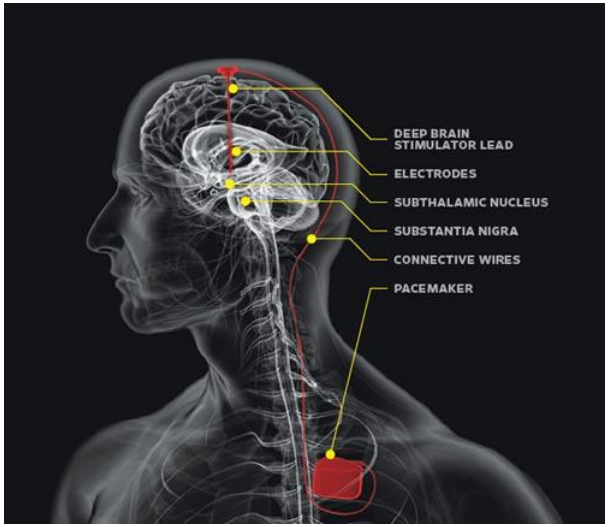
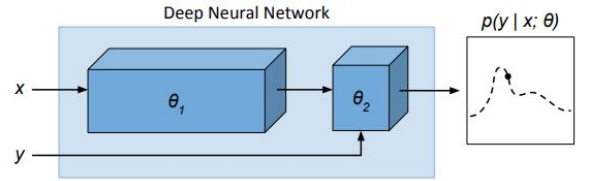
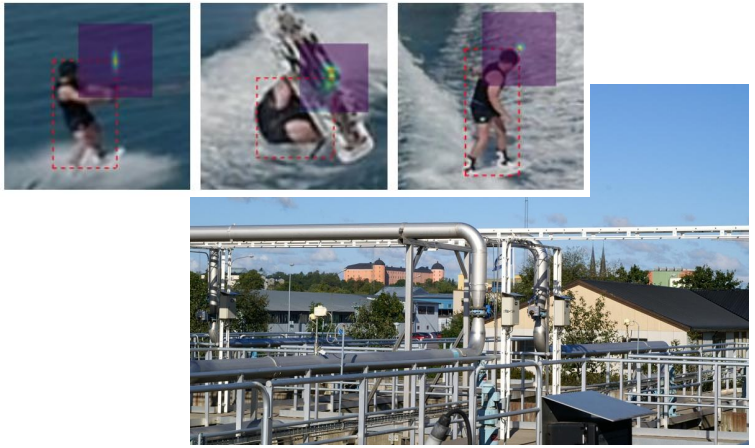


