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

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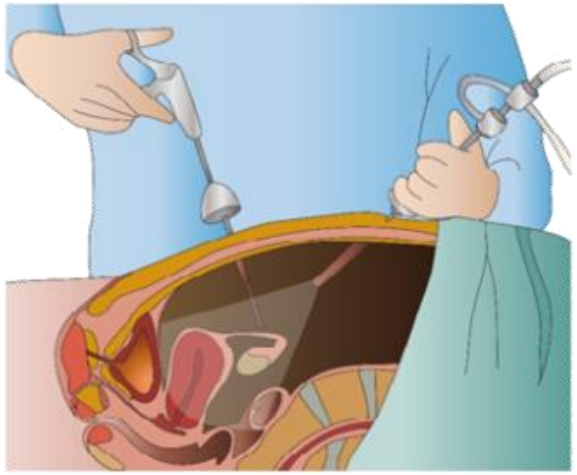
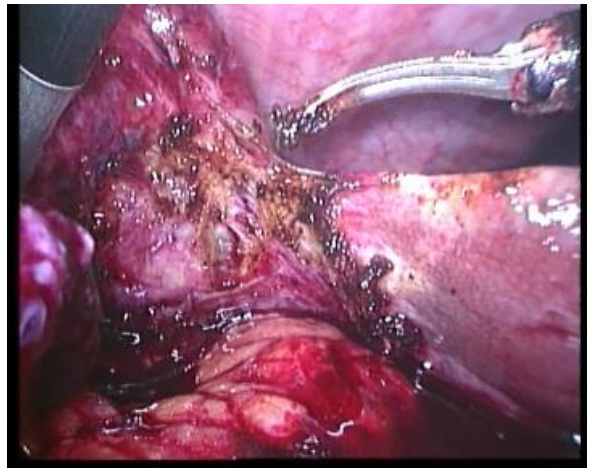
Motivation

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

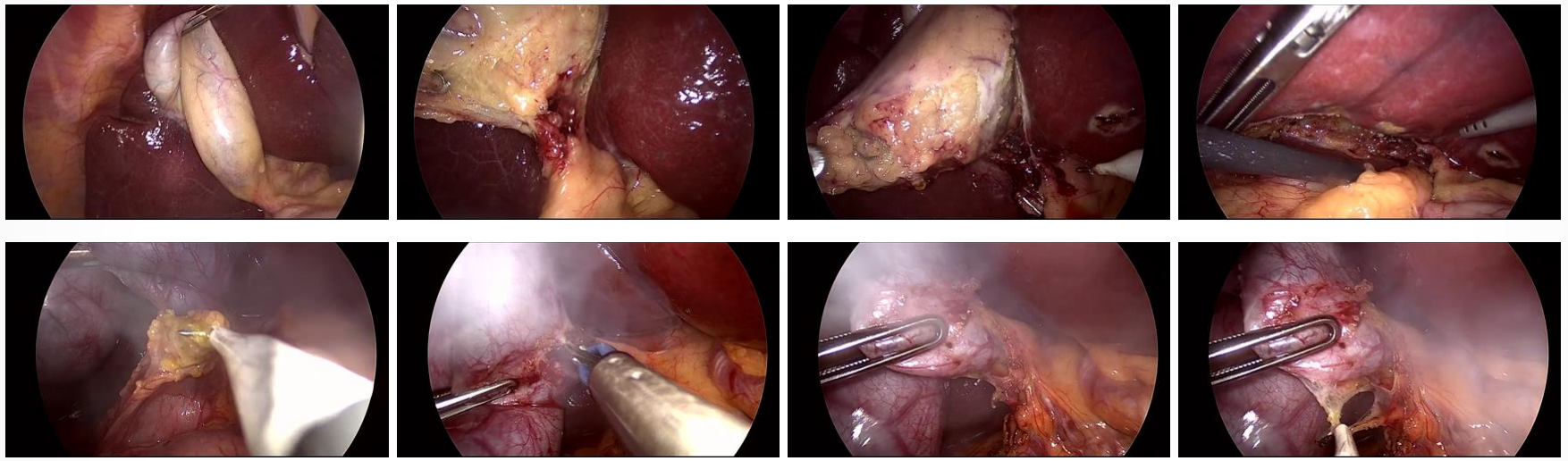
Motivation

- Desmoking techniques
  - Computer vision algorithms
  - Smoke evacuation techniques

