Mars Lab

ImPhys
Image to insight
Insight in imaging
Department of Imaging Physics

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Master's End Project (MEP)

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Beyond fMRI: functional MR Elastography of the brain

Description

Traditional functional MRI can provide great insight into the human cognitive processes. However the current technique, based on the Blood Oxygenation Level-Dependent (BOLD) contrast, is limited in temporal resolution by the hemodynamic response timing (1-10s).
With this project we want to investigate an alternative contrast mechanism to map neuronal activity in-vivo: functional MR Elastography (fMRE). This approach can be used to quantify brain biomechanical properties. It has been shown, in fact, that brain stiffness changes significantly in response to neuronal activity. These changes occur at a much faster time scale than the hemodynamic response, enabling in-vivo imaging of fast neuronal processes down to a 100ms time scale.
The project will be carried out in collaboration with Maresca lab (https://www.marescalab.eu/), focusing on functional Ultrasound Elastography.

Steps & Goals

- Familiarize yourself with the theory of MRE and the sequence development environment (C++).
- Optimize the experimental set-up for phantom and in-vivo fMRE experiments.
- Implement fMRE reconstruction to extract stiffness maps from raw MRI data.
- Perform in-vivo and phantom experiments to validate the sequence and compare results to corresponding US experiments from Maresca Lab.

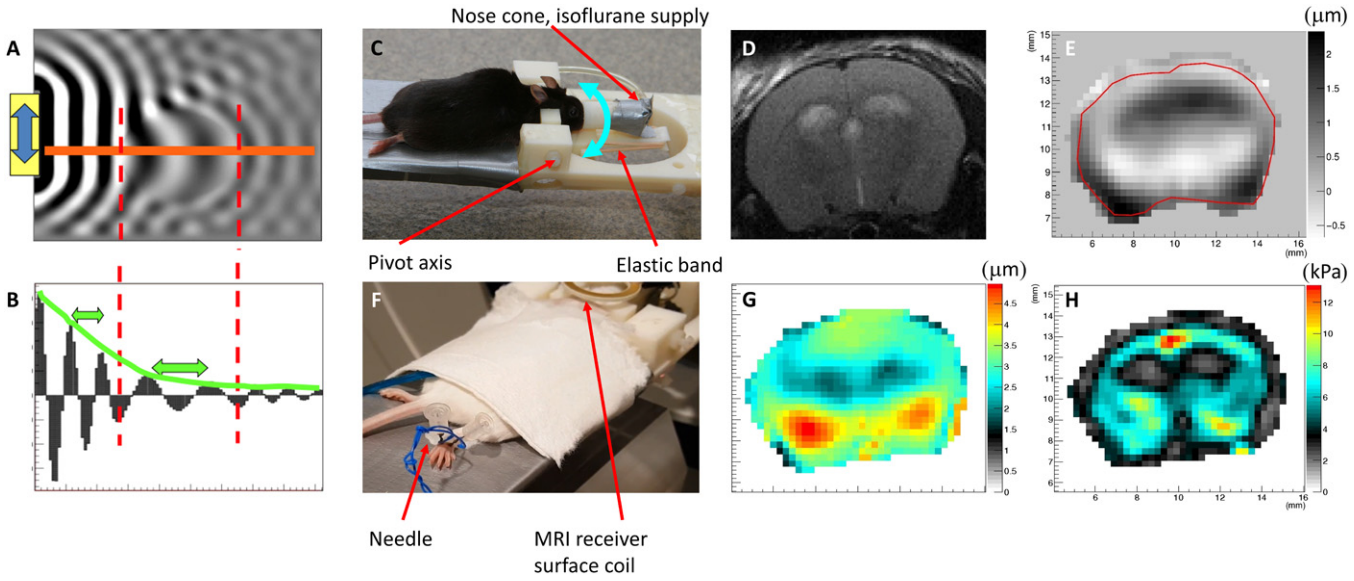

Fig1. [from Patz et al., *Imaging localized neuronal activity at fast time scales through biomechanics*, 2019] MRE basics, experimental setup, and MRE data. (A) 2D numerical simulation example of shear wave displacement field. (B) Plot of displacement along the orange line in (A) shows an increase in wavelength in the stiff ellipsoidal inclusion and attenuation of the wave due to frictional forces in the medium. (C) Head rocking MRE system adapted to the mouse. The cyan double-arrow indicates the pivoting direction of the movable front part. (D) T2-weighted anatomical image, (E) measured displacement field in through-slice direction at one time point (µm), (F) placement of electrical stimulation needles in the hind limb, (G) total induced displacement amplitude (µm), and (H) resulting real part of the complex shear modulus after the reconstruction process.