ESTRO Technology Transfer Grant (TTG) Report

Comparison of dimensionality reduction methods for radiomic studies

Date of Visit: 18 November - 3 December 2019
Host Institute: LTSI (Laboratoire Traitement du Signal et de l'Image)- Université de Rennes 1, Rennes (France)

In radiomics studies, the number of available radiomic features (RFs) is often greater than the number of observations and many of the extracted features may be strongly intercorrelated. To avoid overfitting problems, which would inevitably reduce the "generalisability" of the quantitative-imaging-based models, selection of RFs is one of the essential steps of radiomic analysis. Moreover, reduction of the complexity of the model is desirable for a deeper understanding of the meaning of the individual radiomic parameters and the interpretation of the underlying biological/physical process. A challenge for radiomic studies is therefore to select only the most informative RFs excluding those that are not robust or redundant.

The general aims of this visit were: to deepen knowledge of dimensionality reduction techniques, to learn and apply optimal pre-processing steps to different MRI images (T1- and T2- weighted, diffusion-weighted imaging and apparent diffusion coefficient maps) and to train on RF extraction and analysis. Moreover, the ultimate goal was to customise the radiomic pipeline developed by the French team for an Italian cohort of patients. The data consisted of a MRI database from 20 patients who were undergoing brachytherapy (BT) for cervical cancer and having MRI at multiple time points before each BT fraction. The second part of the goal was to develop methods for the longitudinal analysis of these data.

During the two-week visit to LTSI the following steps of the radiomic workflow were accomplished:

1) Data selection and organisation were performed both for the clinical imaging database and the non-imaging database;
2) Manual segmentation of the selected (T2-weighted) pre-treatment imaging studies;
3) Pre-processing and preliminary extraction of the RFs;
4) Definition and testing on the Italian cohort of patients of a methodology to reduce the RF dimensionality and to provide synthetic "indices" to describe the evolution of the RF dynamics over the course of treatment.

Eighty MRIs (four imaging studies for each patient) acquired with two different scanners of the same vendor were reviewed. From a final patient cohort, which fulfilled both clinical and imaging criteria (i.e. diagnosis of locally advanced cervical cancer (LACC), treatment protocol, available clinical follow-up records and quality of the image sequences), 77 T2-weighted images were segmented. After the pre-processing (i.e. intensity standardisation and resampling) normalisation, RFs were extracted from three regions of interest (ROIs) with different characteristics: (a) muscles (i.e. tissue that exhibited non-uniformity in structure and not receiving dose, so acting as a good check for test-retest of RFs); (b) bladder filling (i.e. a region that exhibited uniformity of structure and not receiving dose, so acting as a good check for test-retest of RFs) and (c) cervical tumour (i.e. tissue that exhibited non-uniformity of structure and received doses, so acting as a good check for the effect of dose on RFs). Preliminary analysis performed at LTSI during the visit showed that it should be possible to describe and characterise the effect of brachytherapy in cervical cancer patients by studying the RF dynamics. Further investigations will be performed in the coming months and the applicability of the methodology to other larger datasets will be also considered.

The visit was very interesting and fruitful: I was able to learn from experts and to use new software for imaging processing, segmentation and registration. Moreover, throughout this visit we strengthened the cooperation between two universities and research hospitals that have complementary experiences and common discussion points.

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In discussion