Title

Neural network based tomographic reconstruction of high-speed interferometric and Schlieren image data for density and velocity detection

Author(s) information

Johannes Gürtler[1], Sami Tasmany[2], Robert Kuschmierz[1], Jakob Woisetschläger[2], Jürgen Czarske[1]

[1]TU Dresden, Laboratory for Measurement and Sensor System Techniques, Helmholtzstraße 18, 01062 Dresden

[2]TU Graz, Institute of Thermal Turbomachinery and Machine Dynamics, Inffeldgasse 25A, 8010 Graz

250-word abstract for technical review

To ensure stable low-emission combustion of green hydrogen is an important current step towards climate neutral ground-based power generation in the field of turbomachinery. Such lean combustion modes burn more unsteadily, resulting in increased noise and instability due to thermoacoustic oscillations. Therefore, the multimodal detection of several physical quantities is needed in order to understand the coupled behavior of combustion, advection velocity and noise production as well as noise dampening, i.e. of significant importance in order to guarantee a stable combustion and improve environmental protection.

We present such simultaneous detection based on the measurement of density oscillations in swirl-stabilized flames, where density is coupled to physical quantities such as heat release rate or sound pressure and advection velocity. The presented measurement approach is a high-speed camera based interferometer in combination with a multi-camera background oriented Schlieren system, both enabling line of sight detection and therefore require solution of the inverse problem by tomographic reconstruction. We further demonstrate a neural network based approach for those reconstructions, resulting in the three-dimensional distribution of the local thermoacoustic oscillations up to 30 kHz. Finally, the advection velocity of those oscillating vortex structures is calculated by image correlation techniques.

The high data rates and computational effort of this new measurement approach are enabled by recent technological developments and accessibility of camera technology using high-speed interfaces and computer science. The demonstrated systems will support the understanding of acoustics and flame dynamics for all types of hydrocarbon and sustainable fuels.

100-word summary for the program

Multimodal sensing is presented based on the measurement of density oscillations in swirl-stabilized flames, where density is coupled to physical quantities like heat release rate or sound pressure and advection velocity. The measurement approach is a high-speed camera based interferometer combined with a multi-camera background oriented Schlieren system, both enabling line of sight detection and therefore require solution of the inverse problem by tomographic reconstruction. Those reconstructions are realized using a neural network, resulting in the three-dimensional distribution of local thermoacoustic oscillations up to 30 kHz. Finally, the advection velocity of those oscillating vortex structures is calculated by image correlation.

Keywords used in search for your paper (optional)

neural networks; high-speed camera; interferometry; inverse problems