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

Motivation

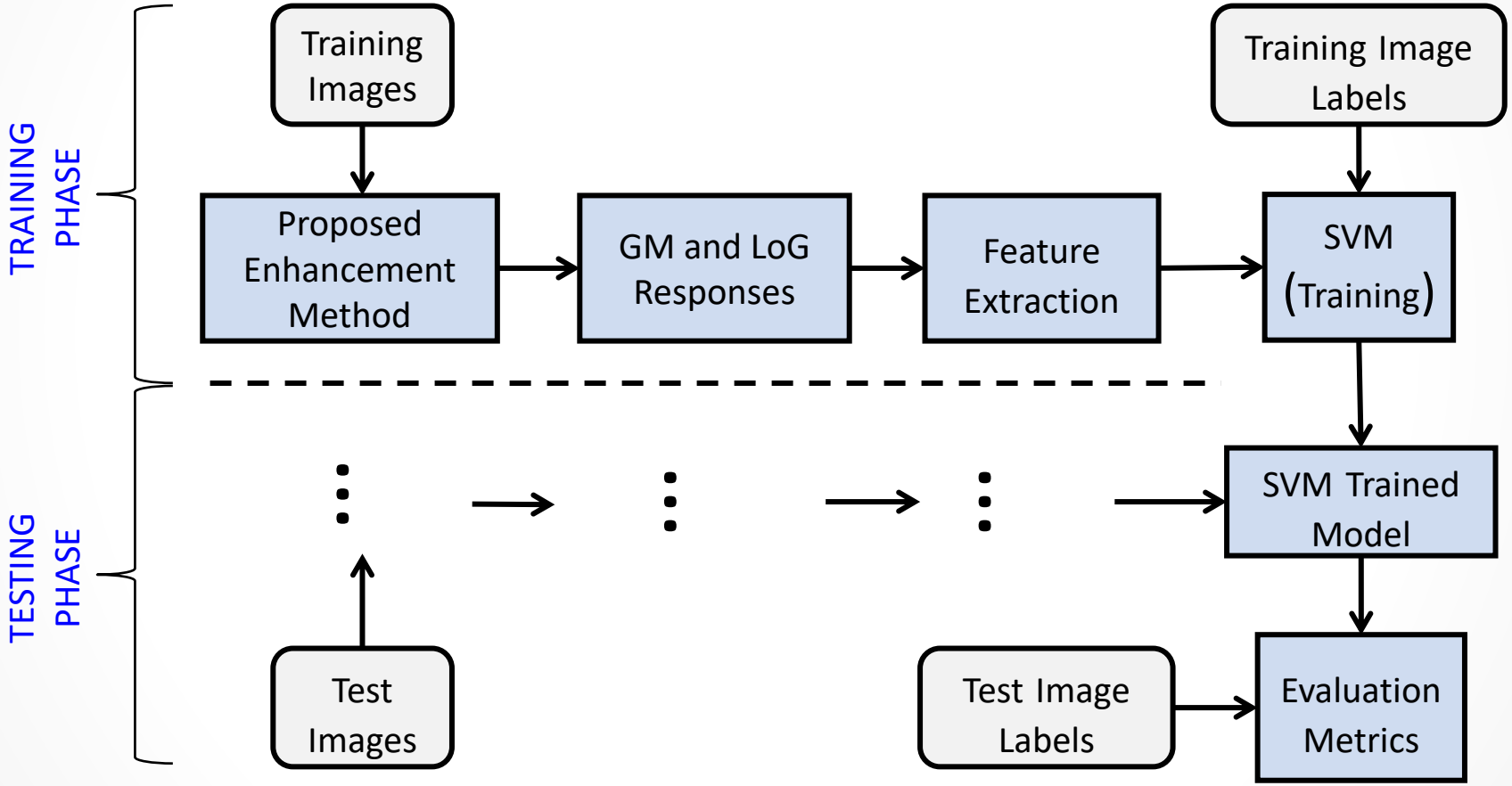
- Smoke/non smoke images classification



- Goal:
