Towards accurate search for neonatal heartbeat: Weighted algorithm for reliable ECG analysis of premature infants

Authors: Jessica Rahman, Aida Brankovic, Mark Tracy, Robert Halliday, Sankalp Khanna

Australia's National Science Agency

Cerebral Palsy ALLIANCE RESEARCH FOUNDATION

NSW GOVERNMENT Health Western Sydney Local Health District

THE UNIVERSITY OF SYDNEY

CSIRO Australian e-Health Research Centre

Overview

- Motivation
- Aim of the study
- Materials and Methods
- Results
- Conclusion

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Motivation

- Extremely preterm infants have a higher risk of death and permanent disabilities
- Physiological characteristics e.g. Heart Rate Variability (HRV) can provide crucial information relating to different disease conditions
- First step of HRV analysis is the accurate detection of the QRS complex
- State-of-the-art QRS detection methods can vary widely depending on the characteristics of the signals, collection methods and pre-processing techniques

Aim of the Study

- Evaluate and compare the performance of several state-of-the-art QRS complex detection algorithms on two real-world premature infant ECG datasets.

- Introduce and evaluate a weighted ensemble algorithm that leverages the best-performing of these algorithms to deliver consistently superior performance

Fig 1: ECG QRS complex

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Materials and Methods

Dataset 1

- Collected at the Neonatal Intensive Care Unit (NICU) at Westmead Hospital, Sydney, Australia
- 16 ECG data snippets from preterm infants
- Total duration ~ 52 hours
- QRS complex detection using ADInstruments Labchart
- Erroneous and missing peaks were manually annotated

Dataset 2

- Preterm Infant Cardio-Respiratory Signals (PICS) database
- 10 ECG data from preterm infants
- Total duration ~ 440 hours
- QRS complex detection using a modified Pan-Tompkins algorithm
- Erroneous and missing peaks were visually inspected and corrected

Materials and Methods (contd…)

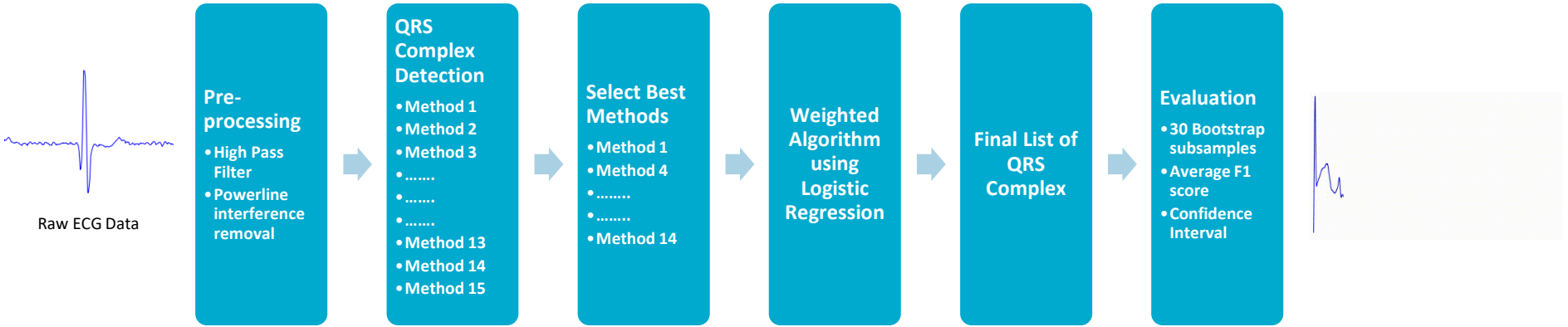

Fig 2: Overview of the process

Materials and Methods (contd…)

Performance Evaluation and Statistical Analysis

- F1-score, the harmonic mean of precision (i.e. positive predictive value) and recall (i.e. sensitivity)
- Performance of the methods compared against ground truth using bootstrap sub-sampling of 20-minute segments
- Process repeated 30 times
- Confidence intervals (CIs) computed with two-sample paired t-tests.

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Results

		PICS Database		Westmead NICU Database	
Algorithm	**Implementation**	**Mean F1**	**CI**	**Mean F1**	**CI**
Christov	Biosspy	0.606	[0.592,0.621]	0.77	[0.768,0.771]
Engzee	Biosppy	0.629	[0.625,0.634]	0.83	[0.83,0.831]
Gamboa	Biosppy	0.584	[0.575,0.592]	0.867	[0.866,0.868]
Neurokit (Default)	Neurokit	0.767	[0.761,0.772]	0.869	[0.868,0.87]
Pan-Tompkins	Neurokit	0.29	[0.279,0.301]	0.331	[0.331,0.332]
Martinez	Neurokit	0.25	[0.247,0.253]	0.836	[0.835,0.837]
Christov	Neurokit	0.643	[0.637,0.648]	0.579	[0.574,0.584]
Gamboa	Neurokit	0.584	[0.575,0.592]	0.867	[0.866,0.868]
Elgendi	Neurokit	0.561	[0.558,0.563]	0.829	[0.827,0.830]
Kalidas	Neurokit	0.001	[0.001,0.002]	0.006	[0.0061,0.0063]
Rodrigues	Neurokit	0.965	[0.961,0.969]	0.674	[0.672,0.676]
Zong	Neurokit	0.69	[0.683,0.697]	0.561	[0.557,0.565]
Nabian	Neurokit	0.481	[0.477,0.486]	0.5	[0.5,0.501]
Hamilton	Neurokit	0.327	[0.323,0.332]	0.583	[0.582,0.584]
Promac	Neurokit	0.73	[0.725,0.735]	0.744	[0.743,0.745]
Ensemble LR		**0.966**	**[0.962,0.97]**	**0.893**	**[0.892,0.894]**

Table 1: Evaluation measures of QRS complex detection methods using two databases

- Proposed weighted ensemble approach performed superior overall
- Obtained results indicate that the state-of-the-art methods are data-sensitive and hence not robust

Conclusion

- Evaluated 15 state-of-the-art QRS complex detection implementations using two preterm neonatal datasets
- A weighted ensemble technique using Logistic Regression which outperformed the individual methods for both datasets
- This study suggests using the ensemble-based approach to ensure consistent performance across multiple datasets where individual methods deliver inconsistent performance

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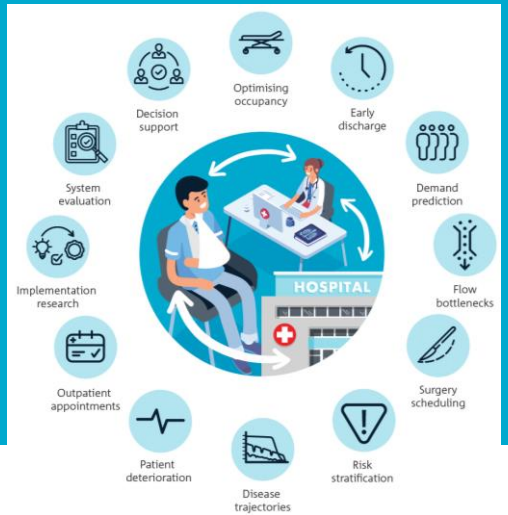

Health System Productivity & Efficiency
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Thank you

Health & Biosecurity
Jessica Rahman
Postdoctoral Research fellow

jessica.rahman@csiro.au
www.aehrc.com

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