Visualization, DD2257

Prof. Dr. Tino Weinkauf

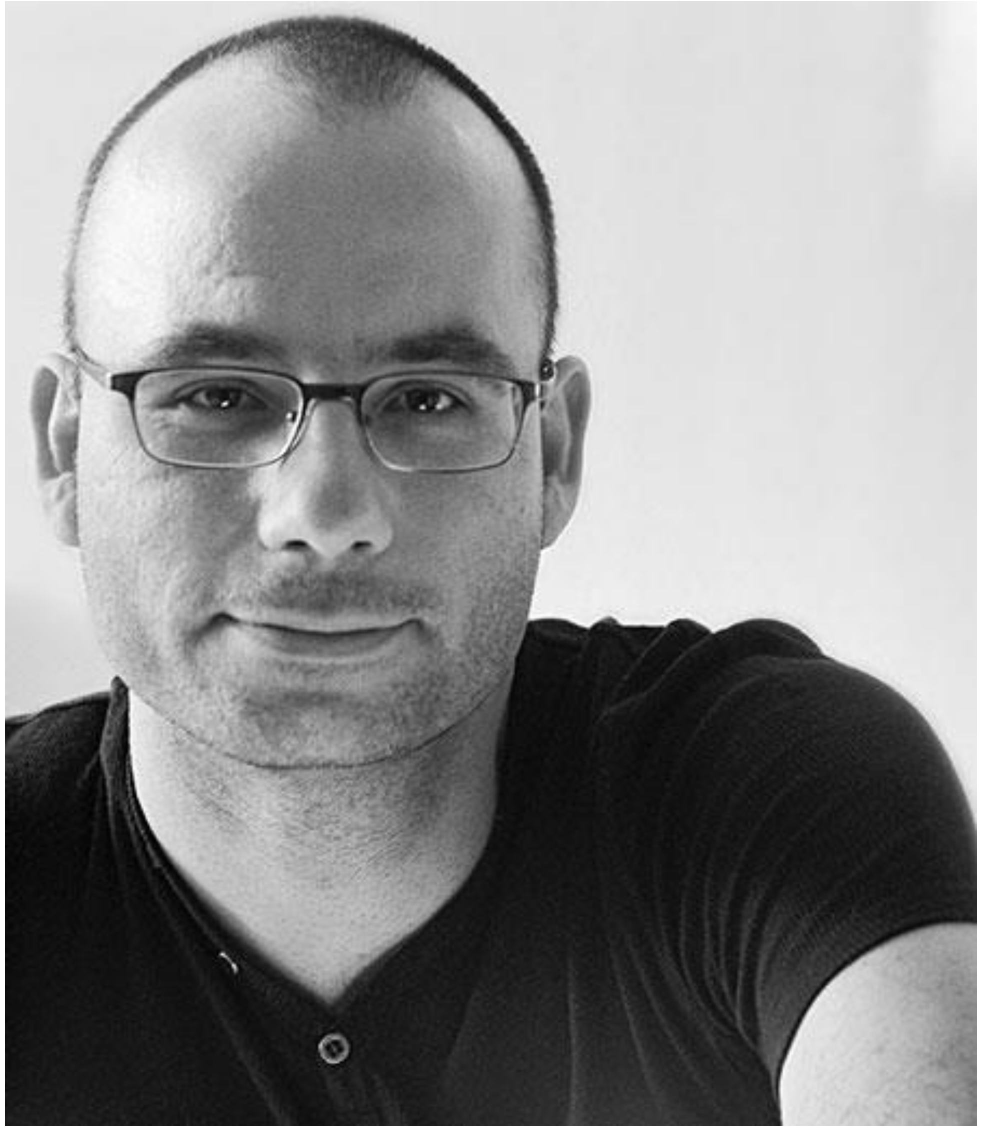
We start at 10:10

Visualization

Tino Weinkauf

- Tino Weinkauf

- Website (Canvas): https://kth.instructure.com/courses/26945
  - announcements
  - course material
  - assignments
  - schedule



- Wiebke Köpp

- Office hours: Mondays, Xpm - Xpm
  - Zoom: same as now

- (We try to look into canvas messages and discussions around 5pm every day.)

- Student TAs:
  - Anna Tranquillini
  - Ao Xu
  - Xinyi Wang

- Tino Weinkauf
- Studied computer science in Rostock, Germany
  - Special focus: computer graphics and visualization
- Worked at Zuse Institute Berlin, Germany (2001 – 2009).
  - Flow analysis and visualization
- Received PhD in computer science (Dr. Ing.) from University of Magdeburg, Germany (2008).
- Post-doc at New York University, U.S.A. (2009 – 2011)
  - Feodor Lynen fellowship from the Alexander von Humboldt foundation
- Head of independent research group at Max-Planck-Institute for Informatics, Saarbrücken, Germany (2011 – 2014)
- Professor of Visualization, KTH Stockholm (since 2015)
- Research interests: Visualization, Data Analysis, Computer Graphics, Topology, Geometric Modeling, Shape Analysis

- Name
- Where do you come from?
- Where did you do your Bachelor?
- In what program are you now?
  - Master Computer Science
  - Master Machine Learning
  - Master HCI
  - Master Media Management
  - Master Media Technology
  - Something else?

- You have to register for the course
  - Grading (exercises, exam) requires registration
    - You are welcome to just sit in and listen
    - Registration is required for credits
  - You will be notified about the signup deadline by the university

- Assistance with registration etc:
  - SWE: www.kth.se/eecs/studentsupport
  - ENG: www.kth.se/en/eecs/studentsupport

- In some courses at CSC there are PhD-students from other universities in Sweden following the course.
    - Since information, material and communication often is done via KTH systems and the student need a **KTH-account** to sign in these systems these students have had problems to attain the same information as the other students.

