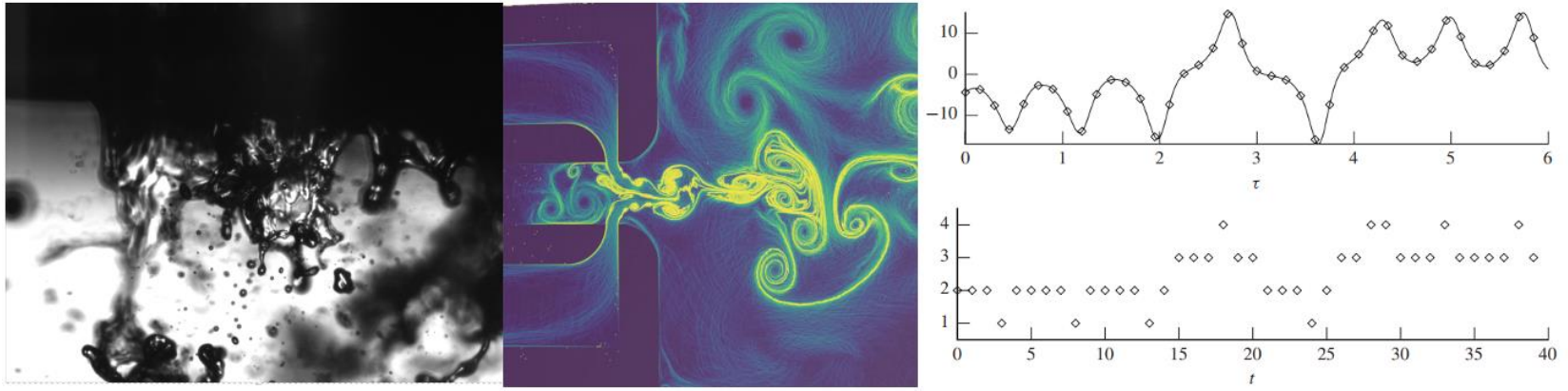
Data Driven Engineering II: Advaced Topics

Introduction to DDE II

Institute of Thermal Turbomachinery
Prof. Dr.-Ing. Hans-Jörg Bauer



Today's Agenda:

1) Announcements

2) Content of the lecture & our aim

3) Candidate Projects & work flow

Workshop on computer-based flow measurement technique

Infrared Thermografy

Electronic Data Acquisition

Communication via TCP/IP

Automated Measurement Routines in LabVIEW

Sensor Calibration

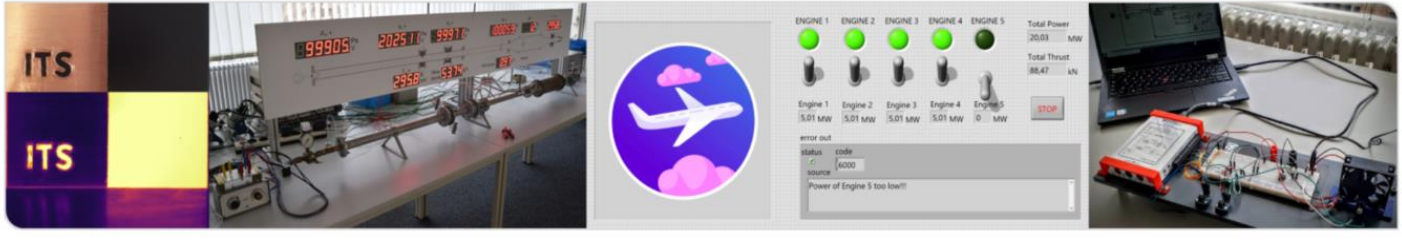
Heat and Mass Flow Measurement

12.10. - 20.10.23

8:00 a.m. - 5:00 p.m.

Limited no. of participants,
Registeration online now! →

Questions? - marco.hahn@kit.edu



Field Trip 2023

Thermal Turbomachinery
Hydraulic Turbomachinery

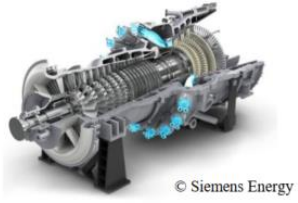
Date:	**May 30th – June 2nd 2023**
Departure:	Tuesday, May 30th 2023, 07:00 a.m., In front of AKK (old Stadium)
Fee:	80 €, pay by girocard, (Bldg. 10.91, Room-No. 115)
Accommodations:	Düsseldorf, Hannover
Registration:	via e-mail to sven.hoffmann@kit.edu Registration deadline: May 16th 2023
Organization:	Sven Hoffmann (Bldg. 30.60, Room-No. 228) Matthias Haber (Bldg. 30.60, Room-No. 228)
Preparatory Meeting:	**Wednesday, May 17th 2023, 12:30 p.m.** Seminar room I, Bldg. 30.60, 2nd floor

MAN Energy Solutions

in Oberhausen
Production site for compressors and turbo chargers
www.man-es.com

SIEMENS energy

in Mülheim/Ruhr
Production site for gas turbines, steam turbines and generators
www.siemens-energy.com



Stadtwerke Düsseldorf

in Düsseldorf
CC power plant
www.swd-ag.de

KSB

in Frankenthal (Pfalz)
Production site for hydraulic pumps and industrial valves
www.ksb.de

MTU Maintenance

in Hannover
Maintenance of civil and military aircraft jet engines
www.mtu.de

What is this lecture about ?

Data Driven Engineering : Advanced topics

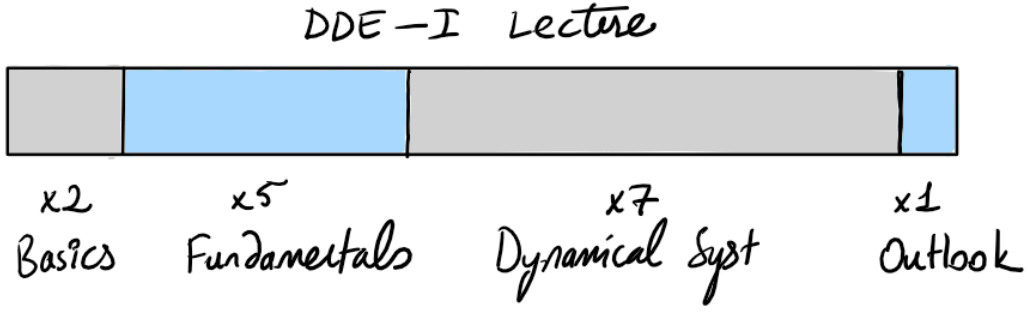
1. Data
   - Lecture
   - Project
2. Method
   - Lecture
   - Project
3. Artefact
   - Lecture
   - Project

i) Beginner
ii) Intermediate
iii) Advanced

DDE 1
DDE 2

What is this lecture about ?

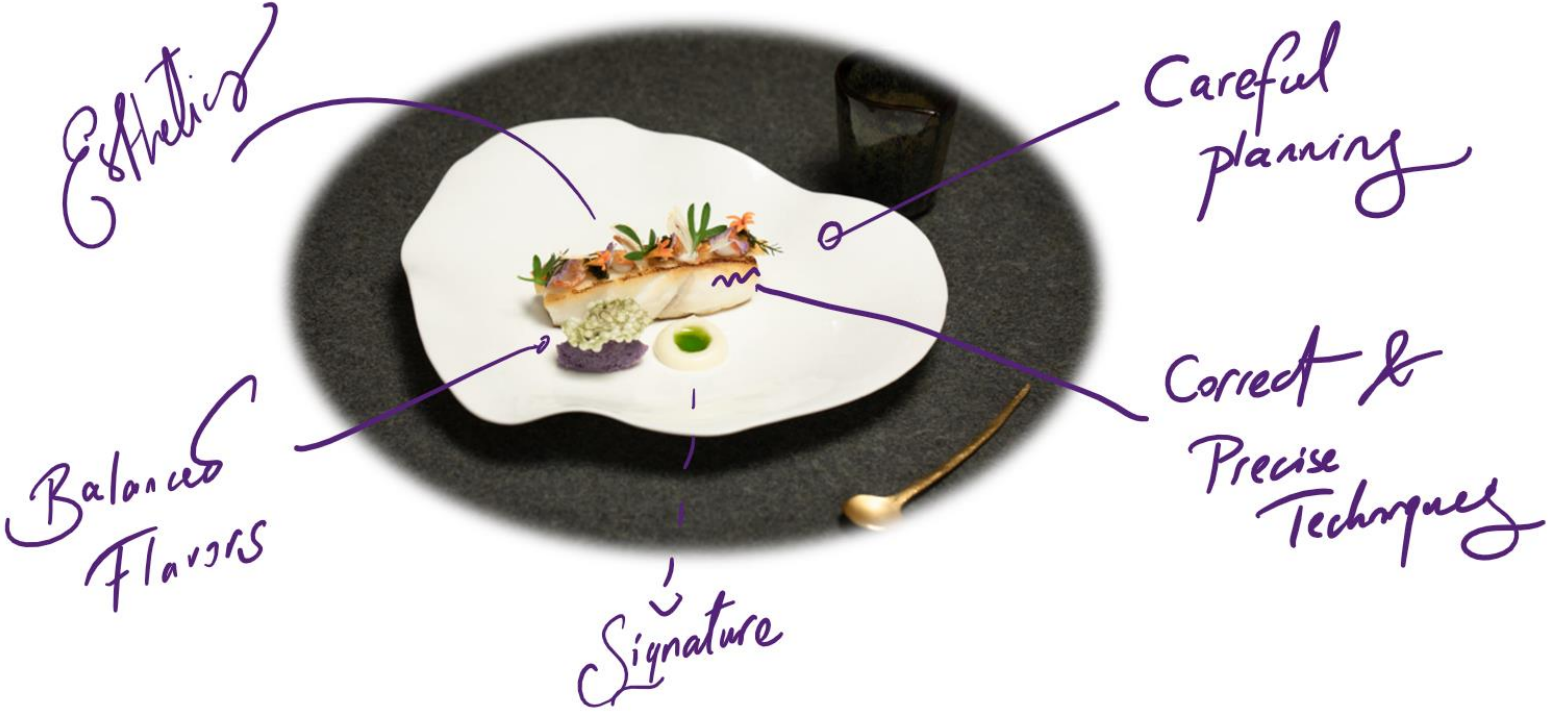
DDE-I



- 6 ML Classes
- 35 model architectures + 11 aux. models
- 10 x 45' Coding Sessions

