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Speed of Sound Tomography
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TECHNOLOGY OVERVIEW

In ultrasound imaging techniques ultrasound waves are send into tissue and the ultrasound waves that are reflected by various tissues are detected.

Photoacoustic tomographic imaging is a hybrid imaging technique that uses pulsed light to induce ultrasound. This ultrasound arises due to thermoelastic expansion at positions where pulsed light is absorbed. The generated ultrasound is detected.

A method has been developed and tested to, on-line, determine the speed of sound in tissue using an acoustic sensor working in reflection mode. The novel element in this technique is the processing of the signal. This specific signal-processing enables to calculate the different velocities of the ultrasound waves in different tissues.

TECHNOLOGY DESCRIPTION

Type of innovation

PROCES

Problem/Motive

Both ultrasound imaging techniques and photoacoustic tomographic imaging techniques require knowledge of the speed of sound in the tissues to reconstruct an image. Accurate sound speed measurement is possible with transmission methods. These methods, however, are limited to small thickness tissues, and are non-local in that they give the average speed of sound throughout the whole tissue thickness. For imaging in biological tissue for medical purposes, the speed of sound has to be determined in reflection mode.

In ultrasound imaging or in photoacoustic tomography a speed of sound in tissue is often assumed of 1540 m/s. The actual velocity in various types of tissue ranges from 1350 m/s for fat to 1700 m/s for skin. When the speed of sound used to generate ultrasound images is deviating from the real speed of sound this will result in serious deformation artifacts in the image.

Solution

A method has been developed and tested to, on-line, determine the speed of sound in tissue using an acoustic sensor working in reflection mode. For application of our method a discrete acoustic source inside the tissue is required. For ultrasound imaging this can be a small tissue structure with acoustic contrast higher than its surroundings. In the case of photoacoustic imaging this discrete source can be a single blood vessel. Information about the depth position of the discrete acoustic source it not required.

The novel element in this technique is the processing of the signal. This specific signal-processing enables to calculate the different velocities of the ultrasound waves in different tissues. This way images can be generated with a higher resolution and with a more realistic representation of the anatomical situation. Furthermore, the new method can be used to monitor changes in the tissue condition which directly affect the speed of sound, such as the tissue temperature.

The speed of sound in water has been measured as a function of temperature. Comparison of our data with published reference data shows an average systematic error of 0,1%. The standard deviation of the estimated speed is 0.1%. The accuracy in the temperature measurement is not taken into account, but a deviation in temperature of $\pm 0.5^{\circ}\text{C}$ will lead to an error in the estimated speed of sound of $\pm 0.1\%$. The accuracy that follows from a single temperature experiment (standard deviation 0.007%,) indicates that our method is able to estimate the sound speed with accuracy a lot better than 0.1%.

Advantages

- The method can be applied with even the simplest ultrasound array sensor.
- The method can be used to correct ultrasound or photoacoustic images for spatial and temporal variations in speed of sound. In case of high-resolution imaging (high frequency ultrasound, photoacoustic tomography) this will be necessary to obtain sufficient image resolution.
- The method provides a means to monitor changes in the tissue condition which change the speed of sound, specifically the application of monitoring the tissue temperature.
- The method will be further developed to realize measurement of the 2D or 3D sound speed distribution in tissue to identify different tissue structures by their speed of sound: "speed of sound tomography".

Patent status

In August 2004 a PCT application has been filed.

COLLABORATION

ID-NL is looking for companies who are interested to participate together with the University of Twente in the further development of this promising technology with the goal to obtain the rights on this technology.

MORE INFORMATION

Non disclosure agreement (NDA) necessary: YES

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