Yale

EUROPEAN CONFERENCE ON COMPUTER VISION

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Project page

Adaptive Correspondence Scoring for Unsupervised Medical Image Registration

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Yale University

Introduction - unsupervised image registration

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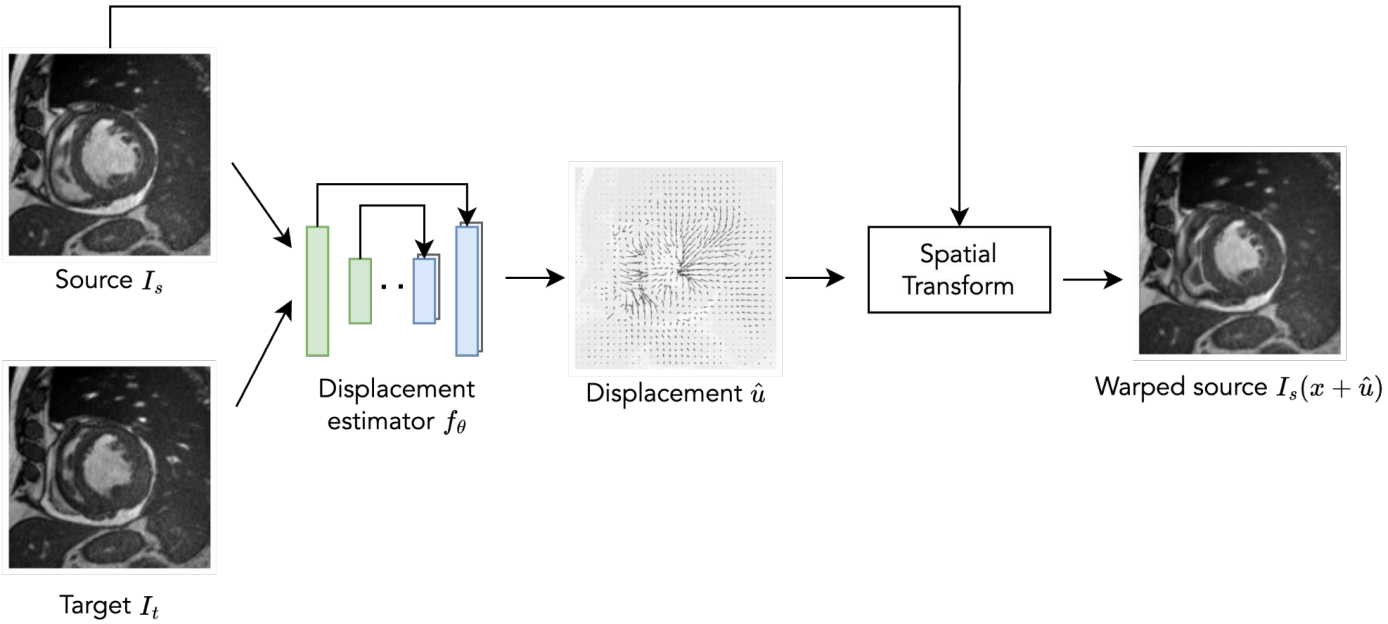

