LabTAU - Unité de recherche U1032
Applications des ultrasons à la thérapie
W. Apoutou N'DJIN, Chargé de recherche

Post-doctoral position – 24 months
Dual-mode cMUT ultrasound transducers for the development of image-guided ultrasound focal therapies of localized tumors

Context of the study

Thermal ablation techniques have been shown to be very promising at the clinical level to treat localized tumors (prostate, uterine fibroids, liver …). The performance and safety of the treatment are greatly conditioned by the control quality of the thermal heating pattern. In order to ablate efficiently localized tumors while improving the safety and tolerance of the therapy, it is essential to ensure a high level of precision to cover the whole tumor region while preserving safe regions in the tumor surrounding. Endocavitary HIFU (High Intensity Focused Ultrasound) and interstitial **HICU** modalities (High Intensity Contact Ultrasound) have shown promising treatment performances by enabling the generation of extended treatment volumes compatible with the ablation of large tumors (several cm3) within a single procedure. Those procedures can be guided by medical imaging in real time using either ultrasound (**US**) imaging or magnetic resonance (**MR**) imaging, However, the spatial-temporal control of the treatment is currently limited when using existing medical devices since the coupling between imaging and therapeutic systems remains very challenging and requires making trade-offs which penalize both performances. Although standard ultrasound piezo technologies have been successful in transferring ultrasound modalities from bench to bedside, they still exhibit limited mechanical and acoustic characteristics (miniaturization, working frequencies, electro-acoustic efficiency, self-heating) which reduce the possibilities to improve significantly the treatment quality. The **LabTAU** (**Inserm U1032**) specialized in the research on therapeutic applications of ultrasound has started a new research project on **cMUT** technology (capacitive **M**icromachined **U**ltrasonic **T**ransducer). This project aims at developing new generations of **HIFU/HICU** applicators dedicated to image-controlled ultrasound therapy for focal/conformational treatment of localized tumors. **cMUT** transducers can be miniaturized down to a few dozen microns, have incomparable electro-acoustic efficiencies and no thermal losses due to mechanical strains during vibration. **cMUTs** have been currently used for ultrasound imaging devices (short-duration, high voltage pulses) but has never been validated for **HIFU**/**HICU** therapy (high power signals). The development of the therapy mode with **cMUT** transducers is expected to lead to significant enhancements of the ultrasound treatment quality, by overcoming some current limits in the treatment accuracy of complex tumor geometries or the lake of real-time portable imaging to guide the procedure. Ultimately, a new generation of medical devices is expected to emerge, which will enable achieving High-Definition **HIFU**/**HICU** for focal/conformal endocavitary/interstitial therapies while allowing real-time ultrasound guidance with the same device (**dual-mode**: ultrasound therapy/imaging) complementarily to **MR**-temperature monitoring (**fusion imaging**).

Project objectives

Two strategies are targeted in the project: **MR**-guided interstitial **HICU** conformational treatment and **US**-guided endocavitary **HIFU** focal treatment. The Post-doctoral fellow will be investigating **both** strategies and the feasibility of using various designs of **cMUT** arrays (planar, concave) for generating high intensity ultrasound, and creating thermal ablations in biological tissues with high spatial resolution while reconstructing ultrasound images to visualize the treatment in real-time. This work will be performed as part of the **MUTATION** project founded by the **FUI** grant (**F**ond **U**nique **I**nterministériel). **MUTATION** (c**MUT** **A**pplications for **T**herapy and **I**maging in **O**nco-**N**anosurgery) aims at developing new therapeutic strategies for image-guided ultrasound thermal therapy of localized tumors in the prostate, liver, lung and brain. The Post-doctoral fellow will be working in a dynamic and pluridisciplinar environment, will be involved in preclinical and clinical studies, in the context of the **MUTATION** project, a national collaboration between the **LabTAU** (**Inserm U1032, Lyon**) and 3 companies specialized in the development of ultrasound medical strategies: **Vermon** (**Tour**), **Carthéra** (**Paris**) and **Edap-TMS** (**Vaulx en Velin**).

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Program: 3 steps

1) Ultrasound thermal therapy with **cMUT**

- Strategies for driving multi-element **cMUT** arrays (wafers) with high power signals. Evaluation and optimization of the electro-acoustic performances of **cMUTs** in continuous mode.
- Numerical modeling and experimental characterizations of **cMUT** vibration modes, nonlinear behavior, collapse mode.
- Feasibility to generate high intensity ultrasound with **cMUT**; ability to increase the temperature in attenuating media and achieve thermal ablations in biological tissues
- Investigations on 2 different therapeutic strategies: planar ultrasound **cMUT** arrays for interstitial **HICU** therapy and focused ultrasound **cMUT** arrays for endocavitary **HIFU** therapy
- Temperature-feedback control methods and modulation of **HIFU/HICU** key parameters for achieving focal/conformal thermal therapy

2) Dual-modality with **cMUT** for ultrasound therapy **and** imaging

- Concept of ultrasound dual-modality with **cMUT** technology: feasibility to enable therapy (high power continuous mode) **and** imaging (pulse echo) with the same **cMUT** system
- Imaging strategies for high performance ultrasound imaging with dual-mode **cMUTs**: multi-planar transducers, concave phased-arrays
- Dual-mode strategies (pulse echo / continuous modes) for ultrasound-guided focal therapy with **cMUTs** : ultrasound beam steering, synchronization imaging/therapy

3) Involvement in in-vivo preclinical studies and clinical application

- Experimental set up for driving multi-element **cMUT** arrays in standard surgical room as well as in **MR** environments
- In-vivo preclinical studies:
  - Therapeutic planar **cMUT** arrays for **MR** temperature-controlled interstitial **HICU** ablations in liver and lung
  - Dual-mode concave **cMUT** arrays for **US**-guided endocavitary **HIFU** ablations in prostate
- Preparation of a clinical study: proof of concept of **MR**-controlled interstitial **HICU** ablations of brain metastasis

Skills

The candidate must hold a PhD degree preferentially in one of the following fields: Biomedical Engineering; Medical Imaging; System, Signal and Image; Micro/Nano electronic and automatic

- Signal and image processing
- Electronic and automatic
- Programming skills: C++ (ideally ITK, VTK), matlab, Comsol
- Medical imaging: MRI, Ultrasound

Additional information

- Location: LabTAU laboratory (Lyon, France)
- Duration: 24 months (renewable 12 months), starting end of 2013

Contacts

Send a CV and a motivation letter to:

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