Development of a Clinically Relevant Image Quality Metric to Evaluate Artificial Intelligence-Enhanced Smoke Removal in Laparoscopic Surgery

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Background

- Lens obstruction is common in Minimally Invasive Surgery (MIS), leading to impaired visibility and interruptions in surgical workflow
- AI based image enhancement system for MIS is a growing field of research, however, quantifying the performance is challenging due to the lack of a standard metric defining visibility
- Existing literature relies on the metric FADE[1], which is not designed for surgical applications and lacks clinical meaning
- This poster proposes a novel Image Quality Metric (IQM) for MIS to create a standardized metric to quantify visibility during surgery

Methods

- 100 smoke frames from 10 laparoscopy cholesystectomy procedure videos were extracted
- 5 experienced MIS surgeons rated visibility on a scale from “Bad ” to “Excellent”
- Various standard computer vision image metrics were extracted for each image
- Grid search identified the best metric combination to correlate with the subjective ratings

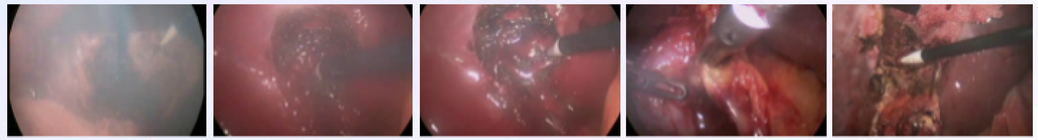


Figure 1: Examples of images at each rating

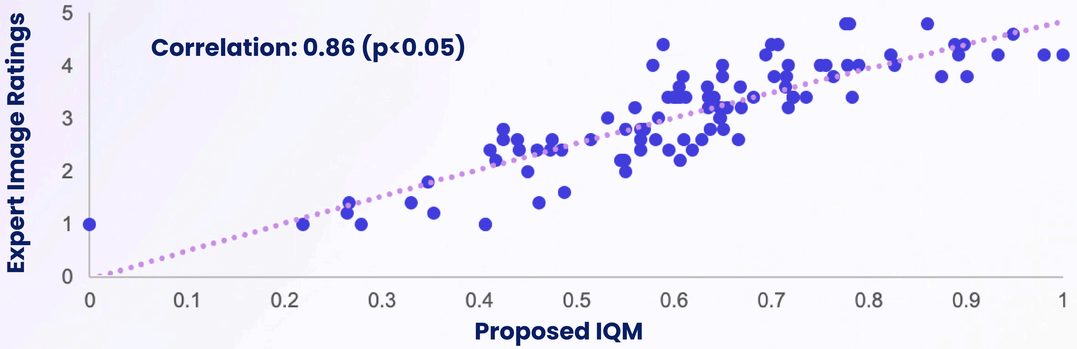


Figure 2: Correlation of proposed IQM with surgeon ratings

Results

- The proposed IQM demonstrated a Pearson correlation of 0.860 ($p<0.05$) with surgeon ratings, outperforming FADE (correlation = 0.72, $p<0.05$)
- The combination of metrics such as entropy, Dark Channel Prior Average, and sharpness variance showed the strongest alignment with subjective ratings

Conclusion

- A novel IQM can bridge the gap between the objective image metric and subjective clinical perception of smoke
- Future works will expand the surgeon participation and expand the metric to be applicable to various surgery types and types of contaminants

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[1] L. K. Choi, J. You, and A. C. Bovik, "Referenceless Prediction of Perceptual Fog Density and Perceptual Image Defogging," IEEE Transactions on Image Processing, vol. 24, no. 11, pp. 3888-3901, Nov. 2015.