Division of Systems and Control

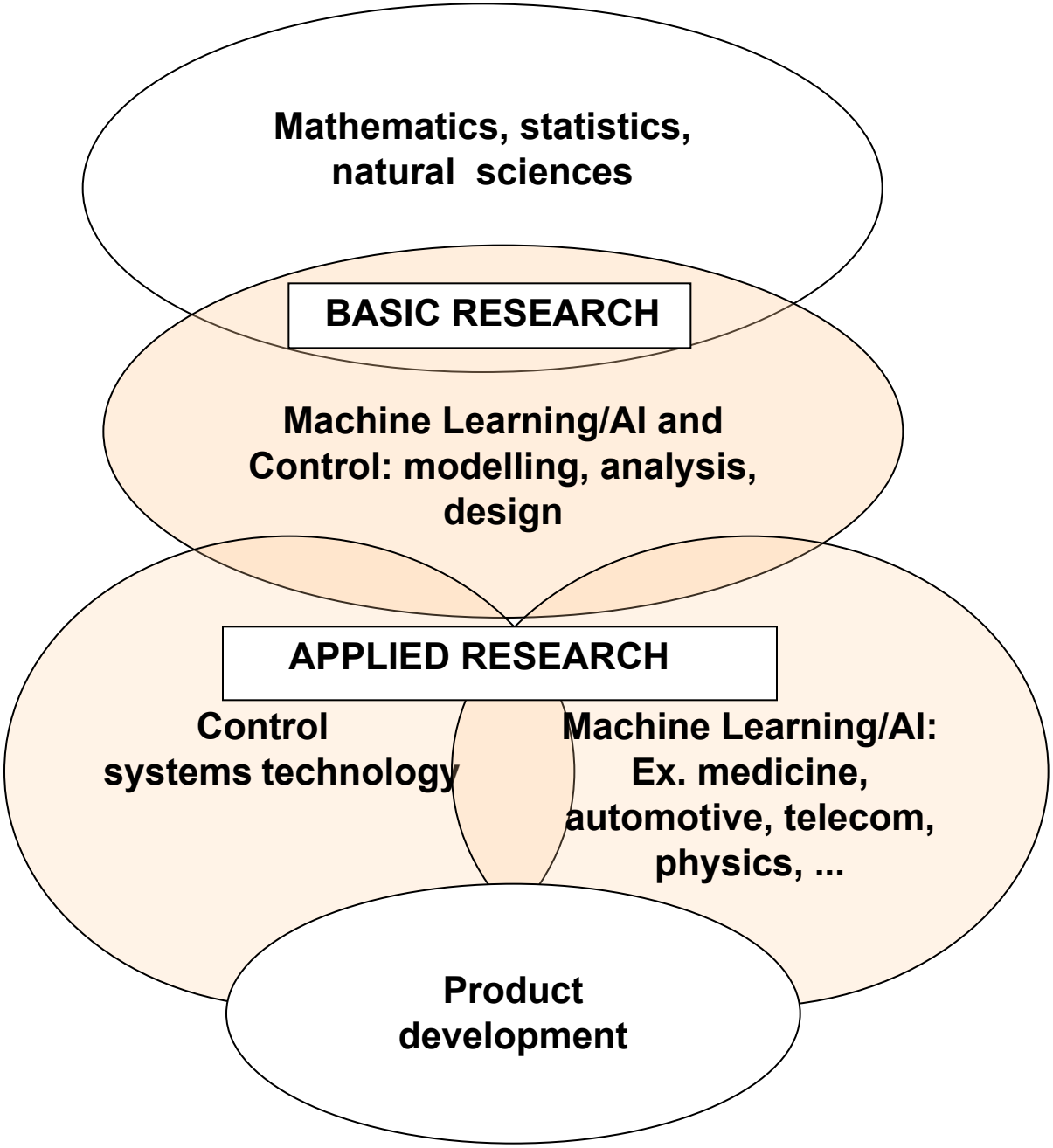
Presentation 2021





Today's program

1. Division of Systems and Control – a brief overview (Stefan)
2. Undergraduate courses (Hans)
3. Research in Automatic Control (Alexander)
4. Research in Artificial Intelligence (Thomas)
5. PhD courses and outreach (David)


Mathematics, statistics,
natural sciences
BASIC RESEARCH
Machine Learning/AI and
Control: modelling, analysis,
design
APPLIED RESEARCH
Control
systems technology
Machine Learning/AI:
Ex. medicine,
automotive, telecom,
physics, ...
Product
development

Characteristics

- Internationally recognized research in **System identification**, **Signal processing**, and **Machine Learning**
- Common theoretical ground – **Dynamical systems**
- **Application driven research** – Motivates and stimulates theoretical development
- Main application areas include:
  Biomedical Systems, Automotive Industry, Environmental systems, Telecommunications, Safety and Security in Control Systems
- Our PhDs/post-docs find good future careers both in industry (e.g., ABB, Ericsson, Klarna, Über, Öhlins Racing, ÅF, Prevas) and at universities (e.g., Columbia, Linköping, Chalmers)

Personnel

- Professors
  - Bengt Carlsson
  - Alexander Medvedev
  - Thomas Schön
  - David Sumpter
- Professor Emeritus
  - Torsten Söderström
  - Petre Stoica
- Visiting researcher Torbjörn Wigren (Ericsson)
- ~7 Teachers and Researchers
- 23+ PhD-students (incl guests and IndD)

Courses and teaching at SysCon

- **Volume**
  - 126 HÅS/FTE ⇔ 9% of IT budget (excl. master theses)
- **Our students**
  - ~20% from master programs
  - ~80% from engineering programs:
    - mainly from F, STS, W, ES, E, IT
- **Our courses** *(in total 15-17 courses)*
  - **G/Bach level:** 5 courses, ~46 HÅS/FTE
  - **A/Master level:** 10 (12) courses, ~80 HÅS/FTE
  - **Subjects:**
    - *Automatic Control:* 6 courses, 9 instances, 50 HÅS/FTE
    - *Machine Learning:* 3 courses (5 incl. 7.5hp versions), 4 instances, 42 HÅS/FTE
    - *Modelling (and others):* 6 courses, 6 instances, 34 HÅS/FTE

Courses and teaching at SysCon

Volume

- 15-17 courses
- 5 new courses in three years
- 126 HÅS/FTE ⇔ 9% of IT budget (excl. master theses)

Our students

- ~20% from master programs
- ~80% from engineering programs:
  - *mainly from F, STS, W, ES, E, IT*

Level

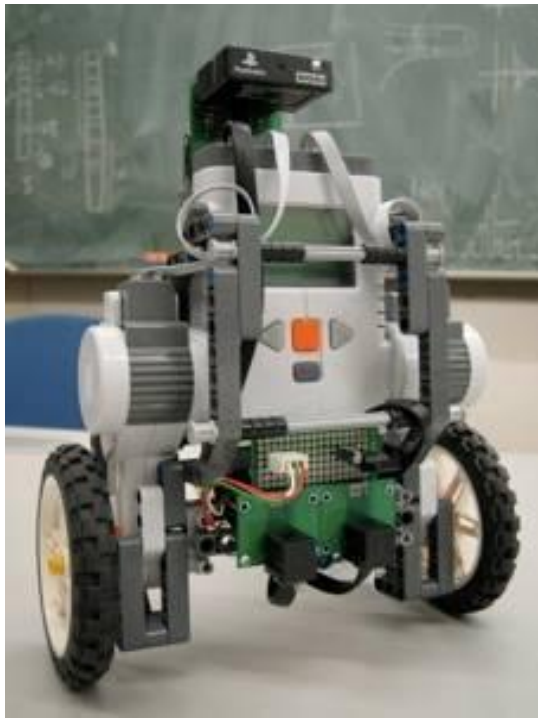
- *G / Bachelor level:* 5 courses, ~46 HÅS/FTE
- *A / Master level:* 10 (12) courses, ~80 HÅS/FTE

