POLITECNICO MILANO 1863
iit ADVR
Department of Electronics, Information and Bioengineering
Department of Advanced Robotics
alessandro.casella@iit.it

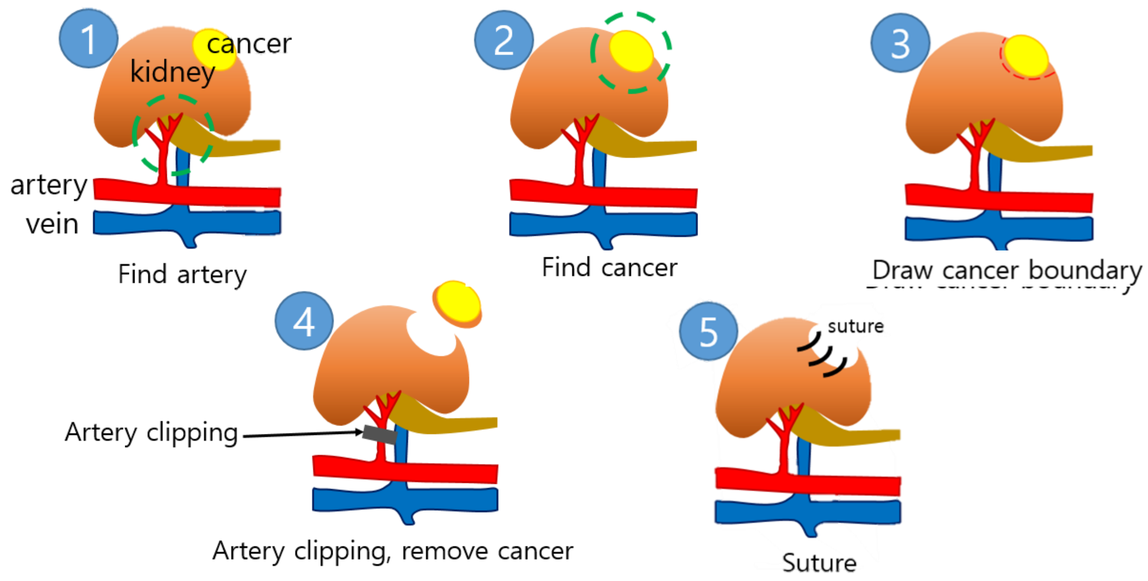
NephCNN A Deep-Learning Framework for Vessel Segmentation in Nephrectomy Laparoscopic Videos

Alessandro Casella[1,2], Sara Moccia[1,3], Chiara Carlini[2], Emanuele Frontoni[3], Elena De Momi[2], Leonardo S. Mattos[1]

[1] Department of Advanced Robotics, Istituto Italiano di Tecnologia, Genova, Italy
[2] Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milano, Italy
[3] Department of Information Engineering, Università Politecnica delle Marche, Ancona, Italy

