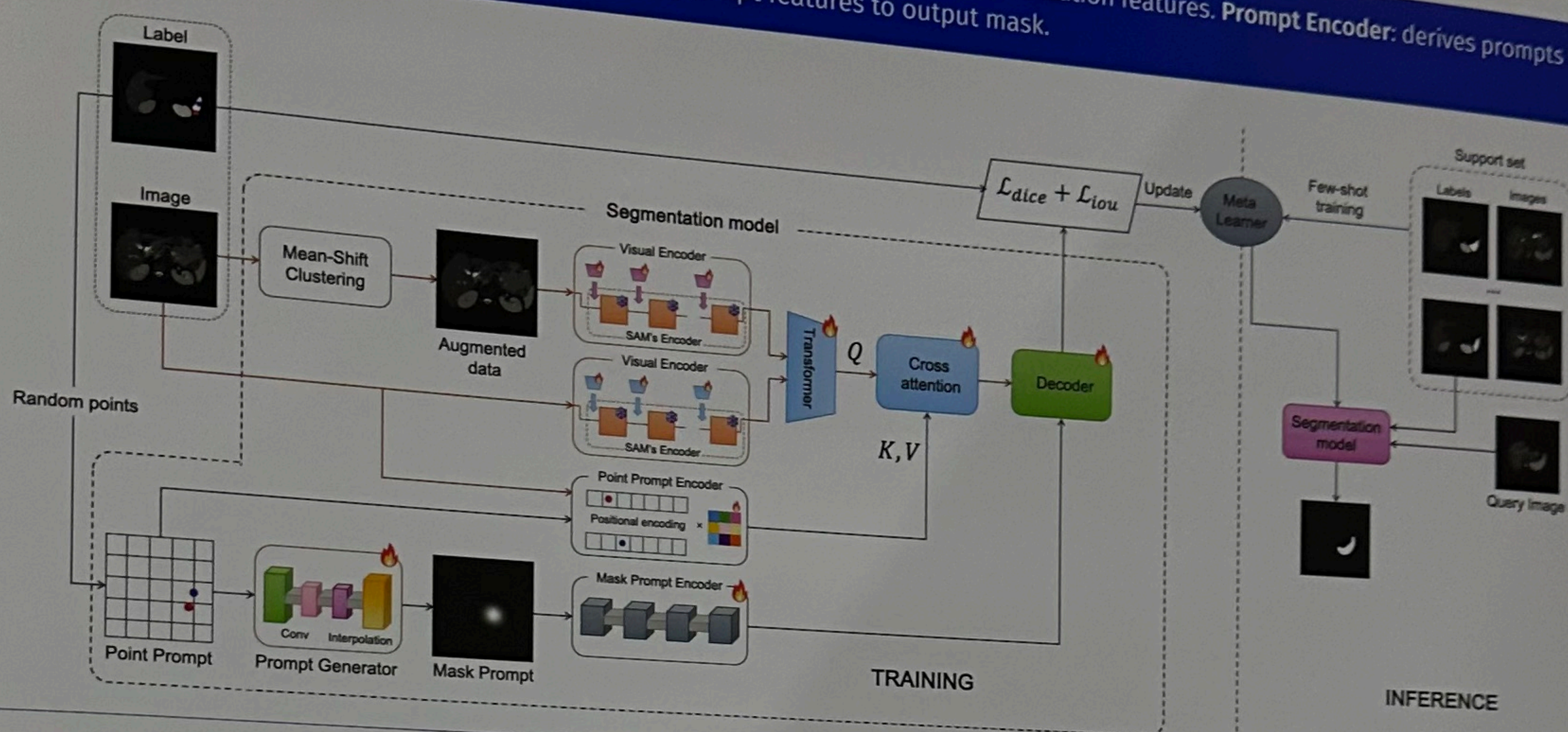# Unleashing SAM for Few-Shot Medical Image Segmentation with Dual-Encoder and Automated Prompting

Cuong M. Pham[1], Phi Le Nguyen[1,*], Thanh Trung Nguyen[2], Vu Minh Hieu Phan[3] and Binh P. Nguyen[4,*]

[1] Hanoi University of Science and Technology; [2] 108 Military Central Hospital; [3] University of Adelaide; [4] Victoria University of Wellington

1 Overview.

Visual Encoder: learns from original + augmented images to extract segmentation features. **Prompt Encoder**: derives prompts from query to guide segmentation. **Decoder**: fuses visual + prompt features to output mask.

- Proposes **AM-SAM**, adapting Segment Anything for **few-shot medical image segmentation**.
- Bridges the natural–medical domain gap via a **dual-encoder** and **medical image–specific augmentation** (mean-shift) to sharpen anatomical boundaries.
- Removes prompt dependence with **automated dual prompts** (point + mask) generated from support images to guide decoding.
- Introduces a **lightweight adapter** for efficient adaptation of SAM's ViT backbone.
- Achieves **state-of-the-art** Dice on ABD-MRI and ABD-30 (gains up to **+3.8%** and **+4.0%**), with ablations validating each component's impact.

2 Comparisons.

ABD-MRI & ABD-30. I. Unseen anatomies present in training (unlabeled); II. Training excludes unseen anatomies.

