Detection and identification of instability and blow-off/ precursors in flames using Deep Learning techniques

PhD position
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In the framework of the SCIROCCO (Simulation and Control of Renewable Combustion) program founded by an ERC advanced grant starting in October 2019, we are looking for PhD candidates.

Context :

Most renewable energies can only be delivered intermittently. Without **massive long-term storage capacities** they will never provide 65 % of our energy mix by 2050, as required to limit global warming to 2°. Throughout this period and beyond, energy generation from combustion will remain a key component of this mix. SCIROCCO has two goals: (1) provide **effective storage** for renewable energies and (2) significantly **improve existing combustion** systems. Objective (1) is addressed by **extending 'Power to Gas (PtG)' strategies,** where excess electricity from renewable sources is converted into fuel, usually hydrogen (H_2), which is easy to store over long periods and burn when power is needed. Objective (2) is addressed by **burning** the 'renewable' **H_2 in smart combustors** with higher efficiencies and reduced emissions. Today, H_2 is diluted in methane lines ('drop-in' strategy) to burn in existing devices. This strategy ignores the exceptional properties of H_2, which burns and ignites faster than all other fuels. We will exploit these properties in new chambers that (1) burn H_2 within a wide range of fossil fuel mixes and (2) use H_2 as a powerful actuator to increase performance. Rather than diluting H_2 in other fuels, we will inject H_2 into the chamber separately. Research is needed to analyse the structure of these new dual-fuel flames that burn a fossil fuel and H_2 simultaneously. This is a challenge for combustion science, requiring a re-think of chamber design and control. These fundamental issues will be addressed for two **applications with fundamental societal impact**: (1) laminar gas-burning flames (stoves, heaters) and (2) swirled liquid fuel turbulent flames (aerospace and power gas turbines). All cases will be studied experimentally (at IMFT) and numerically (with CERFACS simulation codes). SCIROCCO will develop **fundamental knowledge** on **multi-fuel flames** and have a direct societal impact as SCIROCCO burners will pave the way for smart combustors burning renewable H_2

Objectives and program:

This project is funded by the European Research Council advanced grant SCIROCCO which will start at the end of 2019 (see a description of SCIROCCO in the Additional Info section). It will take place in Toulouse in two laboratories: Institut de Mécanique des Fluides de Toulouse and CERFACS. Its objective is to develop Deep Learning (DL) techniques for combustors: using unsteady signals produced by combustion, the task of the DL system will be to recognize how close the combustor is to a critical state where the flame could start to vibrate or to completely disappear through a process called blow-off. Another mechanism will also be studied where the flame flashes back into the injection system, leading to dangerous situations. In SCIROCCO where hydrogen combustion is considered, such events are expected and developing control systems to mitigate them is essential. To teach the DL system, experiments performed at IMFT in Toulouse will be used for a swirling flame where the combustor geometry can be modified rapidly using 3D printing. Multiple swirlers will be

3D printed and tested: it is expected that 30 to 50 different configurations will be tested in the learning phase of the DL system. Geometry modifications mimicking aging effects or fabrication defaults will be introduced so that the DL system can learn their signatures on the overall noise and radical emission produced by the flame. The project has a large experimental part at IMFT but will also require formation on Deep Learning techniques which will be provided by CERFACS experts. Simulations of the combustor (mainly Large Eddy Simulation) using the world leading CERFACS tools (intecocis.inp-toulouse.fr) will also be used in conjunction with the DL system to analyze its performances.

Team :

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