# Machine Design Laboratory
# Diploma Thesis 2020 - 2021
## Fault diagnosis on rotating systems with the usage of Big Data analysis

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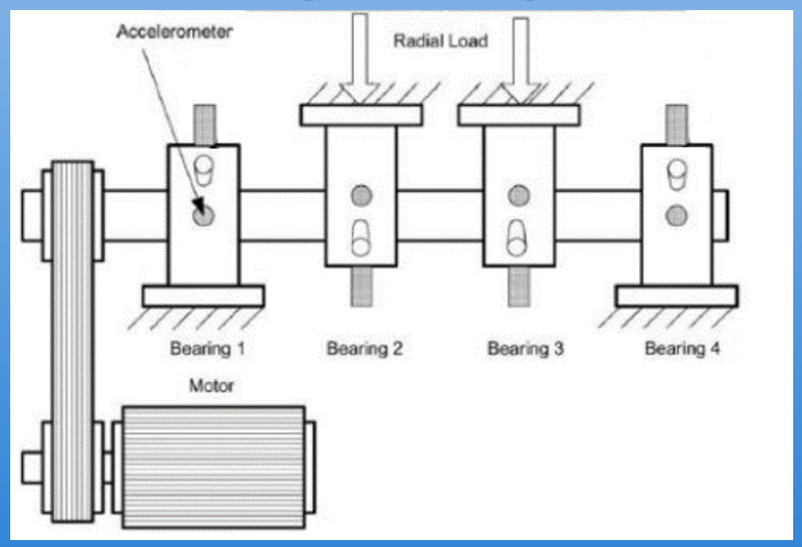
## Abstract

One of the most important issues that engineers have always been concerned of is the study of oscillations and the stability of a structure. Rotating systems and especially shafts exist in a wide range of applications, such as motors, turbines, compressors, pumps and more. In these systems an uncontrolled oscillation can lead to resonance, which may result in devastating consequences for the machine, but also for human safety. So, it has been made clear that it is important to analyze the behavior of rotating systems, in many situations, so to predict an error and especially avoid an accident. In this study, we developed a fault diagnosis algorithm on roller bearings. For this reason, we used experimental data, from an experiment that had been conducted by NSF I/UCR Center for Intelligent Maintenance Systems (IMS – www.imscenter.net), which we used to train a model in MATLAB. This model can diagnose a fault in roller bearings with the usage of the SVM method.

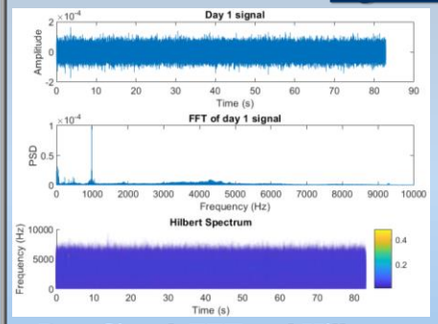
## Experimental setup



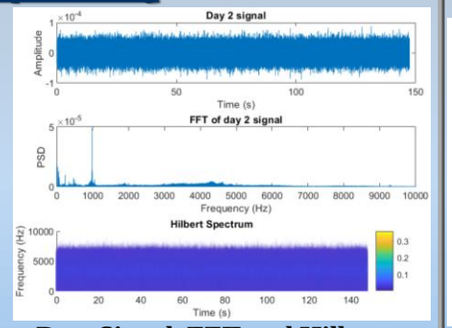

**Experimental setup of the shaft, roller bearings and accelerometers**

- Motor AC
- Rotation speed: 2000RPM
- Radial load: 6000 lbs (2721.5 Kg)
- Four double row roller bearings Rexnord ZA-2115
- Four accelerometer (PCB 353B33 High Sensitivity Quartz ICP)
- Sampling Frequency: $F_s$ = 20kHz
- Total number of data points: 20,152,320
- At the end of the test-to-failure experiment, outer race failure occurred in bearing 1.

