Unsupervised Deformable Image Registration for Respiratory Motion Compensation in Ultrasound Images

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Introduction

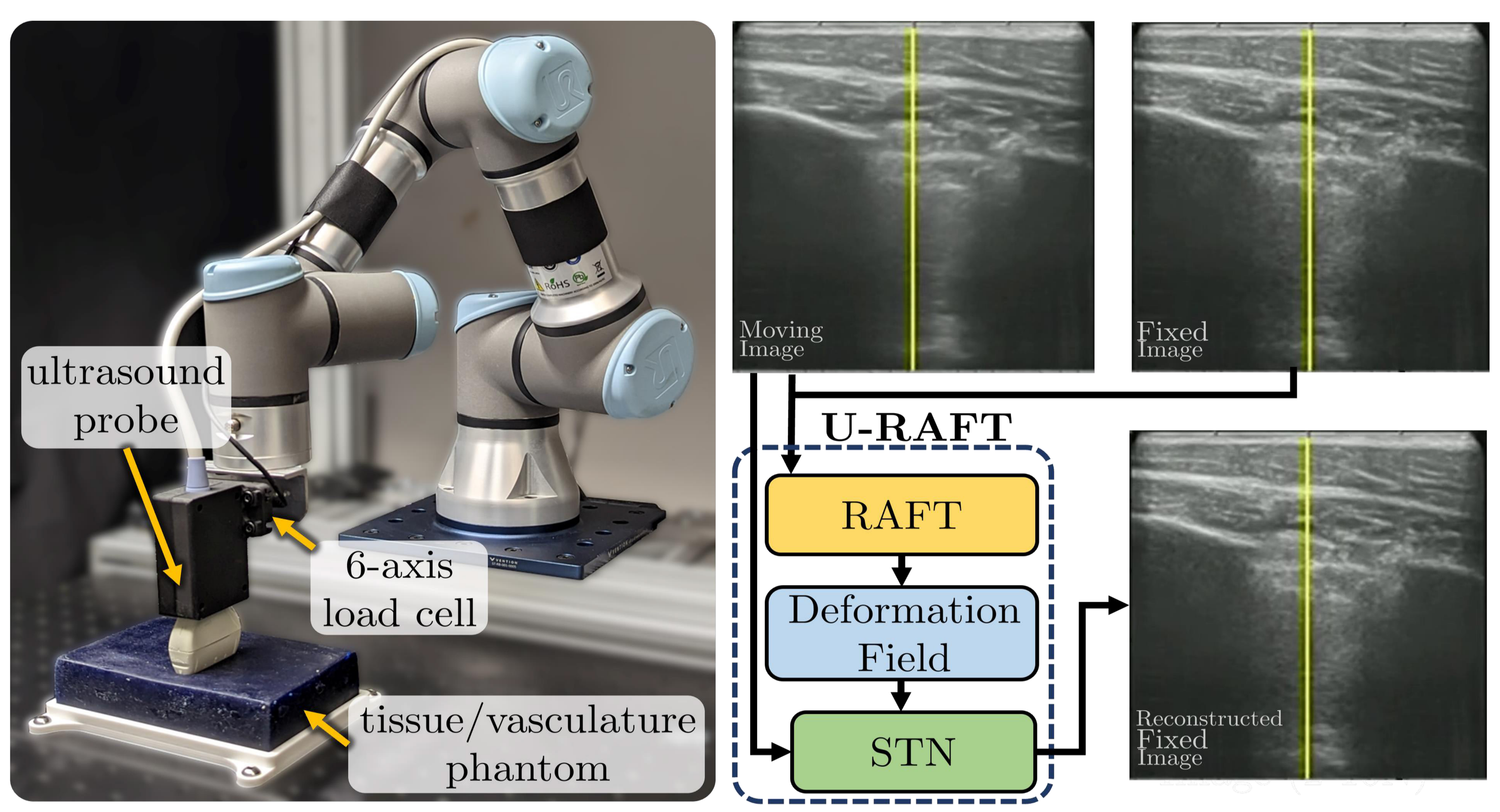
Deformable registration with ultrasound images allows us to track features between slices to do 3D modelling, motion compensation and synthetic data generation

