URSI AP-RASC 2019, New Delhi, India; 09 - 15 March 2019

A Comparative Study of Doppler Frequency Profile from Hand Gestures for Device-free Motion Sensing using Wi-Fi Channel State Information

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1 Extended Abstract

Due to physical limitation of optical devices, the commercial device-free motion sensing applications are restricted to a small active sensing area and also cannot operate in certain scenarios such as a non-line-of-sight (NLoS) environment and private places, despite promising high accuracy and precision. As radio frequency signals are not constrained by these limitations, many researchers have attempted to improve the sensing performance under the above circumstances by exploiting channel state information (CSI) from commodity Wi-Fi devices. Although previous works have produced a fair result in hand motion sensing through pattern recognition approach, to the best of the authors' knowledge, there is no hand kinematic model that can explain the shape of speed profile for certain hand gestures derived from CSI. The lack of speed model makes the intensive analytical and simulation study in CSI-based motion sensing analysis more challenging.

By considering the assumption that any hand gesture can be decomposed into a sequence of fundamental hand movement at different directions, it is possible to describe a complicated motion by the basis speed profile with specific parameters. Therefore, this study aims to examine the profile of CSI Doppler frequency corresponding to the hand-waving gesture at a single direction. Through experiment, Wi-Fi signals were transmitted one transceiver to another while the subject was moving his hand in one direction. The CSI at each timestamp was extracted and analyzed as follows. The temporal Doppler frequency due to the gestures was first extracted from CSI as a time-varying envelope of the processed signal after applying the transfer function of slope detection which is typically used to recover the message from Frequency Modulation (FM) signal. The result from the experiment showed that the gestures similarly produced a bell-shaped Doppler profile. Then, a comparative study of the Doppler profile was performed by fitting the measurement data with models previously introduced in literature for a rapid hand movement, hand writing, and wrist pointing movement [1, 2]. The performance of models will be evaluated based on the similarity between the reconstructed profiles and the measurement data in terms of root-mean-square error (RMSE).

References

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