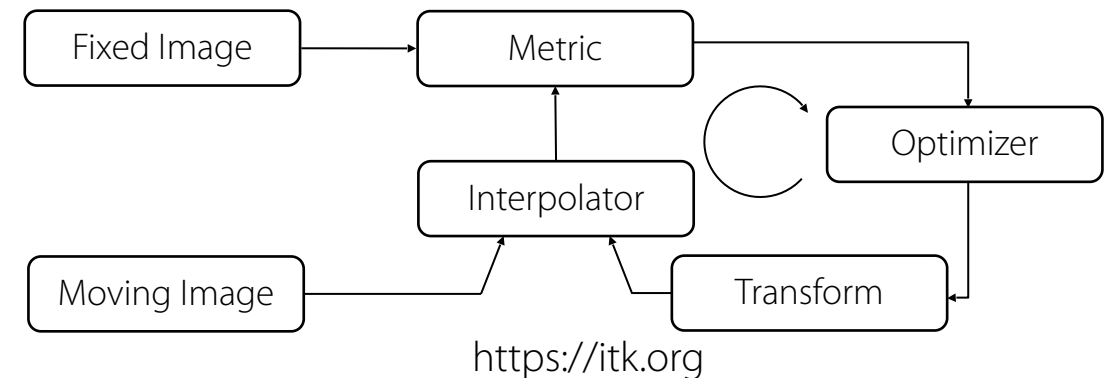# Motivation for Deep Learning Based Registration

deep learning based registration has tremendous potential for

- **(near) real-time applications** reducing computation times from ~minutes to ~seconds

- increased registration accuracy by **task-specific learning** (with/without additional expert annotations)

