Theme- Problem 2: AI in Healthcare

Surgical Tools Detection During Laparoscopic Surgery via Image Segmentation & Automatic Enhancement

Problem Statement - Robotic system used in laparoscopic surgery can cause damage to the surgical instruments, organs, or tissues during surgery due to a narrow field of view and operating space, and insufficient tactile feedback. For efficient feedback during surgery surgical tools need to be identified real time for improving the accuracy and safety of laparoscopic surgical robots and performing robotic surgery more intelligently.

Proposed Solution - We have improved contrast and smoothness of surgery image using CLAHE(Contrast Limited Adaptive Histogram Equalization). This enhanced image is then used to provide segmentation for the surgical tool by efficiently finding a mask for the tool present in the frame using Mask-RCNN algorithm.

Use in Medical Science

- Medical image segmentation has various roles in computer-aided diagnosis systems in different applications like improving the focus on organs and surgical tools during the operation.

- The use case can also be extended by applying it in microscopy, dermoscopy, X-ray, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography .

- Doctors will be able to concentrate more on the body parts & surgical tools because the image is segmented and enhanced.

- The image segmentation is very helpful in identifying the human organs in robotic surgeries for accurate position of the surgical tools.

Image Segmentation

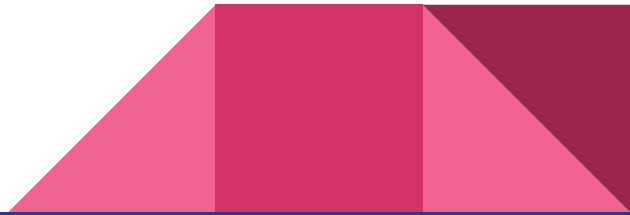
- Image Segmentation is the process by which a digital image is partitioned into various subgroups (of pixels) called Image Objects, which can reduce the complexity of the image, and thus analysing the image becomes simpler.

- We can divide or partition the image into various parts called segments. It's not a great idea to process the entire image at the same time as there will be regions in the image which do not contain any information. By dividing the image into segments, we can make use of the important segments for processing the image. That, in a nutshell, is how image segmentation works.

- We use various image segmentation algorithms to split and group a certain set of pixels together from the image. By doing so, we are actually assigning labels to pixels and the pixels with the same label fall under a category where they have some or the other thing common in them.

- For providing the surgeons with this facility we develop a Mask - RCNN based approach that can identify the presence of any surgical tool in the frame.

- When a tool is identified it gets masked with a color that highlights the particular tool.



Automatic Image Enhancement

- Before image is used as input for segmentation, it is contrasted to improve its quality. We do that using CLAHE.

- The Contrast Limited Adaptive Histogram Equalization method is a histogram-based method used to improve contrast in images. This technique computes the histogram for the region around each pixel in the image, improving the local contrast and enhancing the edges in each region.

- First we convert input image to YCR_CB and apply CLAHE on it. The returned image is converted back to RGB.

Architecture

- The input that is fed in the system is a raw endoscopic image. The input image usually consists of surgical tool performing some operation inside the body.
- This image is firstly fed into the image enhancer (CLAHE) that improves the overall understandability of the image by adjusting the overall contrast and brightness.
- Now this enhanced image is fed into the image segmentation algorithm for which we deployed mask-RCNN algorithm to generate mask around the surgical tool if present.
- Finally the output is the image that is an enhanced masked/ segmented image of the surgical tool that could be present in the image frame.

Result

Input image

Enhanced image

Mask

Future Work

- Since we are planning to enhance robotic laparoscopic surgery in real time, we can apply the same algorithm of image contrasting and segmentation on 3D videos captured real time to assist surgeons during operation.
- We can further classify the name of the exact tool that is in the frame where at present we only classify it as a tool or not tool.
- Further improvement in the image enhancer by making an hybrid system that incorporates various algorithms to enhance the overall understandability of the image.