Tracked ultrasound calibration studies with a phantom made of LEGO® bricks

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PURPOSE: Real-time tracked ultrasound imaging is a non-invasive and safe approach to facilitate needle-based interventions such as biopsy, drug delivery and surgical ablation. These procedures require a degree of accuracy maintained by an accurate and consistent spatial and temporal calibration that relates the image pixels of the ultrasound to the coordinate system of the tracked probe. In this study, spatial calibration of tracked ultrasound was compared by using a calibration phantom made of LEGO® bricks [1] and two 3-D printed N-wire phantoms [2].

METHODS: The accuracy and variance of calibrations were compared under a variety of operating conditions. Twenty trials were performed using an electromagnetic tracking device with a linear probe and three trials were performed using varied probes, varied tracking devices and the three aforementioned N-wire phantoms shown in figure 1. The accuracy and variance of spatial calibrations found through the standard deviation and error of the 3-D image reprojection were used to compare the calibrations produced from the phantoms.

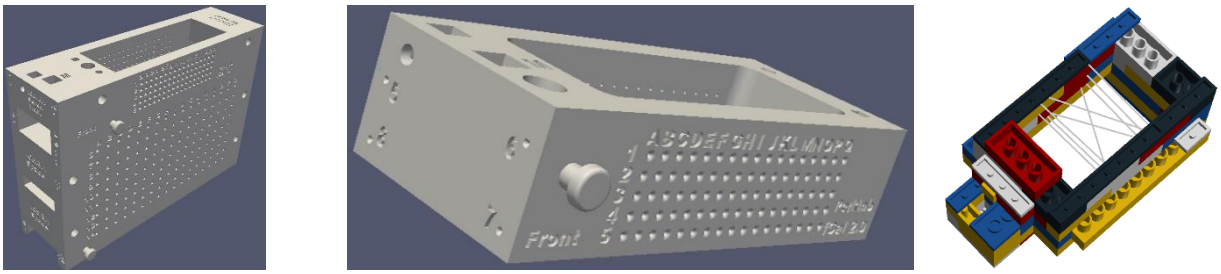

Figure 1. LEFT: fCal-3.1 calibration phantom (Carbajal *et al.* 2013). MIDDLE: fCal-2.0 calibration phantom (Carbajal *et al.* 2013). RIGHT: LEGO® calibration phantom (Walsh *et al.* in review).

RESULTS: This study found no significant difference between the measured variables of the calibrations. The average standard deviation of multiple 3-D image reprojections with the highest performing printed phantom and those from the phantom made of LEGO® bricks differed by 0.05 mm and the error of the reprojections differed by 0.13 mm [3].

CONCLUSION: Given that the phantom made of LEGO® bricks is significantly less expensive, more readily available, and more easily modified than precision-machined N-wire phantoms, it prompts to be a viable calibration tool especially for quick laboratory research and proof of concept implementations of tracked ultrasound navigation.

ACKNOWLEDGEMENTS: This project was supported by Natural Sciences and Engineering Research Council of Canada (NSERC) and Cancer Care Ontario (CCO). Marie Soehl was supported by Queen's University Summer Work Experience Program. Ryan Walsh was supported by NSERC. Gabor Fichtinger was funded as a CCO Research Chair. "LEGO®" is a trademark of the LEGO® group of companies which does not sponsor, authorize or endorse this publication.

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