Spatial filters for focusing ultrasound images

Traditionally focusing is done by taking out one sample in the received signal from each transducer element and then sum these signals. This method does not take into account the temporal or spatial spread of the received signal from a point scatterer and does not make an optimal focus of the data. A new method for making spatial matched filter focusing of RF ultrasound data is proposed based on the spatial impulse response description of the imaging. The response from a scatterer at any given point in space relative to the transducer can be calculated, and this gives the spatial matched filter for beamforming the received RF signals from the individual transducer elements. The matched filter is applied on RF signals from individual transducer elements, thus properly taking into account the spatial spread of the received signal. The method can be applied to any transducer and can also be used for synthetic aperture imaging for single element transducers. It is evaluated using the Field II program. Data from a single 3 MHz transducer focused at a distance of 80 mm is processed. Far from the transducer focal region, the processing greatly improves the image resolution: the lateral slice of the autocovariance function of the image shows a -6 dB width reduction by a factor of 3.3 at 20 mm and by a factor of 1.8 at 30 mm. Other simulations use a 64 elements, 3 MHz, linear array. Different receiving conditions are compared and this shows that the effect of the filter is progressively lower, but the approach always yields point spread functions better or equal to a traditional dynamically focused image. Finally, the process was applied to in-vivo clinical images of the liver and right kidney from a 28 years old male. The data was obtained with a single element transducer focused at 100 mm. The improvement in resolution was in this case less evident and further optimization is needed.