INTERNATIONAL CONFERENCE ON PATTERN RECOGNITION
MILAN 10 – 15 JANUARY 2021

NephCNN

A Deep-Learning Framework for Vessel Segmentation in Nephrectomy Laparoscopic Videos

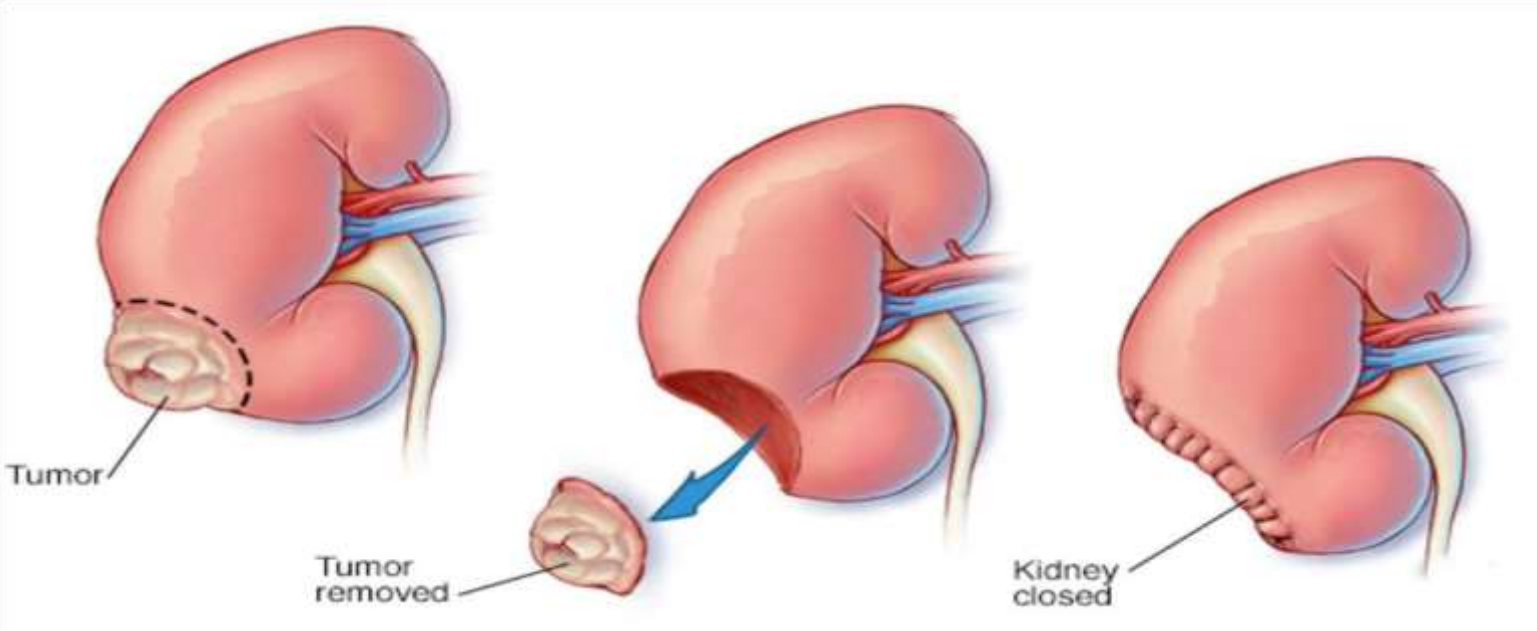
iit ADVR
POLITECNICO MILANO 1863
UNIVERSITÀ POLITECNICA DELLE MARCHE






Clinical background

Nephrectomy is the surgical procedure where all, or a part of, kidney is removed to treat **renal cell carcinoma**. In **radical** nephrectomy, the urologic surgeon removes the entire kidney, while in **partial** one the surgeon removes only the diseased tissue.



