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A Transfer Learning and Domain Adaptation Framework for Imbalance Localization in Rotating Shafts

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Rotating machinery is central to modern industrial applications, and shaft unbalance remains one of the most prevalent causes of premature failure and structural degradation. Effective condition monitoring is therefore essential to ensure operational reliability and optimise maintenance schedules. Modern strategies rely on machine learning algorithms, for which data availability is crucial. However, in real applications, it is common to be in a data-scarce condition, especially for new structures. Thus, this study proposes a transfer learning framework for damage localisation on rotating shafts. In this scope, experimental tests were conducted in which two rotating shafts were subjected to controlled fault conditions and different rotational speeds. Four accelerometers, placed on the shafts' bearings, are used to acquire signals during the shafts' rotation. One shaft is used to mimic a structure for which there is a very good knowledge, e.g., data. The other shaft represents a newer structure, for which there is little data, e.g., poor knowledge. Damage is induced in the form of imbalances by screwing bolts with different masses in varying locations. Domain adaptation and fine-tuning techniques are used to transfer knowledge from one domain to another, and a convolutional neural network is employed for damage localisation. This research provides a transfer learning framework for rotating shaft damage localisation based on vibration monitoring.

Primary authors: LUCII, Libero (Politecnico di Milano); Mr PETRICONI, Emanuele (Politecnico di Milano); Mr PINELLO, Lucio (Politecnico di Milano); Mr GIGLIO, Marco (Politecnico di Milano); Mr SBARUFATTI, Claudio (Politecnico di Milano)

Presenter: LUCII, Libero (Politecnico di Milano)

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