The Style

DDE II Advanced Topics



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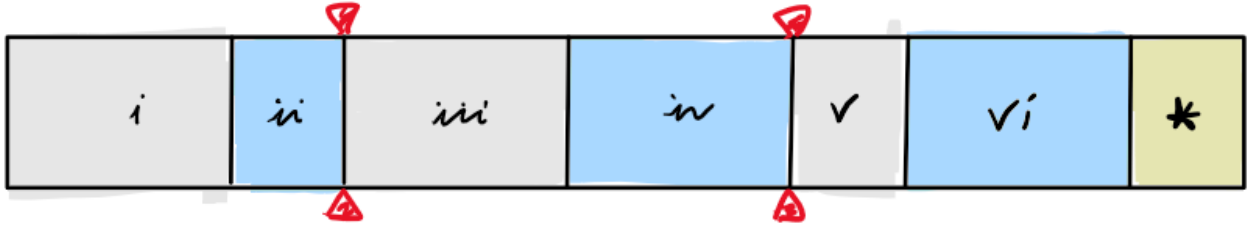
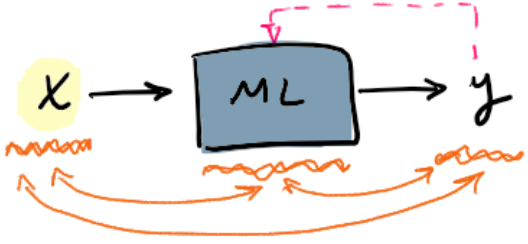


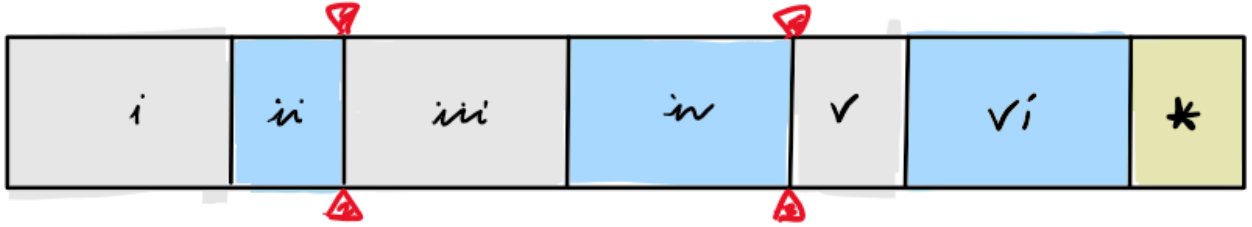
10 lectures.
3 Project sessions

1. Feature engineering



2. Fine tuning ML models

What is this lecture about ?



10 lectures.
3 Project sessions

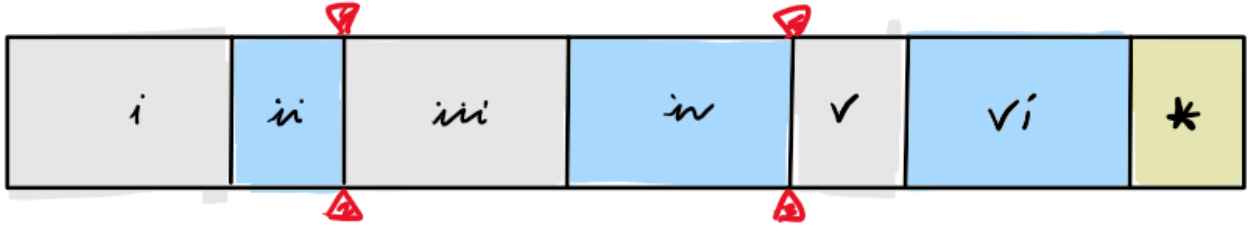
3. Conv. Neural Networks
   - image-like data
   - feature extractor
   - object detection

Structured data
Time spend: 2 weeks

4. Evolutionary Algorithms
   - Feature Selection
   - Optimizer
   - Model Approximator
   - Control tool

Evolutionary learning
Time spend: 3 weeks

What is this lecture about ?



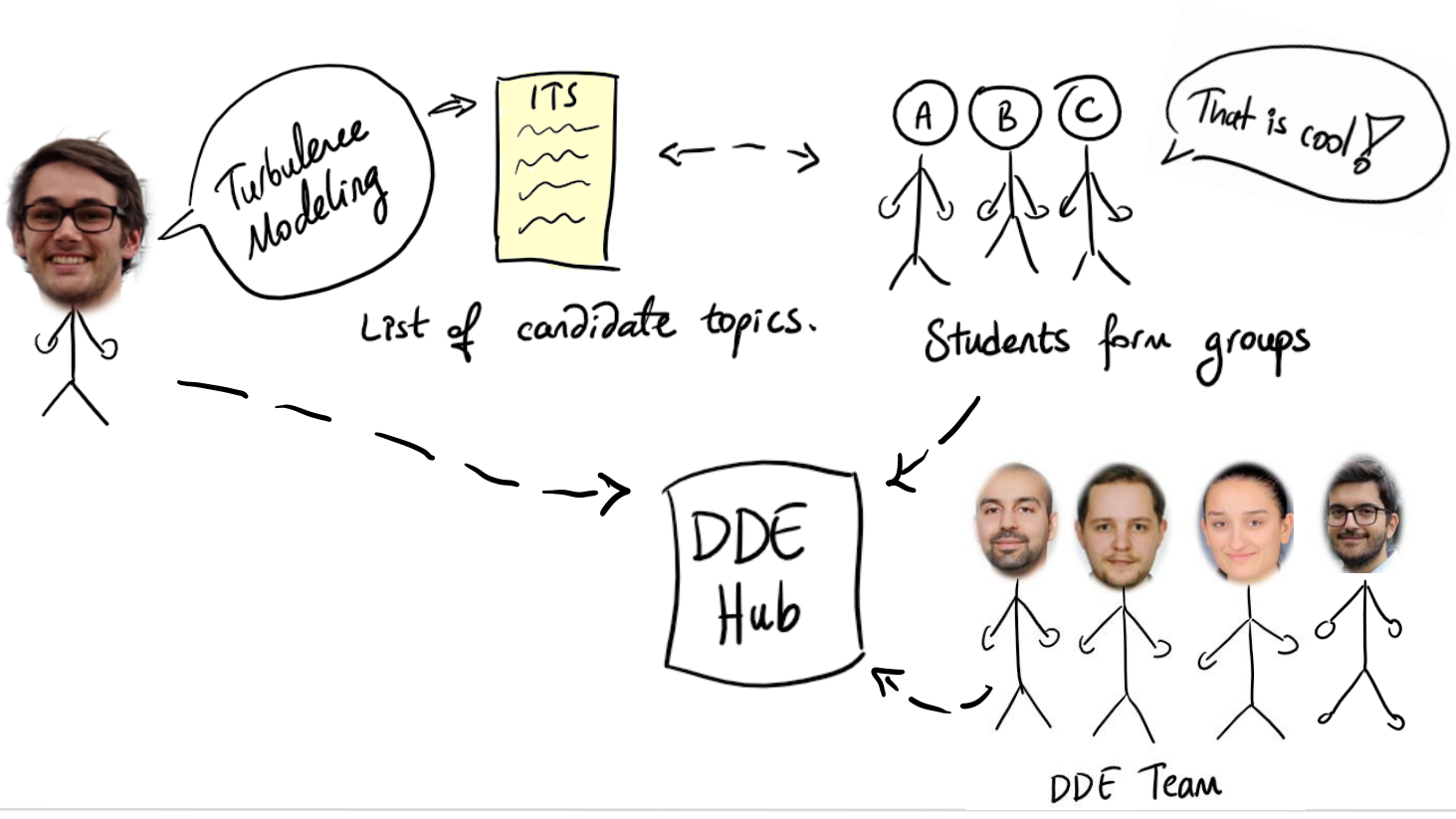
10 lectures.
3 Project sessions

5. Graph Neural Networks
- → Unstructured data space
  - → graph level tasks
  - → node level tasks

Unstructured data
How to treat the data as a graph
Model molecular structures.
We can use it as a CFD simulator.

