Measurement and Simulation of Various On-Body Antenna Utilizing a Modular Arm-Swinging Phantom Model for Wireless Body Area Network Applications
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George Lee* [(1)], Brian Garner [(1)], and Yang Li[(1)]
(1) School of Engineering and Computer Science, Baylor University, Waco, TX 76706, USA

Wireless body area network (WBAN) technology has the potential to improve human quality of life through applications such as remote, long-term health monitoring. One of the main technical challenges inhibiting implementation of usable WBAN systems is the need for miniaturized and power efficient antennas for on-body sensors. Previous work has used human and computer models (Gallo *et. al.*, *IEEE Antennas and Wireless Propag. Lett.*, 7, 321-324, 2008), as well as phantom models (Yamamoto, *et al.*, *IEEE Trans. on Ant. and Prop.*, 61, 4315-4326, 2013), in order to study on-body electromagnetic (EM) wave propagation. However, a more thorough understanding of on-body wave propagation mechanisms, and how those are affected by the presence and motion of the human body, is necessary to guide design of the power-efficient antennas.

In this study we examine on-body wave propagation behavior using experimental and simulation methods with a physical phantom model designed to simulate the effect of the human body. The phantom model consists of hollow plexiglass torso, head, and arms that are connected to represent the shape of the human upper body. The hollow phantom body segments are filled with a water-based fluid having dielectric properties similar to that of human muscle tissue. The phantom model has motorized arms capable simulating human arm swinging motions as during human gait. The phantom model provides a controlled environment for high repeatability and correlation of on-body wave propagation during both experimental trials and computer model simulations. Additionally, the modular phantom model design facilitates study of various model configurations and parameters, such as with or without legs or arms, and varying values for dielectric properties, motion speeds, and motion activities. Finally, the phantom serves as a repeatable platform upon which to test the performance of different antenna types and designs for on-body applications.

Experimental methods involve collection of human and phantom motion-capture data, and on-body antenna wave propagation data from a vector network analyzer. Simultaneous collection of motion and propagation data permits analysis of the body motion's effect on antenna signal transmission. EM transmission data is recorded at 433MHz, 915MHz, and 2.45GHz. Human data and phantom data are compared to verify the phantom model's accuracy as a human representative. Computer simulation of the phantom model is also performed in CST Microwave Studio software for additional verification, and for validation of the computer modeling approach.

Comparison of human measurement, phantom measurement, and phantom simulation data shows generally good agreement in terms of antenna signal fluctuation pattern and periodicity, suggesting the phantom model is a good representative of EM wave propagation on the human body. The phantom model will facilitate further simulation and measurement experiments with additional antenna types and body parameters to gain further insight into on-body wave propagation mechanisms for use in optimizing antenna designs for WBAN applications.