  - Enhance the images for improved classification

Main idea

- Pipeline



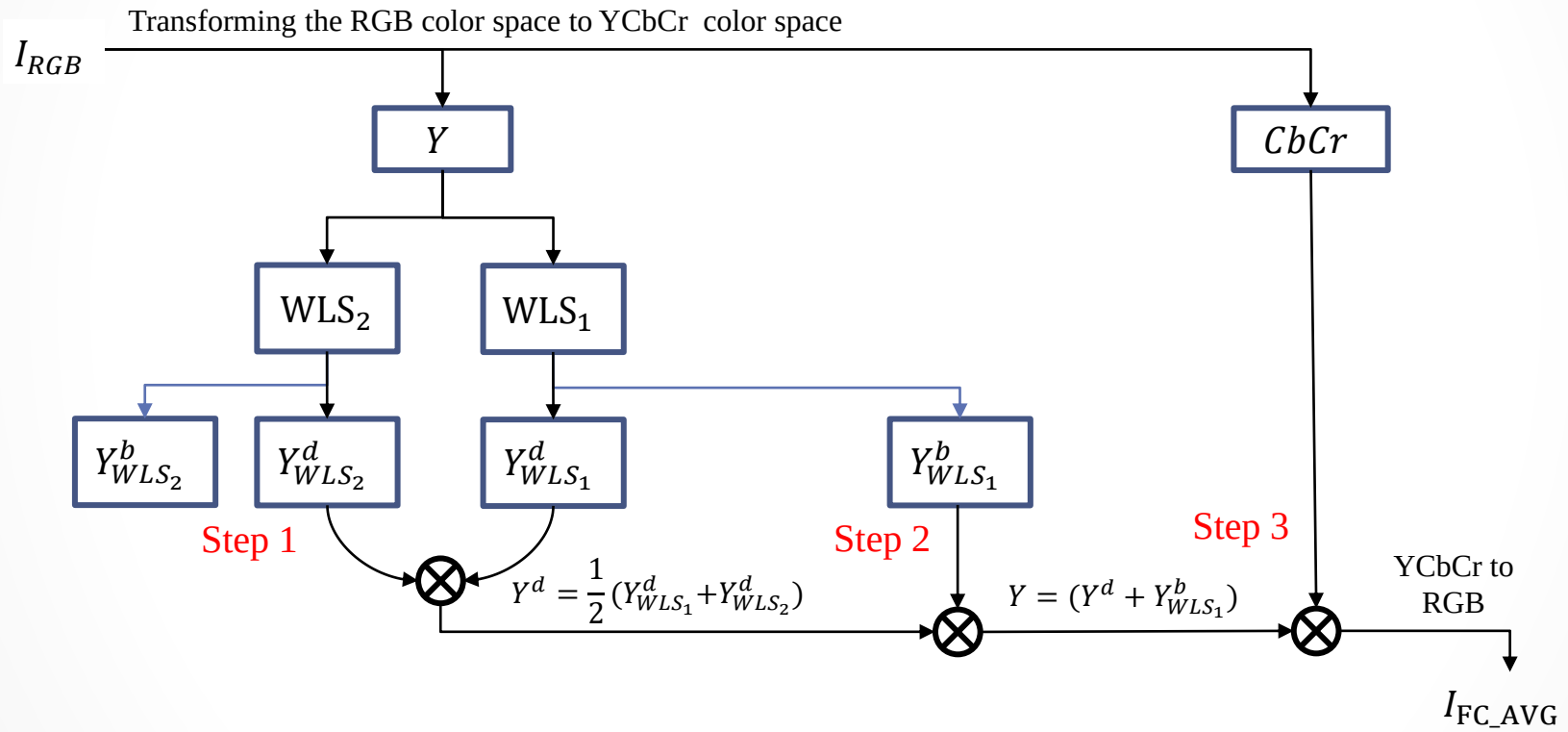
Proposed enhancement method

- Weighted least squares optimization framework (WLS)

