Automated Hierarchical Time Gain Compensation for Ultrasound Imaging

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Summary

Background

- Radiofrequency (RF) echoes are strongly attenuated by the tissues scanned.
- Time gain compensation (TGC) is usually utilized to compensate for the acoustic attenuation.
- Scanning rely on the interaction with the medical doctor to optimize the scan settings.
- Several adjustments on the keyboard of the modern scanners.

Objective

- Decrease the adjustments done by a medical doctor on the ultrasound scanner and optimize the quality of the scans.

Problem

- Automatic time gain compensation used in ultrasound scanners weakens the edges and over-gains large fluid collections such as urine bladder or gallbladder (anechoic regions).

Approach

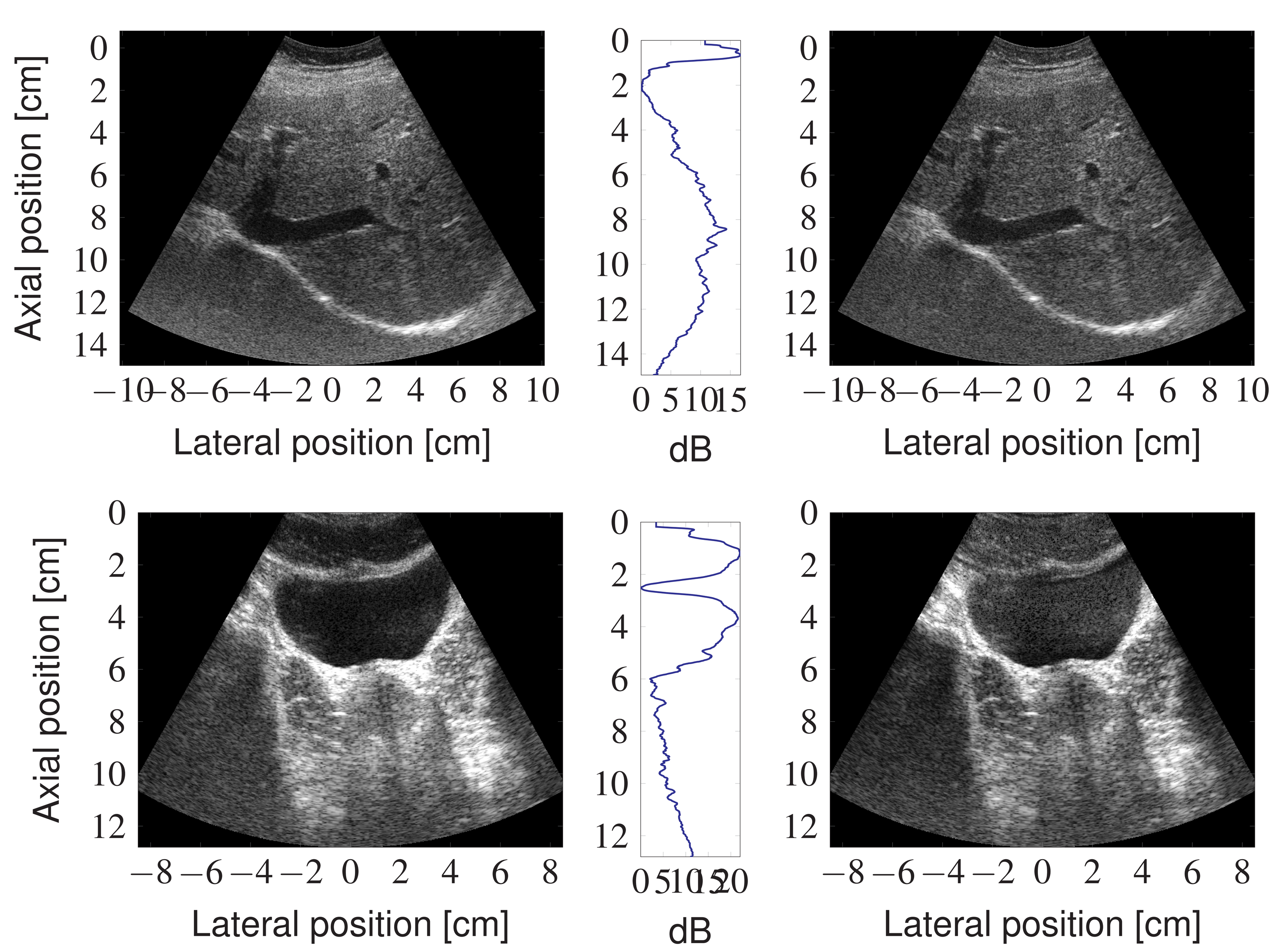
- Estimating the attenuation map using log spectral difference method to correct the gains inside the anechoic regions.

