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Reconstruction of scatter characteristics using 3D Ultrasound Tomography

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Conventional reflectivity imaging with Ultrasound Tomography (USCT) reconstructs qualitative images proportional to the magnitude of the impedance gradient. We propose a method to additionally recover the scatter characteristics of each reconstructed voxel, i.e. whether a reflection is diffuse or specular. This additional information may be used to discriminate different tissue types as it can be hypothesized that plain surfaces of e.g. cysts reflect the ultrasound different than rough surfaces of e.g. spiculated masses.

We recover scatter characteristics based on 3D Synthetic Aperture Focusing Technique (SAFT). In conventional SAFT, the signal amplitude at a certain time of flight for a given emitter-voxel-receiver-combination is added up for each voxel. The novel approach now separates the incoming and outgoing energy in each voxel according to the incident direction e of the emitted wave and the direction to the receiver r. To reduce memory requirements, the directions to emitter resp. receivers are discretized: per voxel a set of n direction vectors d_i with i in $[1,n]$ (Figure 1(a)) is created for emitters and receivers leading to a 2D scatter map for each voxel with size n x n. The energy is assigned to a $d_{(i,s)}$ and. $d_{(i,r)}$ based on a threshold on the angle of e and r to $d_{(i,s)}$ and $d_{(i,r)}$ respectively. The 2D scatter map can be interpreted as the distribution of energy which has been introduced from a certain direction and which has been reflected into a particular direction.

For validation we developed a simulation based on the Phong reflection model in order to simulate signal data for scatterers with different characteristics. For visualization we show plots of the obtained 2D scatter maps in Figure 1(b) of the voxel at which the scatterer (Figure 1(a)) was located. From the maps true point scatterers, diffuse scattering objects and specular reflecting objects can be distinguished: The more concentrated the energy, the more specular the scatterer is reflecting. Furthermore, we performed several experiments to visualize the multidimensional data for the entire volume by calculating characteristic numbers such as the maximum of the scatter map divided by the mean per voxel, see Figure 1(c).

In a next step we are planning to analyze the method with simulated data of more complex objects and finally with experimental data. The novel multidimensional data, which can be reconstructed, may be used to differentiate tissues in future, e.g. by appropriate visualization for doctors or using machine learning.

Preferred Contribution Type

Presentation

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