LAGA - Laboratoire Analyse, Geometrie et Applications
L2TI - Laboratoire de Traitement et Transport de l'Information
USPN - Université Sorbonne Paris Nord

# A Smart System for Processing and Analyzing Gastrointestinal Abnormalities in Wireless Capsule Endoscopy

(Pre-processing Stage)

**PhD Student**: Tan-Sy NGUYEN

Supervisors
Prof. Hatem ZAAG – LAGA
Assoc. Prof. John CHAUSSARD – LAGA
Assoc. Prof. Marie LUONG – L2TI

Tutor
Prof. Azeddine BEGHDADI – L2TI

Collaboration
Hospital Beaujon
Prof. Thuong LE-TIEN[1]

[1]HCMUT - Ho Chi Minh City University of Technology, Vietnam National University (VNU-HCMUT)

# Outline

- Image Enhancement
- Information Filtering
- Anisotropic Diffusion
- Deep Learning

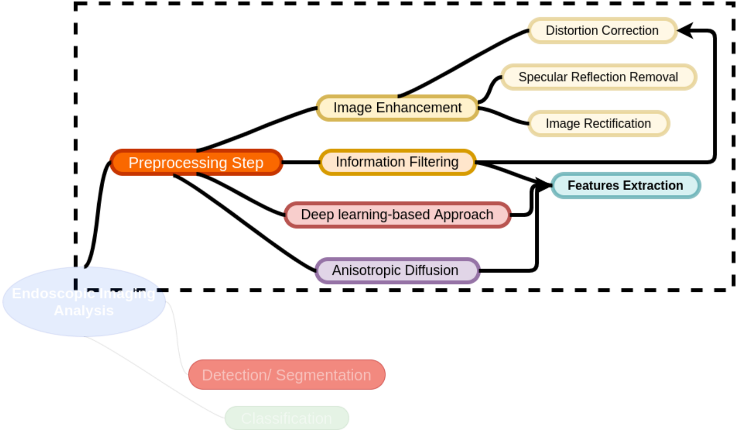


**Figure 1:** Categorisation of publications in the field of endoscopic video pre-processing

# Image Enhancement

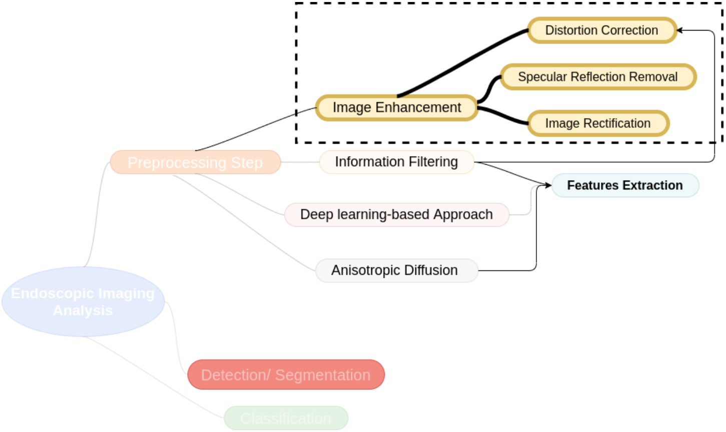


**Figure 2:** Categorisation of publications in the field of image enhancement

# Image Enhancement

- Automatic adjustment of contrast with the help of clustering and histogram modification [1].
- Removal of temporal noise by using a temporal median filter of color values [2].
- Color normalization using an affine transformation [2].
- **Correction of color misalignment** [3].

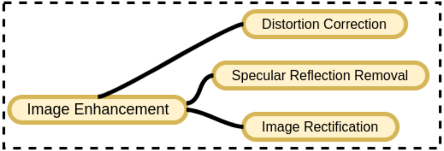


**Figure 3:** Categorisation of publications in the field of eimage enhancement

# Distortion Correction

Typical endoscopes have a fish-eye lens to provide a wide-angle field of view.

1. Vijayan et al. [4] proposed to use a calibration image
2. Resulting the distorted version
3. Build a model for polynomial mapping and least squares estimation .

