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See and Think: Disentangling Semantic Scene Completion

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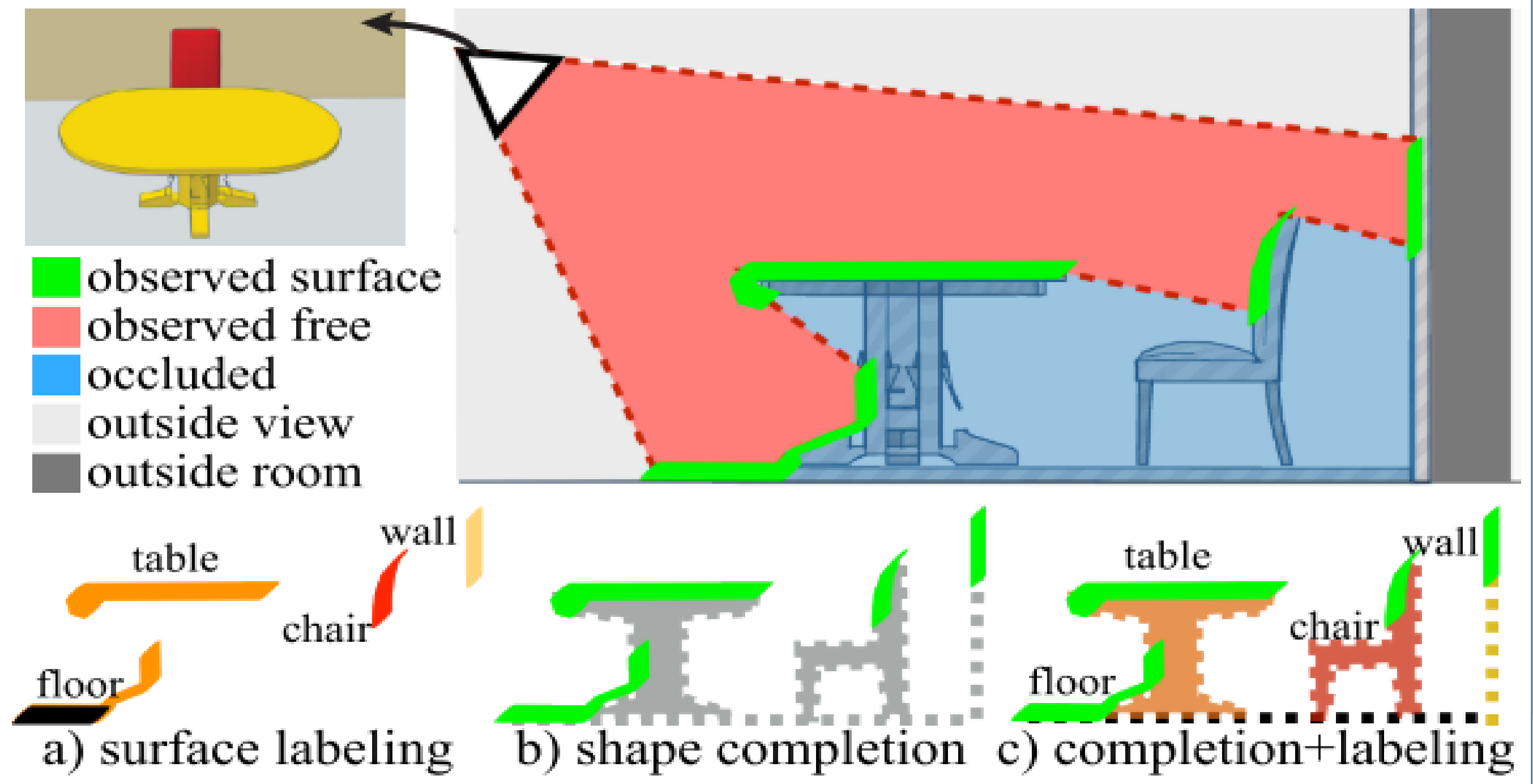
1. Problem Statement



a) surface labeling b) shape completion c) completion+labeling

(The figure is extracted from [1].)