Projects

* Working Frame:



Colab ⇒ High Performance Computing



* Start with Colab
* Running notebooks on BW Unicluster 2.0
* Running python codes on HPC

Needed for projects ⇒ Register on ilias
~05/05

Projects

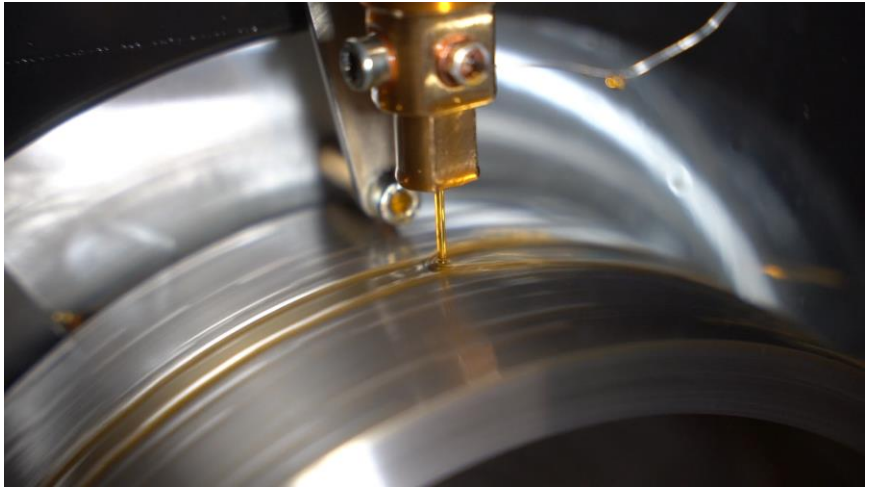
Translating Sensory Data: Gearbox Cooling in Aeroengines

- Geared turbofan with optimized component speeds
- High power transmission over the planetary gearbox
- Need for an adequate cooling solution

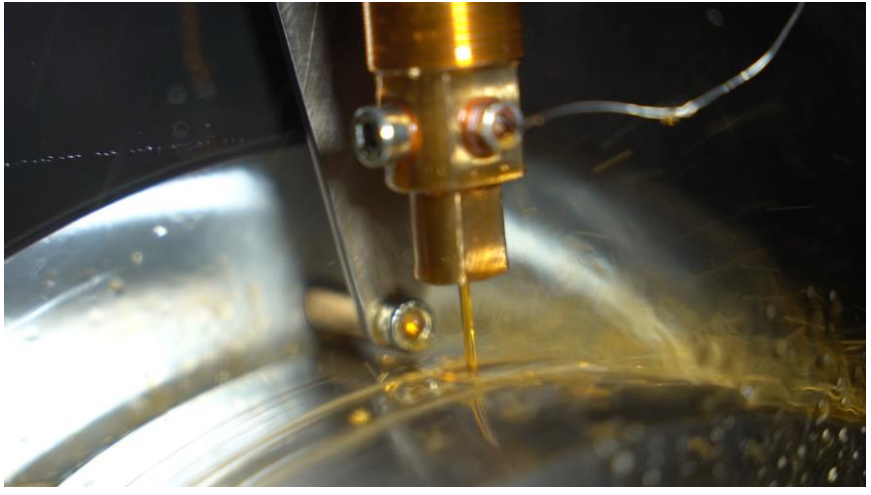
→ Experimental investigation to characterize cooling via oil jet impingement

© Rolls-Royce

Extracting flow regimes from oil jet impingement tests

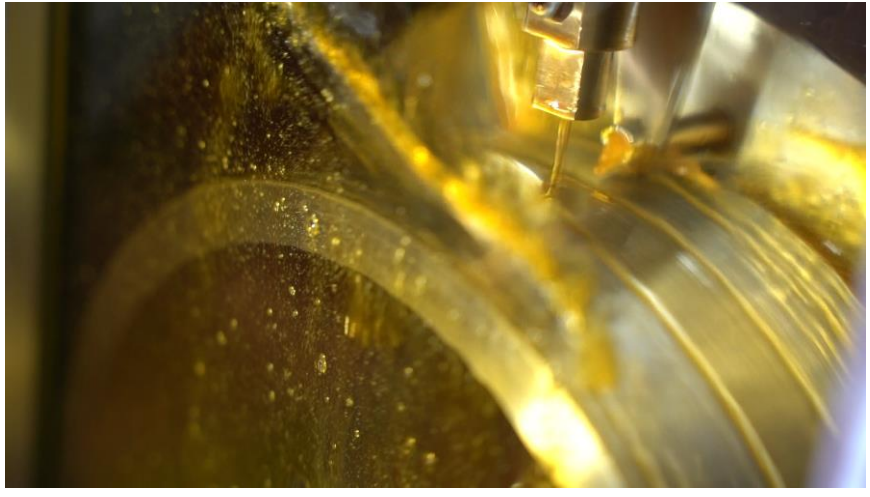


Attached oil film

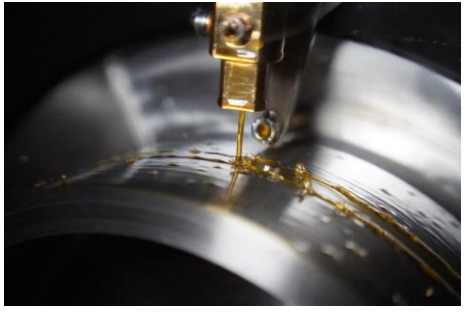


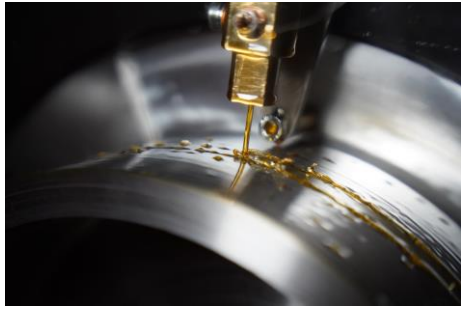
Rim instability

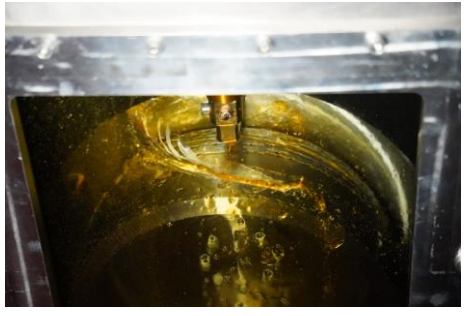
Extracting flow regimes from oil jet impingement tests



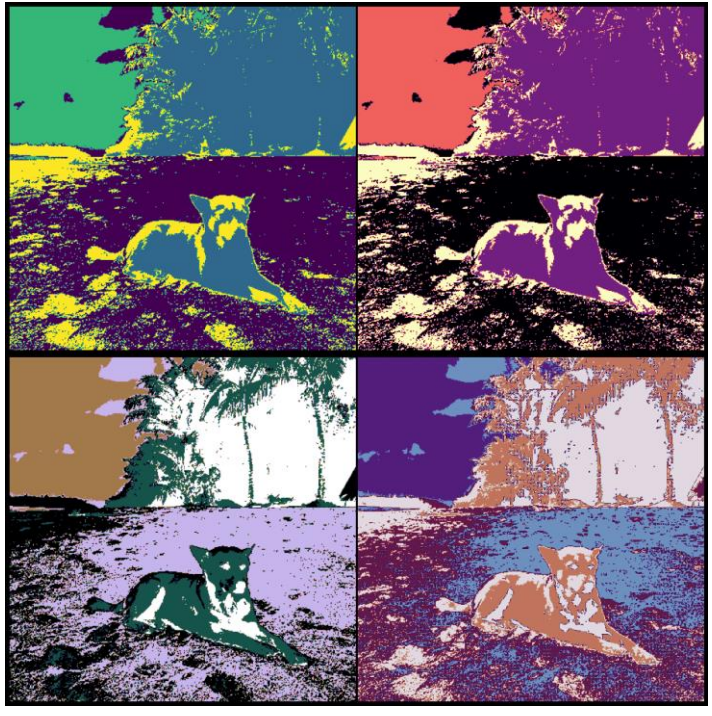
Detached lamella

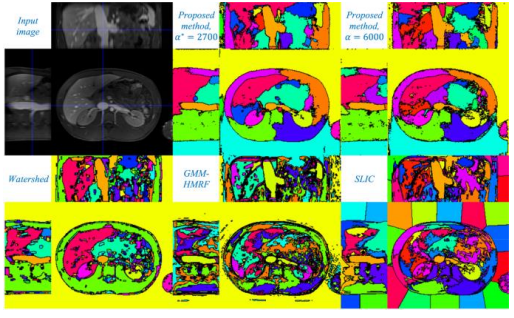


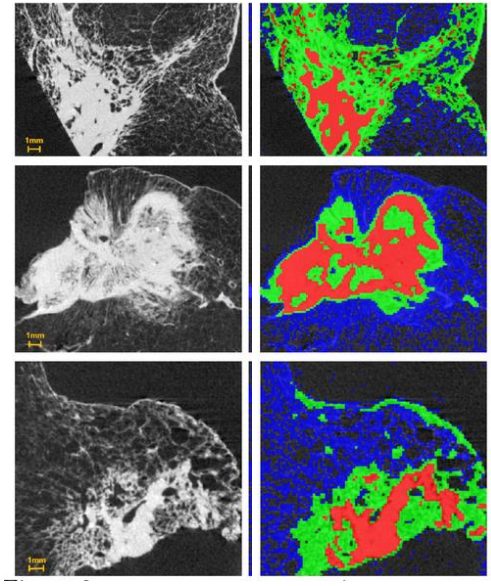




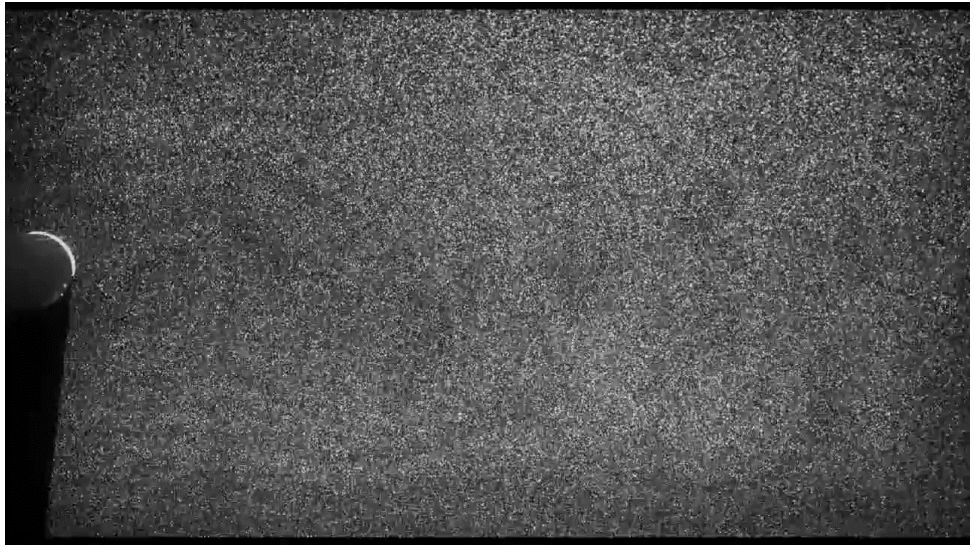
Extracting flow regimes from oil jet impingement tests







