Classification of Human Motions Using a Single On-Body Antenna

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In recent years, there have been emerging interests in applying on-body antennas to monitor human motion patterns during daily activities. Guraliuc *et. al.* used wearable transceivers to monitor lower-body movements [*Guraliuc, et. al., IEEE Trans. Inf. Technol. Biomed., vol. 15, no. 3, pp. 474–480, May 2011*]. Munoz and Hao applied the frequency analysis to identify different activities [*Munoz, et. al., IEEE Trans. on Antennas and Propagation, vol. 62, no. 10, pp. 5268-5281, Oct. 2014*]. We have also utilized on-body creeping wave propagations for motion recognition [*Li, et. al., IEEE Trans. on Antennas and Propagation, vol. 64, no. 11, pp. 4901-4905, Nov. 2016*]. However, most studies have utilized at least two on-body antennas and, the transmission coefficient between them have been used for classification purposes. The use of a single on-body antenna for monitoring human daily activities remains to be investigated.

In this research work, we seek to utilize reflection coefficient (S_{11}) variations with time of a single on-body antenna to classify different human activities. Human activities, even as small as finger movements, are shown to perturb near fields of the on-body antenna, resulting in change of its reflection coefficients. Therefore, the reflection coefficient varies with time as the human body moves. We first measure S_{11} variations of a chest-worn monopole antenna when the subject is performing daily activities. The measurements include seven subjects, six different activities, and three frequencies. The activities include single arm swinging, both arms swinging, boxing, rowing, hopping, and sitting. Next we introduce a classification algorithm, the dynamic time warping (DTW) algorithm, to distinguish signal variations among different activities. Because DTW calculates the similarity between two temporal signals, it can serve to classify signals through finding the most similar reference that is already measured. We also extend the study to utilize a wrist-worn electrically small antenna to classify small human motions like finger movements. We have measured the reflection coefficients of finger motions including click, double click, zoom, and circle motions of the index finger, and classify them using DTW.