3,5%

of total cancer cases

Ferlay et al. 2018

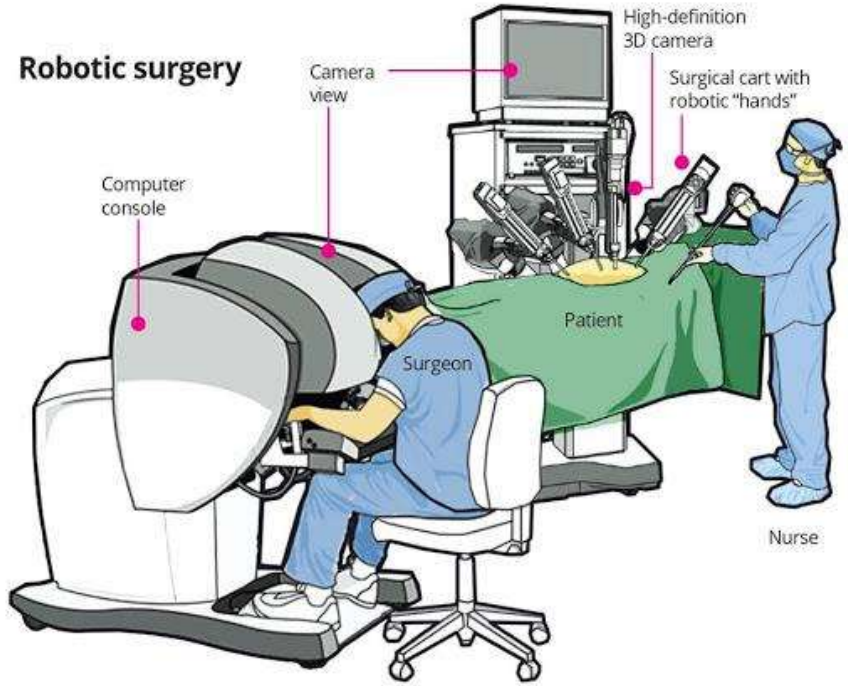
40%

mortality rate

MacLennan et al. 2012

Clinical background

In the last few decades, **robot-assisted partial nephrectomy** (RAPN) has been increasingly adopted in the treatment of renal cell carcinoma, offering **significant advantages** over open or laparoscopic nephrectomy.

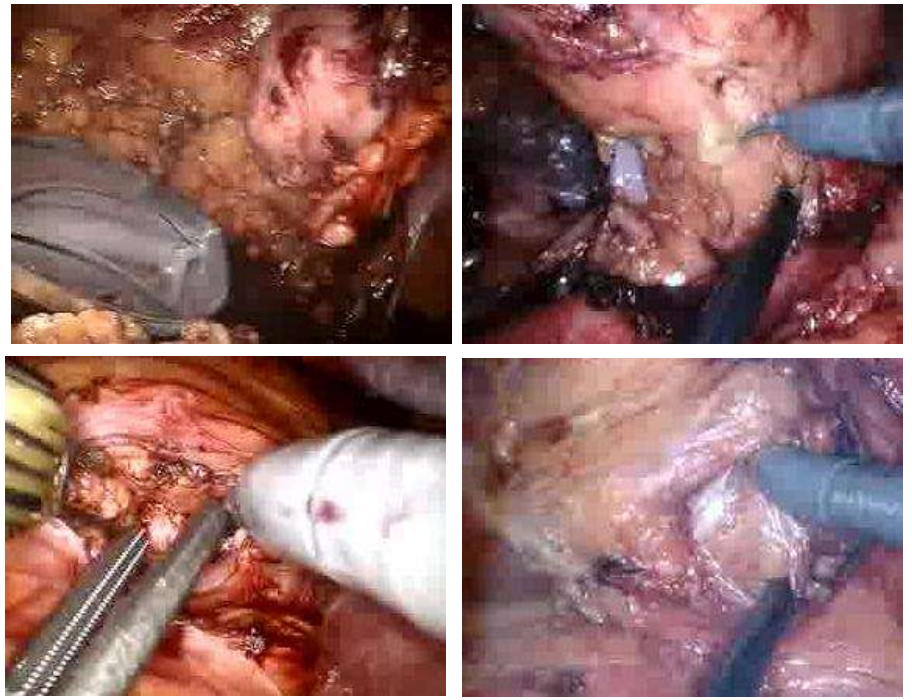


Novara et al. 2016

Challenges in robot-assisted partial nephrectomy

Despite the advantages brought by robotic surgery, surgeons still have to face many obstacles, such as:

- **small field of view**
- field **occluded** by surgical tools
- **reduced manoeuvrability**
- risk of **unwanted blood vessel resection**



Maier-Hein et al. 2017

Aim of the work

Computer-aided tools based on Deep Learning for real-time segmentation and automatic tracking of blood vessels (i.e., renal artery) from RAPN videos could potentially enhance robot assisted intervention quality.

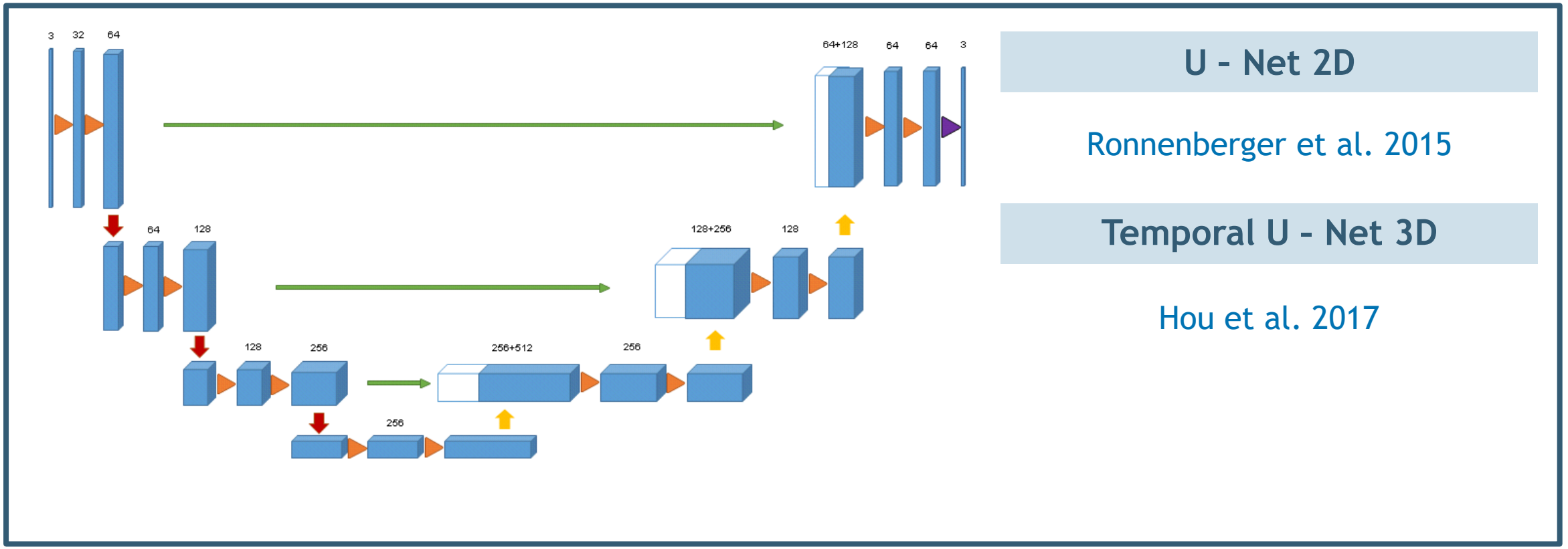
Supporting surgeons in avoiding damages and resections of forbidden vascular regions