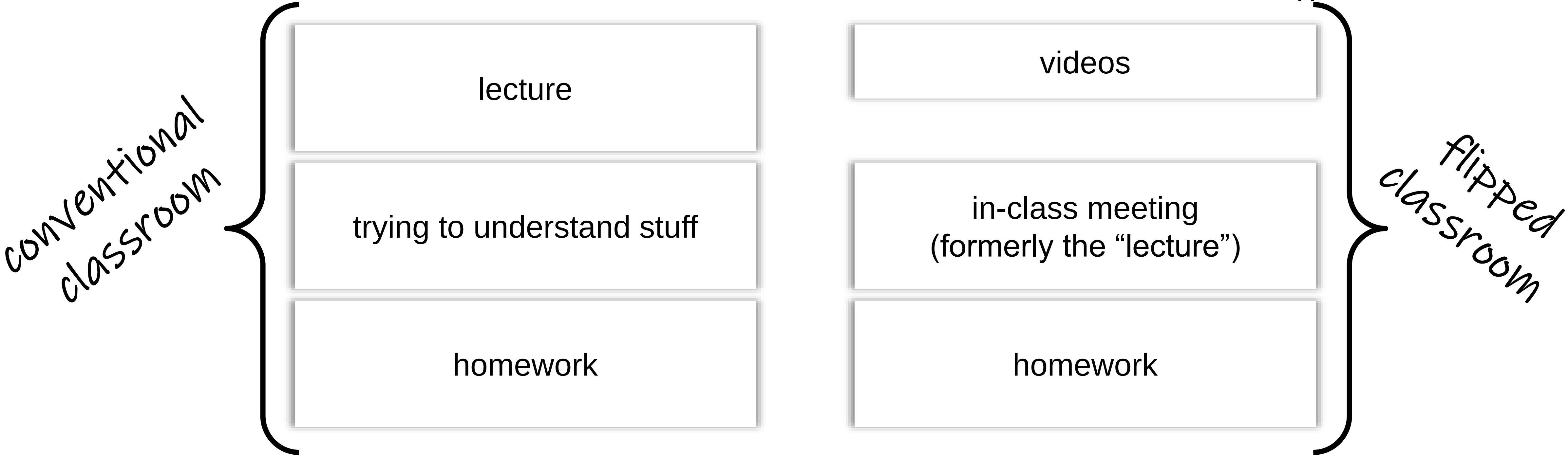
- It is possible for **external PhD-students to get a KTH-account**: Go to the service desk at Lindstedtsvägen 3, level 4, where you can sign a form.

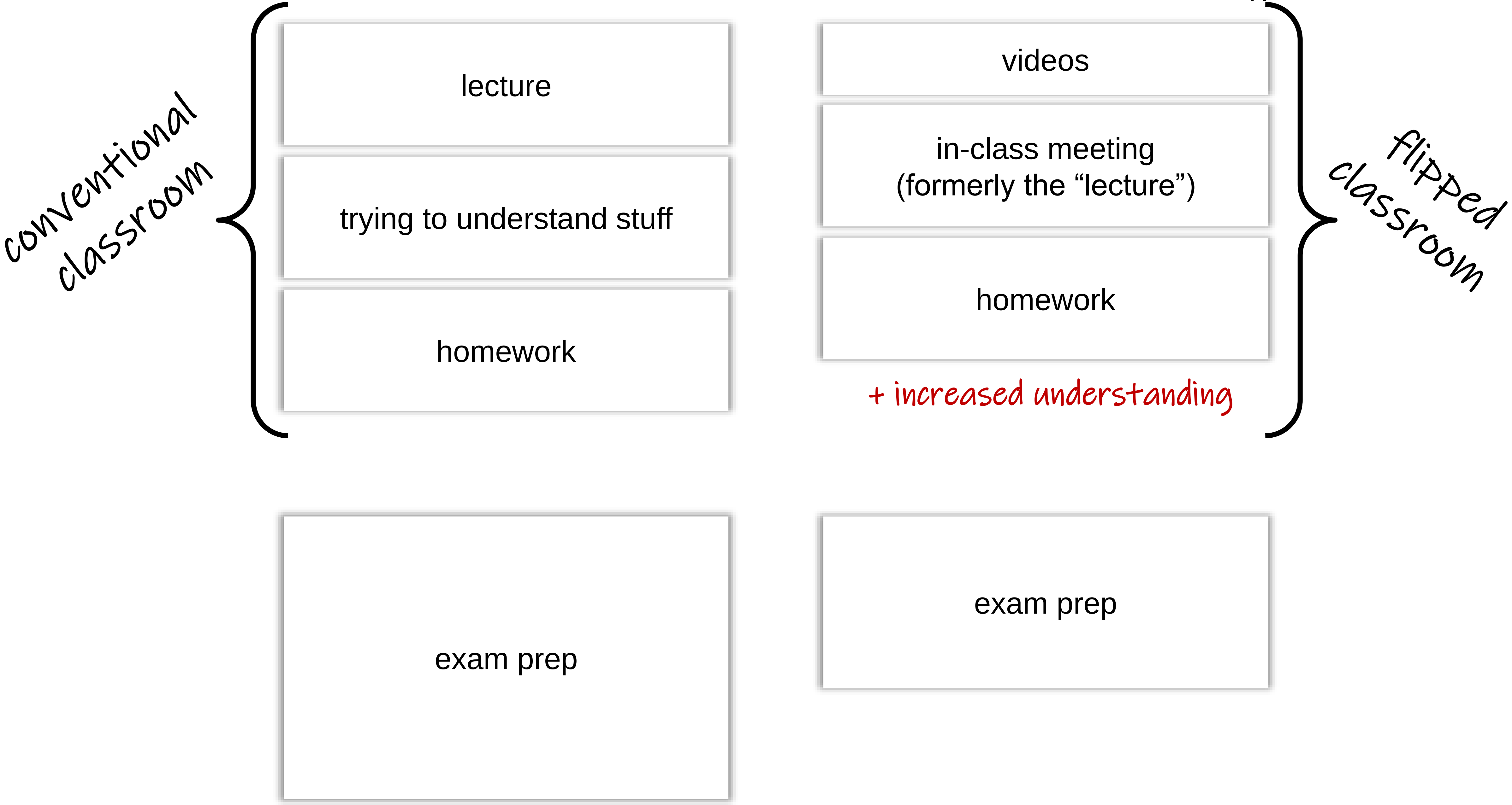
- It will only take a few days to get the account.

