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Improved temperature measurement and modeling for 3D USCT II

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Ultrasound computer tomography for breast cancer relies on accurate SOS information, mostly disturbed by the temperature dependency of H^2O as medium. The current KIT USCT system (3D USCT II) incorporates many temperature sensors: two accurate calibrated and many low accuracy temp. sensors for spatially densely sampled 3d information. The accurate knowledge of the temperature is important for accurate and sharp imaging as in the USCT setup approx. 50% of the US travel distance is through water. Over an USCT measurement duration the sensors are digitized in second's interval. While many experiments are represented accurately some experiments needs an enhanced and robustified approach.

(2) Material and Methods

In a 1st step temporal oversampling reduces the ADC noise and achieve sub-bit "super resolution"by a low-order polynomial fit which also models temperature drifts. In the 2nd step, locality & symmetricity for the sensors surrounding the HQ sensors is utilized. A global compensation is created by utilizing many measurements. A final step integrates all data in a mode assuming a low rate of change over space and time, by that removing individual deviations.

For added robustness, we expand our method to include procedure variations and unknown influences now: air temp., device heat up, water temp. Therefore we installed additional sensors and created a setup which applied fast temperature changes to gain data about the temperature inertia.

(4) Discussion and Conclusion

An ongoing analysis of our results revealed that we have significantly layering effects, meaning that we see significant temperature differences along the vertical axis (about 1℃). We believe this to be due to heating from the DAQs on the outside of the bowl holding the water. We are currently investigating these two phenomena further.

(3) Results

The accuracy and precision of the temp. data has been improved by more than an order of magnitude. This is well-beyond the original hardware-limited 1-bit resolution. We achieved a sub-bit accuracy of 0.005℃ for a confidence interval of 95% as opposed to the original ± 1℃ raw accuracy. Our method automatically minimizes and substitutes outliers and faulty data using a robust model, reduces the sizeable hardware-related variation of about 0.6℃ among individual sensors & runs without additional time-intensive delays on the USCT measurement process.

However, that we do on occasion see significant deviation (± 1℃) from expected results using our method. For this reason, we are currently working to incorporate more data.

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