Innovations in Laparoscopic Imaging: Surgical Instrument Segmentation with a Modified U-Net Model Siamese Branch

National Polytechnic Institute
College of Mechanical
and Electrical Engineering

Authors: Rodrigo Emmanuel Flores-Avalos, Rodrigo Eduardo Arevalo-Acona, Daniel Haro-Mendoza, Manuel Cedillo-Hernandez, Victor j. Gonzalez Villela

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Background

Minimally invasive robotic-assisted surgery has revolutionized healthcare, offering precision and reduced recovery times. However, it also introduces challenges such as the loss of depth perception and tactile feedback. To mitigate risks like iatrogenic injuries, robust surgical instrument detection and segmentation systems are essential.

Question

How can a siamese neural network improve the segmentation and detection of surgical instruments in robotic-assisted surgeries, enhancing accuracy and reliability compared to traditional methods?

Results

The proposed siamese U-Net demonstrated superior performance on benchmarks, achieving an Intersection over Union (IoU) of 0.9641 and accuracy of 0.9689.

It outperformed state-of-the-art methods such as DDANet and SegNet. Moreover, the model maintained computational efficiency, validating its applicabilityin real-time surgical settings.

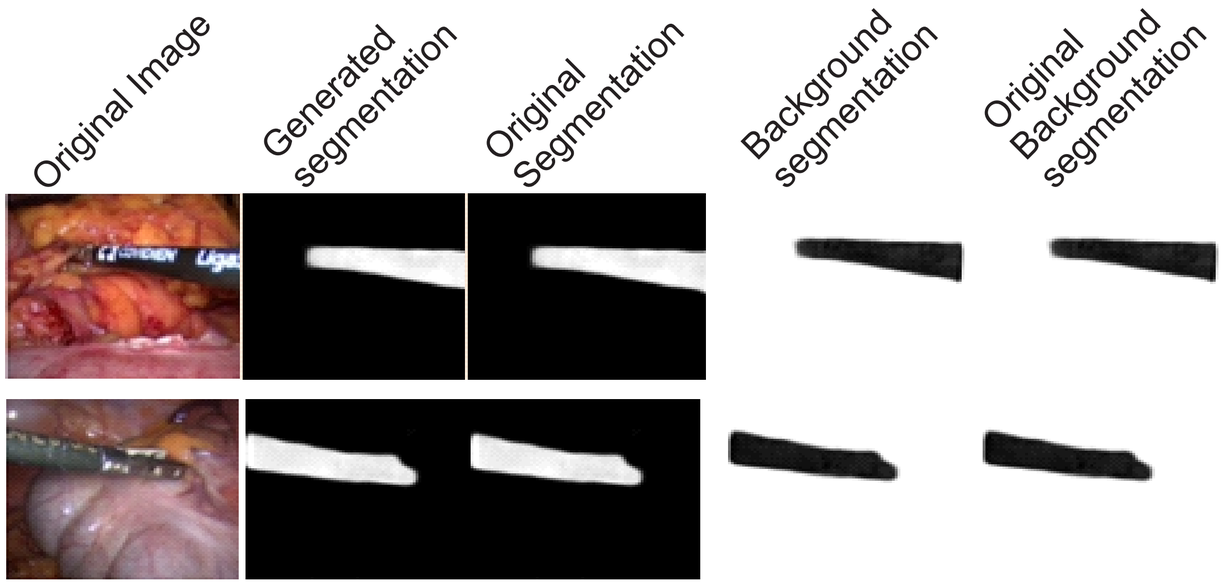

Fig 2. Segmentation results in laparoscopy enviroments

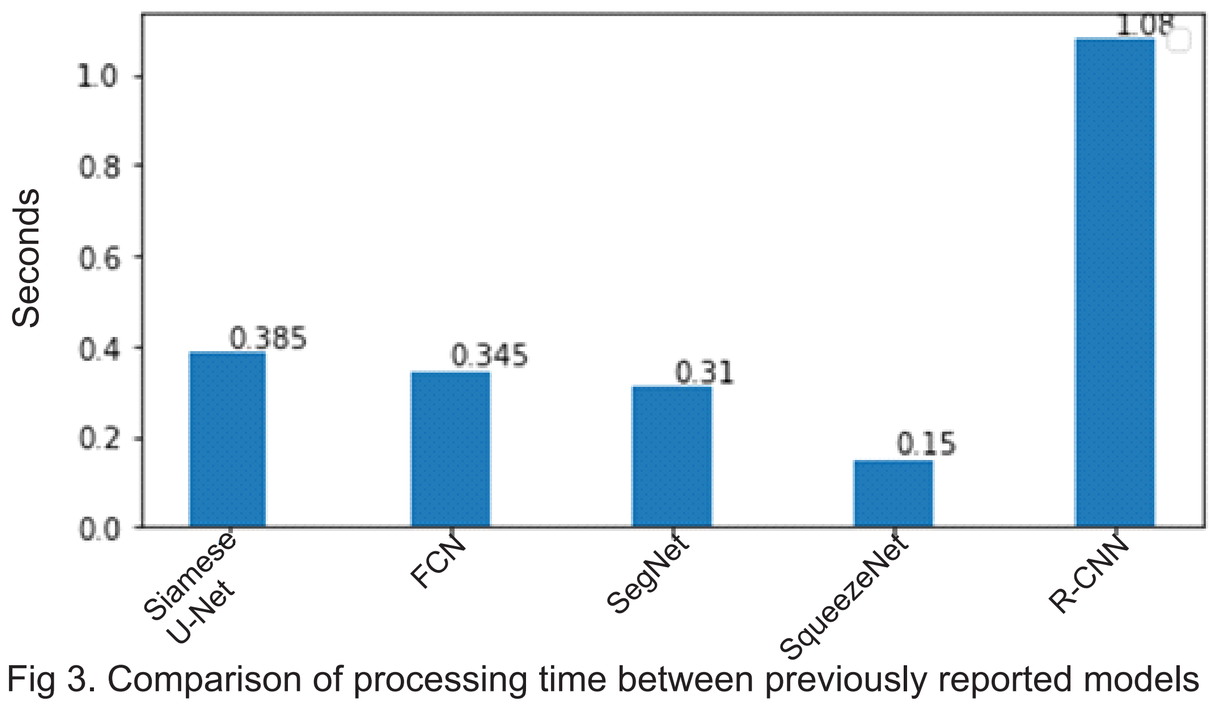

Fig 3. Comparison of processing time between previously reported models

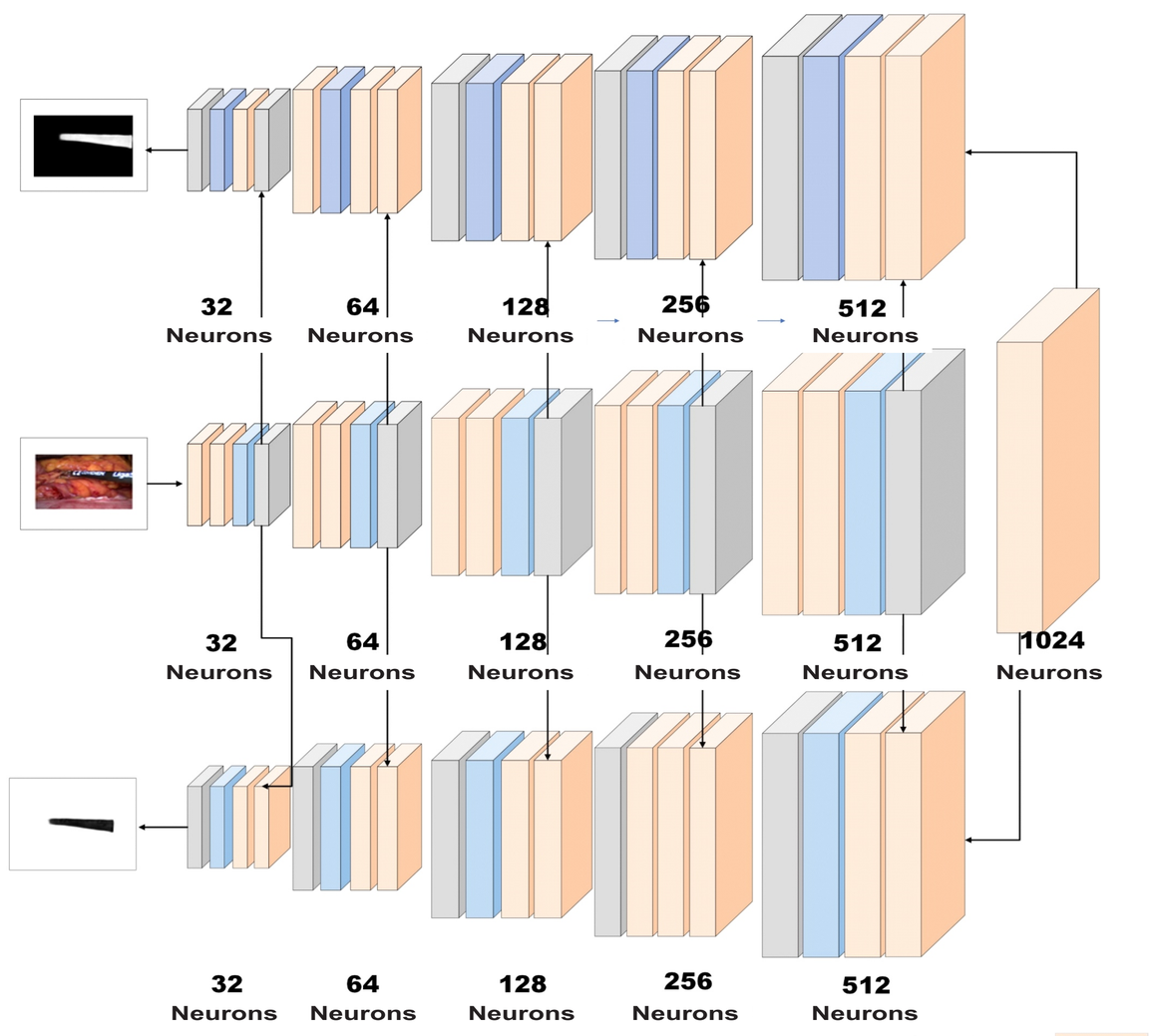

Fig 1. Architecture of Background image segmentation

Conclusions

A siamese neural network effectively segments and detects surgical instruments, significantly enhancing performance metrics over existing models. This system holds potential for advancing semi-autonomous robotic surgeries, surgeon training, and psychomotor skill assessment, thereby improving surgical outcomes.

Autors	Methods	Results
Yu et al, 2020	Hollistic U-Net	Accuracy = 0.9156 IoU = 0.8645
Streckert et al, 2023	SegNet	Dataset Endovis: IoU = 91.21 Synthetic dataset: IoU = 89.55
Our Method	Siamese U-Net	IoU = 0.9641 Accuracy = 0.9689 Recall = 0.9358

References

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[2] E.-J. Lee, W. Plishker, X. Liu, S. S. Bhattacharyya and R. Shekhar, Weakly supervised segmentation for real-time surgical tool tracking, Healthcare Technology Letters, vol. 6, nº 6, pp. 231-236, 2019, doi: https://doi.org/10.1049/htl.2019.0083.