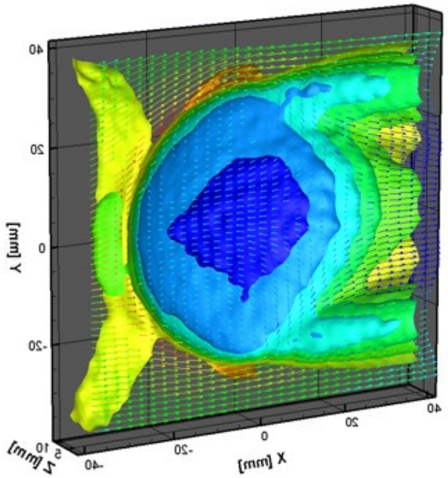
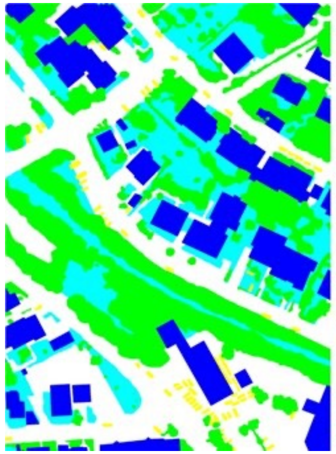
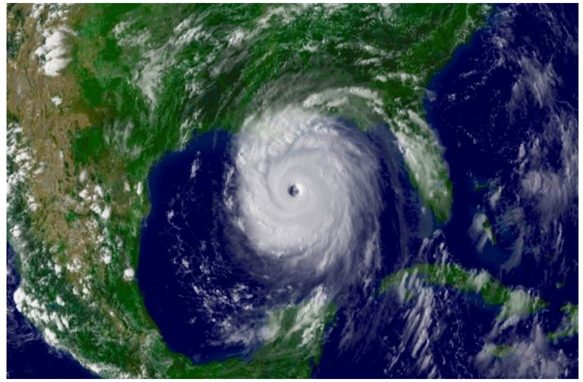
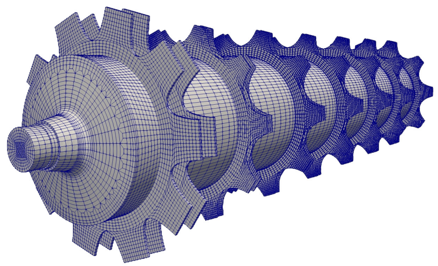
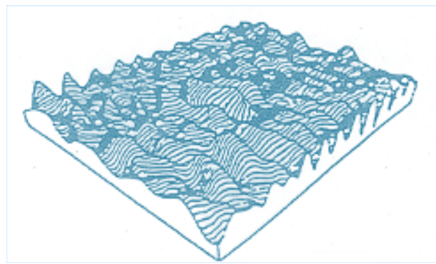










Data Science in Engineering

Prof. Dr.-Ing. Markus Gerke

Application Area: Data Science in Engineering

In the modules offered in this application area we are focusing on typical tasks in engineering. In engineering we develop and use methods for the efficient interpretation of “big data”, but also simulate complex systems, which itself creates massive data.

The modules are offered by
Faculty 3 (Architecture, Civil Engineering and Environmental Sciences)
and
Faculty 4 (Mechanical Engineering)

This presentation shall give a brief overview on the topics. For deeper questions please consult the contact persons indicated.

