Point coordinates

$\mathbf{x}_{n \times 4}$

Inferred planes from P

L_0 — Plane parameters ($P_{p \times 4}$)

L_1 — Signed distances ($D_{n \times p} = \mathbf{x}P^T$)

Connections T

Binary matrix $T_{p \times c}$

Convexes from C

L_2 — Convexes ($C_{n \times c} = relu(\mathbf{x}P^T)T$)

Auxiliary weights

Weighted sum (stage 1) or min-pooling (stage 2) — $W_{c \times 1}$

Output shape S^*

L_3 — Shape ($S_{n \times 1}^+$ or $S_{n \times 1}^*$)

Stage – 1 Continuous

Stage – 2 Discrete

$T \rightarrow [0,1]$

Punish overlap

$W \rightarrow 1$

Reconstruction

Reconstruction

Results

2D toy experiment

Input & target

A visualization of the training process; see more at our oral presentation video.

Reconstruction & correspondence

Learned planes & convexes

A few convexes from the first shape in the left figure, and the planes to construct them. Note many planes are unused.

3D reconstruction & decomposition

(1) Volumetric Primitives
Tulsiani et al, CVPR 2017

(2) SuperQuadrics
Paschalidou et al, CVPR 2019

(3) BAE-NET
Chen et al, ICCV 2019

(4) Ours

(5) Reconstruction ground truth
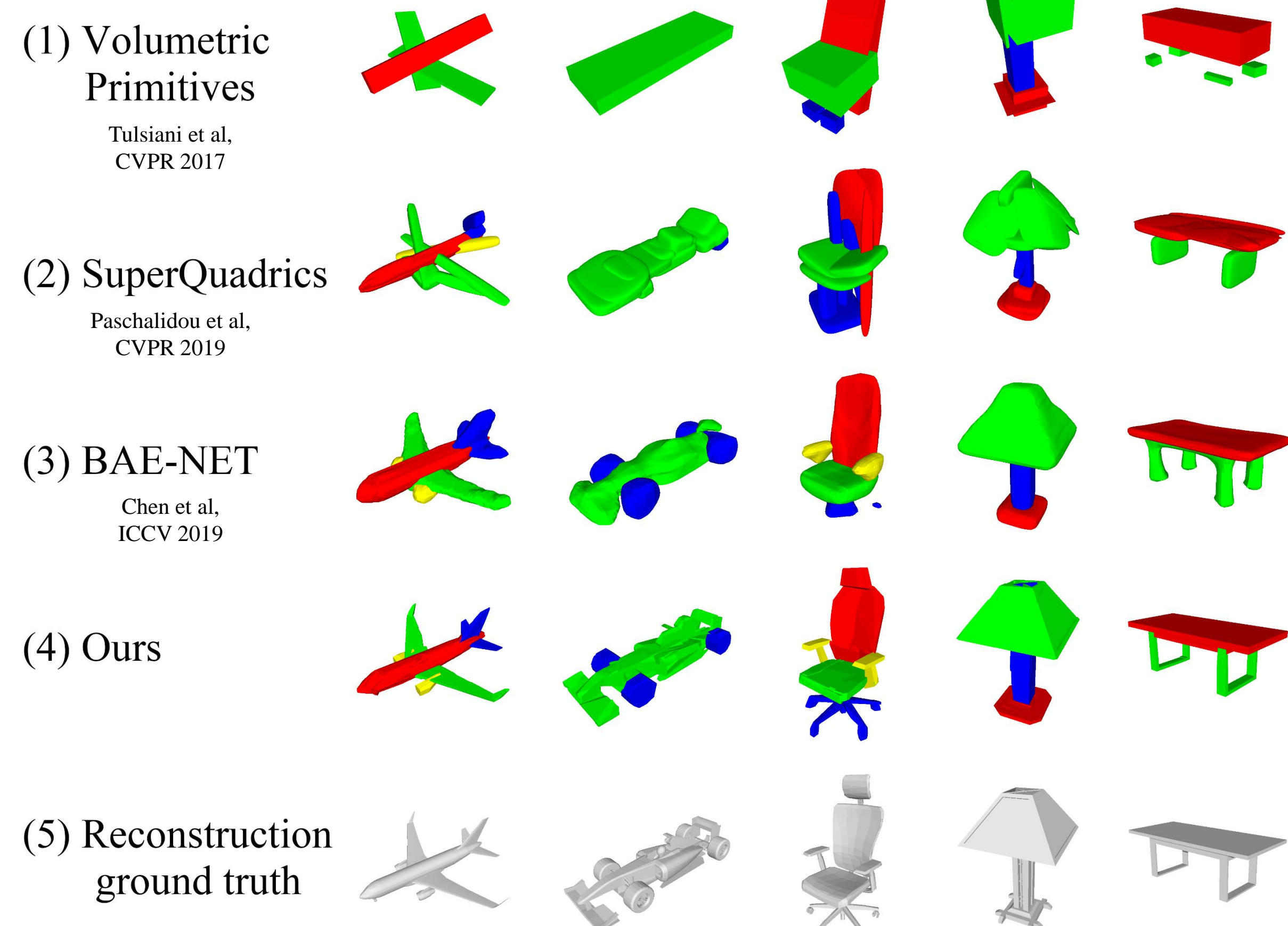
Part correspondence
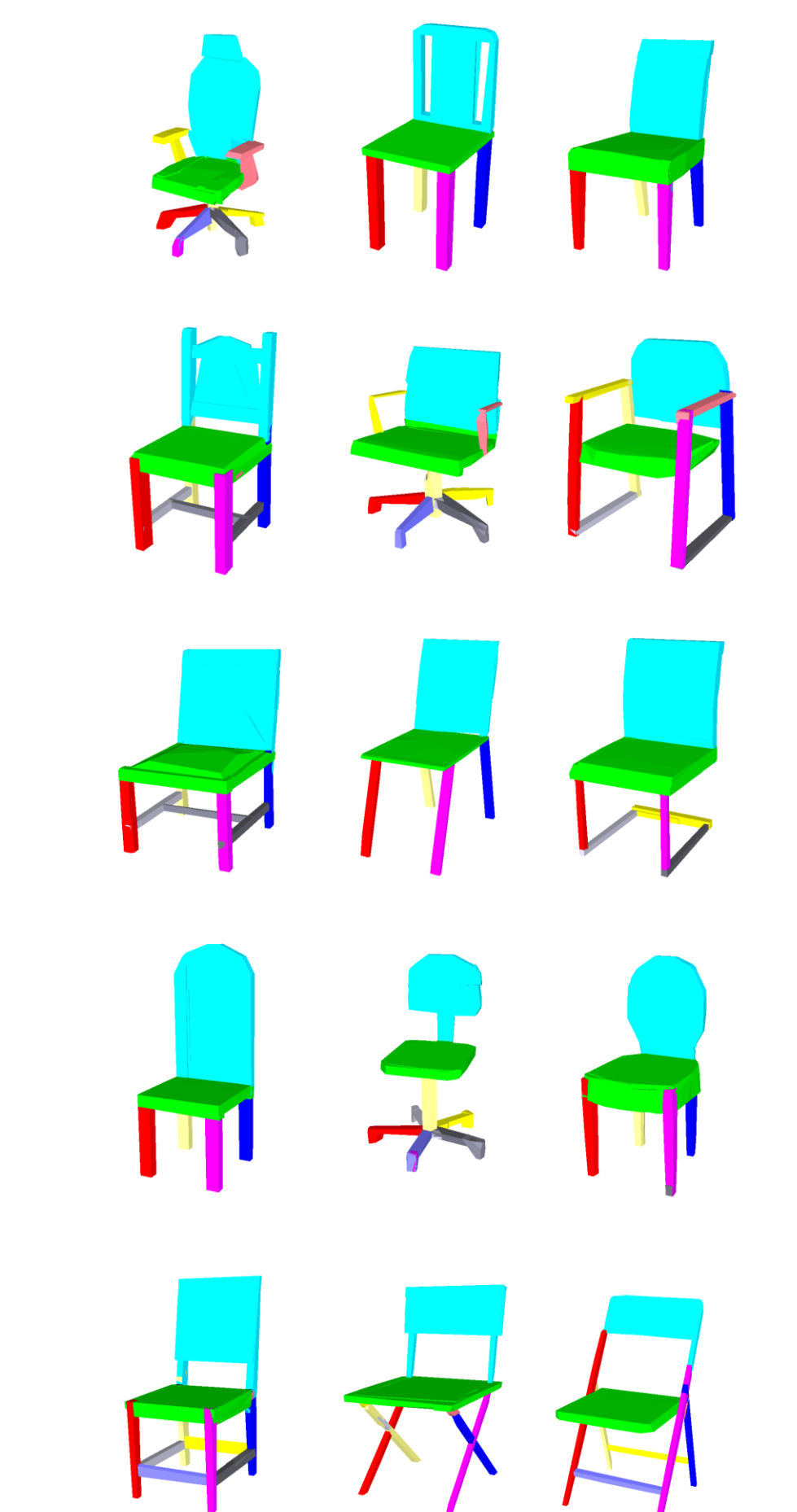
Single View Reconstruction

Input image

(1) Atlasnet (1 sphere)
Groueix et al, CVPR 2018

(2) Atlasnet (25 patches)
Groueix et al, CVPR 2018

(3) OccNet (128^3)
Mescheder et al, CVPR 2019

(4) IM-NET (256^3)
Chen & Zhang, CVPR 2019

(5) Ours

(6) Ground truth