PROPOSITION DE SUJET DE THESE

SIGLE ET NOM DU LABORATOIRE : LIB (LABORATOIRE D’IMAGERIE BIOMÉDICALE)
NOM DE L’EQUIPE : IMAGERIE ET DEVELOPPEMENT DE NOUVELLES THERAPIES
DIRECTEUR DE THESE : LORI BRIDAL
ADRESSE : 15 RUE DE L’ECOLE DE MEDECINE, 75006 PARIS

TITRE DE LA THESE : DEVELOPMENT OF QUANTITATIVE METHODS FOR TUMOR INVESTIGATION WITH 3D+t DYNAMIC CONTRAST ENHANCED ULTRASONOGRAPHY

CO-ENCADRANT EVENTUEL : ALAIN CORON
EQUIPE DU CO-ENCADRANT : IMAGERIE ET DEVELOPPEMENT DE NOUVELLES THERAPIES
LABORATOIRE : LIB (LABORATOIRE D’IMAGERIE BIOMÉDICALE)

PRESENTATION DU SUJET

Un document de 2 à 4 pages (références comprises) qui précise :
- le contexte scientifique du projet

Dynamic contrast-enhanced ultrasonography (DCE-US) is a promising imaging modality with a growing number of clinical applications, such as anti-angiogenic therapy assessment and hepatic lesion classification. In order to compare data at different dates or from different groups, for instance to follow the effects of a therapy, it is necessary to develop consistent and robust techniques to evaluate the microvascular distribution in lesions and tumors. Even though techniques like gating or registration [Bar15] have been developed, motion, due to respiration or probe movements, continues to be a major cause of variability in the estimation of flow parameters in lesions and tumors. Furthermore, DCE-US sequences are currently acquired with 2D probes which strongly limits the evaluation of complex and heterogeneous 3D tumor tissues. Very recently, 3D DCE-US acquisitions with 3D probes have begun to emerge and data from the whole tumor can now be acquired at the cost of a lower SNR and reduced frame rate.

- les questions posées

This thesis will investigate the capacity to develop techniques specifically adapted to 3D, volumetric DCE-US data to compensate for motion-related artifacts and to automatically extract robust DCE-US measurements. The meaningfulness of the measurements obtained as biomarkers for therapeutic response and tumor detection will also be evaluated.

- les sources de données qui seront utilisées

Access to an initial set of 3D+t DCE-US sequences of breast cancer lesions has been obtained via an agreement with the laboratory of Pr. Flemming Forsberg, Thomas Jefferson University, Philadelphia, US. These data have been acquired with a General Electrics Ultrasound System. We also intend to acquire our own 3D+t data on small animals and phantoms.

- les méthodes
The PhD student will adapt and validate a technique for correction of respiratory motion and probe movement to this data. The basis for this technique in 2D+t sequences has been published during a previous PhD project. The techniques includes original aspects that make it more fit to address the multiplicative nature of US noise \[\text{Bar13}\] and more fully utilize the temporal information provided in the DCE-US sequences \[\text{Bar15}\] than other techniques that have been proposed. Tumor flow is highly heterogeneous, in general, such that global analysis of the entire body does not provide an accurate assessment of its development. The signal received from different regions in the imaged volume may also vary due to focusing and attenuation effects. Previous work using a clustering process \[\text{Bar14}\] has begun to investigate techniques to more automatically identify and analyze zones within 2D+t DCE-US sequences that present similar flow features. To extend this to 3D+t sequences it will be necessary to first model the interaction between the US beam and the tissue and then to take these system dependent effects into account within the clustering process.

- **le calendrier prévisionnel** (présenté sous forme d’un échéancier semestriel, doit être suffisamment précis pour constituer un document de référence sans pour autant traiter du détail. Le calendrier doit inclure la période de rédaction et celle d'examen par les rapporteurs)

  - Semester 1: Bibliography, understanding DCE-US and registration, transmission of registration know-how, start extending the 2D+t method to 3D+t.
  - Semester 2: Finish the implementation of the 3D+t method, and test. Write and submit the 1st article.
  - Semester 3: Bibliography on the interaction of the US beam, tissue and DCE-US. Which method is the most suitable to be part of the clustering technique? The student can participate to new acquisitions on small animals and phantoms starting from this semester.
  - Semester 4: Continue investigating the clustering technique and its implementation. Write and submit the second article.
  - Semester 5: Can we extract new biomarkers from clinical data after registration and clustering? We expect yes and should be the subject of a third article.
  - Semester 6: Rédaction de la thèse, soumission et défense

- **le thème de chacun des articles prévus**. Une proposition de sujet de thèse doit comporter au moins deux articles originaux.

  A first article describing the image registration technique and its validation will be submitted during the first year.

  The clustering technique that is based on the modeling of the interaction of the US beam and the tissue will be the subject of the second article.

- **Bibliography**


Prérequis, formation : Master in Medical Image Processing or Applied Mathematics

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Spécialité de la These

Epidémiologie (avec éventuellement mention clinique ou sociale ou génétique)
Biostatistique/biomathématique
Informatique biomédicale (recouvrant aussi l'imagerie biomédicale et la bioinformatique)
Performance du système de soins
Aide à la décision (dont coût-efficacité)
Autres (préciser) : ................................................................................................................

Visa du Directeur du Laboratoire

Avis favorable  √
Signature