

Feature Level Analysis



Nishchal K. Verma, Sumanik Singh, Jayesh K. Gupta,
Rahul K. Sevakula, Sonal Dixit

Department of Electrical Engineering, Indian Institute of Technology, Kanpur

Introduction

Condition based maintenance refers to the process under which an equipment is serviced when the equipment is going to fail or its performance is deteriorating. Proper automatic prediction from the available indicators via machine learning algorithms require a good feature set. Herein, we take a case-study of acoustic and vibrational features from the different working states of an air compressor and graphically analyze them to derive the best feature set. The data is collected from an air compressor under healthy and three faulty conditions using microphone and accelerometer, which is then preprocessed to remove the noise. Next, features belonging to time, frequency and wavelet domain are extracted. We then individually plot these features for different working conditions of the machine against each other. We then select the most relevant features on the basis of their graphical distinction and build an SVM model from these features. For validation, we compare the classification results from this model with that from a standard principal component analysis applied on the entire feature-set.

Dataset

Microphone:

Machine Condition: Healthy, LOV, LIV, NRV

Size: 500, 125 instances of each.

Accelerometer:

Machine Condition: Healthy, LIV

Size: 170, 85 instances of each.

Validation

We ran cross validation tests using manually selected data from the earlier analysis and compared the classification accuracies with those from the PCA models.

Manually Selected data consisted of 1 feature from time domain, 3 from frequency domain, 3 from morlet and 16 from WPT.

The results:

Machine Condition	Manual Selection	PCA
Healthy	99.8	99.6
LOV	99.8	99.6
LIV	100	99.4
NRV	99.8	99.8

We get comparable results from the manually selected and PCA features.

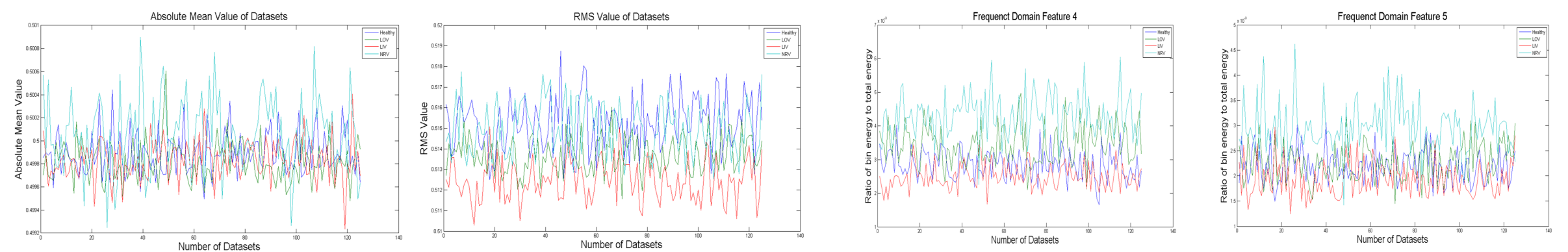
Similarly, we got comparable average cross validation accuracies for the vibrational data from accelerometer.

Results

- Graphical analysis verifies the prediction model being used. [1]
- There are marked differences between features from healthy and LIV states .
- Under the wavelet domain, WPT features are most distinguishable from the plots.
- Time domain and frequency domain features showed satisfactory differences.

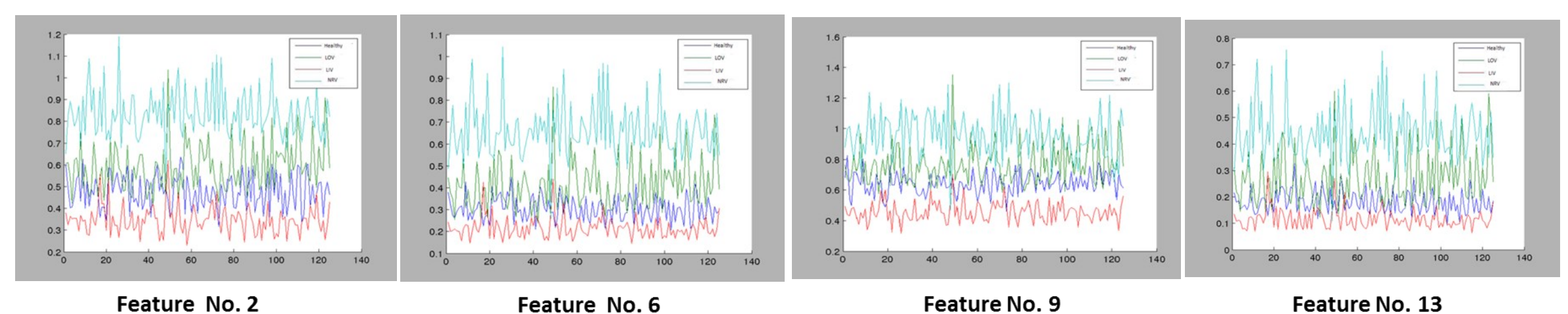
Analysis

Microphone:

