# Long-Short Diffeomorphic Memory Network for Weakly-Supervised Ultrasound Landmark Tracking

Zhihua Liu[1], Bin Yang[1,2], Xuejun Ni[2], Yan Shen[2], Huiyu Zhou[1]

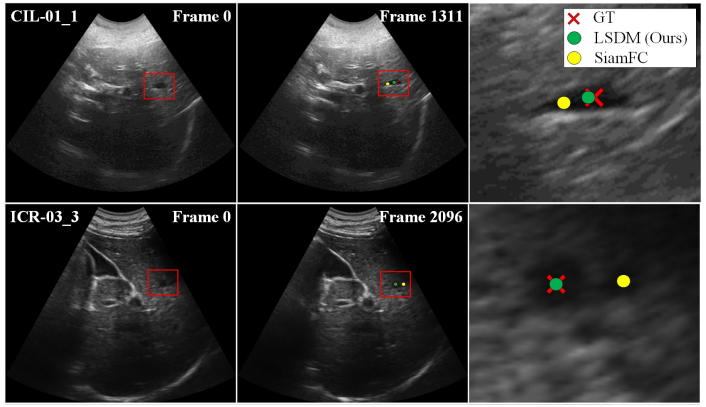
[1] University of Leicester [2] Affiliated Hospital of Nantong University

Full Paper | Find Zhihua here

## Ultrasound Landmark Tracking

**What:** The goal is to locate the same landmark provided by the exemplar frame in the follow-up image sequences.

**Why:** Delivers landmark localization and movement estimation information in temporal-spatial domains, which provides clinicians a measurable therapy margin around clinical and surgical target to increase the chance of tumor control.

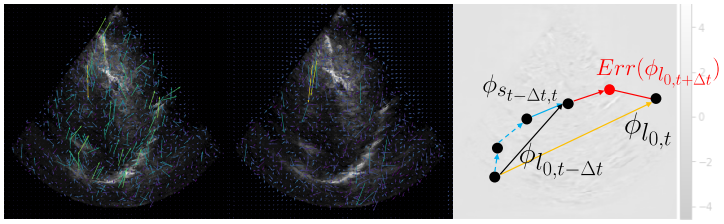



## Tracking with Novel Motion Representation

★**Multi-Task**: A novel landmark tracking network by multi-tasking both tracking and motion learning.

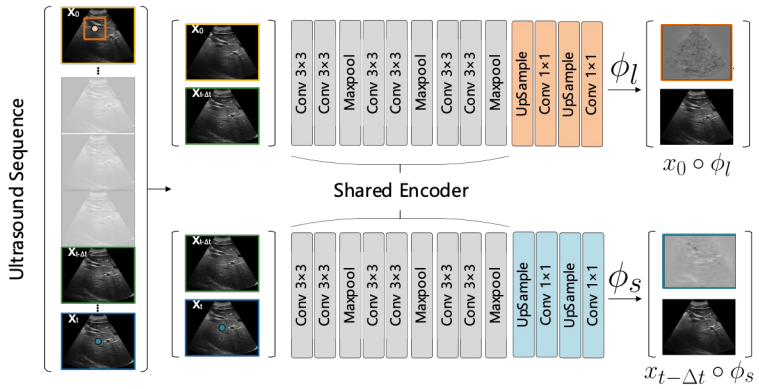
★**Long-Short Representation**: A new representation design containing diffeomorphism in both long and short intervals.

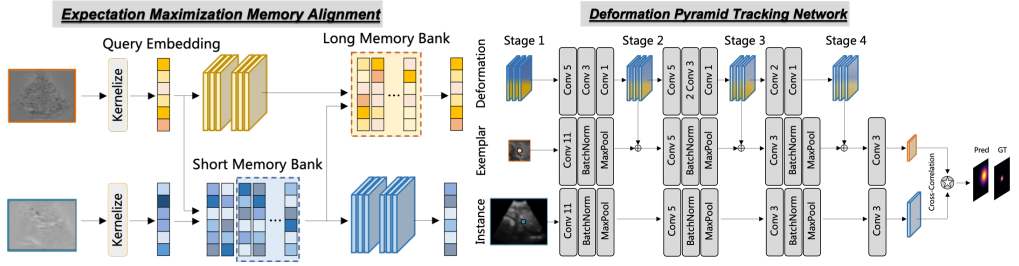
★**Weakly-Supervised**: Only few landmark annotations for tracking and zero annotation for motion learning.




