Influence of Event Duration on Automatic Wheeze Classification

Bruno M. Rocha[1], Diogo Pessoa[1], Alda Marques[2,3], Paulo Carvalho[1], Rui Pedro Paiva[1]

[1]Centre for Informatics and Systems, Department of Informatics Engineering (CISUC), Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal

[2]Respiratory Research and Rehabilitation Laboratory (Lab3R), School of Health (ESSUA), University of Aveiro, Aveiro, Portugal

[3]Institute of Biomedicine (iBiMed), University of Aveiro, Aveiro, Portugal

Respiratory Sounds

- Simple, objective, noninvasive marker to assess patients' respiratory condition

- Normal or adventitious respiratory sounds

  - Discontinuous ARS (crackles)

  - **Continuous ARS (wheezes)**
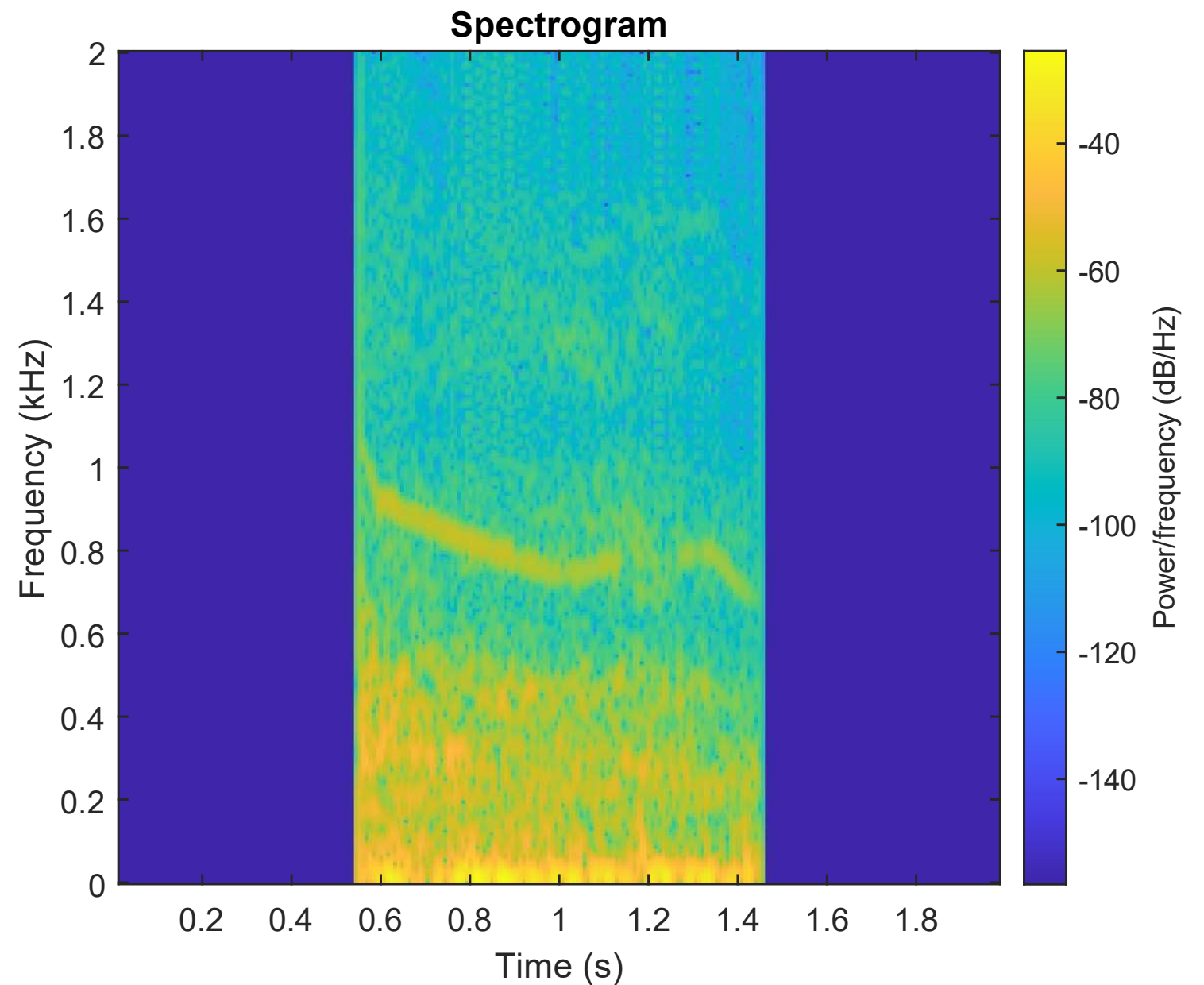
Limitations of Related Work

- Field's reliance on small or private data collections

- Public repositories designed for teaching

- Lack of environmental noise

- Neglected experimental design

- Overestimated non-generalizable results

Random Event Generation

- Study the impact of event duration on performance

- *Other* (negative) class containing speech, cough, crackles, background noise

- Fixed durations

  - Random events with 150 ms

- Variable durations

  - Random events with durations between 100 ms and 2 s

  - Durations from the same distribution of wheeze events

Public Database

- 5.5 hours of recordings

- 126 patients

- 7 locations on the chest wall: trachea; left and right anterior, posterior, and lateral.

