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

- **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

Clip 1

\[ W_s \]

Clip 2

\[ W_d \]

Hou et al. 2017
Methods: NephCNN

Proposed Architecture

Conv3D → Downscaling
Batch Norm → Upscaling
LeakyReLU → Skip connection
UpSampling
Sigmoid

Input image

Segmentation Network (S)

Critic Network (C)

Ground truth

Prediction

L_{MAE}

L_{WCE}
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

[Box plot image showing Dice Similarity Coefficient (DSC) for 2D U-Net, 3D U-Net, and NephCNN. The plot compares the performance of these models, with NephCNN generally showing better results as evidenced by the higher mean and lower variance.]
Results

![Box plot and images comparing different models: 2D U-Net, 3D U-Net, and NephCNN.]
Results
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