Minimizing surgeon mental workload

Reduction of intra- and post-operative complications

Methods: Fully Convolutional Neural Network

State of the art



U - Net 2D

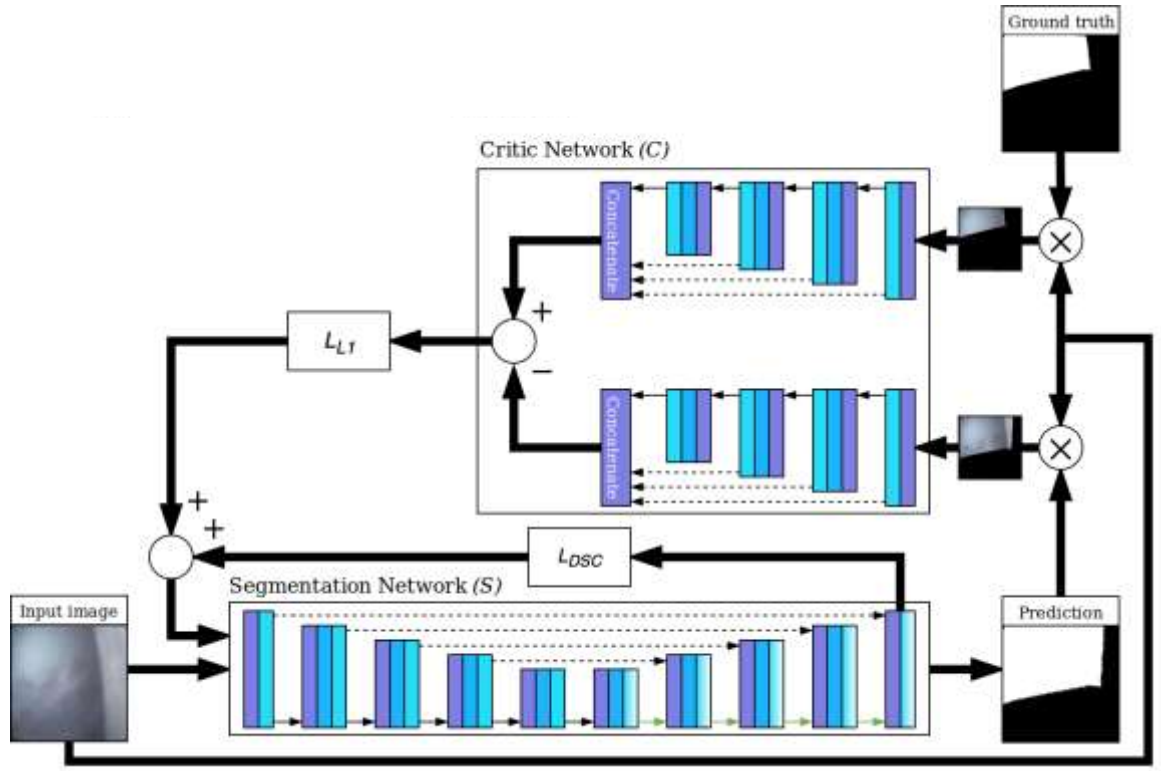
Ronnenberger et al. 2015

Temporal U - Net 3D

Hou et al. 2017

Methods: Fully Convolutional Neural Network