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

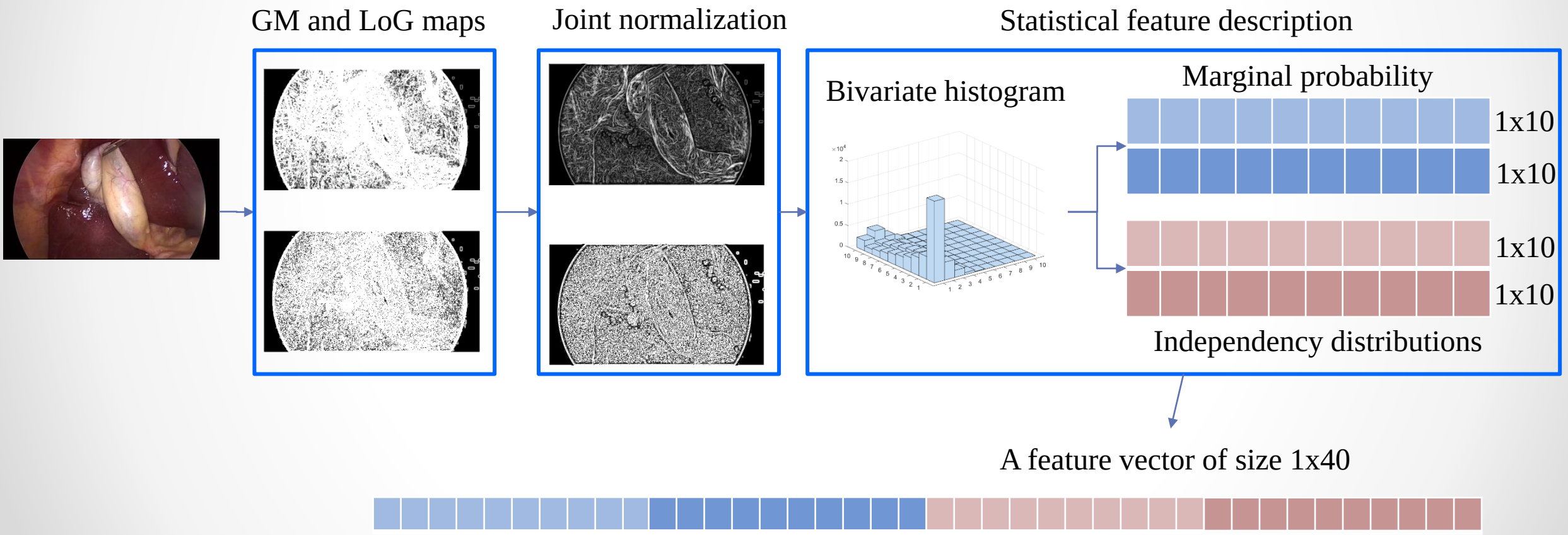
- Decomposition of an image to a base-layer and a detail-layer.
  - Base layer = $g^{Filtered}$
  - Detail layer = $g - g^{Filtered}$

