Derating Method for High Intensity Focused Ultrasound

A method for estimating the parameters of nonlinear high intensity ultrasound fields in tissue from measurements in water is introduced, showing high accuracy compared with existing models. This approach enables more precise targeting in both diagnostic and therapeutic high intensity ultrasound procedures.

What is the Problem?

High intensity focused ultrasound (HIFU) systems are used throughout various medical procedures, in both diagnostic and therapeutic applications. In the therapeutic cases, the acoustic energy is focused into targeted regions to damage or ablate tissue (e.g. tumors, cancerous tissue, etc.) through rapid heating. It is therefore crucial that the way these high-frequency fields behave can be predicted with high accuracy, so that during planning a procedure the parameters of these acoustic fields can be confidently set. Mistakes in the estimation of the location and intensity of the focal region can put at risk the success of a given procedure or cause more damage than intended to tissue in the region.

The estimation of these parameters is typically done through a “derating” process, where the field generated by a low-level ultrasound source is measured in water and then extrapolated to its behavior in tissue with a higher source output. The typical assumption of linear attenuation holds true for typical ultrasound systems, and the resulting parameters are accurate. However, for HIFU systems that can be 100 times higher intensity, nonlinear effects throw off the fundamental assumptions of this process. It is therefore critical to develop an analytic approach to predicting the behavior of the fields generated by HIFU systems based on the fields they generate in water, so that procedures using them can accurately target the regions they intend to.

What is the Solution?

This technology introduces a new derating method specifically designed for nonlinear HIFU fields. It enables more accurate prediction of how ultrasound fields behave in biological tissue by using measurements taken in water. The method is based on the idea that, at the focal point where treatment occurs, nonlinear effects dominate and are primarily influenced by the pressure at that point—not by the path the ultrasound waves take. By maintaining the same focal pressure between water and tissue, the method allows for a linear scaling of the source parameters, rather than scaling the focal pressure itself. This approach provides a more reliable way to plan HIFU procedures and set system parameters with greater confidence.

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Device/Other
Selection of Available Technologies

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What is the Competitive Advantage?

This method improves on previous attempts to model this field, which include local corrections that cannot account for the complex nonlinear interplay over the signal path, or attempts to compensate output signals. Good agreement is shown between the predicted, modeled and experimentally measured focal pressures and intensities. For high-gain HIFU systems, the differences between prediction and measurement are less than 10% for the peak positive pressure, and 5% for strongly focused therapeutic transducers. This allows the planning of diagnostic and therapeutic ultrasound procedures involving HIFU systems to be much more accurate in targeting the regions of interest.

Patent Information:

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References

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