Application Area: Data Science in Engineering

The following modules will be presented:

- Fundamentals of Turbulence Modeling (5 CP, Summer)
- Measurement Methods in Fluid Mechanics (11 CP, Summer)
- Introduction to Finite Element Methods (5 CP, Summer)
- Railway Timetabling and Simulations (6 CP, Winter)
- Basic Coastal Engineering (6 CP, Winter)
- Deep Learning in Remote Sensing (6 CP, Winter 3 + Summer 3)

Fundamentals of Turbulence Modeling

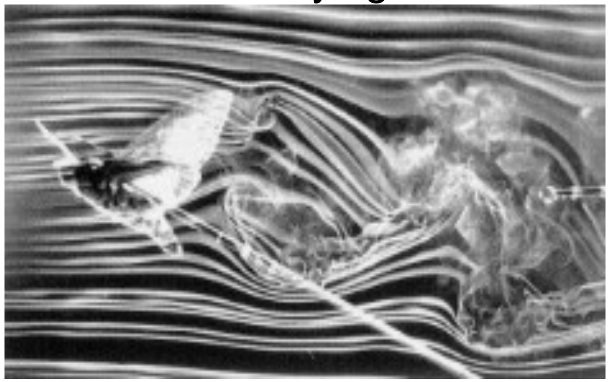
Course content:

- Numerical simulation of fluid flow
- Overview of computational approaches to turbulent flow (RANS, LES, DNS)
- RANS: Turbulence modeling
- LES: Partly resolved turbulence (filtering, modeling of unresolved scales, boundary and initial conditions)
- Hybrid RANS-LES
- Applications of scale-resolving simulations

Details:

- Lecture in Summer Semester
- Lecturer: Dr. Camli Badrya (c.badrya@tu-braunschweig.de)

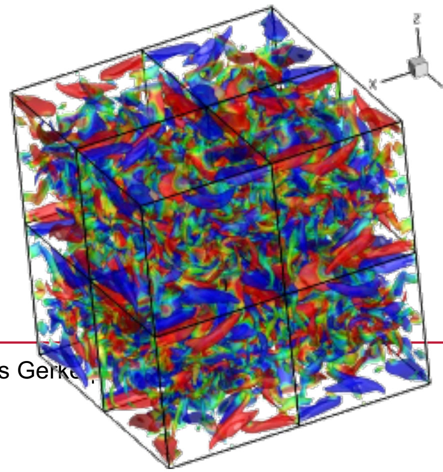
Wake behind flying insect



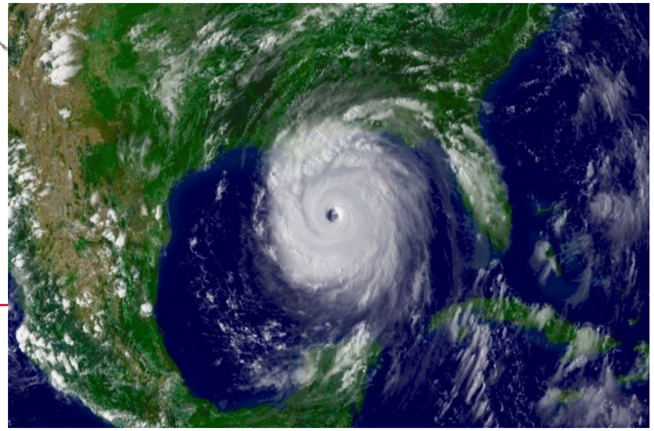
Source: Imperial College London

Visualization of tip vortex

Source: NASA

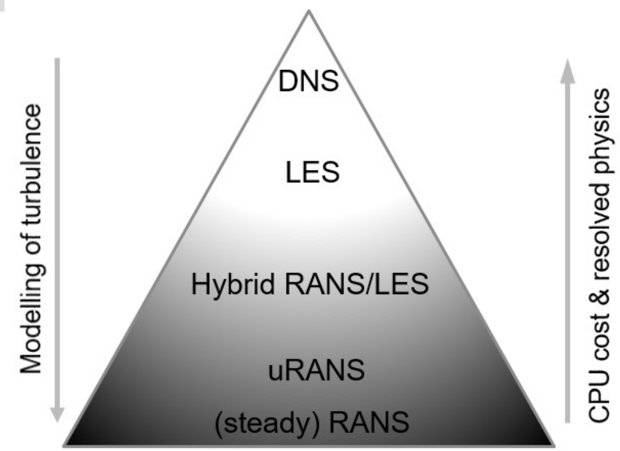


Hurricane Katrina, large



Fundamentals of Turbulence Modeling

(after Sagaut et al



Why study turbulence modeling?