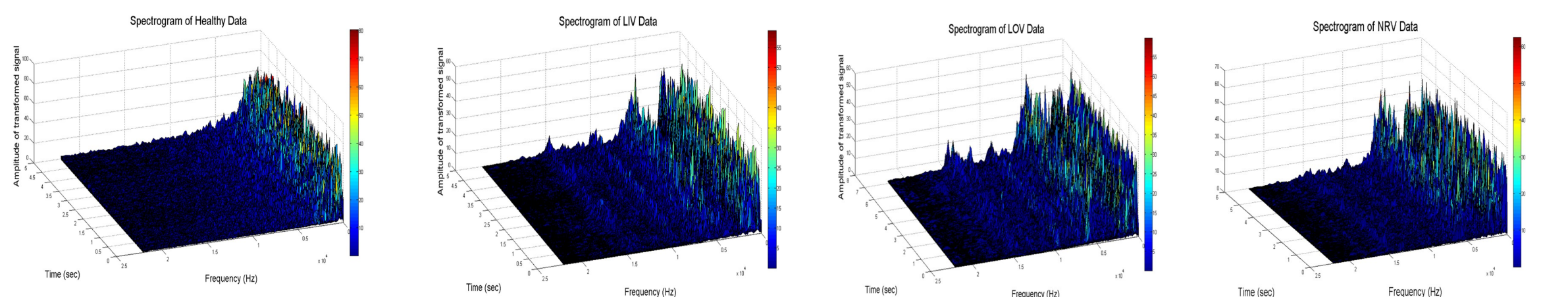


Time Domain

Frequency Domain



Wavelet Domain



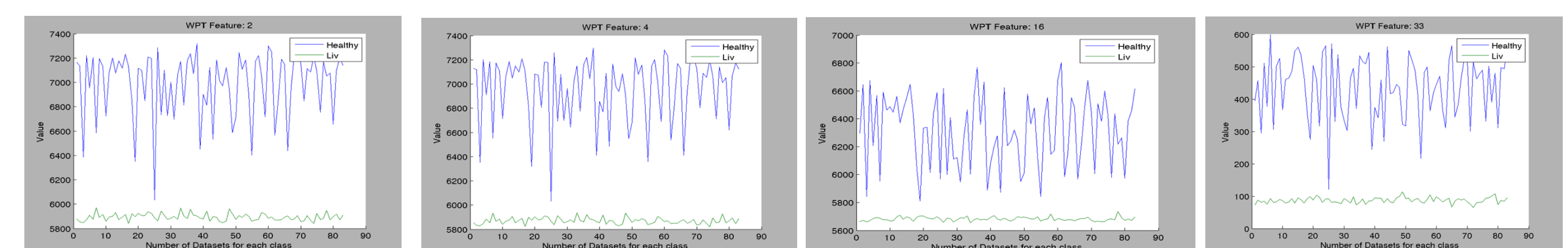
Spectrogram

Accelerometer:

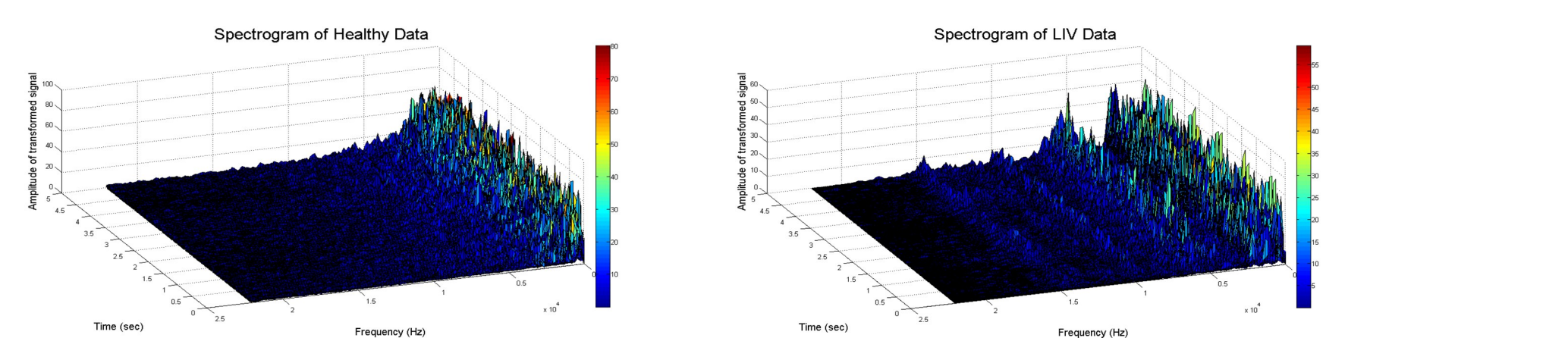


Time Domain

Frequency Domain



Wavelet Domain



Spectrogram

Conclusion

Using graphical analysis, we could skip the computationally intensive feature selection step of PCA and still get comparable results. This analysis could have applications in mobile and other devices with lower processing power for condition based monitoring.

References: [1] Verma, N. K., Singh, S., Gupta, J. K., Sevakula, R. K., Dixit, S., & Salour, A. Smartphone Application for Fault Recognition. [2] Verma, N.K.; Roy, A.; Salour, A., "An optimized fault diagnosis method for reciprocating air compressors based on SVM," System Engineering and Technology (ICSET), 2011 IEEE International Conference on , vol., no., pp.65,69, 27-28 June 2011

Acknowledgements

We would like to express our sincere gratitude to Boeing for their funding support for this research work . We also thank all members of Intelligent Informatics Group at IIT-K for valuable discussions and suggestions.