



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

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Background

Automated monitoring systems trigger alarms to medical staff when an abnormality is seen in a patient vital signs.

Modern ICU with automated monitoring systems



Source: Wikipedia

Vital Signs Monitored

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

Triggered alarms are split into 2 categories: True and False. True alarms require immediate medical attention while False alarms carry no clinical significance.

Motivations

- 80 – 90 % of all alarms are false.
- False alarms cause alarm fatigue, a condition that causes inappropriate reactions by medical staff to triggered alarms.
- Other efforts have been focused on improving hardware, which is expensive and does not cover every situation.
- False alarms can be triggered by benign issues not related to vital signs (patient movement)

Hospital staff experiencing "Alarm Fatigue"

- Alarms per patient: 100s/day
- Alarms per unit: 1000s/day
- Alarms per hospital: 10000s/day

Improper responses

- + Overwhelmed by information
- + Desensitized to number of alarms
- + Immune to alarm sounds
- + Turn down volume
- + Turn alarms off
- + Adjust settings outside safe limits

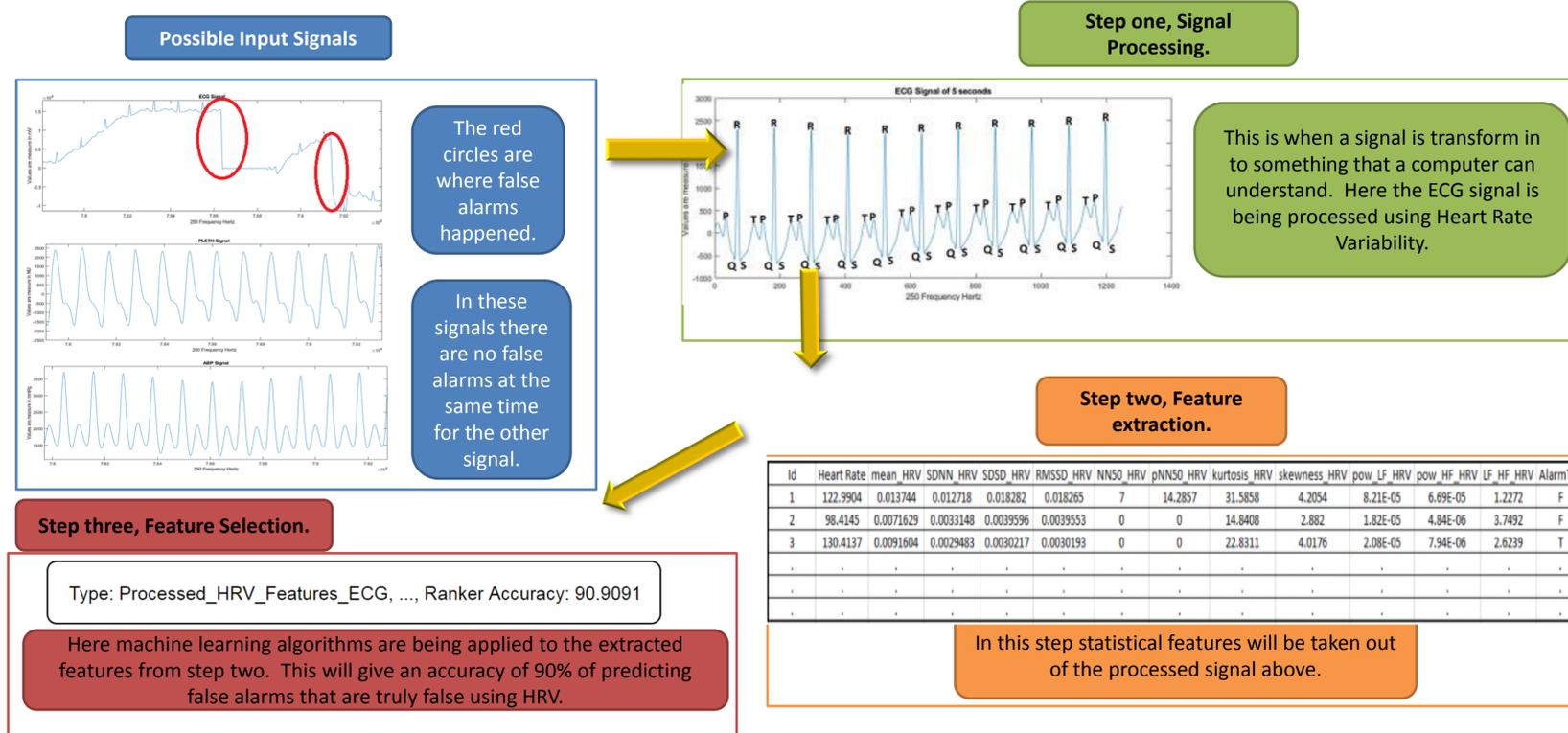
Serious or fatal consequences

- + Patient falls
- + Delays in treatment
- + Treatment errors

Source: The Joint Commission. *Sentinal Event Alert*. April 8, 2013: 58.

METHODS & RESULTS

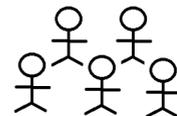
Multi-signal Analysis Flow



Adaptive thresholds

Global data set

The global data set is a training set generated by the machine learning algorithms used in step three. The data used in generating this set is from multiple patients signals. This will be used as a catch all data set for patients. This meaning a wide variety of patients signal can be processed with this data set.



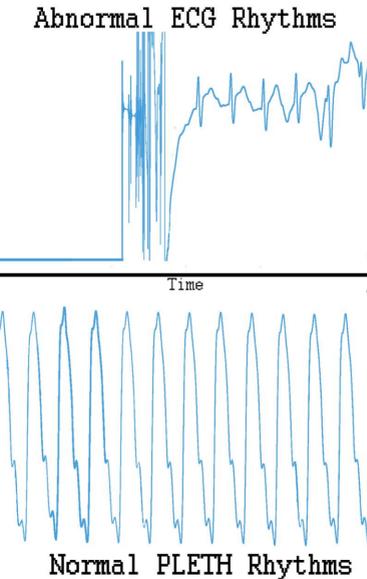