BACKGROUND

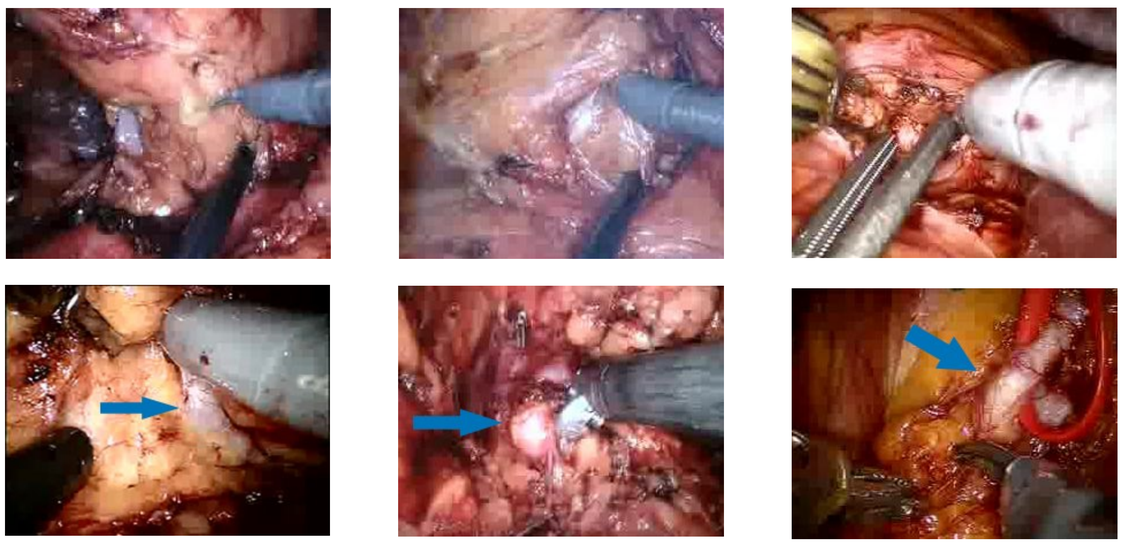
Renal Cell Carcinoma (RCC) is one of the most common kidney cancer in adults (3% of adult cancers in Europe) [1].
Current therapeutic option consist in **nephrectomy**, the complete or partial removal of kidney tissue (95% 5-year survival rate) [2].
Robot-Assisted Partial Nephrectomy (RAPN) provide advantages over laparoscopic surgery in terms of health outcomes, safety, and costs [3].
Detecting critical structures, such as the **renal artery**, can increase surgery safety [4].



