PROJ-H402 | Computing Project

Gastrocopic Exam Images Analysis

Intermediate Report

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Contents

1 Introduction

In the context of a medical study conducted by the service of *Hépato-Gastro-Entérologie* of the *CHU St-Pierre*, the team led by Pr. Pierre Eisendrath is looking for an automatic process for analysis and scoring of gastroscopic images to help them. The study consist in the evaluation of a protocol to improve patient preparation for a gastroscopic exam ; more precisely to reduce the amount of visual 'pollution' induce by foam and saliva in the patient stomac.

Therefore, the purpose of the automatic treatment is to analyze gastroscopic images in real time and output a score corresponding to the level of 'pollution' present in it. In a first time this score will be used to measure the study's protocol efficiency and eventually for indication in future gastroscopic exams.

This intermediate report aims to present the work done on the development of the treatment software since the beginning of the project. It will presents the different thought-process and choices which led to the present implementation of the software.

Note that several sources have been used but are not displayed in this informal intermediate report.

2 Methods and Chosen Language for implementation

It was decided to not use machine learning methods for the following reasons :

1. the images batch size is small, especially in comparison of the input complexity
2. it's interesting to keep the algorithm functioning deterministic considering the medical application

Instead, more classic image processing algorithms are used to achieve the project's objectives.
The language chosen to develop the software prototype is *Python*, because of its flexibility and the number of image processing libraries available. However, it may be interesting to move later to *C++* for efficiency reasons, especially for real-time considerations.

3 Objectives

In order to give a meaningful score from the video sequence processing, it is first needed to automatically determine the frames which must be considered as 'garbage' and not be taken into account into the scoring process. Those can be the frames which are heavily affected by motion blur or the frames where the view is obstructed. In both cases those frames give no relevant information to the medical team. This part of the development is described in the **chapter 4 : Image Selection**.
The second part of the processing of the video is to apply segmentation on each valid frame in order to determine the presence and quantity of 'pollution' in it. It is described in **chapter 5 : Image Segmentation**.
From this information it is then possible to extract and display a meaningful score concerning the video quality, as explained in **Chapter 6 : Scoring**.
The objectives concerning the implementation in real time on *CHU St-Pierre* hardware are let for the next part of the project.

4 Image Selection

The first step is to select the images (frames of the video) that will not be processed because they are not relevant. Down here are some examples of what they can look like.

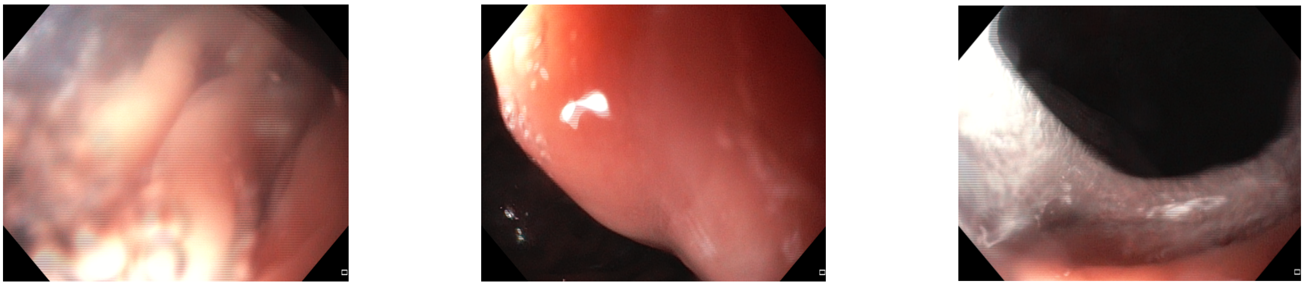


Figure 1: non-relevant frames

Those kind of frames are encountered when the endoscope is obstructed by wall or liquids and when the movement is fast thus creating a lot of motion blur. In the present section different parameters are presented in order to filter those frames.