Introduction - unsupervised image registration

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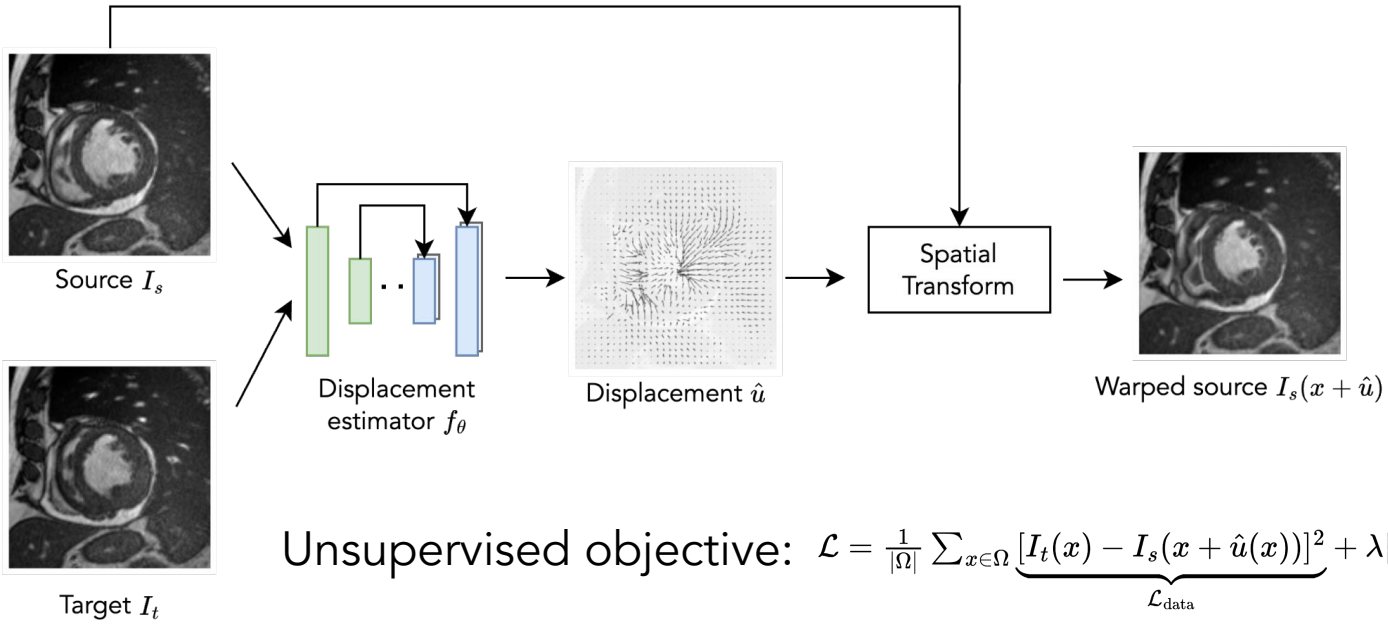

Unsupervised objective: $\mathcal{L} = \frac{1}{|\Omega|} \sum_{x \in \Omega} \underbrace{[I_t(x) - I_s(x + \hat{u}(x))]^2}_{\mathcal{L}_{\text{data}}} + \lambda \|\nabla \hat{u}(x)\|^2$

Assumption: Intensity constancy

Introduction - unsupervised image registration

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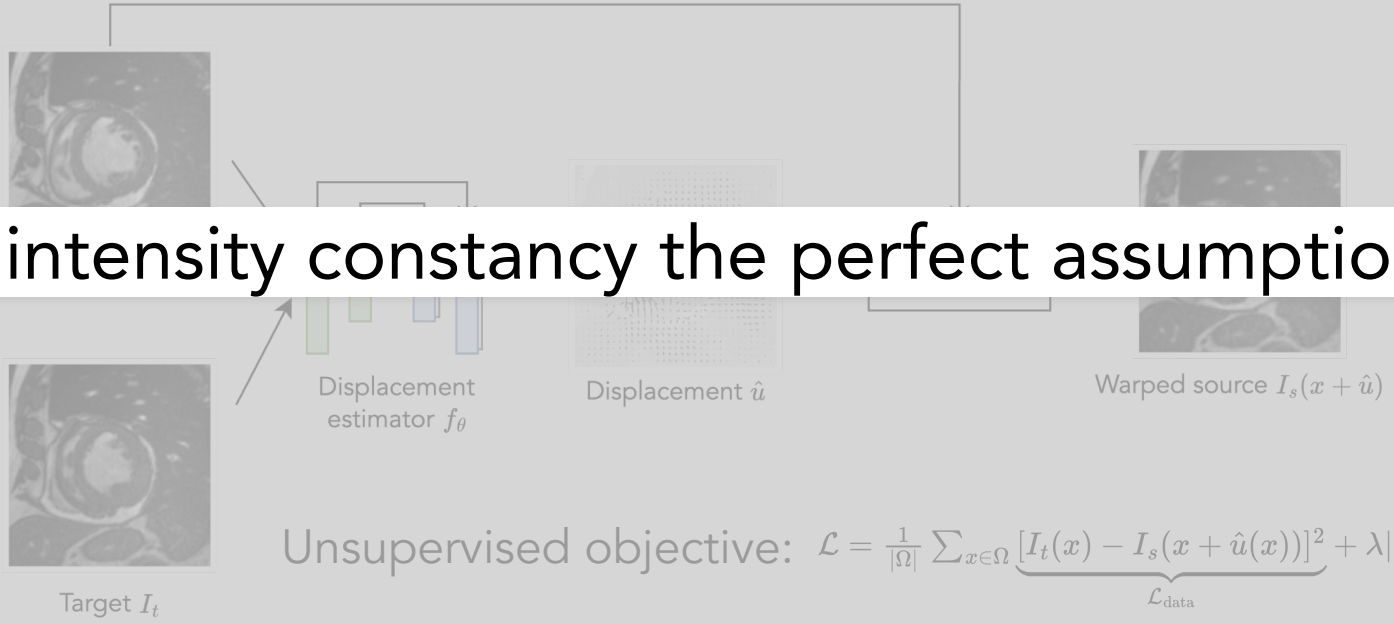