- Vast majority of flows are turbulent
- Transport and mixing is of great practical importance
- Turbulence greatly enhances these processes

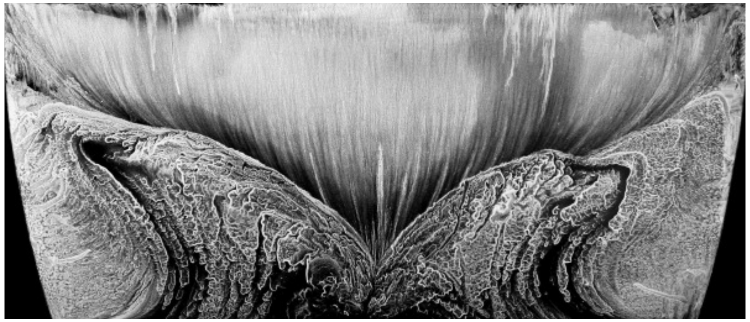
Why data science students need to know the fundamentals of turbulence modeling?

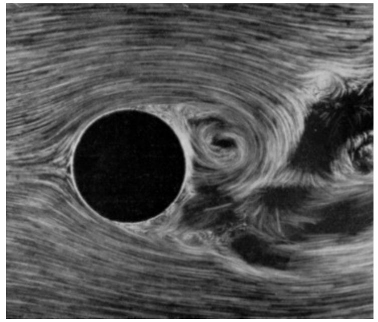
- ➢ The intersection of *computational modeling* of physical systems with data science is a very active research area.
- ➢ No significant progress in developing models for fluid turbulence for two decades
- ➢ Alternative approach: New (old) field of data science to solve → **Data-driven turbulence modeling**

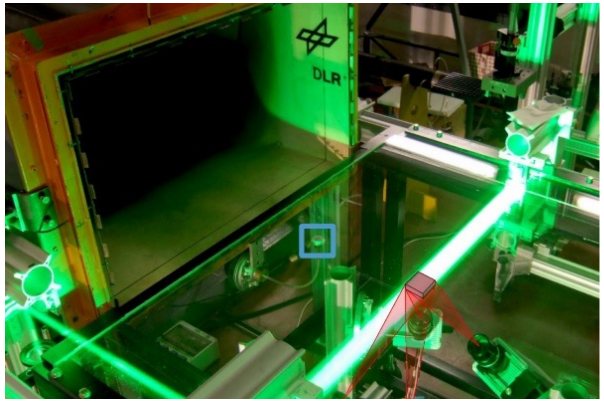
Measurement Methods in Fluid Mechanics

Course content:

- Pressure, force, and electrical measurement methods
- Visualization techniques
- Particle image velocimetry
- Schlieren methods
- Temperature & particle measurements
- Measurement uncertainties







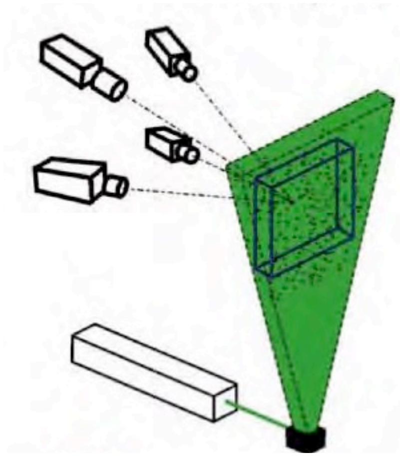
Details:

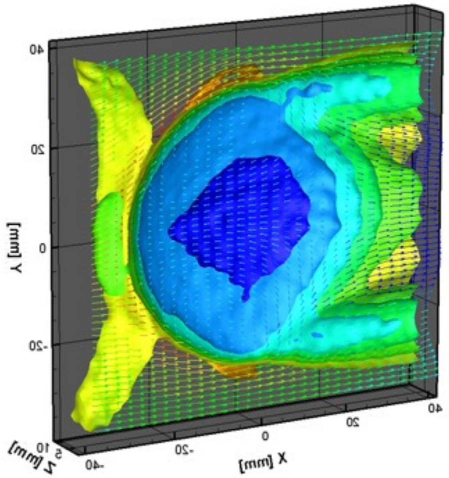
- Lecture in Summer Semester
- Lecturer: Dr.-Ing. André Bauknecht (a.bauknecht@tu-braunschweig.de)

Measurement Methods in Fluid Mechanics

Practical example:

- Growing size of exp. data through improved measurement systems
- E.g. wind tunnel tests with volumetric Particle Image Velocimetry (PIV) produce large amounts of measurement data *(4 × cameras → 500 MB per image set, 500 GB per operating point (1000 images) sets, s of operating points → TBs of data*



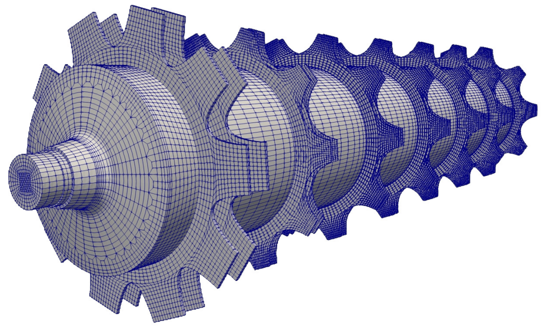


29 Mpix cameras

- Processing, interpretation and modelling of data become challenge → relevant application for Data Science

Introduction to Finite Element Methods

- Governing Equations / Mechanical Principles
- 1D Problems (exact and approximate solutions)
- Criteria of Convergence
- Shape Functions for Membrane and Bending Problems
- Element Geometry
- Numerical Integration
- Isoparametric Element Concept
- Mesh Refinement
- Error Estimation

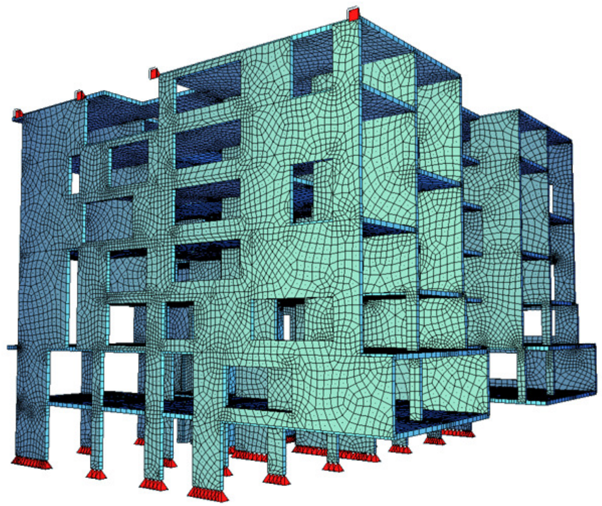


Vortex Wheel
[L. Ostermann et al., ISD TU Braunschweig]

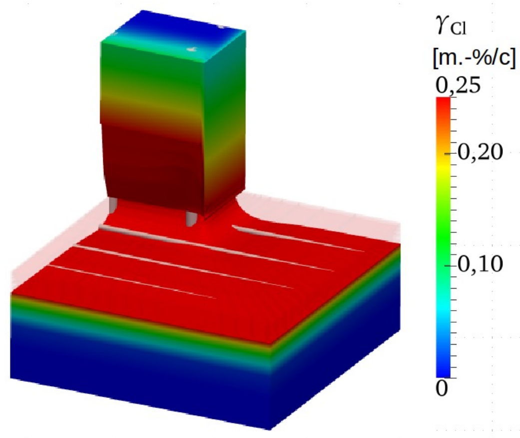
Contact: apl. Prof. Dr.-Ing. Ursula Kowalsky, Institut für Statik und Dynamik