Courses and teaching at SysCon

Subjects *(very roughly)*

Automatic Control:

- 6 courses, 9 instances, 50 HÅS/FTE



Machine Learning:

- 3 courses *(+2 incl. 7.5hp versions)*, 4 instances, 42 HÅS/FTE

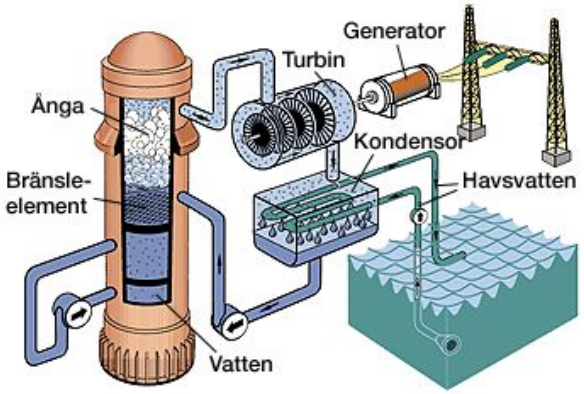
Modelling (and others):

- 6 courses, 6 instances, 34 HÅS/FTE

Research programs

1. Automatic Control (Alexander)

2. Artificial Intelligence (Thomas)



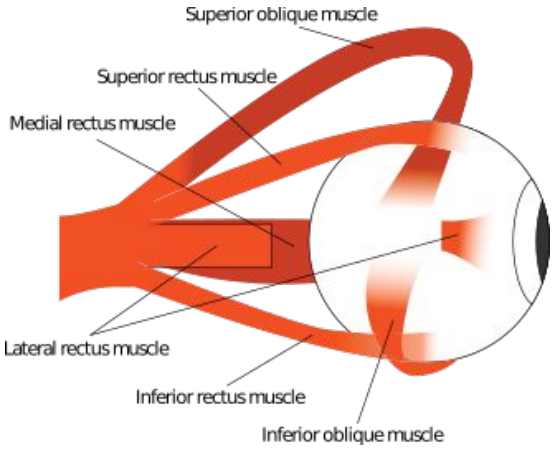
Automatic control – a technology for efficient process operation

Automatic Control

- **Method development**
  - Nonlinear system identification
  - Impulsive feedback systems
- **Control technology**
  - Biomedical systems
    - Medical signal processing
    - Closed-loop and individualized therapies
    - Endogenous biological feedback
  - Biomechanics
  - Environmental systems
    - Modelling and control of wastewater treatment plants
  - Telecommunications
    - Networked data flow control

Automatic Control

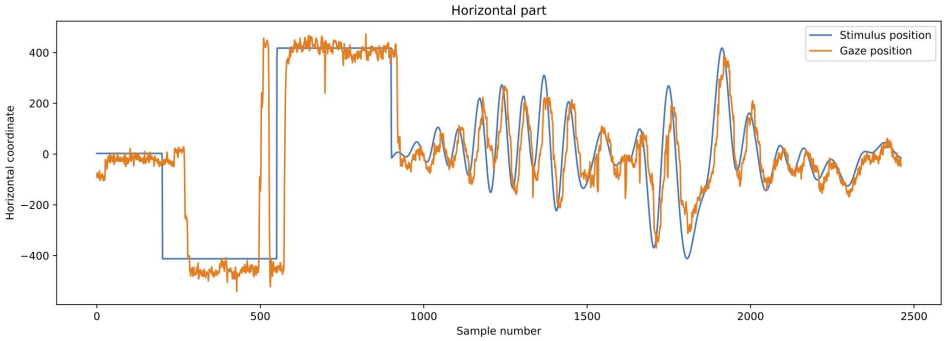
Nonlinear system identification



Project: Modeling of smooth nonlinear infinite-dimensional systems by Volterra series:

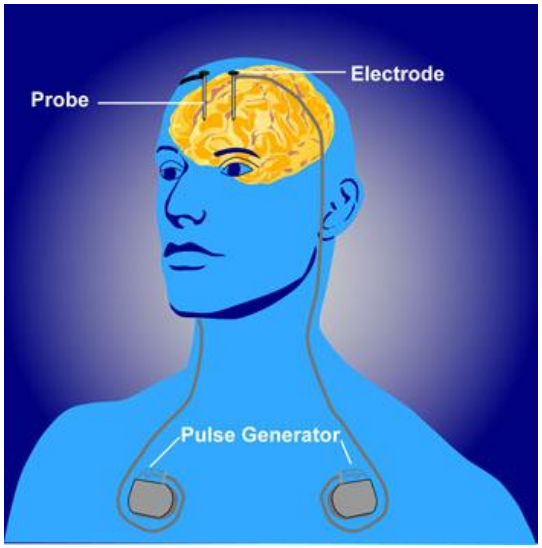
$$y(t) = y_0 + \int k_1(\theta_1)u(t-\theta_1)\,\mathrm{d}\theta_1 + \iint k_2(\theta_1,\theta_2)u(t-\theta_1)u(t-\theta_2)\,\mathrm{d}\theta_1\,\mathrm{d}\theta_2 + \dots$$