Is intensity constancy the perfect assumption?

Unsupervised objective: $\mathcal{L} = \frac{1}{|\Omega|} \sum_{x \in \Omega} \underbrace{[I_t(x) - I_s(x + \hat{u}(x))]^2}_{\mathcal{L}_{\text{data}}} + \lambda \|\nabla \hat{u}(x)\|^2$

Assumption: Intensity constancy

Motivation

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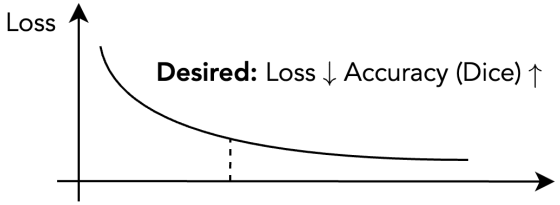

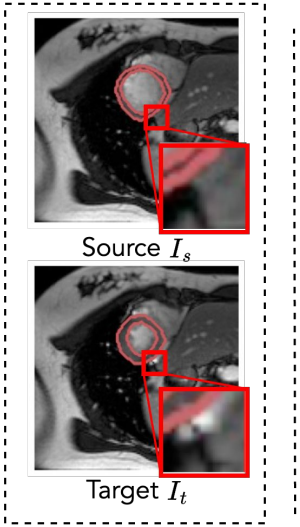

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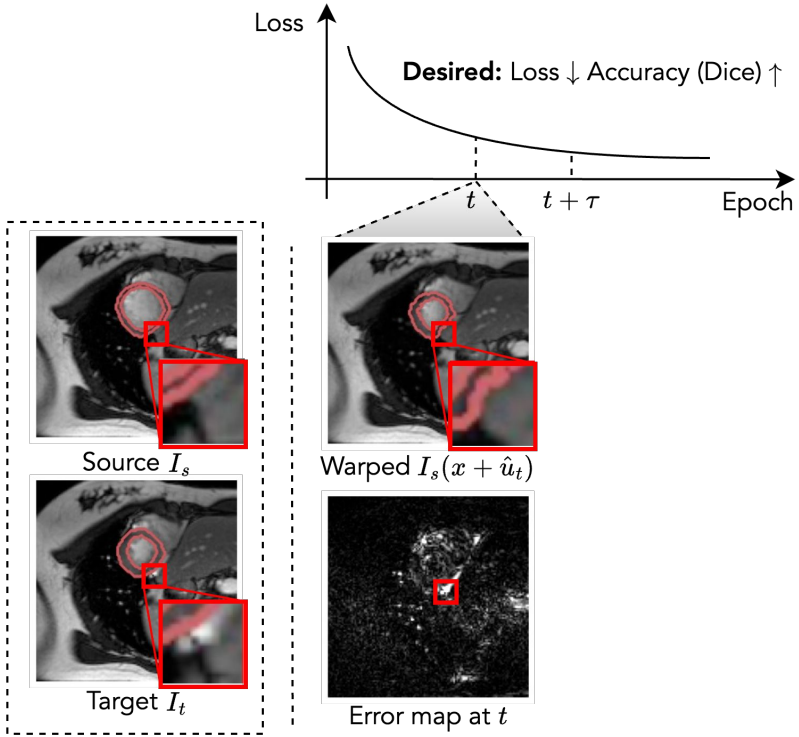

