Statement of Intent for Application to the Doctoral School

Annamalai Natarajan
School of Computer Science
140, Governors Drive
Amherst, MA 01003-9264 USA
anataraj@cs.umass.edu

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Abstract
In this application I outline my research interests, progress made so far and work in progress. I also express my intent to attend the Doctoral school. I conclude this application with a short bio.

Author Keywords
drug use, on-body sensors, classification

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I.2 [ARTIFICIAL INTELLIGENCE]: [Medicine and science]

Introduction
Wearable sensors are pervasive and are used on an everyday basis. They are used, among others, for activity recognition, assessing cognitive load, physiological stress and arrhythmias [8, 4, 5, 6]. These sensors have also penetrated the health domain and are used to monitor complex human activities like smoking, drug addiction and even more complex disorders like Autism [2, 7, 1]. The line of research I am interested in is the intersection between Mobile Health and Machine Learning algorithms which are used to make inference in these domains. My interests stem from the fact that wearable sensors are mobile, relatively inexpensive, practical and are far more accurate than traditional VAS (Visual Analog Scale),

self-reporting methods. For these devices to be useful and accurate we need to plough through huge quantities of data to make predictions, often in short time spans. I am also interested in Machine Learning algorithms to analyze data and make predictions with limited resources.

Research - Completed

My current research focuses on one aspect of drug addiction: Detecting cocaine use with wearable electrocardiogram sensors. Cocaine affects the heart, brain, blood vessels and lungs. It is known to affect the electrophysiology of the heart, potentially altering the shape of electrocardiogram (ECG) waveforms. Identifying these morphological changes from on-body electrocardiogram sensors poses a unique set of challenges. First, we need the sensors to reliably capture and transmit data; second, tools and techniques to identify small morphological changes in noisy time series data; third, to extract features which could aid in detecting traces of cocaine. Thus far we have addressed these challenges by developing a framework through which the electrocardiogram sensor can communicate with a smartphone to transmit data. We also developed a novel computational pipeline which breaks up the raw ECG stream into PQRST complexes (PQRST are standard labels for peaks in ECG), which significantly aid in identifying small morphological changes. Lastly, we used a data driven approach (in contrast with domain experts knowledge) to extract features to detect traces of cocaine. More details can be found in [7]. We reliably detected cocaine use both within and across subjects with area under receiver operating characteristics curve above 0.9.

Research - Work in Progress

One crucial aspect to detecting cocaine use is identifying ECG peaks. The small morphological changes, mentioned above, manifests itself as changes in peak locations. Our current approach to labeling peaks is rule-based and not very robust to noise. Hence we needed a more reliable, flexible and robust technique to detect ECG peaks. We are currently investigating ways to solve the ECG period segmentation and PQRST peak detection problems as joint inference problems in a unified probabilistic model. Another issue with labeling peaks is that the shape of the peaks is influenced by cocaine over time. For instance a T peak at small doses of cocaine is less stretched when compared to a T peak at high doses of cocaine. We are investigating ways to efficiently represent the shape of the peaks irrespective of factors which influence the shape of the peaks.

Objective for attending Doctoral School

By attending the doctoral school I would like to indulge in fruitful discussions with researchers working on similar problems. Particularly, what additional sensors can be deployed, what other physiological data can be gathered, other computational pipelines researchers have used to process data streams (denoising, removing baseline drift, etc), novel features and feature extraction techniques in these settings, suite of algorithms that could perform reliable prediction. Also, our data is collected from subjects in controlled clinical settings, our long term goal is to deploy these sensors in the wild. I would like to interact with experts on what challenges these applications could face and how they might be addressed. Finally, to get a bigger picture on what the future might hold for these applications. Through these discussions I also hope to get a perspective on research problems in this domain and how experts go about solving it. This opportunity comes at a crucial point when I need to start thinking about problems I would like to address in my PhD dissertation.

Brief Bio

I started my PhD in Computer Science in September 2012 at the School of Computer Science at the University of Massachusetts, Amherst. I am jointly advised by Associate professor Deepak Ganesan and Assistant professor Benjamin Marlin. I expect to receive my PhD by 2017. Prior to starting graduate school I worked as a Research Specialist at Princeton Neuroscience Institute, Princeton University. At Princeton we studied the effects of memory retrieval in humans [3]. Even before that I got my Masters in Computer Science in 2009 from Colorado State University. For my Masters thesis I worked with Chuck Anderson on a Brain Computer Interface application.

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