Joint Semantic-Instance Segmentation of 3D Point Clouds: Instance Separation and Semantic Fusion

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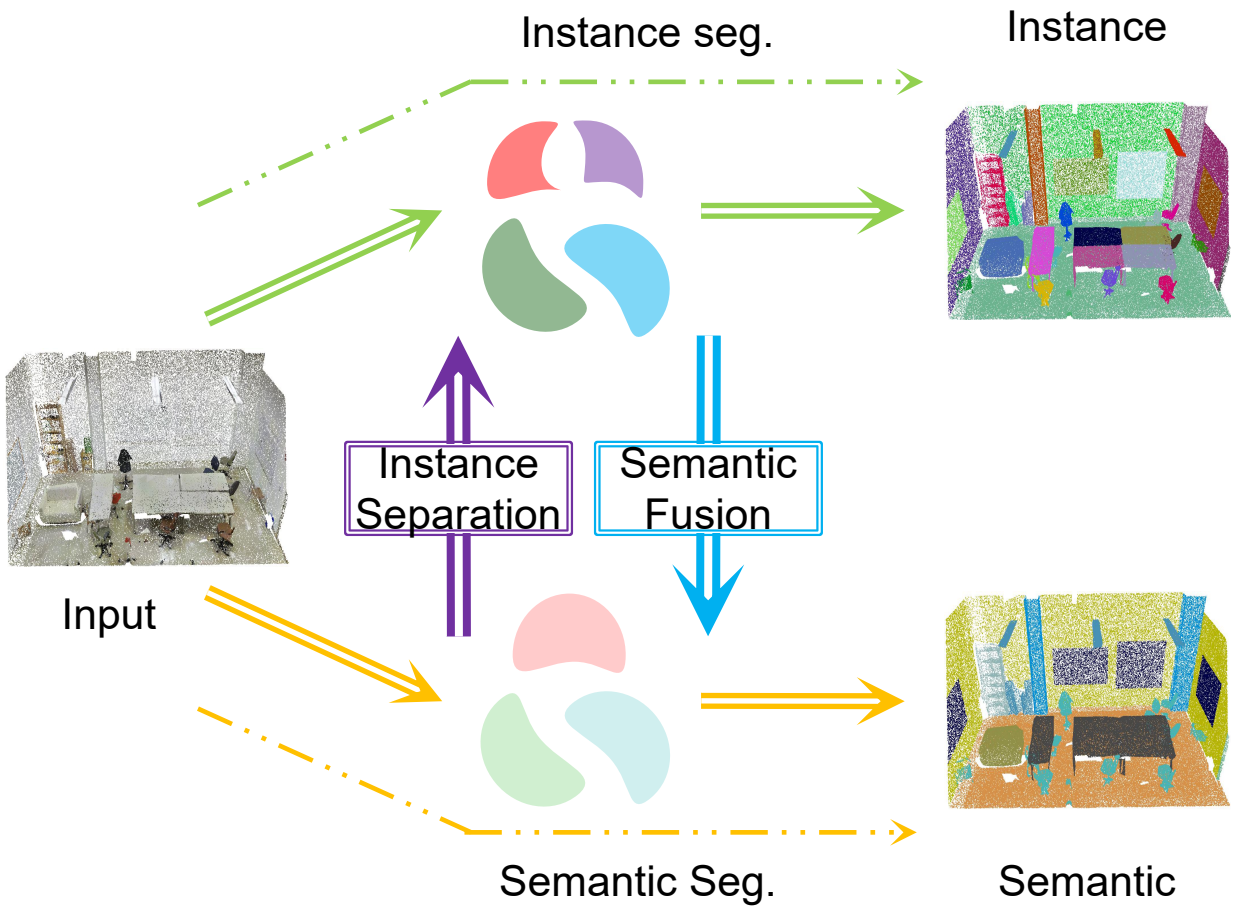
Outline

- **Introduction**
- **Approach**
- **Experiments**

Introduction: 3D Semantic-Instance Segmentation

- **3D Semantic and Instance Segmentation**
  - Input: 3D point clouds.
  - Output: instance labels and semantic labels for each point.

