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Convolutional neural networks to predict the onset of oscillatory instabilities in turbulent systems EUSTAQUIO AGUILAR RUIZ, VISHNU RAJASEKHARAN UNNI, University of California San Diego, R. I. SUJITH, Indian Institute of Technology Madras, ABHISHEK SAHA, University of California San Diego — Oscillatory instabilities marked by ruinous high amplitude oscillations are common in fluid dynamic systems. Examples include thermoacoustic, aeroacoustics, and aeroelastic instabilities. In a turbulent system, the transition regime from safe operation to oscillatory instabilities exhibits a dynamical state of intermittency where the system exhibits bursts of high amplitude periodic oscillations amidst low amplitude aperiodic fluctuations. In this study we identify the extent of periodicity during intermittency by classifying the corresponding recurrence plots utilizing a Convolutional Neural Network (CNN), and thereby predict the onset of oscillatory instability. The CNN we use consists of two convolutional layers each followed by a rectified linear unit (activation function) and a max pooling layer. All of which is followed by a fully-connected layer which classifies the dynamics of the input recurrence plot as aperiodic fluctuations or periodic oscillations. The trained CNN is used to analyze time series of a state variable to which it assigns a probability of periodicity which in turn indicates the proximity of the system to oscillatory instability. We validate this methodology by predicting the onset of instabilities in thermoacoustic, aeroacoustic, and aeroelastic systems.

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