Simulation of Dynamic On-Body Wave Propagations with Experimental Verifications

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Wireless body area network (WBAN) technology is emerging with great potential to improve quality of life through applications such as remote health monitoring. However, wearable sensors must be power efficient and small to operate for long periods of time and not obstruct daily activities. Optimal design of antennas for such sensors will require a thorough understanding of how electromagnetic (EM) waves propagate along and around the human body as the body segments move. Previous studies have largely focused on experimental, point-to-point measurement of EM transmission during common activities such as walking (Gallo et al., IEEE Antennas and Wireless Propag. Lett., 7, 321-324, 2008; Munoz et al., IEEE Transactions on Antennas and Propag., 62, 5268-5281., 2014). The purpose of this paper is to develop a full-wave simulation platform to compute EM propagation paths between on-body transmitters and receivers during various human activities.

This study combines experimental and simulation techniques. For the experiments, several adult volunteers were recruited to perform various tasks such as arm swings, boxing motions, rising from a chair, and jumping. For each trial, three-dimensional motion capture data was collected simultaneously with EM transmission data. The EM transmission data was measured for three frequencies (433MHz, 915MHz, 2.45GHz) using a vector network analyzer (VNA) with antennas placed in various configurations including chest and back, chest and wrist, and on both wrists. The experiments were then repeated in CST Microwave Studio simulation software using a human body model composed of simple geometric cylinders and homogeneous human muscle tissue properties. In a series of successive simulations the human body model was positioned to match each frame of the recorded motion capture data, and EM propagation from transmitter to receiver was computed. The computed transmission was then compared to that measured during the experiments.

Current results have shown good agreement between simulation and experiment for several motion tasks and antenna placements. Continuing efforts to refine the model are ongoing in pursuit of improved agreement. A validated EM simulation model and platform will permit in-depth study of EM propagation paths along and around the human body, guiding design of optimized on-body antennas.