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Exploiting F1 technology to develop a novel paediatric early warning score

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Overview

- An expert derived paediatric early warning system reduced in-hospital cardiac arrest and subsequent mortality (from 18 cardiac arrests per year with 66% mortality to four cardiac arrests per year with 0% mortality). Despite this, some life-threatening events still occurred, we wish to reduce predictable life-threatening events further.
- This study aimed to use novel techniques developed in Formula 1 racing telemetry to develop an adaptive algorithm as a sensitive, specific predictor of deterioration.
- Preliminary results of predicted deterioration based on pulse oximeter (oxygen saturation) measurement are presented.

Methods

Physiological parameters are collected from children in intensive care via Philips Intellivue monitors (figure 1) and transferred in real time to the Advanced Telemetry Linked Acquisition System (ATLAS) developed by McLaren Electronics Systems for analysis of Formula 1 racing cars. High rate data is analysed by applying embedded mathematical techniques and models (figure 2) similar to that in Formula 1 (figure 3).

A sensitive and specific early warning needs to identify deviation from normality for an individual patient. The first step is defining normality for a population. The definition of normality was determined from oxygen saturation measurements from 80 patients. A five minute recording, verified by clinicians to be within the normal range, was combined to form one patient independent time series depicting normality. This data was processed such that it has zero mean and unit variance. The test data is processed to extract the principal components (the characteristic patterns) in the data and projected onto those derived from the normal data to visualize the changing trends in the test data.

Results

1. **Real time detection of the deviation from normal to abnormal of oxygen saturation levels, SpO2 in a patient (test data).** Figure 4 shows two separate regions, the region on the right is the density of the SpO2 when it lies within a normal range while the region on the left is the density when it deviates from the normality. It has to be noted that the model has been plotted for a small duration before and after the abnormal event.
2. **Prediction of deviation from normal.** Vector Auto Regression techniques were applied to the patient independent normality data set to obtain prediction co-efficients. These prediction co-efficients were utilised to predict future trends in the test data. Based on preceding pulse oximetry trends the future trend in the data can be predicted for a period of two minutes, see figure 5.

Summary

We have developed a novel patient specific early warning method. Currently it is possible to determine when oxygen saturation is deviating from normality and developing an abnormal trend for that patient. In addition, it is possible to predict oxygen saturation trends up to two minutes in advance which is appropriate timing for the dynamic and immediate transport or Intensive Care environment.

Ongoing work is testing the model in different patient groups. Real-time deployment is anticipated to reduce length of stay, increasing efficiency and prevent acute life-threatening events reducing the associated morbidity.

Future work will include fusion models to determine whether a combination of parameters will be more predictive than a single parameter, and to extend the period of prediction to one hour for ward patients and eight hours for patients at home. This novel prediction method will be embedded in continuous remote monitoring and will be tested in children and adults.

Figure 1: **Patient monitored in Paediatric Intensive Care**

Figure 3: **High rate data is used routuinely in assessing the performance of Formula 1 racing cars**

Figure 2: **A snapshot of the different parameters of a patient as viewed on the ATLAS**

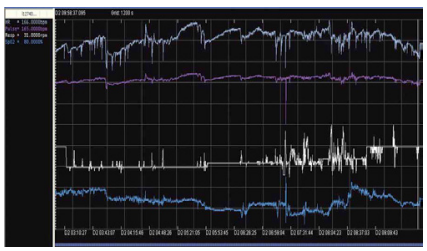


Figure 4: **Density models depicting normality and abnormality in recorded physiological parameter**

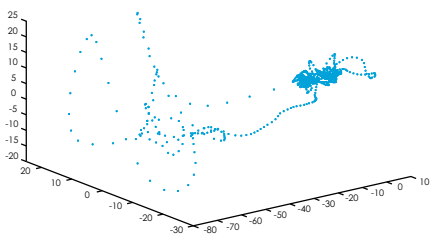
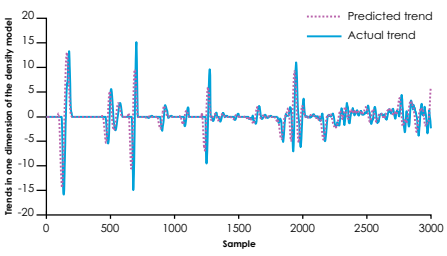


Figure 5: **Prediction of trends in individual parameters. The actual trend is shown in bold while the predicted trend is shown as a dotted line**



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