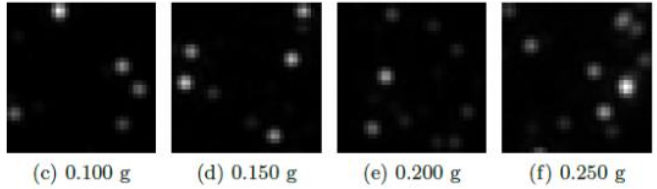
Uncertainity analysis in PIV Measurements : img2img translation



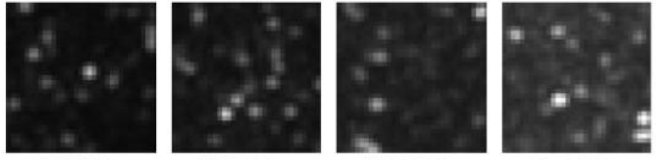
* flow is seeded with particles
* particles are illuminated
* Movement of particles
  ↳ velocity field

Uncertainty analysis in PIV measurements : img2img translation

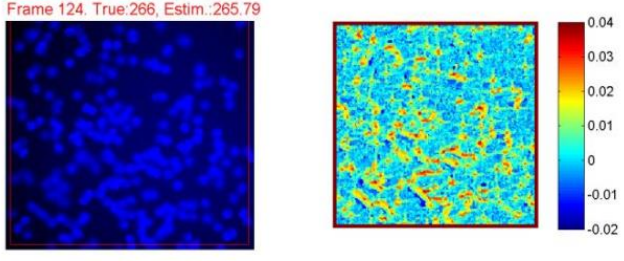
- ☐ Tested direct img ⇒ img regression ~
  - ☑ Extended labelled dataset
- ☐ img2img translation in latent space?
  - (?) cAEs + MLPs
  - (?) Alternative img2img translators



(c) 0.100 g (d) 0.150 g (e) 0.200 g (f) 0.250 g

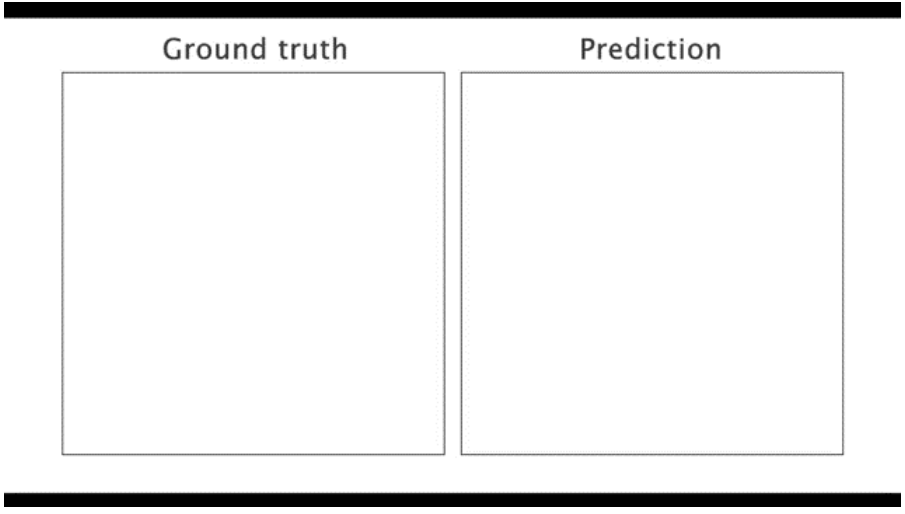


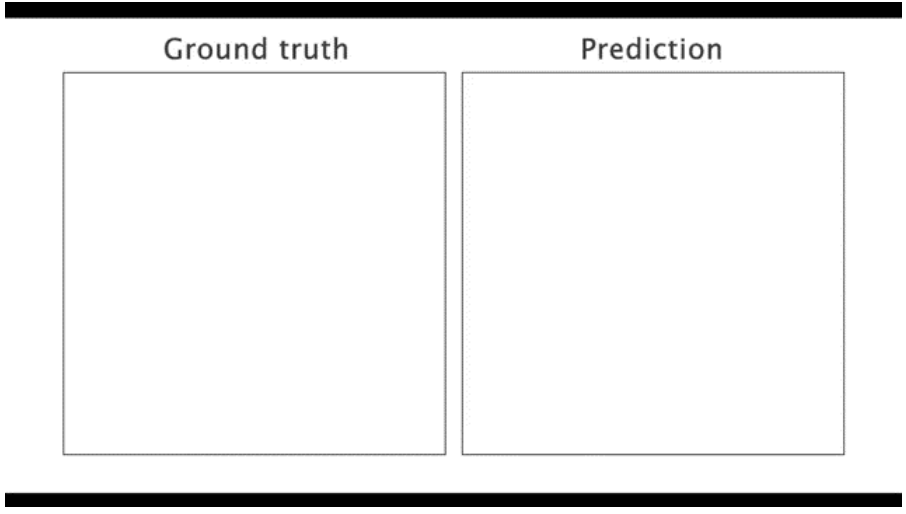
(i) 0.802 g (j) 1.002 g (k) 1.402 g (l) 1.800 g



GNN for Modeling Transport Phenomena:

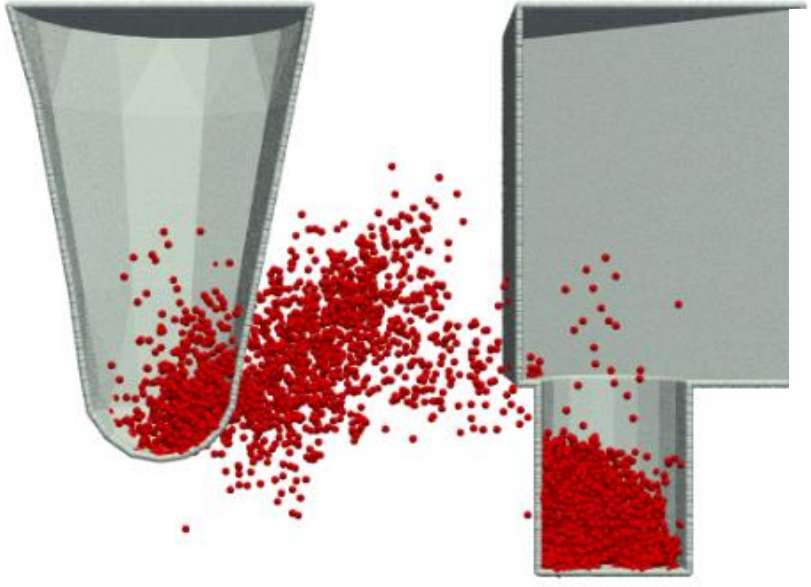
TF ⇒ PyTorch Geometric ★ Multi-GPU Support

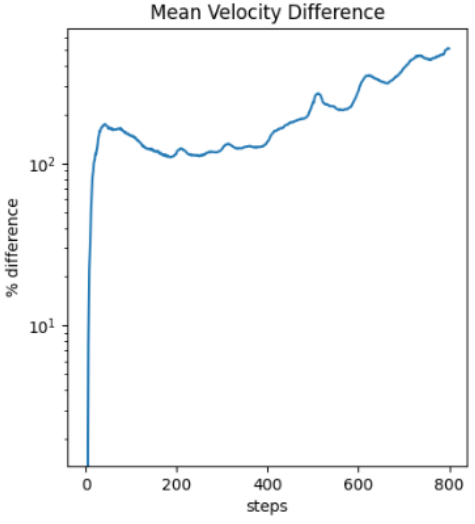


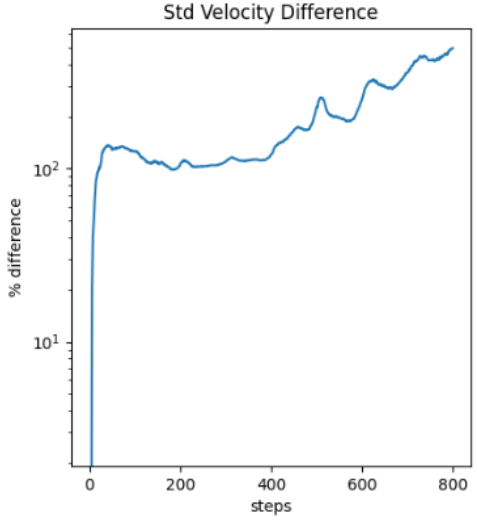


GNN for Modeling Transport Phenomena:

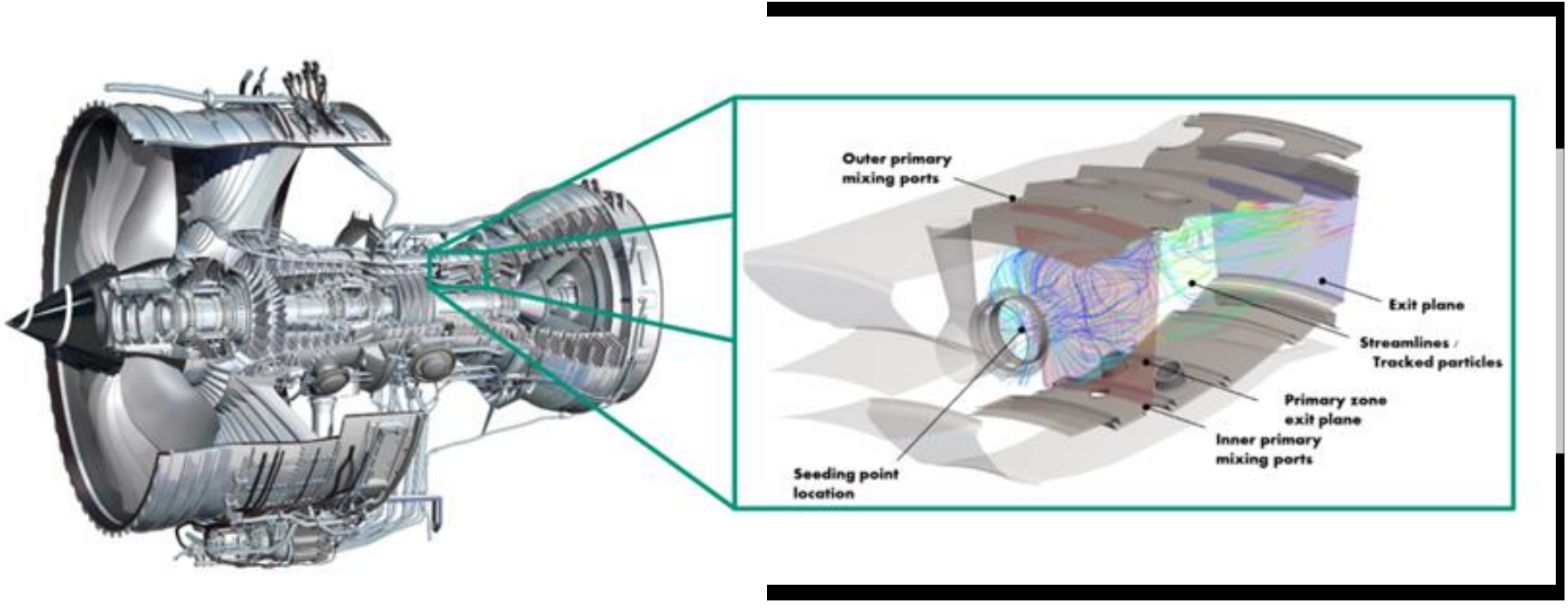
It doesn't conserve the momentum very well.
We can conserve the momentum by
using this loss function.



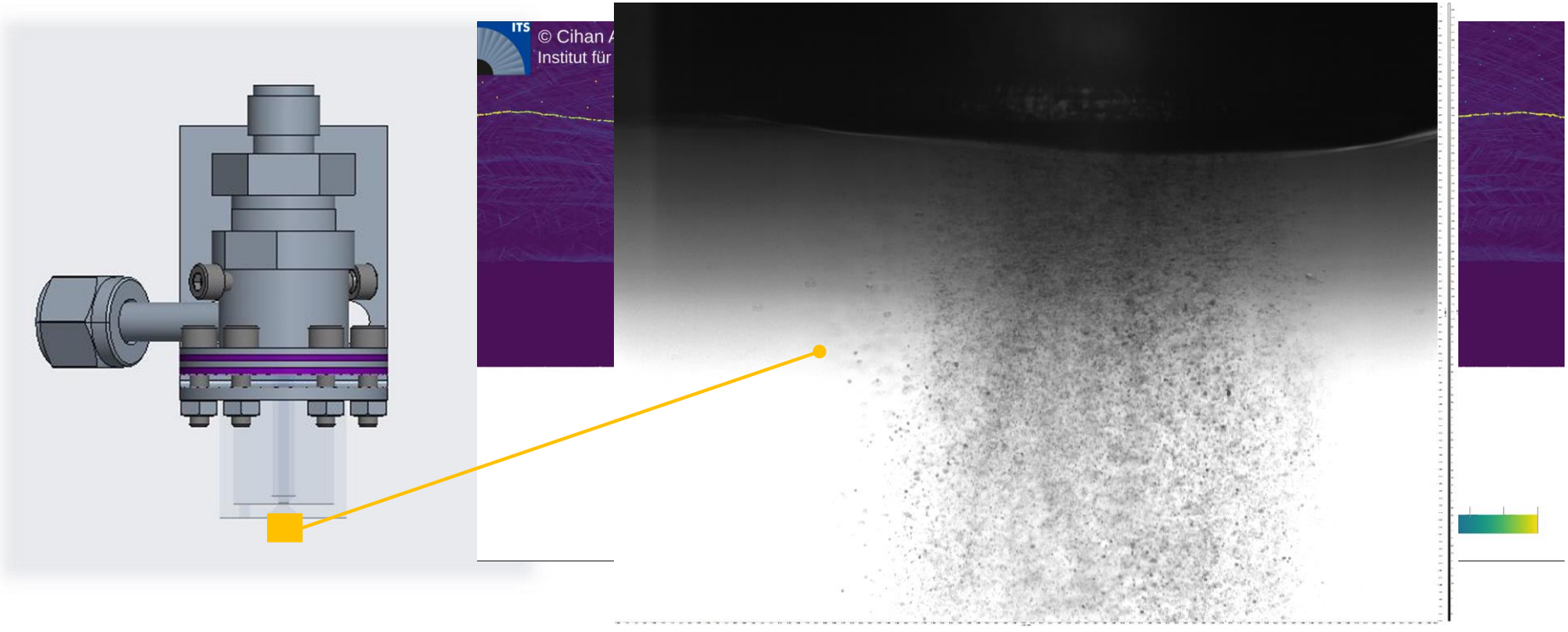




Internally mixed nozzles: Primary Atomization



Internally mixed nozzles: Primary Atomization



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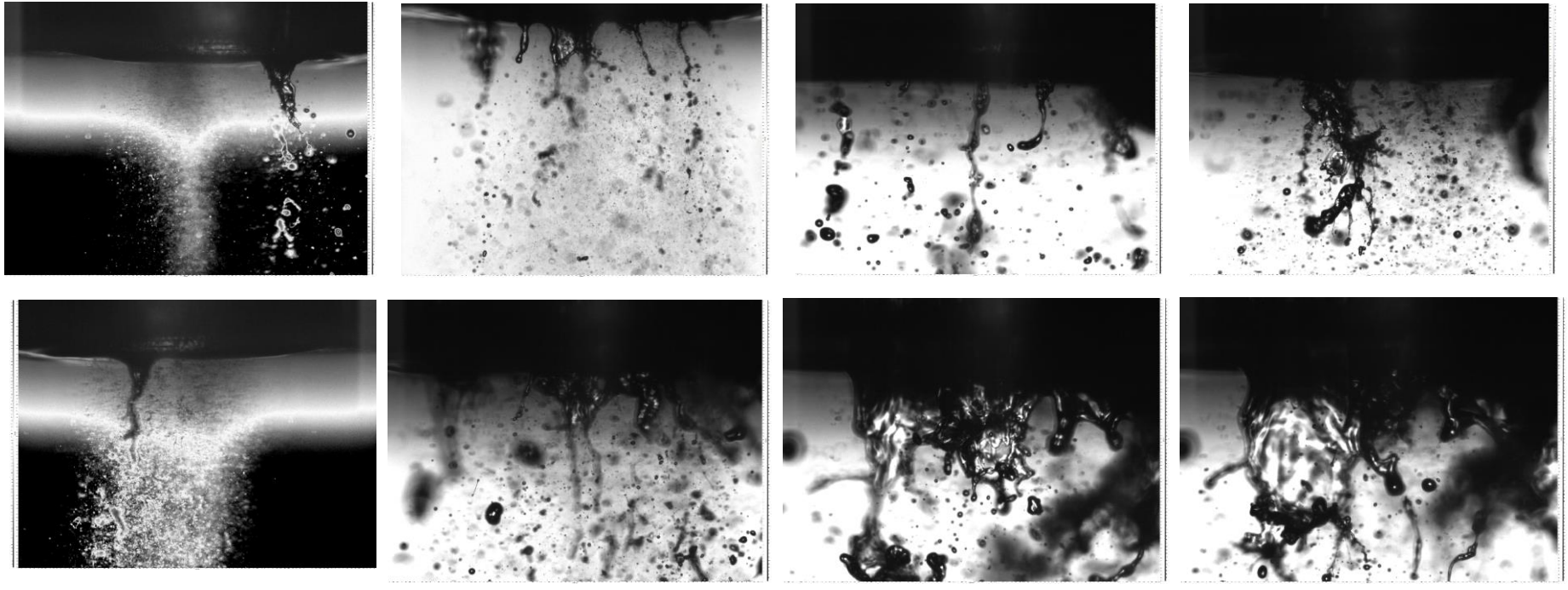

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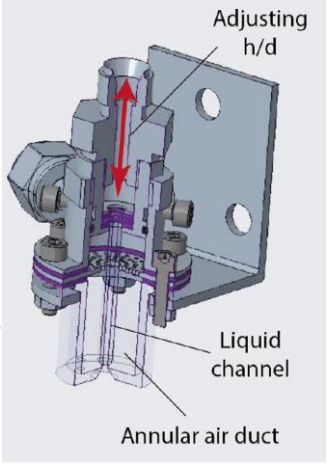
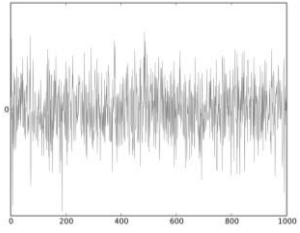


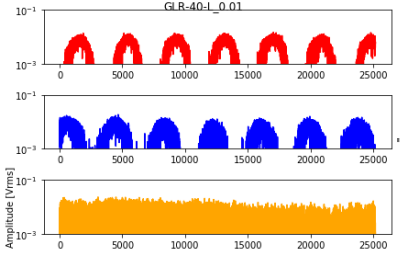
Physical Asset

FFT?