Future work

- ***Using Deep Learning Architectures for segmentation and tracking of tissues in ultrasound scans.***
- ***Learning hierarchical features for scene segmentation.***

What has been done previously for TGC

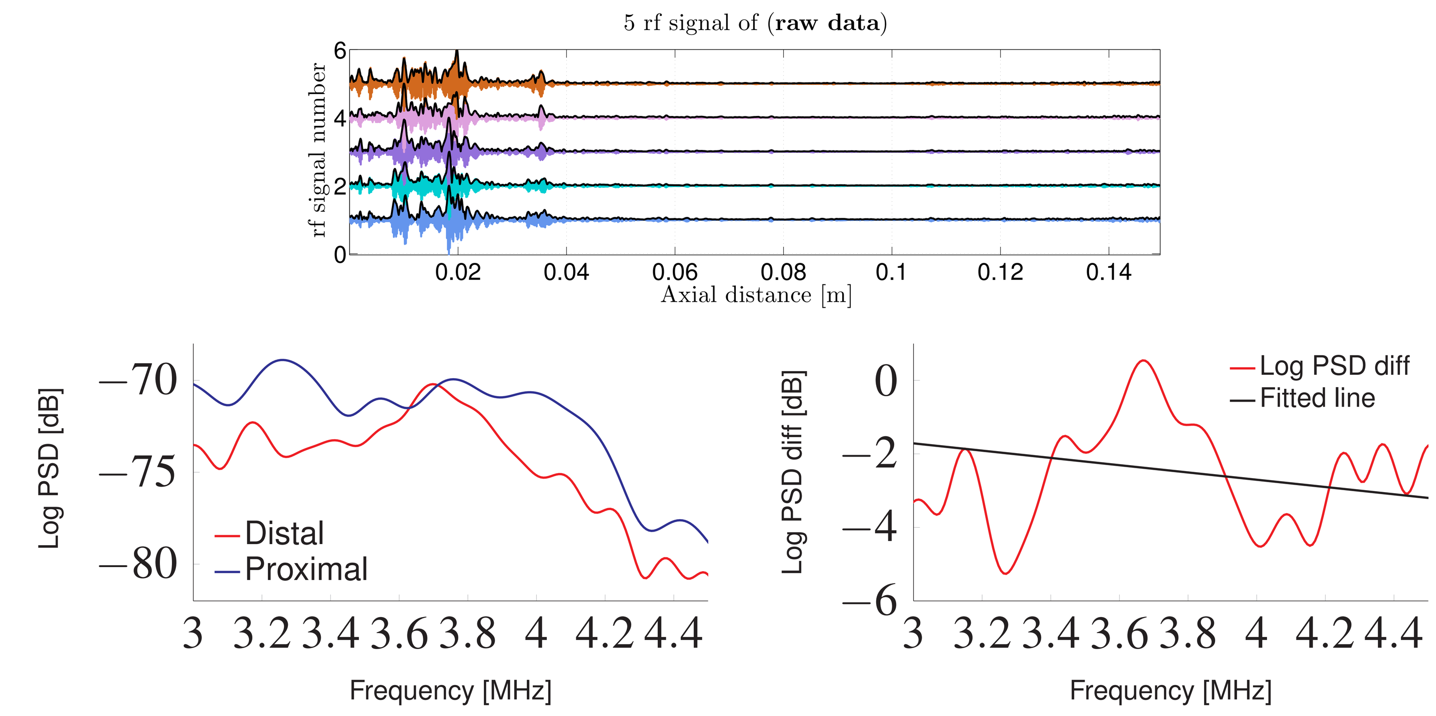
TGC offsets the attenuation of ultrasound echo signals along the depth so that echoes belonging to deep structures are more amplified compared to superficial echoes. This provides more uniform signals to be displayed on the scanner.



- Very good performance on abdominal scans of human liver and bladder.
- TGC over-gains the anechoic region (inside the bladder).