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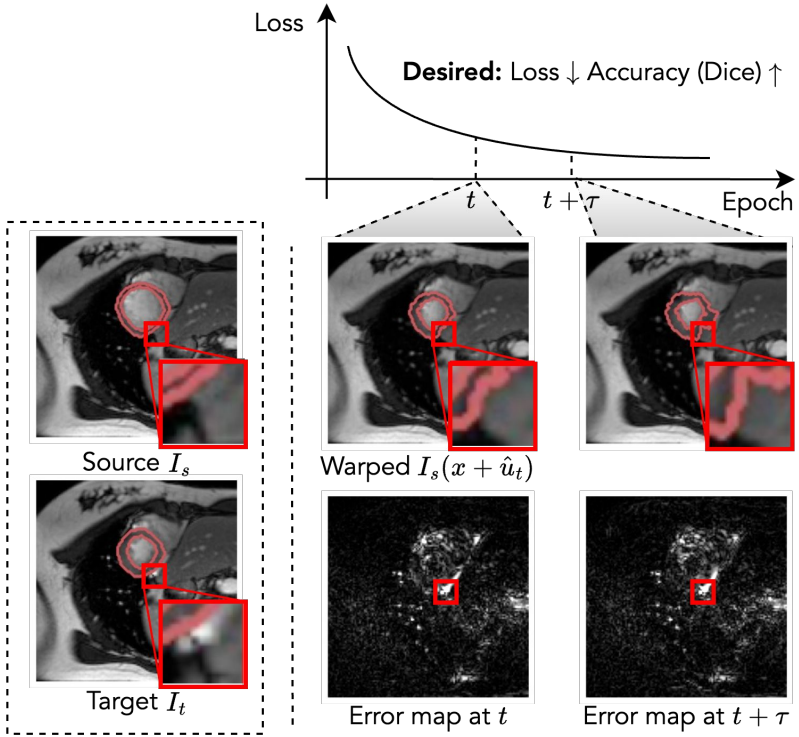

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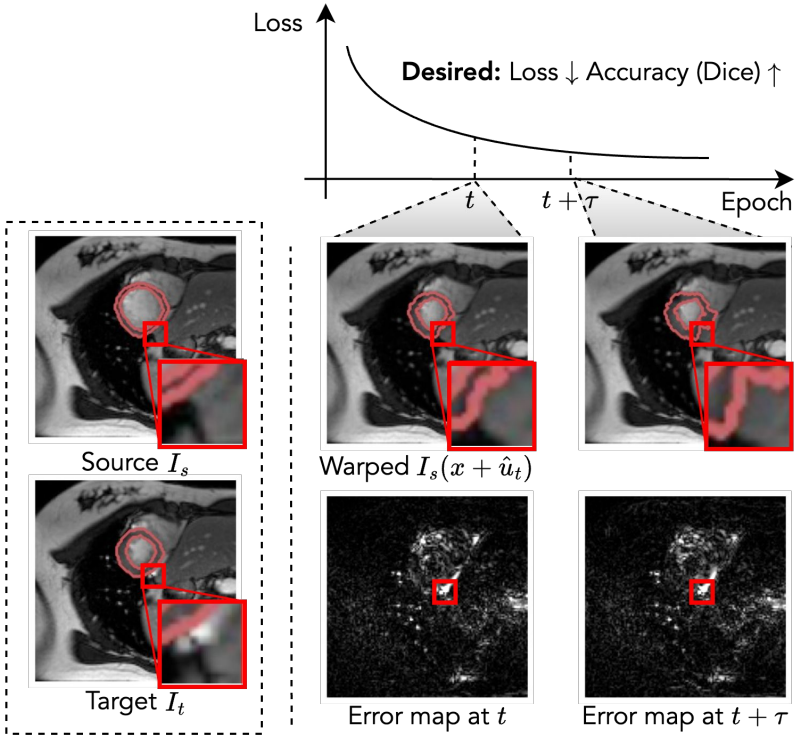

Existing approach:

Irreconcilable penalties due to absence of correspondence

⇩

Intensity constancy assumption violated

⇩

Loss ↓ Accuracy (Dice) ↓

Motivation

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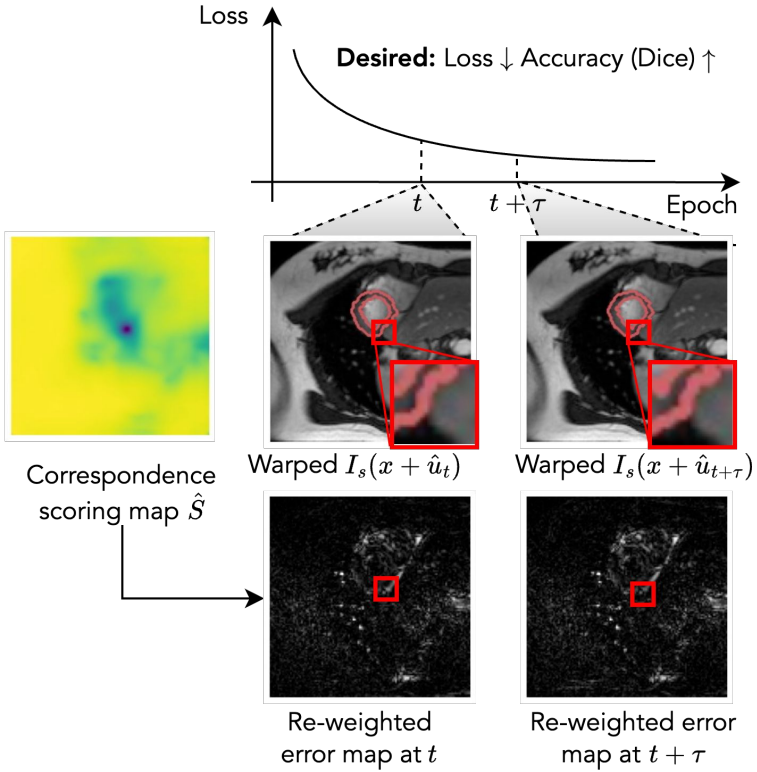

Our approach:

Re-weight loss with correspondence scoring to regularize outliers

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Intensity constancy violation addressed

⇩

Loss ↓ Accuracy (Dice) ↑

Method

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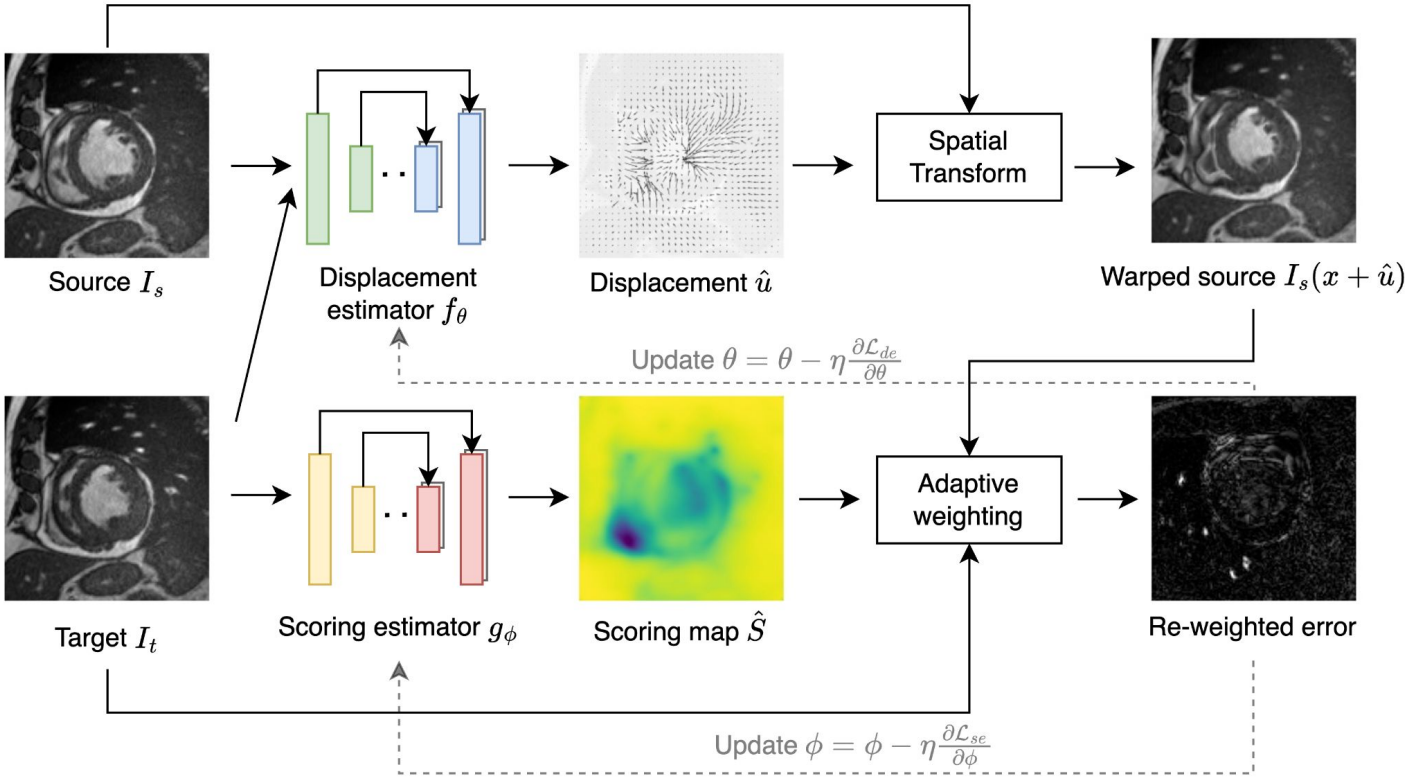

