Dynamic 3D MRI Reconstruction from Single-Spoke via Motion-Compensated Neural Representation

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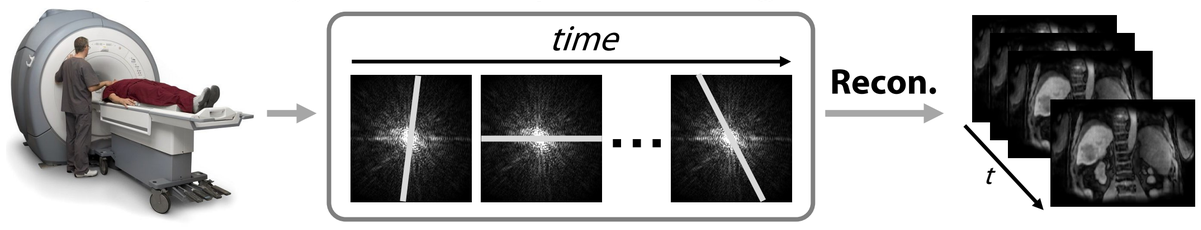
NEURAL INFORMATION PROCESSING SYSTEMS

Motivation

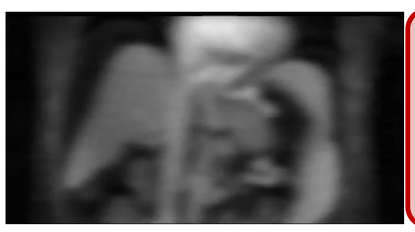
- **Dynamic 3D Magnetic Resonance Imaging (MRI)**
  - Capture dynamic temporal changes



MRI scanner | Continuous acquisition | Dynamic MRI

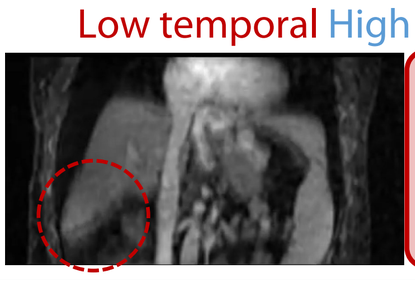
- **Challenge:** trade-off between temporal & spatial resolution due to the slow acquisition time

High temporal Low spatial



Problem: Highly ill-posed

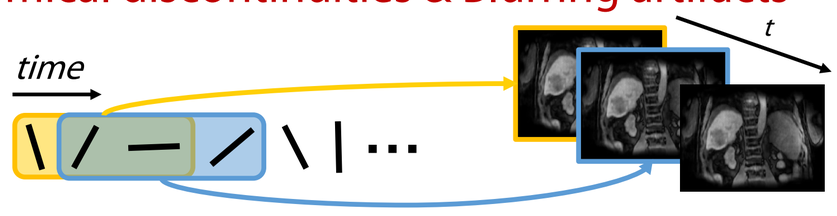
Low temporal High spatial



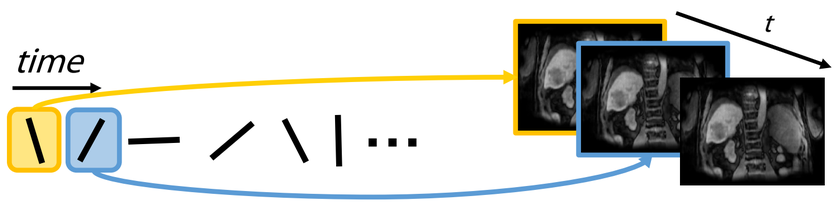
Problem: Motion Artifacts

Single-spoke Motion Model

- **Current reconstruction methods** assume that multiple spokes share the same motion state
  - ✗ Anatomical discontinuities & Blurring artifacts

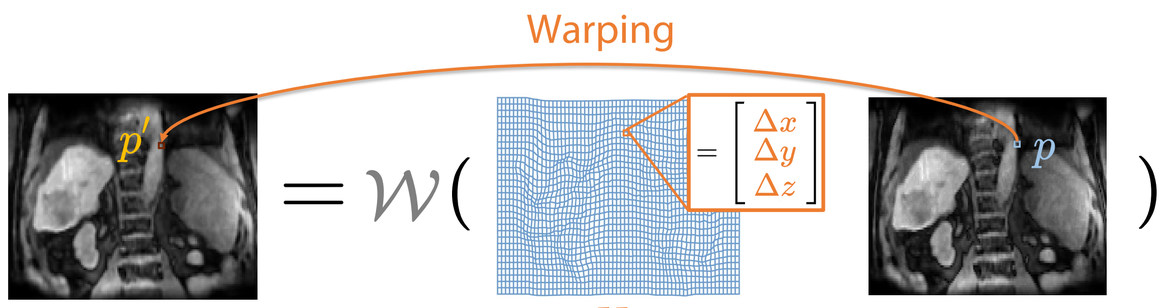


- **Single-spoke motion model** assume that each spoke has its own motion state
  - ✓ Better reflect real-world continuous motion



