DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING -
37TH CYCLE

Title of the research activity:	Early fault detection and lifetime optimization methods for rotating machinery.
State of the Art:	Early fault diagnosis for rotating machines is fundamental in the optimization of the remaining operational life, future condition, or probability of reliable operation of the equipment based on the acquired condition monitoring data [1, 2]. Condition monitoring of rotating machinery is particularly important in energy conversion technology especially when the operation regime is not steady. For example, wind turbines operate under non-stationary conditions so that condition monitoring is challenging and interesting for developing research test cases. The literature on this topic is particularly focused on the drive-train [3] and the bearings [4]. Several are the possible techniques, from physical models to data-driven prognostic models. Each of them has its pros and cons: basically, the main drawback of the former category is that real-life systems are often too stochastic to be successfully modelled, while the main drawback of the latter category is that feature extraction might be very complex, especially if the signal to noise ratio under an incoming damage is low. As regards data-mining methods, several are the possible approaches: basically, the main categories are time-domain [5] and frequency-domain feature extraction. Ciclostationarity has emerged in the last decades [6] for characterizing certain types of non-stationary mechanical signals, as for example from rotating machines like wind turbines. In [6], it is argued that conventional cyclic spectral estimators end up with similar asymptotic results and the rationale for selecting the most appropriate ones depends on the specific application. On these grounds, it is important to critically analyse the techniques for condition monitoring in relation to the target technology.
Short description and objectives of the research activity:	At the Department of Engineering, several test cases for condition monitoring studies of rotating machines are available. For example, a small horizontal-axis wind turbine has been designed and its dynamic behaviour has been studied through wind tunnel tests (also in unsteady conditions [7]) and aero-elastic simulations [8]. Small horizontal-axis wind turbines are characterized by a very high rotational speed, modulated through a small rotor, in order to guarantee a reasonable energy conversion efficiency. This implies that this kind of wind turbines can be affected by severe noise and vibration issues and devoted condition monitoring techniques are

	therefore needed. MW-scale wind turbines have rotational speed of the order of 15 revolutions per minute and most often the slow rotation of the main shaft is converted to the fast rotation of the generator through a gearbox. Gearbox condition monitoring of the gearbox is therefore crucial and a considerable amount of scientific literature is devoted to this topic. Finally, test benches are available at the Department of Engineering for the detailed study of rotating devices, as for example components of wind turbines. The condition monitoring of these components can also be inspiring for optimizing the mechanical design for rotating machinery. On these grounds, the objective of the project is the study of innovative techniques for condition monitoring of rotating machinery through the analysis of real test cases spanning a vast range. A detailed match between the features of each target technology and the techniques for condition monitoring is expected to be discussed and developed; a further step of the application of this methods ([9] and [10]) is the main goal of the research.
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