Can Image Enhancement be Beneficial to Find Smoke Images in Laparoscopic Surgery?

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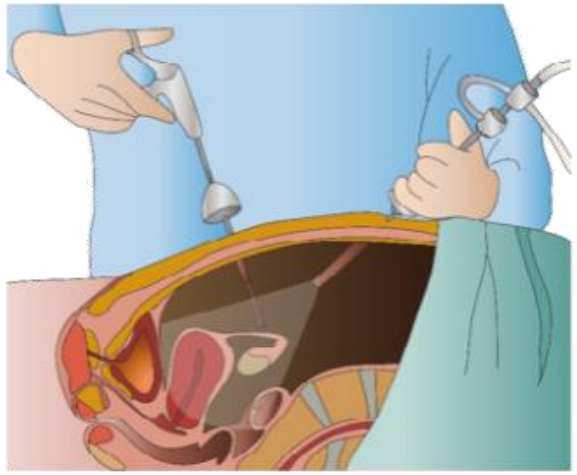
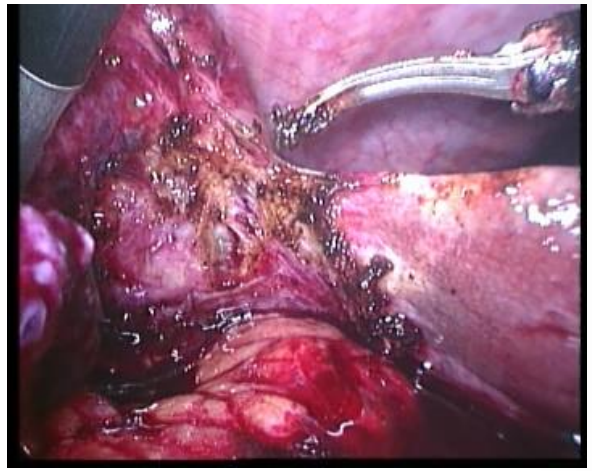
Motivation

Laparoscopic Surgery





- Smoke degrades laparoscopic video quality.
  - Influences surgeon’s visibility
  - Influences the performance of computer vision based navigation systems
  - May be harmful for surgeons and patients

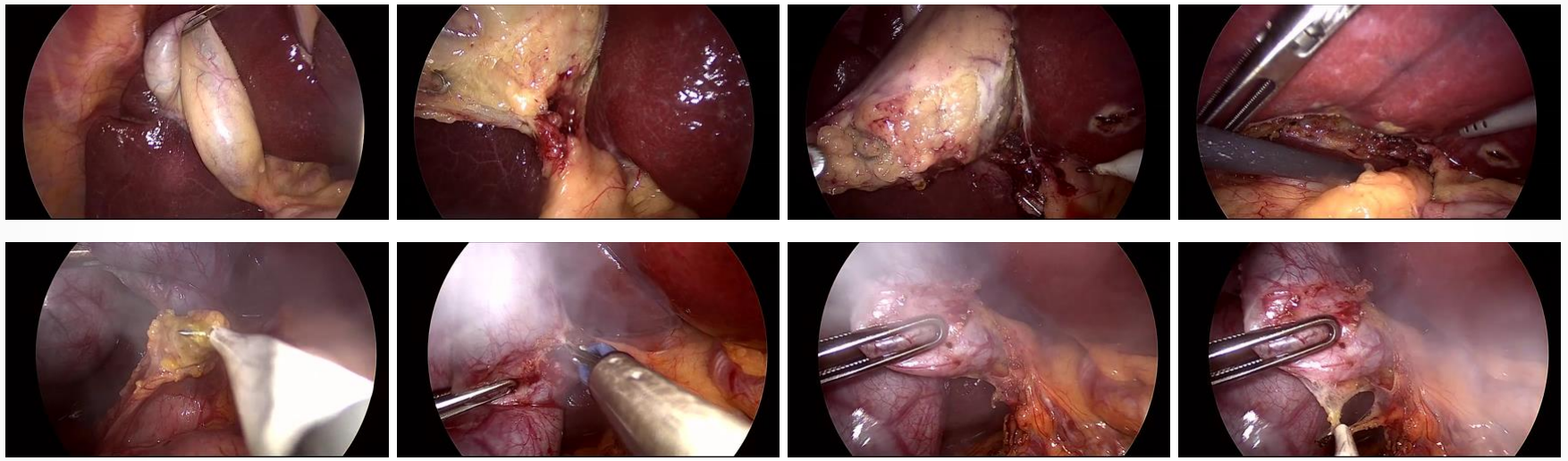
Motivation

- Desmoking technique
  - Computer vision algorithms
  - Smoke evacuation techniques