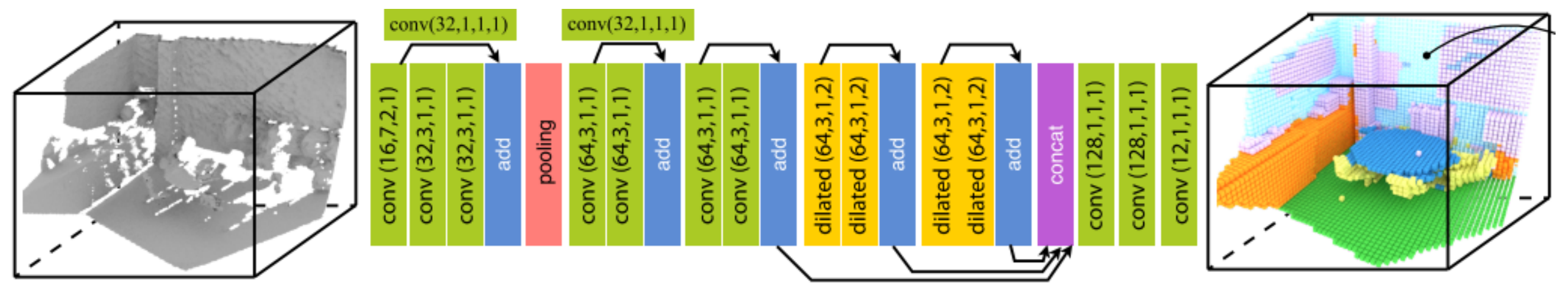
Semantic Scene Completion:

- Introduced by Song et al. in CVPR 2017.
- To predict volumetric occupancy and object category of a 3D scene, simultaneously.

2. Related Works

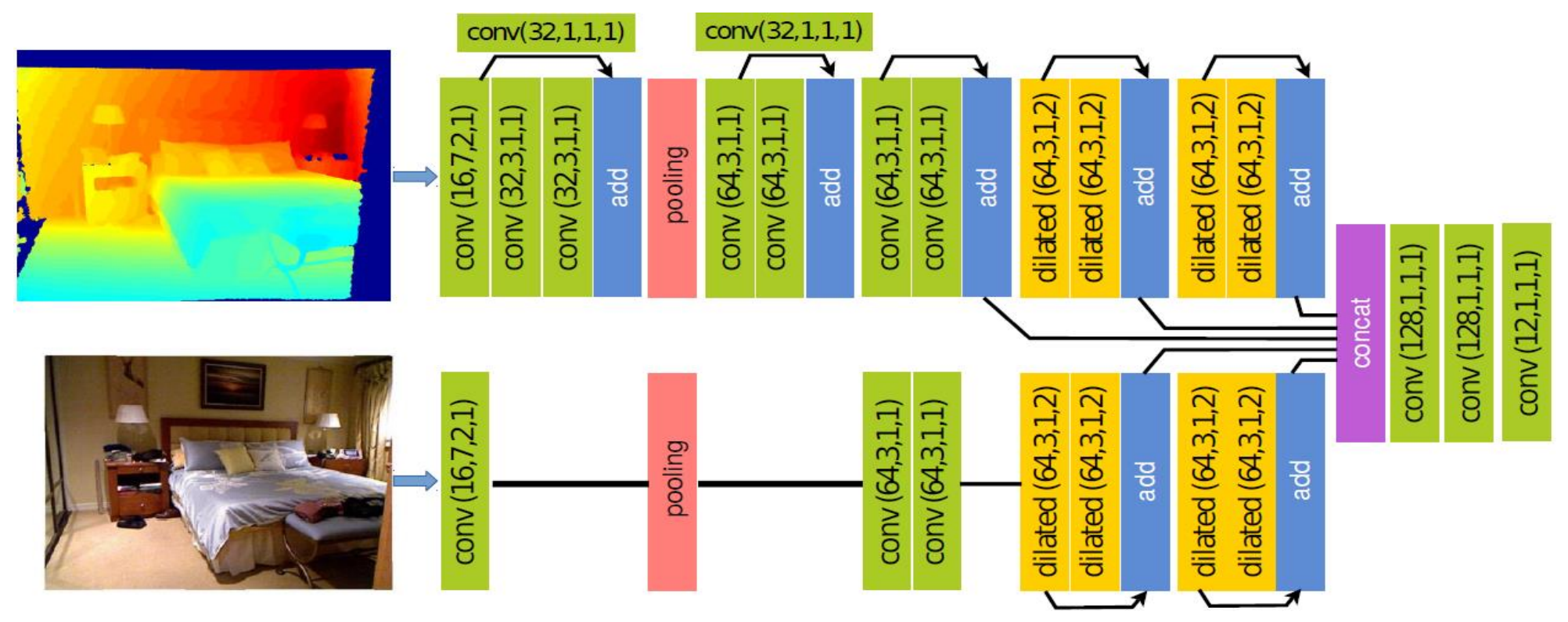
SSCNet [1]:

- The depth is encoded to a 3D tensor by flipped-TSDF.
- 3D convolutions are used for semantic completion.



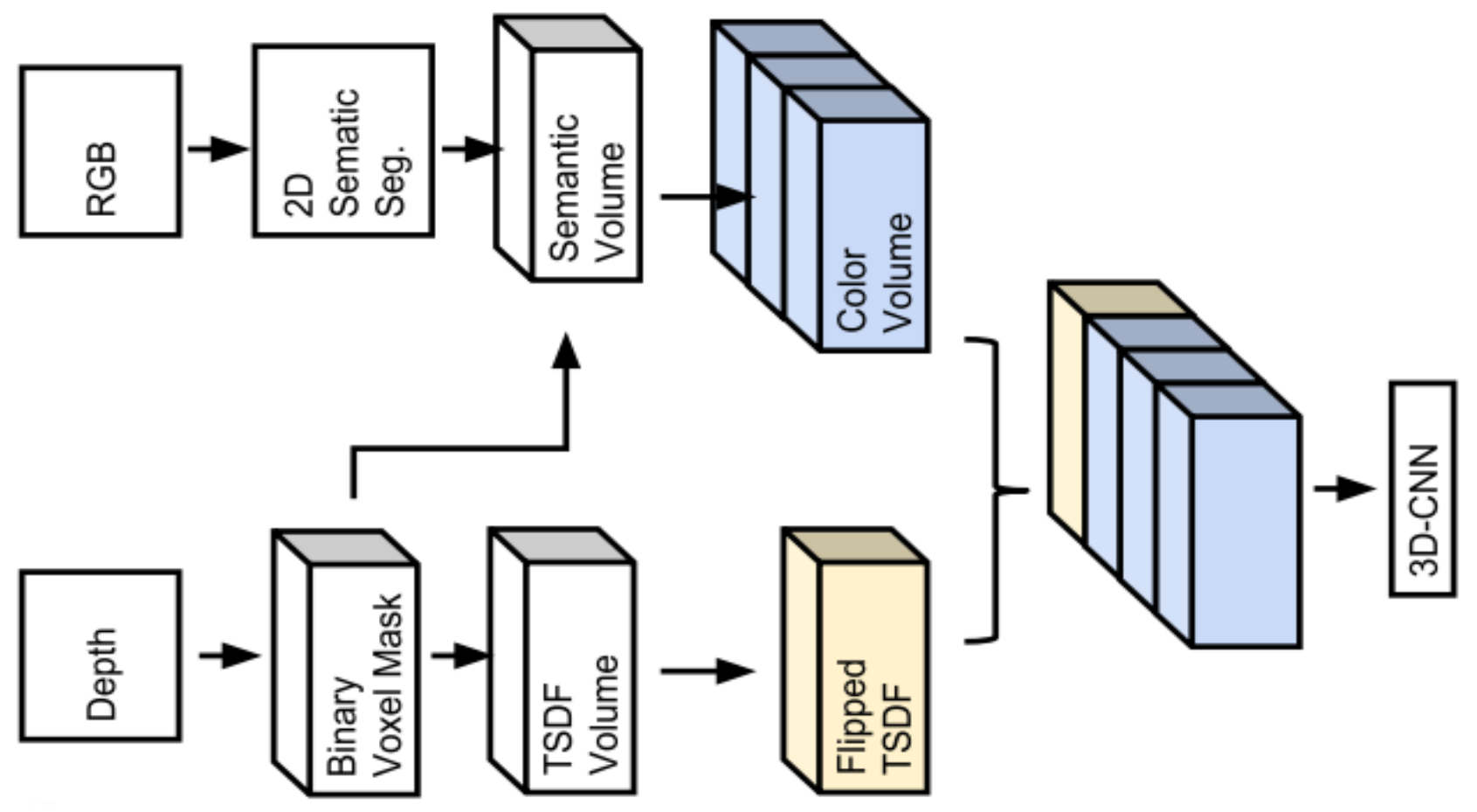
Colour-SSCNet [2]:

- The RGB image is projected to a 3D tensor.
- 3D convolutions for RGB are parallel to those for depth.