Introduction to Finite Element Methods

Olympic Tower, Munich
[A. Winterstein, Statik-Lehrstuhl, TU München]



Office Building, HafenCity Hamburg –
Am Sandtorkai
[U. Jäppelt, BB 9, 2005]



Column and Slab, Parking Deck –
Chloride concentration
[F. Cramer, ISD TU Braunschweig]

Railway Timetabling and Simulations

1 Basic operating terms

- Introduction to basic terms of the railway domain

2 Train control principles

- Key knowledge on signalling, block and interlocking systems
- Needed for headway calculations in chapters 3 and 4

3 Train movement modelling

- Running time calculation
- Train path modelling as a time slot in a time-distance diagram depending on the control principles of chapter 2

4 Timetabling

- Time constraints for conflict-free timetables
- Evaluation of the consumed capacity
- Exercises with a computer-based scheduling tool

5 Timetable evaluation by simulation

- Overview on simulation tools
- Excercises, in which the timetables developed in the exercises of chapter 4 are evaluated by simulation tools

Contact person:
Prof. Jörn Pachl, j.pachl@tu-bs.de

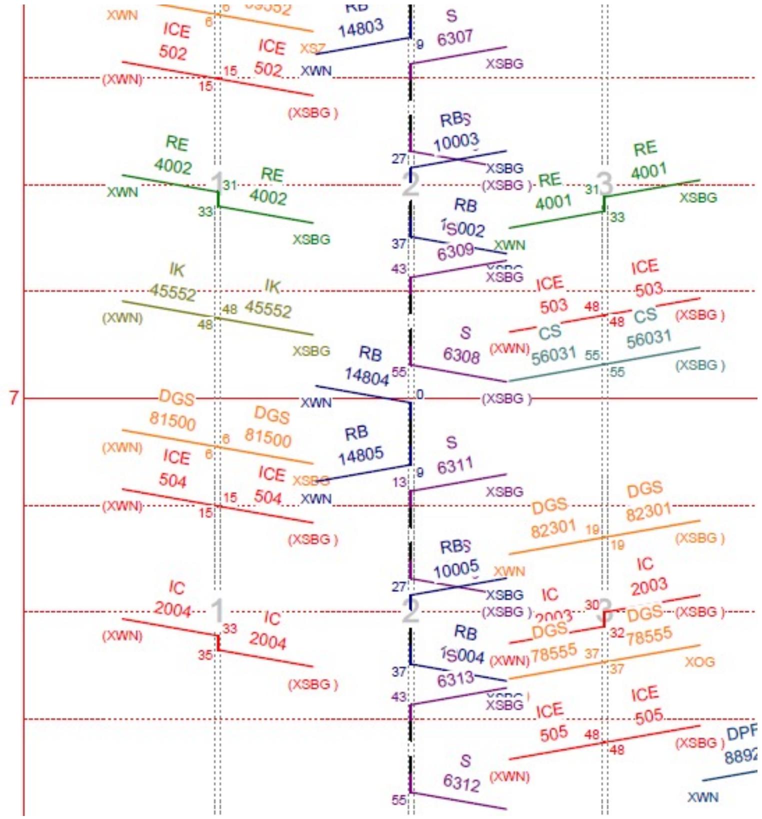
Railway Timetabling and Simulations

In this module, working with data means:

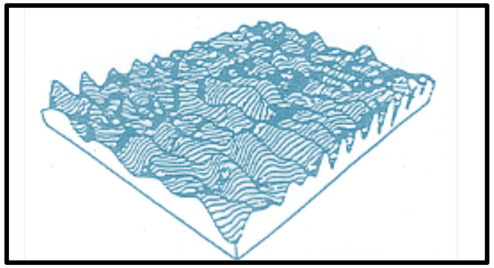
Graphical representation of rail traffic data in time-distance diagrams for

