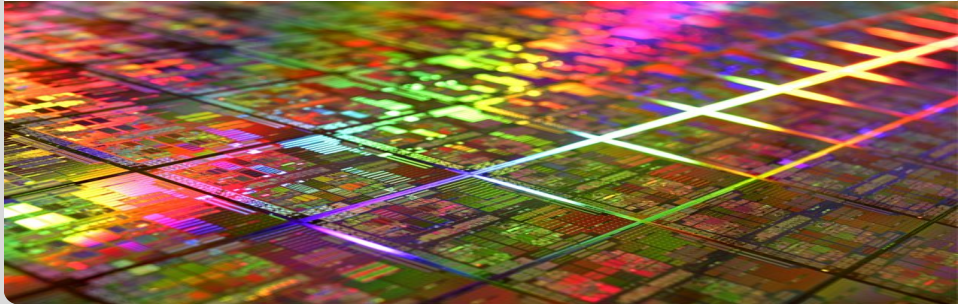


Towards Bringing Together Numerical Methods for Partial Differential Equation and Deep Neural Networks

Progress Update, Supervisor - Markus Hoffmann

Stanislav Arnaudov | September 26, 2019

CHAIR FOR COMPUTER ARCHITECTURE AND PARALLEL PROCESSING



Basic idea: Perform numerical simulation with ML-models

Basic idea: Perform numerical simulation with ML-models

- Concrete problem: Flow around an object according to the Navier–Stokes equations.

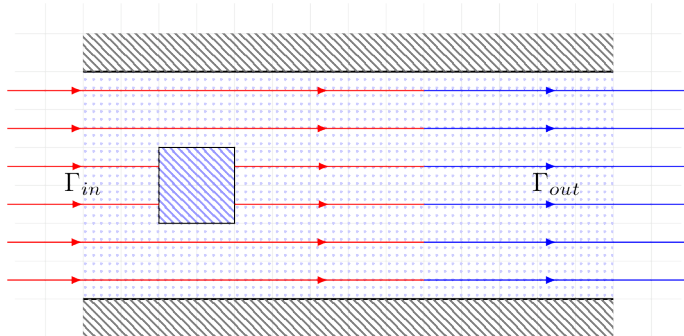


Figure: Simulation Setup

Basic idea: Perform numerical simulation with ML-models

- Solutions of the simulation can be represented as images.

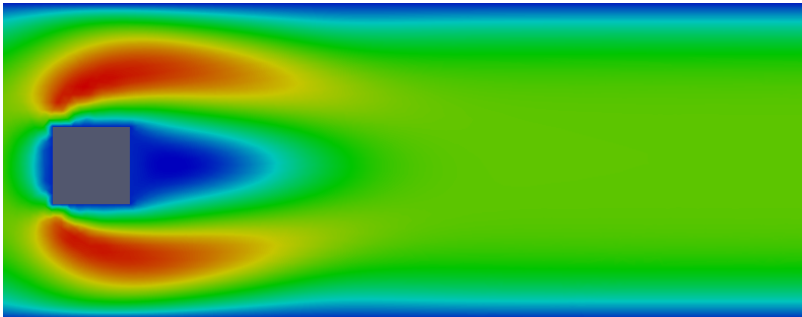
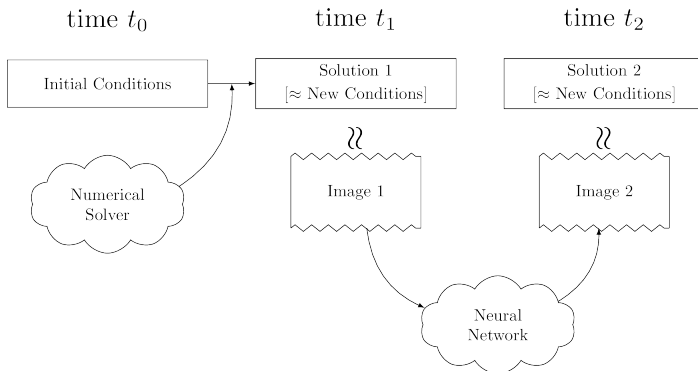


Figure: Simulation Image

Basic idea: Perform numerical simulation with ML-models

- Or ML-model primarily use images as input and output.