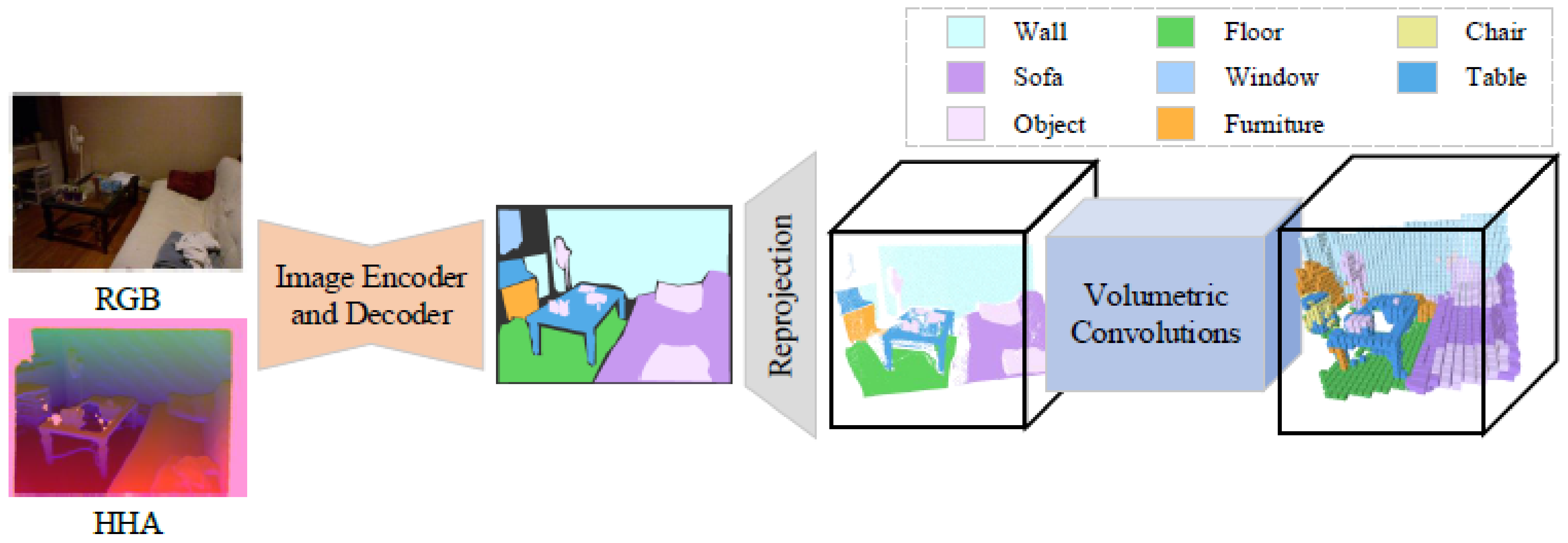
Two-stream SSCNet [3]:

- The semantic segmentation is introduced to RGB images.
- The segmentation result is projected to a 3D tensor.



3. Method Details

See And Think Network (SATNet) consists of three modules: (a) SNet, (b) a reprojection layer, and (c) TNet, sequentially carrying out 2D semantic segmentation, 2D-3D reprojection and 3D semantic scene completion.



(a) SNet: 2D Semantic Segmentation (b) Reprojection Layer (c) TNet: 3D Semantic Scene Completion

(a) SNet: 2D Semantic Segmentation

- 2D convolutions are organized as an encoder-decoder architecture with skip connections.
- Whichever input is given, SNet maintains the same architecture.

(b) 2D-3D Reprojection Layer

- The 2D semantic segmentation results are reprojected into 3D space.

