Classification of Human Head Motion Patterns Using Transmission Coefficient of On-Neck Antennas

Drew Bresnahan*[1], Yang Li[1], and Youngwook Kim[2]
(1) Department of Electrical and Computer Engineering, Baylor University, Waco, TX, 76798
(2) Department of Electrical and Computer Engineering, California State University, Fresno, CA, 93740
Email: drew_bresnahan@baylor.edu, yang_li1@baylor.edu

The topics of wearable electronics and wireless systems have gained popular attention among many researchers for their promising applications in remote health monitoring, personal daily activity tracking, and computer gaming. Recent works like that of Fang *et al.* [*Fang, et al., in 15th ACM/IEEE Int. Conf. Information Processing Sensor Networks (IPSN), Vienna, Austria, 2016, pp. 1-12*] have investigated the possibility of using wearable sensors to adequately measure the perturbations of a body radio channel caused by bodily motions, and have successfully classified distinct activities like breathing, eating, speaking, etc. This on-body channel perturbation approach removes the need of using additional accelerometer and gyroscope sensors. The classification accuracy was reported to be above 86% using their particular signal processing pipeline.

In this work, we seek to use a pair of body-worn antennas to measure the around-neck channel disturbances as the test subject acts out common activities associated with head movements. First, we measure the non-line of sight (NLOS) creeping wave propagations around the neck of a static (unmoving) human subject to establish a baseline model for the propagation channel. Experiments are based on the 2.45 GHz operation. We use two quarter-wavelength monopoles, which are oriented perpendicularly to the neck surface, to sample the S_{21} parameter in 1 cm spacing intervals around the circumference of the neck. The measurement results are compared with numerical simulations and theory predictions for verification purposes.

Next, we place the monopole antennas on the sides of the necks of four test subjects to measure the dynamic (moving) neck channel. Each test subject acts out four different activities (i.e. chewing, swallowing, breathing, and speaking) for 20 seconds as a vector network analyzer measures and records the 2.45 GHz S-parameters against time. We then feed the S_{21} parameter data into a deep convolutional neural network to classify the activities which exhibit unique S-parameter patterns. The classification accuracy is found to be above 90% using our approach.