Recurrent all-pairs field transforms (RAFT) predicts displacement field between two images at online rate

RAFT is supervised & little labelled ultrasound data

Unsupervised RAFT (U-RAFT) registers ultrasound images at online rate without labelled data

We use U-RAFT to track pixels in a sequence of ultrasound images to cancel out respiratory motion in ultrasound images with *in vivo* porcine lung videos



Robotic ultrasound system capturing the ultrasound images with force-controlled scanning, together with a vasculature phantom mode

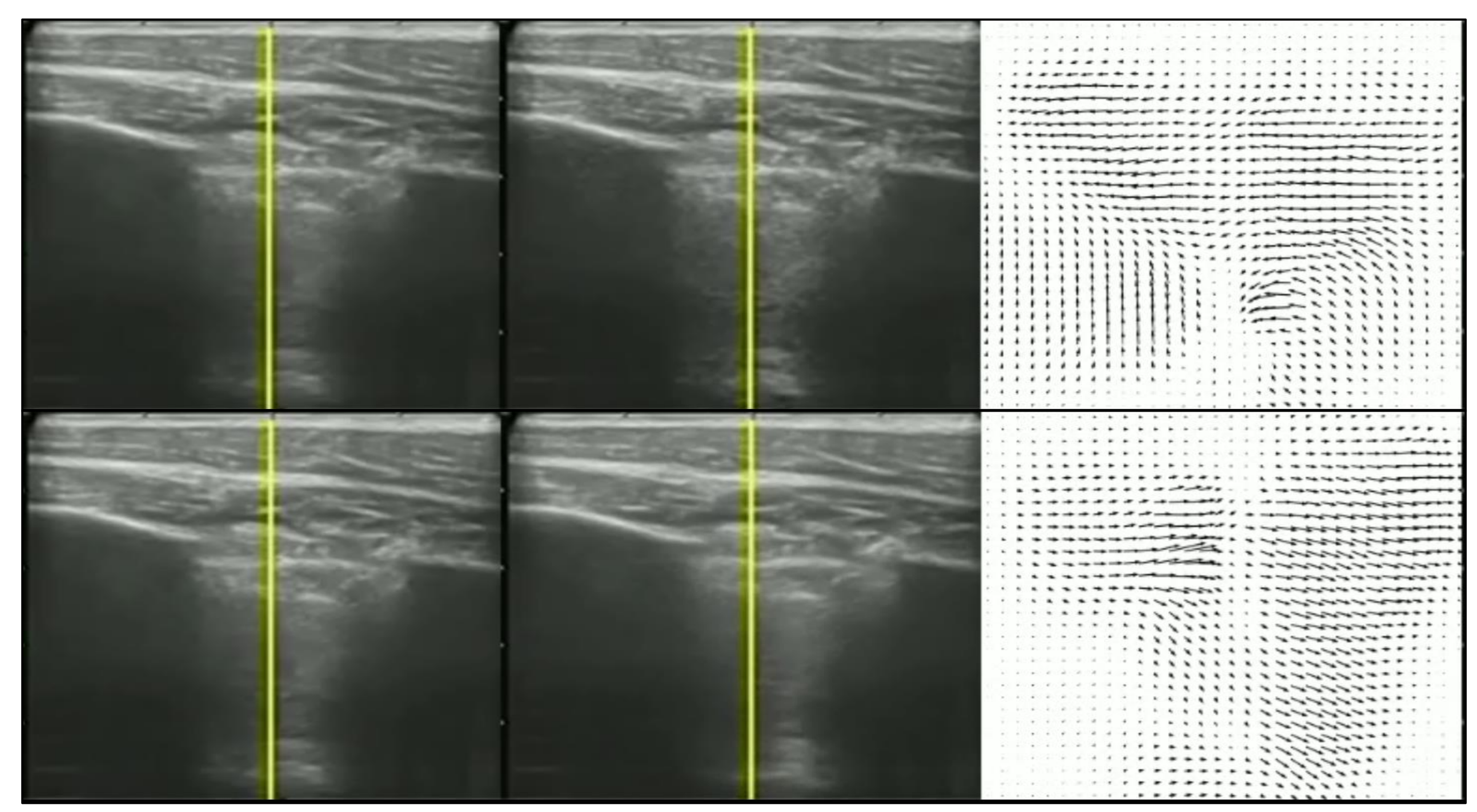
Method

RAFT predicts deformation field between start image & moving image in the respiratory cycle

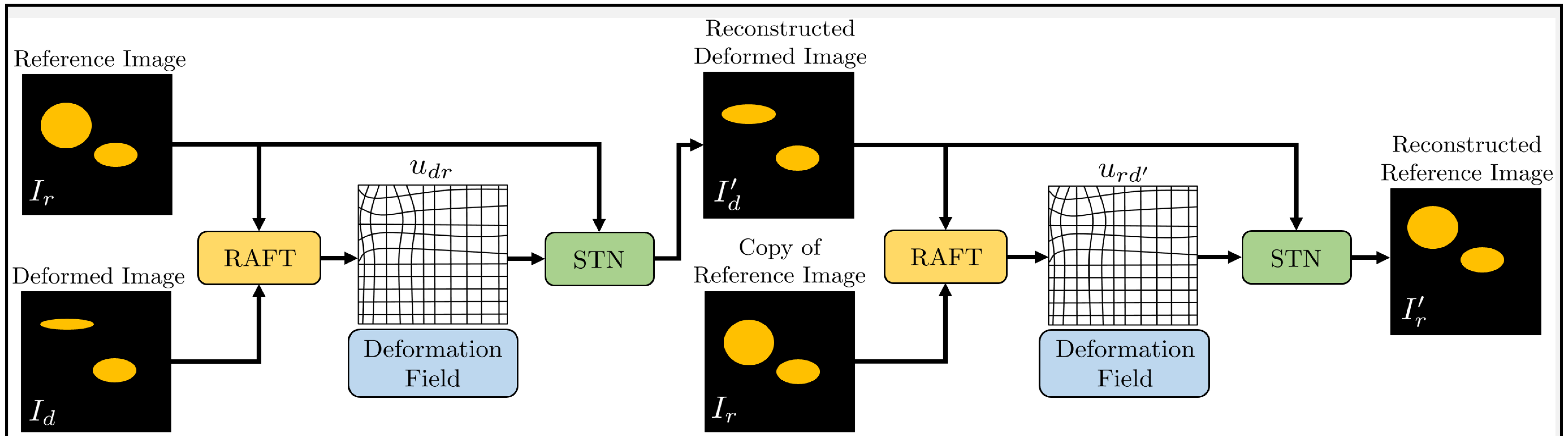
Reconstruct the start image by combining the moving image with the spatial transformer network (STN)

Final loss is SSIM loss between the start image and the reconstructed start image

Predicted deformation field to compensate for pixel movements between the moving images and the fixed images



