Ultrasound image quality can be characterized by two common imaging metrics: resolution and signal-to-noise ratio (SNR). Resolution refers to the extent an imaging system is able to distinguish between details within the image. SNR is a common measure of image clarity which compares the level of the desired signal to the level of corrupting noise.

**Objective**

Improve the resolution and SNR using a combination of pre- and post-processing imaging techniques.

**Significance**

By improving the resolution and SNR of the received ultrasound images, smaller tumors could be identified sooner.

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**System Block Diagram**

**REC Overview**

REC utilizes the convolution equivalence principle to synthetically exchange the transducer’s response with a desired response. The desired response is excited by a linear chirp to produce the desired output. The desired output is then deconvolved by the transducer impulse response to generate a pre-enhanced chirp, which is then used to excite the transducer.

**Wiener Filter**

In order to achieve the greatest possible effect from the REC technique, the received signals must then be passed through a Wiener filter. The Wiener filter acts as a hybrid between a matched filter and an inverse filter, suppressing the noise and deconvolving the signal.

\[
\beta_{\text{REC}}(f) = \frac{|V_{\text{REC}}(f)|^2 + \gamma e_{\text{SNR}}^2(f)}{\text{PSD}_{\text{noise}}(f)}
\]

**GSAU Overview**

The GSAU technique involves transmitting and receiving on each ultrasonic element of the transducer one at a time. This scheme results in cylindrical wavefronts which cause the received signals to have directional ambiguity. This directional ambiguity can be overcome by summing the different images from each transmit event, since they should only all overlap at one point.

**Image Quality Metrics**

**Resolution**

Resolution is typically calculated from the modulation transfer function (MTF), one of the most common imaging benchmarks. The MTF is the normalized magnitude of the Fourier transform of the spatial impulse response. The characteristic wave number \(k_z\) is measured at the point where the MTF crosses a value of 0.1. The resolution \(A\) is then expressed as a function of \(k_z\).

\[
\lambda = \frac{2\pi}{k_z}
\]

**SNR**

The SNR is evaluated along the scan line containing the imaged point. It is typically expressed in decibels (dB) due to the possibility of wide dynamic ranges.

\[
\text{SNR}_{\text{dB}} = 10\log_{10}\left(\frac{P_{\text{signal}}}{P_{\text{noise}}}\right)
\]

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**Results**

Images were captured of a point centered 20 mm before and after Weiner filtering and beamforming, using the REC technique. Significant improvement in the SNR was observed when compared to a conventional pulsed (CP) technique. Switching to the GPU from the CPU resulted in a factor of 116 speedup, reducing the computation time from 30 s to 0.25 s.

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**Conclusions**

Based on preliminary results, it appears that the REC and GSAU techniques improve the SNR and spatial resolution of the images. Using a GPU for parallel computations of each pixel allows for real-time processing of the GSAU algorithm.

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**References**