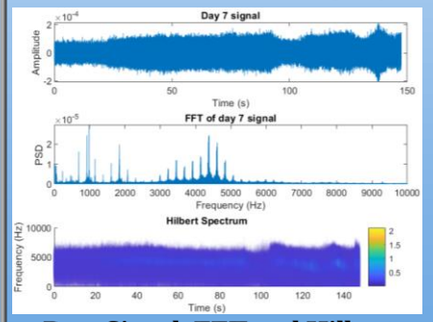
## Signal Preprocessing



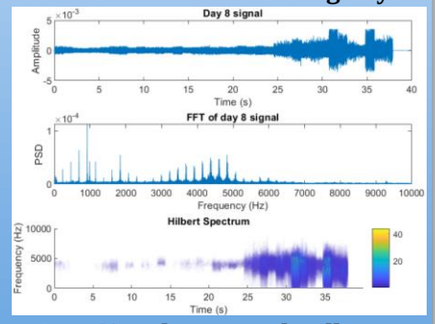

**Raw Signal, FFT and Hilbert transform – 1st recording day.**




**Raw Signal, FFT and Hilbert transform – 2nd recording day.**

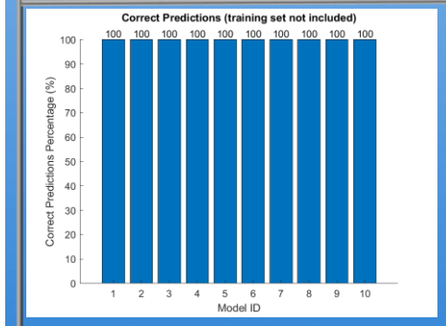



**Raw Signal, FFT and Hilbert transform – 7th recording day.**

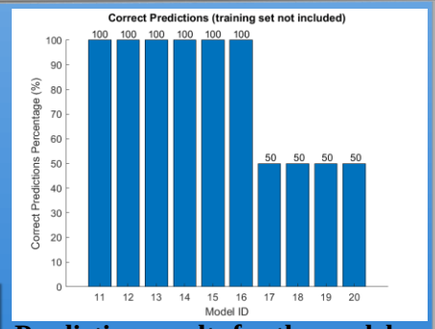



**Raw Signal, FFT and Hilbert transform – 8th recording day.**

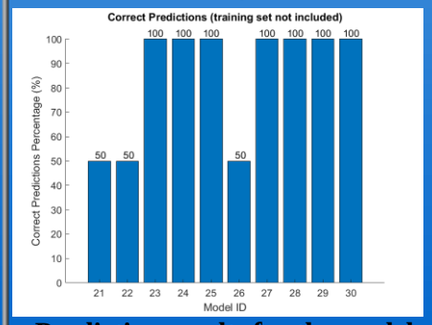
## Results



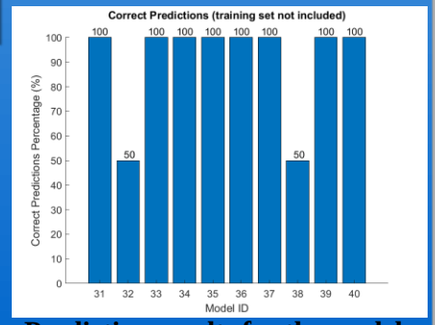

**Prediction results for the models 1-10**




**Prediction results for the models 11-20.**

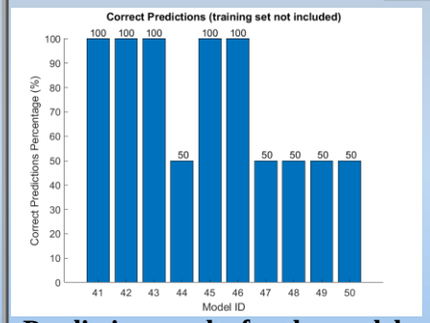



**Prediction results for the models 21-30.**

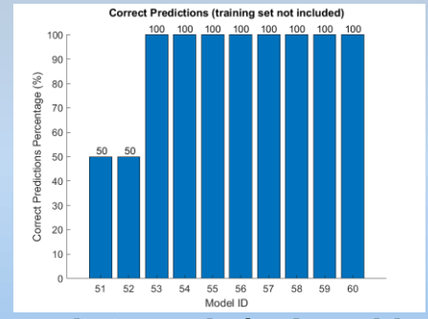



**Prediction results for the models 31-40.**

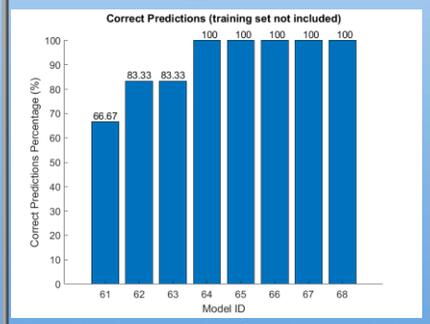
## Results



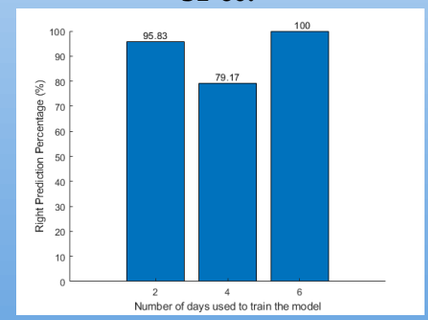

**Prediction results for the models 41-50.**




**Prediction results for the models 51-60.**




**Prediction results for the models 61-68.**




**Overall success rate depending on the number of datasets used in each models training.**

A total of 68 models emerged from the system of permutations we used to train the prediction model:

- 16 models trained the 6 out of the 8 datasets
- 36 models trained the 4 out of the 8 datasets
- 16 models trained the 2 out of the 8 datasets

**Keywords:** SVM, EMD, Big Data Analytics, Fault diagnosis, Roller bearings, Rotating systems.

## Conclusion

- The models that are trained with the 6 out of the 8 datasets, show a success rate that reaches 100%. Of course, this case is quite ideal as in some applications we may not have the appropriate logger to do such an adequate model training.
- If we look at the other two categories of models, we notice that they show quite good percentages. That means that the SVM method can train a model, which makes successful predictions for impending failure, even with a smaller number of data available, as it happens in the category that the models have been trained with 2 or 4 datasets.