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Research

LapTool-Net^{TM}: A Context-Aware Deep Learning System for Automatic Detection of Surgical Tools in Laparoscopic Videos

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Introduction: Monitoring the usage of different surgical instruments in a laparoscopic procedure is a critical part of developing an automated system for tracking surgical actions. The objective of our technology is to develop the LapTool-Net^{TM}, a deep learning-based system for automatic detection of surgical tools.

Methods: LapTool-Net is a multi-label classifier that was designed to detect the presence of surgical tools in a laparoscopic video. It is a deep CNN-RNN model, where CNN is a deep feed-forward artificial neural network that is trained to learn high-level features in still frames of the video, and RNN is trained using a sequence of frames from the videos to learn the temporal features. The unique aspect of the LapTool-Net is the awareness of the context of the usage of the surgical tools, i.e. the tools' co-occurrence pattern, and the correlation between the tools and the tasks.

Results: We used the publicly available cholec80 dataset, which contains 80 videos of laparoscopic cholecystectomy. The extracted frames were manually labeled for seven tools; bipolar, clipper, grasper, hook, irrigator, shears, and specimen bag. The training set contained 40 videos that were used to train the CNN-RNN model based on an inception-V1 and Gated Recurrent Unit (GRU) architectures. The other 40 videos were used for validating the performance of the model. Our current accuracy is 85.77% for online mode and 91.92% for offline mode. The average per-class F1-scores are 93.10% and 96.11% for online and offline respectively. The processing time for each frame is <0.01 seconds, which makes LapTool-Net suitable for real-time applications.

Conclusions: LapTool-Net can be used in real-time for monitoring surgical actions to prevent errors and provide instantaneous feedback for quality improvement. It can also be used offline for the assessment of the recorded videos, information retrieval for education purposes and operative summary report generation.

Input frame for Grasper
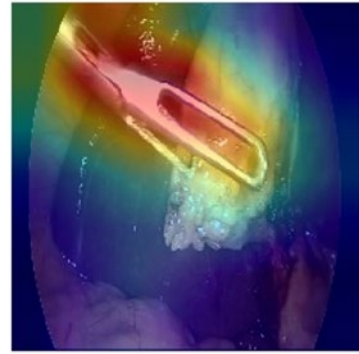
Correct prediction for Grasper