Software Defined Radio Based Testbed for Large Scale Body Movements

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***Abstract*— Monitoring Activities of Daily Livings (ADLs) has opened doors for numerous applications including patient monitoring, search & rescue, intrusion detection and so on. However, the parameters such as operating frequency, transmitting power, and antenna design are static where each application requires particular hardware applications. This paper lays the foundation for ADLs and presents the design of the testbed based on Universal Software Radio Peripheral (USRP) in conjunction with omni directional antenna, that can be used for detecting large scale body movements such as walking, sitting, standing, and critical events such as falls and small-scale movements. The core idea is to extract the channel state information (CSI) from the received signal since each body motion produces a unique CSI signature. In this context, we have performed various human activities such as walking, sitting on a chair etc. in indoor environment using two USRPs. The experimental results indicate that each body motion can be visually identified by examining the CSI data.**

Keywords— human recognition based WCSI, SDR

I. Introduction

Activities of Daily Livings (ADLs) have been widely used in several applications including surveillance, security, search & rescue in the healthcare sector. Monitoring human body motion has become essential in daily life and received increasing attention in life-care [1]. Several researchers have focused on exploiting the channel state information (CSI) data to recognize human movement using the amplitude and phase information of the received signal [2]. Most of the wireless signals implemented using received signal strength indicator RSSI and channel state information CSI. Whereas, RSSI is susceptible to the multipath effect that can lead to a negative impact of the received signal. The variances of CSI data are more efficient, robust and stable as compared to the RSSI [3-4]. Numerous algorithms for human recognition based on CSI have been presented recently, which include human macro-activity recognition based on Universal Software Radio Peripheral (USRP) and Wi-Fi signal to extract amplitude and phase information from CSI [5-8]. Deep Neural Networks to identify human performance detection based on Wi-Fi channel state information CSI [6]. Although previous Wi-Fi CSI work provides significant classification accuracy for human activity detection, however, it is still not suitable to collect data in areas such as search & rescue operations [7]. In this paper, we present the design of a test-bed based on USRP that exploits the CSI data to identify large-scale body movements such as walking, sitting down on a chair, standing up, picking up an object, critical events such as falls and so on. The system uses orthogonal frequency division multiplexing (OFDM) that involves 64 points of fast Fourier transformer (FFT) producing the same number of frequency carriers known as subcarriers. The structure of this paper is arranged as follows; section II describes the experimental setup and system configuration parameters. Section III presents the results and discussion followed by the conclusion in section IV.

II. Experimental Setup

The hardware is comprised of two universal software define radio (USRPs) namely X300/X310 where the software MATLAB /SIMULINK is used to adjust and calibrate the system parameters such as transceiver gain, antenna design, number of subcarriers, operating frequency, and so on. One USRP is used for transmitter operation and the other one works as a receiver involving two PCs. Both USRPs are connected to the host computers PCs using 1GB ethernet cable. Each USRP is equipped with an omni-directional antenna. The trial was performed in a laboratory environment considering one case at a time. The system setup is shown in Fig. 1.

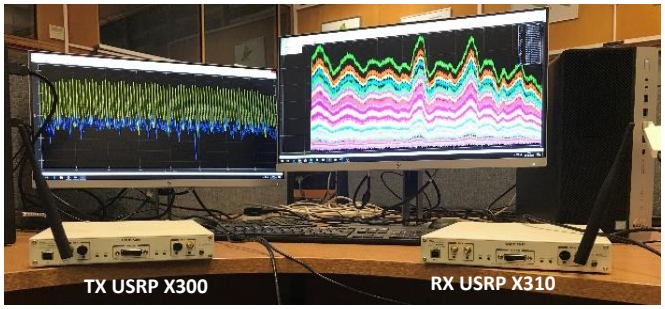

Fig 1. Hardware design of System Setup

The operated frequency was set to 5.32GHz that worked as the central frequency of USRP. The 64 OFDM subcarriers are used using QPSK modulation scheme. The sample rate is taken as 80 KHz. For the hardware, parameters are summarized in Table 1.