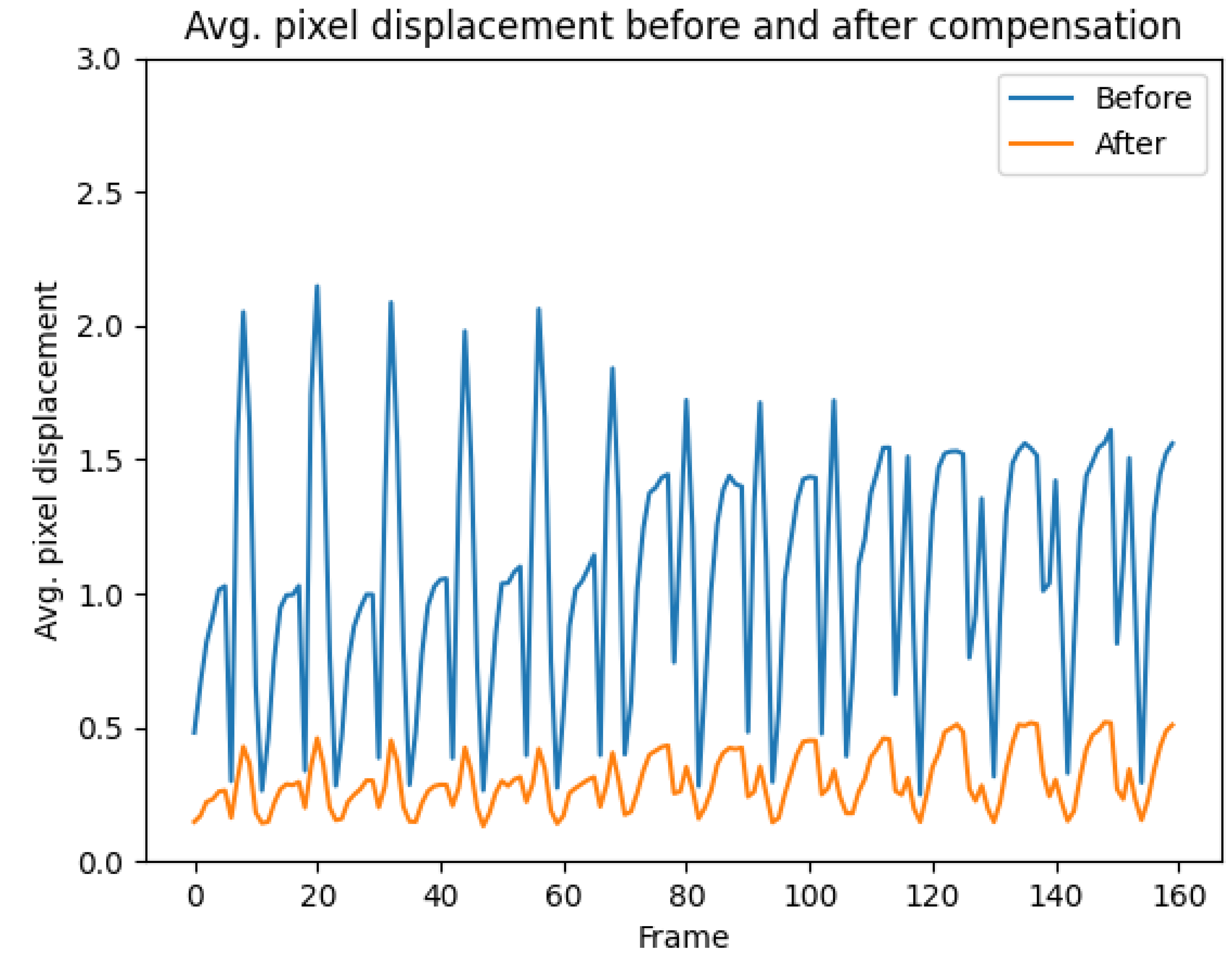
Predicted deformation field between moving and fixed images, shown here for example in-vivo porcine images.



Pipeline used to generate image reconstructions for training in U_RAFT in an unsupervised manner. Our proposed cyclic loss function improves registration quality by comparing the reconstructed reference image to original reference image

Results

A reduction of 76% in average pixel movement using our respiratory compensation strategy



Dataset	Avg. displacement before compensation (pixel)	Avg. displacement after compensation (pixel)
Pig 1	2.09	0.32
Pig 2	2.32	0.65
Pig 3	1.75	0.49

Average pixel displacement before and after applying respiratory compensation on 3 pig lung dataset

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References

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