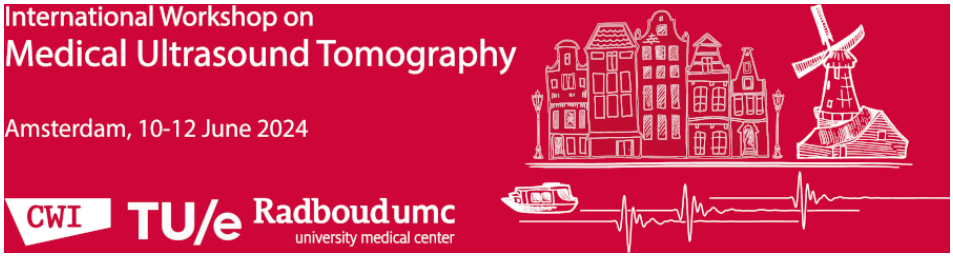

Contribution ID: **17** Type: **not specified**

Coupled Viscoacoustic-Viscoelastic Spectral-Element Modeling for Transcranial Ultrasound

Tuesday, June 11, 2024 1:00 PM (20 minutes)

A formulation of the coupled viscoacoustic-viscoelastic wave equation is proposed for modeling the propagation of ultrasound waves in soft tissue-bone systems using the spectral-element method. Including the attenuative effects within the skull is of considerable relevance across a variety of ultrasound applications due to the highly dissipative nature of the trabecular bone. The incorporation of attenuation within both the fluid and solid regions of the domain using the spectral-element method offers a convenient framework for modeling ultrasound propagation in highly heterogeneous media, such as within transcranial ultrasound, given one's ability to explicitly mesh the soft tissue-bone interfaces accurately within the spatial discretization.

A careful choice in where the attenuative terms enter the wave equations allow for the coupled formulation to be solved fully explicitly while simultaneously maintaining the diagonality of the mass matrix, which is one of the key computational properties of the spectral-element method. While the attenuative terms in the elastic medium are incorporated in the stiffness term, attenuation in the acoustic parts of the domain are introduced by modifying the pressure directly. This allows for the system of equations to be solved fully explicitly within the second-order Newmark time-stepping scheme, while avoiding the need to solve a linear system for the interface conditions.

Several numerical examples applied to transcranial ultrasound are presented, particularly within the area of focused ultrasound. Domains with varying degrees of geometric complexity are shown in order to illustrate this technique's efficacy and flexibility.

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Session Classification: Reconstruction Methods & Modeling

Track Classification: oral presentations