Method

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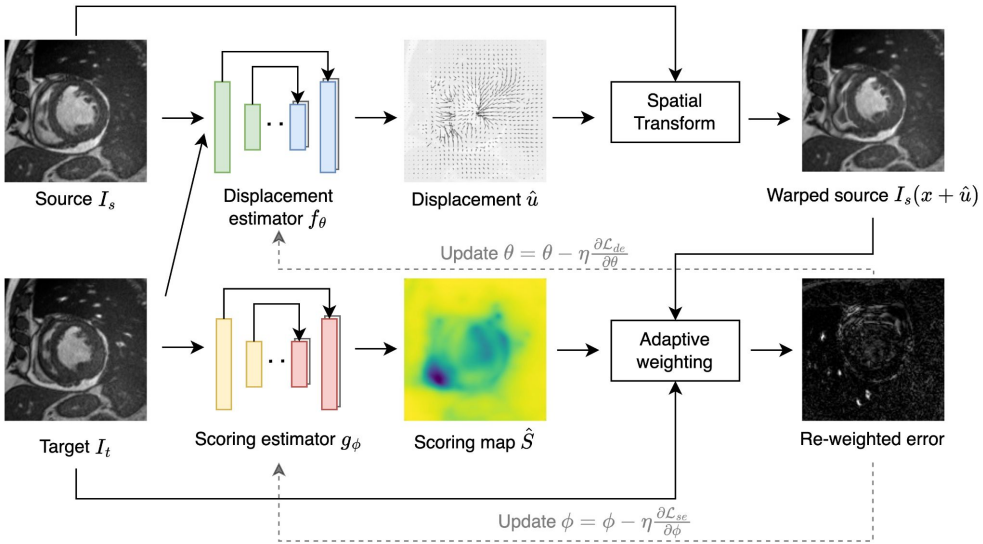

Unsupervised correspondence scoring:

$$\mathcal{L}_{\text{ucs}} = \frac{1}{|\Omega|} \sum_{x \in \Omega} \hat{S}(x)[I_t(x) - I_s(x + \lfloor \hat{u}(x) \rfloor)]$$

Scoring estimator regularization:

$$\mathcal{L}_{\text{reg}} = \frac{1}{|\Omega|} \sum_{x \in \Omega} [1 - \hat{S}(x)]^2$$

Smoothness regularization:

$$\mathcal{L}_{\text{smooth}} = m_T \frac{1}{|\Omega|} \sum_{x \in \Omega} \|\nabla \hat{S}(x)\|^2$$

