DEVELOPMENT OF DEEP LEARNING MODEL FOR SAFETY DIRECT OPTICAL TROCAR INSERTION IN MINIMALLY INVASIVE SURGERY: AN INNOVATIVE METHOD FOR PREVENTING TROCAR INJURIES

AI for prevent direct trocar injury

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Objective

To develop a deep learning model for ensure the surgeon's safety during direct optical trocar placement with alarming tools that could assist surgeons in reducing tragic complications resulting from misinterpretation of abdominal wall anatomy.

Method

The surgeon labeled the bounding box and defined the classes based on the annotation of six layers of the abdominal wall: subcutaneous, anterior rectus sheath, rectus muscle, posterior rectus sheath, peritoneum, and abdominal cavity. The YOLOv7 model, the most advanced deep learning detector, was used to detect the abdominal wall layer. In order to prepare for real-time detection in the operating room, we trained the model on still images and also applied it to laparoscopic videos. After identifying the peritoneum layer and abdominal cavity, the alarm system was activated. Mean average precision (mAP), precision, and recall were calculated for the purpose of evaluating this model.

Results

From 39 laparoscopic video cases, 1,127 images were captured. The proposed model was trained with 790 images, validated with 112 images, and evaluated with 225 images. The model was trained for 100 epochs before being fine-tuned with 200 epochs by transferring the pre-trained weight from the first hundred epochs. The evaluation results from validation set were 80.0% mAP, 77.6% precision, and 80.6% recall. The alarming system has been validated and accepted by experienced surgeons at our institute.

Conclusion

In this study, we discovered that the potential of deep learning could be utilized to aid surgeons in the direct optical trocar insertion process. During the insertion of a trocar, the proposed model identifies and provides accurate landmark references in real-time, accompanied by an alarming system could prevent direct optical trocar complication.

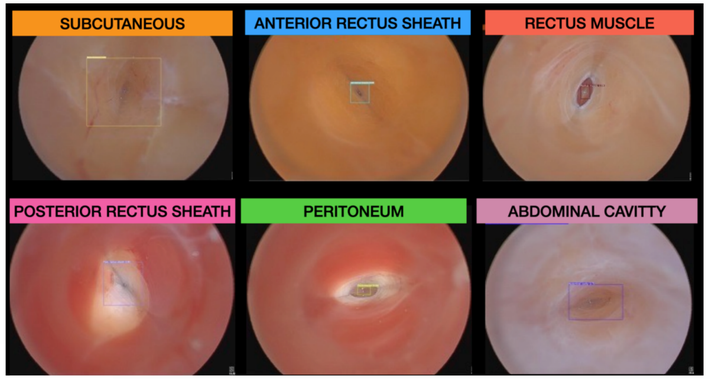


Table 1 : The results of predicted bounding box for each class

Class	Precision	Recall	AP
Subcutaneous	80.0%	76.5%	77.3%
Anterior rectus sheath	56.2%	83.3%	69.2%
Rectus muscle	84.6%	87.5%	90.9%
Posterior rectus sheath	69.5%	87.5%	80.6%
Peritoneum	71.7%	80.9%	77.2%
Abdominal cavity	59.1%	59.0%	60.6%
Average	70.2%	79.1%	76.0% (mAP)

Table 2: The evaluation of abdominal wall detection model

Number of acceptance (%)
Inferenced alarming sound on 15 laparoscopic videos

Surgeon ID	Accept	Reject
Surgeon I	14	1
Surgeon II	13	2
Surgeon III	14	1
Average	13.67 (91.13%)	1.33 (8.87%)

Table 3: : The surgeon's acceptance of the alarming sound algorithm on the testing set

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