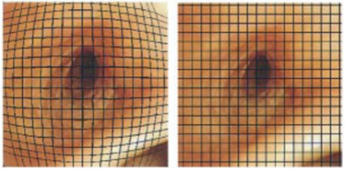

**Figure 4:** Distortion correction of a bronchoscopic image

# Specular Reflection Removal

Endoscopic images often contain specular light reflections caused by the inherent frontal illumination

1. The highlights are detected in each frame using histogram analysis, thresholding and morphological operations [5, 6].
2. The pixels identified as reflections are "corrected" [7].

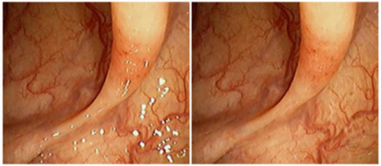

**Figure 5:** Specular reflection removal

# Image Rectification

- A commonly used type of endoscopes are **oblique-viewing** endoscopes.
  - This enables a larger field of view.
  - The problem is that also the image rotates, resulting in a non-intuitive orientation of the body anatomy.
- $\rightarrow$ Tracking the 2D image features to estimate the camera motion [8].

# Information Filtering

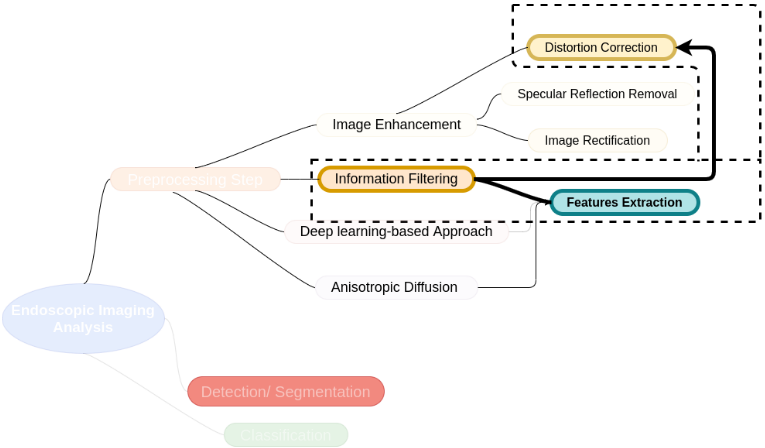


**Figure 6:** Categorisation of publications in the field of information filtering

# Information Filtering

- Different criteria can be found for a frame to be considered as informative or non-informative.

  1. Using the filter to make image more contrast or to determine and process the blurriness [9].

  2. Extracting the relevant feature to ignore the distorted frame or to be used as the input of the classification model [5].

# Summary

| Publ./System | Abnormality | pre-processing type | Recall | Precision | Specificity | Accuracy |
|---|---|---|---|---|---|---|
| Wang et al. [10] | polyp | Information filter | 81.4% | - | - | - |
| Mamonov et al. [11] | polyp | Normalization of intensity | 47% | - | 90% | - |
| Hwang et al. [12] | polyp | Information filter | 96% | 83% | - | - |
| Li and Meng [13] | Tumor | Wavelet transform | 88.6% | - | 96.2% | 92.4% |
| Zhou et al. [14] | polyp | RGB averaging | 75% | - | 95.92% | 90.77% |
| Ameling et al. [15] | polyp | Information filter | AUC = 95% | - | - | - |
| Michael et al. [16] | polyp | Information filter | 98.5% | 93.88% | 72.49% | 87.70% |
| Min et al. [17] | 5 types [17][1] | Label Shadow and Highlight | 99.01% | 99.00% | - | 98.99% |

**Table 1:** A performance comparison of detection approaches. Not all performance measurements are available for all methods, but including all available information gives an idea about each preprocessing step

[1] M. Yu et al., "Automatic Classification Based on Features Fusion for Upper Gastrointestinal WCE Images," 2019 IEEE 8th Data Driven Control and Learning Systems Conference (DDCLS), Dali, China, 2019, pp. 510-515, doi: 10.1109/DDCLS.2019.8908920.

