Phone-based Gait Analysis to Detect Alcohol Usage

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ABSTRACT
This study proposes a phone-based system to detect the gait anomalies of a person waking under the influence of alcohol. This phone-based system can sense a person's alcohol usage and record the location/time context. This data can help identify problem drinking behaviors, such as drinking before work or before driving.

Author Keywords
Alcohol usage, mobile sensing, gait detection

ACM Classification Keywords
H.4.0 Information systems applications: General

General Terms
Experimentation, measurement

INTRODUCTION
Reports from the U.S. Department of Health and Human Services and the National Institutes of Health (NIH) have presented overwhelming evidence that excessive drinking negatively affects the brain, heart, liver, and other organs, and increases the risk of developing certain cancers [1]. In addition to health problems, alcohol consumption often results in risky and violent behavior, such as drunk driving and physical fights. Approximately 30% of adults in the United States drink at levels that increase health risks and social problems [2]. Mobile sensing provides opportunities to sense a person's alcohol usage in his or her natural living environment, and to detect problem drinking behaviors, such as drinking before work or before driving. Data collected from a mobile sensing system can be used to increase people's awareness about drinking problems and the need to receive proper treatment.

A previous study [4] has shown that a blood alcohol concentration (BAC) of less than 0.4 mg/ml (BAC of 0.04%) can produce noticeable gait unsteadiness while increasing a person's walking stride length. Thus, a phone-based system can recognize alcohol usage by detecting alcohol-caused anomalies in walking patterns as people carry their mobile phones. The proposed phone-based system can also record before and after context of drinking and generate just-in-time alerts after detecting problem drinking.

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SYSTEM DESIGN AND IMPLEMENTATION
This study proposes and analyzes a phone-based gait anomaly detection system targeting the after-effects of alcohol consumption. This system consists of (1) a data collection module that gathers accelerometer data from a phone and analyzes regular and after-drinking gait patterns, and (2) a gait anomaly detection module that extracts unique features from the gait data and differentiates intoxicated walking patterns from regular patterns.

Data Collection
The proposed system measures gait data using a 3-axis accelerometer in an HTC Magic smartphone. The preliminary study presented here chose the trouser pocket as the phone placement location. To observe a person's gait patterns before and after drinking, gait data was collected from 3 participants (a 22 years old female and two 24 years old males). All three participants were regular drinkers, and were compensated $15 USD for their participation in the study. Before drinking, participants placed a mobile phone in their trouser pocket and walked 40 meters to record regular gait data. Participants then drank 100 ml of 12% wine every 30 minutes. At the end of each 30-minute period, each participant's BAC was measured with a breathalyzer. The 30-minute period was chosen because it takes some time for the human body to absorb alcohol [3]. This drink-absorb-measure process was repeated until each participant's BAC exceeded 0.05%, i.e., the legal alcohol limit for driving in Taiwan. During each repetition, participants were asked to

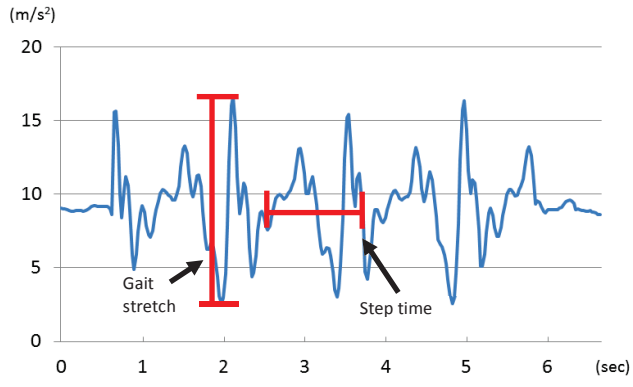

Figure 1. Gait signals collected from y-axis accelerometer.

