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Introduction

Ionoacoustic (IA) range verification uses thermoacoustic waves generated from regions irradiated with pulsed proton beams to derive the Bragg peak (BP) positions. Superimposing IA and ultrasound (US) images can provide the BP locations on tissue anatomy, hence enabling real-time dosimetry and treatment monitoring. In the work presented here, the possibility of such superimposition and subsequent dose reconstruction (DR) is investigated.

Materials & Methods

Spatial co-registration was achieved using the same ultrasonic transducer (a 12 MHz CMUT single-element) whereas a synchronized IA and US data acquisition ensures the temporal co-registration. Both co-registrations were validated in simple water phantoms irradiated by a 20 MeV pulsed proton beam. The effect of tissue heterogeneities was investigated by irradiating a 3D printed realistic mouse phantom and acquiring separate US measurements. A simulation study was performed to investigate the feasibility of DR, in the phantom mentioned above, using the k-Wave platform. For realistic case of IA signal generation and propagation, CT data of the mouse phantom and impulse response of the transducers were modeled in the simulations.

Results

An accurate range verification and precise co-registration between the two modalities were obtained. From the simulation study, it was inferred that the *a priori* knowledge of tissue properties is essential for a ~ 0.2 - 0.5 mm error in BP localization in mouse and also for an accurate DR. The tissue properties can be further deduced using US and CT images.

Conclusion

IA and US co-registration was investigated by simulations supported by experimental results for a mouse model. Simulation results indicate the need to account for the tissue acoustic properties for accurate DR. The next step will involve accurately deriving those properties from US/CT and quantifying the influence of uncertainties in tissue properties on the accuracy of DR.

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