Proposed enhancement method

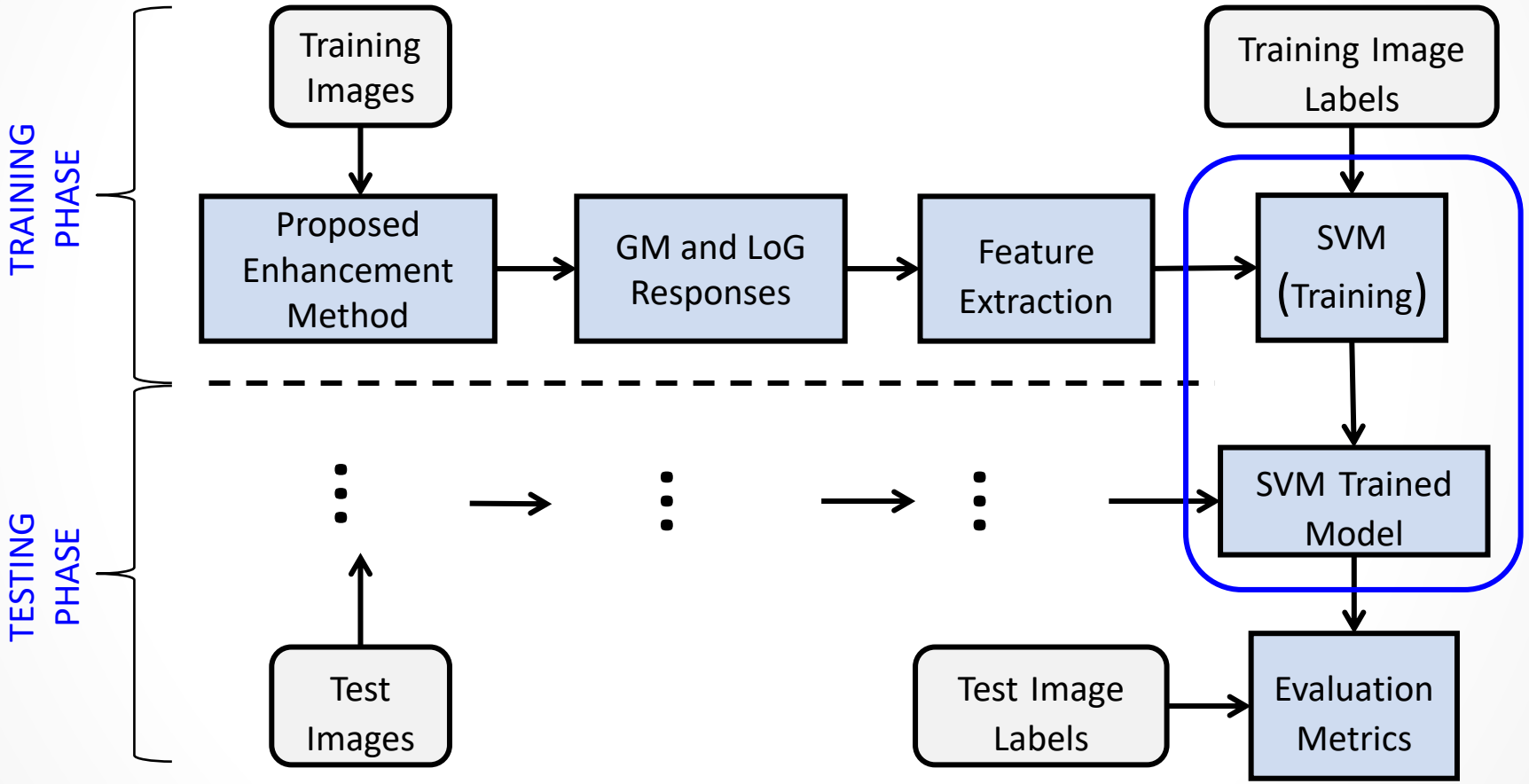


Feature extraction

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



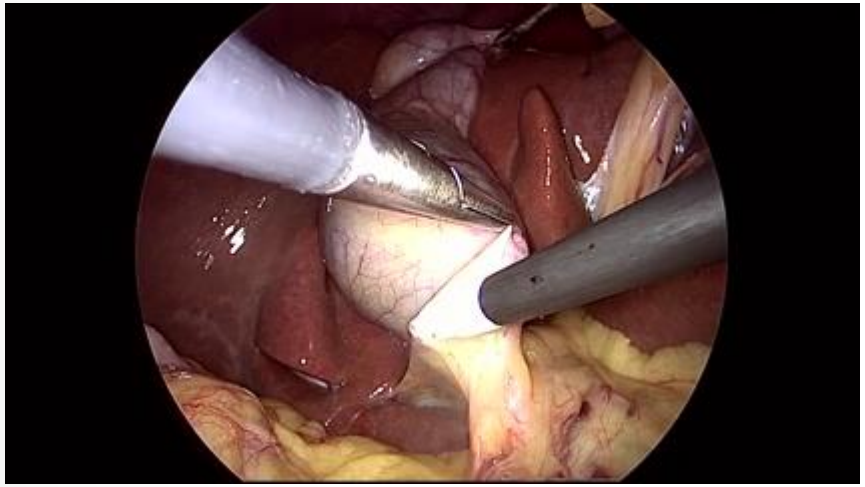
Classifier


TRAINING PHASE
TESTING PHASE
Training Images
Proposed Enhancement Method
GM and LoG Responses
Feature Extraction
Training Image Labels
SVM (Training)
SVM Trained Model
Test Images
Test Image Labels
Evaluation Metrics