Our approach: Latest results

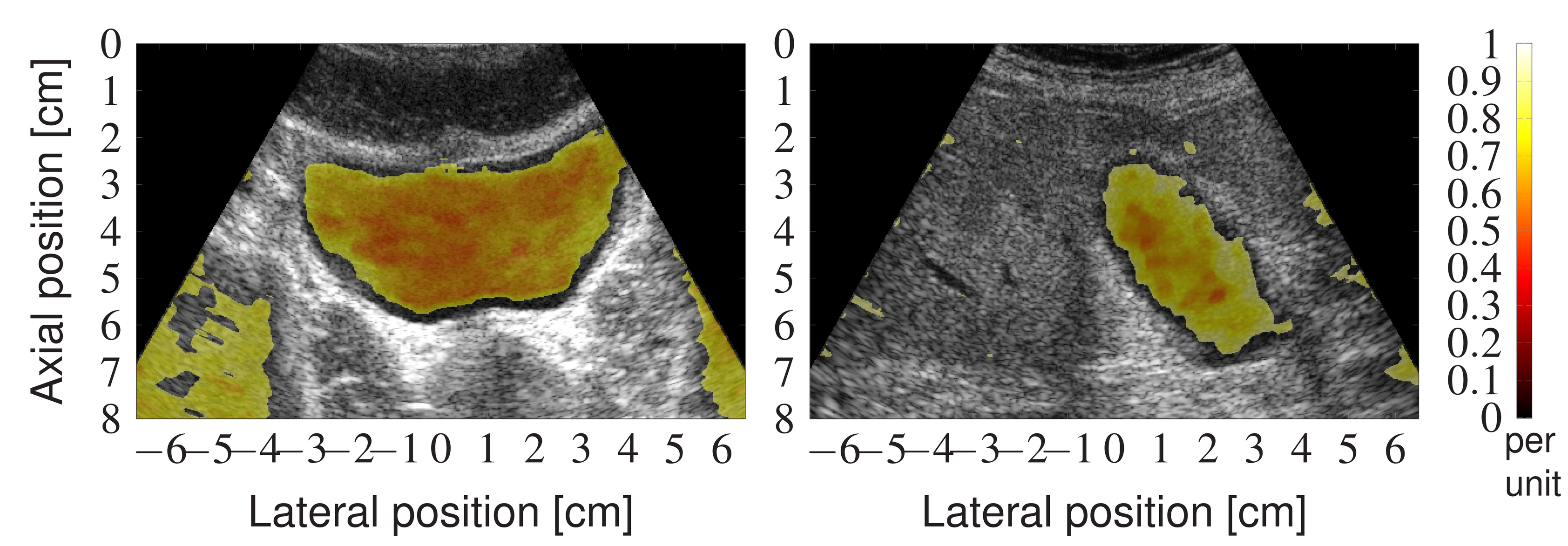
- Estimating the attenuation slopes, and generating the 2-D attenuation map using the spectral log difference of RF-data.



(a) Example Log PSD of a paired proximal and distal segments, where the $f_0 = 3.75$ MHz. (b) Log PSD difference, and fitted line with slope $= -0.502$ dB/cm×MHz.

Illustration of how the attenuation value for a pair of proximal and distal segments are computed.

