Detecting Horse Cardiac Arrhythmia with ECG Data

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Statistics & Data Science

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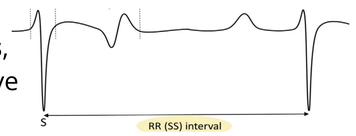
Introduction

Cardiac arrhythmias in horses are serious conditions that are potentially life-threatening. Our research focuses on analyzing **horse ECG data** to understand arrhythmia patterns comprehensively. By employing advanced statistical methods on ECG data, we aim to enhance the detection of horse cardiac arrhythmia.

Research Question: How can advanced data analysis of ECG data enhance our comprehension of cardiac arrhythmias in horses?

Data

- ECG data of **13** horses with **11** windows of time across a **24-hour period**
- Our focus is on **RR intervals**, the time between consecutive R waves in ECG



- Horses received an **endotoxin** injection that **simulates cardiac arrhythmia symptoms**
- Treatments were given in the 5-7h window

Endotoxin Admin	Severe Symptoms	Recovery Stage
Before Endotoxin Pre-Sedation Post-Sedation	0-1 Hour 1-3 Hours 3-5 Hours	5-7 Hours to the end of experiment

Table 1 11 time windows divided into 3 phases

- **Poincare plots**: RR(n) on the x-axis vs. RR(n + 1) (the succeeding RR interval) on the y-axis
- **Data Preprocessing**: Atrioventricular blocks (AV blocks) are removed

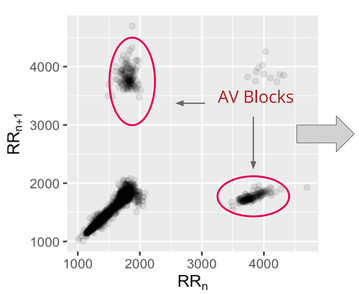


Figure 1 Poincare plot with AV Blocks

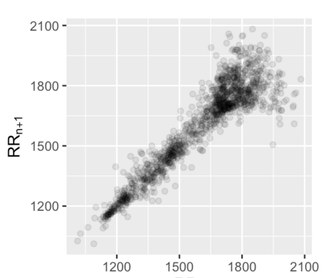


Figure 2 Poincare plot with AV Blocks removed using fixed threshold

Methodology

- Important summary statistics of RR data:
  - Mean, Variance, Min, Max
  - **SD1 and SD2**: short-term and long-term variability to quantify cluster shape
  - **Number of components** by Gaussian Mixture Model: capture complexity in cluster dispersion (disperse → more components)

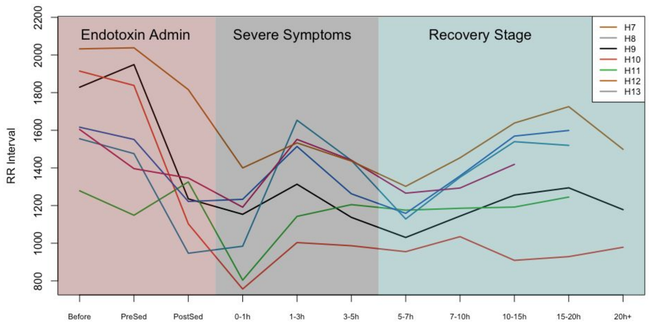


Figure 3 Trends of Mean RR of 7 Horses

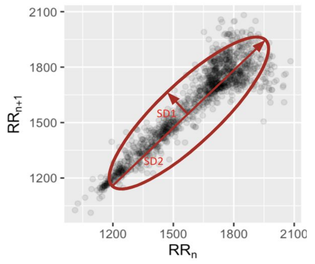


Figure 4 Illustration of SD1 and SD2

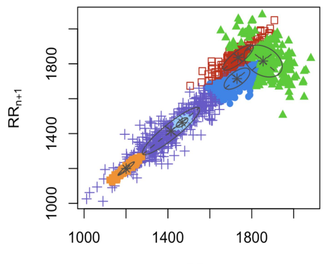


Figure 5 Components by GMM (G=6)

