CNN Based Approach for Rotor Crack Depth Estimation

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Abstract

Predicting the health of machinery is becoming of paramount importance as the complications and interconnectedness in systems is increasing. It becomes difficult to predict the exact working condition of the machinery due to the inherent complexity and the dynamical nature of the system under consideration. To overcome such difficulties, an approach which quantifies the phase space evolution of a dynamical system is considered in this work [1]. A phase space incorporates velocities along with the generalized coordinates of a system and can sufficiently describe a dynamical system. Thus, the topology of the phase space trajectories gives a pictorial representation of all possible states a dynamical system can visit. Surely a dynamical system will then show significant differences between healthy and faulty states based on the phase space. Previously a density based decomposition of phase portraits was developed for machinery diagnostics wherein the density based decomposition provided features for a machine learning classifier [2]. This approach relied on using hand crafted features for making a decision. To overcome the limitation of using hand selected features (which can miss relevant information) Convolutional Neural Nets (CNN) are used in this paper which can automatically extract features from the phase portraits of a dynamical system. In this work CNNs are used to estimate the crack depth of rotor shaft using phase space topology.

Fig. 1(a) depicts the input phase space topology used, from which density distributions are obtained as shown in Fig. 1(b). Subsequently the CNN learn the phase space topology as evident from the activation maps in Fig. 1(c). The red areas correspond to those regions of the phase portraits which are crucial for the CNN to make a decision. These regions correspond to the peaks of the density distribution of the phase portraits. The peak regions correspond to the locations where the probability of occurrence is highest. These peak points were previously shown to have excellent performance as features for diagnosing a fault in a dynamical system. Thus this work not only shows the usefulness of phase portraits in estimating the crack depth of a rotor shaft with appreciable accuracy but also the ability of CNNs to learn distinguishing features from phase portraits for fault severity estimation in rotating machinery.

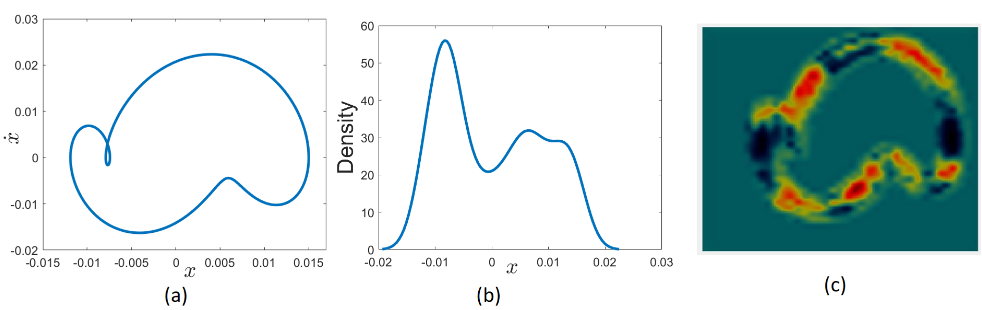

Figure 1: Phase portrait (a), probability density function of x coordinate (b) and (c) CNN activation map of a rotor shaft vibrations having crack depth to diameter ratio of 5.59%

References

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