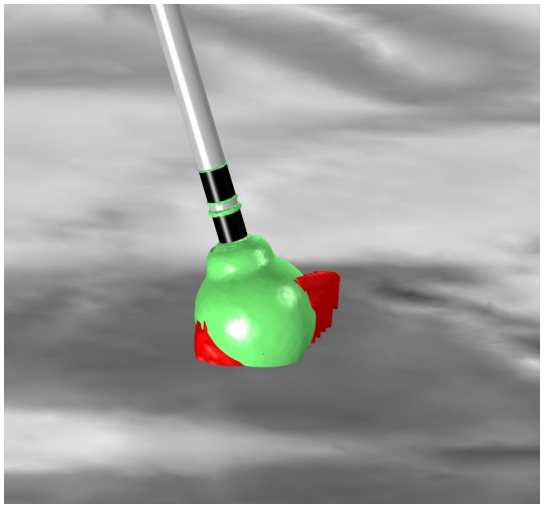
Application: Quantification of human smooth pursuit in health and disease from eye-tracking data
Result: Smooth pursuit is linear in health and nonlinear in disease



Automatic Control

Individualized therapies





Project: Individualization of deep brain stimulation (DBS)
DBS: Electrical stimulation of a target in the brain through surgically implanted electrodes
Funding: The Swedish Research Council (The EU Joint Program – Neurodegenerative Disease Research)
Partners:

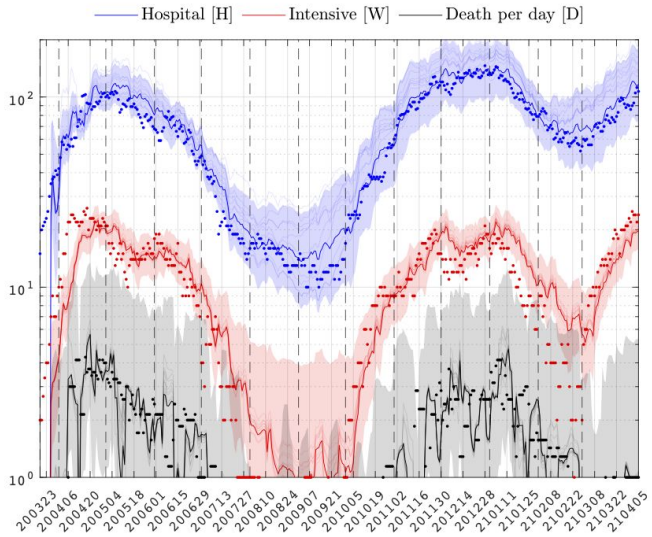
- Uppsala University Hospital
- Charité – Universitätsmedizin Berlin
- University of Amsterdam
- University of Luxembourg

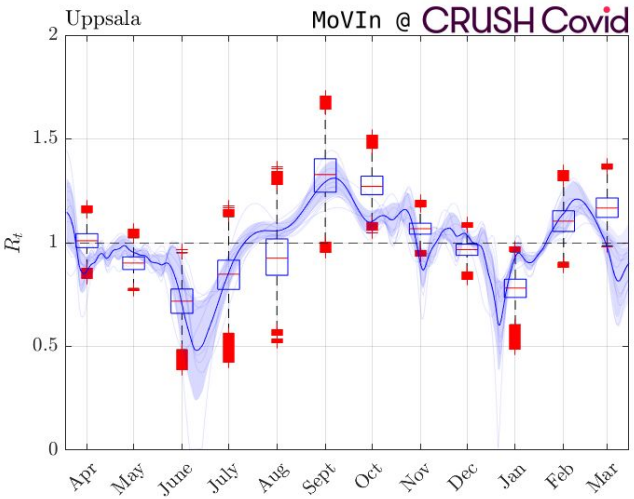
Results:

- Stimuli design formulated and solved as an *optimization problem*
- The therapeutical effect of DBS is evaluated in terms of *measurable symptoms*, e.g. tremor

Automatic Control

MoVIn@CRUSH Covid





Project: Model-based data-driven tools for optimization of proactive epidemiological interventions (part of CRUSH Covid)

CRUSH Covid is run at Uppsala University to support the authorities of Uppsala County in pandemic management

Data sources:

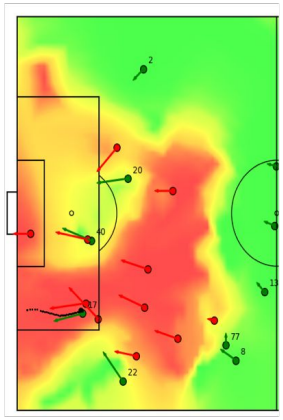
- Healthcare
- Covid-19 Symptom App
- Wastewater analysis (in cooperation with Uppsala Vatten)

Funding: Vinnova (Innovation projects that damp the spread and effects of the Covid-19 pandemic)

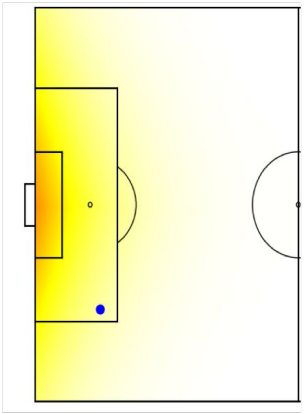
Results:

- Weekly reports with analysis and prediction of the epidemiological status
- Online public information through CRUSH Covid dashboard
- Data delivered to The Swedish Covid-19 Data Portal