- **When to start to remove smoke?**

Motivation

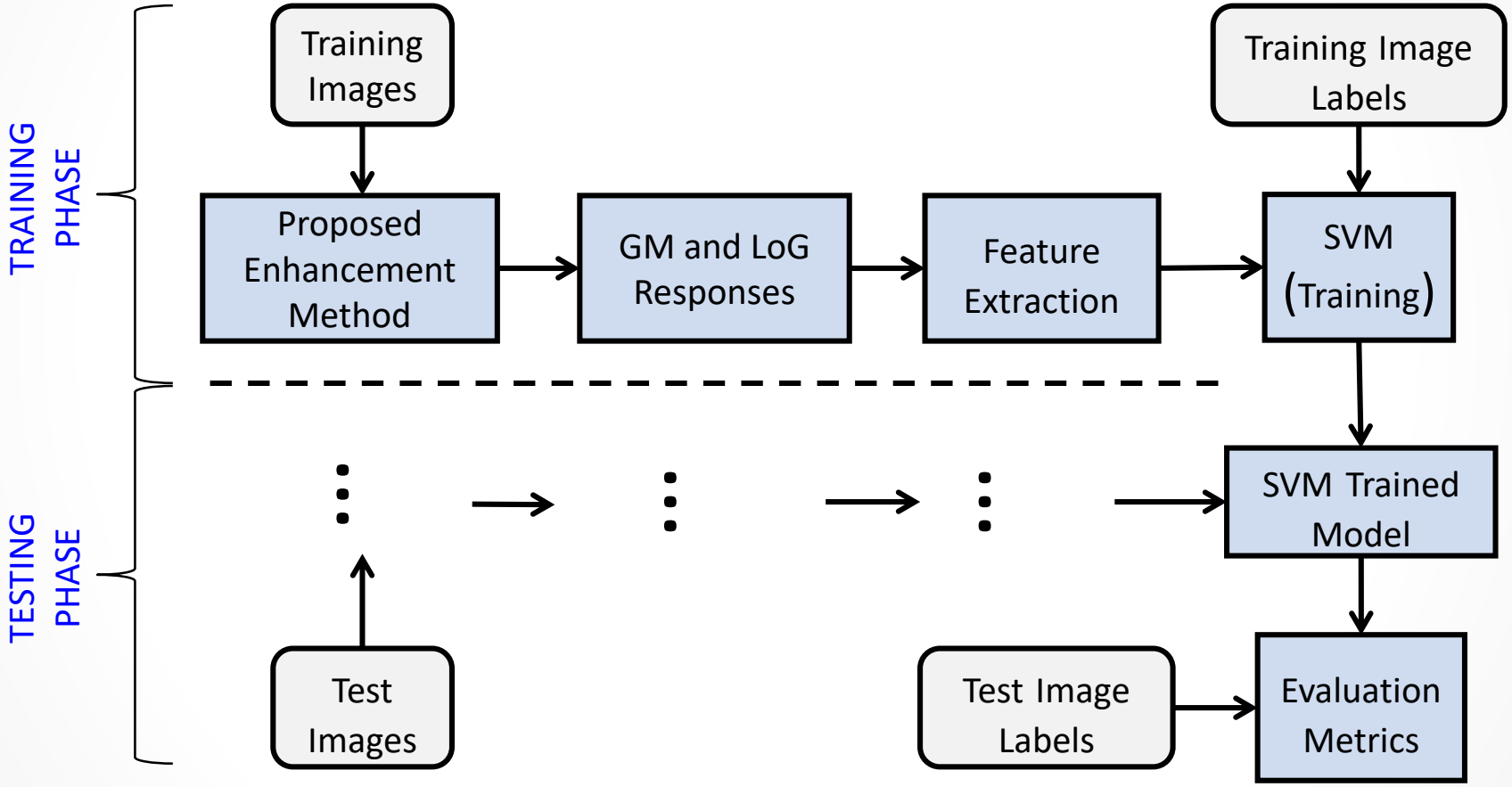
- Smoke/non smoke images classification



- Goal:
  - Enhance the images for improved classification