Settings	Methods	L Kidney ↑	R Kidney ↑	Liver ↑	Spleen ↑	Mean ↑
Setting I ABD-MRI	SE-Net	45.78	47.96	29.02	47.30	42.51
	ALPNet	70.17	77.05	72.45	67.71	71.85
	Q-Net	73.96	81.07	72.36	65.39	73.20
	CAT-Net	75.31	83.23	75.02	67.31	75.22
	SSM-SAM	74.13	81.22	76.16	74.97	76.62
	Ours	78.28 (+3.9%)	81.46 (-2.1%)	79.70 (+4.6%)	78.80 (+5.1%)	79.56 (+3.8%)
Setting II ABD-MRI	SE-Net	62.11	61.32	27.43	51.80	50.66
	RP-Net	79.30	84.66	71.51	75.69	77.79
	ALPNet	73.63	78.39	73.05	67.02	73.02
	Q-Net	74.05	77.52	78.71	67.43	74.43
	CAT-Net	74.01	80.38	78.98	68.83	75.18
	SSM-SAM	81.70	80.38	77.50	78.81	79.59
	Ours	84.17 (+3.0%)	84.95 (+0.3%)	76.12 (-3.6%)	80.36 (+1.7%)	81.40 (+2.3%)
Setting I ABD-30	SE-Net	24.42	12.51	35.42	43.66	29.00
	ALPNet	72.36	71.81	78.29	70.96	73.35
	Q-Net	68.55	63.47	71.12	68.95	68.02
	CAT-Net	72.34	69.91	75.90	73.39	72.89
	SSM-SAM	79.12	80.03	81.36	82.92	80.86
	Ours	82.78 (+4.6%)	84.02 (+5.0%)	85.40 (+5.0%)	83.97 (+1.3%)	84.04 (+4.0%)
Setting II ABD-30	SE-Net	32.83	14.34	0.27	0.23	11.91
	RP-Net	70.48	70.00	79.62	69.85	72.48
	ALPNet	63.34	54.82	76.36	60.62	63.02
	Q-Net	63.26	58.37	76.64	63.36	64.83
	CAT-Net	63.36	60.05	78.96	67.65	66.59
	SSM-SAM	80.96	84.47	87.12	86.95	84.87
	Ours	84.37 (+4.2%)	86.01 (+1.8%)	87.28 (+0.2%)	87.11 (+0.2%)	86.19 (+1.6%)

3 Proposed Adapter & Mask-Prompt.

vs. Adapter-SAM's adapter & vs. SSM-SAM's mask.

Settings	Methods	L Kidney ↑	R Kidney ↑	Liver ↑	Spleen ↑	Mean ↑
Setting I ABD-MRI	AS Adapter	77.12	80.36	79.42	75.09	78.00
	Ours	78.28	81.46	79.70	78.80	79.56 (+1.3%)
Setting II ABD-MRI	AS Adapter	83.33	81.46	74.34	80.21	79.84
	Ours	84.17	84.95	76.12	80.36	81.40 (+2.0%)
Setting I ABD-30	AS Adapter	80.18	82.86	82.13	83.60	82.19
	Ours	82.78	84.02	85.40	83.97	84.04 (+2.3%)
Setting II ABD-30	AS Adapter	83.12	84.24	86.33	85.17	84.72
	Ours	84.37	86.01	87.28	87.11	86.19 (+1.7%)

Settings	Methods	L Kidney ↑	R Kidney ↑	Liver ↑	Spleen ↑	Mean ↑
Setting I ABD-MRI	SSM-SAM	75.45	81.25	77.60	78.13	78.10
	Ours	78.28	81.46	79.70	78.80	79.56 (+0.9%)
Setting II ABD-MRI	SSM-SAM	83.21	83.18	76.61	79.12	80.53
	Ours	84.17	84.95	76.12	80.36	81.40 (+1.1%)
Setting I ABD-30	SSM-SAM	80.15	83.26	83.35	81.99	82.19
	Ours	82.78	84.02	85.40	83.97	84.04 (+2.3%)
Setting II ABD-30	SSM-SAM	82.49	84.88	86.32	84.79	84.62
	Ours	84.37	86.01	87.28	87.11	86.19 (+1.9%)

4 Ablation Studies.

AM-SAM vs. its variants: without augmented data (w/o MSC) and without automated prompts (w/o MP).

Settings	Methods	L Kidney ↑	R Kidney ↑	Liver ↑	Spleen ↑	Mean ↑
Setting I ABD-MRI	w/o MSC	71.99	76.52	72.13	69.36	72.50
	w/o MP	75.73	79.68	76.93	75.31	76.91
	AM-SAM	78.28 (+3.9%)	81.46 (+2.2%)	79.70 (+3.6%)	78.80 (+4.6%)	79.56 (+3.4%)
Setting II ABD-MRI	w/o MSC	75.91	77.97	75.15	73.27	75.58
	w/o MP	79.40	80.64	76.87	77.49	78.59
	AM-SAM	84.17 (+6.0%)	84.95 (+5.3%)	76.12 (-1.0%)	80.36 (+3.7%)	81.40 (+3.6%)
Setting I ABD-30	w/o MSC	74.55	73.86	70.08	72.42	72.73
	w/o MP	78.94	79.22	79.01	78.36	78.88
	AM-SAM	82.78 (+4.9%)	84.02 (+6.1%)	85.40 (+8.1%)	83.97 (+7.2%)	84.04 (+6.5%)
Setting II ABD-30	w/o MSC	76.83	75.58	78.20	77.46	77.02
	w/o MP	80.16	82.11	81.39	83.25	81.73
	AM-SAM	84.37 (+5.3%)	86.01 (+4.7%)	87.28 (+7.2%)	87.11 (+4.4%)	86.19 (+5.5%)