CS486C – Senior Capstone Design in Computer Science

Project Title	**Multi-factor Analysis to Reduce False Alarms in Intensive Care Units**
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Project Description :

Automated monitoring has revolutionized care in modern hospital Intensive Care Units (ICUs), allowing continual monitoring of nearly all vital functions around the clock. While this proliferation of smart monitoring devices (see Figure) holds great promise for improving care, efficacy is hampered by the information overload that can occur as each of these devices reports information and, in particular, sounds alarms based on its current sensor information.

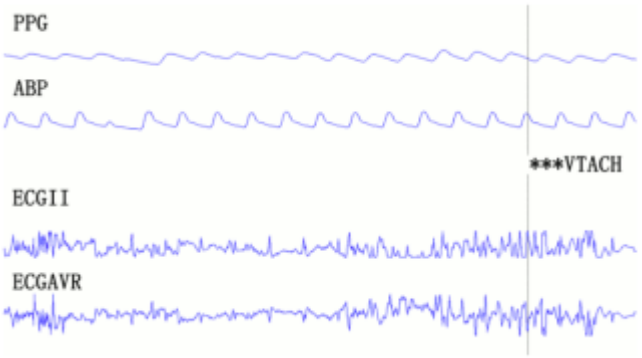
The key problem is false alarms; statistics show that caregivers are overwhelmed with up to 350 alarm conditions per patient per day, of which 80-99% are meaningless or false. Because of the high false alarm rate, "alarm fatigue" (also known as "cry-wolf effect) sets in for caregivers, greatly increasing the chances of missing a true life-threatening event in the cacophony of multiple alarms. In fact, false alarms were placed at number one in the "Top 10 Health Technology Hazards" for 2012, 2013 and 2015 by the Emergency Care Research Institute (ECRI). From 2005 to 2008, the FDA database received 566 reports of patient deaths related to alarms of monitoring devices. False alarms can also result in care disruption, sleep deprivation, patient anxiety, inferior sleep structure and depressed immune systems. Thus, false alarms have become an important concern in healthcare particularly in Intensive Care Units (ICUs).

Alarms are signaled when anomalous measurements are detected by individual devices/monitors in their sensor data; false alarms result when the anomalies are simply due to innocuous factors such as patient movement, motion artifacts, detached sensors, malfunction of individual sensors and imperfections in the patient–equipment contact. Most efforts to reduce the false alarm rate are focused on improving monitors, developing more accurate sensors, and applying filtering to improve signals in particular instruments. This project is based on the more realistic view that sensor anomalies *will always occur* regardless of the sophistication of sensors and monitors, due simply to human factors in the complex ICU environment. Patients move, sensors come loose, staff are imperfect. As a result, the motivating idea driving this project is that false alarms could

be greatly reduced if alarms are signaled, not based on a single device and its (often inaccurate) sensors, but based on a holistic pattern-based analysis spanning all data streams from all devices.

Objectives

The objective of this project is to develop a signal processing and data analysis application that integrates information from a variety of devices, extracts correlation among the collected signals from these different sensors, and uses the resulting information to reduce the number of false alarms while avoiding the suppression of true alarms in ICUs. We have already developed a variety of signal processing algorithms in techniques in our laboratory to drive this application, including:



- Implementation and integration of existing signal processing techniques such as Dual-Tree Complex Wavelet Transform and Gaussian signal expansion on recorded physiological signals such as electrocardiogram (ECG), arterial bold pressure (ABP), and to detect heart arrhythmias.
- Machine learning techniques for feature selection and classification to identify "true alarm" patterns, trained using all past and future data streams.
- Feature selection and data mining techniques to extract the most salient features common among different arrhythmias as well as identifying informative features related to each medical conditions.

The aim of this project is to develop an application that implements and integrates these analytic tools and techniques within a single application that would serve as a prototype for a smart "data hub" device that might appear in tomorrow's ICUs. This "smart hub" would gather information streams from all of the various monitoring devices, and be able to use holistic analysis of all data to reduce false alarms and signal caregivers only in case of true emergency. Some key features of the product will include:

- An application with a well-designed GUI that is able to take in (simulated) data streams and alarm signals from a range of ICU instruments.
- Application must provide GUI for configuring and adjusting the underlying computational tools, making it easy to explore different parameters and weightings in making alarm decisions.
- Will show status of various incoming data streams, potential alarm conditions, and their likelihood of being false alarms based on the holistic analysis.

Knowledge, skills, and expertise required for this project:

- Programming Skills: Team members are expected to have software development and programming skills appropriate for seniors in CS. Some of the candidate programming environments are C++, MATLAB, R and Weka.

- Basic knowledge of signal processing and data mining is useful, and sponsor will be able to provide appropriate background materials needed.

Equipment Requirements:

- There is no specific equipment required for this project. The required datasets will be provided for the students.

Deliverables:

- The application described above, for alarm detection and classification. Must include a User Manual for configuring and operating the software.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. Must include brief technical description of the utilized methods, and sample simulation results. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub, BitBucket, or some other version control repository; and as a physical archive on a USB drive. Professionally documented code with complete user manual.