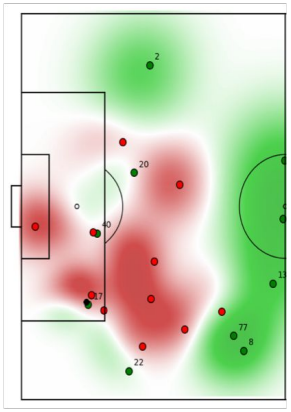
Artificial Intelligence



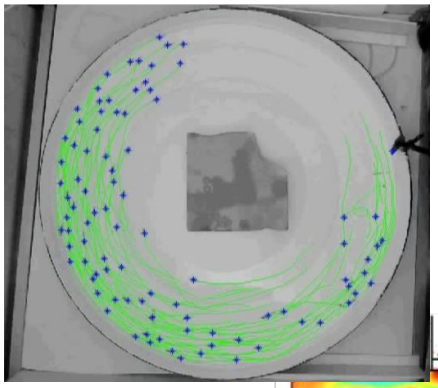
Pass Probability

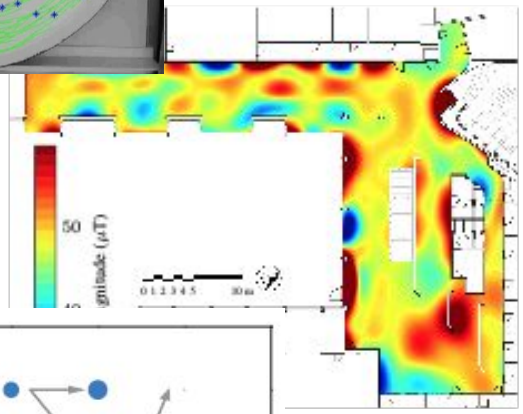


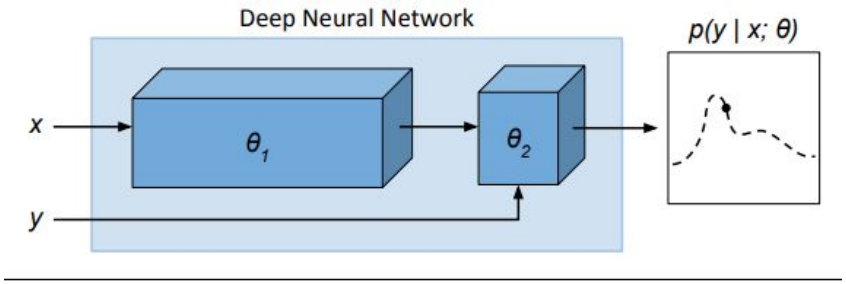
Pass Impact

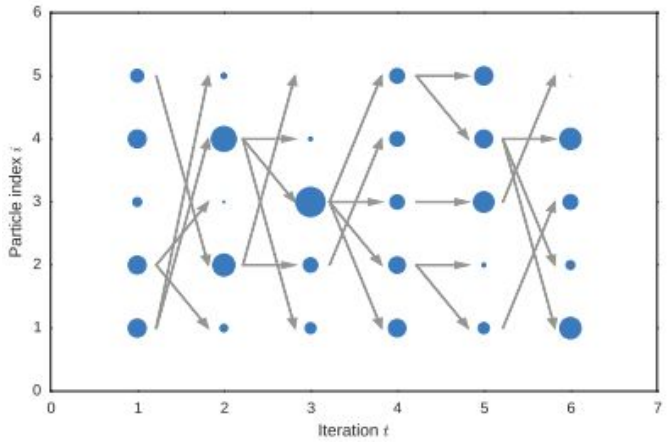


Pitch Control



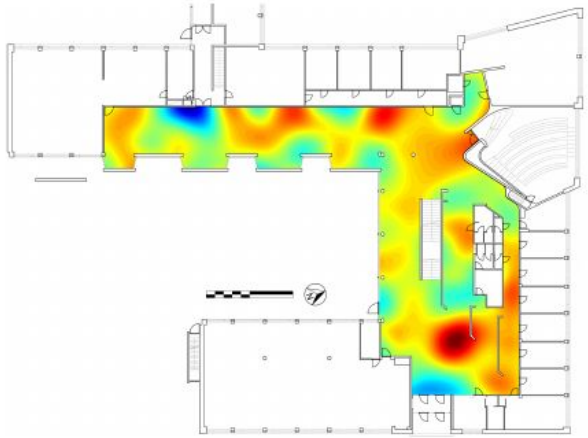




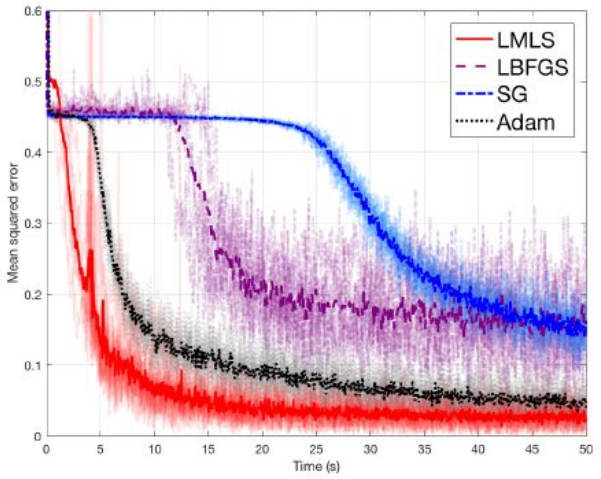


Research in Artificial Intelligence

1. **Probabilistic modelling**
   a) General: Flexible models, in particular the Gaussian process (GP), deep GPs.
   b) Specific: **Dynamical** phenomena and their surroundings.