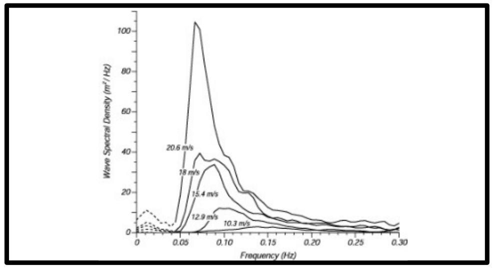
- Conflict-free train path modelling in timetables
- Evaluation of the capacity consumption
- Display and evaluation of simulation results

Note: Beside the data management issue, that module also provides a lot of basic knowledge on rail traffic control, which is needed to understand the processes behind timetabling and simulations



Basic Coastal Engineering



Objective

- understand, calculate and determine parameters for structural and functional design of coastal engineering measures

Topics

- Mechanics of Ocean Waves
  wave parameters, linear and non-linear water wave theories, wave spectra, Fourier Transformation
- Coastal Hydrodynamic Processes
  wave transformation, diffraction, refraction, reflection, shoaling, breaking, wave stability, wave-induced currents, sediment transport, …
- Tides and Currents, Sea State Prediction

Contact

Leichtweiß-Institute for Hydraulic Engineering and Water Resources

Dept. of Hydromechanics, Coastal and Ocean Engineering

Univ.-Prof. Dr.-Ing. habil. Nils Goseberg
✉ hyku@tu-braunschweig.de

Benedikt Bratz M. Sc.
(Teaching Assistant)
✉ hyku-lehre@tu-braunschweig.de
✆ 0531 391 3929

Basic Coastal Engineering

Why do Coastal Engineers need Data Science?

- Coastal Engineers need data about all relevant coastal processes
  wave characteristics & sea state, topography, morphology, sediment transport, pressure, forces, currents
- Coastal Engineers need data from …
  real world, experiments, models, e. g. wave data from gauges, buoies, geodata from satellites, velocity data
- The necessary data need to be **acquired, generated, measured, processed, analyzed, merged, linked**

python MATLAB®

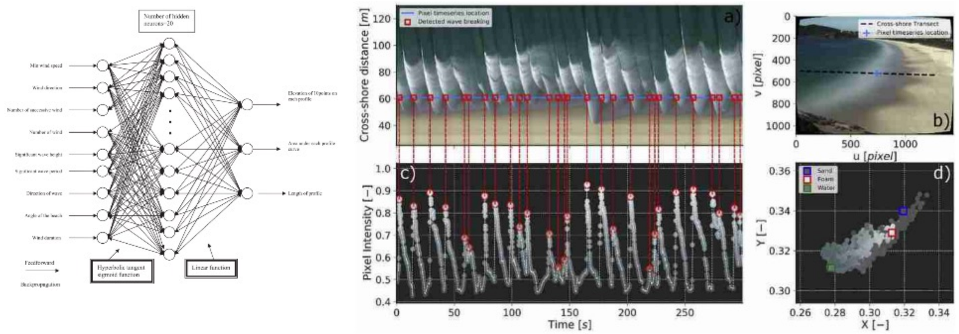
SWAN Simulating WAves Nearshore

OpenFOAM®

XB

REEF3D

Artificial Neural Networks



Coastal Engineering requires
skills and expertise in Data Science *and* **understanding of coastal processes**.

Deep Learning in Remote sensing

Deep Learning in Remote sensing
(6 ECTS)

Machine Learning → **Deep Learning**

Winter semester	Summer semester
3 ECTS	3 ECTS

Classification
Regression
Clustering
Dimensionality Reduction

Neural Network
Convolutional Neural Networks
Land Cover Classification
Object Detection
Semantic Segmentation

Contact
Institute of Geodesy and Photogrammetry (IGP)
https://www.tu-braunschweig.de/igp/
Dr. Mehdi Maboudi
m.maboudi@tu-bs.de

Deep Learning in Remote sensing

SAR data?