- **Joint 3D Semantic-Instance Segmentation**.
  - points with different semantic labels must belong to different instances
  - points within the same instance must share the same semantics



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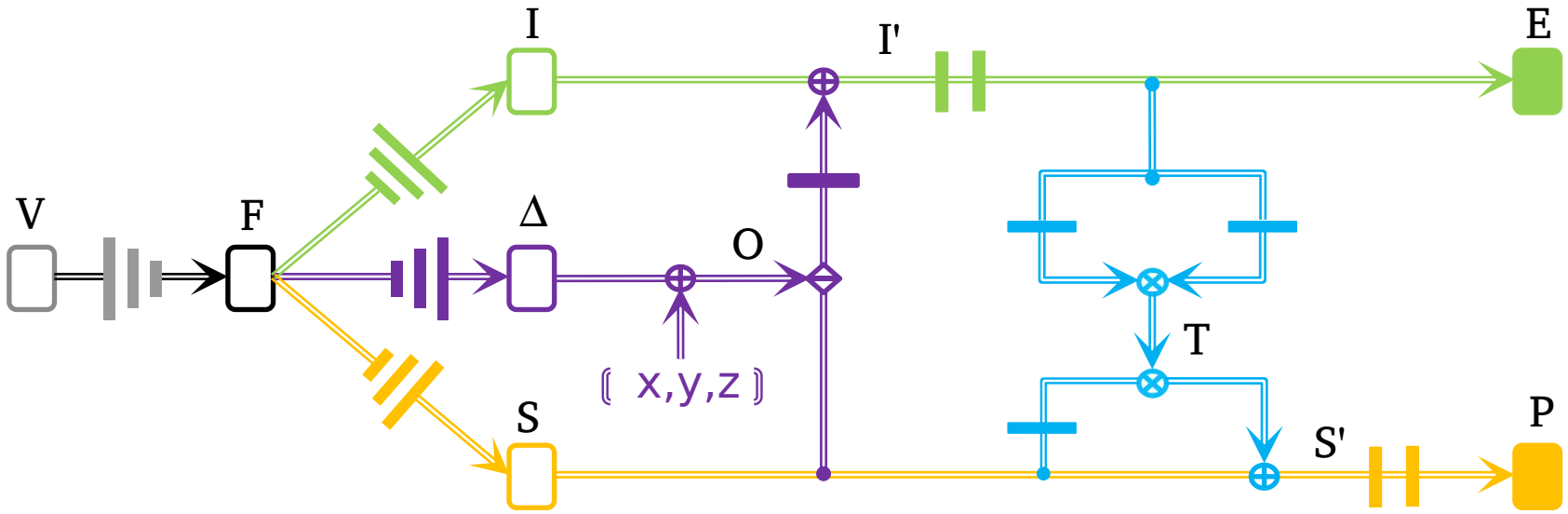
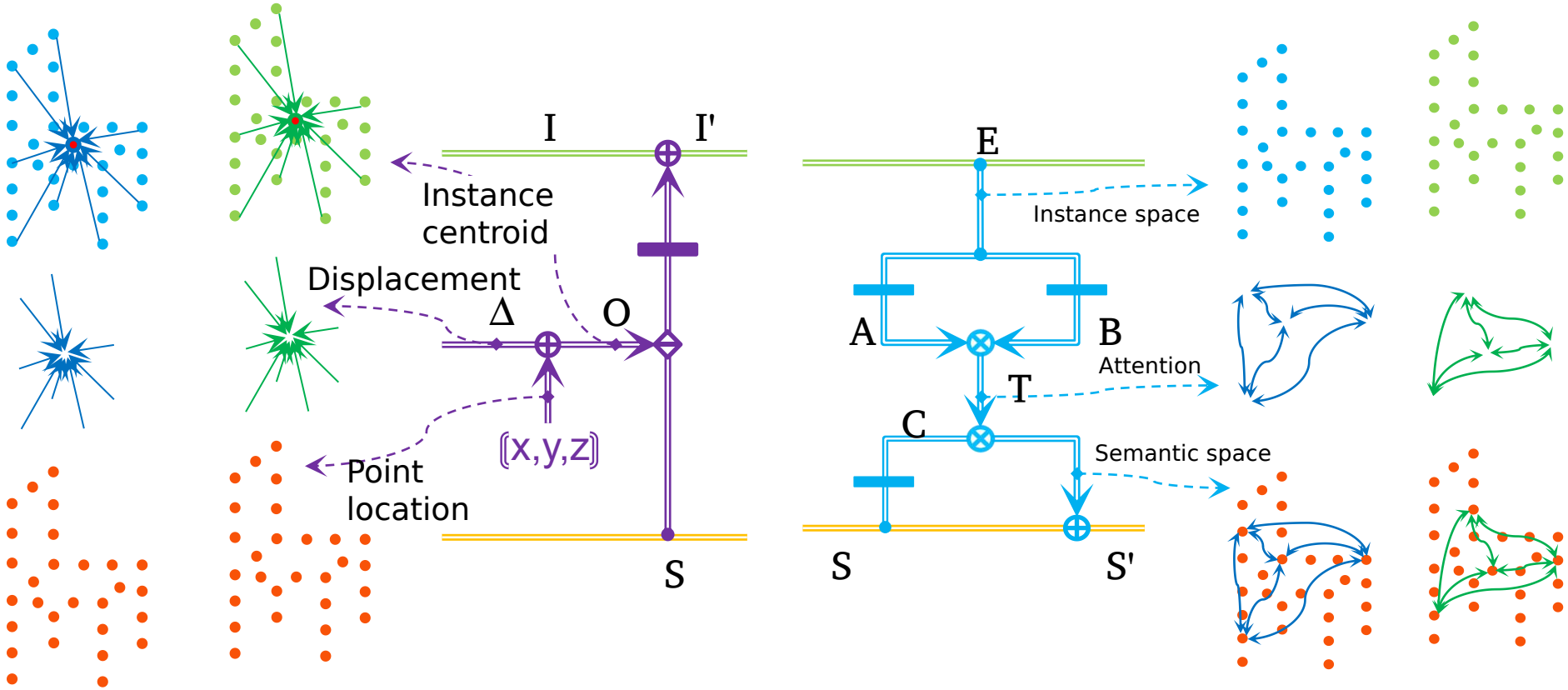
Approach: The overall framework