Digital Signal

Feature Extractor Model

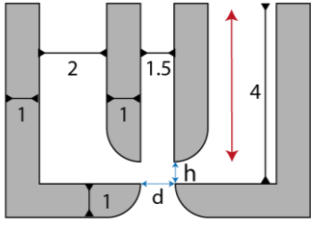


Decision Model

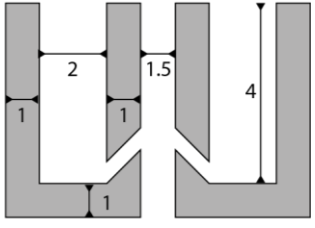
Internally mixed nozzles: Primary Atomization

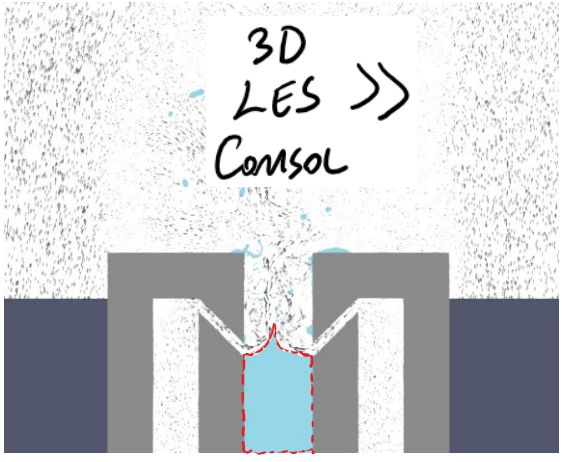
Cases

h/d ratio:



Alternative geometry:





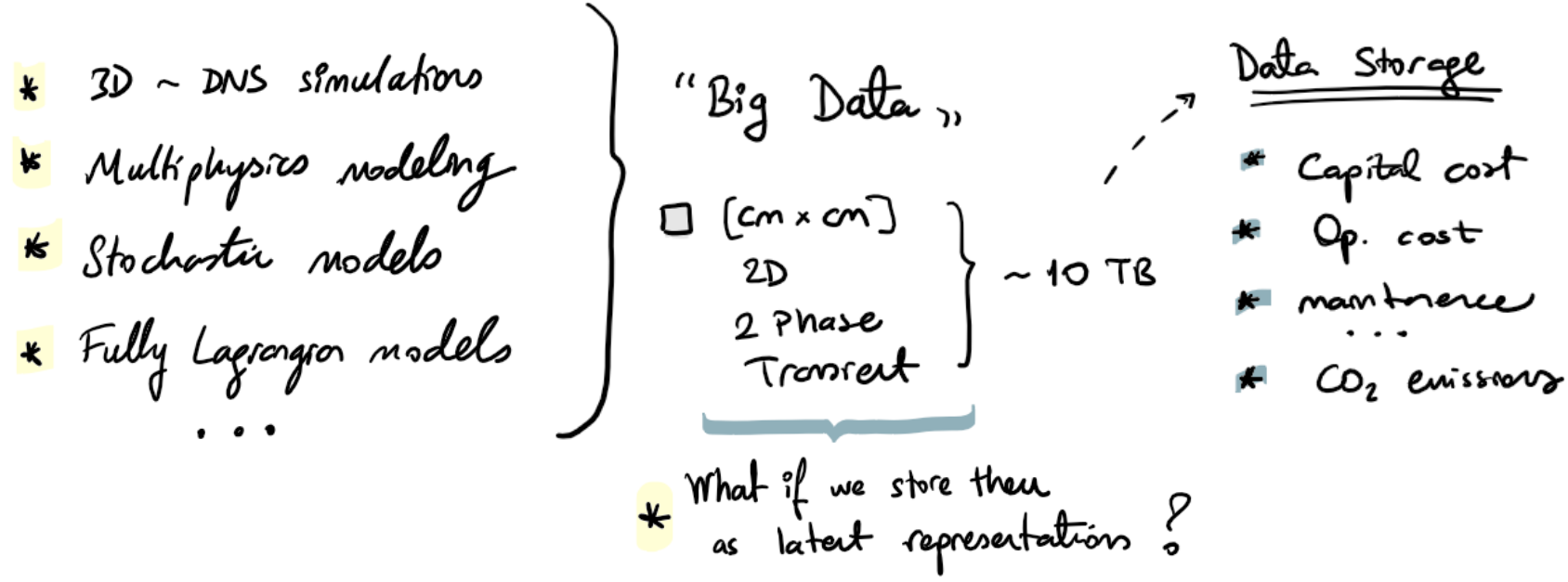
Task I

"Virtual pressure measurements"
vs
Shear

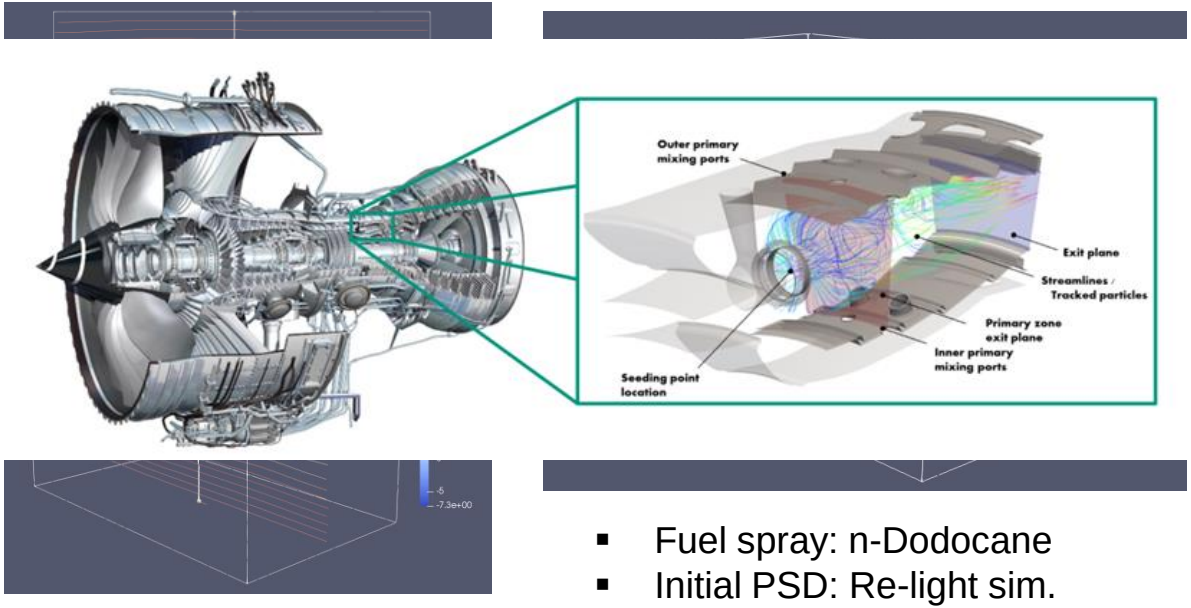
Task II

Data Compression → 3D ⇔ 2D
↳ → 3D ⇔ 3D

Internally mixed nozzles: Primary Atomization



Generative Spray Models for fuel injection



- 3D, EL – LES Simulations
- Iterative, resistance body

- Fuel spray: n-Dodocane
- Initial PSD: Re-light sim.
- 400,000 parcels/s
- Non-reactive, hot gas

Trajectory arrays:

Feature (d,T,x,y,z,u,v,w,τ)