Table 1. Hardware Configuration and Parameters Selection

PLATFORM	**X300, X310**
Channel Mapping	1, 2
Frequency Range Hz	1 G - 10 G
Master Clock Rate Hz	120e6 TX, RX
Gain dB	TX 50 RX 40
Interpolation Factor, Decimation Factor	500 TX, RX

III. Results and Discussion

The experimental campaign was carried out in an indoor environment and where the data is represented in terms of the WCSI that denote human recognition for three different activities. We tested our system in two scenarios, first when no activity performed and then activities such as walking and sitting down on chair actions were performed. 10000 packets were sent, and 8640 packets were received in 10 second time duration for each activity. Both cases were recorded in the lab environment, as we can see from Fig 2, the amplitude of the signal remains constant indicating no activity was done between transmitter and receiver. Also, Fig 3 and 4 show the detection result once body movement performed. The amplitude changes based on human motion. These variations represent the information of WCSI for human activity recognition. The walking and sitting on chair activities were repeated 10 times and each time we received distinguished amplitude response.

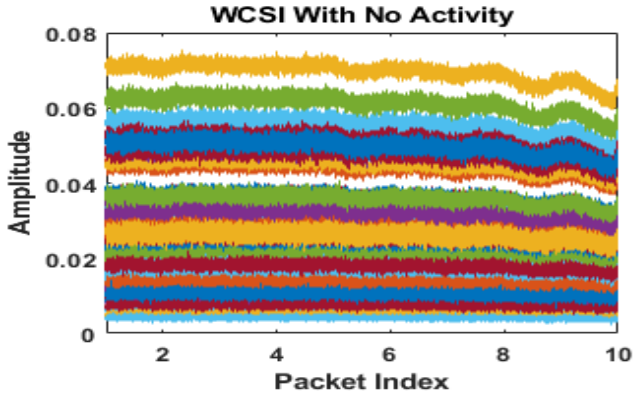

Fig 2. WCSI with no activity performed.

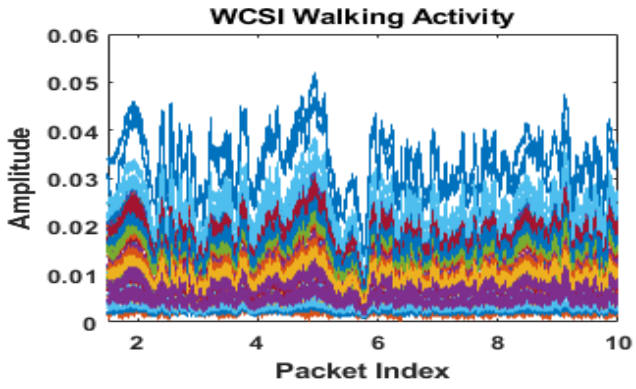

Fig 3.WCSI once walking performed

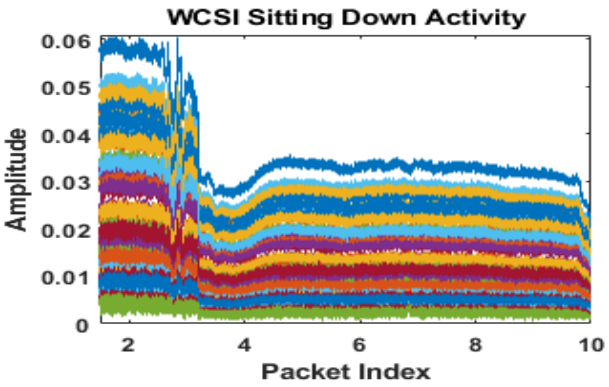

Fig 4. WCSI once sitting on a chair.

IV. Conclusion

This paper presented preliminary results for human activity recognition based on software-defined radios. Two USRPs were used to record the data for three-body motion including standing still, implying no activity was performed, walking talk and forth in front of the transceiver and sitting down on the chair. These activities were classified based on CSI signatures represent in terms of variances of amplitude and phase information. In the future, we aim to increase the number of activities and introduce small-scale body movements such as breath and heart-beat detection and apply cutting-edge deep learning algorithms to classify ADLs.

Acknowledgement

Sincere gratitude of the authors to the Libyan Government for this research support.

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