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In vivo bone position measurement using high-frequency ultrasound validated with 3-D optical motion capture systems: a feasibility study

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Abstract— Accurate measurement of bone position in vivo during dynamic activities has the potential to improve our identification and understanding of injury mechanisms and enhance our ability to design protective equipment and/or devices for rehabilitation and human augmentation. Existing technologies such as skin-mounted reflective markers and fluoroscopy are limited either in accuracy or portability. The purpose of this study was to demonstrate a proof of concept for an ultrasound (US) sensor array to measure bone positions around a human joint in vivo. A single off-the-shelf US sensor was tested for repeatability and accuracy in measuring soft tissue depth between the skin surface and embedded bone with (a) a gelatinous analog for human tissue, and (b) a porcine leg specimen. In measuring the hydrogel analog the sensor was able to measure depth with a repeatability of 0.25 mm. In measuring the porcine leg specimen, measurement accuracy was compared to a Qualisys optical motion capture system with accuracy on the order of 0.5 mm, and the US measurement uncertainty was found to be 1.1 mm. An additional set of tests on a similar system performed on a human participant performing elbow flexion/extension confirms that the method is usable for evaluating both the bone position and the muscle volume during movement analysis measurements. This study demonstrates that low cost off-the-shelf US sensors have acceptable quality to measure bone positions accurately in vivo. Link of the paper: http://rdcu.be/txkG

Index Terms— Biomedical transducers; Ultrasonic transducer arrays;

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