Motion-compensated Method

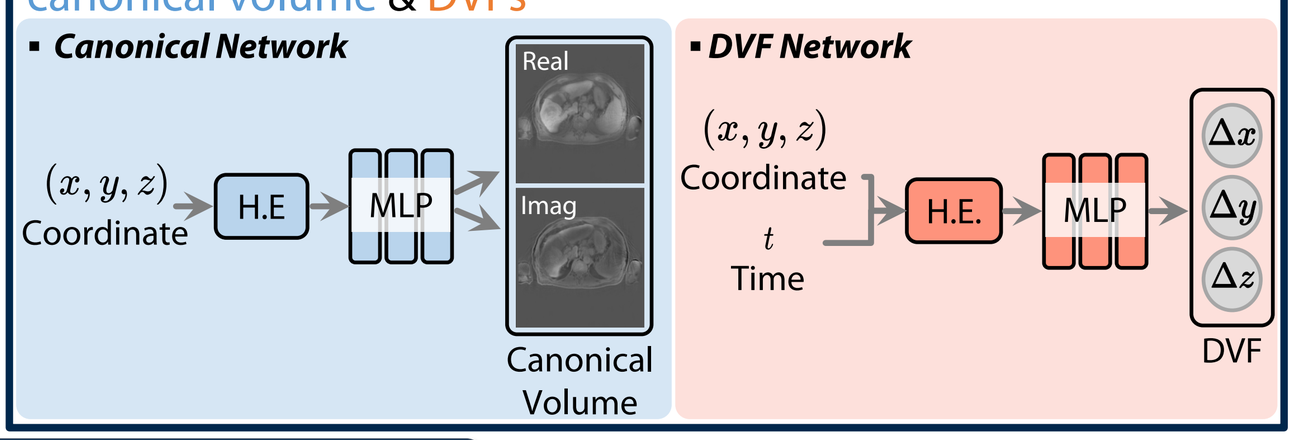
- Decouple 3D volume at time t into a canonical volume and the deformation vector field (DVF)



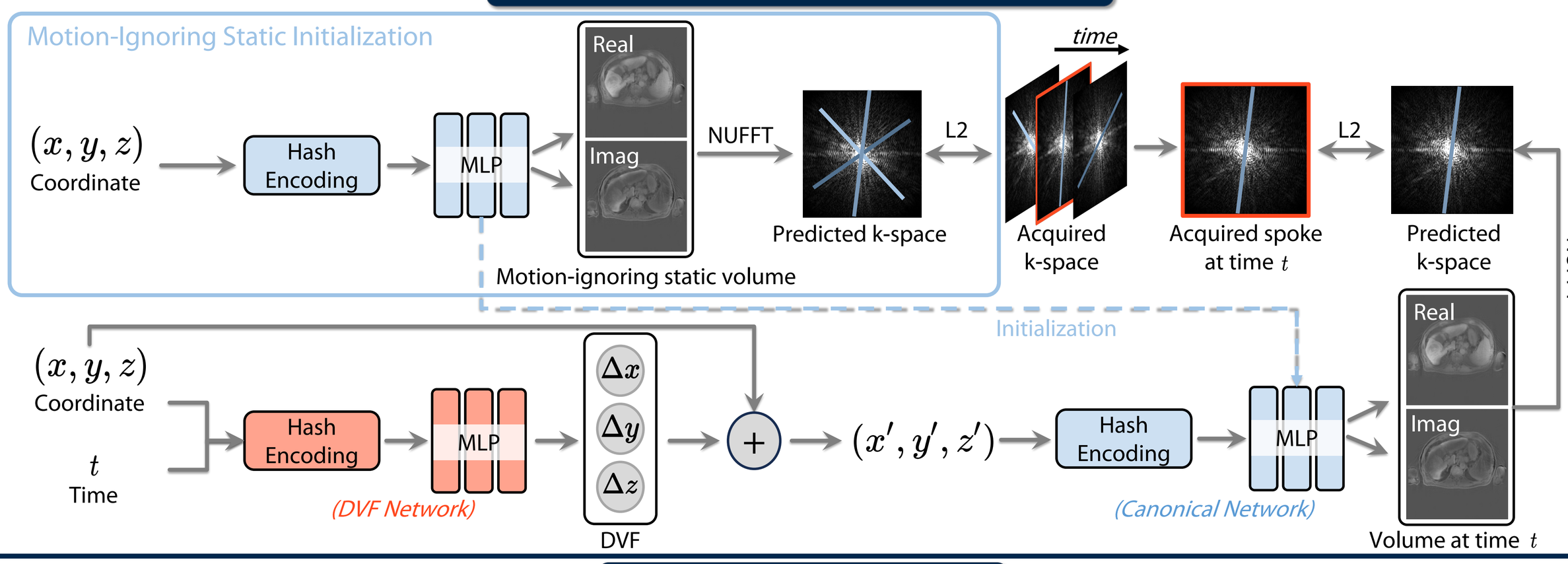
$\mathbf{x}_t$ 3D volume at time t | $\mathbf{u}_t$ DVF | $\mathbf{m}$ Canonical 3D volume