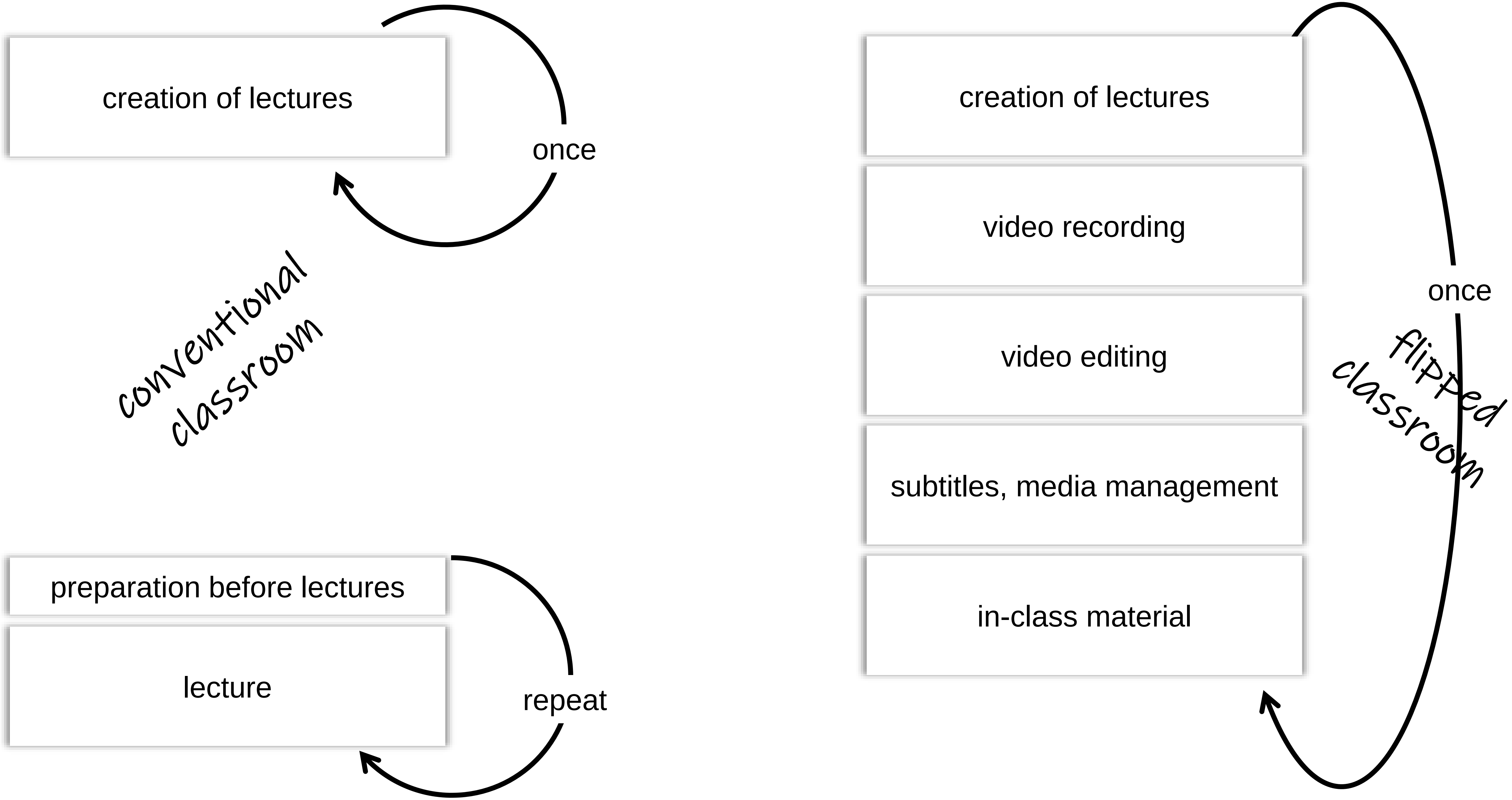
- **Disability**
  - *Support via Funka*
    If you have a disability, you may receive support from Funka.
    https://www.kth.se/en/student/studentliv/funktionsnedsattning
  - *Inform the teacher*
    We recommend that you inform the teacher regarding any need you may have. Funka does not automatically inform the teacher.

- **Funktionsnedsättning**
  - Om du har en funktionsnedsättning kan du få stöd via Funka:
    https://www.kth.se/student/studentliv/funktionsnedsattning
    Informera dessutom kursledaren om du har särskilda behov. Visa då upp intyg från Funka.

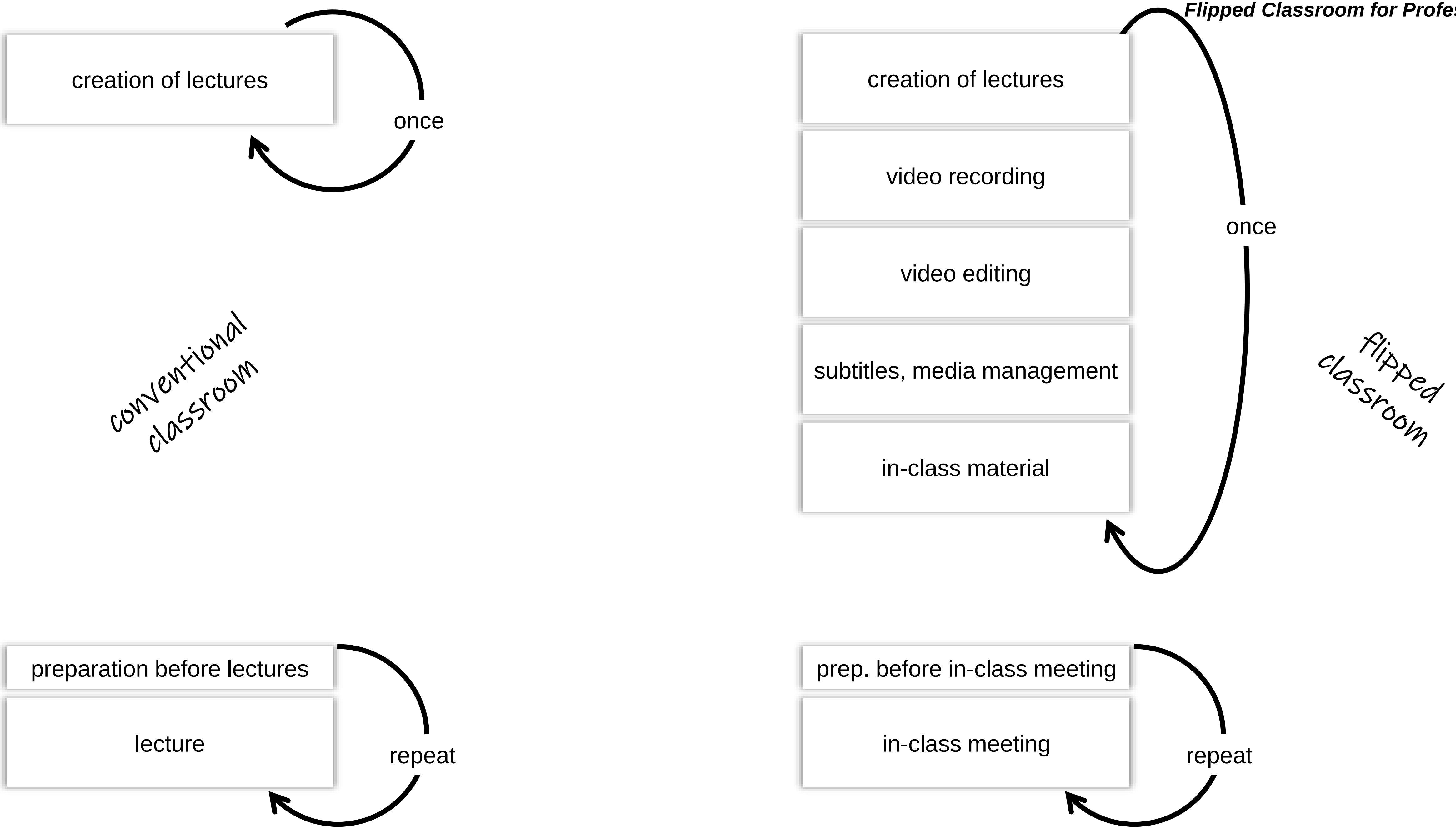
- Lectures / Interactive Sessions:
  - Monday & Wednesday (mostly)
- Tutorials
  - Friday (mostly)
- See online schedule and Canvas for details