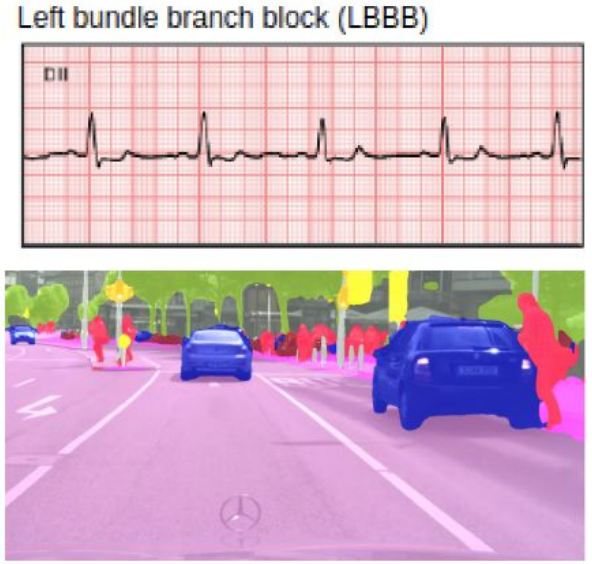


2. **Probabilistic numerics** (numerical methods and statistical models are deeply connected)
   a) Stochastic optimization (large-scale non-convex)
   b) Approximate integration/inference
      i) Sequential Monte Carlo
      ii) Variational inference
      iii) Markov chain Monte Carlo



Research in Artificial Intelligence

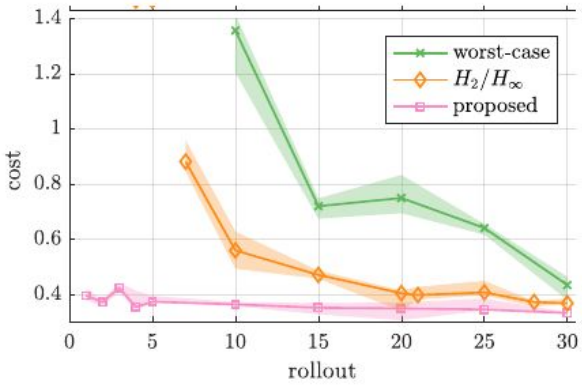
3. **Deep learning (DL)**
   a) Representing uncertainty within deep learning (including Bayesian DL)
   b) Deep GP constructions
   c) Large-scale non-convex optimization algorithms
   d) Mathematical understanding of DL



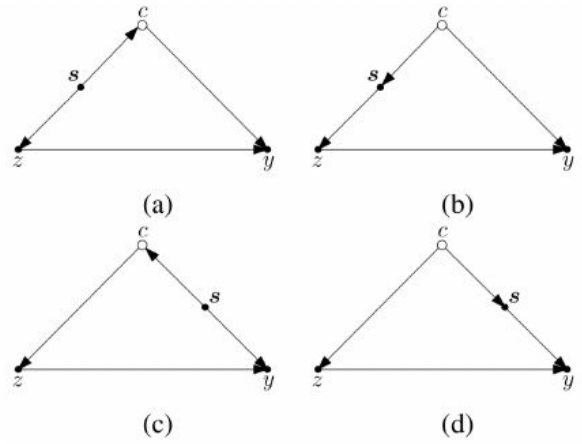
4. **Probabilistic programming**
   a) Represent probabilistic models using computer programs
   b) Potential to automate modelling!
   c) Developing our own probabilistic programming language (Birch)

Research in Artificial Intelligence

5. **Reinforcement learning/control**
   a) Intersection of reinforcement learning (RL) and robust control (RC)
   b) Given observations find a policy to optimize the expected cost (as in RL), subject to certain robust stability guarantees (as in RC)



6. **Causality** (our newest topic)
   a) Aiming to learn causal relationships (not just associations/correlations)
   b) Naturally leads to the need for combining human knowledge **and** data.



PhD-level courses

- Deep learning (5+3hp)
- Sequential Monte Carlo methods (5hp)
- Reinforcement learning (5+3hp)
- Statistical inference and learning for data science (9+3hp)

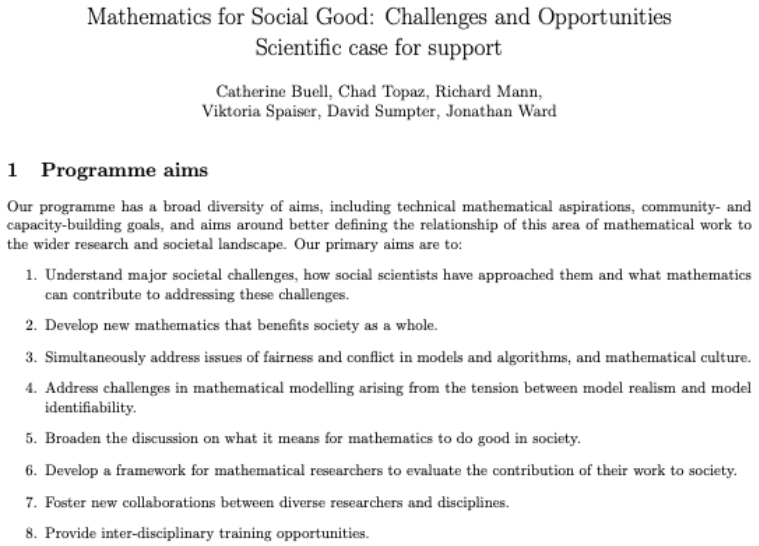
Outreach

Using maths and computer science to do social good

PhD course, autumn term.