Main idea

- Pipeline



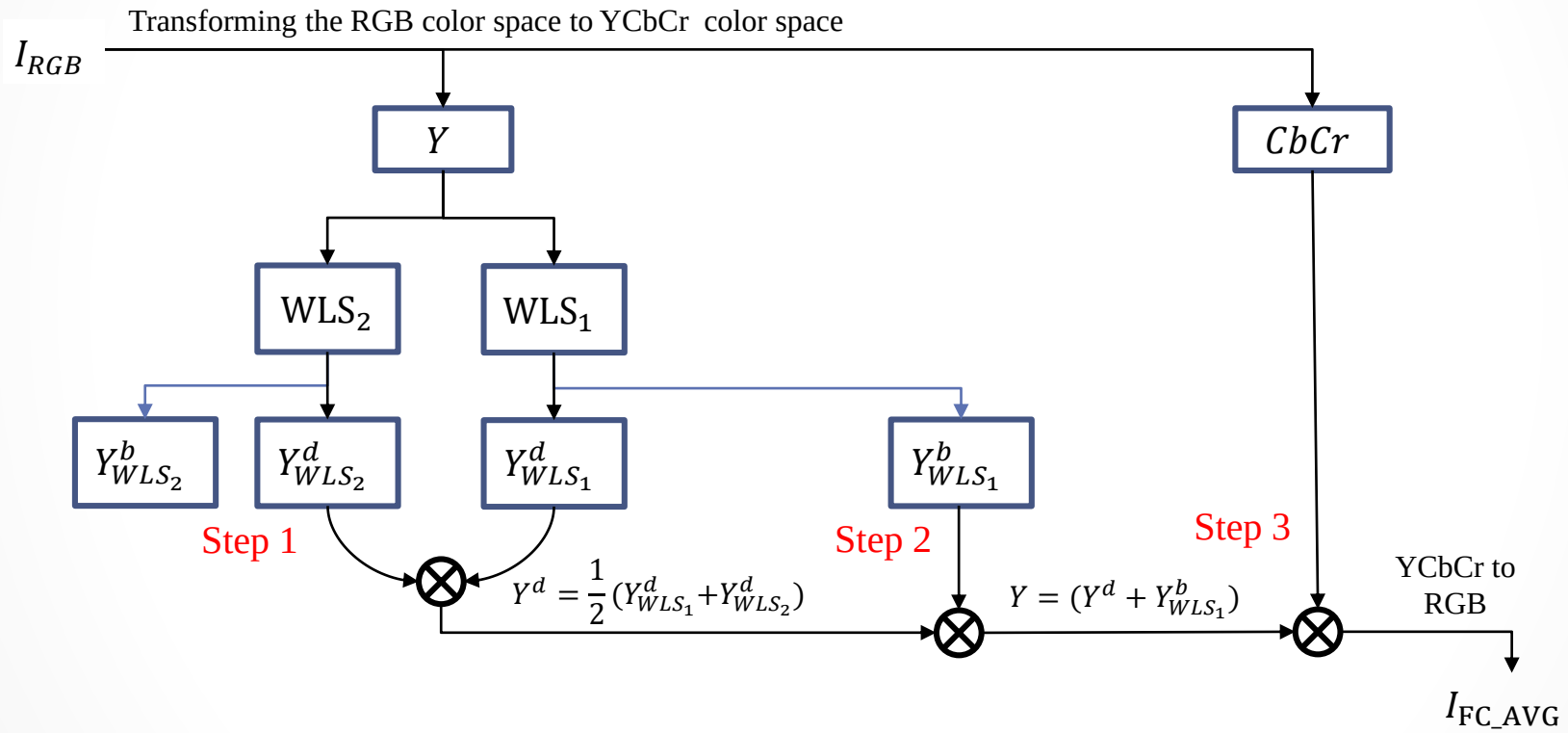
Proposed enhancement method

- Weighted least squares optimization framework (WLS)