conventional classroom
lecture
trying to understand stuff
homework
videos
in-class meeting
(formerly the “lecture”)
homework
flipped classroom


conventional classroom
lecture
trying to understand stuff
homework
exam prep
videos
in-class meeting (formerly the "lecture")
homework
+ increased understanding
flipped classroom
exam prep


creation of lectures
once
conventional classroom
preparation before lectures
lecture
repeat
creation of lectures
video recording
video editing
subtitles, media management
in-class material
once
flipped classroom

Flipped Classroom for Professors

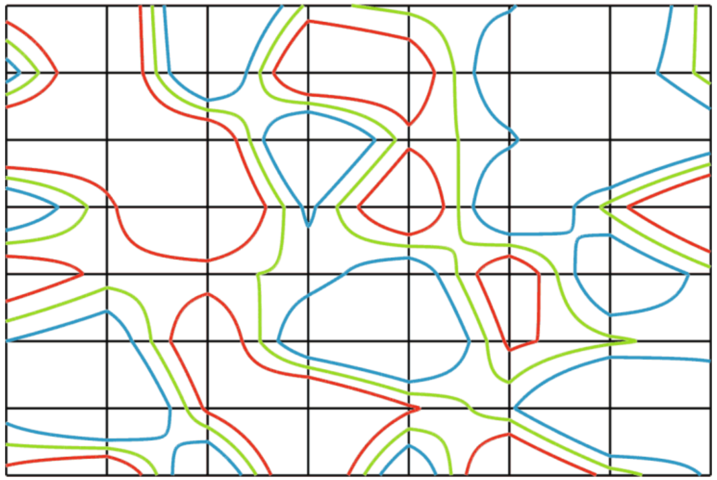


- To pass the course, you need to...
  - Work on **all homework assignments**
  - Obtain at least **50%** of the assignments score
  - **Pass** the final written exam == grade
- Date for the written exam:
  - October 28, 14-16 h
- Date for the re-exam:
  - December 21, 14-16 h
- 7.5 CP

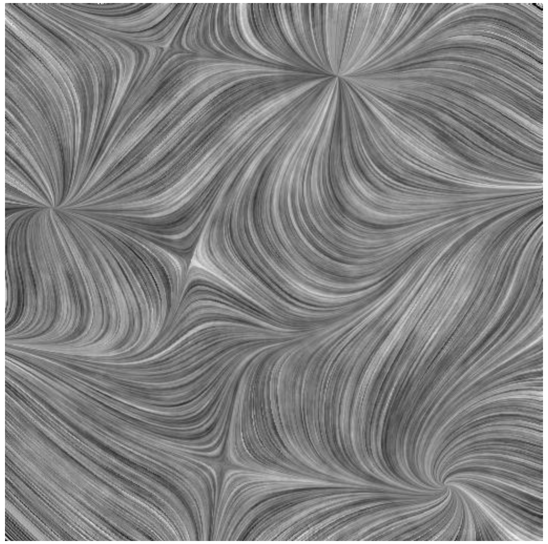
- Concept
  - Theory & practice
- Theoretical Assignments
  - Each student must prepare a write-up
  - Hand-in solutions: **before the tutorial** (after one week)
    - **Upload as PDF to Canvas only**
      - Scanning available at every printer at KTH
  - Will be graded a week later
  - Solutions will be discussed in the tutorials

- Practical Assignments
  - Programming assignments
    - Group work: **groups of three students**
  - A C++/QT framework will be provided (Unix/Windows)
    - Windows users:
      Visual Studio Express is available for free download
      Other versions of Visual Studio are available through Microsoft Imagine
      https://intra.kth.se/en/it/programvara/microsoft-imagine-1.675383
    - Linux users:
      Multiple options: Console, K-Develop, QT Creator, VS Code
    - Mac users:
      XCode

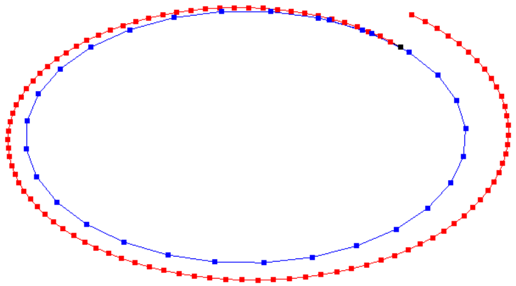
- Practical Assignments
  - Groups of three students
    - Form groups yourselves
    - Need to be formed by **September 17**
  - Signup in Canvas for groups
  - Use your own equipment (laptop)
    - Possible for everyone?



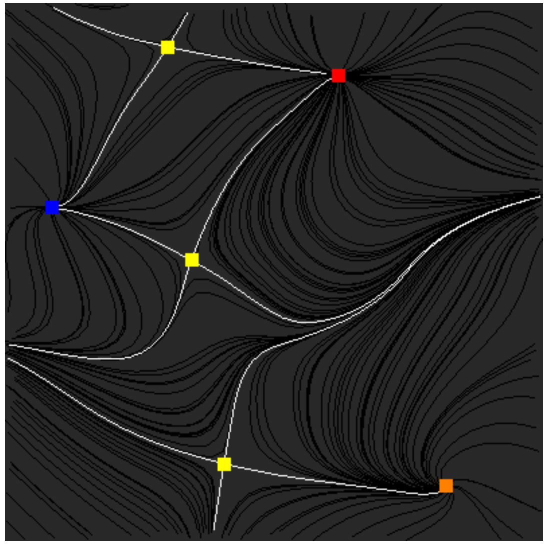
Marching Squares



Line Integral Convolution



Integration



Vector Field Topology

- Practical Assignments: Grading
  - Grading by TAs in interviews
  - Group must show up entirely
    - Option to get individual time slots
  - Everybody is graded individually, based on:
    - The group’s implementation
    - Personal knowledge about the implementation
    - Everybody must be able to explain all of the code