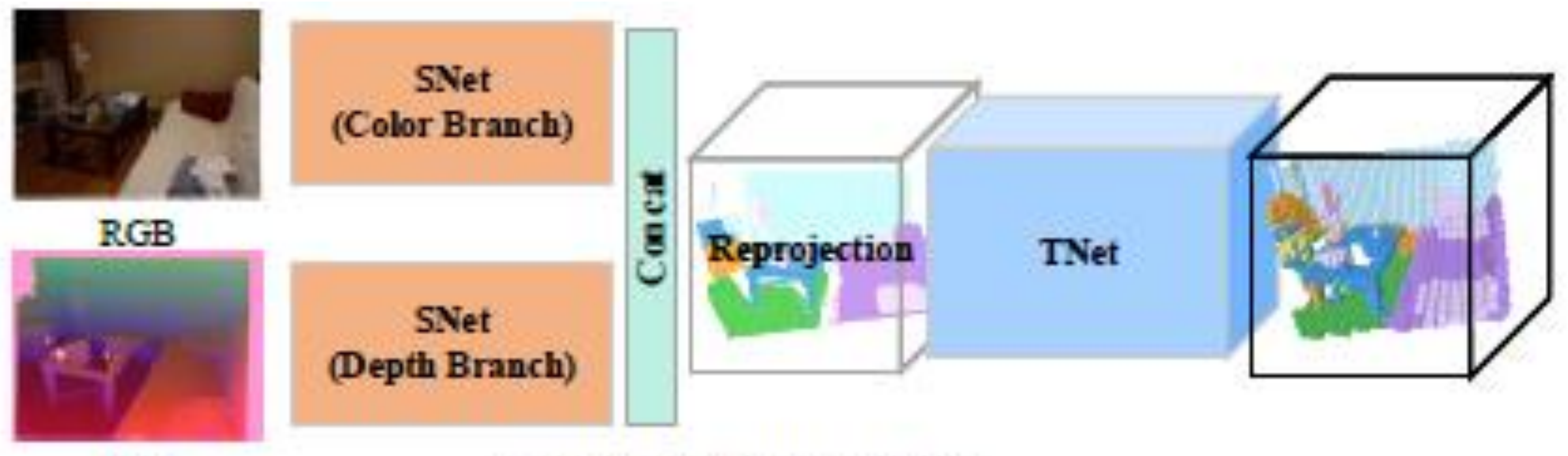
(c) TNet: 3D Semantic Scene Completion

- 3D convolutions are utilized to produce semantic scene completions by the 3D semantic surfaces of the scene.
- TNet cares only about the semantic segmentation results, instead of the types of inputs.