Long Deformation | Short Deformation | Long/Short Deformation

## Long-Short Diffeomorphic Memory Network (LSDM)




## Training

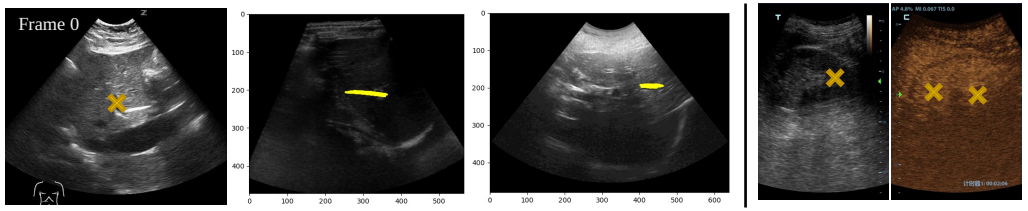
Deformation : Normalized Local Cross-Correlation (Long)/Mean Squared Error (Short )/ Smooth

Tracking : Element-wise Cross Entropy

Hardware : BatchSize 4 on NVIDIA Tesla P100

## Datasets

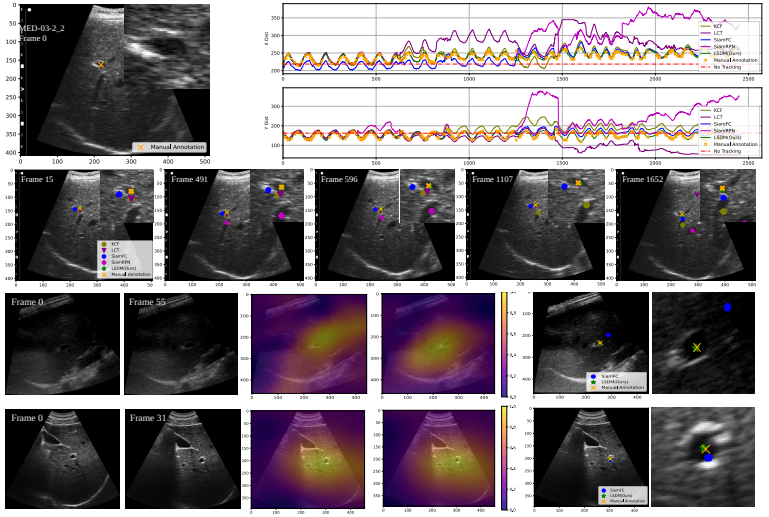
**Public**: CLUST2D(Liver) **Private**: Affiliated Hospital of Nantong University(Kidney)




V. De Luca, et al., "Evaluation of 2d and 3d ultrasound tracking algorithms and impact on ultrasound-guided liver radiotherapy margins," Medical Physics, vol. 45, no. 11, pp. 4986–5003, 2018

https://clust.ethz.ch/data.html

## Tracking Visualization




## Ablation Study

| | Components | | | | Metrics |
|---|---|---|---|---|---|
| | Complete | Partial | EMMA | DPN | TE Mean +/- Std |
| Deformation Prior | ✓ | | | | 2.63 +/- 2.11 |
| | | ✓ | | | 2.69 +/- 2.87 |
| EMMA | ✓ | | ✓ | | 1.21 +/- 2.19 |
| | | ✓ | ✓ | | 1.56 +/- 1.73 |
| DPN | ✓ | | ✓ | ✓ | 0.92 +/- 0.76 |
| | | ✓ | ✓ | ✓ | 0.81 +/- 0.98 |

## In-House Test

Test sequence from a specific scanner is hidden during training.

| In-House Partition | Mean | | Std | | 95th | | Scanner Type |
|---|---|---|---|---|---|---|---|
| | SiamFC | LSDM | SiamFC | LSDM | SiamFC | LSDM | |
| CIL | 2.01 | 1.82 | 3.47 | 1.63 | 11.49 | 3.81 | Ultrasonix MDP |
| ETH | 5.33 | 1.98 | 10.16 | 1.21 | 17.3 | 4.67 | Siemens Antares |
| ICR | 1.09 | 2.19 | 3.22 | 1.76 | 5.64 | 3.76 | Elekta Clarity-Ultrasonix |
| MED1 | 3.17 | 1.35 | 2.46 | 1.9 | 7.71 | 2.91 | Zonare z.one |
| MED2 | 4.93 | 3.19 | 9.27 | 1.31 | 19.15 | 5.18 | DiPhAs Fraunhofer |

## Failure Cases