- First Tutorial course (September 3):
  - Using Inviwo
  - Using the programming environment
  - Programming C++
  - Introduction to the provided C++ framework
  - Help with forming groups
- Second Tutorial course (September 8)
  - Help with installing Inviwo
  - Help with forming groups

- Bonus points
  - obtained during the period
  - count towards final grade
- Exam gives 100 regular points in total
- Example:
  - you achieve 76 regular points in the exam
  - you have 5 bonus points obtained during the period
  - makes a total of 81 / 100 points for the final grade
  - this may be the difference between a C and a B

- Two ways to obtain bonus points:

- Homework
  - We give extra tasks in the homework assignments which give extra points
  - Let x the total sum of all regular points
  - Let y be the sum of your achieved points (regular + extra)
  - Then, $\max(100\frac{y}{x} - 100, 0)$ is the number of your bonus points for the exam

- Bonus Projects
  - Define a visualization-and-graphics-related advanced project yourself: what do you want to explore in more detail?
  - Present your project (5 min) in the final lecture.

- Rules for bonus projects

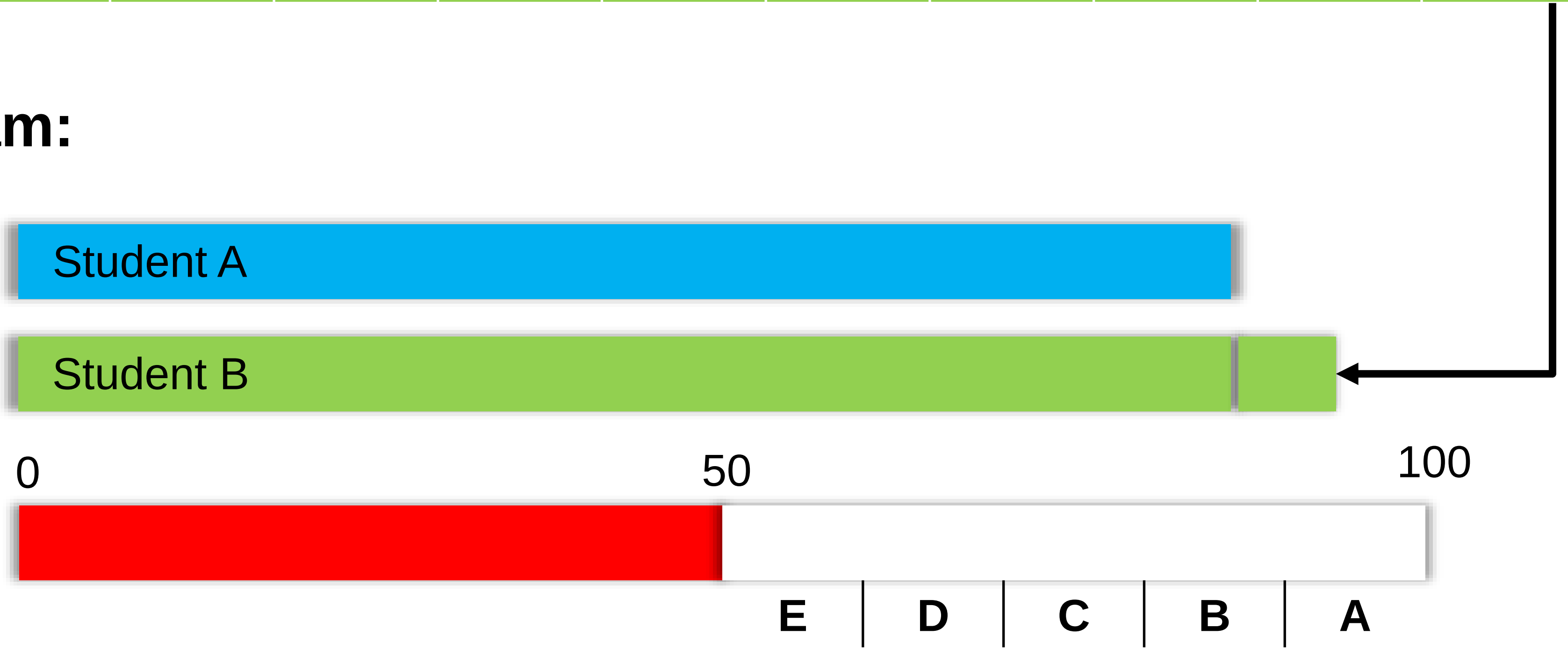
- Topic
  - self-defined
  - visualization-related
  - advanced: goes beyond the topics of the course
  - some amount of coding; environment of your choice

- Presentation:
  - final lecture
  - 5 minutes
  - demo! (slides as an alternative)

- Grading
  - Typical: 5 bonus points
  - Exceptions: 3 or 8 bonus points
  - Rare: 0 bonus points

	Home-work 1	Home-work 2	Home-work 3	Home-work 4	Home-work 5	Home-work 6	Total	Percent	Bonus Points
Max Points	20	20	20	20	20	20	120		
Student A	20	10	20	20	15	25	110	91.6	0
Student B	25	20	15	25	20	25	130	108.3	**8**

Exam:



- See Canvas for a self-test regarding math.

- Questions & Suggestions
  - Please let us know if there are any issues anytime
  - We appreciate your feedback! Please let us know:
    - ...if you find a certain part of the lecture hard to understand or not well explained.
    - ...any suggestions how to improve the lecture or the exercises.
    - ...any other questions, suggestions or concerns.

- The script of this class contains parts of the following scripts:
  - Prof. Heidrun Schumann (University of Rostock, Germany)
  - Prof. Helwig Hauser (University of Bergen, Norway)
  - Prof. Holger Theisel (University of Magdeburg, Germany)
  - Prof. Rüdiger Westermann (TU Munich, Germany)
  - Prof. Ronald Peikert (ETH Zürich, Switzerland)
  - Prof. Thomas Schulz (University of Bonn, Germany)
  - Prof. Bernhard Preim (University of Magdeburg, Germany)
  - Prof. Miriah Meyer (University of Utah, U.S.A.)
  - Prof. Jens Krüger (University of Duisburg/Essen, Germany)

Thank you!