4.1 Image Saturation

Decomposition of the frames characteristics led to the following observation : the saturation level in the frame is - in a certain way - function of the proximity of the endoscope from the subject. It is understandable since when there is direct contact between the subject and the light source, the light is consequently diffusing through it. It means that mean saturation level in the picture could be used in some way as a threshold parameter to select images that are too close from the wall and therefore useless.

Figure 2 and *Figure 3* shows two opposite examples : one acceptable frame and one 'garbage' frame alongside their representation in saturation level and the corresponding histogram.

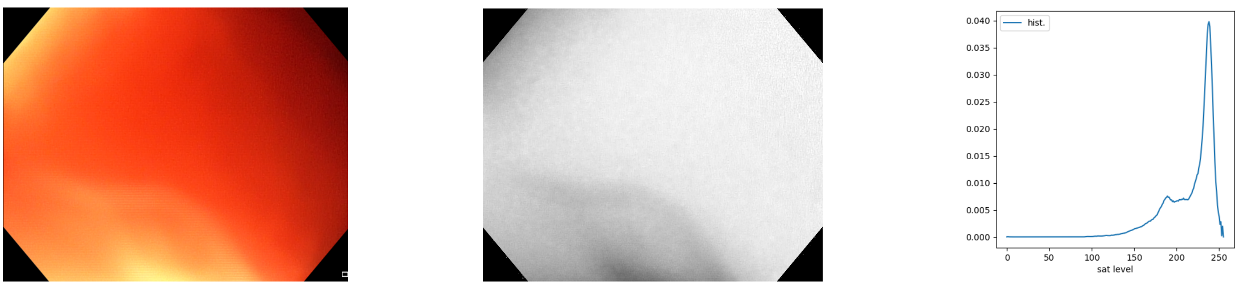


Figure 2: non-relevant frame | representation in sat. level | sat. histogram

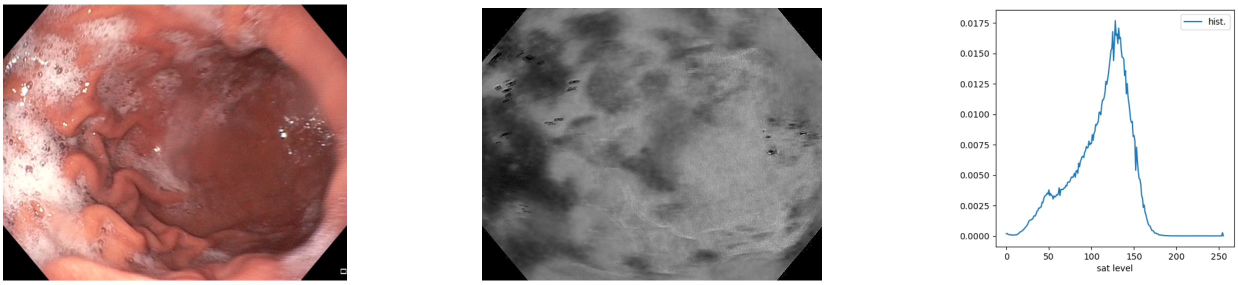


Figure 3: acceptable frame | representation in sat. level | sat. histogram

The respective mean saturation levels are 145 for *Figure 2* and 75 for *Figure 3*. This repeated observation led to the assumption that using the mean saturation level of a frame could be a good threshold to filter it.

4.2 Blur Measure

In the frames the blur can occurs when there's motion or when liquid is in front of the lens. Motion blur appears when a significant motion is made during the exposure time of the given frame. *Figure 4* shows an example of motion blur.

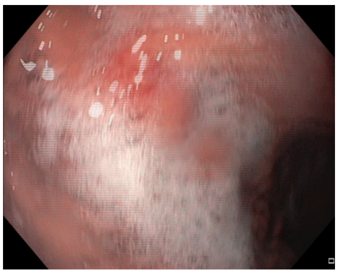


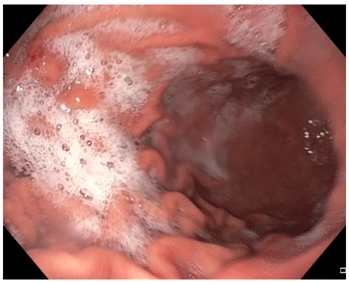
Figure 4: frame affected by motion blur

In addition to the motion blur there is also the presence of horizontal lines that are supposedly caused by the refreshing rate.