- **Two task branches**: A point cloud encoder (e.g. PointNet) used to extract feature F. Then one branch for semantic seg. (orange) and the other for instance seg. (green).

- **Two modules set up cooperation.** Instance Separation Module(purple) estimates object centroid O, which concat with S to create semantic-aware instance feature. The Semantic Fusion Module(blue) uses instance embedding to produce attention map and get more instance consistent semantic feature.

Approach: Two interaction modules



- **Instance Separation.** Semantic feature can help separate different semantic instances. However, the same semantics may contain different instances. So we futher supplement the semantic feature with object center information.
- **Semantic Fusion.** Points within the same instance must have the same semantics. We produce an attention map between each pair of points in the instance embedding space, and then used to fuse the semantic information in the semantic feature space.

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Comparison with Other Methods

Backbone	Method	mCov	mWCov	mPrec	mRec
Test on Area 5					
PN	SGPN [28]	32.7	35.5	36.0	28.7
	ASIS [29]	40.4	43.3	44.5	37.4
PN++	ASIS [29]	44.6	47.8	55.3	42.4
	Ours	**48.7**	**51.8**	**58.2**	**46.6**
Test on 6-fold CV					
PN	SGPN [28]	37.9	40.8	38.2	31.2
	ASIS [29]	44.7	48.2	53.2	40.7
PN++	ASIS [29]	51.2	55.1	63.6	47.5
	Ours	**54.2**	**58.1**	**65.3**	**50.8**

Instance Seg.

Backbone	Method	mAcc	mIoU	oAcc
Test on Area 5				
PN	PN (*RePr*)	52.1	43.4	83.5
	ASIS [29]	55.7	46.4	84.5
PN++	ASIS [29]	60.9	53.4	86.9
	Ours	**62.7**	**55.3**	**87.7**
Test on 6-fold CV				
PN	PN (*RePr*)	60.3	48.9	80.3
	ASIS [29]	62.3	51.1	81.7
PN++	ASIS [29]	70.1	59.3	86.2
	Ours	**71.6**	**60.9**	**86.7**

Semantic seg.

- we propose two improved modules, which improve the performance in both tasks.
- It demonstrates that our novel modules can catch the relationship between semantic and instance features better than ASIS.

