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CONVOLUTIONAL NEURAL NETWORK BASED COMBUSTION MODE CLASSIFICATION FOR CONDITION MONITORING IN A SUPERSONIC COMBUSTOR

Abstract

Supersonic combustor is one of the core components in a scramjet, so it is of great significance to monitor the combustion modes in a combustor to ensure the safe and stable operation of a scramjet engine. Traditionally, several key parameters or manually-engineered features are selected as the indicators to evaluate the operation conditions, which usually heavily depends on the professional experience and carries significant limitations. Convolutional neural networks (CNNs) have been proved to be effective in feature extraction without domain expertise and prior knowledge and have shown better generalization performance because of its translation invariance characteristics. It is attractive and promising to apply CNNs to condition monitoring in mechanical systems due to their pattern recognition abilities. To accomplish the detection of combustion modes, a CNN-based method is proposed, which can learn features directly from the raw pressure data collected during supersonic combustion experiments. In this method, feature extraction is achieved by alternating and stacking convolutional layers and pooling operations. Next, fully-connected layers and a softmax function are used to complete the classification. The traditional machine learning methods, such as multilayer perceptron (MLP), support vector machine (SVM) and k-nearest neighbor (kNN), are used to compare with the CNN-based method. The results show that the proposed CNN-based method is able to reveal intrinsic characteristics from raw data and effectively complete the classification of four main combustion modes occurring in the combustor. In addition, the novel approach achieves a higher classification accuracy and better generalization performance than other comparative methods.