During this course the students will conduct their own individual project to use maths, computer science, statistics, machine learning or similar methods to give insight in to and/or improve society.

For the hands-on/project part of the course the students will get help with:
1, Formulating a problem.
2, Downloading relevant data.
3, Applying tools from mathematical modelling and machine learning to the problem.
4, Presenting their work in a Youtube video and as a blog.
5, Learn how to balance rigour with time constraints.



Mathematics for Social Good: Challenges and Opportunities
Scientific case for support

Catherine Buell, Chad Topaz, Richard Mann,
Viktoria Spaiser, David Sumpter, Jonathan Ward

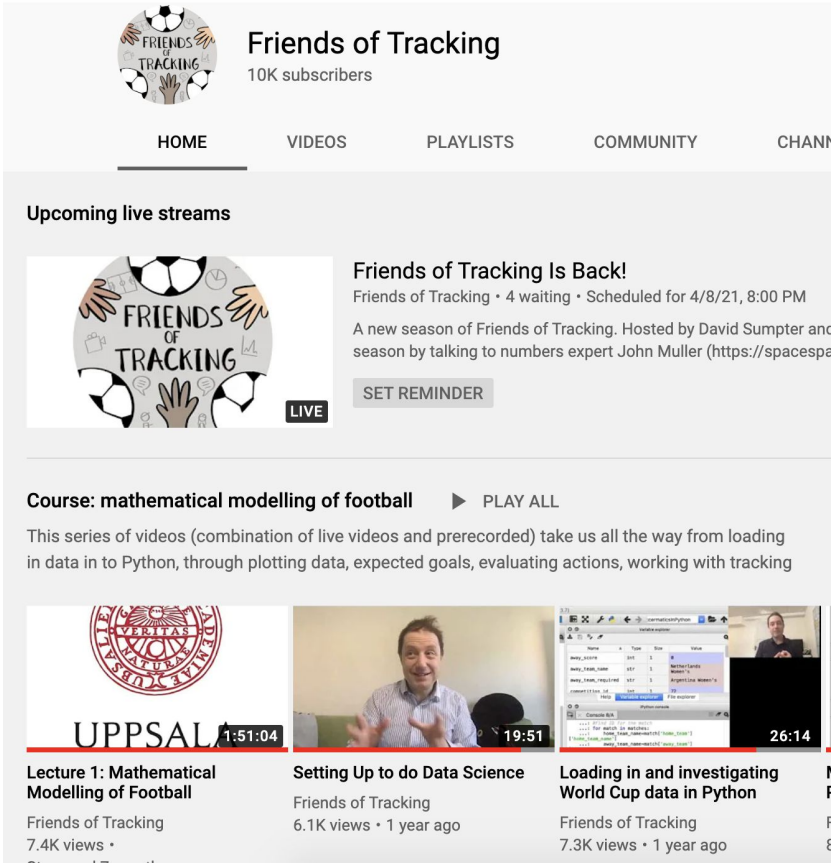
1 Programme aims

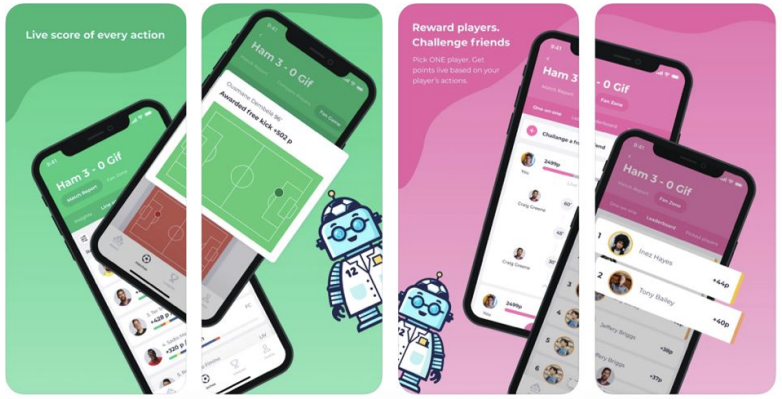
Our programme has a broad diversity of aims, including technical mathematical aspirations, community- and capacity-building goals, and aims around better defining the relationship of this area of mathematical work to the wider research and societal landscape. Our primary aims are to:

1. Understand major societal challenges, how social scientists have approached them and what mathematics can contribute to addressing these challenges.
2. Develop new mathematics that benefits society as a whole.
3. Simultaneously address issues of fairness and conflict in models and algorithms, and mathematical culture.
4. Address challenges in mathematical modelling arising from the tension between model realism and model identifiability.
5. Broaden the discussion on what it means for mathematics to do good in society.
6. Develop a framework for mathematical researchers to evaluate the contribution of their work to society.
7. Foster new collaborations between diverse researchers and disciplines.
8. Provide inter-disciplinary training opportunities.

