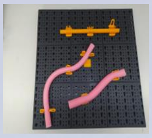

Validation of Deep-Learning-based lumen segmentation methods in anatomical phantoms.

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Introduction

- In recent years, with the development of new tools for Minimal Invasive Robotic Surgery (MIRS), the implementation of navigation algorithms has risen as an interesting challenge [1]. Some novel developments have proposed the use of navigation methods based on image information, and specifically by using Deep Learning-based methods[2].

- As a further step to determine the feasibility of applying these image-based methods for lumen segmentation, and its later merge with a robotic endoscope, for autonomous navigation, a platform where to test this devices is needed.

Fig 1. Sample of images of the robotic prototype used to acquire images..

Method

- A total of 10 silicone phantoms of different colors and diameters were manufactured.

- Video-clips with the robotic endoscope's camera were recorded to use as training/test data

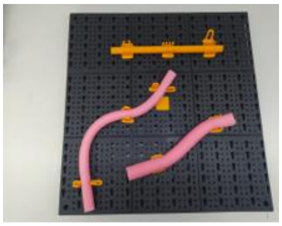

Fig 2. Sample of the phantoms built

- In total 1,996 frames were used and manually annotated. The frames from 1 phantom were set apart as a validation dataset, of the rest 60% was used for training and 40% for validation.

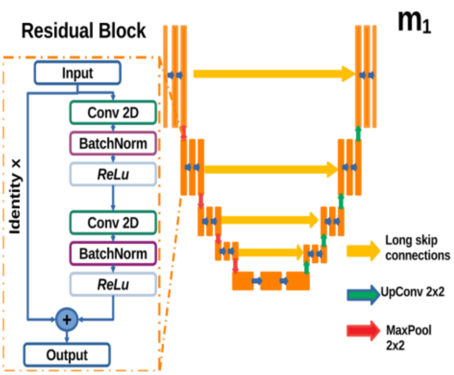

Fig 3. Diagram of the backbone of the 3 CNN architectures used.

Three different models based on the ones presented in [2] were trained. One of them is the original one. The second one uses transpose convolutions and the 3rd one uses 3 continuous frames as input.

The Dice Coefficient DSC, was used as metric to compare the models.

Results

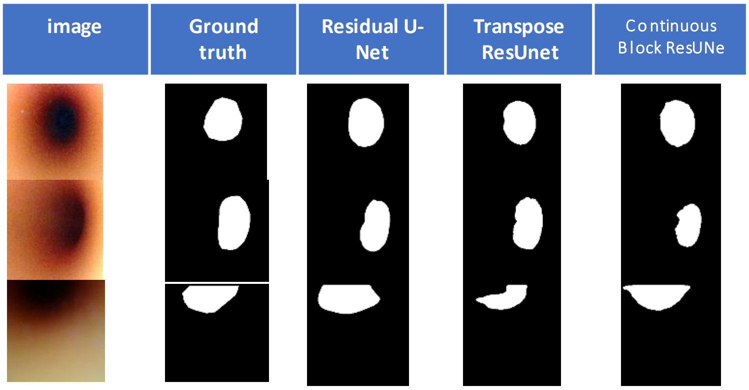

Fig 4. Sample of images obtained with each of the different architectures of CNNs.

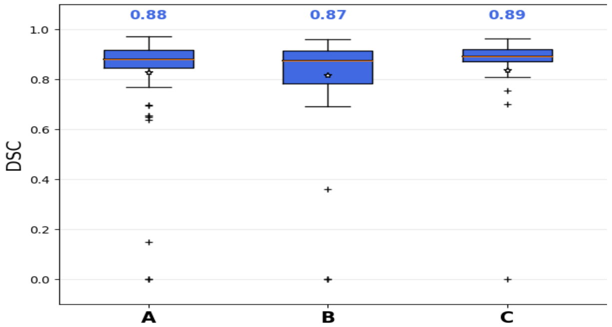

Fig 5. Comparison of the three models tested. A: Residual U-net, B: Residual U-net with transpose convolution. C: Residual U-net with input blocks of 3 continuous frames.

Discussion

- The model that obtained the better performance was Continuous Block ResUNet, however, no statistical significance was observed between it and residual U-Net.

- With the results obtained we can say that the use of Deep-Learning based methods for lumen segmentation can be useful for the task of center detection and autonomous navigation or robotic endoscopes [3].

- Future steps in this research may include the acquisition of a broader dataset, the study of different new types of architecture and the implementation of surgical footage provided by clinicians.

References

[1] Ben H. Chew, Thomas Chi, Manoj Monga,Mitchell R. Humpheyrs. Robotic ureteroscopy: The future of stone management?, Urology.

[2] Lazo, Jorge F., et al. "Using spatial-temporal ensembles of convolutional neural networks for lumen segmentation in ureteroscopy." *International Journal of Computer Assisted Radiology and Surgery* (2021): 1-8.

[3] Chen, Alvin I., et al. "Deep learning robotic guidance for autonomous vascular access." *Nature Machine Intelligence* 2.2 (2020): 104-115.