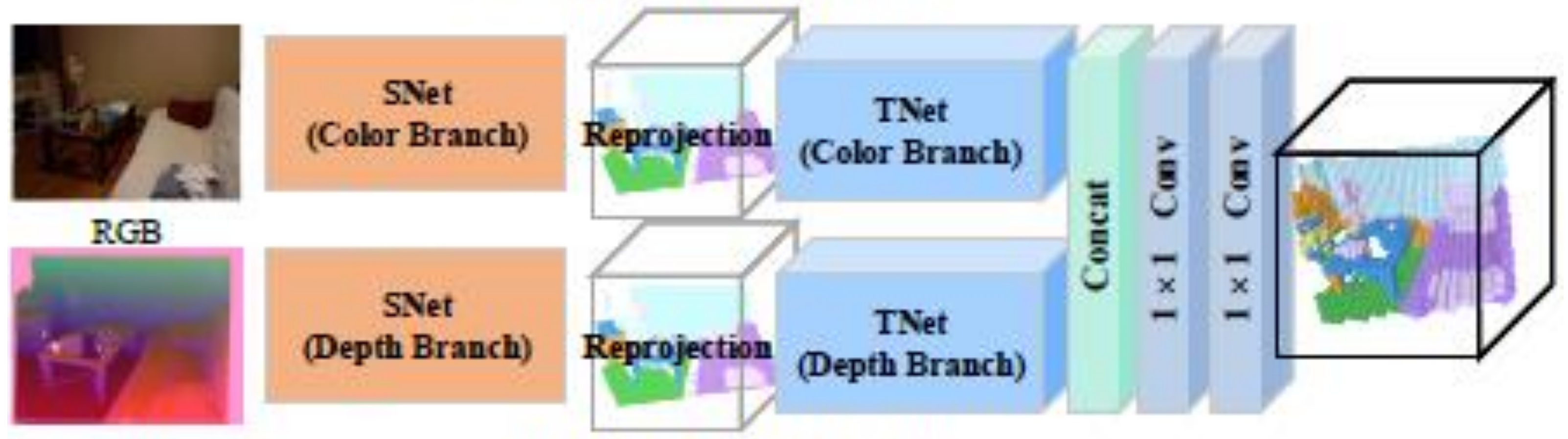
Double-branch RGB-D Fusion

(a) RGB-D Fusion in SNet: The semantic segmentation of RGB-D images is introduced for semantic scene completion.

(b) RGB-D Fusion in TNet: The two semantic scene completions generated by RGB and depth are integrated at the end of the TNet.



(a) RGB-D Fusion in SNet



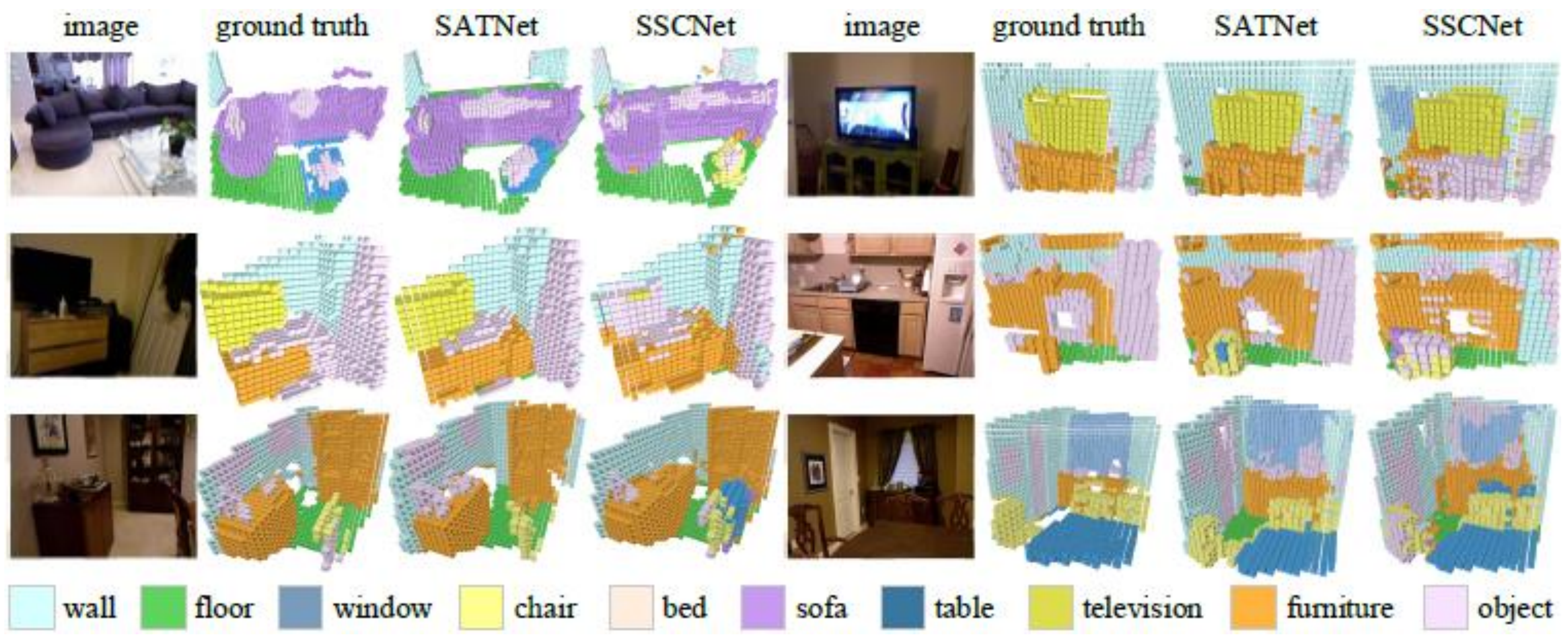
(b) RGB-D Fusion in TNet

4. Experimental Results

Datasets:

- **SUNCG:** A synthetic dataset with 40k~100k training samples.
  - SUNCG-D: Composed of depth images and annotations.
  - SUNCG-RGBD: Composed of RGB images, depth images and annotations.
- **NYUv2:** A real dataset whose ground truths are annotated with CAD model library.

