Institut für Technische Verbrennung

RWTH AACHEN UNIVERSITY

Master thesis

Turbulent Combustion Modeling through Convolutional Neural Networks

The topic is suitable for

✓ Master thesis

Field of activity

Machine Learning
Hydrogen combustion
Flame instabilities

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Last updated on

21.11.2023

To facilitate the shift from fossil fuels to green renewable options like hydrogen, the use of accurate combustion modeling is essential. Lean hydrogen flames are prone to thermodiffusive instabilities, which have a strong effect on the structure and dynamics of the flame and can potentially accelerate flame speed significantly. Although direct numerical simulation (DNS) can provide accurate predictions, its computational demands limit its applicability to simple configurations, requiring the adoption of reduced-order modeling strategies for more complex computations, such as large eddy simulations (LES). However, available conventional LES combustion models perform poorly for unstable hydrogen flames, prompting the need for the development of innovative approaches. Recent advances in machine learning, especially in Convolutional Neural Networks (CNNs), have shown significant potential for combustion modeling, yet their application in this domain remains largely unexplored.

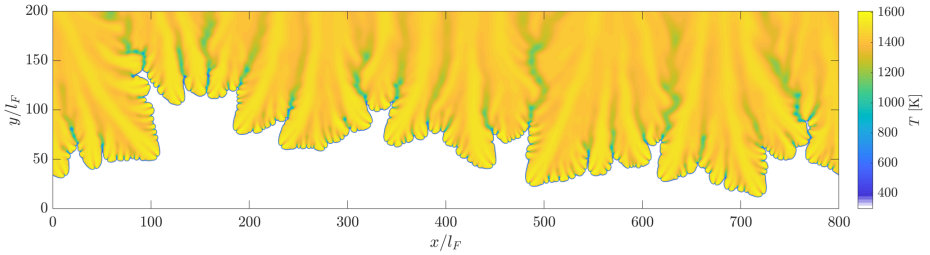

Figure 1. Large-scale two-dimensional numerical simulation of a thermodiffusively unstable, lean, premixed hydrogen flame (*Berger et al.*, Proc. Combust. Inst. 37, pp. 1879-1886, 2019).

The study aims to investigate the potential of using CNNs to model the unclosed reaction rate term in LES of laminar hydrogen premixed flames, performing a priori analyses using DNS data for training. The developed model will then be integrated into our in-house numerical solver and evaluated a posteriori.

Your tasks

- ◊ conduct a priori validation of the proposed methodology.
- ◊ integrate the CNN model into our in-house numerical solver.
- ◊ validate its performance through a posteriori testing.

About you

This thesis could be a perfect fit if you:

- ◊ have a keen interest in programming and numerical methods for CFD.
- ◊ are familiar with HPC environments and machine learning applications.
- ◊ are self-motivated and eager to enhance your knowledge and skills

If you are interested, this thesis can be combined with a HiWi position. Contact us for more details.

This thesis does not quite fit your ideas? Feel free to contact me to customize this topic or to find an alternative thesis.