Reducing False Arrhythmia Alarms in the Intensive Care Unit

Daniel Miller, Katarina Miller, Andrew Ward
Advisors: Nicholas Bambos, David Scheinker

INTRODUCTION

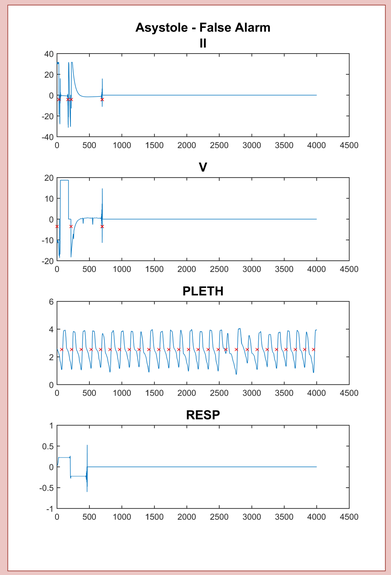
- Intensive Care Units have false arrythmia alarm rates up to 86%, causing slower alarm response times and decreases in patient care
- PhysioNet Challenge provides entrants with time-series data of monitors for 750 patients along with the alarm type (one of five alarms) and accuracy
- We added features and investigated different machine learning techniques to reduce false-alarm rates while maintaining true alarms
- Competition scored by weighted combination of FP, FN, TP, TN

METHODS

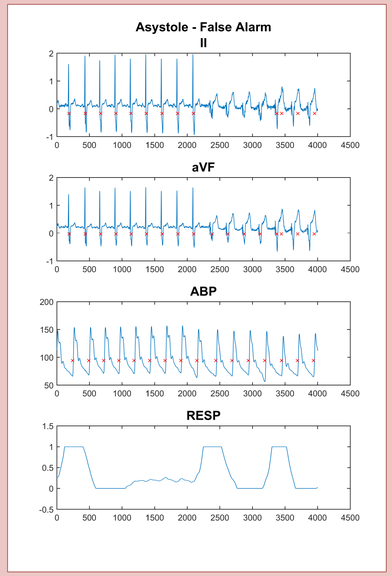
- Extracted additional features from time-series traces using MATLAB, using the ECG traces available for every patient and the PPG and ABP traces available for some patients
- Created randomly generated hold-out sets of five different sizes in Python to find which hold-out size was appropriate for the data set due to concerns about the small number of patients with certain alarms.
- Implemented logistic regression, SVM (with CV tuning), and boosted regression trees in R on each group of patients separated by alarm type with the above features; implemented multi-class random forest in R to analyze whether including features from all patients improved sensitivity and specificity.
- Will perform greedy feature selection to see how algorithms perform on a subset of features.

FIGURES

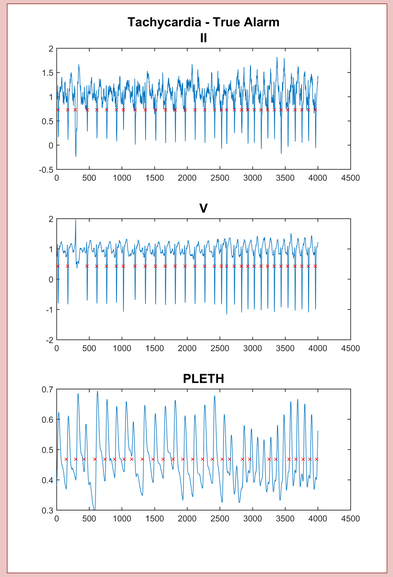
Traces provided for three sample patients showing difference in data quality



Inconclusive Data



Acceptable Data

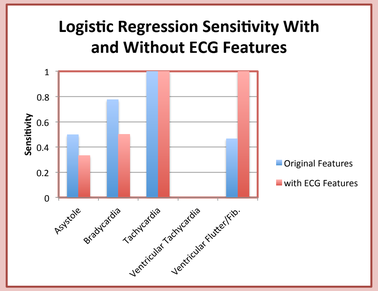


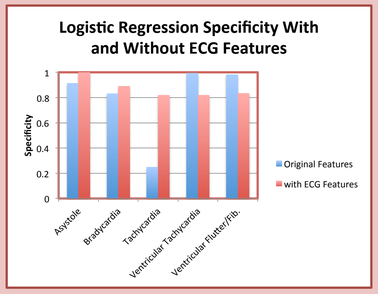
Ideal Data

The below table shows how each of our 22 features were calculated in MATLAB from the traces

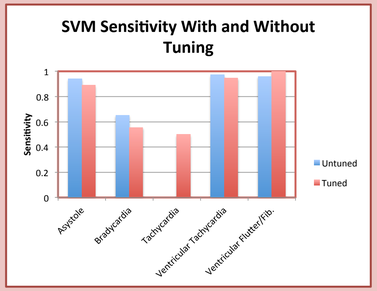
Features	
Low heart rate	*For each of: PPG, ABP, ECG1 and ECG2*
High heart rate averaged over 16 beats	
Max heart rate	
Highest voltage difference between two heartbeats	
Number of heartbeats in 16 seconds	
Signal-quality index	*For each of: PPG, ABP*

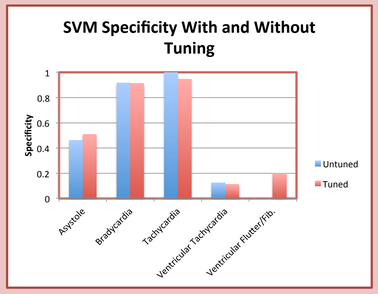
The below figures show the difference in CV performance of logistic regression when we added features using the more reliable ECG trace.





The below figures show the difference in CV performance of SVM when we added CV tuning based on the score metric provided by the competition.





RESULTS

Best results highlighted in blue

	Logistic Regression		Untuned SVM		Tuned SVM		Boosted Classification Tree		Multiclass Random Forest		
	Sensitivity	*Specificity*	*Sensitivity*	*Specificity*	*Sensitivity*	*Specificity*	*Sensitivity*	*Specificity*	*Sensitivity*	*Specificity*	*M.C. Rate*
Asystole	1	0.333	0.97	0.27	0.86	0.47	0.97	0.47	0.499	0.614	0.24
Bradycardia	0.889	0.5	0.7	0.744	0.675	0.851	0.883	0.871	0.436	0.753	0.00769
Tachycardia	0.818	1	0	1	0.3	0.939	0.4	1	0.52	0.762	0.22991
Ventricular Tachycardia	0.818	0	0.945	0.184	0.87	0.228	0.921	0.327	0.569	0.719	0
Ventricular Flutter/Fib.	0.833	1	1	0	0.809	0.3	1	0.2	0.511	0.73	0

The boosted regression trees and logistic regression classifiers based on each alarm individually were most effective for the alarms. The multiclass random forest including all patients was not as effective as we hoped, possibly because the alarm types are too correlated.

FUTURE WORK

Lucile Packard Children's Hospital AT STANFORD

This project will be continued with the Lucille Packard Children's Hospital in partnership with David Scheinker and Nicholas Bambos.