State of the art



U - Net 2D

Ronnenberger et al. 2015

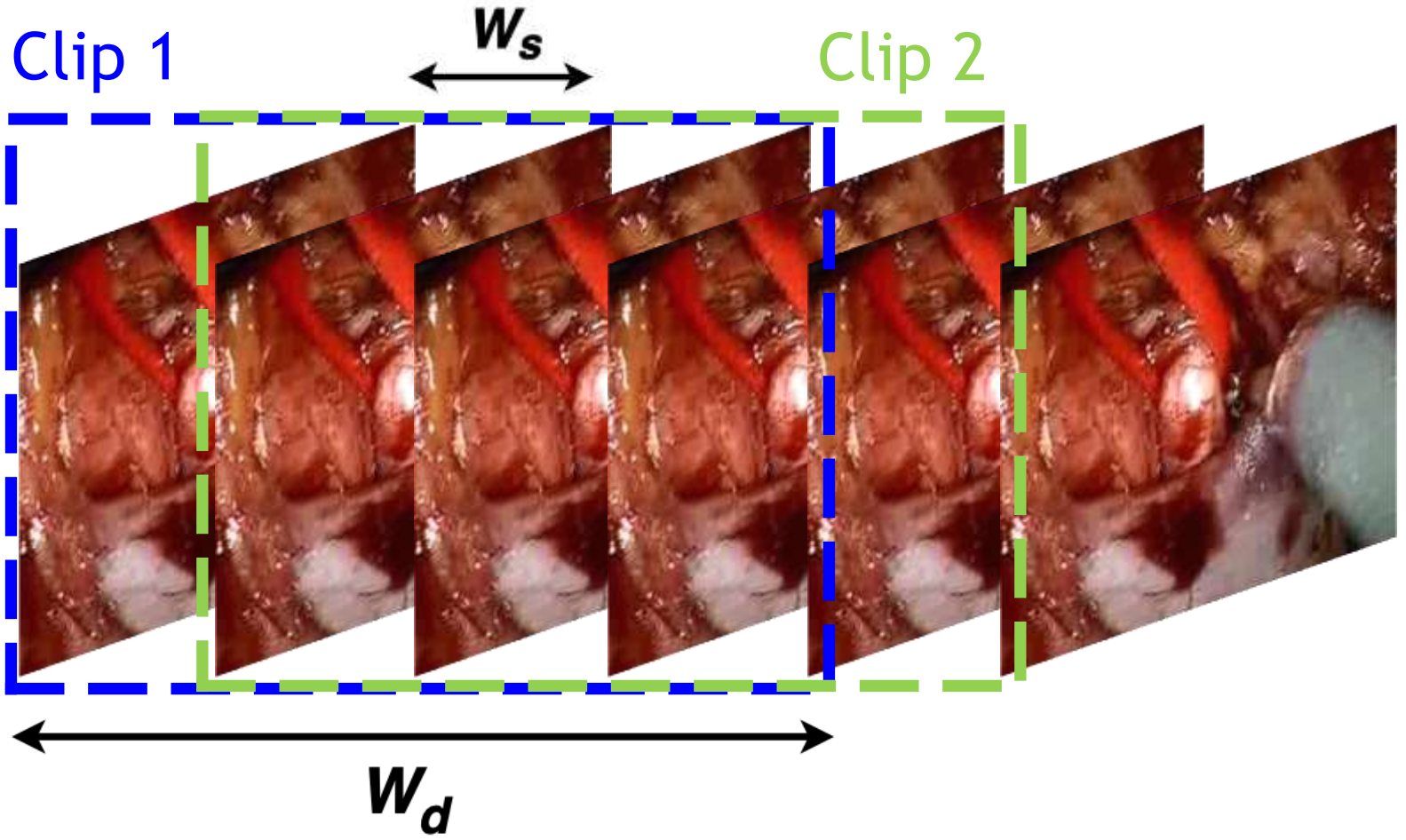
Temporal U - Net 3D

Hou et al. 2017

Adversarial Training

Casella et al. 2020

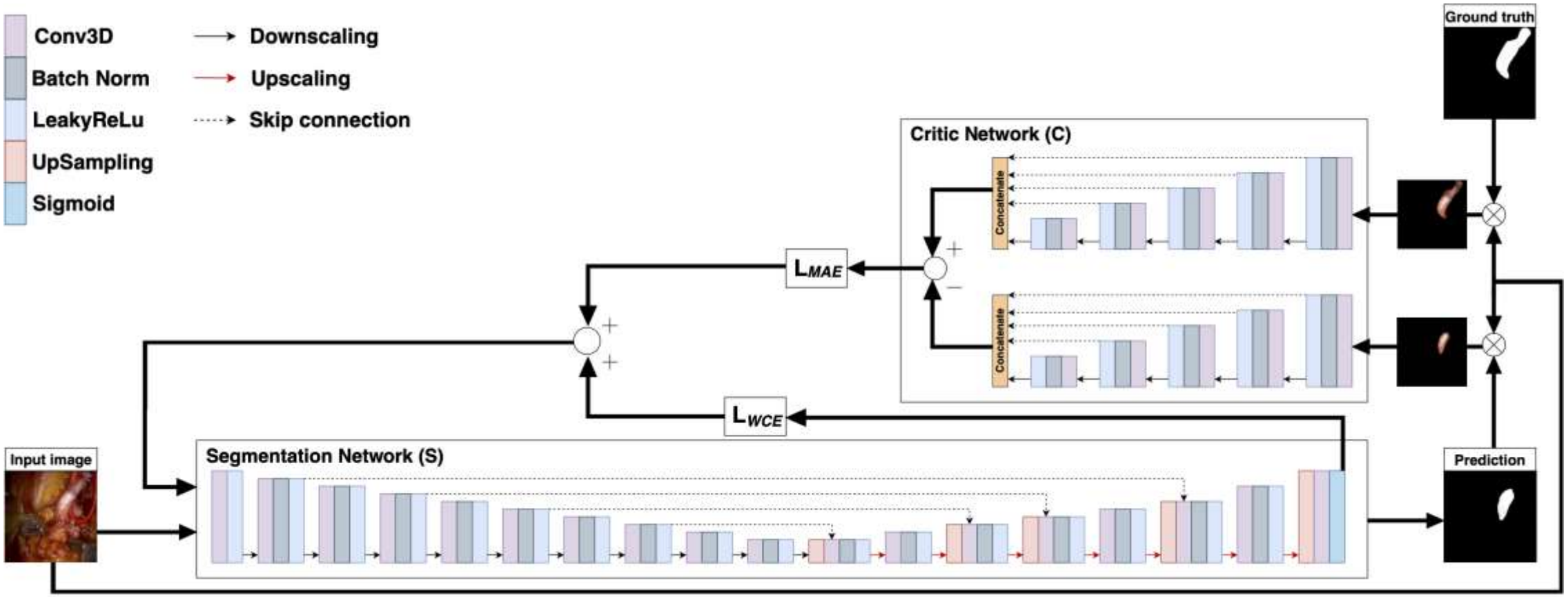
Methods: 3D Convolution for Temporal Information



