Leveraging Labeling Representations in Uncertainty-based Semi-supervised Segmentation

"Adding <u>Anatomically-aware</u> Representation for <u>Uncertainty Estimation</u>"

Sukesh Adiga V, Jose Dolz and Hervé Lombaert
ETS Montréal

September 20, 2022

Introduction – Uncertainty in Semi-Supervision

- **Context:**
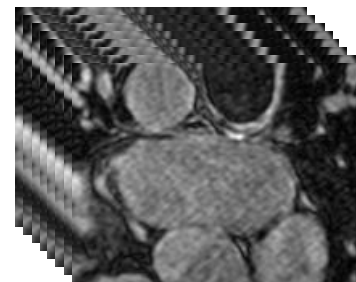 - Predictions from **unlabeled data** can be **uncertain**
  - Uncertainty estimation is **costly** with multiple inferences

- **Idea:**
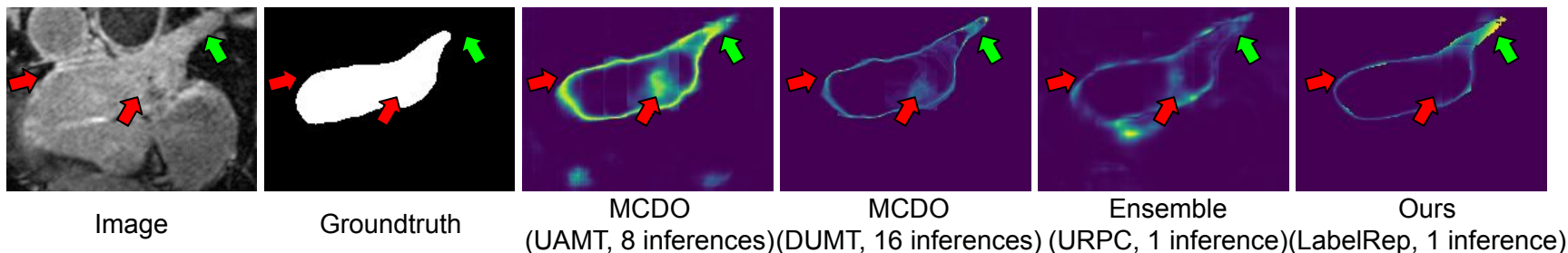 - Estimate uncertainty with a **single inference** that leverages an **anatomically-aware representations**

- **How:**
  - Exploit anatomical information **from available masks** to estimate uncertainty


Labeled Data

Unlabeled Data

Context: Uncertainty-aware methods

- Uncertainty estimation
  - Monte-Carlo Dropout (MCDO)
  - Ensembling

- UAMT - Yu et al., MICCAI'19
- DUMT- Wang et al., MICCAI'20
- URPC - Luo et al., MICCAI'21

| Image | Groundtruth | MCDO (UAMT, 8 inferences) | MCDO (DUMT, 16 inferences) | Ensemble (URPC, 1 inference) | Ours (LabelRep, 1 inference) |

➤ Uncertainty is captured primarily on boundaries

➤ Need high computation (multiple inferences)

