**PhD title:** **Hyperspectral image analysis of skin erythema after radiation therapy**

**Research team:** Ayin

**Context:** The AYIN team is devoted to the modeling of spatio-temporal structures, for use in the analysis of high-resolution image data, with particular application to images arising in remote sensing and in skin care.

**PhD topic:** Radiotherapy is one of the most common treatments for malignant tumors. The diagnosis and tumor location are usually defined by MRI or CT, while high energy photons are delivered, from multiple directions, to the targeted volume to damage the tumor cells. The radiation doses should be optimally chosen to maximize the radiation response of the tumor, while minimize damage to collateral normal tissue. A wide intra- and inter-patients variation in radiotherapy response has been observed for the same dose due to a number of factors including: tumor size, disease stage, oxygenation, interstitial fluid pressure, etc. Since many of these factors cannot be accurately estimated, current radiation treatment is not optimized for individual patients. Tumor morphology change and blood tests are used to determine radiation response in individual patients. However, these are long term (a few weeks to months) physiological changes hence usually not sufficient for effective treatment optimization.

Radiation exposure to skin causes a reaction know as erythema, which displays as skin redness change within a few days after radiation. Skin erythema has been reported to correlate to individual patient response to radiation. Upon visual examination, a qualitative score can be assigned by the oncologists to characterize this erythema which then being used for assessing radiation response. Nevertheless, the clinical assessment of redness is not a quantitative measure and subjective.

In the past decade, significant progresses have been made in optical imaging instrumentation and image processing. The aim of this PhD is to use data from new hyperspectral imaging technologies developed at Mc Master University in Canada and to propose relevant classification algorithms that can precisely quantify skin erythema and identify optical features that closely correlate to radiation response. The key to success is developing innovative tools able to exploit the rich content of the hyperspectral cube at our disposal to address practical issues. For instance, the development and the validation of a skin erythema segmentation algorithm robust to the pigmentation and light condition change between patients and in the time or, the correlation between the metadata associated individually to each patient and the optical properties related to the inflammatory tissue previously extracted from the hypercube represent some of the practical issues that must be tackled. The main challenge in this PhD is to deal with the phenomenon of multicollinearity of the feature set: small changes in the feature values may lead to inconsistent and erratically changes in the quantification measurement of skin redness.

To address this problem, we propose to explore the use of a class-aware dimensionality reduction tool, the Partial Least Square regression algorithm (PLS) and its kernel variants (see A. Krishnan et al., 2011 and R. Rosipal at al. 2002). In contrary to the other linear supervised algorithms, PLS is able to reduce the dimensionality of the feature space while preserving the most informative features since the class labels of each sample is considered during the dimensionality reduction process. In the aim of evaluating the efficiency of the proposed method (i.e. PLS), a quantitative comparison will be made with the state of the art methods, known for performing well on classification of skin hyper-pigmentation on multi-spectral images. For instance, the method proposed by S. Prigent et al. at INRIA-SAM in 2010, that combines the projection pursuit algorithm, for dimensionality reduction, and the Support Vector Machines, for classification, could be used for comparison purpose. Other techniques must be also explored such as decision trees for instance. Nevertheless, particular care must be taken to avoid any effects of the curse of the dimensionality by determining, a priori, an appropriate mapping from the high dimensional space to the low dimensional embedding.

**Profile of the candidate:** The ideal candidate should have:

1. basic skills in understanding and use of statistical and applied mathematical tools and image processing.
2. a basic knowledge of optical imaging systems.
3. a good knowledge of programming languages (matlab and C or C++)
4. fluent in English, French is not necessary, but will be appreciated

**Duration:** 3 years

**Place of work:** INRIA-SAM

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**Web-page of the team:**

see https://team.inria.fr/ayin/ and http://wiki.mcmaster.ca/Biophotonics/start