Analysis of Gas Leakage during Laparoscopic Surgery

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Introduction

Laparoscopic surgery is a less-invasive form of abdomen surgery that removes the need for large incisions, instead relying on small incisions combined with cameras and specialized tools to work within the pressurized cavity. However, these ports, while useful for maintaining pressure and allowing the tools entry and exit have been found to leak, exposing the surgeons to potentially hazardous bodily fluids. Through the use of a Schlieren imaging system, these gas leaks can be observed and recorded in order to determine what conditions create the worst leaks and what can be done to prevent them. In order to assess this data, the videos must be analyzed by a code and the data converted to air velocity values, which can become a problem when the air-stream in the video is obstructed by tools, cords, or even surgeons. Through masking, erosion or cropping, these otherwise obstructed videos can still be used.

Schlieren Imaging Systems

- Light provided by light source at angle relevant to the mirror setup
- Light bounced off of parabolic mirror which makes the rays of light all run in parallel with each other
- Parallel light beams bend around changes in density of fluid
- Light hits second mirror and focuses to a point on edge of blade
- The changes in density and light are recorded by the camera the results are shown in Figure 2

The schematic of the setup is shown in Figure 1.

This raw video, while precise, still runs into issues when there are obstructions to the light rays. Without further processing the raw footage will show the velocity of these moving obstructions instead of just the fluid flow, which is why further processing is required.

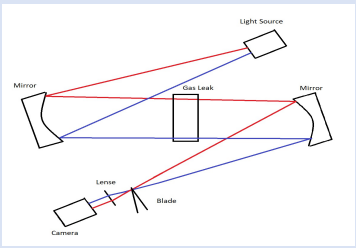

Figure 1: Schematic of Schlieren Setup

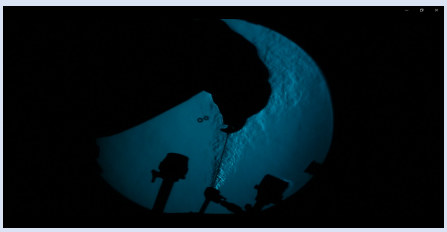

Figure 2: Raw Footage of Gas Leak recorded by Schlieren

Methodology

There are 2 methods to fix the issues produced by the stray velocity vectors: Cropping or Masking

Cropping:
- Used for issues along the edge of the field of view of the camera
- Easiest to fix as it only requires changing the parameters of the frame within the code

Masking:
- More difficult as in most cases an obstruction moves in front of the frame and creates a stray velocity vector not produced by the gas leak
- In order to fix this, a masking system must be implemented into the code
- Afterwards, the borders of this mask must be increased to remove the velocity vectors around the obstruction

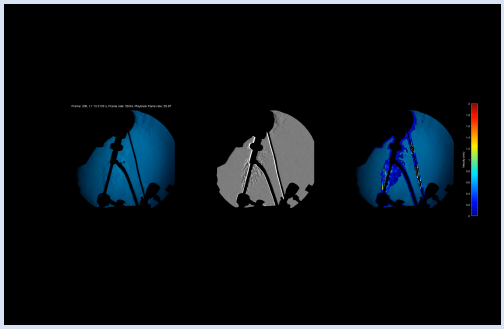

Figure 3: Video data showing a Cropping Issue

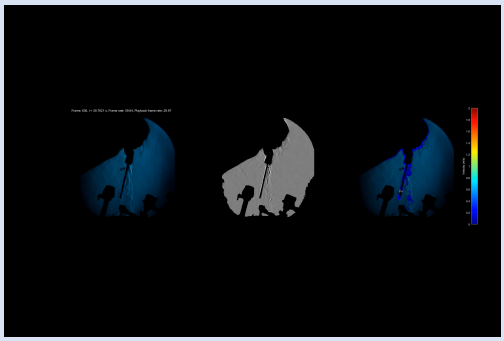

Figure 4: Video data showing a Masking Issue

Future Work:
- Model the ports in an FSI model to determine where failure occurs
- Determine which ports fail and what criteria they fail under