Horse_Window	Phase	num_comp	SD1	SD2	Mean	Var	Min	Max
H1_Before	Endotoxin Admin	1.246	3.352	0.042	1.619	0.09	2.21	0.955
H1_PreSed	Endotoxin Admin	-1.331	2.561	1.227	1.361	1.081	0.763	0.961

Table 2 Standardized summary statistics table used in PCA

We want to find patterns between the shape of Poincare plot cluster and the cardiac arrhythmia phase using trends in RR summary statistics

- **Principal Component Analysis (PCA)** is used to find what variables "contribute" the most to the change in phases
- Each point is assigned to a cluster based on **hierarchical clustering** with complete linkage and Euclidean distance
- Cluster assignments are used for **Chi-squared test** and **Mosaic plot** against phases and horses

Results

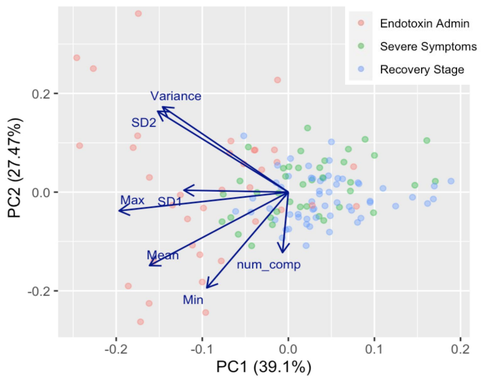


Figure 6 PCA biplot, with points colored by phases

PCA:

- 66.6% of total variance are explained
- Contributors to PC1: SD1, Max
- Contributor to PC2: Number of components
- Endotoxin Admin associated with small PC1

Mosaic Plots:

- Cluster assignments and phases are not independent
- Cluster assignments are mostly independent with horse

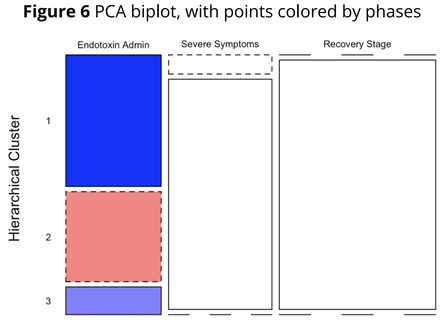


Figure 7 Mosaic plot of phases vs. hierarchical cluster assignment

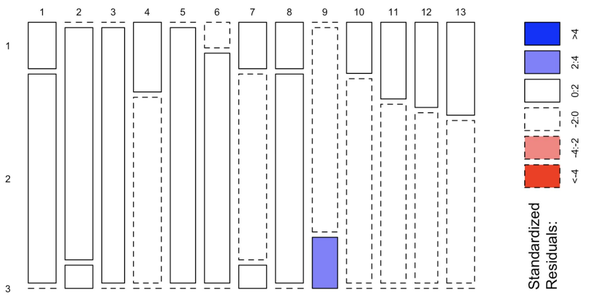


Figure 8 Mosaic plot of horses vs. hierarchical cluster assignment

Conclusion

Using our results from PCA and the Mosaic plots, **we can distinguish periods before and after endotoxin injection**:

- The larger the SD1 and Max, the more likely the horse has not shown severe cardiac arrhythmia symptoms
- If a horse's RR summary data is assigned to cluster 1 or 3, there is high probability that this horse is in the Endotoxin Admin phase

Future Research:

- Detect differences between Severe Symptoms and Recovery Stage
- Increase sample size for better generalizability
- Incorporate horse info (age, weight, etc.) and further explore the variability among horses

References

Karmakar, Chandan K, et al. "Complex Correlation Measure: A Novel Descriptor for Poincaré Plot - Biomedical Engineering Online." BioMed Central, BioMed Central, 13 Aug. 2009.
KJ;, Mitchell. "Equine Electrocardiography." The Veterinary Clinics of North America. Equine Practice, U.S. National Library of Medicine.
Zhang L;Guo T;Xi B;Fan Y;Wang K;Bi J;Wang Y; "Automatic Recognition of Cardiac Arrhythmias Based on the Geometric Patterns of Poincaré Plots." Physiological Measurement, U.S. National Library of Medicine.