# Anisotropic Diffusion - Deep Learning

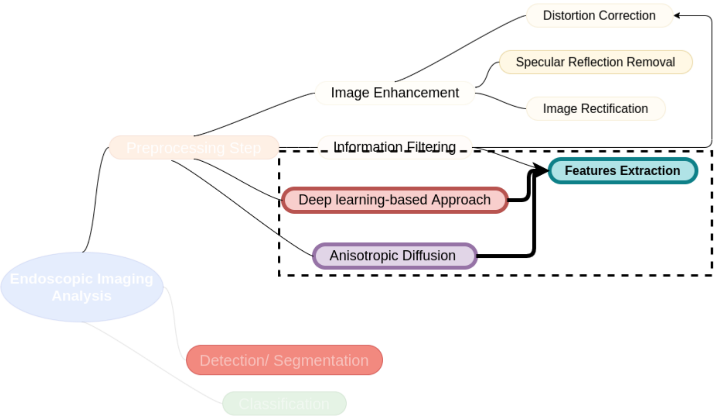


**Figure 7:** Categorisation of publications in the field of anisotropic diffusion and deep learning

# Anisotropic Diffusion

- Anisotropic contrast diffusion is employed to contrast the images due to low dark quality of the WCE images.

| Publ./System | Abnormality | PSNR | Recall | Precision | Specificity | Accuracy |
|---|---|---|---|---|---|---|
| Li et al. [18] | 4 patients [18] | 22.57 | 69.5% | - | 73.5% | 71.5% |
| Shahril et al. [19] | 4 patients [18] | 22.47 | - | - | - | - |

**Table 2:** A performance comparison of detection approaches. Not all performance measurements are available for all methods, but including all available information gives an idea about each preprocessing step

# Deep Learning

- Multiple approaches are proposed to inpaint problematic areas in the images to improve the anomaly classification [20].
- Look into the layers of a deep neural network and present the network's decision in a way that that medical doctors may understand [21].

| Publ./System | Abnormality | pre-processing type | Recall | Precision | Specificity | Accuracy |
|---|---|---|---|---|---|---|
| Min et al. [20] | Kvasir dataset v1 [22] | Auto-generate by autoencoder | 93.94% | 93.96% | - | - |
| Hicks et al. [21] | Kvasir dataset v2 [22] | Layer by layer visialization | 94.30% | 96.80% | 74.90% | 94.30% |

**Table 3:** A performance comparison of detection approaches. Not all performance measurements are available for all methods, but including all available information gives an idea about each preprocessing step

# Example

The visualisation process starts once the user has selected an image, layer, and class for further analysis.

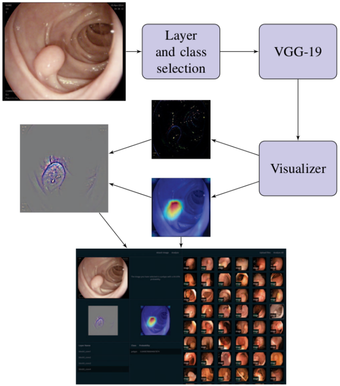


**Figure 8:** An overview of how they produce the two visualisations included in the image analysis, and how it is presented in the user interface where a visualisation of the different convolutional layers can be selected.

# Thank You!

# References I


[1] S. Sheraizin and V. Sheraizin. "Endoscopy Imaging Intelligent Contrast Improvement". In: (2005), pp. 6551–6554.

[2] Florian Vogt et al. "A System for Real-Time Endoscopic Image Enhancement". In: (2003). Ed. by Randy E. Ellis and Terry M. Peters, pp. 356–363.

[3] Rozenn Dahyot, Fernando Vilariño, and Gerard Lacey. "Improving the Quality of Color Colonoscopy Videos". In: *EURASIP J. Image and Video Processing* 2008 (Jan. 2008). DOI: 10.1155/2008/139429.

[4] K. Vijayan Asari, S. Kumar, and D. Radhakrishnan. "A new approach for nonlinear distortion correction in endoscopic images based on least squares estimation". In: *IEEE Transactions on Medical Imaging* 18.4 (1999), pp. 345–354.

[5] JungHwan Oh et al. "Informative frame classification for endoscopy video". In: *Medical Image Analysis* 11.2 (2007), pp. 110–127. ISSN: 1361-8415. DOI: https://doi.org/10.1016/j.media.2006.10.003. URL: http://www.sciencedirect.com/science/article/pii/S136184150600079X.

# References II


[6] R. Yao et al. “Specular Reflection Detection on Gastroscopic Images”. In: (2010), pp. 1–4.

[7] Martin Gröger, Tobias Ortmaier, and Gerd Hirzinger. “Structure Tensor Based Substitution of Specular Reflections for Improved Heart Surface Tracking”. In: (2005). Ed. by Hans-Peter Meinzer et al., pp. 242–246.