Results

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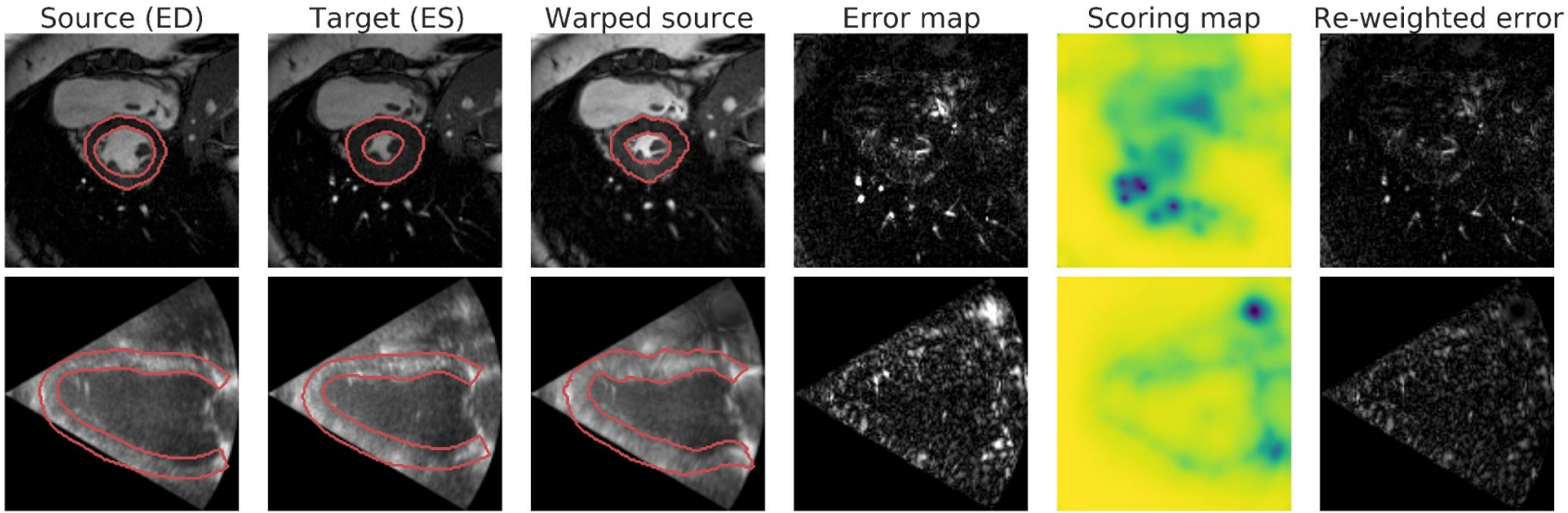
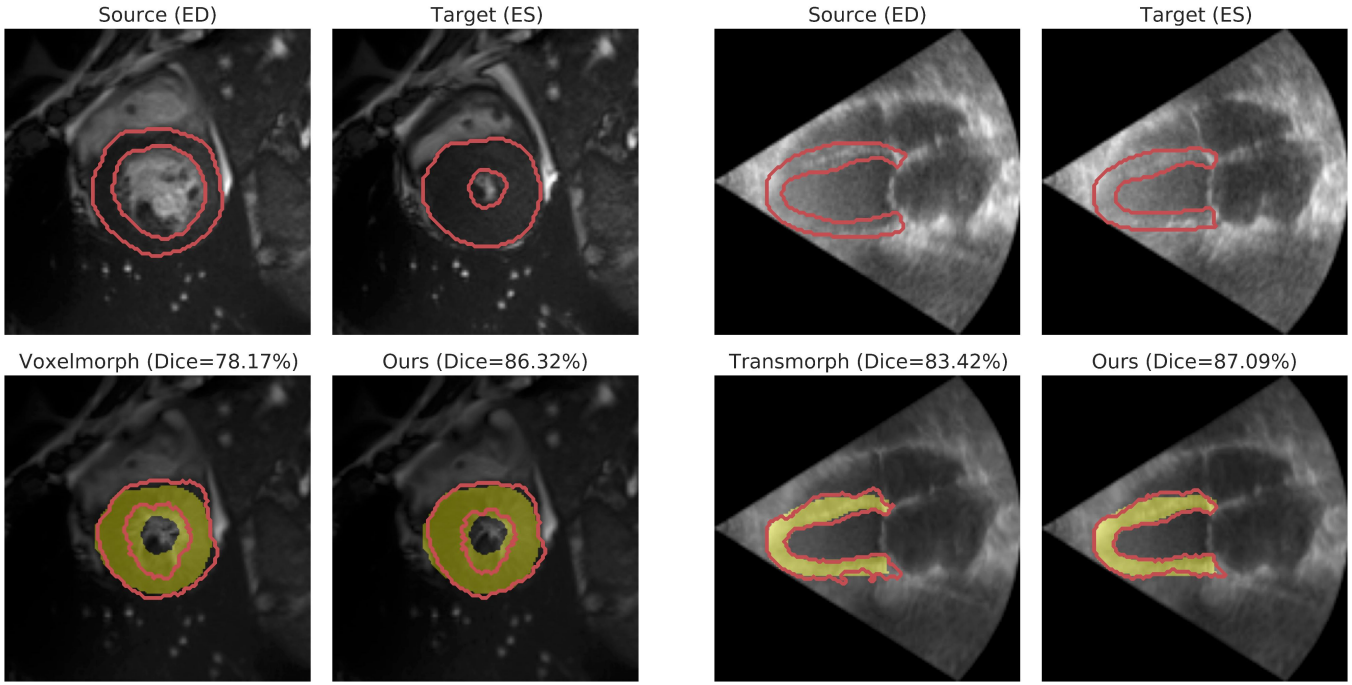