Contact: Ida-Maria (ida.sintorn@it.uu.se)

Outreach


Friends of Tracking
10K subscribers
HOME
VIDEOS
PLAYLISTS
COMMUNITY
Upcoming live streams
Friends of Tracking Is Back!
Friends of Tracking • 4 waiting • Scheduled for 4/8/21, 8:00 PM
A new season of Friends of Tracking. Hosted by David Sumpter and
season by talking to numbers expert John Muller (https://spacespa
SET REMINDER
LIVE
Course: mathematical modelling of football
PLAY ALL
This series of videos (combination of live videos and prerecorded) take us all the way from loading in data in to Python, through plotting data, expected goals, evaluating actions, working with tracking
1:51:04
19:51
26:14
Lecture 1: Mathematical Modelling of Football
Friends of Tracking
7.4K views •
Setting Up to do Data Science
Friends of Tracking
6.1K views • 1 year ago
Loading in and investigating World Cup data in Python
Friends of Tracking
7.3K views • 1 year ago


Live score of every action
Reward players, Challenge friends


H
I
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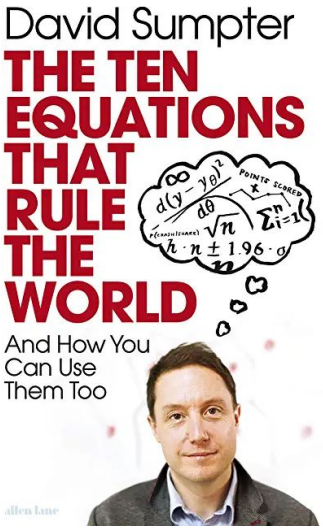
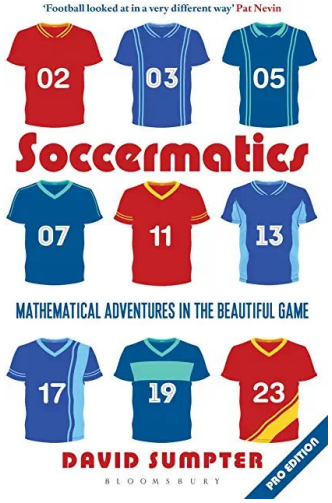
Outreach



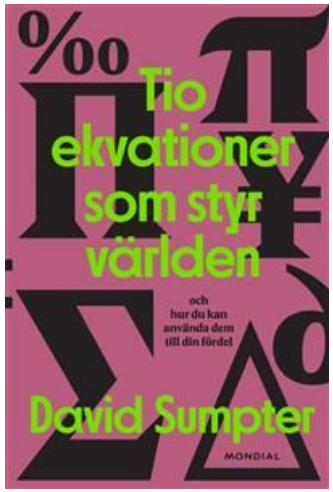


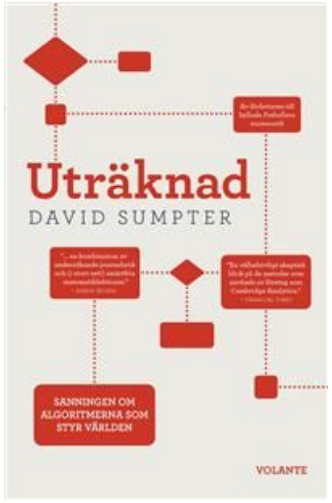
SVENSKA FÖRLÄGGARE FÖRENINGEN

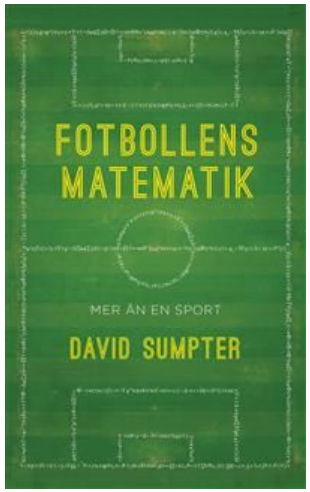
SVENSKA BOKHANDLARE-FÖRENINGEN

V 12, 22 - 28 mars 2021
FACKLITTERATUR

Plats	Författare	Titel	Förlag	B-typ
1	Sumpter, David	Tio ekvationer som styr världen : och hur du kan använda dem till din f	Mondial	Inbunden
2	Natthiko Lindeblad, Björn; Bankler, Caroline	Jag kan ha fel och andra visdomar från mitt liv som buddhistmunk	Bonnier Fakta	Inbunden
3	Eriksson, Marléne & Eriksson, Desirée	Ren städglädje : hållbara tips för hemmet, kläderna & prylarna	Norstedts	Inbunden
4	König, Catarina	Mat med guldkant : recept och menyer för vardag och fest	The Book Affair	Inbunden
5	Berggren, Henrik	Landet utanför Del 2 : Sverige och kriget 1940-1942	Norstedts	Inbunden
6	Taylor, Tareq	Mat på en plåt : smarta middagar och andra enkla ugnsrätter	Bonnier Fakta	Inbunden







The final slide...

Thanks!