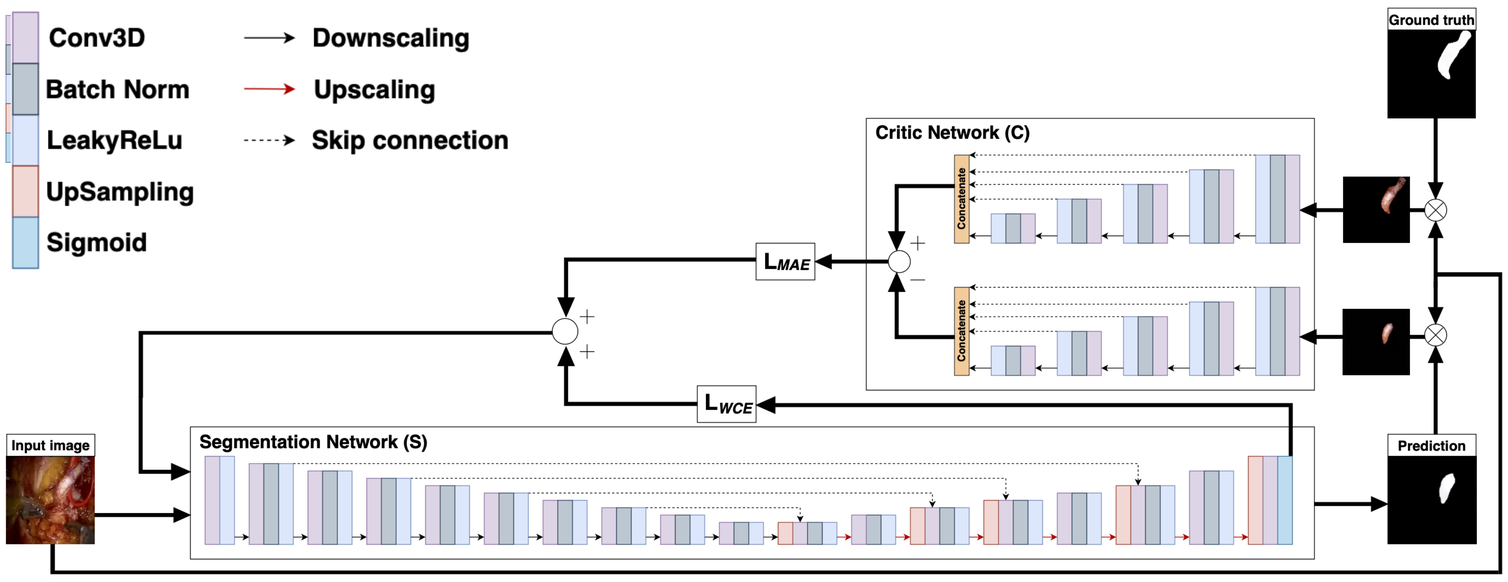
AIM

Low visibility could lead to accidents during surgery (e.g., unwanted vessel resection and bleeding due to surgical tools misplacement) [5].
Surgeons' vision is hampered by:
- Small field of view
- Occlusion by surgical tools
- Reduced Manoeuvrability

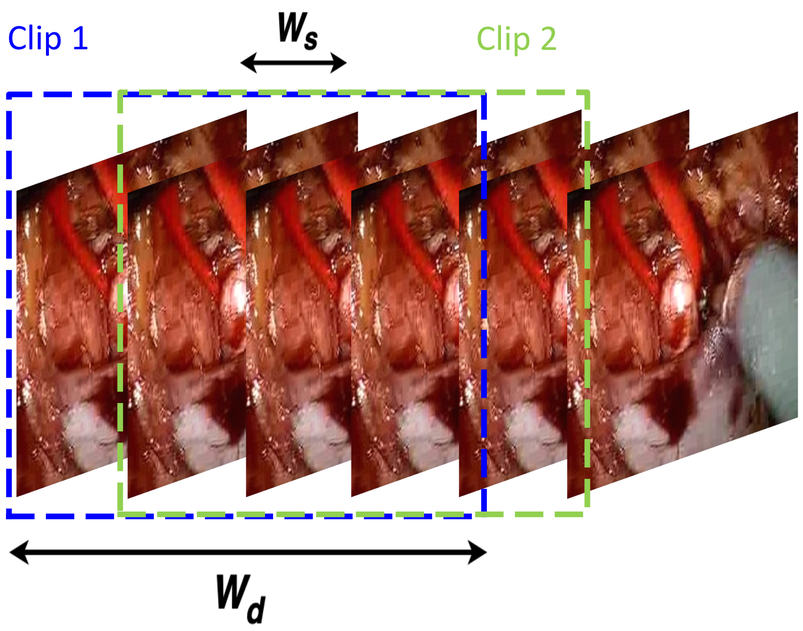
This paper propose an **automatic and fast renal artery segmentation from intra-operative RAPN videos.**