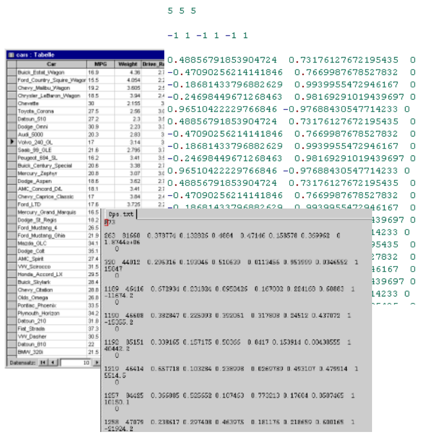
- Alexandru Telea, Data Visualization: Principles and Practice, A K Peters Ltd, 2007, ISBN 978-1568813066, 502 pages
- Charles Hansen and Chris R. Johnson (eds.), The Visualization Handbook, Academic Press, 2004, ISBN: 978-0123875822, 984 pages
- Proceedings of IEEE Visualization Conferences
- Proceedings of EuroVis/VisSym

- K. W. Brodlie et al. (eds.): Scientific Visualization - Techniques and Applications, Springer 1992
- R. A. Earnshaw, N. Wiseman (eds.): An Introductory Guide to Scientific Visualization, Springer, 1992
- P. Keller, M. Keller: Visual Cues, IEEE Computer Society Press, 1993
- L. Rosenblum et al. (eds.): Scientific Visualization, Academic Press, London, 1994
- H. Hearnshaw, D. Unwin: Visualization in Geographical Information Systems, John Wiley & Sons, Chichester, 1994
- G.M. Nielson; H.Hagen; H.Müller: Scientific Visualization, IEEE Computer Society Press, Los Alamitos, 1997

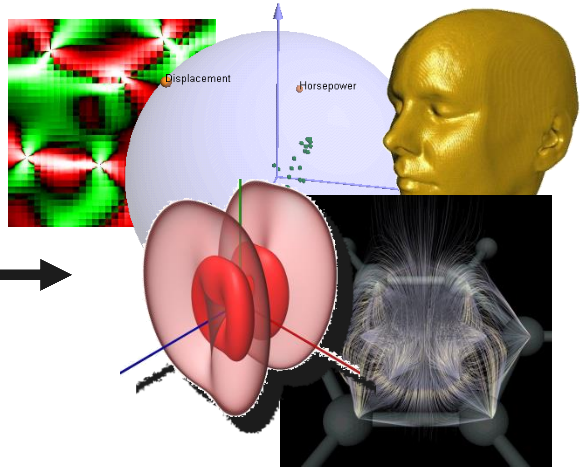
- Introduction
- Visualization Meta
- Visualization Pipeline
- Data Description: Variables, Sampled Data, Continuous Data
- Multiparameter Visualization
- Volume Visualization
- Flow Visualization
- Feature-based Visualization
- Topological Data Analysis

Introduction

Problem Description



Visualization



large

complex

various structures

„Visualization“ means to find an appropriate visual representation for a given (large) data set in order to allow a more effective analysis and evaluation of the data.

- **Aim:**
  - not only see the data but gain understanding and insight into the data
  - show what is really going on inside the data,
  - reveal important structures and correlations in the data
- **Motivation:**
  - human eye is able to recognize a high amount of data instantaneously

- Visualization simplifies
  - the analysis,
  - the understanding and
  - the communication
- of
  - models,
  - concepts and
  - data
- in science, engineering, and society.

- **This means, Visualization**
  - provides appropriate visual representations for the scientist
  - shows inner correlations of the data which were lost otherwise, and
  - supports the exchange of exploration results

Visualization is used in 3 ways:

- **Explorative analysis**
  Given: Data without hypotheses about them
  Process: interactive search for information, usually by chance
  Results: Visualization which supports a hypothesis on a data set

- **Confirmative analysis**
  Given: Hypothesis about data
  Process: Specific checking of hypothesis
  Result: Visualization which supports verification/falsification of a hypothesis

- **Presentation**
  Given: already known facts
  Process: Recognizing these facts
  Results: Visualization which emphasizes the facts

Data Acquisition

There are three principal data sources:

- **real world**

  (measuring instruments provide data, such as CT scanner or satellite images)

- **theoretical world**

  (computations based on mathematical models, such as molecule modeling and meteorology)

- **artificial world**

  (human creates data, for instance in art, television, film)

Visualization, DD2257

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Introduction

History

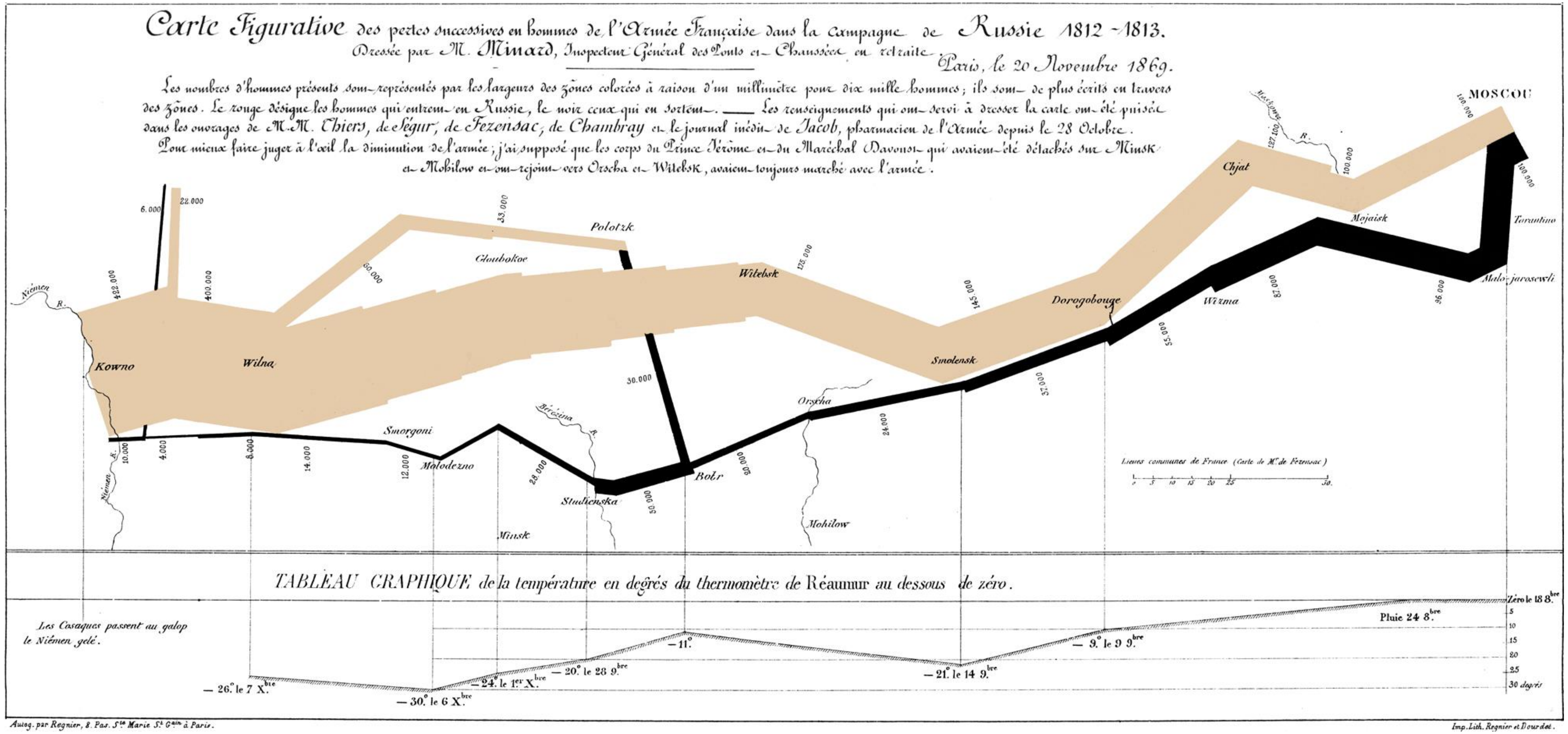
- Idea of (spatial) visualization very old
- **Euclid’s ”Elements**”: drawings to represent and illustrate properties in geometry.
- **Middle Ages**: astronomical maps with arrow plots to visualize prevailing winds over the oceans.
- **18th century**: height lines used in topographical maps

