Automated Surgical Phase Recognition for Laparoscopic Hiatal Hernia Repair using Artificial Intelligence

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Background

- Automatic phase recognition is a useful tool for surgical workflow analysis that can be used for improving case timing, identifying outliers in case duration, and reviewing critical steps
- We sought to develop a deep learning-based computer vision model for automatic phase recognition for hiatal hernia repair

Methods

- Seven surgical phases were defined for hiatal hernia repair, based on the SAGES video-based assessment tool
- Dataset of 46 videos was labeled and split into training, validation, and test sets
- Model architecture (Figure 1):
  - Visual: convolutional neural network (CNN) extracts visual information from frames
  - Temporal: data from CNN is passed to a transformer model in series
  - Combined visual-temporal model
- Model assessed on the test set with overall accuracy, area under the receiver operating characteristic curve (AUROC), and area under the precision-recall curve (AUPRC)
- Grad-CAM used to identify which parts of the image were used by the model

Results

- 28 cases used for training, 8 for validation, and 10 for test set
- Overall accuracy of 75%, AUROC per class was >0.95, AUPRC ranged from 0.63 – 0.99 (Figure 2)
- Analysis with Grad-CAM showed that the model identified relevant anatomy (Figure 3)

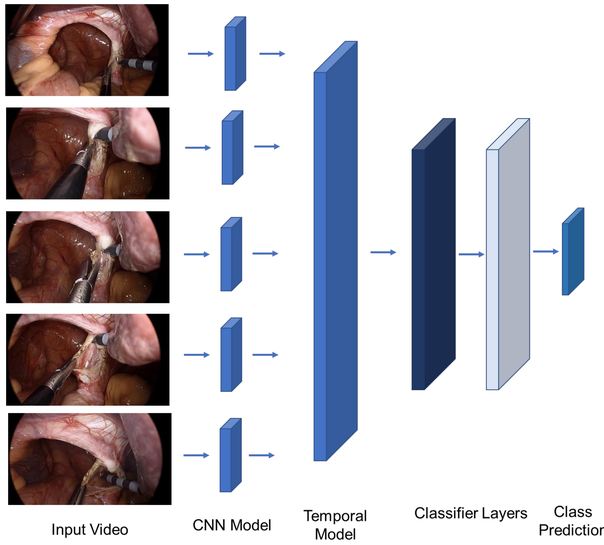


Figure 1: Model architecture

Conclusions

- Next steps: label additional videos and re-train with more data (semi-supervised learning)
- Phase recognition model will be useful for education and quality improvement
- Foundation for more complex surgical artificial intelligence tools, such as anatomic identification and skill assessment

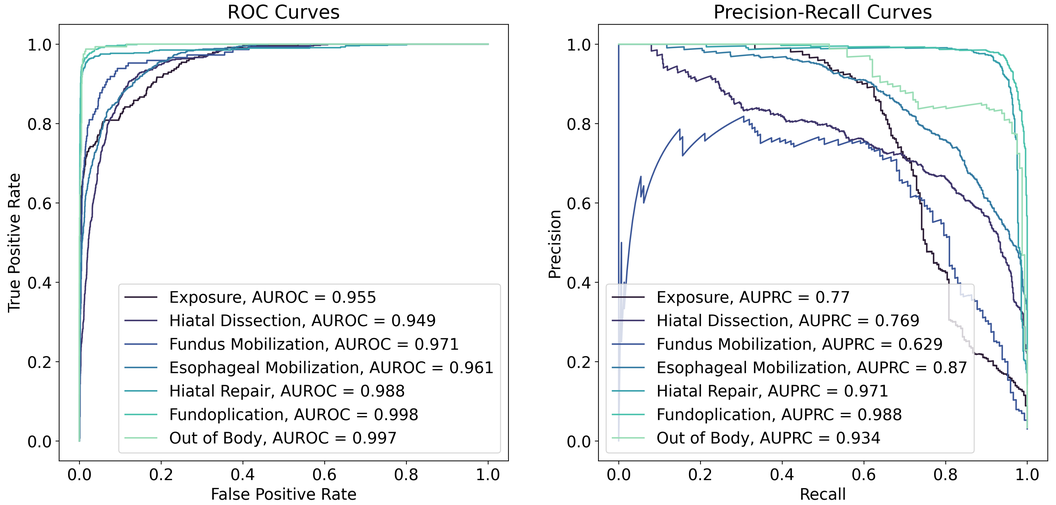


Figure 2: Receiver operating characteristic and precision-recall curves

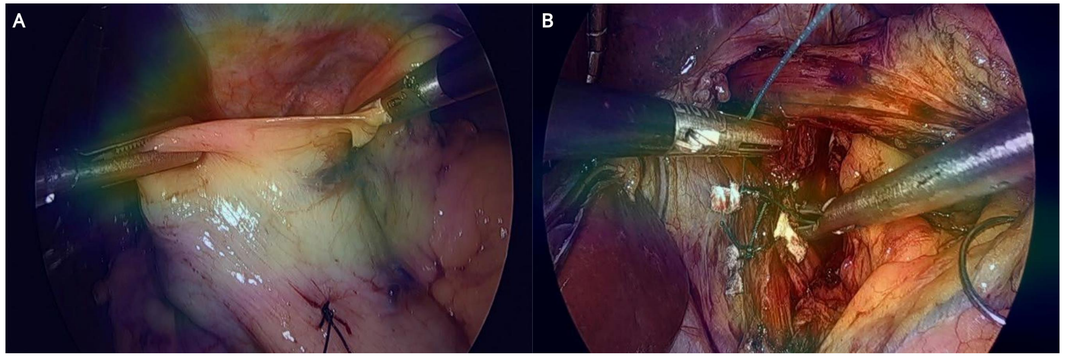


Figure 3: Grad-CAM heatmaps of pixel importance, red marks highest importance, A – Fundus mobilization, B – Hiatal repair

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