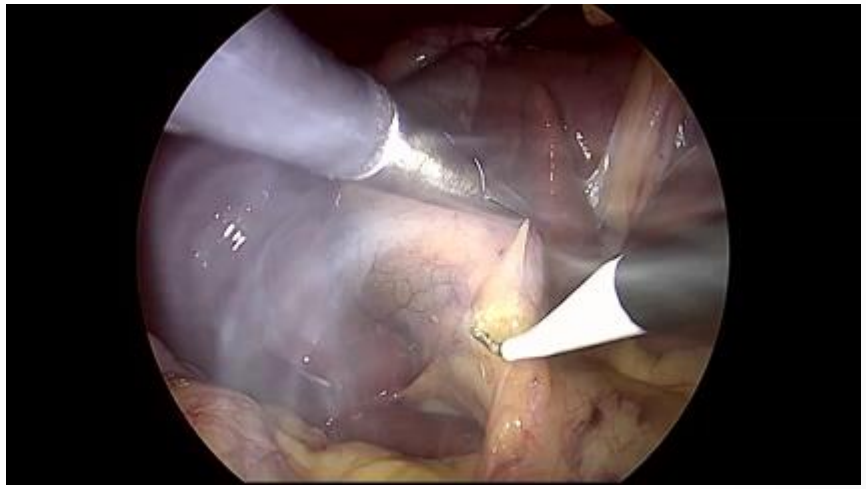
Experiments

- 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

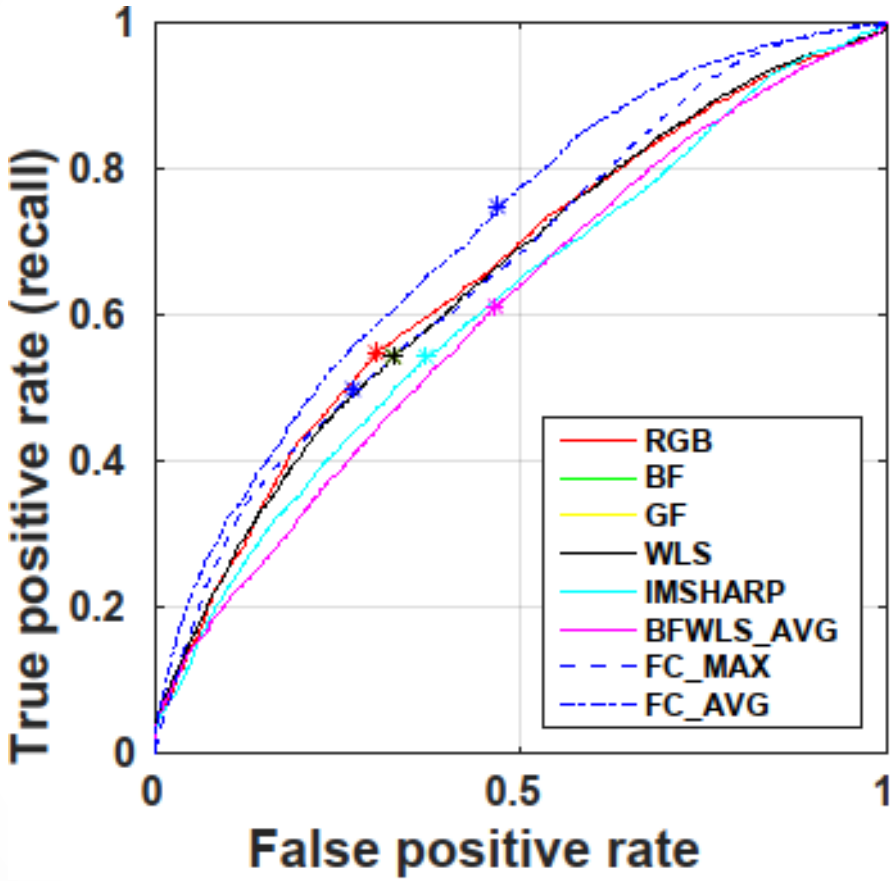


Fig. 1: The ROC curves for smoke/non-smoke classification task. * denotes the EER when the false accept rate is equal to the false reject rate.

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)