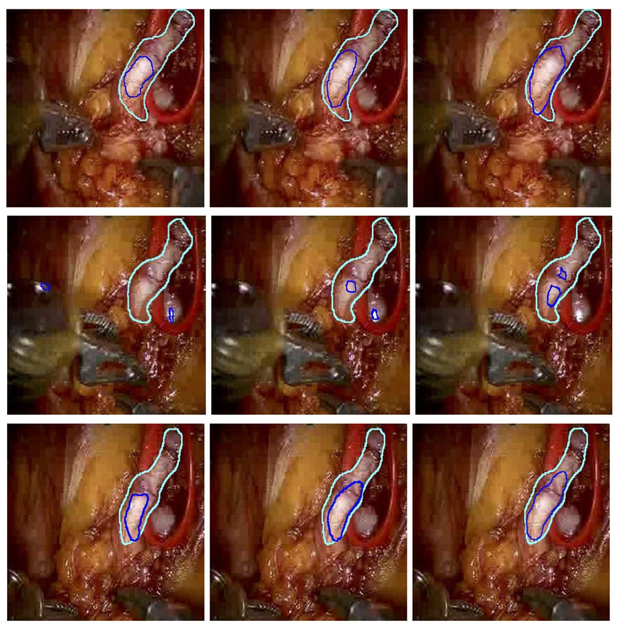


METHODS

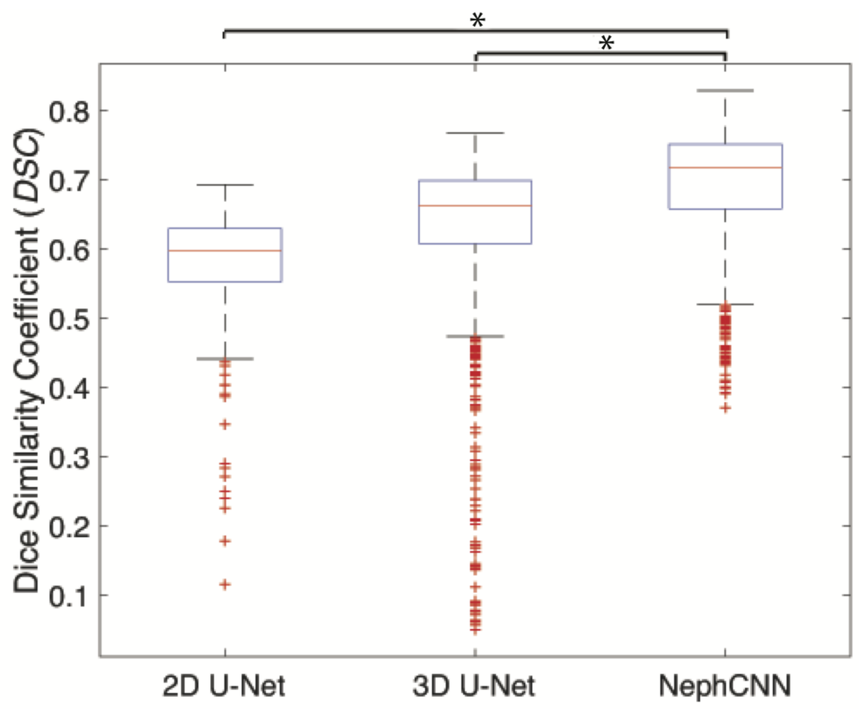


- **Dataset**: Nephrec9 [6] dataset of RAPN videos acquired at **European Institute of Oncology (IEO), Milan, Italy.**
- **Dataset annotation performed with expert clinicians' support.**
- We proposed an **adversarial segmentation framework** inspired by Casella et al. [7] along with a **novel weighted L1 adversarial loss function** and **3D convolution for temporal information processing** [8].
- Finally, we compared accuracy, in terms of Dice Similarity Coefficient (*DSC*) with state-of-the-art networks





RESULTS



CONCLUSIONS AND FUTURE DEVELOPMENTS

- In this study, **our proposed framework achieved a median *DSC* = 71.76%**
- This work is among the **first attempts that combines adversarial training and spatio-temporal features for segmentation in robot-assisted renal surgery.**
- Further improvements will deal with
  - **Extensive validation** with broader dataset
  - Consider **advanced data augmentation techniques**
  - Exploitation of **extension to this framework**

REFERENCES

[1] S. MacLennan et al. (2012) Systematic review of oncological outcomes following surgical management of localised renal cancer, European Urology, 61(5) 972-993
[2] J. E. Abel et al. (2010) Identifying the risk of disease progression after surgery for localized renal cell carcinoma, BJU International, 106(9) 1227-1283
[3] G. Novara et al. (2016) Robot-assisted partial nephrectomy, International Journal of Surgery
[4] S. Moccia et al. (2018) Toward improving safety in neurosurgery with an active handheld instrument, Annals of Biomedical Engineering, 46(10) 1450-1464
[5] L. Maier-Hein et al. (2017) Surgical data science for next-generation interventions, Nature Biomedical Engineering, 1(9), 691-696
[6] H. Nakawala et al. (2017) Nephrec9 (version 0.1), Zenodo
[7] A. Casella et al. (2020) Inter-foetus membrane segmentation for TTTS using adversarial networks, Annals of Biomedical Engineering, 48(2), 848-859
[8] E. Colleoni et al. (2019) Deep learning based robotic tool detection and articulation estimation with spatio-temporal layers, IEEE Robotics and Automation Letters, 4(3) 2714-2721