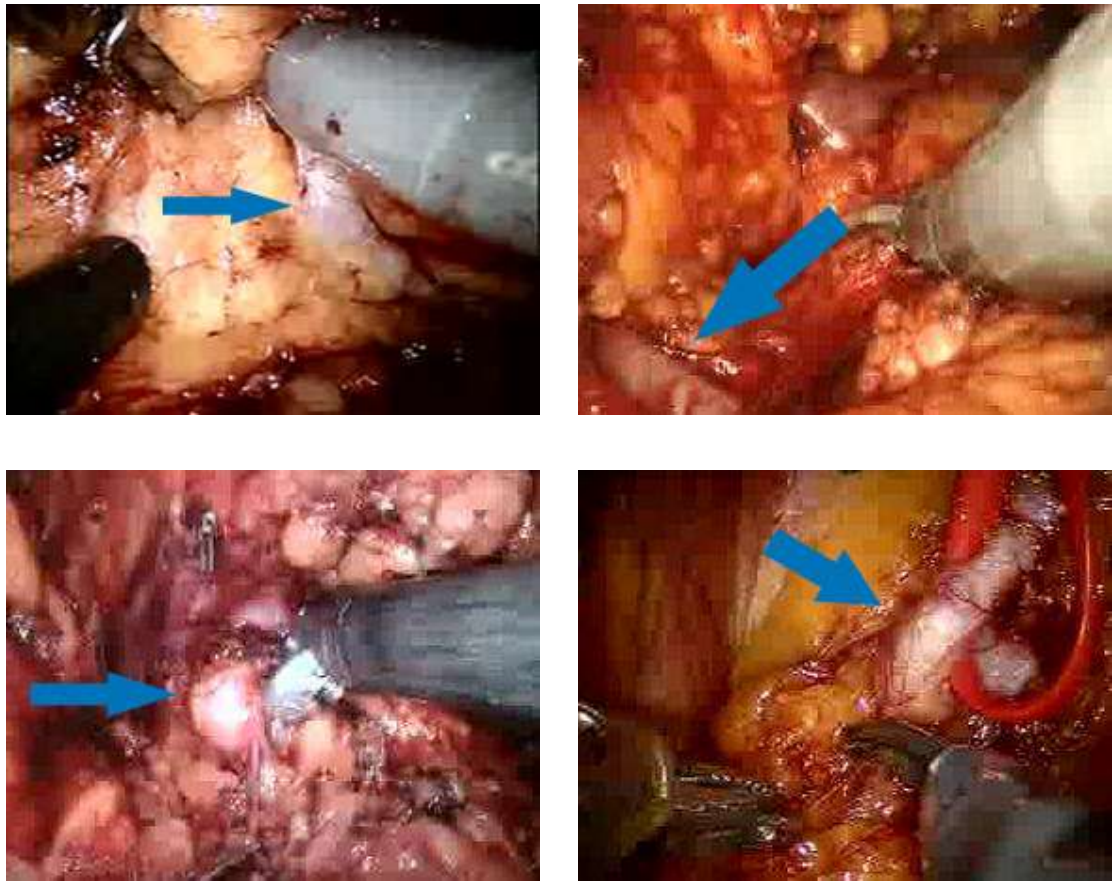
Hou et al. 2017

Methods: NephCNN

Proposed Architecture



Experimental Protocol: Dataset



Nephrec9 Dataset

Intra-operative RAPN surgery videos
European Institute of Oncology (IEO), Milan, Italy

