DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
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Title of the research activity:	Condition monitoring techniques for rotating machinery and applications to wind energy.
State of the Art:	Machinery prognosis is the forecast of the remaining operational life, future condition, or probability of reliable operation of an equipment based on the acquired condition monitoring data [1]. Condition monitoring of rotating machinery is particularly important in energy conversion technology. For example, wind turbines operate under non-stationary conditions and there is a flourishing literature about condition monitoring techniques, especially as regards the drive-train and the bearings. 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 that basically divide in time-domain [2] and frequency-domain feature extraction. Ciclostationarity has emerged in the last decades [3] for characterizing certain types of non-stationary mechanical signals, as for example from rotating machines like wind turbines. In [3], 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 study critically the techniques for condition monitoring in relation to the destination 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 [4] and its dynamic behaviour has been studied through wind tunnel tests and aero-elastic simulations [5]. Small horizontal-axis wind turbines are characterized by considerable criticality, because economic sustainability of the investment dictates the adoption of cheap technology and at the same time horizontal-axis wind turbines must have a very high rotational speed 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. Full-scale wind turbines are characterized, instead, by a completely

	different criticality: the rotational speed is much lower (up to 15 revolutions per minute, generally) and the wind turbines have a gearbox. Condition monitoring of the gearbox is therefore the most pressing demand and a considerable amount of scientific literature is devoted to this topic [6]. The collaboration between the Department of Engineering and Renvico (www.renvicoenergy.com), owning and managing 335 MW of wind turbines in Italy and France, provides the availability of data sets for the study of real test cases. 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 can also be a laboratory for optimizing the mechanical design of components of 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 criticality of each technology and the techniques for condition monitoring is expected to be discussed and developed.
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