- **Alexander von Humboldt** (German scientist and explorer, 1769 – 1859)

  Investigations of temperature gradients on the northern hemisphere. (1817)

- **René Descartes** (French philosopher, mathematician, physicist, 1596 – 1650)

  ”Imagination or visualization, and in particular the use of diagrams, has a crucial part to play in scientific investigations”. (1637)

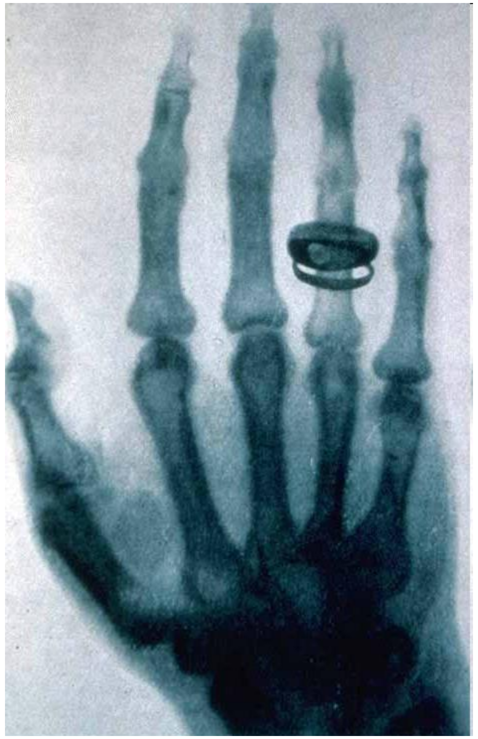


1869 Cartography by Charles Joseph Minard

Napoleons campaign against Russia (1812/13)

- **Wilhelm Conrad Röntgen** (German physicist, 1845 – 1923)

  X-rays (1895)
  first Nobel Prize in Physics (1901)



- **Rosalind Franklin** (British biophysicist, 1920 – 1958)

  X-ray diffraction images of DNA (1952)

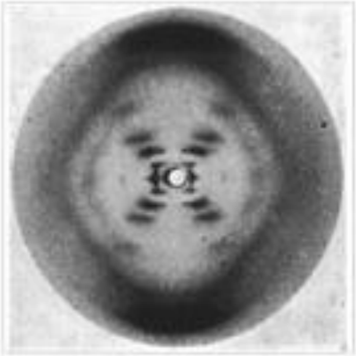
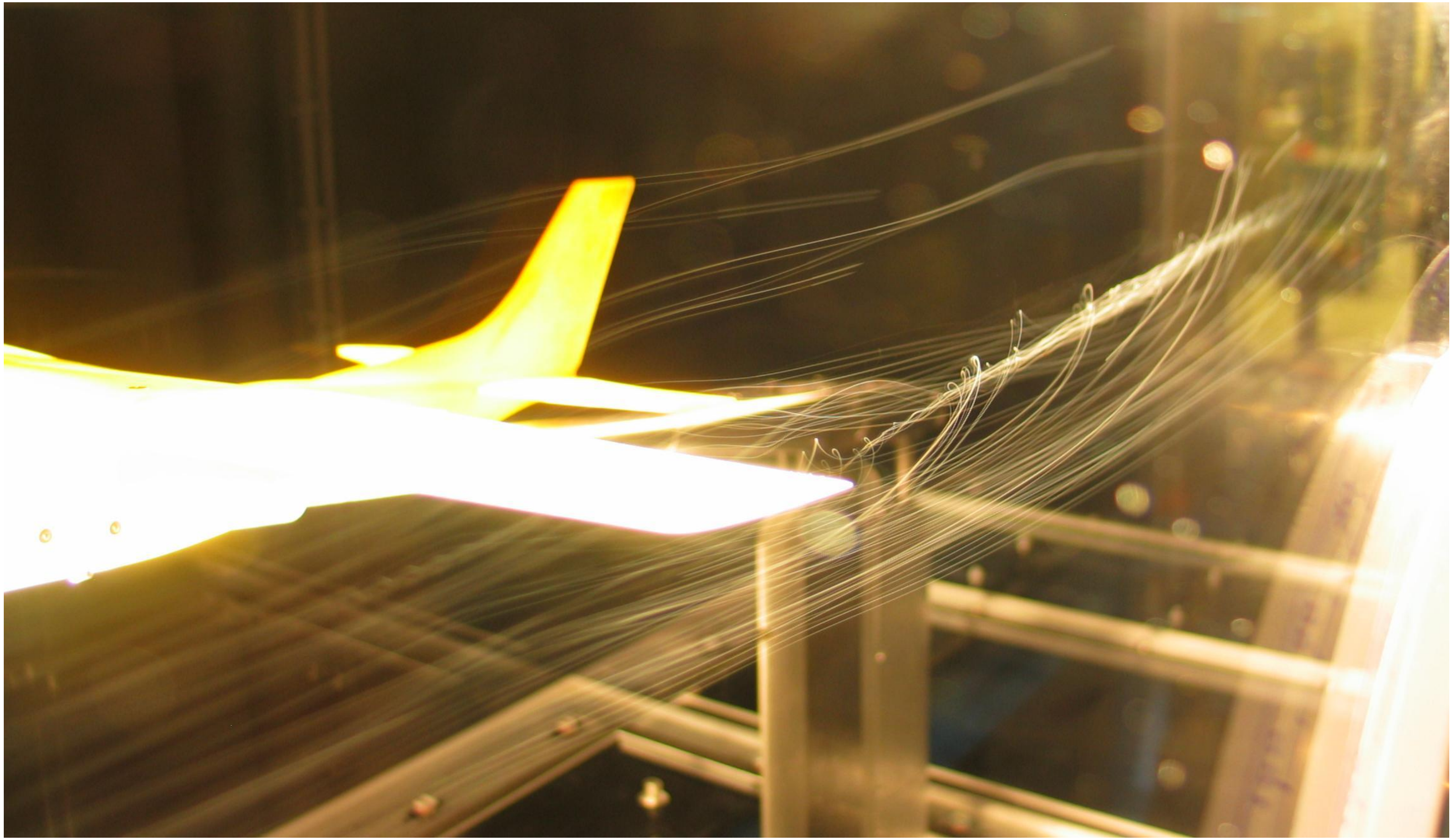