➤ **Anatomically-aware representation** to **estimate uncertainty in a single inference**
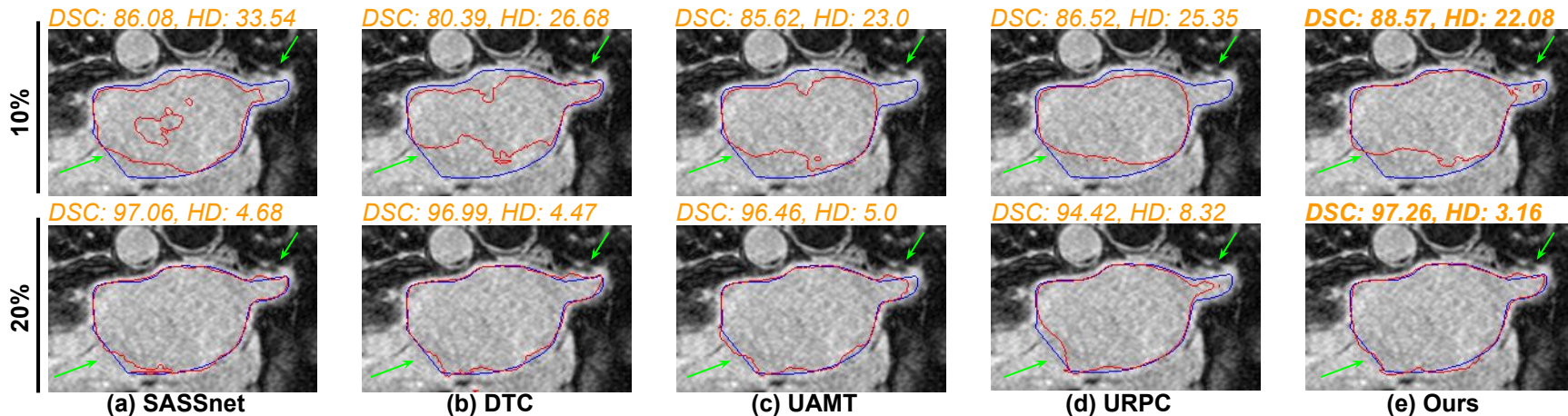
Labeling Representations in Semi-Supervised Segmentation
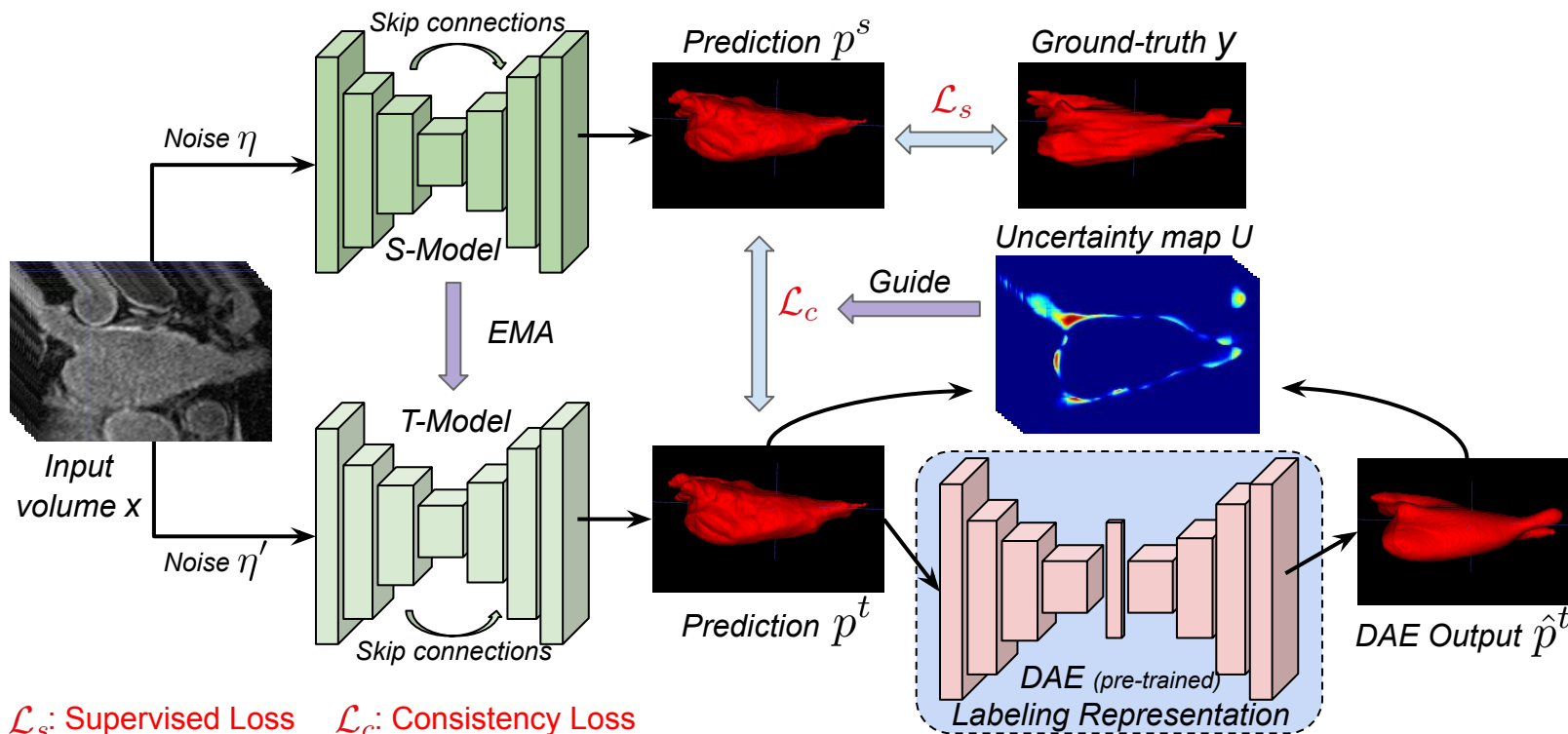
Results on LA dataset

