Chair of Space Propulsion and Mobility
Prof. Manfletti
TUM School of Engineering and Design
Technische Universität München

Master's Thesis

Topic: Structural Optimization of Film Cooling in Hydrogen Combustion Chamber Based on Machine Learning Method

Background

In recent years, with the advancements in Computational Fluid Dynamics (CFD) techniques and the availability of high-performance computing resources, numerical investigations pertaining to film cooling within hydrogen combustion chambers have gained prominence. These investigations have yielded noteworthy insights, demonstrating that CFD simulations possess the capability to accurately capture the intricacies of the film cooling flow field. However, it is worth noting that the conventional discrete methods traditionally employed in numerical simulations incur substantial computational expenses. The comprehensive process of simulating film cooling in rocket engines, particularly when meticulous details are considered, often necessitates a considerable amount of time, particularly during the mesh generation and iterative solving phases.

In light of the recent advancements in machine learning, these methodologies have found relevance in addressing complex physical phenomena, including intricate fluid flow problems. Building upon our prior experience with simulations and experimental studies, we propose the establishment of a predictive model based on the U-net architecture, leveraging Convolutional Neural Networks (CNNs). This model is designed to directly forecast the mixing characteristics between the coolant film and combusted gas within the combustion chamber.

Subsequently, within the framework of deep reinforcement learning (DRL), we intend to train various algorithms, including Proximal Policy Optimization (PPO) and Soft Actor-Critic (SAC), to govern the flow parameters. These parameters encompass aspects such as mass flow rate and temperature of the film cooling process under varying main flow conditions or the geometries of the cooling injectors. The overarching goal is to obtain an optimized configuration that effectively reduce the combustion chamber wall temperature and wall skin fraction coefficient, thus enhancing the overall efficiency and safety of rocket propulsion systems.

Your Tasks

- Numerical simulation of two dimensional Hydrogen combustion chamber with film cooling
- Training prediction model with numerical simulation data
- Combine prediction model with DRL platform, training the policy network for optimization

Kick-off: 01.08.2024 Supervisors: Mai Ye Contact: mai.ye@tum.de

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Your Profile

- Familiar with Python, CNN, and DRL is necessary
- Previous experience in Ansys ICEM, Fluent or deep neural network training is pretty useful
- Mechanical Engineering, Aerospace Engineering or Computer Science

We offer

- An amazing team that you can work with
- A large network of people
- Challenging exchanges with peers
- The possibility of getting involved into something big

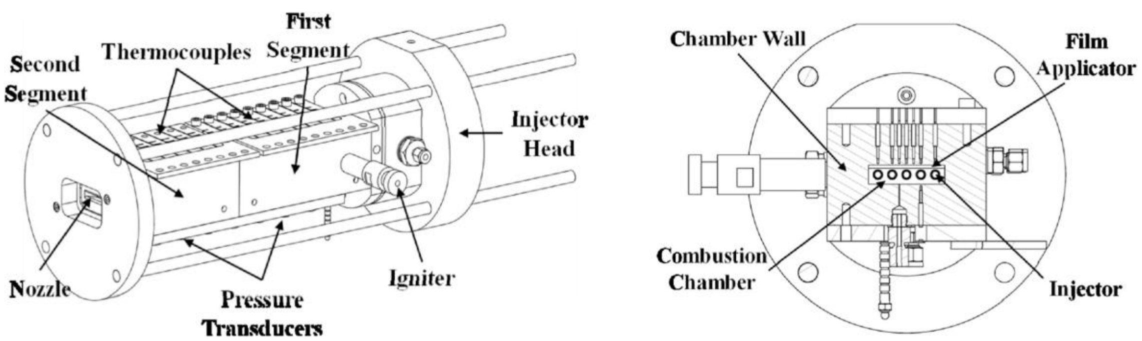

Fig. 1. Combustion chamber of the reference experiment.

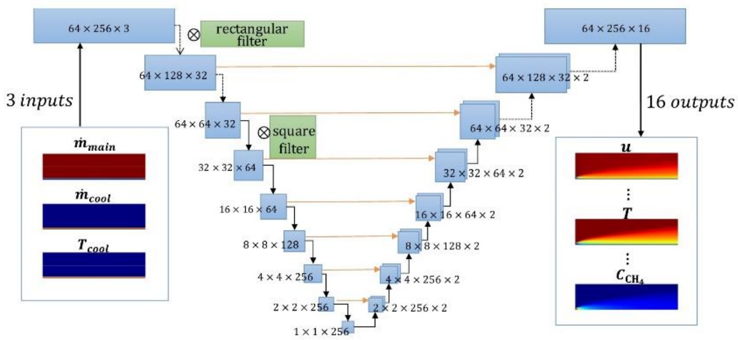

Fig. 2. Schematic of U-net architecture.

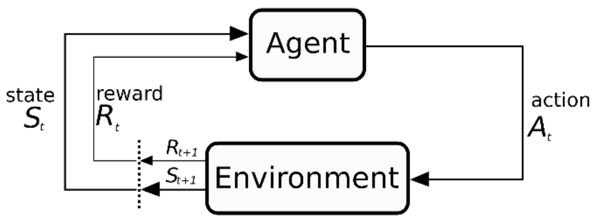

Fig. 3. Diagram of the loop recurring in reinforcement learning algorithm.

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