Data Menders
Capstone Presentation

Multi-factor Analysis for False Alarm Reduction in Intensive Care Units

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Modern Medical Intensive Care Units (ICUs)

- Intensive care units cater to severe illnesses and injury.
- Automated monitoring has revolutionized care in modern ICU units.

First ICU in 1955 requiring manual patient monitoring

Source: dartmed.dartmouth.edu

Modern ICU with automated monitoring systems

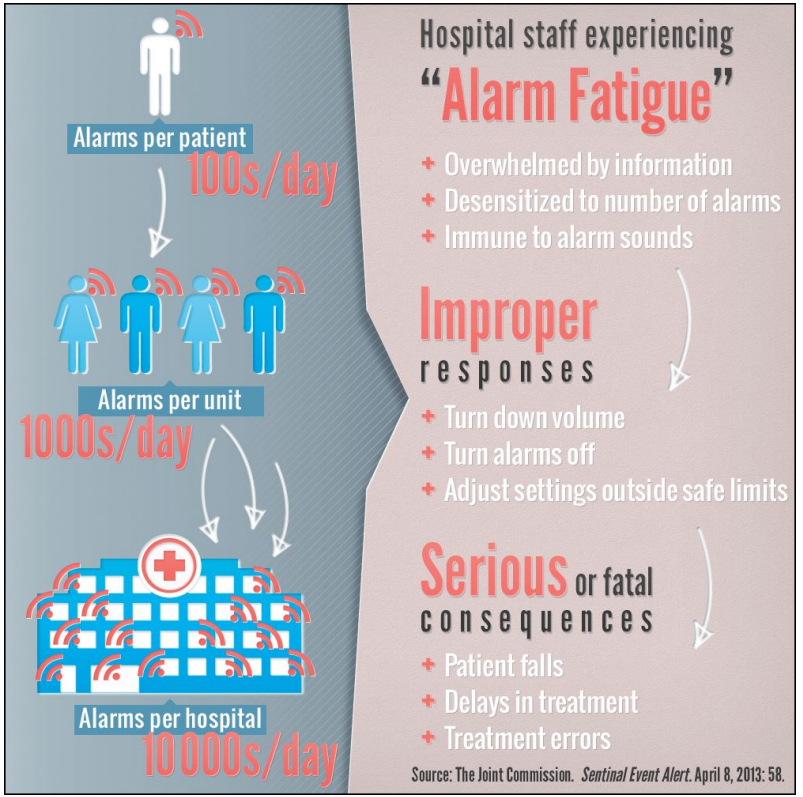
Source: Wikipedia

Vital Signs Monitored

- ECG (Heart Signals)
- ABP (Blood Pressure)
- PLETH (Oxygen Level)
- Respiratory Rate
- Temperature

Problem Statement

- 80-99% of alarms triggered are false or meaningless.
- Emergency Care Research Institute (ECRI) placed false alarms at number one in the list, “Top 10 Health Technology Hazards” for the years 2012, 2013 and 2015.



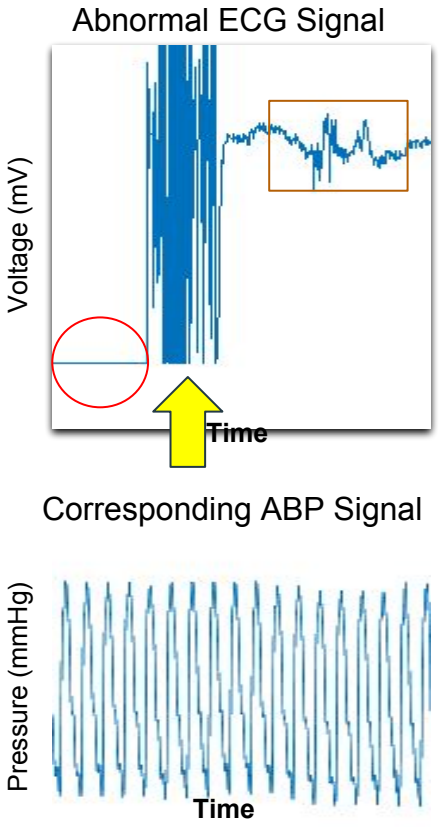
False Alarm Example

Flatlining signal, possibly the result of sensor disconnect.