Implicit Neural Representation

- Using a coordinate-based neural network to approximate canonical volume & DVFs

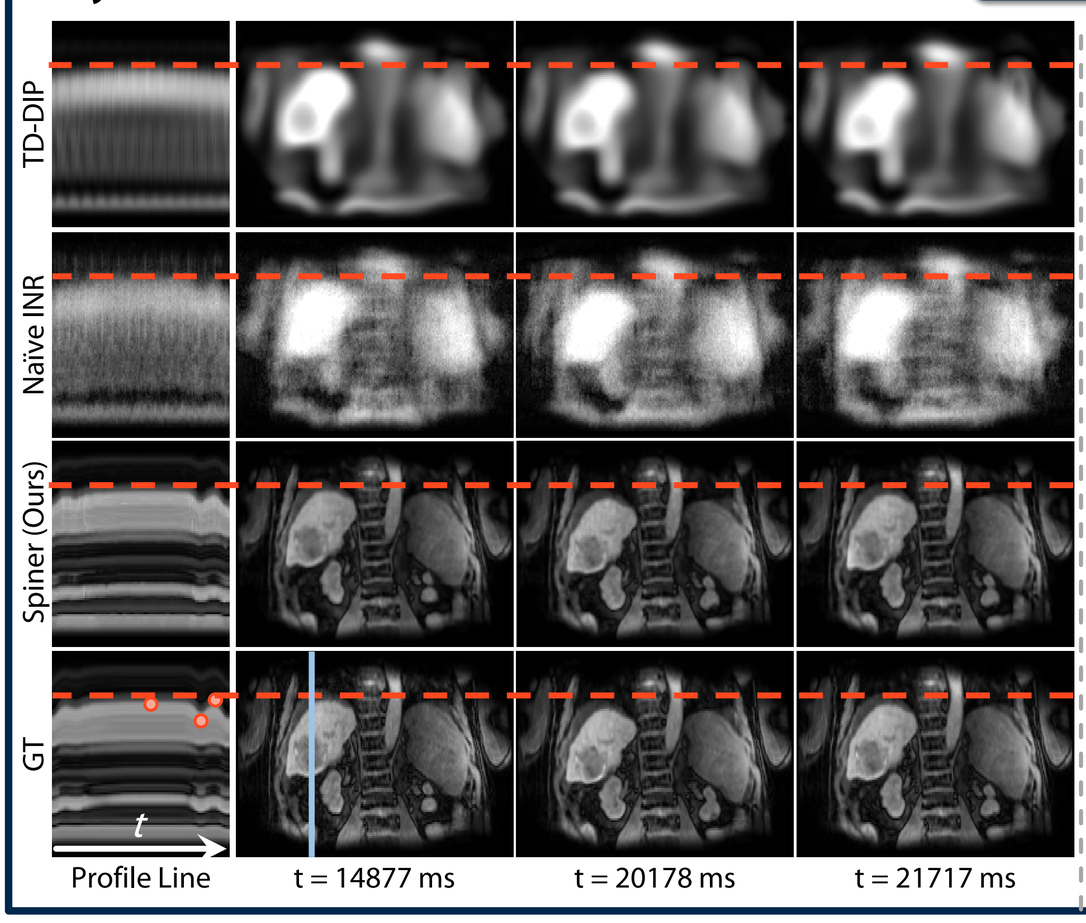


Motion-Ignoring Static Initialization



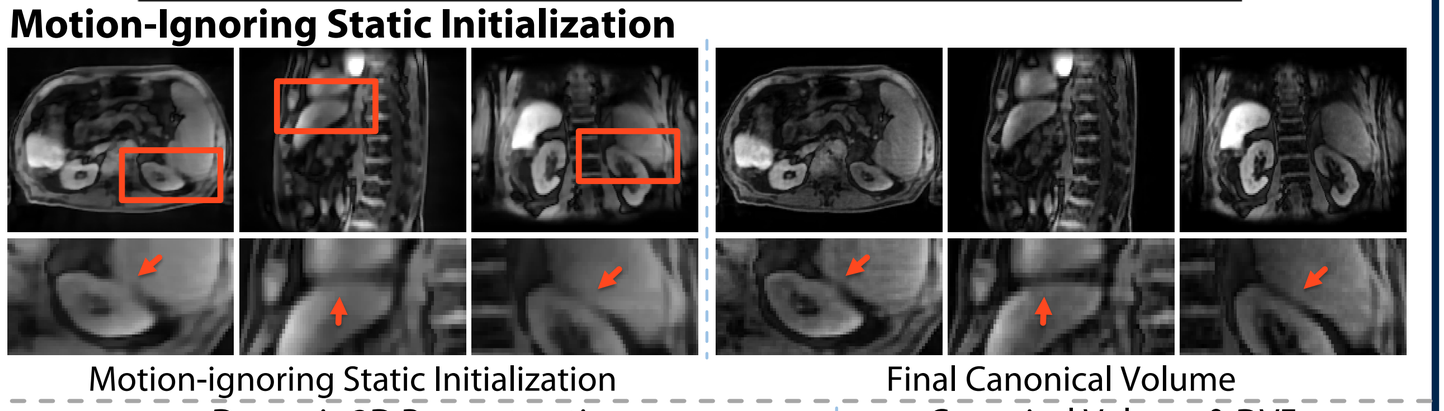
Experimental Results

- **Dynamic 3D Reconstruction**



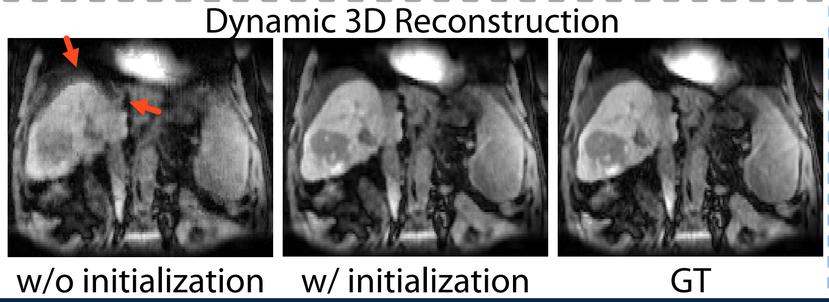
	NUFFT [2]	TD-DIP [3]	Naïve INR [1] (single-spoke)	Naïve INR [1] (20 spokes)	SPINER (w/o Init.)	SPINER (w/ Init.)
PSNR	10.64	23.83	19.16	27.13	<u>32.59</u>	**38.99**
SSIM	0.3309	0.6539	0.2113	0.7339	<u>0.7564</u>	**0.9664**

- **Motion-Ignoring Static Initialization**



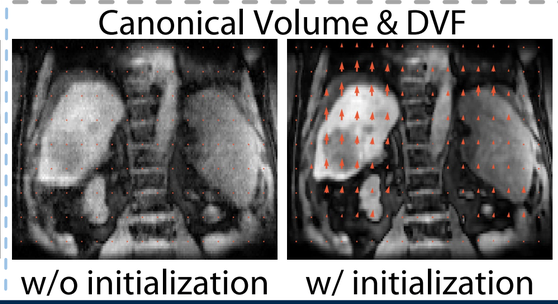
Motion-ignoring Static Initialization | Final Canonical Volume

Dynamic 3D Reconstruction



w/o initialization | w/ initialization | GT

Canonical Volume & DVF



w/o initialization | w/ initialization