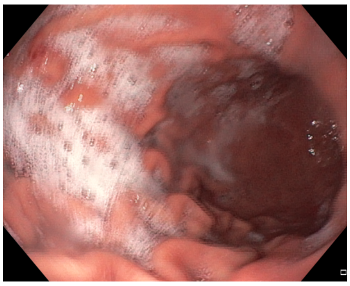
The method tested to measure the blur level in the video's frames consist in calculating the variance of the Laplacian operator. The Laplacian is implemented in the *OpenCV* library and convolve the image (in grayscale) with the following kernel.

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

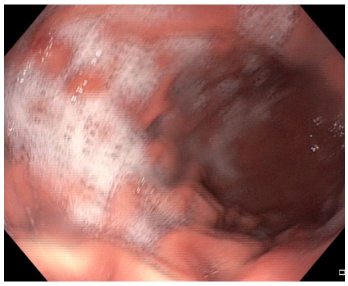
Then the variance is applied to the result of the convolution and gives a single output that can be use to define the blur of the frames. As an example, below is shown 3 consecutive frames with different blur levels caused by motion.



(a) blur = 731



(b) blur = 981



(c) blur = 1582

Figure 5: blur comparison

The method has shown to be also very efficient to help determine which frames are affected by liquid obstruction in addition to movement as in *Figure 6*.

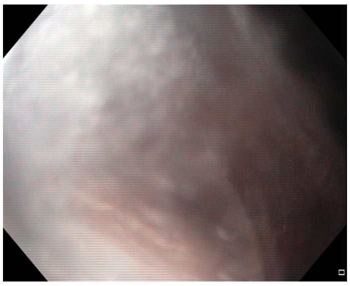


Figure 6: obstruction + movement (blur = 3508)

In conclusion this method has shown to be a good way of filtering non-relevant frames.

4.3 Entropy

The measure of the mean entropy of the frame with the use of *openCV* library has shown to be a good criteria for selection of frames similar to *Figure 2*. Unfortunately the very poor performance of the method (approx. 0.5s per frame) made it unsuitable for real-time purposes and therefore wasn't implemented.

5 Image Segmentation

After having determinate if the frame deserved to be process, it's needed to measure the level of visual 'pollution' in it. In *Figure 7* are shown 2 acceptable frames where pollution cause by foam is visible.

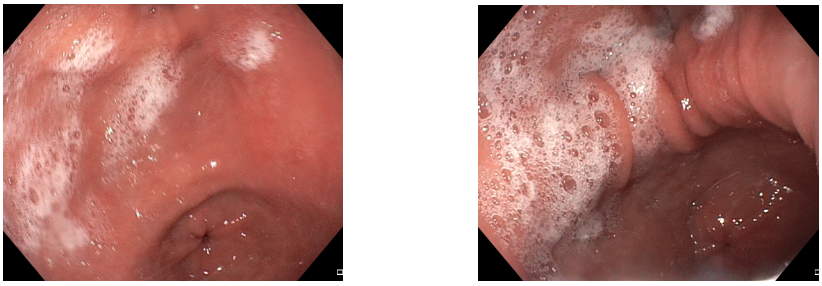


Figure 7: Two polluted acceptable frames

5.1 HSV color-space

The pollution possesses some characteristics which makes it easily segmentable in **HSV** space (Hue, Saturation, Value). After studying it on samples it was found that the pollution can be of two natures

1. under direct light : great hue-range, low-medium saturation, high value
2. else : hue range around red values, low saturation, low-medium value

The image can now be segmented on this basis by only keeping the pixels corresponding to those criteria. An example of segmentation is shown below.

