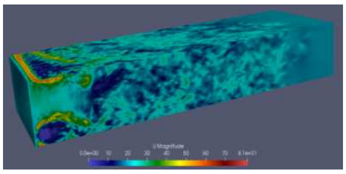
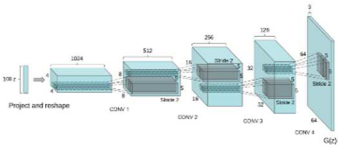
Sujet de stage

Deep Learning for improving fluids mechanics simulations



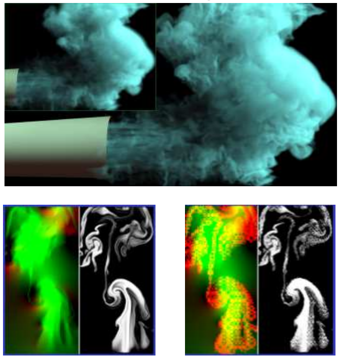
Example of a turbulent fluid flow in 3D



Architecture of a neural network

*Safran is an international high-technology group, operating in the aircraft propulsion and equipment, space and defense markets****.*** *In modern complex industrial contexts, the numerical simulation is an important tool involved at all the levels of a product conception. Unsteady simulations for fluid mechanics are increasingly costly. Due to the statistical nature of unsteady and turbulent fluid flows, data driven algorithms could potentially reduce the computational burden through reduced trained models.*

Recent developments in deep neural network approaches in machine learning have drastically changed the landscape of several research fields such as image classification, object detection, self-driving cars and many more. In fluid mechanics for computer graphics, the abundant amount of high quality simulation has been leveraged for training deep neural networks to approximate the behavior of a complex solver [1], to compress and decompress fluid simulations [2] or to synthesize high-resolution fluid flows starting from low-resolution velocities or vorticities [3]. Other applications, such as aerodynamic shape optimization [4] are starting to be addressed by means of deep neural networks as well. Among the novel paradigms emerging from the deep learning community, Generative Adversarial Networks (GAN) [5] are particularly relevant for our task. GANs aim to capture the data distribution such that they can then easily generate new realistic samples similar to the real ones. In spite of the impressive progress in the field, learning to approximate accurately the behavior of a complex physical model using data-driven methods is still a highly difficult task.



Example of application of a GAN

The objective of this internship is to study and design a deep neural network based on GANs for the super-resolution of fluid simulations. More precisely, the internship will be carried in the following main stages:

- *In a first stage, you will study and implement the recently proposed tempoGAN architecture [3] for augmenting low-resolution flows into high-resolution ones. The method will be subsequently improved for specific constraints and available data for industrial fluid simulations.*
- *In a second stage, you will explore the feasibility of learning to forecast the flow of a fluid from the low-resolution field. A low-resolution prediction will be made by a physical solver for a new geometry, and the ability of the neural network to correctly increase its resolution will be compared to the reference high-fidelity physical prediction.*

A relevant dataset is available for experiments during this internship.

Keywords: *Turbulence; statistics; simulation for fluid mechanics; machine learning; deep learning;*

Candidate profile

- Specialization: applied mathematics, statistics, machine learning
- Programming language: python

References:

1. *J. Thompson et al., Accelerating Eulerian Fluid Simulation With Convolutional Networks, arXiv 2016.*
2. *B. Kim et al., Deep Fluids: A Generative Network for Parameterized Fluid Simulations, SIGGRAPH Asia 2018.*
3. *Y. Xie et al., tempoGAN: A Temporally Coherent, Volumetric GAN for Super-resolution Fluid Flow, SIGGRAPH 2018.*
4. *P. Baqué et al., Geodesic Convolutional Shape Optimization, ICML 2018.*
5. *I. Goodfellow et al., Generative Adversaripal Networks, NIPS 2014.*

INFORMATION

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Duration : 4-6 months

Location : Safran Tech

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