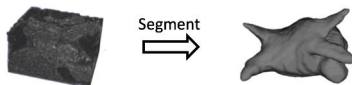


## Research Problem

### Weakly Supervised Volumetric Semantic Segmentation

- Input: 3D volume image
- Output: 3D mask
- Supervision: weak labels



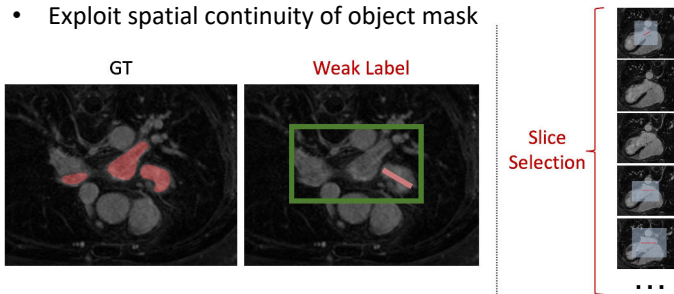
## Main Ideas

### Build a shape-aware segmentation model

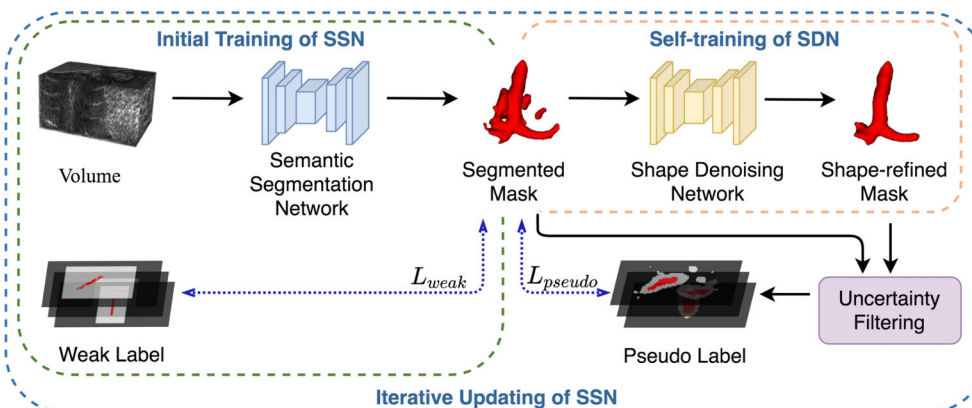


### Adopt a sparse annotation scheme

- Facilitate learning the shape context
- Exploit spatial continuity of object mask

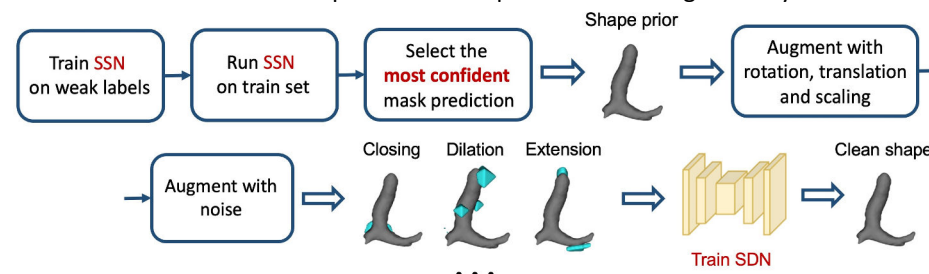


## Methodology



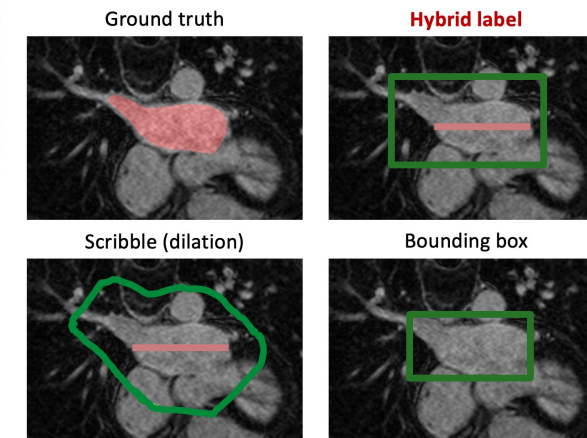
### Self-taught Learning for SDN

- Extract a self-taught shape prior with SSN and augment it into a shape manifold.
- Train our SDN on this shape manifold to perform denoising on noisy masks.



Our model contains a Semantic Segmentation Network (SSN) and a Shape Denoising Network (SDN). To learn our model, we adopt an **iterative learning** framework.

### Sparse Annotation Scheme :



- **Hybrid label**  
a long-axis scribble for FG & a loose bounding box
- **Slice selection**  
10% / 30% / 50% / 100% of labeled FG slices!



## Experimental Results

- Quantitative results on Trachea, LA and Prostate datasets.

Method	Annotation	Trachea (Test)				Left Atrium (Test)				Prostate (Val)			
		100%	50%	30%	10%	100%	50%	30%	10%	100%	50%	30%	10%
nnU-Net (Isensee et al., 2020)	Full label	89.74				92.63				91.11			
BoxPrior(Kervadec et al., 2020)	Box	79.82	48.78	-	-	83.93	83.51	81.86	-	83.82	80.60	76.93	-
KernelCut(Tang et al., 2018)	Scribble*	84.39	83.44	82.77	67.78	78.97	76.71	74.42	64.93	78.68	77.13	76.72	72.84
Ours	Scribble*	84.61	83.88	83.37	81.82	85.61	84.11	83.26	83.11	85.55	84.09	83.87	80.59
KernelCut(Tang et al., 2018)	Hybrid	84.74	83.55	83.38	76.43	77.54	76.72	73.64	67.27	80.18	77.90	77.58	73.45
Ours	Hybrid	<b>85.54</b>	<b>83.97</b>	<b>83.78</b>	<b>83.19</b>	<b>86.31</b>	<b>86.25</b>	<b>83.81</b>	<b>83.41</b>	<b>86.01</b>	<b>85.71</b>	<b>85.56</b>	<b>80.89</b>

- Ablation study on our model components.

Method	Shape prior	Iterative	Trachea (Val)		
			50%	30%	10%
Ours	✓	✓	<b>83.45</b>	<b>83.18</b>	<b>83.18</b>
	CRF	✓	81.08	80.48	80.36
	-	✓	78.97	78.59	78.11
	✓	-	74.91	74.80	74.17
Baseline	-	-	69.17	68.39	62.50

- Qualitative results with 30% labeled slices.

