|  |  |
| --- | --- |
| Title | Real-time Motion Tracking of Abdominal Targets based on MRI |
| Name | Tianyu Zhou |

Introduction

* High-intensity focused ultrasound (HIFU) is a non-ionizing, non-invasive therapeutic technology that is particularly suited for creating localized thermal ablation in diseased internal organs such as the kidneys, liver, pancreas, and spleen.
* Magnetic Resonance (MR) thermometry provides real-time temperature measurement to enable monitoring, tracking and targeting for the HIFU procedure.
* Throughout the procedure, abdominal targets undergo both periodic (e.g. respiration) and aperiodic (e.g. peristalsis) movements as well as non-rigid deformations.
* Sustained sonications are preferred for highly perfused abdominal organs in order to achieve a sufficiently high temperature elevation to induce necrosis, which is challenged by the movements and deformations of the target, since dynamic repositioning of the HIFU focal point is required.
* MR thermometry suffers from motion and susceptibility artifacts caused by target movements, which are corrected by a hybrid method that is able to achieve a temperature stability and precision of 0.85 °C and 1.00 °C in *in vivo* porcine and human kidneys.
* However, more *in vivo* trials are needed to validate and to streamline this method.
* An automated method is needed to continuously quantify the organ movement and deformation, which is the basis for dynamic adjustment of the focal point of the HIFU beam in order to track a targeted organ.

Research Question

Can movement and deformation of abdominal targets be quantified in real time to facilitate focusing of the HIFU beam to track a target?

Research Hypothesis

Quantifying movement and deformation of abdominal targets in real time will enable the dynamic refocusing of the HIFU beam during *in vivo* treatments.

Research Objectives

* Develop a novel algorithm to quantify abdominal organ movements
* Refine the algorithm to achieve acceptable accuracy and speed
* Evaluate the algorithm with periodic and aperiodic movements during *in vivo* treatments

Study Rationale and Review of Previous Work

* Principle component analysis (PCA) is an algorithm that demonstrates effective correction of periodic motion artifacts in Magnetic Resonance Thermometry (MRT) while reducing computational costs.
* Projection onto dipole fields (PDF) is an algorithm that provides a correction of aperiodic motion artifacts in MRT with excellent discrimination between local heating and edge susceptibility artifacts.
* Both PCA and PDF correct MRT without registering exact organ displacement, whether periodical or aperiodical; intermediate results may be manipulated to obtain the displacement itself.

Specific Aims

* Calculate the amount of target displacement within an abdominal organ at any given time
  + Process data obtained through PCA and PDF
* Determine the feasibility of algorithm in an *in vivo* preclinical setting
  + Evaluate the accuracy and speed of the algorithm with periodic and aperiodic movements during *in vivo* treatments

Expected Outcomes/Significance

This study will:

* Enhance the focusing of the HIFU beam within abdominal targets
* Facilitate safe application of HIFU for treatment of abdominal targets in a free breathing animal model