Time

3000-7000 points

Generative Spray Models for fuel injection

Karlsruhe Institute of Technology

Features

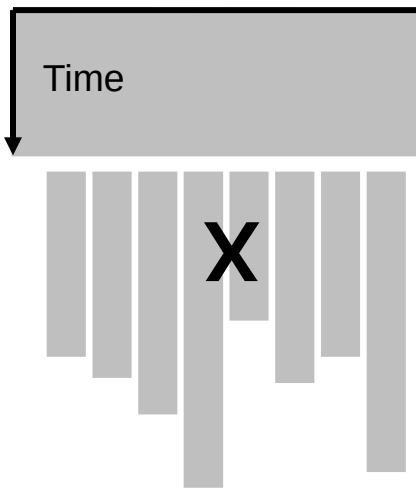
Time

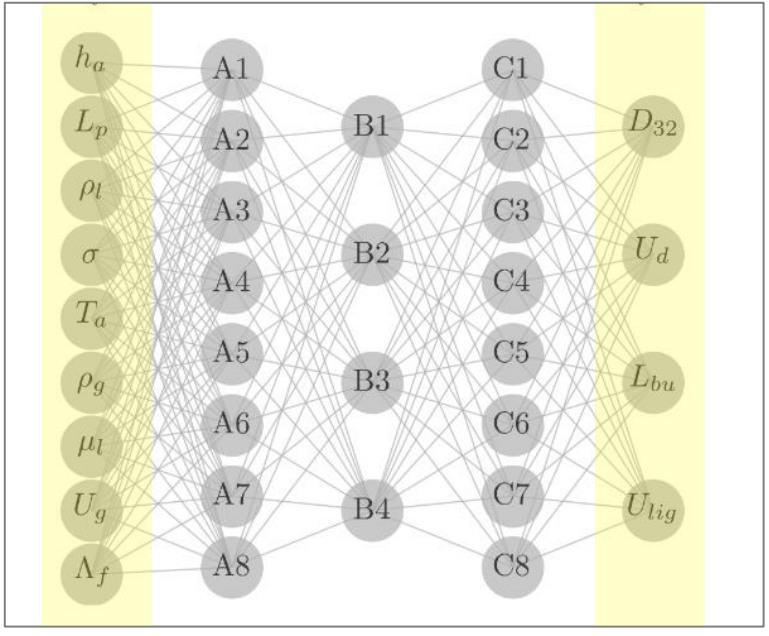
	origId	origProcId	d	d0	T	age	ux	uy	uz	x	y	z
0	7136.0	2.0	0.000186	0.000182	467.916016	0.053118	3.923058	0.228048	0.271680	0.211509	-0.007400	-0.008609
1	7136.0	2.0	0.000186	0.000182	468.006134	0.053218	3.922683	0.227817	0.270981	0.211901	-0.007377	-0.008582
2	7136.0	2.0	0.000186	0.000182	468.099640	0.053318	3.922040	0.227513	0.270086	0.212293	-0.007354	-0.008555
3	7136.0	2.0	0.000186	0.000182	468.190063	0.053418	3.921393	0.227391	0.269143	0.212685	-0.007331	-0.008528
4	7136.0	2.0	0.000186	0.000182	468.277313	0.053518	3.920729	0.227171	0.268320	0.213077	-0.007308	-0.008501
...	...	...	...	...	...	...	...	...	...	...	...	...
92	7136.0	2.0	0.000187	0.000182	481.352966	0.062318	4.034315	0.199198	0.223944	0.247991	-0.005412	-0.006367
93	7136.0	2.0	0.000187	0.000182	481.441895	0.062418	4.035440	0.198665	0.223595	0.248394	-0.005392	-0.006345
94	7136.0	2.0	0.000187	0.000182	481.536316	0.062518	4.036671	0.198134	0.223234	0.248798	-0.005372	-0.006322
95	7136.0	2.0	0.000187	0.000182	481.621765	0.062618	4.037628	0.197615	0.222858	0.249201	-0.005352	-0.006300
96	7136.0	2.0	0.000187	0.000182	481.728729	0.062718	4.040018	0.196627	0.222255	0.249605	-0.005332	-0.006278

Generative Spray Models for fuel injection

Trajectory arrays:

Feature (d,T,x,y,z,u,v,w,τ)





Idea I:

Model with

“temporal memory”

Idea II:

Binning in time

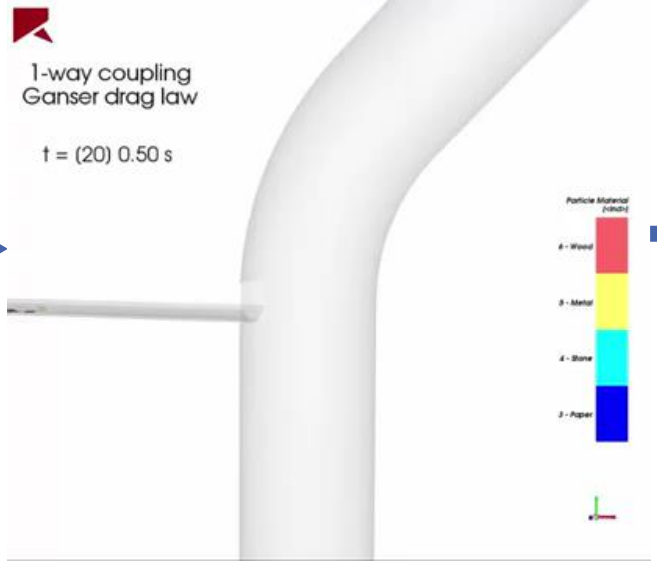
(temporal quantization)

Secondary Motion of Particles: PDF extraction

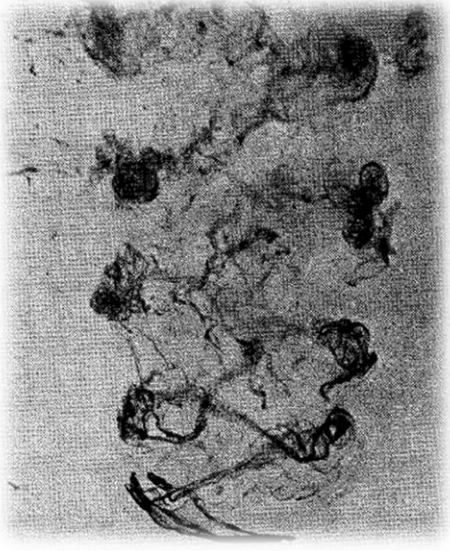
Waste plant

www.instalmec.it

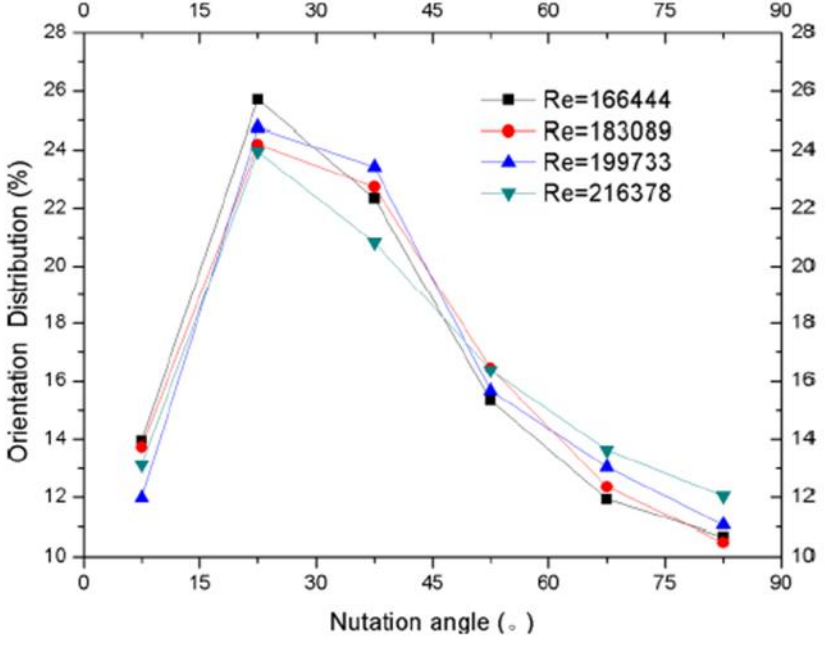
Gas-solid flow



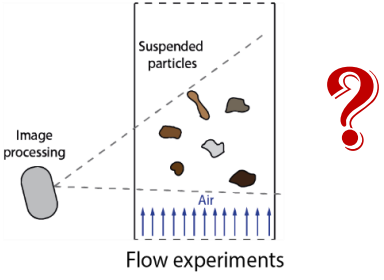
Complex Secondary Motions



Secondary Motion of Particles: PDF extraction



Secondary Motion of Particles: PDF extraction

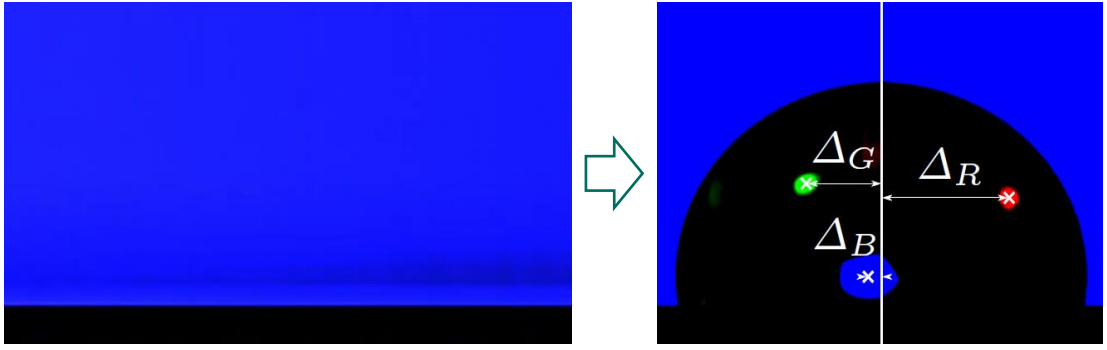


Flow experiments

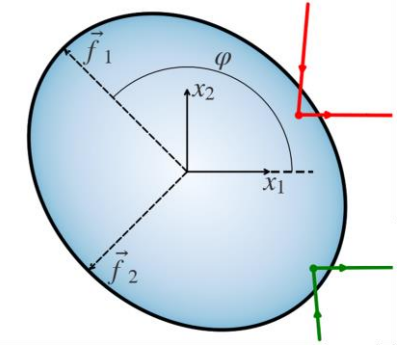
- Synth. data via Blender
- Object detection
- Classification + Regression
- Seq. Based vs. Multiple view