283 x 218 pixels

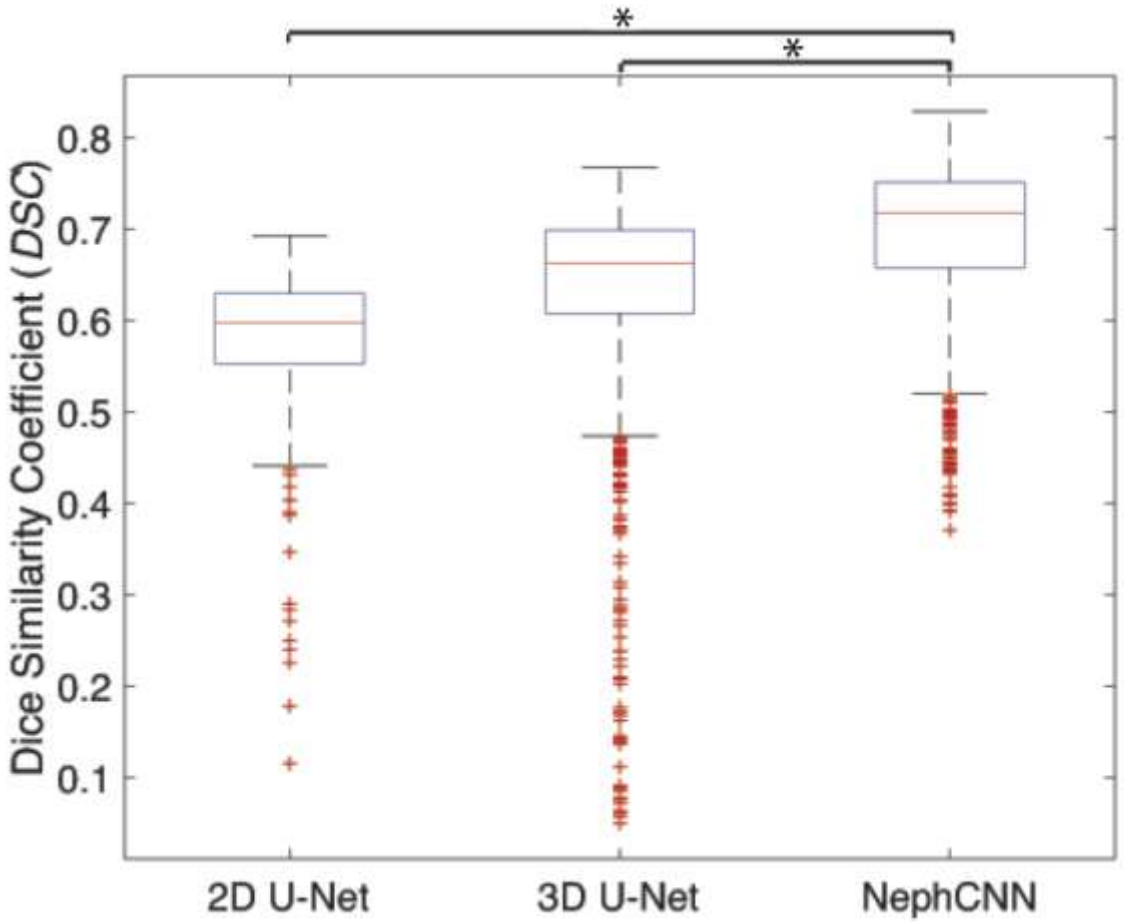
741573 frames (8 patients)

Data augmentation

Training set
was rotated by 45, 90, 180 and 270 degrees

Nakawala et al. 2017

Results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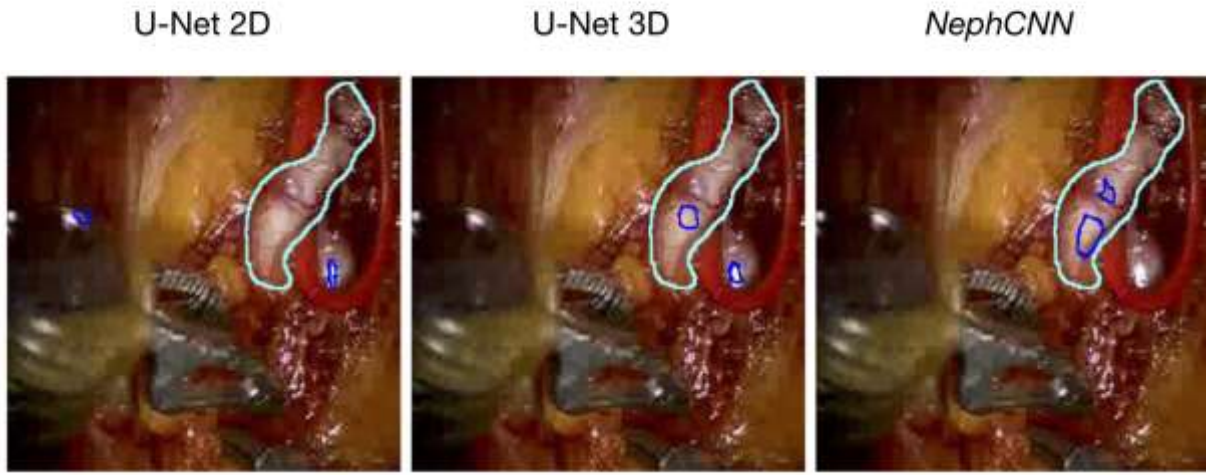
Dice Similarity Coefficient (DSC)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2D U-Net
3D U-Net
NephCNN