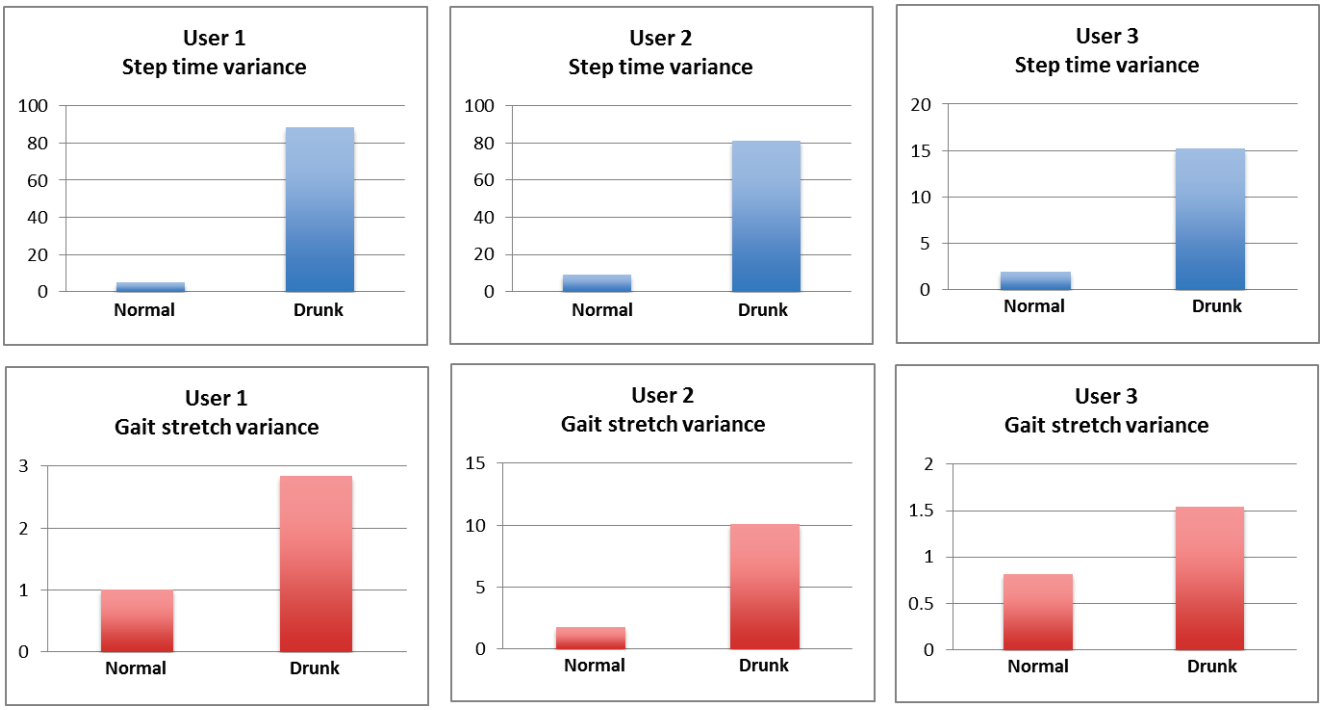

Figure 2. Results from the extracted features for the normal and drinking gaits for participants 1, 2, and 3.

walk 40 meters to record additional gait data. The three participants drank a total of 360, 500, and 400 ml of alcohol, respectively, and reached BAC values of 0.062%, 0.066%, and 0.051%.

Gait Anomaly Detection

Figure 1 shows the accelerometer data collected from the smartphone. Because the phone was placed in a fixed-upward orientation in a trouser pocket, the y-axis value of the accelerometer data captures the most significant signals. Figure 1 shows that the gait signals consist of periodic gait cycles. Each gait cycle begins when one foot touches the ground and ends when the same foot touches the ground again.

This study defines several gait cycle attributes as follows. Step time measures the duration of a gait cycle or the amount of time to complete a walking step. Gait stretch measures the difference between the maximum amplitude and the minimum amplitude within a gait cycle.

Because alcohol usage produces gait unsteadiness, drinking gaits have larger variance than non-drinking gaits. To measure gait unsteadiness, the proposed system extracts the (1) step time variance and (2) gait stretch variance from the gait data.

PRELIMINARY EVALUATION

Figure 2 shows how well each extracted feature (step time variance and gait stretch variance) can distinguish a drinking gait from a normal gait. Based on the gait data from three participants, drinking gaits show larger step time variance and longer gait stretch than normal gaits. Based on the promising results of this preliminary research, future work should develop a complete system to detect drinking gait. This preliminary study involves only three participants and places the smartphone in the trouser pocket. Future research should recruit larger number of participants and test different phone placement positions, such as a bag or shirt pockets.

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