HeaRRt: Development Of A New R Library for Processing Analog ECG Data

Cara A. Spencer[1], Alaa M. Khader[1], Sheena I. Dev[2], and Suzanne T. Bell[3]

[1]JES Tech, [2]KBR Inc., [3]NASA Johnson Space Center, Houston, TX

Purpose

1. Examine common heart rate pre-processing and analysis pipelines
2. Develop an R package to address gaps found
3. Compare the new R pipeline to the pipelines identified in step 1

Motivation

Heart rate data is often used in lab studies to gain insight into various physical and psychological health, sleep, and team science outcomes (e.g., autonomic arousal as indicated by the ratio of high and low frequency, an indicator of stress). Using it longitudinally in spaceflight could allow crews to monitor themselves more autonomously but, like other biological signals, using heart rate data poses challenges. Managing and using this big data source has been neglected due to its complexity and has resulted in stagnated heart rate related science and missed opportunities to optimize its usage. The purpose of this project is to develop and validate a data processing pipeline that reads, preprocesses, analyzes and tidies ECG data collected in spaceflight analog studies.

Method

1. Conduct literature review (n = 167)
2. Summarize and try common processing pipelines
3. Try to develop a pipeline using existing libraries
4. Make a new library to address identied gaps
5. Preliminary validation

The State of the Art

Common Software
Commercial:
- Kubios*
- BioPac*

Open Source:
- PhysioNet
- HRV Toolkit
- HeartPy + SciPy
- rHRV
- ARTi-iFACT

Common Pipeline Structure
- Read in signal & segment (if needed)
- Remove noise (outliers, artifacts, baseline drift)
- Extract R-R intervals
- Generate heart beats
- Interpolate missing or removed beats (if needed)
- Generate metrics of interest

Summary:
Kubios is a frequently used research tool but has a heavy manual processing requirement. There are difficulties handling Big Data and the output is not easily parsed. The MatLab packages are more cardiology-centric, some difficult to use, and do not always provide the behavioral health related metrics. HeartPy and rHRV would be ideal but both are missing what the others provide.

HeaRRt: New R package for Heart Rate Research

A comprehensive R package with capabilities from HeartPy & compatibility with rHRV

Workflow: Read in data > Filter, clean and interpolate > Metric generation and visualization

Features: Automatable + Batch apply + File-type agnostic + No black box + Flexible
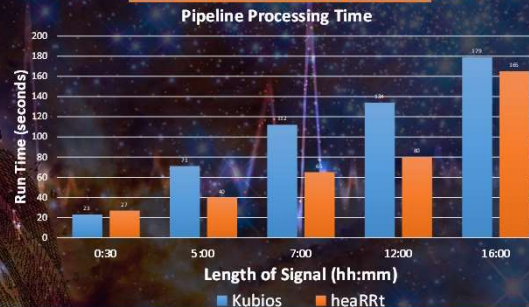
Preliminary Validation

Data from MD5 ROBoT run during HERA C5 and C6 (n=29)

Data Comparison

Metric	P-value of the difference
Avg HR	0.765832
RMSSD	0.645453
LF/HF	0.99947

Error Comparison

Pipeline	% Avg Beats Removed
Kubios*	12
HeaRRt	15

Performance Comparison (n= 10)

Pipeline Processing Time

Conclusion

HeaRRt is a package capable of providing the essential steps in a heart rate processing pipeline for research. Preliminary results show little to small differences in the data comparison, a more conservative beat removal algorithm, and better speed. Results are comparable to gold standard research tools. With continued refining, the HeaRRt + rHRV pipeline can be a useful, valid and robust alternative to the current tools. Future work includes adding additional features (filters, logging for reproducibility, etc.), and further validation.

Please contact the first author for notification when the package is released.