Real-Time AI-Based Smoke Removal in Laparoscopic Surgery: First In-Vivo Feasibility Study

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Background

- Smoke generated by electrocautery during laparoscopy obstructs vision, leading to interruptions and prolonged procedure times
- AI-based applications have shown promise in offline smoke reduction, but **not in real time**
- This presents the first documented in-vivo demonstration of **real-time AI-powered smoke removal** using a system called **CLARIS by vopemed**

Methods

- A feasibility session of a live laparoscopic **nephrectomy** in a porcine model was performed (18,139 frames)
- Surgical smoke was generated via monopolar electrocautery
- **Dark Channel Prior** (DCP) and **Fog Aware Density Evaluator** (FADE), two common referenceless smoke metrics, were calculated retrospectively

Fig. 1. Real-time AI-based smoke removal with CLARIS (left) and the original feed (right)

Table 1 - Mean and standard deviation values of DCP and FADE.

	Input	CLARIS
Mean DCP	1.25±0.35	1.09±0.33
Mean FADE	61.47±20.73	42.32±15.98
Mean Improvement		**22%**

Results

- CLARIS operated **continuously without any frame instability**
- CLARIS consistently improved the DCP and FADE (Table 1)
- Qualitatively, the surgeon reported **improved visibility,** noting greater **contrast** and more **defined anatomic structures** during smoke (Fig. 1)
- **No adverse events** occured and integration required **no workflow modifications**

Conclusion

- Preliminary results show that **CLARIS improves visibility** by reducing smoke during **live nephrectomy**, making it a promising technology to enhance vision in MIS in real-time
- Future work will explore CLARIS' effectiveness in other MIS procedures, camera setups to assess generalization