Seminar

Department of Biomedical Engineering
香港城市大學
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Noninvasive Ultrasound Neuromodulation: Unraveling Mechanisms and Enhancing Precision

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Abstract

Neuromodulation technologies not only hold the key to unlocking the mysteries of brain functions but also herald groundbreaking treatments for brain disorders. Existing neuromodulation techniques, such as deep brain stimulation, tDS (transcranial direct current stimulation), tMS (transcranial magnetic stimulation), or optogenetics, face challenges of spatial resolution or require invasive implants due to fundamental physical constraints of electromagnetic wave. Ultrasound, being a mechanical wave, is unique in its ability to penetrate the human skull, focusing on any deep or superficial brain region with sub-millimeter precision. This positions it as a transformative neuromodulation technique. Yet, it confronts hurdles: an undefined mechanism, absence of cell-type precision, and a system for spatially-precise targeting. My previous research addressed these by leveraging multidisciplinary knowledge and engineering skills: 1) discovering that ultrasound-induced mechanical and thermal effects can bolster neuromodulation and unveiling TRPM2 as an ultrasound-sensitive ion channel, 2) developing sonogenetics for cell-type-specific ultrasonic neuromodulation, and 3) developing an ultrasound image and PET image-guided focused ultrasound system for enhanced spatial precision. Built on the new mechanism and advanced engineering system, I invented ultrasound-induced artificial hibernation technology, marking a non-invasive and non-genetic method to induce hibernation-like state in animals with immense translational potential for humans, possibly redefining urgent care paradigms and enabling long-distance space travel. In essence, with enhanced precision and a clarified mechanism, focused ultrasound emerges as a superior non-invasive neuromodulation technique, heralding a new era for probing brain function and treating brain diseases.

Biography

Dr. Yaoheng Yang earned his Ph.D. in Biomedical Engineering from Washington University in St. Louis, where he was distinguished with the Outstanding Doctoral Dissertation Award. Following his Ph.D., he continued at the university as a postdoctoral fellow. Prior to his doctoral studies, Dr. Yang completed his Bachelor's and M.Phil degrees at the Hong Kong Polytechnic University. Dr. Yang's research focuses on harnessing multidisciplinary approaches and theories, drawing from fields such as physics, electrical engineering, and neuroscience, to address pivotal challenges in noninvasive and spatiotemporally precise neuromodulation. Among his notable achievements are: 1) Developing preclinical and clinical focused ultrasound instrumentations for precise brain stimulation. 2) Innovating sonogenetics to enable cell-type specific neuromodulation. 3) Achieving artificial hibernation using non-invasive neuromodulation technique. As a testament to his research excellence, Dr. Yang has published 9 research papers as the leading author in top-tier academic journals, including Nature Metabolism, Radiology, and Brain Stimulation. Dr. Yang has been honored with 4 international awards, including the Nadine Barrie Smith Award, which is regarded as the top trainee award in the therapeutic ultrasound field. Further, he has graced two premier international conferences as an invited speaker, delivered 17 oral presentations, and secured the Best Presentation Award at four distinct conferences.