U-Net 2D
U-Net 3D
NephCNN

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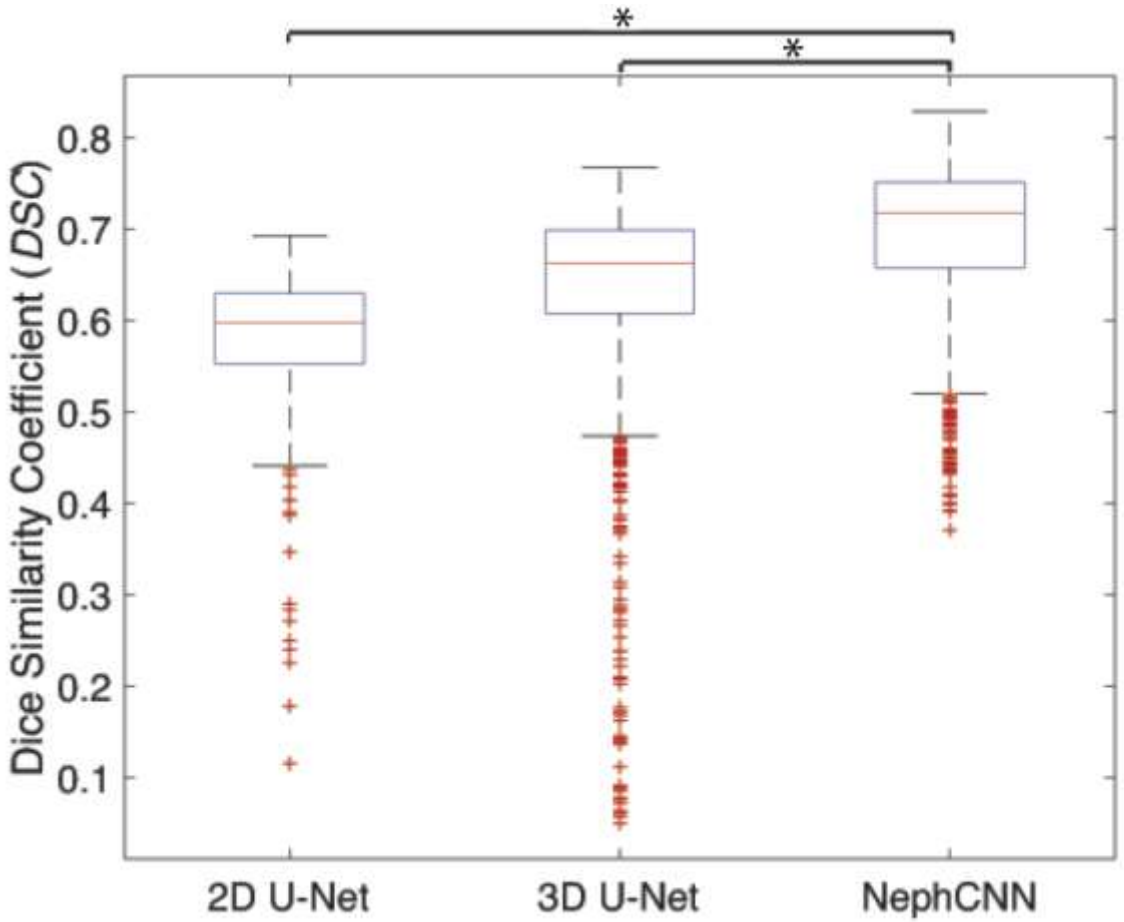
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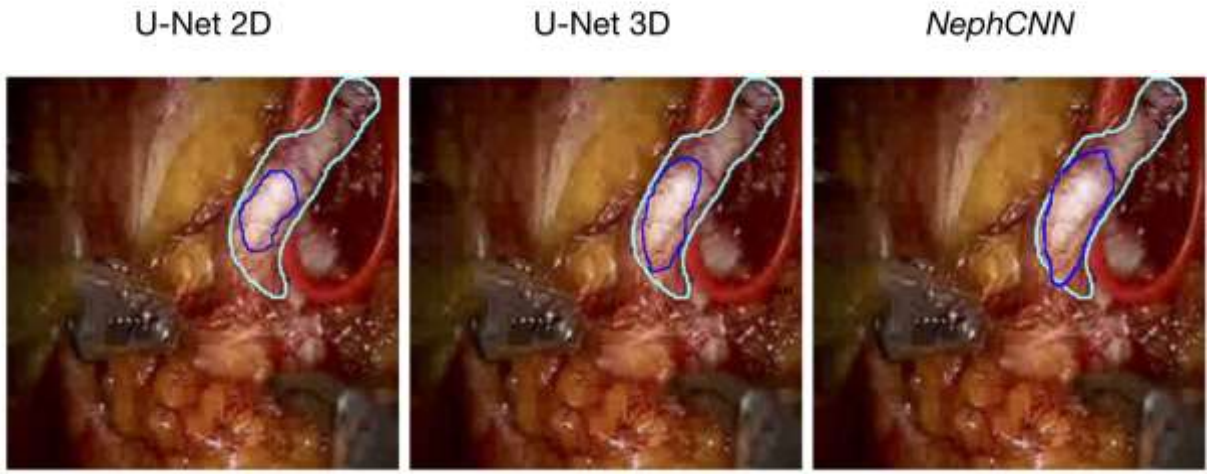
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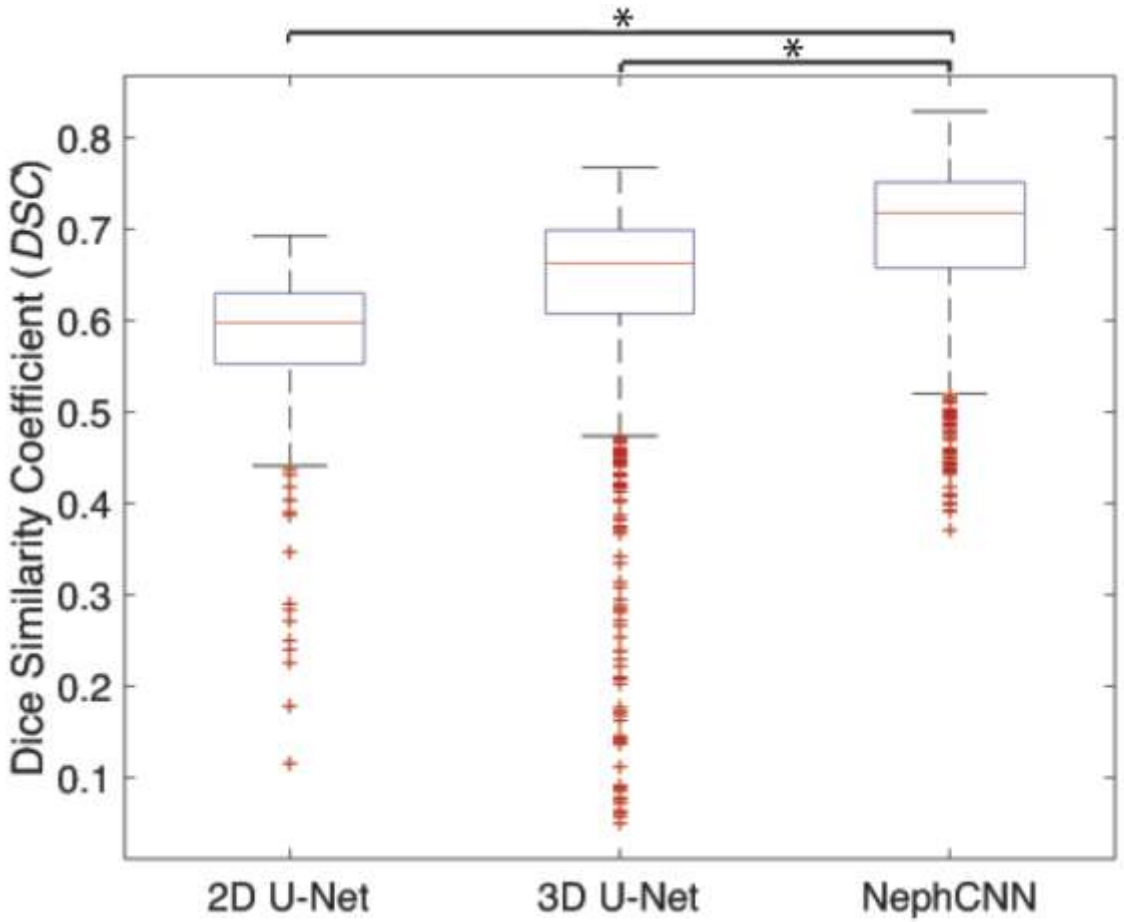
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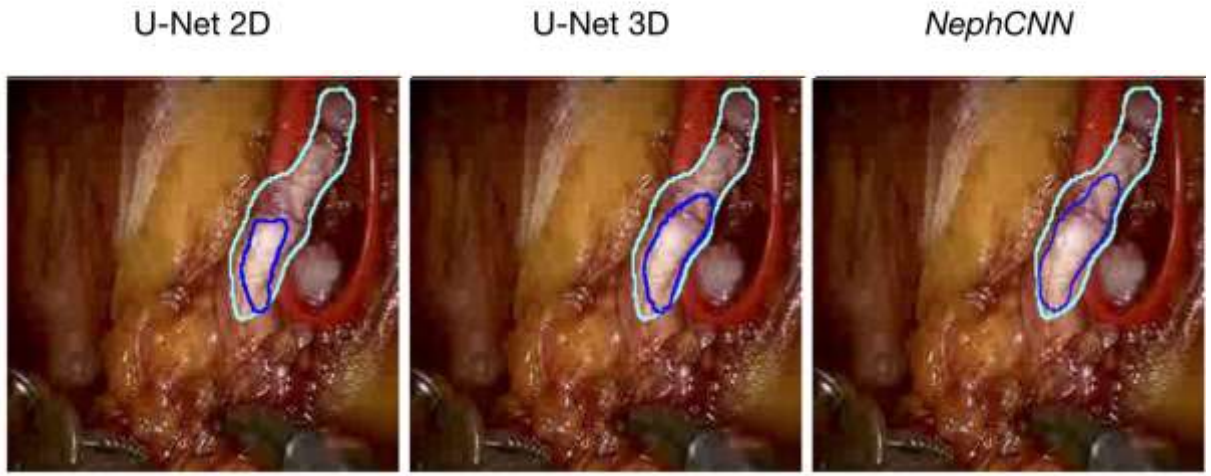
U-Net 2D
U-Net 3D
NephCNN

Conclusions and Future Development

Conclusion

- Overview of state of the art, adversarial network technique and 3D Convolution to perform vessel segmentation from RAPN videos.
- The achieved results highlight the potential of shape-constraints and temporal information in intraoperative RAPN videos to enhance accuracy and tackle the complexity of the dataset.

Future developments

- Increase the number of frames and patients of the dataset
- Consider advanced data augmentation techniques
- Densely connected CNN with Atrous Pyramid Pooling to preserve features at different complexity levels

Thank you for your kind attention

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