Initial progress on Wholebody QT applications

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Normal thought would say that wholebody ultrasound can’t be done

- Attenuation is too high
- Can’t get enough SNR
- Low frequencies don’t yield enough resolution
- It’s not practical
- We already have MRI/CT/…., so why do it?
- Nobody wants it
Wholebody Ultrasound is difficult, but possible

• What exactly are the problems?
• What are the benefits?
• How does QT solve these, or at least suggest a solution?
• Results of initial experiments in wholebody
We need to examine some of our basic premises

• Until now, medical imaging techniques have a basis of sampling and statistics
  - Resolution and CNR limited by sampling

• Why is that? **Scattering is a big part of it, computational resources another**

• With inverse scattering, ultrasound tomography looks more like microscopy
  – It's more of an analog problem
  – Resolution becomes limited by diffraction

*Hold that thought*
Problems with wholebody ultrasound in general

• The gold standard is MRI. This is what we should shoot for.
• Distances are long, especially for high BMI patients
• This involves more power for vanishingly small amounts of signal
• Refraction and Diffraction also steadily warp and degrade the signal

MRI (T2 Fat-suppressed sequence)
Attenuation is a large problem facing wholebody applications

- Attempts to use higher frequencies fail due to high attenuation
- SNR at any reasonable depth is not useful without additional methods
- There are ways to improve SNR beyond just adding power
- Clinicians tend to prefer unreasonably high frequencies because of perceived resolution at lower frequencies. (mostly due to scatter)
Compounding can significantly improve SNR

- Sampling a volume from multiple source locations improves the statistical quality of the measurement
- This is the equivalent in optics of using a lens with higher numerical aperture (NA)
Problems with wholebody ultrasound in general

• We think of the response from a standard ultrasound transducer as a perfectly flat fan
• In reality, it is far from flat due to refraction and diffraction effects
• This limits our ability to compound scans because nothing lines up spatially
• These problems get worse as the depth gets deeper
To solve this problem we need to work in reverse!

1. Using transmission ultrasound (low F), solve for attenuation and speed
   - This enables a variety of spatial corrections in reflection data
2. Correct for refraction, diffraction, and attenuation in reflection modes
   - Eliminate geometric artifacts
3. Compound over the widest angle range possible
   - This improves SNR while retaining good resolution
4. Parametrically combine reflection and transmission information
   - This creates images with the most useful components of both
Transmission Ultrasound in 3D
Ultra Low Frequency Transmission

Standard Protocols  
Increased Iterations at HF  
Increased Iterations at LF
Wide angle compounded Kidney Imaging
Transmission imaging (Kidney)
Combining Reflection and Transmission information

- Previous work in automated tissue segmentation and identification yielded excellent results (Malik et. al., 2016)
- Combining these methods parametrically can yield further improvement in the final SNR of the image volume
Parametric Wholebody piglet cross section QT vs MRI (3T)

QT Ultrasound

MRI (T2 Fat-suppressed sequence)
ANATOMY CORRELATION OF QT

Piglet Abdomen

Luminal air
Spiral colon
External abdominal oblique m
Internal abdominal oblique m
Transversus abdominis m
Renal pelvis
Renal medulla
Ureter
Vertebral body
Rectus abdominis mm
Small intestine
Renal cortex
Renal medulla
Epaxial muscles
Hypaxial muscles

Anatomical correlation courtesy of Dr. Catherine Ruoff, DVM, Texas A&M University
Wholebody Ultrasound works
Questions?