Robert Mattila

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Summary

I am currently a Ph.D. student at the *Division of Decision and Control Systems* at the KTH Royal Institute of Technology. My research is centered around:

- learning and controlling stochastic dynamical systems; in particular,
- hidden Markov models (HMMs) and (partially observed) Markov decision processes;
- machine learning and optimization.

At KTH, I have taught M.Sc.-level courses on Reinforcement Learning and Stochastic Control and Optimization, as well as supervised several B.Sc. and M.Sc. theses. In general, my interests are in machine learning, data analytics and their future applications in real-world scenarios – for example, in next-generation health-care.

Selected Publications:

- **Robert Mattila**, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Inverse filtering for hidden Markov models. In *Advances in Neural Information Processing Systems (**NIPS'17**)*, 2017. [pdf]

- **Robert Mattila**, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Asymptotically efficient identification of known-sensor hidden Markov models. *IEEE Signal Processing Letters*, 2017. [pdf]

- **Robert Mattila**, Antti Siika, Joy Roy, and Bo Wahlberg. A Markov decision process model to guide treatment of abdominal aortic aneurysms. In *IEEE Conference on Control Applications (CCA)*, 2016. [pdf]

Education

- **KTH Royal Institute of Technology** — Stockholm, Sweden
  Ph.D., Department of Automatic Control — *2015 - 2020 (Projected)*
  - Supervisors: Prof. Bo Wahlberg and Assoc. Prof Cristian R. Rojas.
  - Topic: *Markovian models: Learning, control and application.*

- **KTH Royal Institute of Technology** — Stockholm, Sweden
  Licentiate Degree. Department of Automatic Control — *March, 2018*
  - Title: *Hidden Markov models: Identification, control and inverse filtering.* [pdf]
  - Opponent: **Prof. Eric Moulines** of Ecole Polytechnique (Paris, France).

- **KTH Royal Institute of Technology** — Stockholm, Sweden
  B.Sc. Engineering Physics, M.Sc. Systems, Control and Robotics — *2010 - 2015*
  - The Swedish degree of *Civilingenjör i Teknisk Fysik*.
  - Graduated in 4.5 years, instead of nominal 5 years.
  - B.Sc. GPA of 4.98/5.0 and M.Sc. GPA of 5.0/5.0 .

- **UCM, Universidad Cumplutense de Madrid** — Madrid, Spain
  ERASMUS Exchange studies — *Spring 2013*
  - All (five) courses taken were taught in Spanish (including reading material).
  - GPA of 8.13/10.0 .

- **THG, Thorildsplans gymnasium** — Stockholm, Sweden
  Natural Sciences with specialization in Mathematics and Computer Science — *2007 - 2010*
  - GPA of 20.0/20.0 .

Courses

University (Ph.D.):

- **Math:** Game Theory, Matrix Algebra, Mathematical Methods in Signals, Systems and Control (e.g., Functional Analysis)

- **Statistics:** Bayesian Networks, Probabilistic Verification and Synthesis, Probability and Random Processes, Optimal Filtering (attended lectures)

- **Machine Learning:** Partially Observed Markov Decision Processes, Convex Optimization, Stochastic Control and Optimization, Deep Learning in Data Science (attended lectures)

- **Other:** Scientific Writing, Basic Communication and Teaching, Supplementary Course in Theory and Methodology of Science, Hybrid Systems (Stability, Stabilization, Abstraction and Formal Verification)

University (M.Sc., B.Sc.):

Grade A in all courses except one B (GPA 5.0/5.0):[1]

- **Programming:** Fundamentals of Programming and Computer Science (Python, Algorithms and Data-Structures), Object-Oriented Program Construction (Java), Numerical Methods

- **Physics:** Thermodynamics, Classical Physics, Mechanics I, Mechanics II, Strength of Materials and Solid Mechanics, Modern Physics, Electromagnetic Theory, Quantum Physics, Statistical Physics, Fluid Mechanics, Atmospheric Physics, Geophysics, Solid-State Physics

- **Math:** Linear Algebra, Single-Variable Calculus, Multi-Variable Calculus, Complex Analysis, Differential Equations and Transforms II, Mathematical Methods in Physics (Vector Analysis, Partial Differential Equations), Probability Theory and Statistics

- **Systems:** Automatic Control, Modelling of Dynamical Systems, Mathematical Systems Theory, Nonlinear Control, Hybrid and Embedded Control Systems, Geometric Control Theory, Advanced Control Theory and Practice, Optimal Control Theory

- **Other:** Theory and Methodology of Science, Spanish B1, Spanish B2

Other:

- NVIDIA Deep Learning Institute:
  - *Fundamentals of Deep Learning for Computer Vision*
    - `https://courses.nvidia.com/certificates/20ceae161e844e13a5a3ea35cf15e905`
  - *Medical Image Segmentation with DIGITS*
  - *Image Segmentation with TensorFlow*

Skills, Merits and Awards

- **Computer Skills:**

Programming:	Matlab, Python, Julia, Java
Operating Systems:	OSX, Linux, Windows
Other:	LaTeX, git

- **Languages:** Swedish (native), English (fluent) and Spanish (intermediate).