Spiking signal, result of sensor movement resulting in noise.

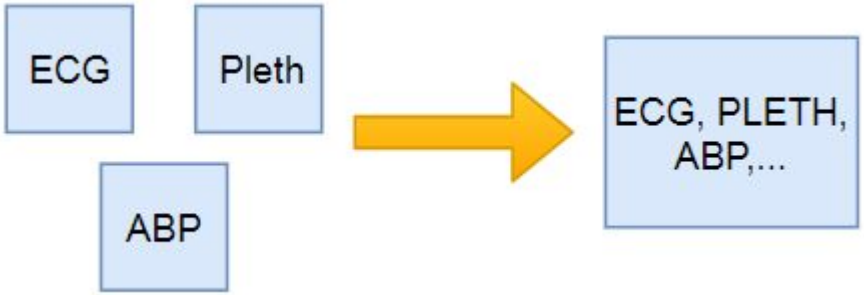
Normalized signal, result of sensor taking in the correct vitals.

Most other efforts to reduce false alarm rate are focused on improving hardware



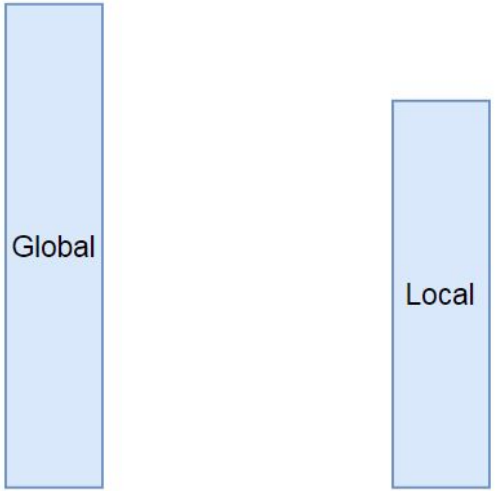
Solution

- Because there are multiple signals and there are being recorded on a patient. Our solution will be to take the signals and analyze them all together!



Solution cont..

- There are two kinds of datasets we will be using to help analyze our signals. Both of datasets we will make.



Solution cont..

- With our Global set of data, which we will test incoming signals against. We will be making out Global set of data from a training set given to us.

Solution cont..

- We will also be saving the patient's data so that we can make a local data set about them. This data set will be more personalized to the patient and thus better false alarm detection.

Requirements Acquisition

Researcher Application

- Import large database of patient information.
- Process data and extract useful information (ie. features)
- Produce trained classifiers used to detect alarms.

