# Classification of Finger Movements Using Reflection Coefficient Variations of a Body-Worn Electrically Small Antenna

Bin Xu(1), Yang Li (1), and Youngwook Kim(2)
(1) Department of Electrical and Computer Engineering, Baylor University
(2) Department of Electrical and Computer Engineering, California State University, Fresno

Monitoring hand and finger motions has long been of interest because of its important applications in human-computer interface, virtual control, computer game, and biomechanics research, etc. One way of classifying human motions is utilizing Doppler radar [Y. Kim, *IEEE Geoscience Remote Sensing Letters*, vol. 13, pp. 2-8, 2016], which can classify human activities based on micro-Doppler signatures. However, it is not trivial to integrate such Doppler radar into a wearable device. In addition, the radar has to face the target at a proper angle for data collection and interpretation. With recent proliferation of wireless body area networks, another alternate approach for recognizing human motions is to apply different kinds of wearable sensors, such as accelerometer, gyroscope [C. Xu, *Proc. 16th Int. Workshop Mobile Computing Systems Applications*, pp. 9-14, 2015], and surface electromyogram [S. M. Mane, *Procedia Computer Science*, vol.49, pp. 58-65, 2015]. However, these sensors need to be integrated into wireless wearable devices, which increases cost as well as overall power consumption.

Lately, it was found that the impedance variation of an on-body antenna through near field perturbations can be utilized to classify various human activities, such as boxing, hopping, arm swinging etc. [Y. Li and Y. Kim, *IEEE Antennas and Wireless Propagat. Lett.*, Issue 99, 2016]. Compared to the above physical sensors or radar, this approach is of low cost and low power consumption, and can provide high classification accuracy. Moreover, users do not have to attach or setup another sensor because an antenna from a handheld device can be utilized. A similar approach to the motion classification is applied in this study for finger gesture recognition. In this work, an electrically small antenna, a folded cylindrical helix (FCH), is selected for on-body measurements for its unique characteristics of low profile and narrow resonance bandwidth.

In our measurements, the FCH antenna is placed at the left wrist of participants and its reflection coefficient is recorded as the subject performs eight different finger motions: click, double click, circle, and zoom of left hand index finger as well as those motions of right hand index finger. Each motion is iterated for 120 seconds for each trial, whilst the corresponding reflection coefficient $S_{11}$ is recorded by a vector network analyzer (Agilent PNL N5230C). The experiment is conducted on two ISM frequency bands around 900 MHz and 2.4 GHz. Four volunteers, including two males and two females, are included in the experiment. It is found that the average classification accuracies are higher than 90% when the dynamic time warping algorithm is employed for the calculation of similarity between two signals.