One-Shot Medical Landmark Localization by Edge-Guided Transform and Noisy Landmark Refinement

Zihao Yin[1] Gong Ping[2] Chunyu Wang[3] Yizhou Yu[4] Yizhou Wang[5,6]

[1]Center for Data Science, Peking University [2]Deepwise AI Lab [3]Microsoft Research Asia [4]The University of Hong Kong

[5]Center on Frontiers of Computing Studies, Peking University [6]Inst. For Artificial Intelligence, Peking University

Background

Problem

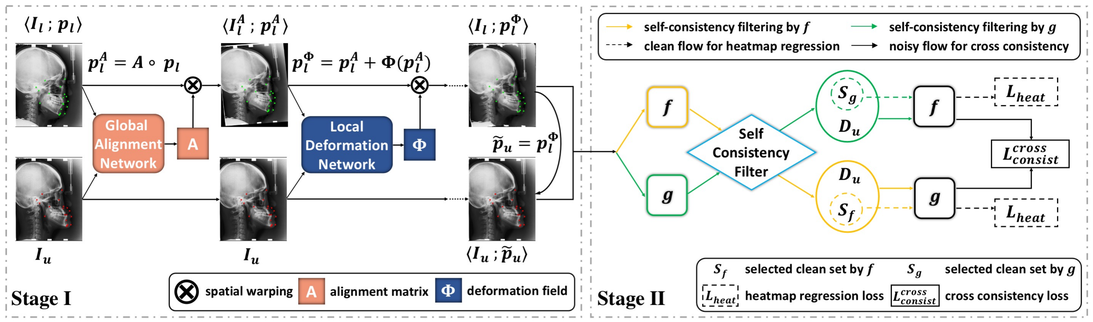
- One-shot medical landmark localization, which generalizes well with only one exemplar and several unlabeled images.
- Scalable to different anatomical parts, reduce annotation cost.

Motivation

- Landmarks denote correspondence across instances.
- Noisy dense correspondence is free by registration.
- Given clean labels and noisy labels, techniques from SSL & NSL can yield performance close to FSL.

SSL: semi-supervised learning; NSL: noisy label learning

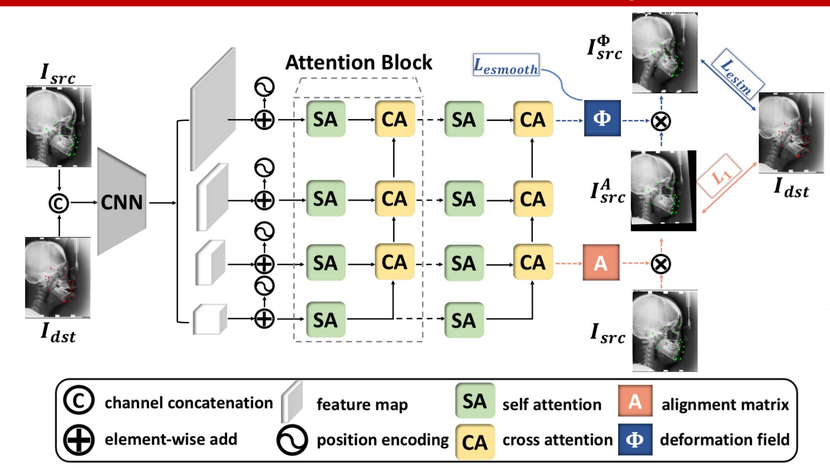
Framework



Stage I: Infer landmarks by unsupervised registration from the labeled exemplar to unlabeled targets. The registration is learned through end-to-end global alignment & local deformations, with edge-guided loss terms.

Stage II: Explore self-consistency for selecting reliable pseudo labels and cross-consistency for semi-supervised learning.

Pipeline



Lesim

$$\mathcal{L}_{esim} = \mathcal{L}_{sim}(I^{\Phi}_{src}, I_{dst}) + \mathcal{L}_{sim}(\text{edge}(I^{\Phi}_{src}), \text{edge}(I_{dst})) \odot \text{Mask}(p^{\Phi}_{src})$$

$$\text{Mask}(p) = \frac{1}{N}\sum_{i=1}^{N} \exp(-\frac{1}{2\sigma^2}||u - p_i||^2),\ p \in \mathbb{R}^{N\times 2},\ \forall u \in \Omega$$

Lesmooth

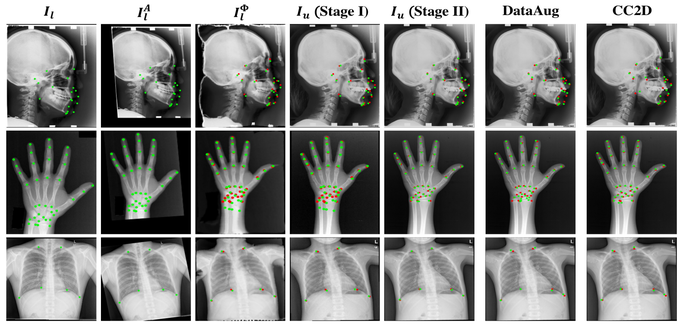
$$\mathcal{L}_{smooth}(\Phi) = ||\nabla\Phi(u)||^2,\ \forall u \in \Omega$$

$$\mathcal{L}_{esmooth}(\Phi|I^{\Phi}_{src}) = \mathcal{L}_{smooth}(\Phi) \odot \exp(-||\text{edge}(I^{\Phi}_{src})||^2/T)$$

Experiments

Comparison with baseline

Method	Head MRE↓ (mm)	Head SDR↑(%) 2mm	2.5mm	3mm	4mm	Hand MRE↓ (mm)	Hand SDR↑(%) 2mm	4mm	10mm	Chest MRE↓ (px)	Chest SDR↑(%) 3px	6px	9px
YOLO*	1.54	77.79	84.65	89.41	94.93	0.84	95.4	99.35	99.75	5.57	57.33	82.67	89.33
3FabRec#	20.12	2.42	3.86	4.98	7.23	9.81	3.98	15.24	60.92	48.67	0.67	2.33	4.67
DataAug#	3.18	32.81	44.42	55.12	73.16	2.51	48.87	85.67	98.91	10.15	15.67	40.67	61.67
CC2D-SSL#	3.41	40.63	49.58	60.31	72.14	2.93	51.59	81.29	95.59	17.37	9.87	27.99	42.11
CC2D-TPL#	2.72	42.59	53.18	66.48	83.22	2.47	54.95	87.16	97.84	12.91	12.67	38.67	57.67
Ours-stage I	2.70	42.78	54.88	65.03	81.01	2.13	60.93	89.43	99.21	10.16	12.33	39.00	60.33
Ours-stage II	**2.13**	**54.69**	**67.47**	**77.85**	**90.02**	**1.82**	**66.39**	**92.93**	**99.97**	**6.89**	**17.33**	**50.33**	**75.33**



Ablation

Loss	Head MRE↓ (mm)	Head SDR↑(%) 2mm	2.5mm	3mm	4mm
w/o $\mathcal{L}_{inv}$	3.24	32.67	44.95	55.52	71.81
w/o $\mathcal{L}_{smooth}$	2.97	39.01	50.23	60.46	75.85
w/o $\mathcal{L}_{syn}$	2.86	39.54	51.43	61.68	77.14
$\mathcal{L}_{esim} \rightarrow \mathcal{L}_{sim}$	3.17	33.31	45.64	57.31	73.01
$\mathcal{L}_{esmooth} \rightarrow \mathcal{L}_{smooth}$	2.75	40.27	52.95	64.65	81.12
ours	2.70	42.78	54.88	65.03	81.01

Exemplar Selection