	Training set	Test set	Total
Wheeze events	1173	725	1898
Other events	1781	1129	2910
Total	2954	1854	4808

Feature Extraction

| Feature	Description
Spectral Centroid	Center of mass of the spectral distribution
Spectral Spread	Variance of the spectral distribution
Zero-crossing Rate	Waveform sign-change rate
Spectral Entropy	Estimation of the complexity of the spectrum
Spectral Flatness	Estimation of the noisiness of a spectrum
Spectral Roughness	Estimation of the sensory dissonance
Spectral Irregularity	Estimation of the spectral peaks' variability
Spectral Flux	Euclidean distance between the spectrum of successive frames
Spectral Brightness	Amount of energy above {100,200,400,800} Hz
Spectral Rolloff	Frequency such that {95,75,25,5}% of the total energy is contained below it
MFCC	13 Mel-frequency cepstral coefficients
Delta-MFCC	1st-order temporal differentiation of the MFCCs
Chromagram Centroid	Tonal centroid
Chromagram Peak	Tonal peak
Pitch	Fundamental frequency estimation
Voicing	Presence of fundamental frequency
Inharmonicity	Partials non-multiple of fundamental frequency

Classification

- ❖ Logistic Regression (Baseline)

- ❖ Linear Discriminant

- ❖ Linear SVM

- ❖ Gaussian SVM

- ❖ Boosted trees

- ❖ Convolutional Neural Network

Evaluation

MCC
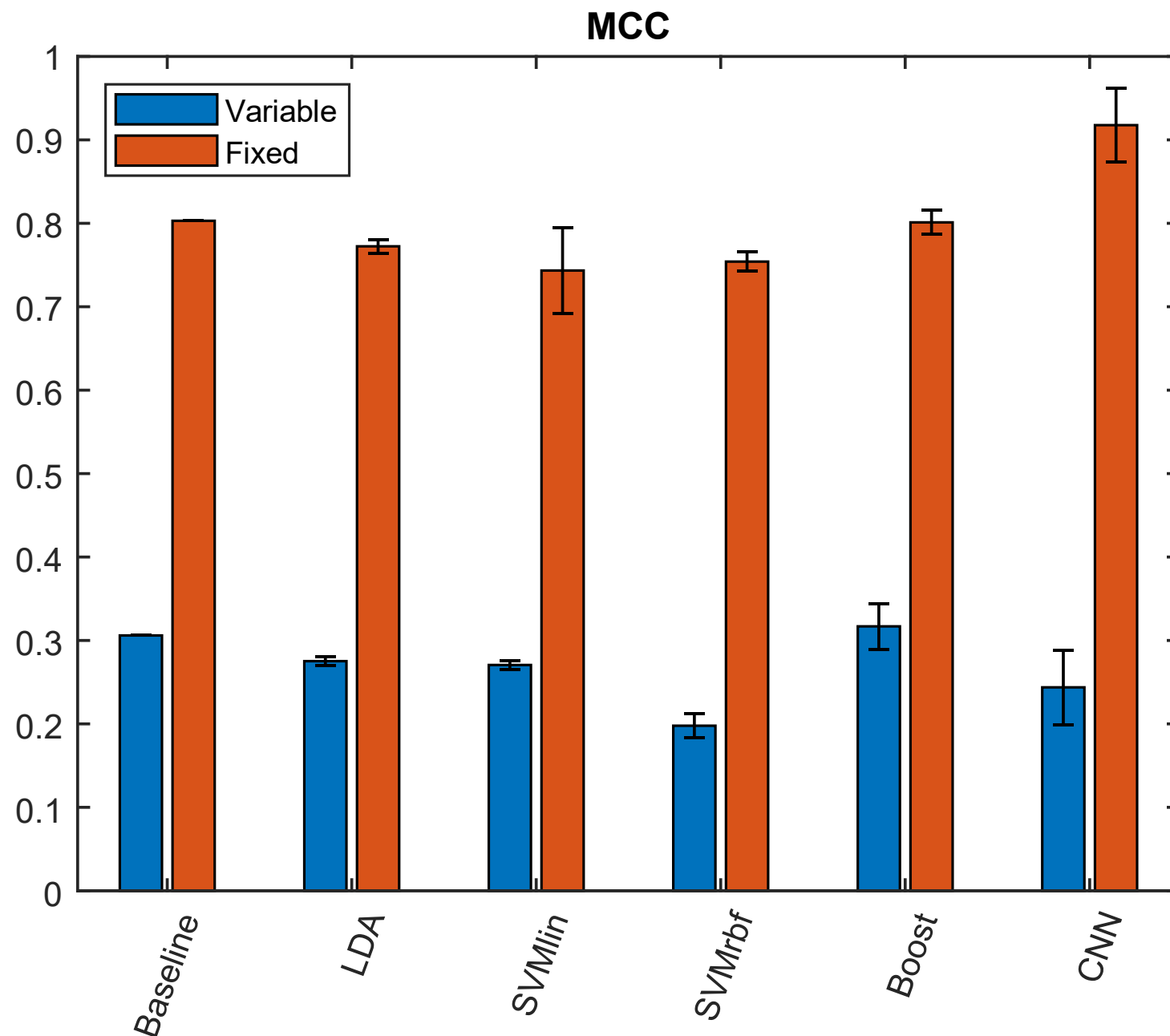
❖ Significant variation in performance between fixed and variable duration events: CNN: FD - 0.92; VD - 0.24