Photo 51
X-ray diffraction image of sodium
salt of DNA. B configuration

Nobel prize went to Watson, Crick, and Wilkins in 1962

- NASA: Experimental flow visualizations (1970s)

Smoke angel
A C-17 Globemaster III from the 14th Airlift Squadron, Charleston Air Force Base, S.C. flies off after releasing flares over the Atlantic Ocean near Charleston, S.C., during a training mission on Tuesday, May 16, 2006. The "smoke angel" is caused by the vortex from the engines.
(U.S. Air Force photo/Tech. Sgt. Russell E. Cooley IV)



A wind tunnel model of a Cessna 182 showing a wingtip vortex.
Tested in the RPI (Rensselaer Polytechnic Institute) Subsonic Wind Tunnel.
By Ben FrantzDale (2007).

- upcoming computer technology: new challenges!
- virtual experiments, where the real ones are too expensive or dangerous
- larger data sets
- new opportunities to create visual representations (Computer Graphics)
- 1987: Visualization becomes discipline of its own
  - 1987 Marching Cubes
  - 1987 Parallel Coordinates
  - 1989 Vector Field Topology
  - 1993 Line Integral Convolution

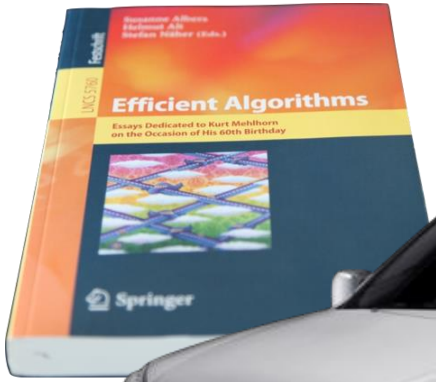
- Since 1990: annual IEEE Visualization Conference
- Since 1999: annual Eurographics Symposium/Conference on Visualization (EuroVis)
- journals, books...
- many research groups worldwide, strong funding

- Global data volume (stored) at the end of 2009:
  ➔ 800 exabytes

- Square Kilometre Array (SKA)
  - Radio telescope under development in Australia and South Africa
  - Total collecting area of approximately one square kilometer
  - Fully operational by 2024
    - construction begins 2016
    - initial observations begin 2019
  - IBM expects more than **1 exabyte** of information **every day**

Kilobyte
1,000 bytes, 10^3

Megabyte
1,000,000 bytes, 10^6



Gigabyte
1,000,000,000 bytes, 10^9

Terabyte
1,000,000,000,000 bytes, 10^{12}

1-2 TB: An academic research library

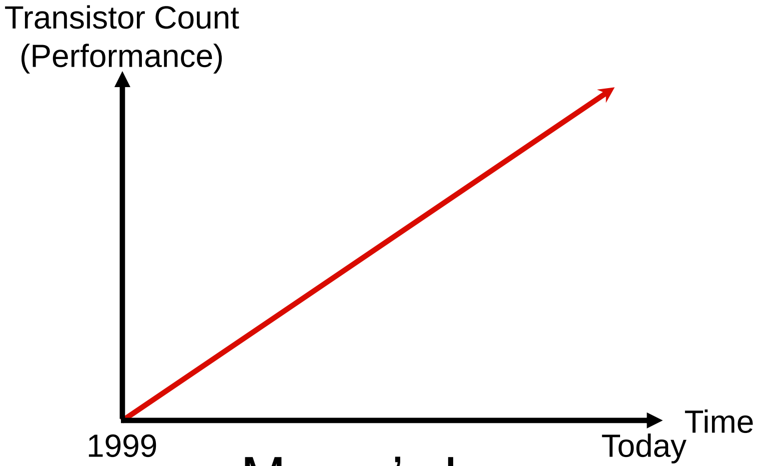
50,000 trees made into paper

Petabyte
1,000,000,000,000,000 bytes, 10^{15}

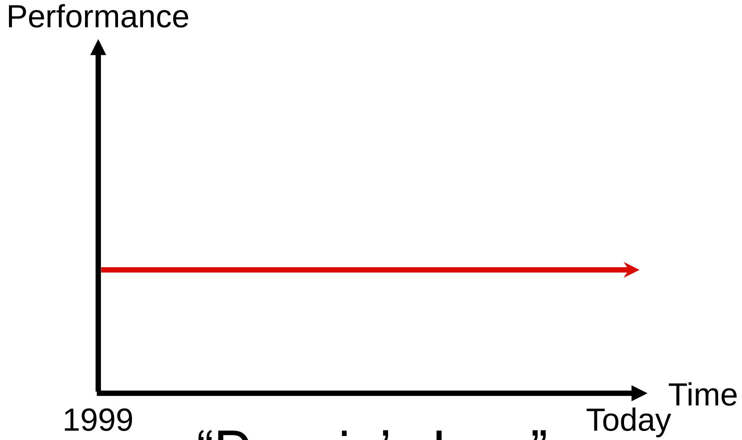
200 PB: All printed material

4 PB: A human life
(87 years of 1080p HD recording, Blu-Ray encoding)

Petabyte
1,000,000,000,000,000 bytes, 10^{15}



Moore's Law



"Darwin's Law"

Today, a simulation on a supercomputer can yield up to a few petabyte.

4 PB: A human life
(87 years of 1080p HD recording, Blu-Ray encoding)

The Human Visual System

Information

↓

aggregate
filter
visualize

↓

Visual System

↓

understand