[8] D. Koppel, Yuan-Fang Wang, and Hua Lee. “Image-based rendering and modeling in video-endoscopy”. In: (2004), 269–272 Vol. 1.

[9] N. Rungseekajee, M. Lohvithee, and I. Nilkhamhang. “Informative frame classification method for real-time analysis of colonoscopy video”. In: *2009 6th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology* 02 (2009), pp. 1076–1079. DOI: 10.1109/ECTICON.2009.5137231.

[10] Y. Wang et al. “Part-Based Multiderivative Edge Cross-Sectional Profiles for Polyp Detection in Colonoscopy”. In: *IEEE Journal of Biomedical and Health Informatics* 18.4 (2014), pp. 1379–1389. DOI: 10.1109/JBHI.2013.2285230.

# References III


[11] A. V. Mamonov et al. “Automated Polyp Detection in Colon Capsule Endoscopy”. In: *IEEE Transactions on Medical Imaging* 33.7 (2014), pp. 1488–1502. DOI: 10.1109/TMI.2014.2314959.

[12] Sean Stanek et al. “Automatic real-time detection of endoscopic procedures using temporal features”. In: *Computer methods and programs in biomedicine* 108 (May 2011), pp. 524–35. DOI: 10.1016/j.cmpb.2011.04.003.

[13] B. Li and M. Q. -. Meng. “Tumor Recognition in Wireless Capsule Endoscopy Images Using Textural Features and SVM-Based Feature Selection”. In: *IEEE Transactions on Information Technology in Biomedicine* 16.3 (2012), pp. 323–329. DOI: 10.1109/TITB.2012.2185807.

[14] M. Zhou et al. “Polyp detection and radius measurement in small intestine using video capsule endoscopy”. In: *2014 7th International Conference on Biomedical Engineering and Informatics* (2014), pp. 237–241. DOI: 10.1109/BMEI.2014.7002777.

[15] Stefan Ameling et al. “Texture-Based Polyp Detection in Colonoscopy”. In: *Informatik aktuell* (Jan. 2009), pp. 346–350. DOI: 10.1007/978-3-540-93860-6_70.

# References IV


[16] M. Riegler et al. "EIR — Efficient computer aided diagnosis framework for gastrointestinal endoscopies". In: *2016 14th International Workshop on Content-Based Multimedia Indexing (CBMI)* (2016), pp. 1–6. DOI: 10.1109/CBMI.2016.7500257.

[17] M. Yu et al. "Automatic Classification Based on Features Fusion for Upper Gastrointestinal WCE Images". In: *2019 IEEE 8th Data Driven Control and Learning Systems Conference (DDCLS)* (2019), pp. 510–515. DOI: 10.1109/DDCLS.2019.8908920.

[18] Baopu Li and Max Meng. "Wireless capsule endoscopy images enhancement via adaptive contrast diffusion". In: *J. Visual Communication and Image Representation* 23 (Jan. 2012), pp. 222–228. DOI: 10.1016/j.jvcir.2011.10.002.

[19] Rosdiana Shahril, Sabariah Baharun, and A.K.M. Islam. "Pre-processing Technique for Wireless Capsule Endoscopy Image Enhancement". In: *International Journal of Electrical and Computer Engineering (IJECE)* 6 (Aug. 2016), pp. 1617–1626. DOI: 10.11591/ijece.v6i4.9688.

# References V


[20] M. Kirkerod et al. “Unsupervised preprocessing to improve generalisation for medical image classification”. In: *2019 13th International Symposium on Medical Information and Communication Technology (ISMICT)* (2019), pp. 1–6. DOI: 10.1109/ISMICT.2019.8743979.

[21] S. Hicks et al. “Dissecting Deep Neural Networks for Better Medical Image Classification and Classification Understanding”. In: *2018 IEEE 31st International Symposium on Computer-Based Medical Systems (CBMS)* (2018), pp. 363–368. DOI: 10.1109/CBMS.2018.00070.

[22] Konstantin Pogorelov et al. “KVASIR: A Multi-Class Image Dataset for Computer Aided Gastrointestinal Disease Detection”. In: *Proceedings of the 8th ACM on Multimedia Systems Conference*. MMSys’17 (2017), pp. 164–169. DOI: 10.1145/3083187.3083212. URL: http://doi.acm.org/10.1145/3083187.3083212.