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Predicting Thermoacoustic Instabilities in Gas Turbine Engines Using Machine Learning

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Thermoacoustic instability in gas turbine engines is a major challenge to operational safety and efficiency. Precise detection of instabilities at the initial stages will help avoid possible damage and ensure that the engine operates reliably. A previous study focused on using pressure signals to detect early warning signs of thermoacoustic instabilities through Critical Slowing Down (CSD) metrics. To build on this foundation, the current study introduces a trained Machine Learning (ML) algorithm to predict thermoacoustic instability from data obtained by multiple sensors at different engine locations. Each sensor provides several parameters, such as pressure, frequency, and phase values. As the number of data points varies from feature to feature, imputation techniques are employed to handle missing values and create a homogeneous dataset. Data points are marked as “approaching instability” or “stable” based on their proximity to known times of instability to provide early warning indicators. A tree-based classifier is trained to predict whether oscillations are expected. The results confirm that the new approach can predict impending thermoacoustic instabilities with prominent early warning signs. Employing imputation strategies ensures that the algorithm is trained on the entire dataset, thereby enhancing accuracy and validity. The findings demonstrate that ML algorithms can identify instability precursors several seconds before oscillations develop, making them a valuable tool for real-time detection and integration into gas turbine engine control systems.