Human Motion Detection in Indoor Environment – A Model Using Multilevel Fast Multipole Algorithm on Graphical Processing Unit Cluster

Nghia Tran*, Tuan Phan, Ozlem Kilic,

Department of Electrical Engineering and Computer Sciences
The Catholic University of America, Washington, DC 20064, U.S.A.
16tran@cardinalmail.cua.edu, 30phan@cardinalmail.cua.edu,kilic@cua.edu,

Detecting, tracking and monitoring human motion in cluttered media such as indoor environments, play an essential role in security and surveillance operations such as health monitoring and homeland security. Several different radio-frequency devices have been developed for this purpose. In particular, small variations in the carrier frequency caused by human walking can be detected by Doppler radar systems which provide low-cost, and low-maintenance solution to detect motions. The micro-Doppler (m-D) frequency shift depends on the transmitted frequency and the velocity of the different body parts over time. M-D spectrogram can be generated from frequency shifts to identify and classify different types of motions. For example, human m-D signatures can be differentiated from others, including those caused by four-legged animals.

Many authors have investigated micro-Doppler effects to classify and identify different human motions. The scattered fields in human motion studies conventionally have been calculated using simple point scatterers to present the different body parts. An iterative physical optical (PO) approach has also been utilized at higher frequencies. These techniques, however, do not include mutual coupling effects between the different human parts and the environment.

In this paper, we propose to use a full-wave scattering model based on the Multilevel Fast Multipole Algorithm (MLFMA) to calculate the m-D signatures from the scene as the human moves. Due to the large size of this problem, MLFMA parallel implementation is performed on our GPU cluster. The utilization of MLFMA for this application incorporate the mutual coupling effects between different human body parts and the indoor environment as human walks in the scene. PEC canonical objects, such as ellipsoids and spheres, are used to model different body parts which is described by 16 joints based on Boulic model. The human walking signature in the indoor environment will be analyzed for different test cases such as different speeds and paths for the human.