$$g^{Filtered} = F_{\lambda}(g) = (I + \lambda L_g)^{-1} g$$

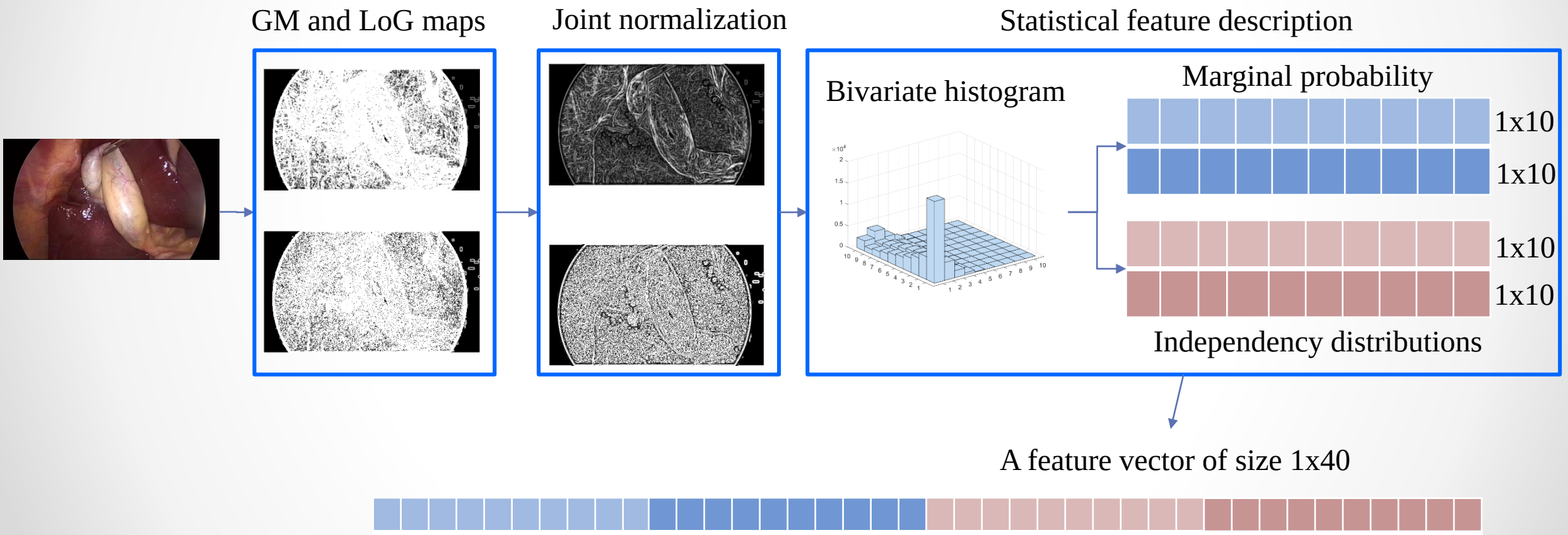
- Decomposition of a base-layer and detail-layers.
  - Base layer = $g^{Filtered}$
  - Detail layer = $g - g^{Filtered}$