- ➤ Dataset: 2018 Atrial Segmentation Challenge

- ➤ Our method improves performance
  by up to 1.5% Dice score and 2.5mm Hausdorff

- ➤ Our uncertainty estimate needs a single inference

- ➤ Our representation improves segmentation in
  uncertain regions

Methods	#K	N/M	DSC (%)	HD (mm)
Upper bound	-	80/0	91.23 ± 0.44	6.08 ± 1.84
Lower bound	-	8/0	76.07 ± 5.02	28.75 ± 0.72
Lower bound	-	16/0	81.46 ± 2.96	23.61 ± 4.94
MT Tarvainen et al. (2017)	-	8/72	78.22 ± 6.89	16.74 ± 4.80
SASSnet Li et al. (2020a)	-	8/72	83.70 ± 1.48	16.90 ± 1.35
DTC Luo et al. (2021a)	-	8/72	83.10 ± 0.26	12.62 ± 1.44
UAMT Yu et al. (2019)	8	8/72	85.09 ± 1.42	18.34 ± 2.80
URPC Luo et al. (2021b)	1	8/72	84.47 ± 0.31	17.11 ± 0.60
Ours	1	8/72	**86.58 ± 1.03**	**11.82 ± 1.42**
MT Tarvainen et al. (2017)	-	16/64	86.06 ± 0.81	11.63 ± 3.40
SASSnet Li et al. (2020a)	-	16/64	87.81 ± 1.45	10.18 ± 0.55
DTC Luo et al. (2021a)	-	16/64	87.35 ± 1.26	10.25 ± 2.49
UAMT Yu et al. (2019)	8	16/64	87.78 ± 1.03	11.10 ± 1.91
URPC Luo et al. (2021b)	1	16/64	88.58 ± 0.10	13.10 ± 0.60
Ours	1	16/64	**88.60 ± 0.82**	**7.61 ± 0.78**

10% — DSC: 86.08, HD: 33.54 | DSC: 80.39, HD: 26.68 | DSC: 85.62, HD: 23.0 | DSC: 86.52, HD: 25.35 | *DSC: 88.57, HD: 22.08*

20% — DSC: 97.06, HD: 4.68 | DSC: 96.99, HD: 4.47 | DSC: 96.46, HD: 5.0 | DSC: 94.42, HD: 8.32 | *DSC: 97.26, HD: 3.16*

(a) SASSnet   **(b) DTC**   **(c) UAMT**   **(d) URPC**   **(e) Ours**

Take-home message

- **Proposal**: **Anatomically-aware** **uncertainty estimate** to guide segmentation models

  - **labeling representation** to approximate **new pixel-wise uncertainty maps**
  - needs a **single inference**, **reducing** computation **complexity**

- **Results**:

  - Our **labeling representation improves the segmentation performance** by up to 1.5% Dice score and 2.5mm Hausdorff Distance
  - **improves segmentation** in **uncertainty regions**

Leveraging Labeling Representations in Uncertainty-based Semi-supervised Segmentation

"Adding <u>Anatomically-aware</u> Representation for <u>Uncertainty Estimation</u>"

Sukesh Adiga V, Jose Dolz and Hervé Lombaert
ETS Montréal

September 20, 2022