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EARLY CLASSIFICATIONS OF BEARING FAULTS USING HIDDEN MARKOV MODELS, GAUSSIAN MIXTURE MODELS, MEL-FREQUENCY CEPSTRAL COEFFICIENTS AND FRACTALS

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Abstract. *Most rotating-machines failures are often linked to bearing failures. Proper condition monitoring on bearings is therefore essential to reduce the duration of machine down-times. This paper introduces feature extraction methodologies that can facilitate early detection of bearing faults. The time-domain vibration signals of a rotating machine with normal and defective bearings are processed for feature extraction. Both linear and non-linear features are extracted using Multi-Scale Fractal Dimension (MFD), Mel frequency Cepstral Coefficients and kurtosis. The extracted features are then used to classify faults using Gaussian Mixture Models (GMM) and hidden Markov Models (HMM). Results demonstrate that HMM outperforms GMM in classification of bearing faults. However, the disadvantage of HMM is that it is computationally expensive to train compared to GMM.*

Keywords: Multi-scale fractal dimension, Hidden Markov models, Gaussian mixture models

1. **Introduction.** Rotating machines are the most used components in various industrial applications ranging from system maintenance to process automation. Most machine failures are linked to bearing failures [1], which often result in lengthy industrial downtimes that have economic consequences. Bearing faults induce high vibrations which generate noise and lead to malfunctions on the rotating machinery. There is therefore a high demand of a cost effective and automated condition monitoring system that can detect faults as early as possible. The early identification of defects in a machine can reduce off line time, maintenance periods, avoid accidents and catastrophic break-down. An automated condition monitoring of bearings is necessary as manual checks may take an unacceptably long duration resulting in money losses. Vibration-based condition monitoring is the most popular approach and has been used extensively in various bearing condition monitoring techniques [1, 2]. Vibrations can also be used to detect existence of faults such as mass imbalance, shaft misalignment and gear failures by simply comparing the vibration signals of a machine operating in faulty conditions and in normal, un-faulted conditions. There are several causes of bearing failure such as incorrect design, acid corrosion, poor lubrication and plastic deformation [3]. Damage in bearings is typically on the rolling element, inner race or outer race[1]. The difficulty of fault detection in bearings lies in