ImViA

UBFC UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ

école doctorale **sciences pour l'ingénieur et microtechniques** SPIM

Thesis title: Similarity measurements between spectral textures

Host Laboratory: ImViA Lab, université de Bourgogne, France

Speciality: instrumentation et informatique de l'image

Keywords: color and spectral imaging, texture, distance and similarity measurements, perception, application to endoscopy

Job description

This PhD thesis focuses on spectral imaging (color, multi- and hyper-spectral). We are interested in the study of the texture of this type of image and its link with human perception [Cha19]. At present, texture processing and analysis is mainly carried out in grayscale. We want to work jointly on texture combined to spectral dimension.

Texture feature extraction is divided into four main categories. The transform features are based on the Fourier transform and its derivatives [Cog85]. The structural features rely on textons (the pattern that defines the texture). It is the family of the Local Binary Pattern ([Oja94]). The model-based features assume a model for the texture such as fractals [Pen84] or Markov random fields [Cro83]. The last category is based on statistical features with the analysis of probabilistic characteristics linked to texture [Har73].

The aim of this thesis is to propose a distance measure between multivalued textures. To achieve this, spectral texture features will have to be developed that combine both image's spectral and spatial dimensions [Chu21]. We will consider the spectral texture as a joint probability between the spectral and the spatial distributions of the spectra responses. To measure the distance between features, we need to consider the nature of the data. Depending on which category of features you are in, one should not use any distance measure. The Minkowski distance should be used for orthogonal data, while finite state distance (Hamming distance) is adapted to finite state data (usually binary). When dealing with statistical features, the use of probabilistic measured is needed [Ric16]. Nowadays, metric learning is used a lot [Kay19]. Several measures of distance between texture features will be proposed. A validation process will have to be defined. These measures will need to be validated according to the application.

In particular, this work will be applied to endoscopy images in order to offer physicians a richer perception of mucosal structure [Kre19]. The research team has an extensive background in medical endoscopy image analysis. Thanks to its collaborations, it has access to spectral videos, particularly in relation to inflammatory diseases of the digestive system. The inflammatory process induces various tissue modifications that can be investigated by several existing techniques during digestive endoscopy. Dye-free digital chromoendoscopy, or virtual chromoendoscopy, is based on the illumination of the mucosa with a specific light to recognize changes in mucosal structure. The very recent emergence on the market of endoscopic systems for highlighting textural features demonstrates the interest of such features in addition to spectral and shape one [Sat21], [Sug22]. In the context of the PhD, we will work on the interpretability of multivalued textures to characterize inflammatory lesions in relation to the physician's perception.

As well as texture features, a key element we would like to develop is the uncertainty associated to feature extraction. Indeed, the uncertainties due to acquisition are not the focus of this work. Yet, those coming from the computation side can be extracted and must be calculated to add value to the result presented to the physician. To estimate them, the model error will be measured such as a distance between the approached probability and the true one.

Working Plan

- T0 to T0+6: the PhD student will study the state-of-the-art method to extract features for texture on spectral images. Another literature study will be done in parallel on similarity metrics and distances between feature attributes.

- T0+6 to T0+15: the candidate will develop his/her research and texture extraction feature based on the knowledge acquired studying the state-of-the-art.
- T0+15 to T0+24: the PhD student will develop uncertainty estimation of the feature developed to complete the feature. It has to be associated with the distance to present a "certainty score" to the measured obtained.
- T0+24 to T0+30: the candidate will have to work with the physician to help develop the "right" way to show the results with the interface used by physician. Should it be a heatmap, transparency, etc.
- T0+30 to T0+36: this time will be dedicated to the redaction of the PhD thesis and the preparation of the defence.

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Research context

Image and Vision Computing (ImViA) is a university of Burgundy laboratory, France (https://imvia.u-bourgogne.fr/): its thematic is Imaging and Artificial Vision. The lab is structured into two teams with complementary activities. The thesis will be carried out within the CoReS (COmputer vision for REal time Systems) team in Dijon. This group is composed of researchers working in the field of vision, embedded electronics, signal and image processing for the joint development of imaging systems and associated methods. Particular emphasis is put on the design of unconventional and multimodal vision systems, on the consideration of strong constraints on processing times and on the use of machine learning techniques in specific contexts (e.g. embedded targets, little data or explainable AI).

The application domains are numerous, such as heritage, health or quality control, and include quality control of manufactured products, biomedical engineering and human monitoring.

Applicant profile:

Master in imaging, computer vision or mathematics

Skills / Preferred selection criteria:
- Image
- Python, C++, MATLAB

Personal characteristics:
- Enthusiasm for research
- Fluency in English (written, spoken)
- Teamwork and autonomy

Funding: MESRI Etablissement

Application to be sent by: **31st of May**
Beginning of contract: 1st October 2024
Gross monthly salary: 2100 €

Thesis Supervisor

Franck MARZANI – franck.marzani@u-bourgogne.fr

Thesis co-supervisor

Hermine CHATOUX – hermine.chatoux@u-bourgogne.fr

Applicants are invited to submit their application to the two PhD supervisors.
Application must contain the following documents:
- CV
- Cover letter
- Transcript of the last few years
- At least 1 reference letter