Comparison with Other Methods

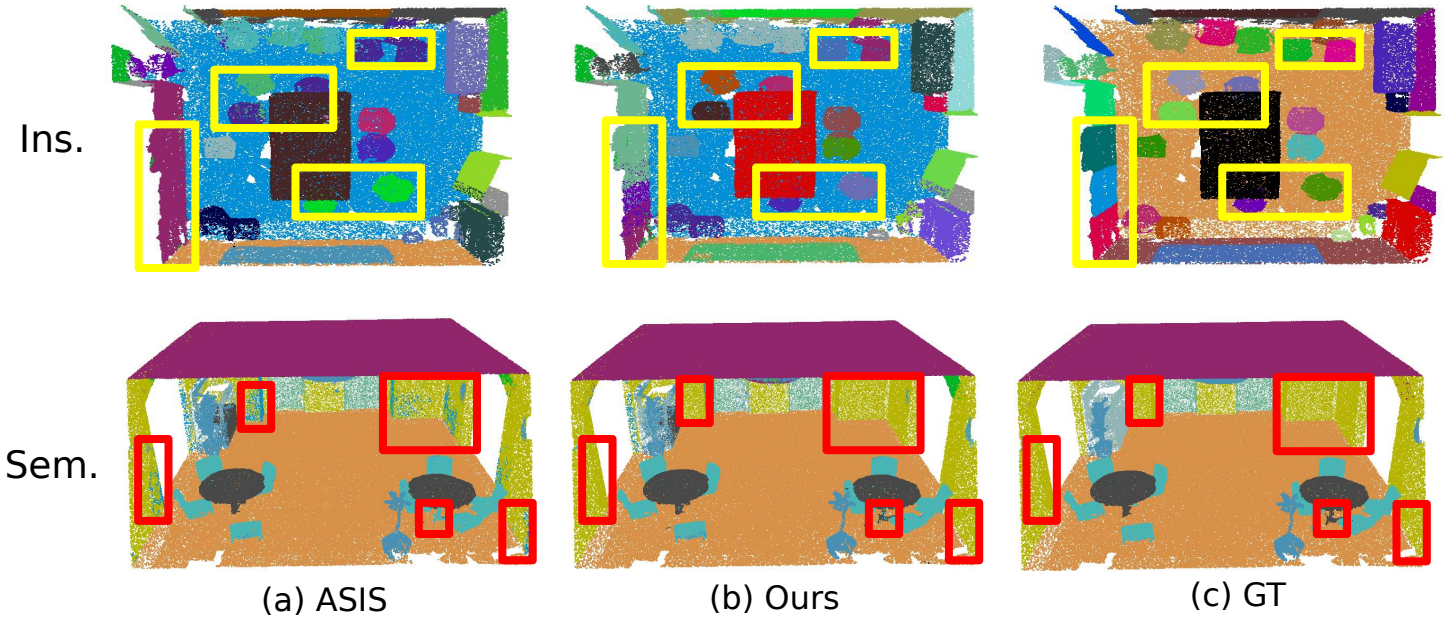


Fig. 4: The semantic and instance seg. results. compare with the ASIS method.

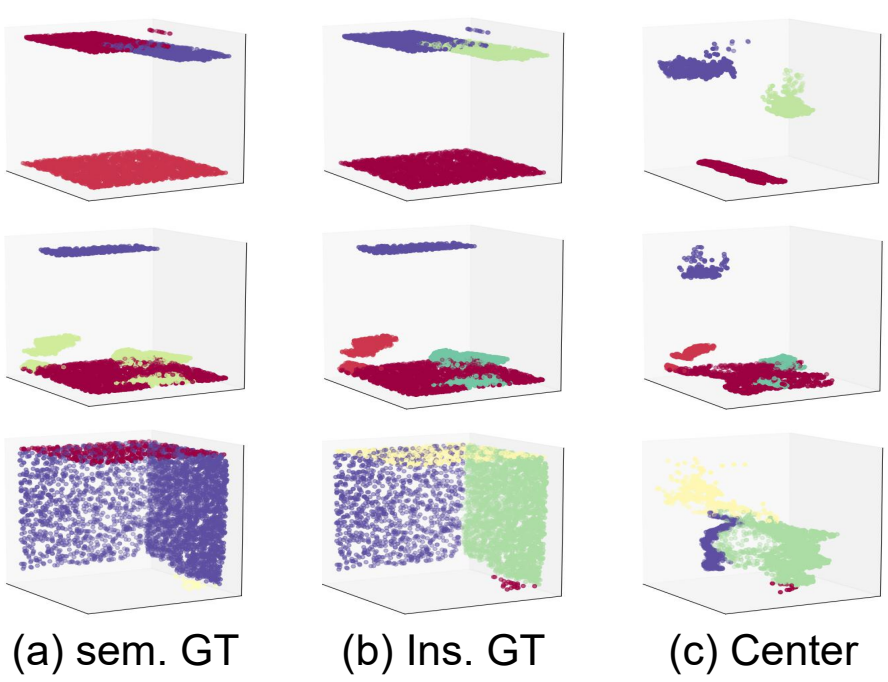
- The same category instances are better distinguished as we take the object center into consideration
- Our semantic segmentation results are more consistent because our attention based Semantic Fusion Module can capture long-range contexts.