Discussion
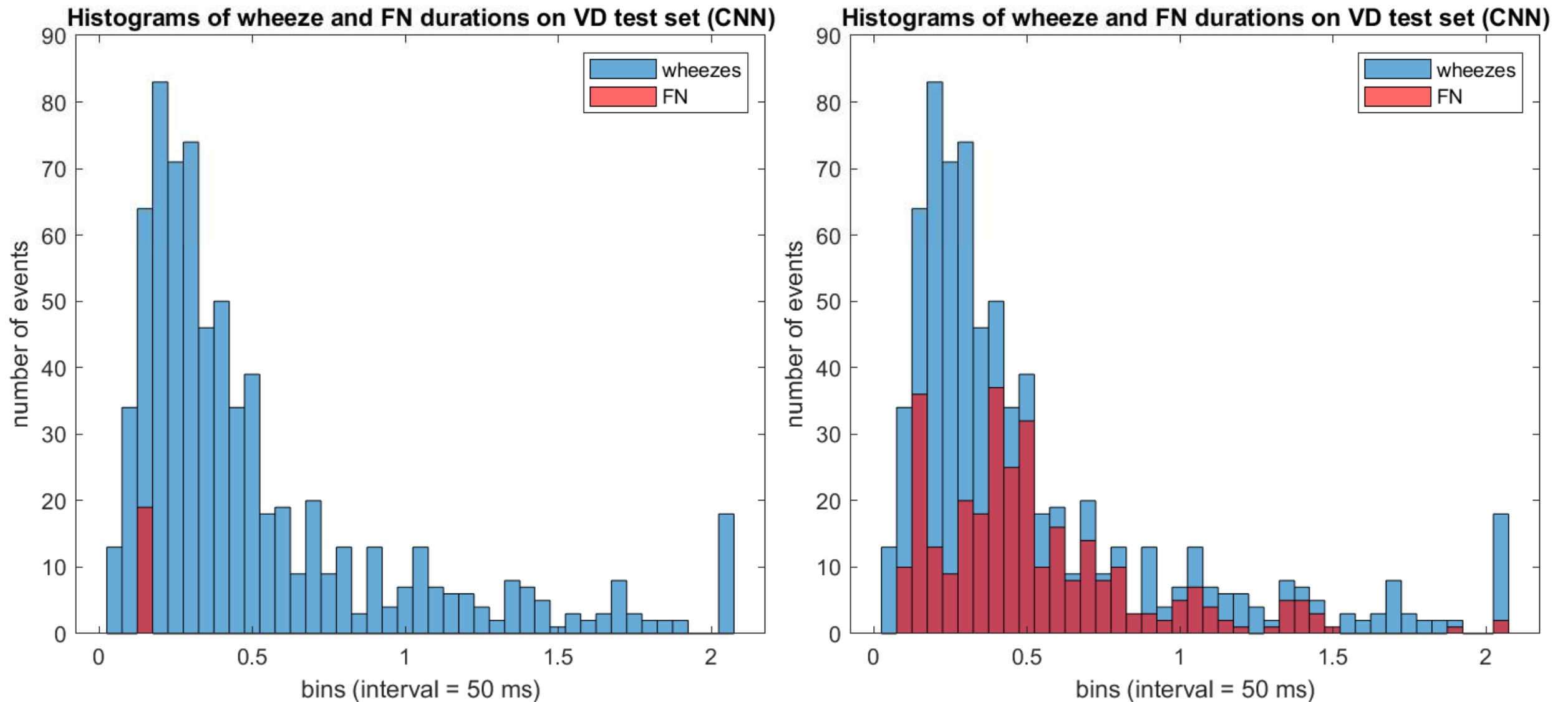
- Distributions of false negatives are quite different
  - Concentrated around 150 ms on FD test set
  - Encompassing all durations on VD test set

Discussion

❖ Significant variation in performance

❖ Classifiers are **implicitly learning an irrelevant characteristic** of the dataset, event duration

❖ Wheeze classification is a complex task not yet solved

❖ Robust **experimental design is crucial for realistic evaluation** of wheeze classification algorithms

Thank you!