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Department of Imaging Physics

Quasi-tomographic ultrasound imaging of the brain

BEP project – april 2018

Introduction

Deep brain stimulation (DBS) is a technique in which brain function is modified locally by means of electrical signals from an implanted electrode. Electrodes are usually placed deep in the brain and are connected to a pulse generator similar to a heart pacemaker. Precise localization of the DBS electrodes inside the brain is a key to success of such a treatment. Transcranial ultrasound imaging could be an easy-to-use, accurate and cheap modality for detecting the position of the electrodes in DBS procedure. However, transcranial ultrasonic brain imaging on adults is currently limited by the strong aberrating effect of the skull bone. In order to obtain a good ultrasound image, it is necessary to focus ultrasound beams inside the brain and reduce the sidelobes of the ultrasound beam to increase resolution and contrast respectively. The skull bone is absorbing the ultrasonic wave and the speed of sound is not homogeneous inside the skull, so that the phase of the wave front is locally shifted. As the speed of sound and absorption inside the skull are spatially dependent and are a priori unknown, it is necessary to use adaptive methods to focus through the skull.

Research goal

The ultimate goal of this master project is achieving image quality sufficient to reliably differentiate various anatomical structures in the brain as well as the location of the DBS electrodes in respect to those anatomical structures (e.g. subthalamic nucleus).

Approach

Various techniques have been proposed for aberration correction in skull such as: using an alternative imaging modality (MRI or CT) to obtain information about the skull to compute the expected aberrations (Sun Hynynen 1998 and 1999, Clement and Hynynen 2002a and 200b, Aubry et al. 2003, Hynynen et al. 2006); Point-target based aberration correction (Flax and O'Donnell 1988, Zhao and Trahey 1991, Fink 1992, Pernot et al. 2006, Kripfgans et al. 2002, Psychoudakis et al. 2004); Obtaining the approximate aberration of the skull using two arrays that are placed on opposing sides of the skull, one on each of the parietal (or temporal) bones (Vignon et al 2006).
Following the approach proposed by Vignon et al. we have developed a setup with 2 phased array transducers (P4-1) positioned opposite to each other. Each transducer has a centre frequency of 2.5 MHz, 96 elements of 16 mm long, and a pitch of 0.3 mm. These clinical transducers are hardwired to an research ultrasound module (Verasonic) (figure 1).

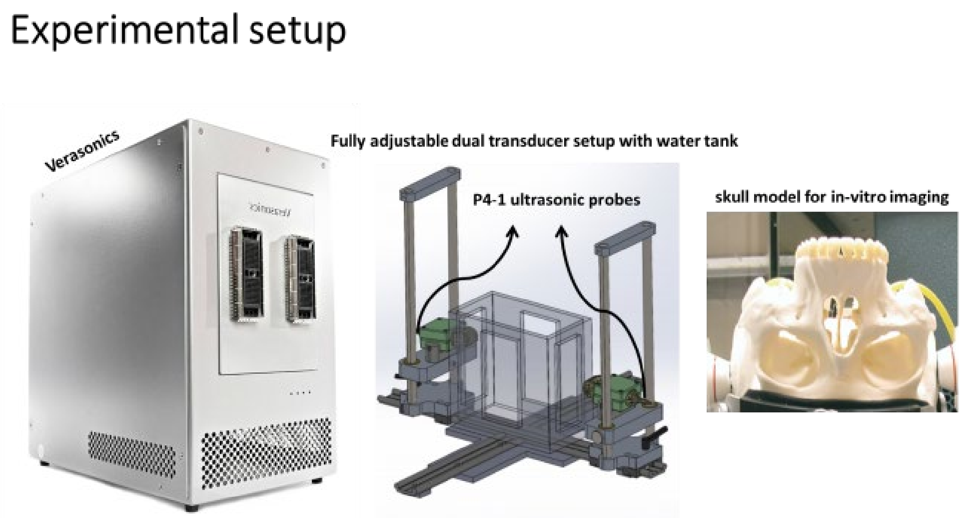

Figure 1: Demonstration of the experimental setup for this project

Activities

Literature review of the proposed approaches and creating a systematic comparison between the methods and their pros. and cons.

Calibration of the system: large realization of the transmit and receive data (96 × 96) in this setup gives the opportunity to calculate the translational misalignments (up-down and left-right) as well as the angular misalignments (tilt and rotation) independently. The arrival time of the acoustic wave can be used to detect such misalignments and correct for them in the rest of the measurements.

Realization of the state of the art aberration correction technique based on the dual transducer approach for *phased array transducers*.

Implementing the calibration, imaging and phase correction sequences on the Verasonics system.

Performing in-vitro experiments on simplified situation (water thank).

Performing in-vitro experiments on human skull model.

Performing in-vivo experiments on volenteers.

Publications

More information: Verya Daechin v.daechin@tudelft.nl – Acoustical Wavefield Imaging

Overview of the literature

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