Qualitative Results:



Quantitative Results on NYUv2:

	Scene completion			Semantic scene completion											
method	prec.	recall	IoU	ceil.	floor	wall	win.	chair	bed	sofa	table	tvs.	furn.	objs.	avg.
Lin [29]	58.5	49.9	36.4	0.0	11.7	13.3	14.1	9.4	29.0	24.0	6.0	7.0	16.2	1.1	12.0
Geiger [26]	65.7	58.0	44.4	10.2	62.5	19.1	5.8	8.5	40.6	27.7	7.0	6.0	22.6	5.9	19.6
Song [1]	59.3	**92.9**	56.6	15.1	**94.6**	24.7	10.8	17.3	53.2	45.9	15.9	13.9	31.1	12.6	30.5
Guedes [6][1]	62.5	82.3	54.3	-	-	-	-	-	-	-	-	-	-	-	27.5
Garbade [24]	**69.5**	82.7	**60.7**	12.9	92.5	25.3	20.1	16.1	56.3	43.4	17.2	10.4	33.0	14.3	31.0
Depth	66.8	86.6	60.6	20.6	91.3	27.0	9.2	**19.5**	56.9	**54.7**	16.9	15.2	37.1	15.7	33.1
RGBD	69.2	81.2	59.5	**22.5**	87.0	**30.0**	**21.1**	17.9	52.4	44.5	15.1	**19.5**	36.0	17.3	33.0
SNetFuse	67.6	85.9	**60.7**	22.2	91.0	28.6	18.2	19.2	56.2	51.2	16.2	12.2	37.0	17.4	33.6
TNetFuse	67.3	85.8	60.6	17.3	92.1	28.0	16.6	19.3	**57.5**	53.8	**17.7**	18.5	**38.4**	**18.9**	**34.4**

Quantitative Results on SUNCG-D:

	Scene completion			Semantic scene completion											
method	prec.	recall	IoU	ceil.	floor	wall	win.	chair	bed	sofa	table	tvs.	furn.	objs.	avg.
Song [1]	76.3	95.2	73.5	96.3	**84.9**	56.8	28.2	21.3	56.0	52.7	33.7	10.9	44.3	25.4	46.4
Depth	**80.7**	**96.5**	**78.5**	**97.9**	82.5	**57.7**	**58.5**	**45.1**	**78.4**	**72.3**	**47.3**	**45.7**	**67.1**	**55.2**	**64.3**

Quantitative Results on SUNCG-RGBD:

	Scene completion			Semantic scene completion											
method	prec.	recall	IoU	ceil.	floor	wall	win.	chair	bed	sofa	table	tvs.	furn.	objs.	avg.
Song [1]	43.5	90.7	41.5	64.9	60.1	**57.6**	25.2	25.5	40.4	37.9	23.1	29.8	45.7	4.7	37.7
Depth	52.3	92.7	50.2	62.5	57.8	48.6	**58.5**	24.4	46.5	50.4	26.9	**41.1**	40.7	20.2	43.4
RGBD	49.8	94.3	48.3	59.0	45.0	46.0	50.6	24.9	42.0	49.0	26.8	40.8	**46.6**	22.4	41.2
SNetFuse	**56.7**	91.7	**53.9**	**65.5**	**60.7**	50.3	56.4	26.1	**47.3**	43.7	**30.6**	37.2	44.9	**30.0**	44.8
TNetFuse	53.9	**95.2**	52.6	60.6	57.3	53.2	52.7	**27.4**	46.8	**53.3**	28.6	**41.1**	44.1	29.0	**44.9**

5. Main References

[1] Shuran Song et al. Semantic Scene Completion from a Single Depth Image. In CVPR, 2017.

[2] Andre B. S. Guedes et al. Semantic Scene Completion Combining Colour and Depth: Preliminary Experiments. arXiv:1802.04735, 2018.

[3] Martin Garbade et al. Two Stream 3D Semantic Scene Completion. arXiv:1804.03550, 2018.