Micro–Doppler Signature of Human Walking in Forest Environment

N.Tran*, O. Kilic, J.M. Garcia-Rubia, V.Dang, Q. Nguyen

Department of Electrical Engineering and Computer Sciences
The Catholic University of America, Washington, DC 20064, U.S.A.
16tran@cardinalmail.cua.edu, kilic@cua.edu, garciarubia@cua.edu,
13dang@cardinalmail.cua.edu, 93nguyen@cardinalmail.cua.edu

Detecting, tracking and monitoring human motions in dense environments, such as forests, play an important role in security and surveillance operations. Several different radio-frequency devices such as Doppler radars have been developed for this purpose. In particular, micro-Doppler radar systems are able to detect phase variations between the transmitted and received signals which correlate with the motion of body parts as the human moves.

Many authors have investigated micro-Doppler effects to classify and identify different human motions. Originally, backscattered signals from human have been computed using a simple approach with point scatters to calculate the radar cross section (RCS) for body parts modeled as simple shapes, such as cylinders, ellipsoids or spheres. An iterative physical optical (PO) approach has also been employed at higher frequencies. These approaches, however, do not incorporate mutual coupling effects between the different human parts and the environment.

In this paper, we propose to use an analytical forest model integrated with a full-wave human scattering model to calculate the micro-Doppler signatures from the scene as the human moves. The analytical forest model is a first-order solution, which accounts for the ground effects. The human scattering model uses Method of Moments (MoM) enhanced by the Fast Multipole Method (FMM), which includes the mutual coupling effects between body parts. The forest is created by using finite cylinders distributed randomly in space to replicate the trunks and branches. In this solution, the contribution of mutual coupling between the cylinders to the micro-Doppler signature is assumed negligible. Due to the complexity of the human scattering model which can be result in 200,000 unknowns, we implement the MoM-FMM algorithm on a High Performance Graphics Processing Unit (GPU) cluster. The human walking signatures created by the model are analyzed for different test cases such as different speed and paths for the human as well as different forest properties.