Master M2 B2OA 2018

Développement et évaluation de méthodes de CT spectral pour la détection précoce de l'arthrose

Development and assessment of spectral CT for detection of early osteoarthritis

OA is a severe public health problem, the most common joint disorder which concerns a large percentage of patients and is estimated to increase on the next 10 years. It is associated with pain, problems in quality of life and disability. This disorder is characterized by cartilage loss, abnormal subchondral bone and meniscus, and synovial effusion. The main treatment is to control pain, to reduce stiffness, and ultimately to replace the joint if necessary. For humanistic and economical reasons, there are many reasons to identify and treat OA as early as possible. The cartilage does not repair itself; consequently, it is essential to detect changes in the early phase of the disease. OA should preferably be prevented by medical treatment in the early stage.

The relevance of diagnostic imaging for assessing the integrity of the joint is well recognized, especially for early detection of Osteoarthritis (OA). The most used methods are **plain X-rays** and Magnetic Resonance Imaging (**MRI)**. Plain X-rays is still the standard imaging diagnostic tool, which is sensitive to late OA. MRI is a widely used modality to visualize cartilage, joint effusion, ligaments, tendons, meniscus, osteophytes, and bone marrow lesions. The main drawback of MRI exams is to have a limited resolution. The minimal configuration to obtain information on cartilage must be 0.3x0.3 mmx0.5 mm that cannot be achieved by clinical routine device.

However, there are not current methods for detecting early OA with sufficiently high resolution and image quality to visualize at the same time the internal structure of the bone, meniscus and details of cartilage. A new generation of X-Ray CT systems called Spectral CT (SP-CT) also called “colour-CT should provide energy-dependent information, which translates into material decomposition capabilities allowing a better quantification of the different constituents of tissue. However, such systems are currently only available at the stage of prototypes and must be thoroughly assessed and validated. The main objectives are to investigate the ability of SP-CT based on photon counting detectors and associated to new data processing methods to characterize cartilage and meniscus integrity and to investigate possible biomarkers that could improve diagnosis of OA, especially devoted to early detection of OA. To achieve these goals the following sub-objectives will be addressed:

The working **hypotheses** are the following:

- The energy dependence of x-ray attenuation/ Multi-energy CT images can be exploited to assess integrity of internal structures of the joints (cartilage, meniscus, ligaments, calcifications);
- SP-CT can provide energy-dependent information especially at low energy that allows to differentiate cartilage and bone tissue;
- Material decomposition capabilities of SP-CT can improve the vizualization of the cartilage border and could suppress the need of a contrast agent to visualize the cartilage with CT
- SP-CT could provide new biomarkers that could be used to assess cartilage integrity, by quantifying calcification of the cartilage, and glycosaminoglycans contents;
- SP-CT can provide energy-dependent information that allows differentiate cartilage integrity, thickness and to quantify calcifications of the cartilage.

The different work packages are the following:

1) Verify the theoretical feasibility of SP-CT to image soft tissue of joints (cartilage, meniscus, and ligaments).
2) Validate the energy resolution of SP-CT images by using energy-dependent gold-standard images from the synchrotron radiation.
3) Enhance image quality of SP-CT by testing state-of-the art reconstruction algorithms.
4) Test the feasibility of SP-CT for OA diagnosis in comparison with histopathology scorings of the meniscus and cartilage.
5) In case of image of sufficient quality, investigate possible biomarkers for detection of early OA.

This work is integrated in an ANR project SALTO N° ANR-17-CE19-0011-02.

The master student will participate in the project:
Task 1 : For biological and experimental material preparation of knee specimens,
Task 2 : Image data acquisition of knees specimens on SP-CT prototype (CERMEP, Lyon), on high resolution peripheral quantitative computed tomography (hôpital Lariboisière, Paris),on synchrotron radiation quantitative computed tomography (ID 17 line, ESRF, Grenoble).
Task 3 : Image reconstruction by using the ESRF interface: NO-machine
Task 4: Image analysis such as co-registration of different modalities imaging, segmentation of the cartilage

Compétences et qualités requises

- Bonne maîtrise des outils de base en traitement d'image: Matlab et Image j,
- Bases physiques sur les rayons X
- Maîtriser les systèmes d'exploitation Windows, Linux et informatique générale
- Maîtriser les outils de travail collaboratif à distance
- Avoir de bonnes capacités de dialogue et d'écoute en particulier à l'interface entre les ingénieurs et le milieu médical
-Avoir un bon sens de l'organisation et aimer l'expérimentation