Transcranial ultrasound focusing with reduced cranial invasiveness

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Background

Wavefield focusing, as required in Ultrasound Neuromodulation, can be achieved by Time Reversal Mirrors (TRM). Theoretically, to achieve proper mirroring wavefields emitted by a source at the focal point are first evaluated at a boundary enclosing that focal point. Next, the wavefields are reversed in time and sent back into the medium. Unfortunately in TRM the resulting wavefields are infinite in time and propagate through the entire medium.

Methods

To overcome the problems associated with TRM we propose aFinite Time Focusing (FTF) method where the wavefields are focused using Marchenko focusing functions. In FTF series of wavefronts are emitted into the medium from the surrounding boundary in such a way that only the first wavefronts reaches the focal point \cite{Meles2019}. In contrast to TRM, Marchenko focusing functions have the advantage that they are confined in time and space by the direct propagation path from the boundary to the focal point \cite{Wapenaar2014}.

Results

Both methods have been numerically tested by focusing the wavefield in the brain from outside the skull. Results show that the proposed finite time focusing method (FTF), as compared to TRM, leads to less exposure of the brain outside the focal point. This is beneficial as it would provide focusing with reduced level of cranial invasiveness. In conclusion, the proposed FTF method has the potential to outperforms standard TRM when used for wavefield focusing inside the brain.

References


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