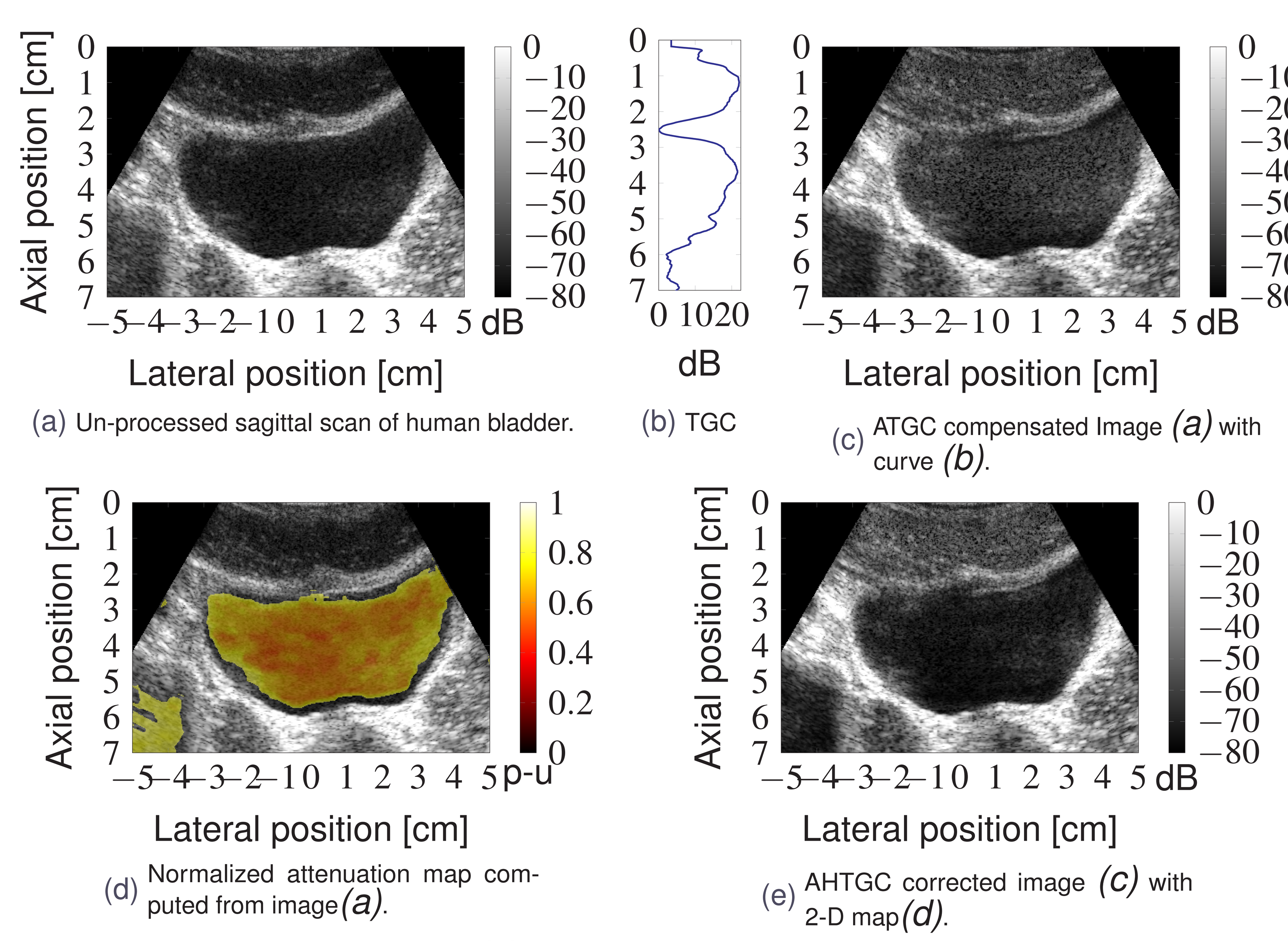
- The attenuation maps characterising the scanned media are computed and used to correct the mis-adjusted high gains inside the anechoic regions.



(a) Normalized attenuation map of a bladder scan. (b) Normalized attenuation map of a gallbladder scan.

Examples of normalized attenuation maps overlaying on B-mode images

- The original scan including a large collection of fluid (urine bladder) is first compensated using a TGC curve. The 2-D attenuation map is then applied to avoid over-gaining inside the bladder.



(a) Un-processed sagittal scan of human bladder. (b) TGC (c) ATGC compensated Image *(a)* with curve *(b)*.

(d) Normalized attenuation map computed from image *(a)*. (e) AHTGC corrected image *(c)* with 2-D map *(d)*.

Illustration of how the proposed AHTGC algorithm is applied to a sagittal scan of human bladder. (a) Un-processeed scan. (b) TGC curve computed for image *(a)*. (c) ATGC compensated image *(a)* with curve *(b)*. (d) 2-D attenuation map compuetd from image *(a)*. (e) Attenuation corrected image *(c)* with 2-D map *(d)*.

Results and Discussion

- Matching Pairs of *in vivo* sequences, unprocessed and processed with the proposed AHTGC were visualized side by side and evaluated by two radiologists in terms of image quality.
- Wilcoxon signed-rank test was used to evaluate whether radiologists preferred the processed sequences or the unprocessed data.
- The results indicate that the average VAS score is positive (p-value: 2.34×10^{-13}) and estimated to be 1.01 (95% CI: 0.85; 1.16) favoring the processed data with the proposed AHTGC algorithm.
- The 2-D attenuation profiles also provide solid foundation for other processes like segmentation of the tissues.