Our estimated scoring map identifies and prevents drift caused by spurious error residuals during training.

Results



Our proposed approach outperforms Voxelmorph & Transmorph in ACDC and CAMUS datasets.

Application - cardiac strain analysis

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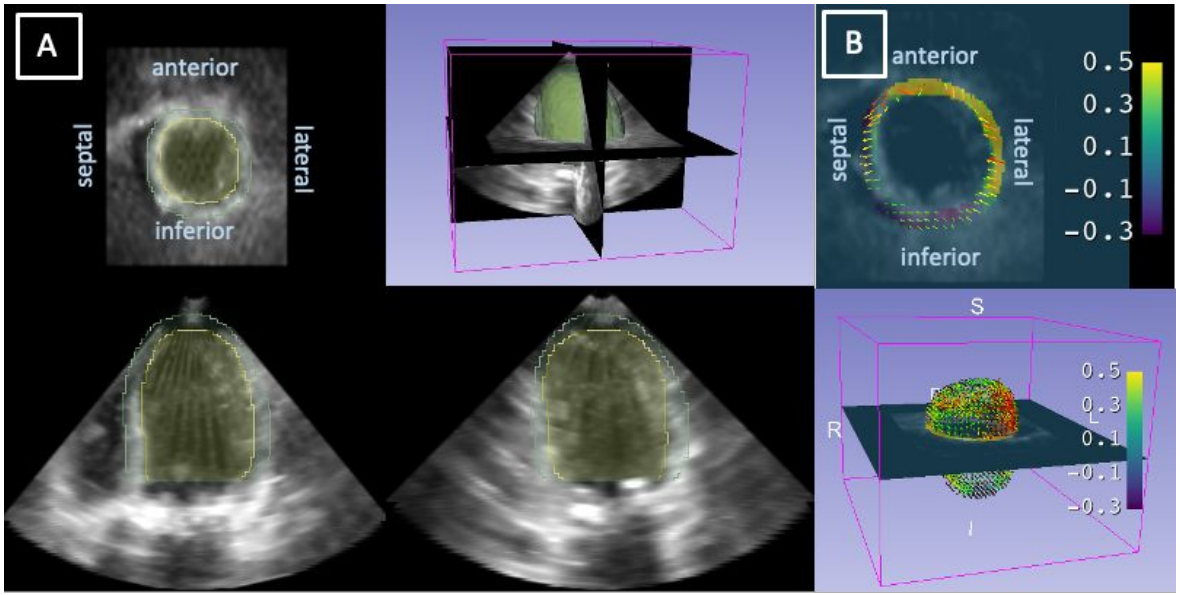

Figure: A) Segmented clinical echo (rest); B) Rest radial strain overlayed with estimated displacement revealing akinetic septal and inferior walls;

Conclusion

- We identify the limitation of the widely used intensity constancy assumption in unsupervised image registration.

- We address this by proposing an adaptive correspondence scoring framework during training.

- Our proposed approach can be plugged-and-played into existing frameworks with no extra cost during inference.

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