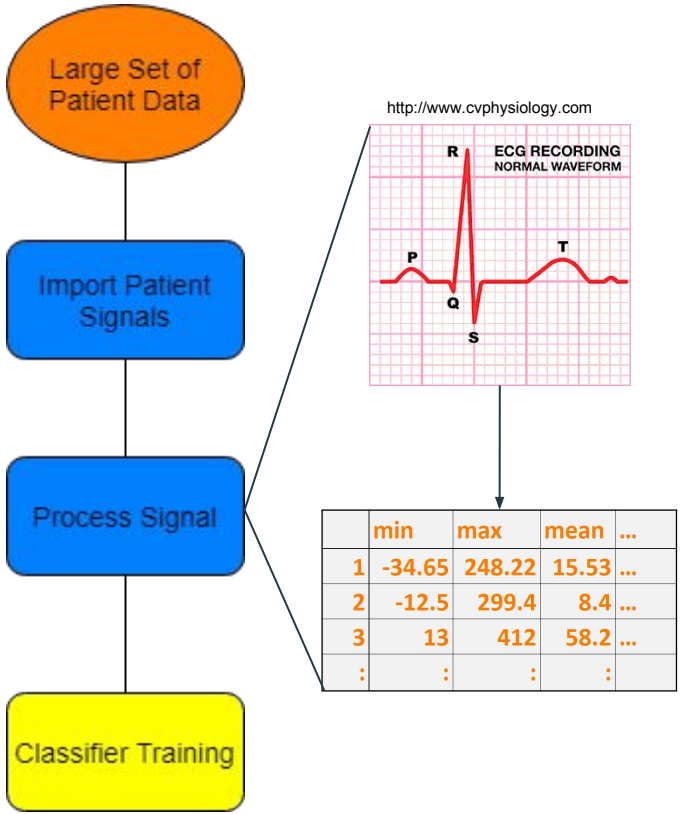
ICU Application

- Import a single patient's information
- Process data and extract useful information (ie. features)
- Use the trained classifiers to make a decision on the alarm.

Architectural Overview

Researcher

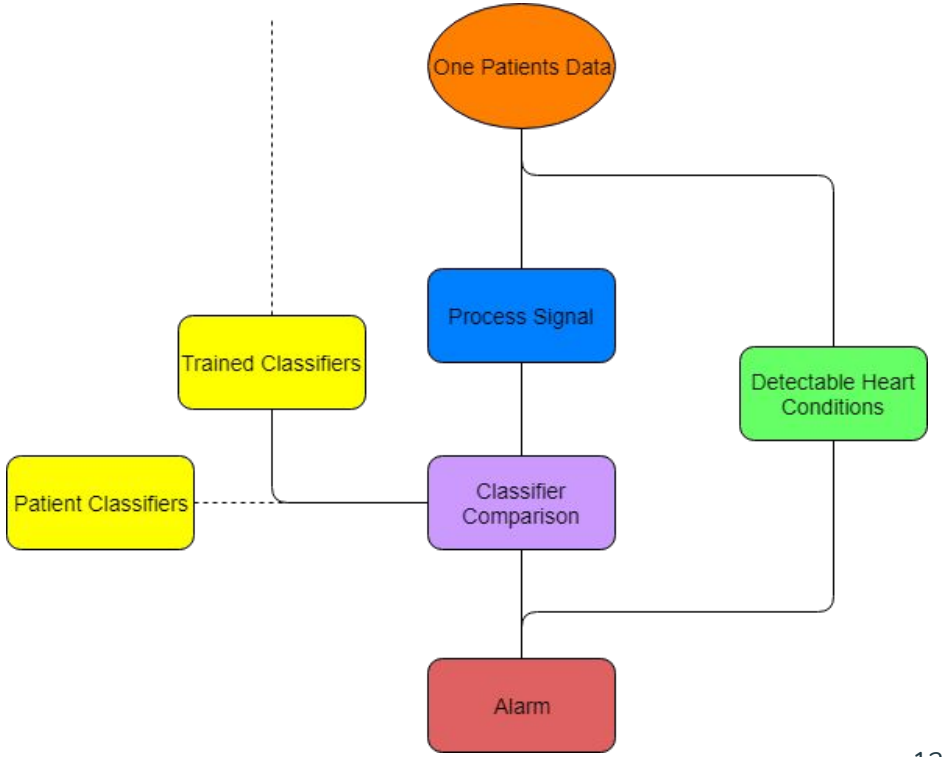
- **Database of ECG, ABP, and PLETH signals for many patients**
- **Use signal processing to extract useful data (ie. features)**
- **Train predictive models using Weka**



Architectural Overview

ICU Application

- A single patients ECG, ABP, and PLETH signals.
- Use an ECG signal to detect heart conditions manually.
- Use signal processing to extract useful data (ie. features)
- Use trained/patient classifiers to determine if a patient has a condition.

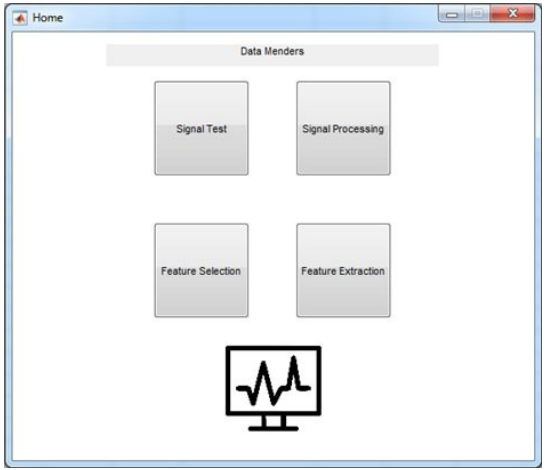


Implementation

Out implementation of our solution will be a Graphical User Interface, GUI.