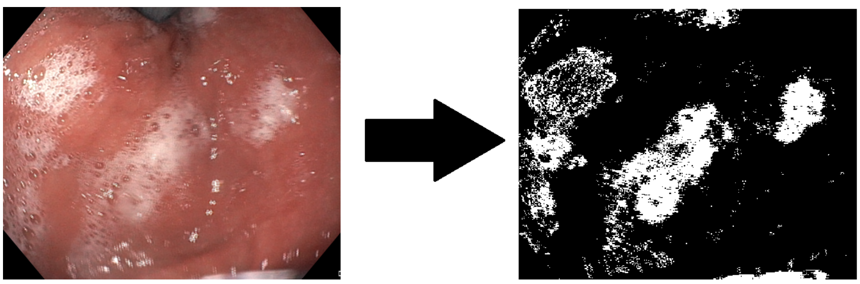


Figure 8: example of HSV segmentation

5.2 Morphological Transforms

Morphological Transforms are used here to refine the segmentation result. In this process the morphological operations used are *CLOSE* and *OPEN*.

The effect of the *CLOSE* operation is to fill the gaps inside the foam detected areas. Below is the result following the previous example. The operation is applied with $7x7$ kernel.

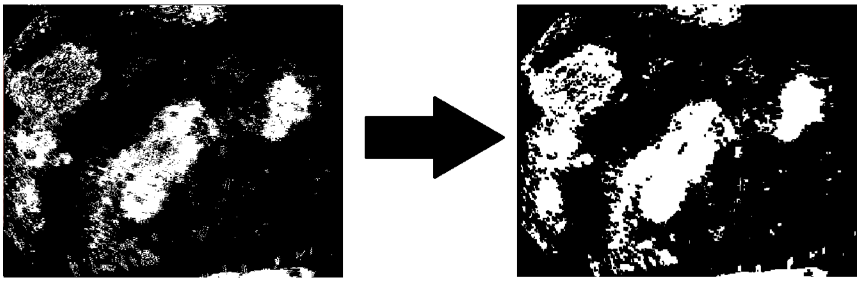


Figure 9: *CLOSE* transformation

The next transformation, *OPEN*, is used here to delete the noise area which are smaller than the used kernel ($7x7$ again). The result is shown in *Figure 10*.

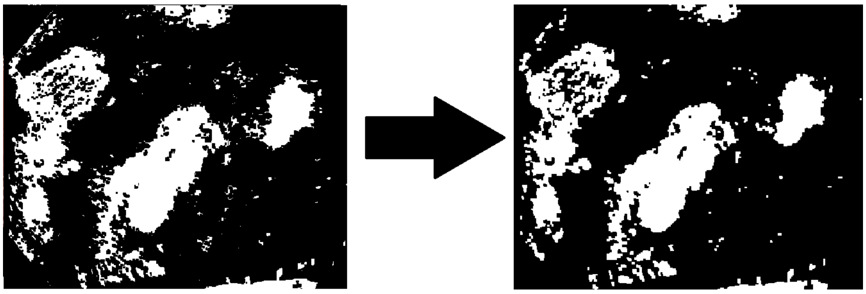


Figure 10: *OPEN* transformation

The de-noising operation could be improved by using a bigger kernel for the *OPEN* transformation and/or adding an *OPEN* transformation with a smaller kernel before the *CLOSE* operation. There's indeed still a lot of false-positives triggered by flares.

6 Scoring

The final step is to generate a score for each acceptable segmented frame. The most obvious method is to base the scoring on the density of pollution-pixels detected per frame. The medical team needs to globally know the sequence quality, so a **mean score** for the whole set of acceptable frames is introduced.

Note that only the succession of at least 4 positive frames are taken into account in the scoring process in order to remove the false-positive accepted frames.

7 Conclusion

The work done yet is mainly an empirical process rather than a careful design based on papers, however the results obtained are encouraging. The next steps of the software's development should be aimed at fine-tuning the actual image processing and starts working on the hardware implementation for real-time use by *CHU St-Pierre* team. To conclude, below are some examples of the software actual processing on sequences, showing what's actually working and what could be improved at this point.