Proposed enhancement method



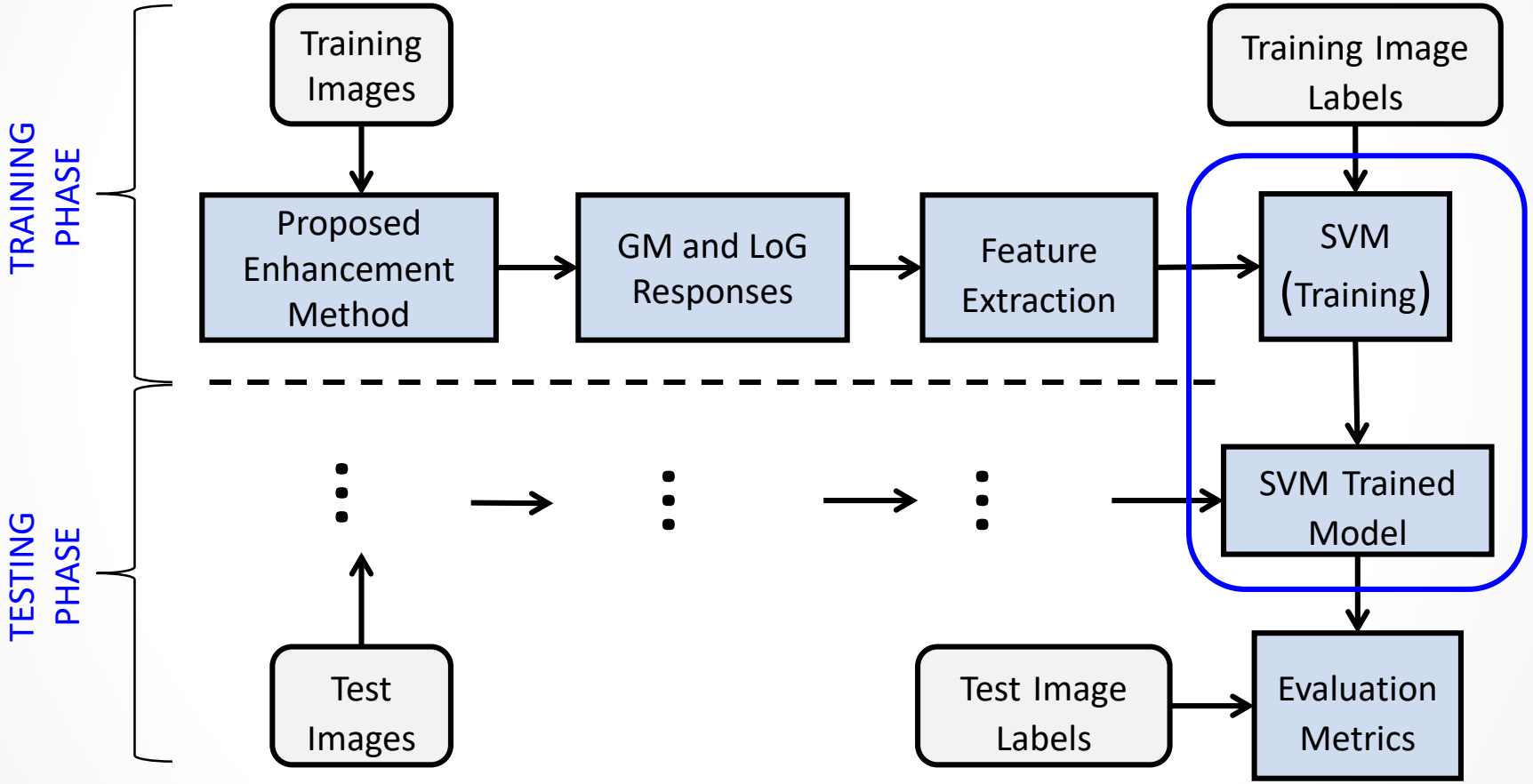
Feature extraction

- Gradient Magnitude (GM) features
- Laplacian of Gaussian (LoG) features



Classifier

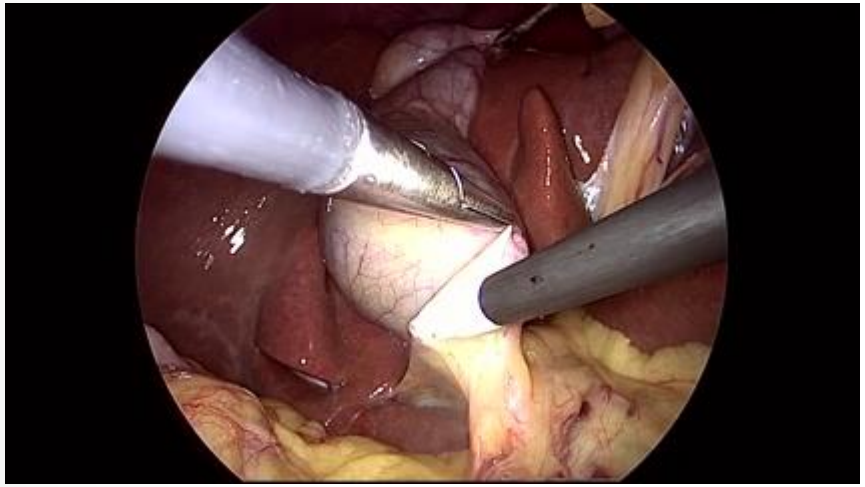
- Pipeline



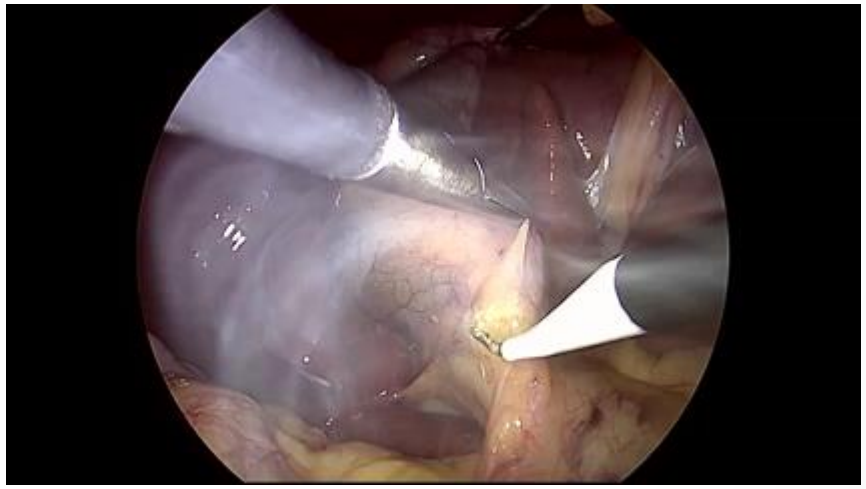
Experiments

- Cholec80 dataset: cholecystectomy surgeries manually labeled with smoke/non-smoke image sequence
  - Training: 4,381 images obtained from three videos
  - Testing: 10,653 images obtained from nine videos

0 - -non smoke



1 - -smoke



Experiments

- How to evaluate the classification result ?
  - Accuracy
    - The higher the better

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$= \frac{The\ number\ of\ \ correct\ classified\ \ smoke / non\ smoke\ images}{Total\ \ number\ of\ \ testing\ \ images}$$

