Separation of Ambulatory Skin Conductance in Day and Sleep Activities based on Activity Magnitude and Sleep-Wake Scoring

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***Abstract*— Ambulatory skin conductance (SC) signals often need to be analyzed independently for different user activities. As an ambulatory SC sensor is usually combined with an accelerometer, we examined its measurements to identify if a user is sitting, walking and running. We present our method for estimating the activities and how SC signals are distributed across daytime and sleep contexts.**

I. Introduction

Skin conductance (SC) is commonly used as a measure of psychological or physiological arousal [1]. With ambulatory measurement systems, researchers have started measuring 24/7 SC data in daily life and identifying SC features related to stress and sleep [2, 3]. SC responses can be elicited from multiple processes, including thermoregulation, motor, and affective processes. In order to understand long-term ambulatory SC, we separate daytime and sleep SC. Within the daytime, we also separate exercise vs non-exercise-related SC activity. A lot of research has conducted to recognize activities [4]. In this paper, we aim to obtain rough estimate of three activity levels (sitting, walking and running) in a simple way and leverage it to compute SC features under different activity levels. We used wrist acceleration data (ACC) and identified activity magnitude thresholds to separate daytime activity into sitting, walking and running levels. We compare ambulatory SC amplitude and peaks under sitting, walking, running level activities and 1st-4th quarters of sleep.

II. Methods

We collected non-dominant outer wrist 3-axis ACC data from N=68 participants using the Q-sensor (Affective, USA) while participants went through the following experimental procedure 1) sit still and watch a relaxing video for 5 minutes 2) sit and fill out surveys 3) sit and perform a "counting backwards by 7's" and stroop tasks for 5 minutes 4) walking 5) running. We computed activity magnitude using the equation (1) and drew histograms of mean activity magnitude under 5 different tasks. Then, we applied a maximum likelihood decision rule to identify thresholds to separate sitting (1-3), walking and running distributions. We applied these thresholds and sleep-wake scorings (from activity data and sleep-wake diaries) to ambulatory ACC and SC data from N=20 people collected over ~30 days per person, for a total of 600 days. We compared SC amplitudes and number of peaks per 30s epoch for sitting, walking and running and for the first through fourth quarters (1Q-4Q) of each night's sleep (see the detailed peak detection method in [2]).

$$AM = \sum_{t=0}^{x} AM_t + \sqrt{(Raw_{xt} - Rm_x)^2 + (Raw_{yt} - Rm_y)^2 + (Raw_{zt} - Rm_z)^2} \quad (1)$$

where AM = Activity Magnitude, Raw = Raw accelerometer sample Rm = running mean in a 5 seconds window, N = number of raw data samples received in one second

III. Results

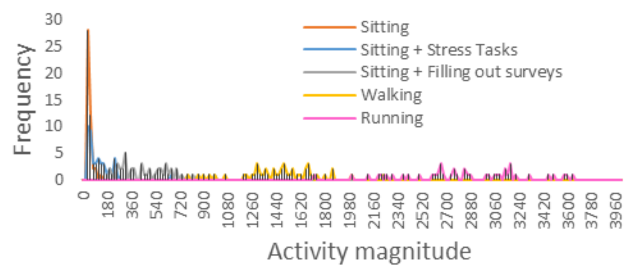

Figure 1. Histograms of activity magnitude

Figure 1 shows histograms of the activity magnitude from 5 activities. We obtained values 966 and 2059 for sitting-walking and walking-running thresholds. We compared the mean of SC amplitude and # of peaks (Figure 2). SC amplitude and peaks increased as activity level got higher. For sleep, we found the highest amplitude in 2Q sleep and the largest number of peaks in 1Q sleep (ANOVA, post-hoc).

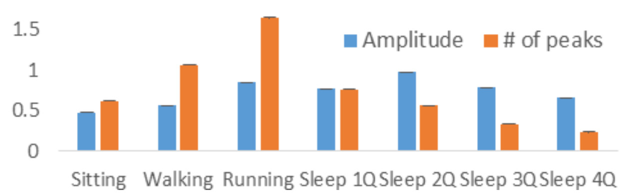

Figure 2. Comparison of ambulatory SC amplitude

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