Local data set

The local data set like the global data set where it is generated by the machine learning algorithms. however what is different in local data set compared to the global data set is that there is only one person generating this set. This makes that the local data set will be more patient specific when it comes to alarm classification.



Solution

To reduce false alarms, we use a machine learning approach to identify feature that have the highest accuracy in predicting an alarm. Once the set of features is identified, a trained model can be produced. Using the trained model, a decision can be made about a patient in an ICU. Then, as a patient spends time in an ICU, the model can be altered to include a patient's own data increasing the accuracy. This figure illustrates how an abnormal ECG signal and would normally trigger an urgent alarm, while PLETH maintains its normality. Previously, this example would cause a false alarm but our method can identify it as false alarm.



Outcomes & Contributions

Outcomes:

Our motivation was to design an application that could reduce the number of false alarms in an ICU. Using a machine learning approach, hundreds of patients were used to train classifiers. These classifiers were used to decide whether false alarm conditions were present and if so suppress the alarm. With reducing the number of alarms, we can alleviate stress caused on nurses while maintaining a high degree of true alarm detection.

References:

1. N.Payton-McCauslin,A.Grzesiak, J. Todd, M. Zaeri Amirani, F. Afghah, "Multi-factor Analysis to Reduce False Alarms in Intensive Care Units", submitted to IEEE Engineering in Medicine and biology Society (EMBC'18).
2. F. Afghah, A. Razi, S.M.R. Soroushmehr, S. Molaei, H. Ghanbari, and K. Najarian "AGame Theoretic Predictive Modeling Approach to Reduction of False Alarm", 2015 International Conference for Smart Health (ICSH'15).

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