  - F1-Score
    - The higher the better

$$F1 - Score = 2 \bullet \frac{precision \bullet recall}{precision + recall}$$

Experiments

- Comparison with other enhancement methods

Method	Accuracy	F1-Score
RGB	0.60	0.60
IMSHARP	0.58	0.58
BF	0.60	0.59
GF	0.60	0.59
WLS	0.60	0.59
BFWLS_AVG	0.57	0.56
FC_MAX(**Ours**)	0.60	0.59
FC_AVG(**Ours**)	**0.64**	**0.64**

Tab. 1: Comparison with the baseline RGB images and other enhancement methods

Experiments

- Comparison with other enhancement methods

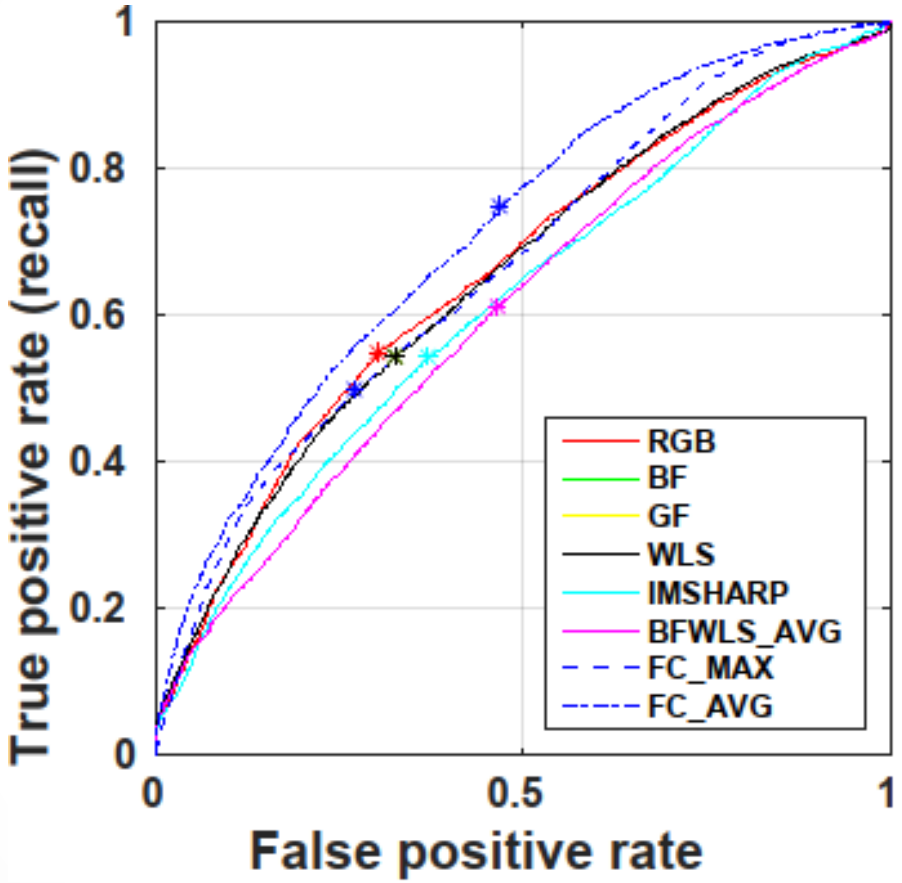


Fig. 1: The ROC curves for smoke/non-smoke classification task. * denotes the EER when the false accept rate is equal to the false reject rate.

