Integration of Random Forests and MM-Wave FMCW Radar Technology for Gait Recognition

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Abstract

Technologies that identify and monitor walking, and other characteristics could support detection, evaluation, and monitoring of parameters related to changes in mobility, cognition, and frailty. Integrating with a Random Forests classifier, we develop an ultrahigh-frequency FMCW (frequency modulated continuous wave) radar sensor that can distinguish walking from other activities.

1 Introduction

Features related to gait can be fundamental metrics of human motion [1]. Commonly available gait feature and motion capturing methods include force mats, wearable sensors and video camera systems. However, radar technology is a promising technique since it uses non-invasive wireless technologies and people do not need to wear or carry a device on their body. Additionally, due to the fact that there is no camera, privacy is preserved.
Almost all of these systems have been used for walking speed, however, other gait qualities, i.e., speed, stride length and cadence, are increasingly being recognized as a measure a person's health status [2]. However, these systems are not able to distinguish walking from other activities, cleaning, dressing or cooking, which involve taking steps but do not qualify for gait speed measurements. To address this problem, we trained a Random Forests classifier, based on the Doppler effects of different activities, to distinguish walking trace from other activities, and to monitor the gait qualities.

2 System Design

The range FFT is applied on the received chirp samples. At the receiver, the signal is collected and assigned to a virtual channel such that each channel contains the data transmitted and received from and to a unique pair of transceiver, which is done in stationary clutter removal stage together with removing the average of each range bin. Then, Capon filter was applied to estimate the angle of arrival spectrum of each range. By putting them in a matrix, range-azimuth map will be constructed and is delivered to Random Forests, to perform classification.

3 Procedure and Measurement Results

As one of the most promising among other radar techniques, we chose to use a FMCW radar in the 79GHz band. FMCW radar can provide information about range, angle and velocity of targets. One of the key pieces of information obtained from the radar is Doppler information, which is useful for activity recognition, especially walking. In order to obtain Doppler effects of human activities, we obtained short time Fourier transform (STFT), as shown in Fig. 1, of the received signal for different activities, such as walking, cleaning, sitting, standing. We defined three classes, walking ,"W", in-place movement, "I", and stationary, "S". For each classes, we collected 20000 dataset for 0.5 second. Based on SFTF results, we trained different machine learning algorithms, and found that the Random Forests classifier has the best performance in distinguishing walking from other activities. Fig. 2 shows confusion matrix of the defined scenarios.

4 Conclusion

In this paper, we applied the Random Forests classifier to identify human activities. Using mm-wave FMCW radar technology, the system first obtained doppler effects of activities and fed the classifier. The Random Forests classifier showed very good accuracy in distinguish walking from other in-place movement and also a stationary living body. Also, our future work is to combine radar signal processing technique with deep learning to identify human activities in multiple people scenarios.

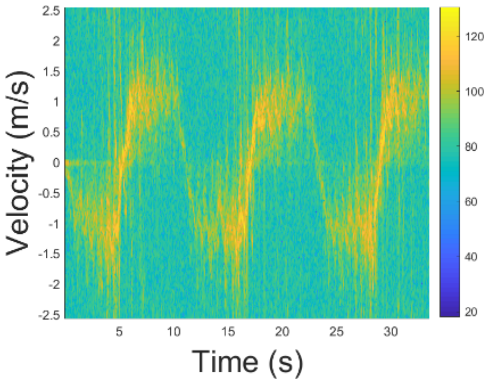

Fig. 1: FMCW radar results of STFT method.

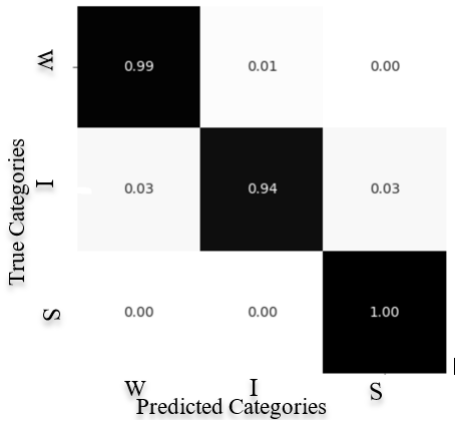

Fig. 2: Confusion matrix for Random Forests where "W", "I" and "S" stand for walking, in-place movement and sitting/standing, respectively.

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