There will be 4 parts to this GUI,

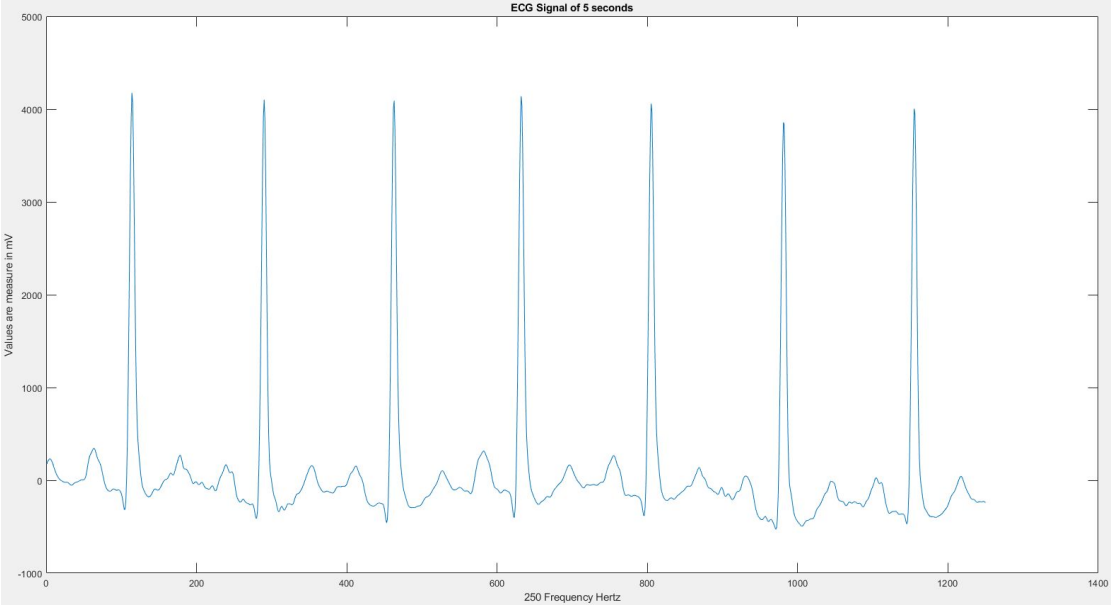
1. Signal Processing
2. Feature Extraction
3. Feature Selection
4. Signal Test



Implementation cont..

Signal Processing gets meaningful data

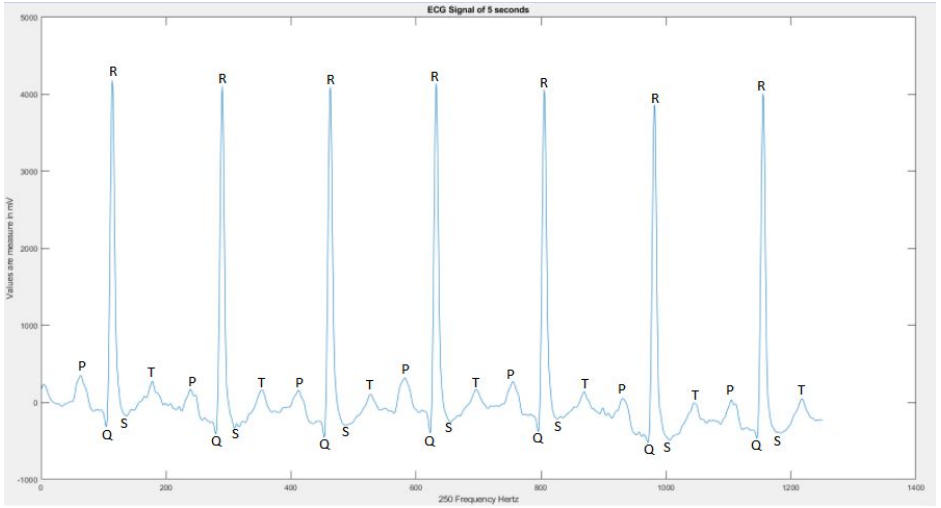
From the input



Implementation cont..