conventional registration framework
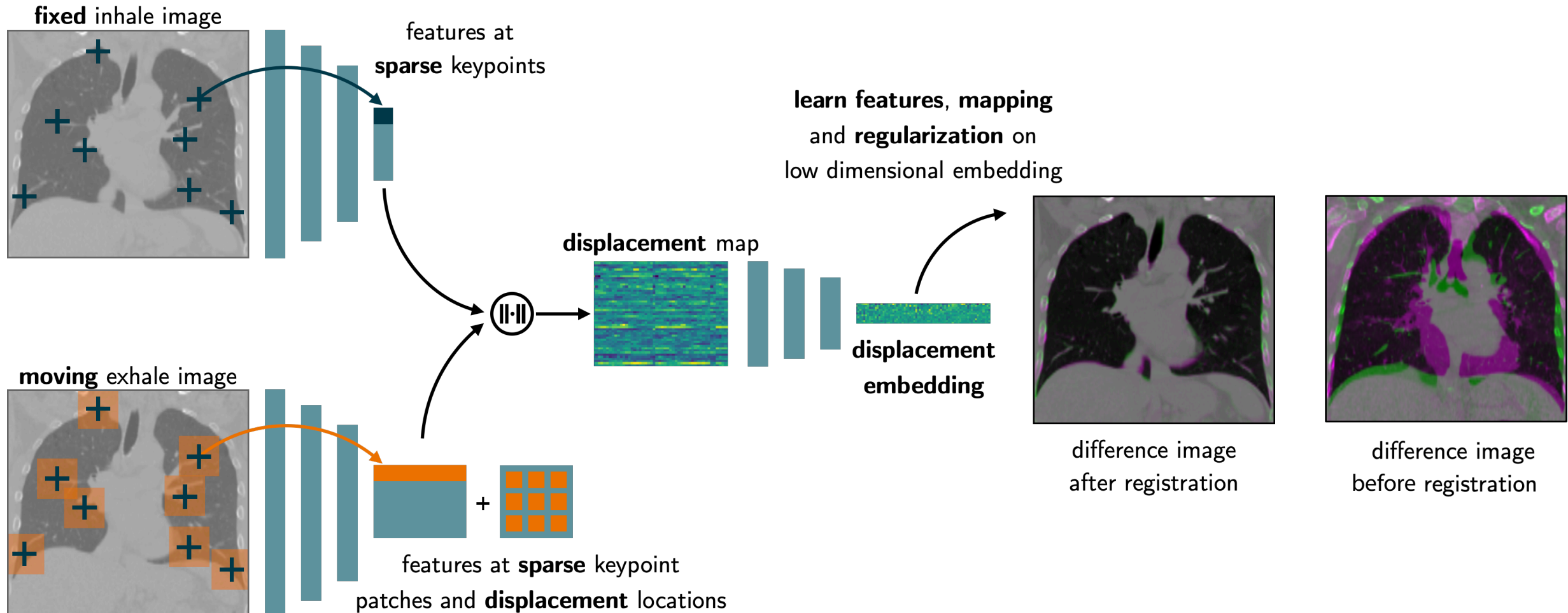

https://itk.org

deep learning based registration
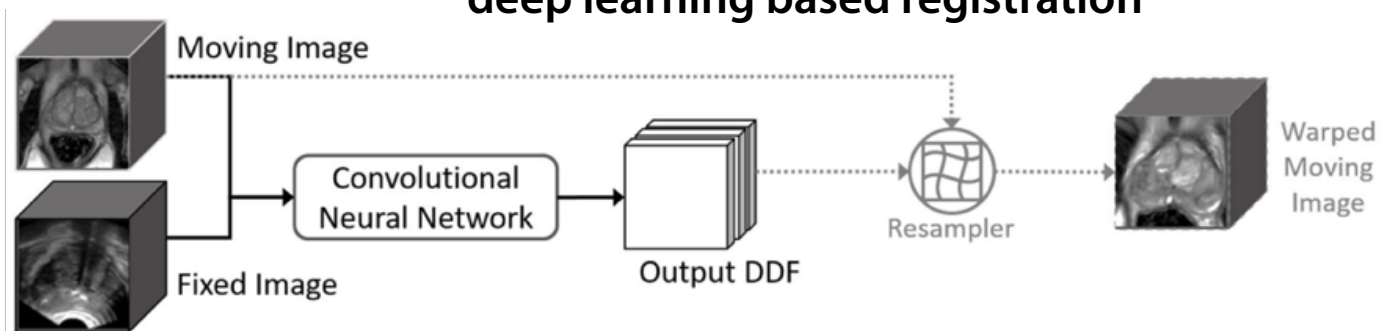
Hu, Yipeng, et al. "Weakly-supervised convolutional neural networks for multimodal image registration." Medical Image Analysis 49 (2018): 1-13.

Discrete Registration with Displacement Embeddings

fixed inhale image

features at
sparse keypoints

learn features, **mapping**
and **regularization** on
low dimensional embedding

displacement map

moving exhale image

displacement
embedding

difference image
after registration

difference image
before registration

features at **sparse** keypoint
patches and **displacement** locations

UNIVERSITÄT ZU LÜBECK
INSTITUTE OF MEDICAL INFORMATICS

Early Experiments and Evaluation

- fixed feature extractor (lightweight U-Net with 3 encoder and 2 decoder blocks) pretrained to predict **MIND-like descriptors**

- comparison of fixed features at **~1500 Foerstner keypoints** and **corresponding feature patches (21^3 voxels)** in moving image

- **Laplacian diffusion on PCA embedding** of displacement maps

	# levels	DIR-Lab 4D-CT	DIR-Lab COPD
initial	–	8.46(6.58)	23.36(11.86)
(Eppenhof et al., 2019)	1	3.68(3.32)	–
DLIR (de Vos et al., 2019)	3	2.64(4.32)	–
VoxelMorph*(Balakrishnan et al., 2019)	2	3.65(2.47)	9.18(4.48)
mlVIRNET (Hering et al., 2019)	3	2.19(1.62)	–
(Hansen et al., 2019)	1	–	4.30(3.60)
ours-256	1	2.13(1.65)	4.73(8.56)
ours-512	1	**1.97(1.42)**	**3.42(5.63)**

- **uniform sampling** of keypoints consistently worse (0.3 – 0.7 mm)

- **lightweight feature net**: ~150.000 trainable parameters

- **inference time** of <2 seconds

Work in Progress and Learn2Reg Challenge

- replaced by **learned displacement embeddings and graph CNN regularization**

- introduces **dense image supervision for irregular grids**

- **state of the art results** for deep learning based registration on DIR-Lab **4DCT (< 1. 5 mm)** and **COPDgene (< 1.7 mm)**
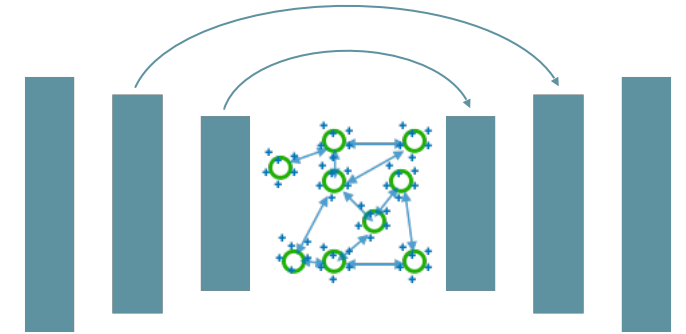
- join the **Learn2Reg challenge** at MICCAI 2020 (including 4 different tasks/data sets)

- challenge website: https://learn2reg.grand-challenge.org

- **test data release**: mid July 2020
  submission deadline: end July - early August 2020 (for computation time bonus)
  up until workshop in October 2020