Experiments

- Comparison with the saturation histogram based classification methodologies

Method	Accuracy	F1-Score
SPA	0.63	0.58
SAN	0.63	0.59
FC_AVG(Ours)	0.64	0.64

Tab. 2: Comparison with the saturation histogram based classification methodologies Saturation Analysis (SAN) and Saturation Peak Analysis (SPA)

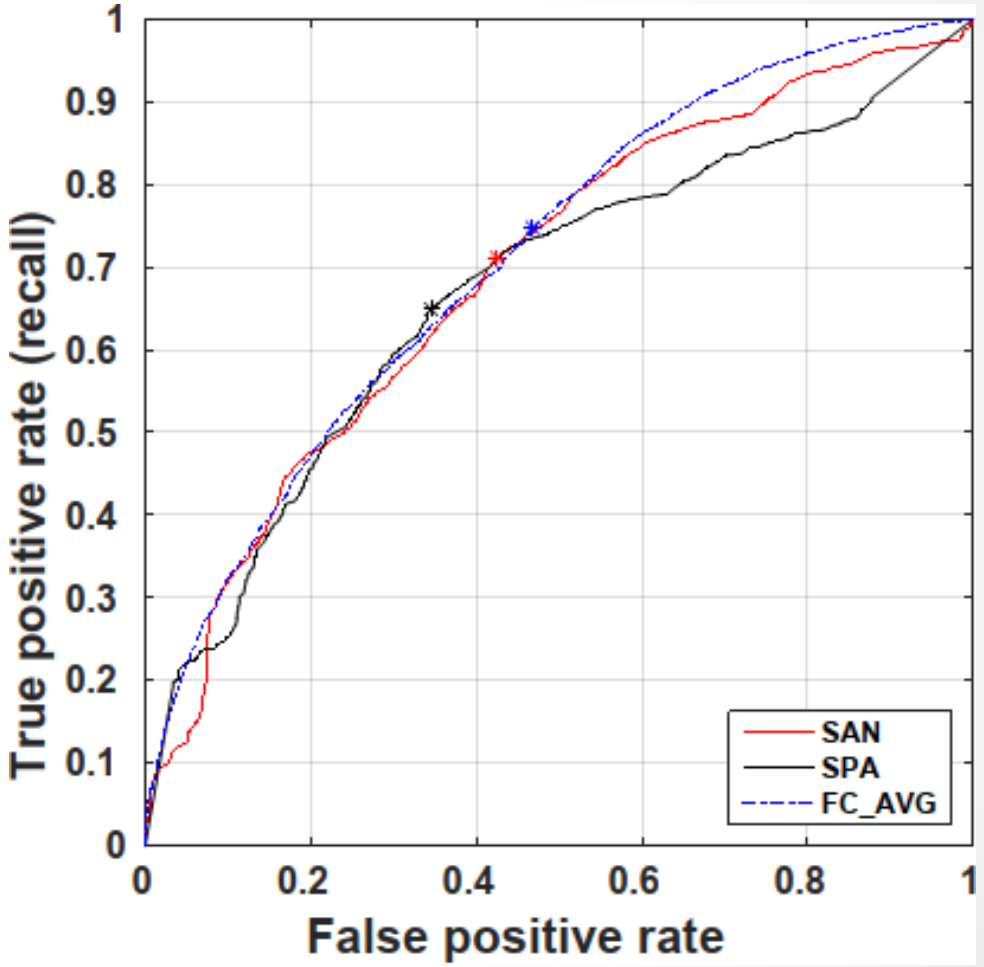


Fig. 2: The ROC curves for the three methods

Conclusion & Discussion

- Propose a method to enhance the informative features
- Combine the enhancement method with a SVM based classification method
- Improved smoke/non-smoke classification results
  - Better result compare to the baseline RGB images
  - Better result compare to he saturation histogram based classification methodologies.
- Future work
  - Employ CNN architecture for the classification task

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Thank you, any questions ?

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