Multi-sensor based framework for machine condition monitoring

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ABSTRACT

The desire to reduce the risk of disastrous failures, minimize maintenance costs, maximize system availability, and increase platform reliability is leading industries to develop better machine maintenance practices. It is clear from a review of the literature that a significant amount of research and development work has been done to date in the field of gear Condition Base Maintenance (CBM) and Prognosis and Health Management (PHM). Many different techniques have been applied in an attempt to resolve an accurate machine fault detection, diagnosis and prognosis method which could then be the basis of gear CBM. In most of the published research, one type of transducer, typically vibration or acoustic has been considered to determine the existence of faults in a gearbox. The objective of this research is to investigate the potential advantages of merging different types of data and to modify existing clustering techniques used in general gearbox diagnosis algorithms. Within the system, data fusion will be used to combine the information from a multi-sensor data array to validate signals and create useful features. Fused data from multiple sensors provides several advantages over data from a single sensor including an improved observation process and detection parameters for a particular operating system. An online condition monitoring system would seek to combine these observations in order to identify precursors to failure, such as abnormal gear wear, shaft misalignment or bearing failure.

The key to effectively implementing CBM is the ability to detect, and classify faults with sufficient robustness and use that information as a basis to plan maintenance for critical systems. The objective of this work is to investigate and develop both analytically and practically a general method for initial identification of faults in the various operating components within a gearbox. The methods used will be based on multi-sensor data fusion. The results should allow detection of new faults as they develop and prediction remaining useful life of gearbox components

The first main task in this research concentrates on developing analytical models to describe the applied transducers. Analytical simulations based on experimental measurements are also conducted to modify or verify the analytical models. Analysis involves the application of time-varying Autoregressive (AR) models and some other signal processing techniques and classification methods on the data. The correlation of the analytical models, the numerical models and experimental measurements is shown in Figure1. If the models show reasonable predictions of defect initiation it will be a significant contribution in this field.

The data must be filtered and reduced to extract information that is relevant to the stage of the diagnosis task. Therefore, which features contribute the greatest differentiation between fault classes are studied. This can be achieved by rejecting redundant features or combining features that are functional combinations of each other. Once the feature vector parameters and signals are measured or computed for the running machinery, the result is analyzed to determine the current fault operating condition. This is accomplished using fault classification decision making. Several decision-making tools are used. The combination of techniques attempt to address some of the weaknesses of single approaches being

used independently. This requires a sufficient database of signals (both baseline and faulty conditions) to train and validate diagnosis algorithms before final on-line implementation

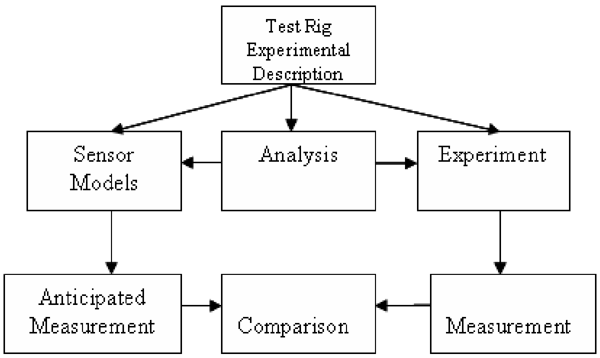

Figure1: The comparison of simulation with measurement.

This study investigates if the best solution to the multi-sensor monitoring of different operating machinery is comprised of a combination of several approaches working together. The classifier should handle noisy and corrupted data in order to assure reliability. The automated approximate reasoning will be capable of interpreting the results of the sensor measurements and the processed data in the context of an operational environment.

There are three locations where the data fusion task can be applied. Data fusion can be used to combine raw multi-sensor machinery data and then extract the useful. Data fusion may be applied before feature extraction which provides information with fewer dimensions in comparison with the raw data fusion structure. Raw multi-sensor data and extracted features can be combined and incorporated to obtain the best possible detection solution. The task is to apply these tools and knowledge into a working diagnosis system and then to subject the proposed system to performance testing to investigate the best diagnosis system for the given experimental and theoretical gearbox dataset. The most common data fusion techniques, such as weighting/voting, neural networks and Bayesian inference is applied to discover which technique is best suited for the multi-sensor gearbox defect detection. However, one of the main concerns will be to build a structure that performs better than a single-sensor based tool.