A signal processing technique we use is called

Heart Rate Variability, HRV.



Implementation cont..

Feature extraction will be the next step in our process. Time to get statistical features out of our processed signal. Here is an example of HRV feature extracted signal.

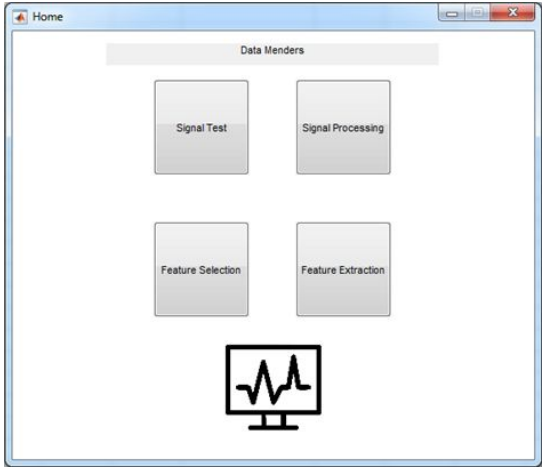
Id	Heart Rate	mean_HRV	SDNN_HRV	SDSD_HRV	RMSSD_HRV	NN50_HRV	pNN50_HRV	kurtosis_HRV	skewness_HRV	pow_LF_HRV	pow_HF_HRV	LF_HF_HRV	AlarmTag
1	122.9904	0.013744	0.012718	0.018282	0.018265	7	14.2857	31.5858	4.2054	8.21E-05	6.69E-05	1.2272	F

Implementation cont..

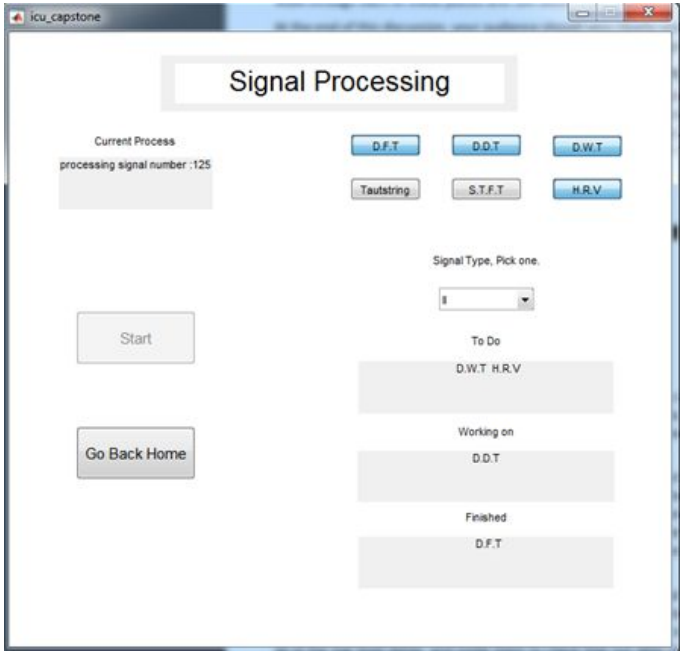
Next is feature selection. With our training set we process over 200 patient using HRV this is our results on how well we can predict if an alarm is true or not.