Ablation studies on two modules

Method	+FC	+FS	+FF	mCov	mWCov	mPrec	mRec	mAcc	mIoU	oAcc
Test on Area 5										
Baseline				42.6	45.7	53.4	40.6	58.3	50.8	86.7
FC-Layer	✓			45.0	48.0	54.9	42.3	61.0	53.1	87.2
FS-Module		✓		47.3	50.2	56.8	45.0	61.3	53.2	86.9
FF-Module			✓	45.5	48.5	54.8	42.2	61.7	54.5	87.7
Ours-Full		✓	✓	**48.7**	**51.8**	**58.2**	**46.6**	**62.7**	**55.3**	**87.7**
Test on 6-fold CV										
Baseline				49.6	53.4	62.7	45.8	69.0	58.2	85.9
FC-Layer	✓			50.5	54.4	62.6	46.3	69.1	58.0	85.6
FS-Module		✓		53.3	57.1	64.9	49.9	70.6	59.2	86.0
FF-Module			✓	50.7	54.6	63.0	46.5	70.9	60.2	86.5
Ours-Full		✓	✓	**54.2**	**58.1**	**65.3**	**50.8**	**71.6**	**60.9**	**86.7**

- The Instance Separation and Semantic Fusion Module can achieve the best instance and semantic performance respectively (highlighted with underlines).
- By combining both modules, the improvement is larger than applying only one of them (highlighted with bold).

Visulization of two modules.



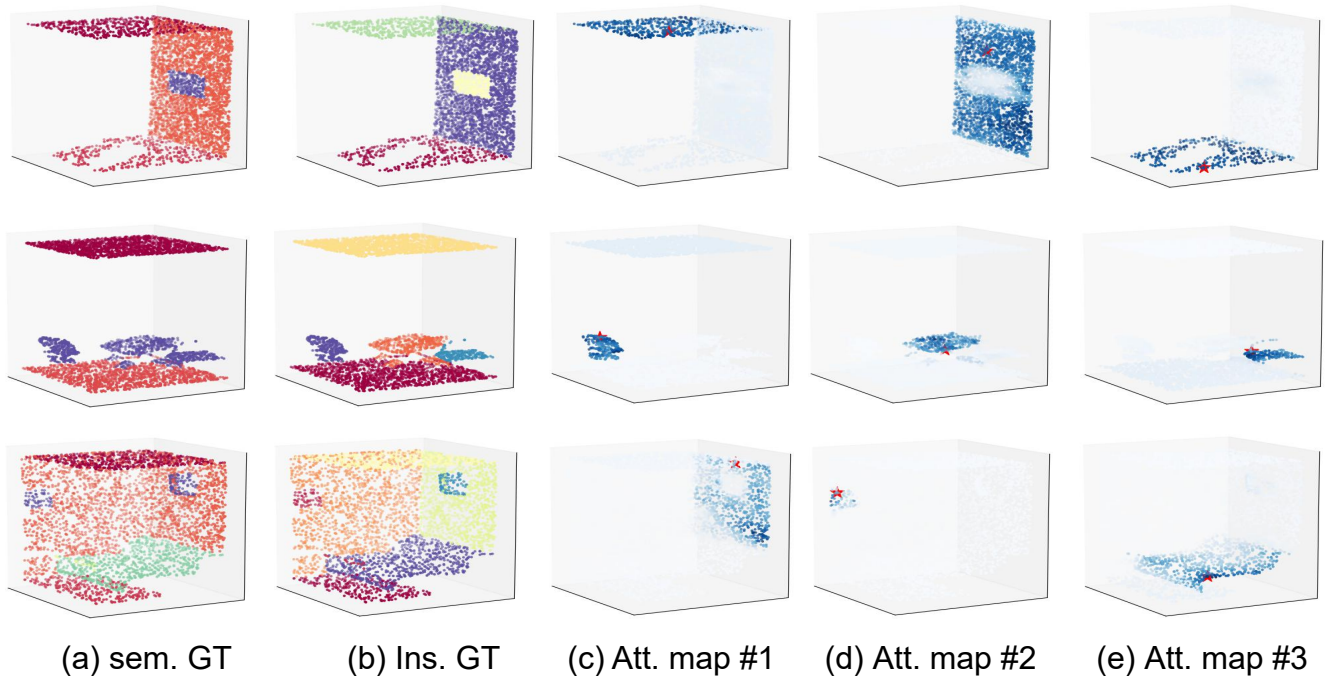


Fig. 5: Visulization of the learned object centers (left) and the attention maps (right)

- The point are shift to the object center.
- The attention map can foucs on the same object.

Thank You !