PhD Thesis Proposal

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

Context and motivations

Wireless Capsule Endoscopy (WCE) or Video Capsule Endoscopy (VCE) is an innovative and non-invasive endoscopic technique that can be used for gastrointestinal (GI) tract diagnosis of several abnormalities or lesions including bleeding, angiodysplasia, polyps or tumors.

In this study, we focus on the most encountered pathological classes of lesions in the intestines, for example bleedings, ulcers and petechiae. However, the clinician's analysis of the enormous amount of visual information acquired during the long process of travelling through the gastrointestinal tract is a rather difficult and tedious task, which increases the risk of misdiagnosis. A dedicated system is then necessary to assist clinicians in their diagnosis with an intelligent system for automatic detection and identification of pathologies. One of the very first problems that arise is the rather limited quality of the images acquired due to some distortions such as noise, blur, uneven illumination, low-light and specular reflection. Therefore, image pre-processing techniques are of high importance to improve the quality of the acquired frames for subsequent high-level tasks such as detection and classification of the abnormalities.

After different pre-processing steps, visual features are extracted and transmitted into a classifier which provides the diagnosis with a classification result. Most of the common classifier methods are based on Support Vector Machine (SVM) and Neural Networks (NN). In this thesis, we will focus on the recent Deep Learning (DL) based approaches developed for natural images classification. The idea is then to adapt the new DL-based architectures to the specificities of the WCE images. Indeed, the high inter-frame redundancy and particular patterns to be detected could be exploited in the design of a dedicated DL-based pathological patterns classification.

Work plan and solutions to be developed

The main objective of this PhD project is to develop a smart system for detection, identification, and classification of abnormalities in WCE images. This system includes also a pre-processing module that aims at improving the quality of the acquired images before to be fed into the detection and classification part. We will develop a set of image quality enhancement solutions based on Partial Differential Equation (PDE) and particularly non-linear anisotropic diffusion models.

On the other hand, with the ongoing advances in AI development, and specifically in Deep Learning (DL) based technologies, the Convolution Neural Networks (CNN) can be viewed as a powerful approach for image classification. In this work, the lesions' classification will be based on deep convolutional networks, for its advantage in modelling useful representation of complex and large volume data. The detection and identification of abnormalities will be facilitated by the use of pre-processing followed by segmentation process.

Research team and supervision: This research project will be supervised by DR CNRS Hatem ZAAG (LAGA) and co-supervised with Dr. John CHAUSSARD (LAGA), and Dr Marie LUONG (L2TI), in collaboration with the Hospital Beaujon (with DR Hatem ZAAG), and Prof. LE Tien Thuong (Institut Polytechnique de HCM-Ville or National Vietnam University-University of Technology (VNU-HCMUT)), who will give support on Deep Learning and hardware realization with embedded deployment of DL on FPGA.

Key References

[1]. D. Iakovidis, A. Koulaouzidis, "Software for enhanced video capsule endoscopy: challenges for essential progress". Nat Rev Gastroenterol Hepatol 12, 172–186 (2015). https://doi.org/10.1038/nrgastro.2015.13

[2]. M. Long *et al.*, "Guide image based enhancement method for wireless capsule endoscopy," 2017 IEEE Biomedical Circuits and Systems Conference (BioCAS), Turin, 2017, 1-4, doi: 10.1109/BIOCAS.2017.8325109.

[3]. B. Li and M. Q. Meng, "Tumor recognition in wireless capsule endoscopy images using textural features and svm-based feature selection", IEEE Transactions on Information Technology in Biomedicine, vol. 16, no. 3, 323-329, 2012.

[4]. Y.-P. Ding, Y. Ladeiro, Y. Bouhnik, A. Marah, H. Zaag, D. Cazals-Hatem, P. Seksik, F. Daniel, J.P. Hugot, I. Morilla, G. Wainrib, X. Tréton, and E. Ogier-Denis. Integrative network-based analysis of colonic detoxification gene expression in Ulcerative Colitis according to smoking status. J. Crohn's Colitis (2016), 1-11. doi:10.1093/ecco-jcc/jjw179.

[5]. I. Morilla, M. Uzzan, D. Cazals-Hatem, H. Zaag, E. Ogier-Denis, G. Wainrib, X. Tréton. Topological Modelling of Deep Ulcerations in Patients with Ulcerative Colitis. J. Appl. Math. Phys. 5 (2017), 2244-2261. doi:10.4236/jamp.2017.511183.

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