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Electromagnetic Modeling of Human Subject Vital Signs, Motion Tracking, and Gait Analysis and Experimental Validation

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The analysis and monitoring of human activities using contactless radar technology is an alternative to the conventional costly and invasive methods. To design efficient signal processing algorithms and optimal hardware configuration in such systems, an accurate analysis and understanding of the electromagnetic interactions in the scene is important. Electromagnetic (EM) analysis paves the way to employ non-contact methods for vital and motion events unlike wearable sensors that require maintenance by the user. Analyzing the data produced by EM modeling, if accurate, could shed light on the fine details of human movements that could help us understand the normal and the abnormal activities. EM modeling addresses one of the major issues in conventional investigation that is repeatable and completely under our control that can identify the fine details of human activities at different scales from torso to feet, lung, knees, toes, hands, and legs.

Advanced EM modeling has been used already for analyzing human motion kinematics. Various events like walking and falling have been studied in detail and developed models have been validated experimentally. For example, human gait has been investigated and various body parts motion kinematics including velocities, acceleration and jerks were estimated. Two EM models based on an empirical human body representation "The Boulic Model" for human vital signatures and human motion have been developed. The scattering waves from a human body are used to study the motion through Doppler effect, or the motion signature to extract the motion kinematics. Typically, such calculations are computationally intensive due to the problem size, and the multi-level fast multiple method (MLFMA) is used to accelerate our calculations. Further acceleration has been achieved using multi-node GPU cluster.

In this presentation, we will present our developed models, computation strategy, and the various radars that have been developed and successfully implemented to validate such human models.