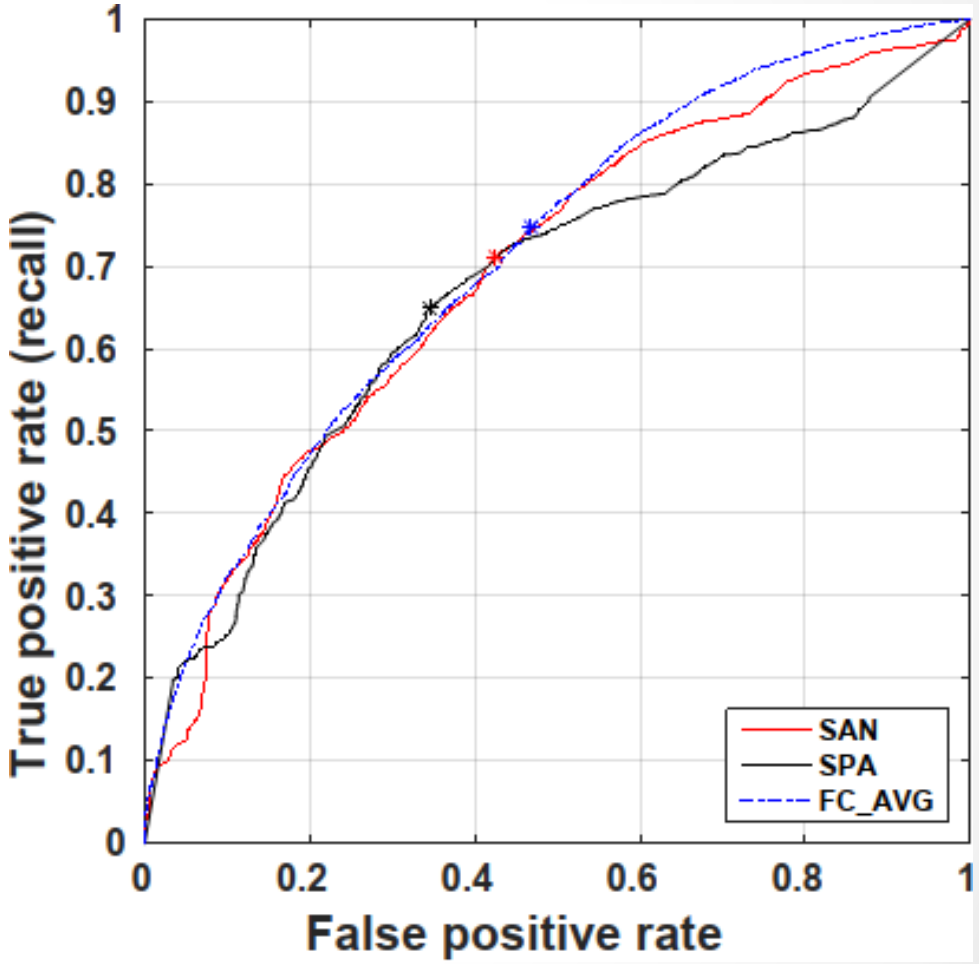


Fig. 2: The ROC curves for the three methods

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 compared to the baseline RGB images
  - Better result compared to the saturation histogram based classification methodologies.
- Future work
  - Employ CNN architecture for the classification task

Thank you, any questions ?