Type: Processed_HRV_Features_ECG, ..., Ranker Accuracy: 90.9091

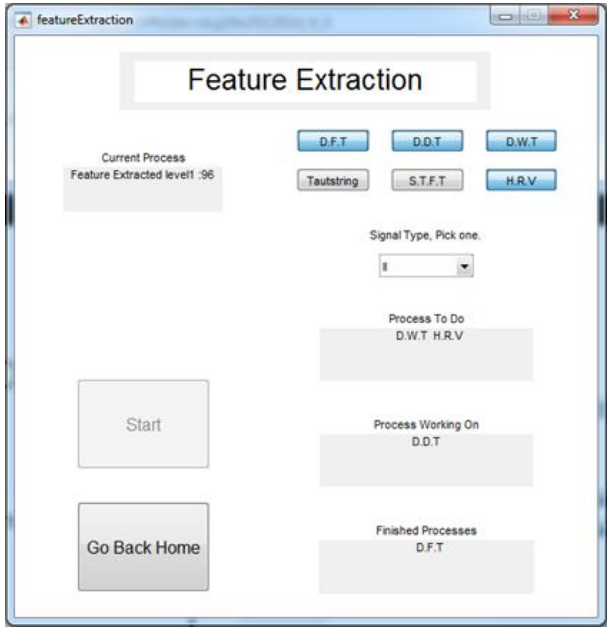
Prototype


Home
Data Menders
Signal Test
Signal Processing
Feature Selection
Feature Extraction

Prototype cont...

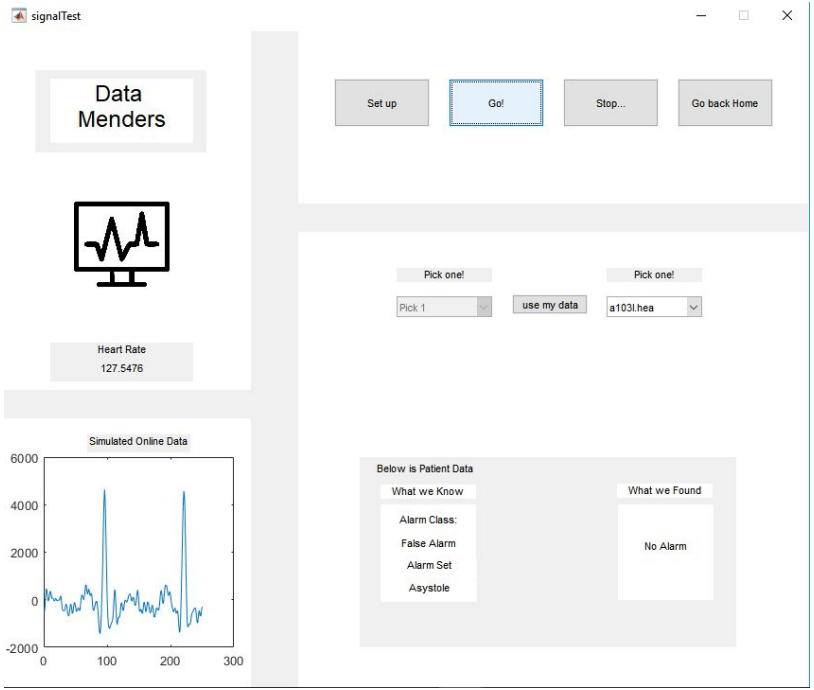


Prototype cont..



Prototype cont..

Prototype cont..



Challenges

- Signal integrity
  - Using corrupt data when training the classifiers
- Hindrances of Matlab
- Volume of calculations done in processing
  - Which calculations don’t need to be done?

Future Work

- Move the package into a different language
- Ensure patient data is stored according to HIPPA regulations
- Increase test cases to include more types of true and false alarms
- Install in an ICU

Schedule

Tasks	Jan			Feb				Mar				Apr					May	
	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	6-May	13-May
Signal Processing																		
Feature Extraction																		
Feature Selection																		
GUI																		
Testing																		

Testing Plan

Unit Testing	Integration Testing	Usability Testing	Accuracy Testing
• Test subsets of code. • Ensures that code actually works as intended.	• Bulk of testing • Tests code links	• User Interface • Ease of use • Intuitive Design	• Competitor Comparisons • WEKA GUI

- Deal with issues as they appear rather than in waves.

Conclusion

- In the end, the goal for our project is to develop a software that reduces false alarms in the ICU.
- This can give nurses and patients a more relaxed environment.
- Nurses can have better reaction times.
- This is not only helpful, but important to help people and save lives.