Project description

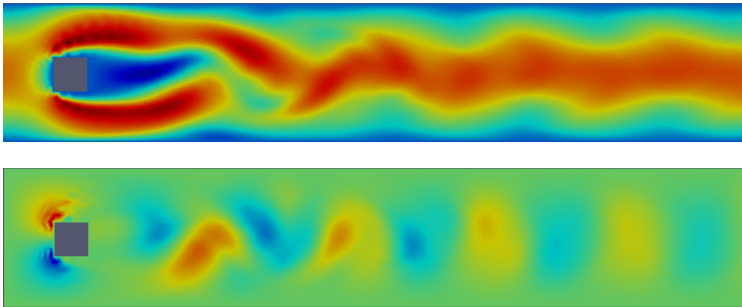
Several cases to investigate

- Constant model
- Fluid speed model
- Fluid viscosity and density model
- Object in space model

- Use of numerical solver for real simulation data generation.
- The simulation has several adjustable parameters
 - inflow speed
 - fluid viscosity
 - fluid density
- Reynolds Number in the range of [90, 350]

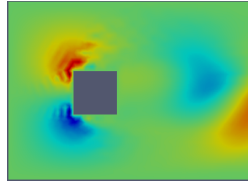
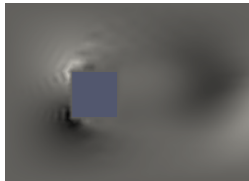
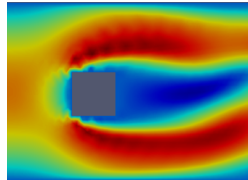
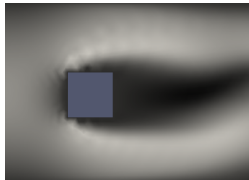
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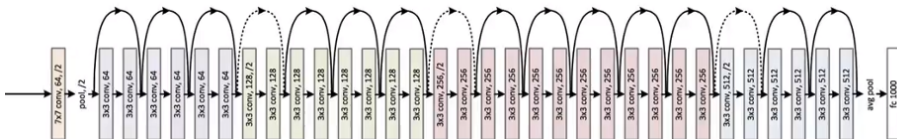
Karman vortex street

- Use of numerical solver for real simulation data generation.
- The simulation has several adjustable parameters
- Reynolds Number in the range of [90, 350]
- Choosing appropriate color space : Grayscale or RGB

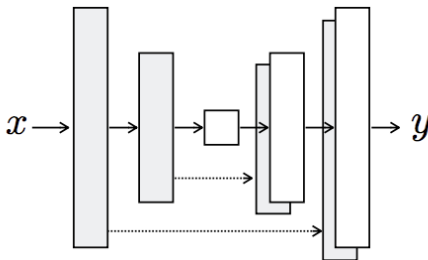


- Two types of architectures based on our preliminary research:

- Two types of architectures based on our preliminary research:
 - ResNet



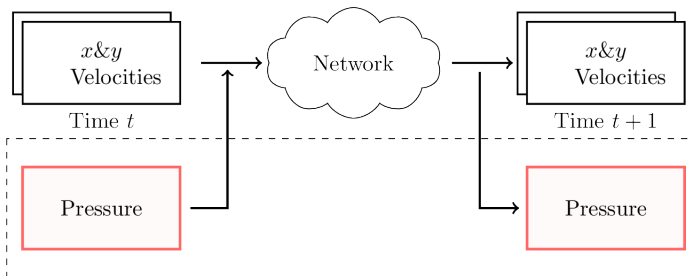
- Two types of architectures based on our preliminary research:
 - UNet



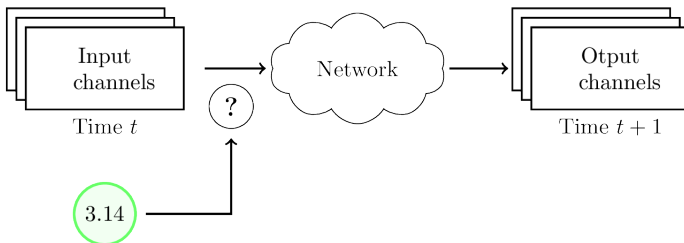
- Two types of architectures based on our preliminary research:
 - UNet turned out to perform better.

- Two types of architectures based on our preliminary research:
- Data being used by the network.

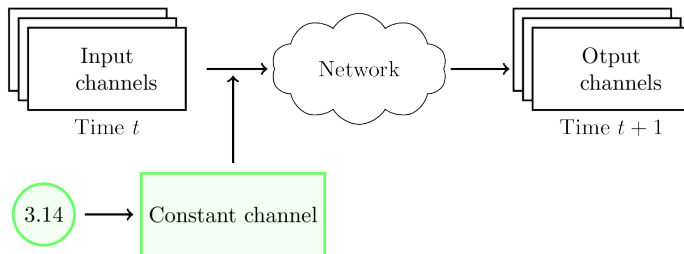
- Two types of architectures based on our preliminary research:
- Data being used by the network.
 - Usage of pressure field



- Two types of architectures based on our preliminary research:
- Data being used by the network.
 - Processing of real values



- Two types of architectures based on our preliminary research:
- Data being used by the network.
 - Usage of pressure field → the pressure field turned out to be useful
 - Processing of real values → extra image channel filled with the value



Evaluation cases

Evaluating the results

Thank you for your attention.

Questions?