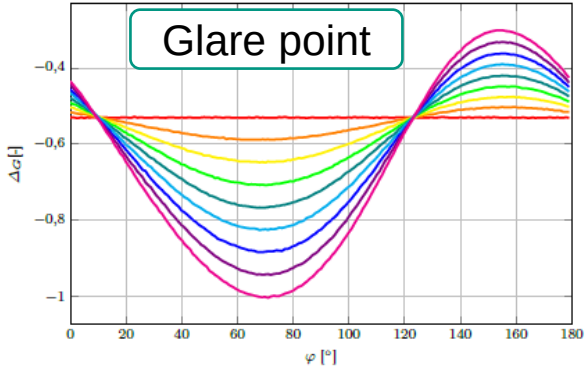
CNN-based regression of drop impact parameters

- Drop impact experiments
  - RGB-Shadowgraph images
  - 2D-representation of non-axissymmetrical droplets
- Colored glare points encode volumetric data
- CNN-based regression of droplet parameters
  - ➔surface area, rotation angle, aspect ratio
  - ➔temporal development

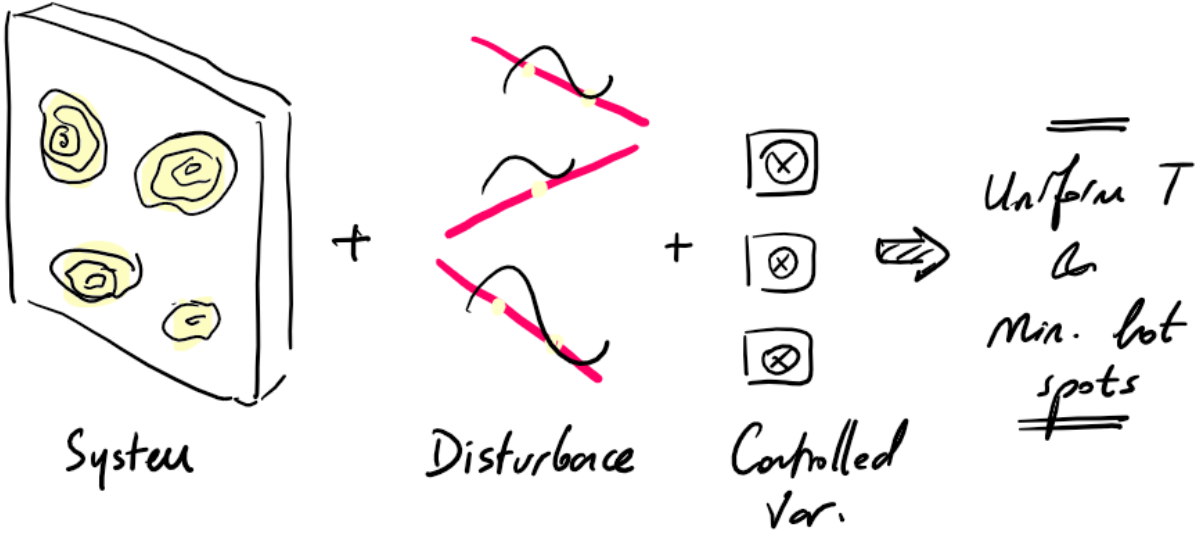


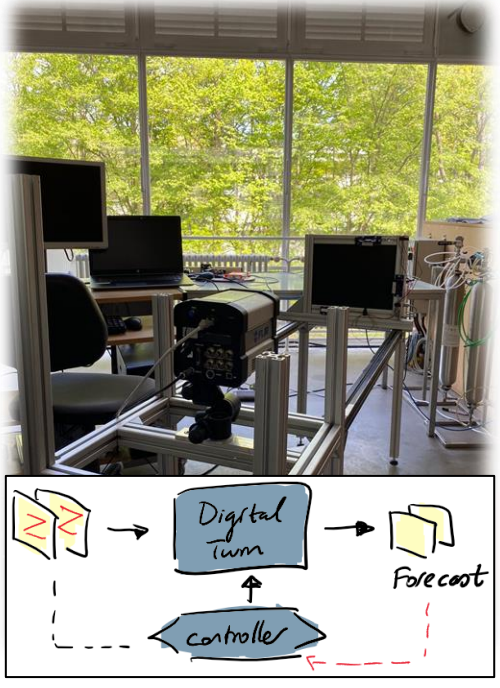
Maximilian Dreisbach



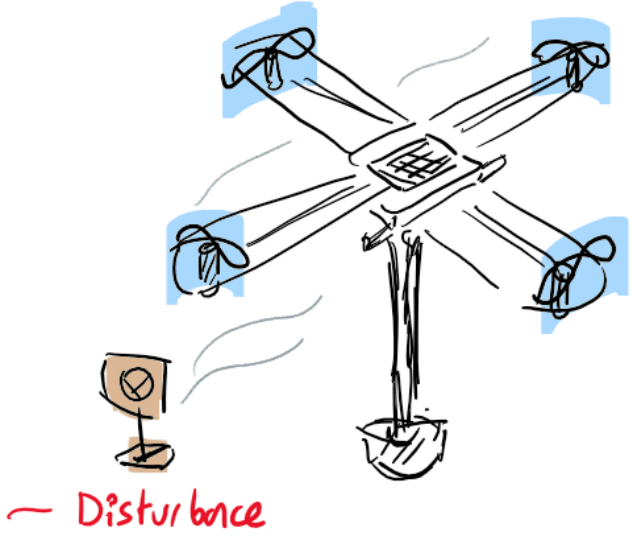


DIY: Data Driven Temperature Control





Data Driven Flight Control : Drones



* Arduino - based
  - ↳ bluetooth
  - ↳ Accel. + gyro.
* Pitch - Roll Control
  - ↳ Data Driven Controller

$$|\text{Set Angle}| - |\text{Current State}| \Rightarrow [4]$$

* 3D - printer

Tasks

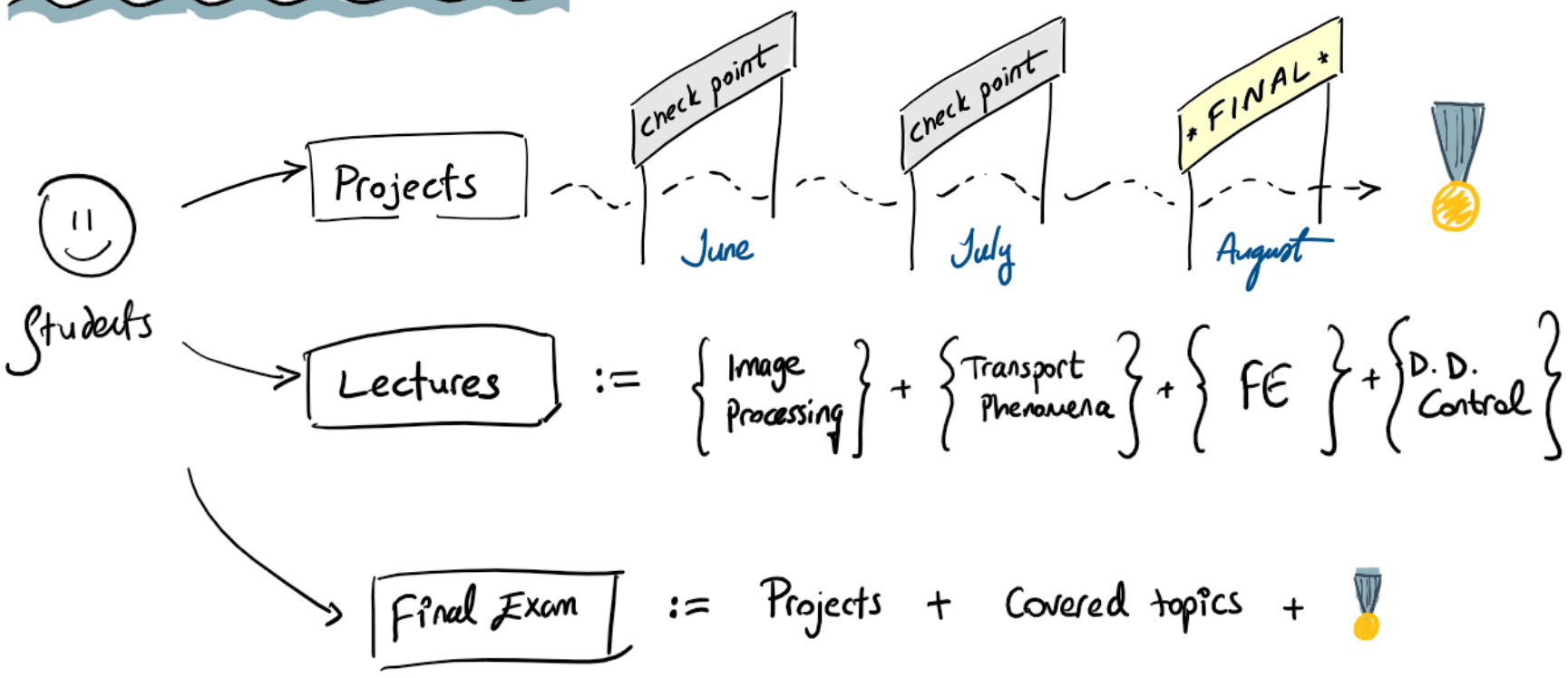
* Sensor calibration
* Arduino ⇔ Labview connection
* Build the rig
* PID tuning
* Custom Controller

Topic # n ....

any other ideas?

more than welcomed!

What is this lecture about ?



To Do List

- [ ] Check & think about projects
- [ ] Register via Ilias ⇒ latest 13th May
- [ ] Check dataset & materials

Involve in projects ⇒ Register for HPC Access (ILIAS)