AutoSense: Wireless Skin Patch Sensors to Detect and Transmit Addiction and Psychosocial Stress Data

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AutoSense is a distributed Body Area Wireless Sensor Network that consists of wireless sensors to quantify personal exposures to addictive substances and psychosocial stress as experienced by subjects in their natural environments. Currently, AutoSense consists of wireless sensors to detect blood alcohol concentration using an Interstitial Fluid (ISF) based biochemical sensor and five wireless sensors (ECG, Respiration Rate, Skin Conductance, Temperature, and Accelerometer) to infer levels of psychosocial stress. All the six sensors are attached to a wireless sensor computing platform called "mote" which is a tiny self-contained, battery-powered computer with a wireless radio that can host a variety of sensors, collect data from these sensors, process them using customized algorithms, and transmit the processed information on secure wireless channels. Sensors can be monitored remotely via the mote platform and software running on the entire system can be updated/replaced over the wireless channel.

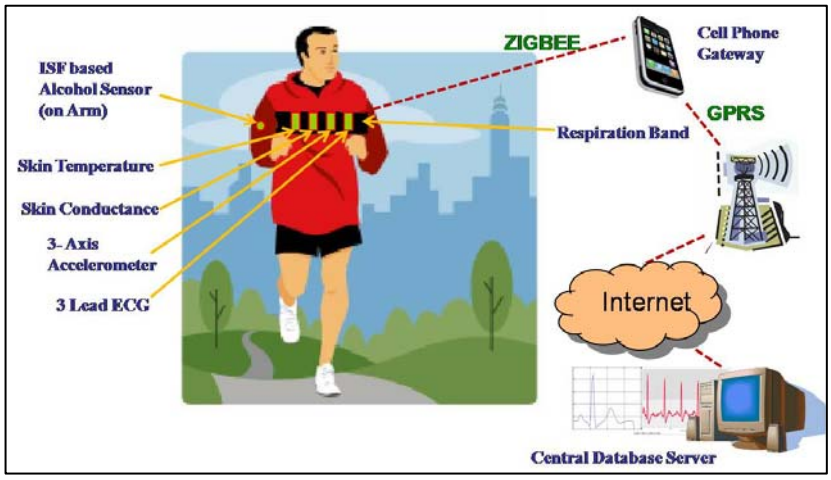

Figure 1: The AutoSense System attached to a subject.

Sensor Description: The AutoSense system consists of two wearable sensing units – an arm band and a chest band (See Figure 1). The Arm Band hosts the ISF based alcohol sensor which harvests interstitial fluid from the micropores created in the stratum corneum (see Figure 2) and assays it for alcohol concentration continuously and in real-time. The sensor responds within minutes of a drinking event and the data is highly correlated with the blood alcohol concentration. The Chest Band hosts five sensors – Three Lead electrocardiogram (ECG) for measurement of heart rate, Piezo-electric respiration band for measurement of relative lung volume and breathing rate at rib cage, Skin conductance between two electrodes placed under arm area of the chest, Skin temperature thermistor under arm, and Three-axis acceloremeter for motion sensing. This is used to assess motion artifacts of the data and provide a general activity, rest information for subjects.

The mote unit in the chest band processes ECG and respiration band signals to extract heartbeat interval and respiration rate. This enables a continuous detailed study of heart rate variability (or more precisely, variability of individual cardiac periods) to assess changes in autonomic control of cardiac functions. The data from these five sensors are processed) to compute a robust index of psychosocial stress.

Figure 2: Four micro pores for harvesting ISF (shown relative to a penny). Note that the pores do not extend to the dermal layer.

Clinical Validation: To validate the use of these multiple sensors under a more controlled environment, we are conducting a laboratory study that examines effects of acute stress and alcohol on hormonal, cardiovascular, and affect state measures. The study will determine the reliability of the interstitial fluid alcohol assessment and will incorporate multiple measures

within the Autosense modules and assess their reliability for the assessment of the effects of stress. The research design includes repeated measurement of alcohol levels in blood and in interstitial fluids, and measurement of cardiovascular variables, cortisol concentrations, and mood reports during two sessions (alcohol and placebo). Measures will be compared across the two sessions to examine the influence of alcohol administration during rest and in response to the stress challenges. The lab study will help us refine both the biochemical and technological pieces of the project.

Field Validation: The goals of the field study are to assess participant compliance with and acceptance of the data collection protocol (primarily the usage of the AutoSense system) over a 3-day period, and to assess the validity of sensor collected data on blood alcohol concentration and psychosocial stress (inferred from blood pressure, heart rate, respiration rate, skin conductance, and motion) with self-reported alcohol intake and perceived stress. Data will be collected in participants' usual environment.

Thirty men and women who are regular social drinkers will be recruited for the study. Participants will report to the lab at the start of the data collection period (Day 0) where they will be outfitted with the sensor suites and cell phone and undergo baseline stress assessment, alcohol screening, and respond to other questionnaires.

The AutoSense device will collect data on the participants while they go about their usual activities for three days. At the end of each of the 3 data collection days, participants report to the lab where the equipment will be checked for proper functioning and an interview will be conducted to ascertain alcohol use, stress perceptions, and process ratings of response to the monitoring protocol, including ease of use, comfort, and interference with daily routines.

Data analysis will include summaries of compliance and acceptability, as well as time-series procedures to quantify the concordance of self-report and Autosense-derived alcohol use and stress responses. The field study is planned to help us refine the AutoSense system for increased ease of use, greater compliance, reliable remote data collection, and remote health monitoring of the system.