a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Supervisor Contact: Prof. Lyndia Wu, Ph.D.
Department of Mechanical Engineering
office: Room 2059 CEME Bldg, 6250 Applied Science Lane
The University of British Columbia, Vancouver, B.C. V6T 1Z4, Canada
email: lwu@mech.ubc.ca

MECH 493 project: Investigating Mild Human Head Vibrations

Research Project Overview

Magnetic resonance elastography (MRE) is an imaging technique that allows for studying the mechanical properties of biological tissues, especially the human brain, in which direct traditional palpation is not possible [1]. In this imaging technique, mechanical vibration is applied to the organ of interest using an external actuator to study tissue behavior in response to mechanical waves. Recently, MRE has become a popular alternative to magnetic resonance imaging (MRI) and x-ray computerised tomography (CT) to diagnose neurological disorders, as it is highly sensitive to small pathological alterations in the brain that are occult to other methods [1]. Furthermore, it has been observed that biological tissues respond differently to different frequencies of mechanical wave, therefore brain MRE studies have focused on a range of actuation frequencies [2]. The actuation frequencies that have been tested on the human heads in vivo are usually between 10-100 Hz [1-4]. Previous studies have found the resonance frequency of the brain to be around 15Hz, at which the brain-skull relative motion is increased [5].

The key step in doing an MRE analysis of the brain is to generate mechanical vibration using external sources such as electromagnetic, acousto-mechanical, pneumatic, or piezoelectric devices, and transmit the vibration to the human head using passive drivers such as hollow tubes, special pads or air cushions [1][4]. The induced vibration can cause the head to move in a slight nodding motion ranging between 5-50 µm [1]. Moreover, the number of layers and configuration of MRE paddings used during the experiment can significantly affect the frequencies at which the head vibrates. This finding motivates the present study. Given that the clarity and quality of the acquired signal is highly dependent on the applied actuation frequency, it is important to study the correlation between the induced vibration frequency and the frequencies experienced by the human head. As well, the effect of the configuration and number of MRE head paddings head vibrations should also be studied.

References

[1] L. V. Hiscox et al., “Magnetic resonance elastography (MRE) of the human brain: technique, findings and clinical applications,” Phys. Med. Biol., vol. 61, no. 24, pp. R401–R437, 2016.
[2] P. Latta, M. L. H. Gruwel, P. Debergue, B. Matwiy, U. N. Sboto-Frankenstein, and B. Tomanek, “Convertible pneumatic actuator for magnetic resonance elastography of the brain,” Magn. Reson. Imaging, vol. 29, no. 1, pp. 147–152, 2011.
[3] M. Kurt et al., “Optimization of a multifrequency magnetic resonance elastography protocol for the human brain,” J. Neuroimaging, vol. 29, no. 4, pp. 440–446, 2019.
[4] L. V. Hiscox et al., “High-resolution magnetic resonance elastography reveals differences in subcortical gray matter viscoelasticity between young and healthy older adults,” Neurobiol. Aging, vol. 65, pp. 158–167, 2018.
[5] K. Laksari, L. C. Wu, M. Kurt, C. Kuo, and D. C. Camarillo, “Resonance of human brain under head acceleration,” J. R. Soc. Interface, vol. 12, no. 108, p. 20150331, 2015.

Research to be performed by the student

- Development and/or testing of head vibration equipment, including an acoustic driver, 3D-printed air pillow, head coil, head padding, and inertial measurement units.
- Laboratory head vibration data collection involving human volunteers.
- Head vibration data processing and frequency analysis.

Facilities and team:

Main lab location: ICICS Building, Room X015
Team: the undergraduate student will work with a postdoctoral fellow on this project, with direct guidance from Prof. Wu