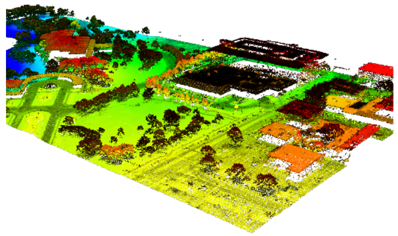
Platforms

https://www.catalyzex.com/paper/arxiv:1812.07770

Data

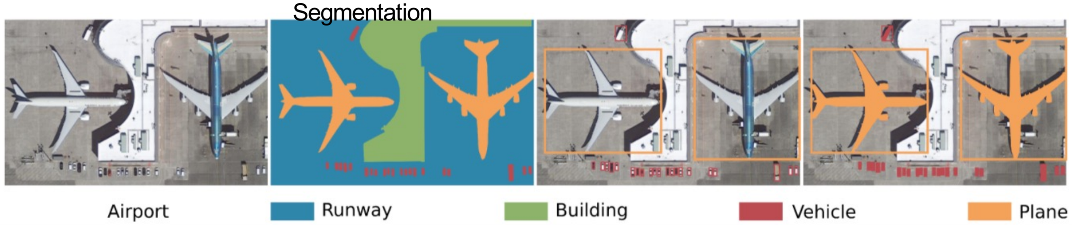
Image

Point cloud



Some Applications

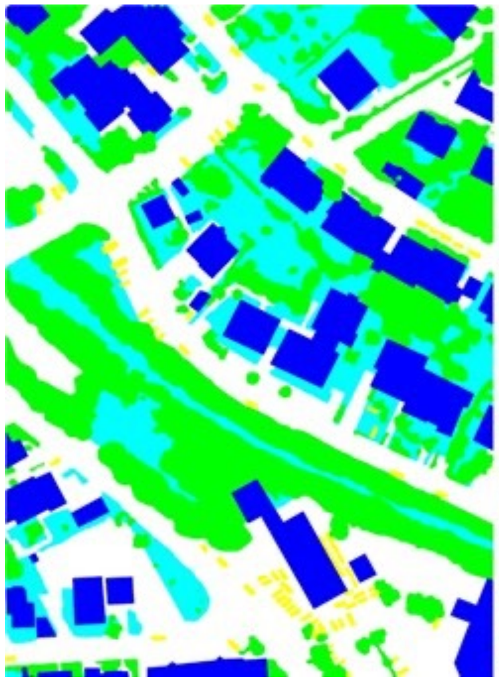
Scene Classification | Semantic Segmentation | Object Detection | Instance Segmentation



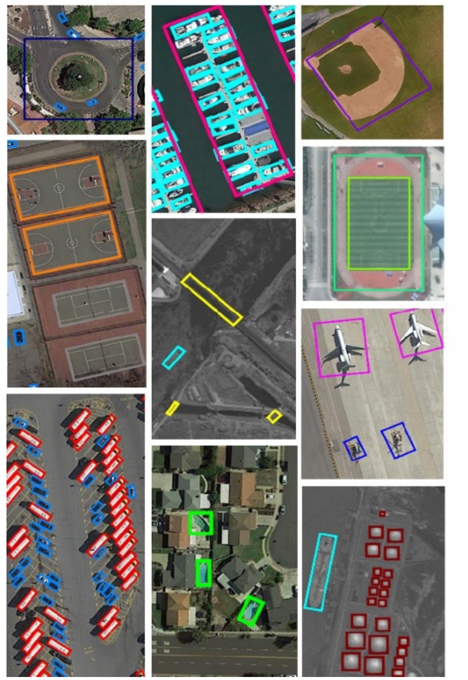
Hoeser et al 2020

Deep Learning in Remote sensing (Some Applications)

Scene Classification



Semantic Segmentation



Object Detection

Thanks for your attention

Time for remarks and questions