- **Awards:**

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[1]Grading scale: Excellent (A), Very Good (B), Good (C), Satisfactory (D), Sufficient (E)

- Awarded Jubilee Appropriation from the Knut and Alice Wallenberg foundation in 2018.

- Awarded the KTH Electrical Engineering Scholarship of Excellence (1 MSEK) in 2015.

- Awarded travel scholarship from the Borgquist Foundation in 2015.

- Awarded a SURF scholarship from Caltech to work with Prof. Richard Murray in 2014.

- Awarded the Henrik Göransson's Sandviken Scholarship and the KTH Student Scholarship (twice) for outstanding grades during B.Sc. and M.Sc. studies.

- Participated in the final of *Wallenbergs Fysikpris 2010* (Swedish qualifications for the International Physics Olympiad).

- Awarded scholarship for outstanding grades when graduating from THG.

- **Reviewer** for:

  - IFAC American Control Conference (ACC),

  - IFAC Automatica journal,

  - IEEE Conference on Decision and Control (CDC),

  - ACL Conference on Learning Theory (COLT),

  - IEEE Signal Processing Letters (SPL).

- **KIBok** (`www.kibok.se`): A website for buying and selling used medical textbooks, aimed for students at the Karolinska Institute. The website was developed using Python and Django, and has been running since 2013.

- Hold a Swedish driver's license (B).

Teaching

- **EL2805 Reinforcement Learning**   KTH
  Teaching assistant, 120 students   *Autumn 2018*

  The course provides an in-depth treatment of the modern theoretical tools used to devise and analyse RL algorithms. It includes an introduction to RL and to its classical algorithms such as Q-learning, and SARSA, but further presents the rationale behind the design of more recent algorithms, such as those striking optimal trade-off between exploration and exploitation. The course also covers algorithms used in recent RL success stories, e.g., deep RL algorithms.

- **EL2800 Stochastic Control and Optimization**   KTH
  Teaching assistant   *Autumn 2017*

  This course introduces basic theories and methodologies for the analysis and the design of stochastic control policies, including: Markov chains, Markov Decision Process (MDP), Dynamic Programming and value / policy iteration methods, design of approximate controllers for MDPs, stochastic linear quadratic control and Multi-Armed Bandit problems.

- **EL1000 Automatic Control**   KTH
  Teaching assistant   *Autumn 2016*

  An introductory course on control systems. It provides the students with the basic engineering knowledge of dynamic systems and feedback.

- **EL1000 Automatic Control**   KTH
  Teaching assistant   *Autumn 2015*
  See above.

Supervision

- **Bachelor Thesis** — KTH
  Supervisor of Ossian Krödel and Rasmus Jerndal — *Spring 2018*
    - Title: *Portfolio Optimization with Market State Analysis*

- **Bachelor Thesis** — KTH
  Supervisor of Gustav Ekman and Fredrik Rubin — *Spring 2018*
    - Title: *Portfolio Inversion: Finding Market State Probabilities from Optimal Portfolios*

- **Master Thesis** — KTH
  Supervisor of Daniel Merkoulova — *Spring 2017*
    - Title: *Optimal Input Design by Model Predictive Control for System Identification*

- **EH1010 Project Course in Electrical Engineering** — KTH
  Supervisor of six students — *Spring 2016*
    - Modeling and designing various control architectures for a segway. Implementation in Java.

Academic and Professional Experience

- **IFAC Symposium on System Identification (SYSID'18)** — Stockholm, Sweden
  Volunteer in the organizing crew — *Summer 2018*

- **Cornell Tech, Cornell University** — Manhattan, USA
  Invited researcher by Prof. Vikram Krishnamurthy — *Summer 2017*
    - Worked on inverse problems for Bayesian optimal filters.

- **VUB-ELEC, Workshop on System Identification** — Brussels, Belgium
  Included courses on — *Summer 2017*
    - Frequency response function measurements (non-parametric tools), dynamic system identification (parametric tools) and control-oriented system identification by, among others, John Lataire, Yves Rolain, Rik Pintelon, Ivan Markovsky, Philippe Dreesen and Simone Formentin.

- **S^{3}CS, Swedish Summer School in Computer Science** — Djurö, Sweden
  The courses were taught by — *Summer 2016*
    - Michael Mitzenmacher (Hashing Algorithms);
    - Sergei Vassilvitskii (Algorithms for Modern Parallel Systems).

- **UBC, University of British Columbia** — Vancouver, Canada
  Invited researcher by Prof. Vikram Krishnamurthy — *Summer 2015*
    - Worked on method of moments for hidden Markov models.

- **UBC, University of British Columbia** — Vancouver, Canada
  Master thesis with Prof. Vikram Krishnamurthy — *Autumn 2014*

- **Caltech, California Institute of Technology** — Pasadena, USA
  SURF in the Control and Dynamical Systems (CDS) group — *Summer 2014*
    - Supervisors: Prof. Richard M. Murray and Asst. Prof. Yilin Mo
    - Developed an improved abstraction algorithm for the correct-by-construction controller synthesis framework TuLiP (implemented in Python).

- **KTH, Royal Institute of Technology** — Stockholm, Sweden
  Research intern for Prof. Bo Wahlberg — *Summer 2013*

- **ZJU, Zhejiang University** — Hangzhou, China
  Participated in the Joint Research Center of Photonics Workshop — *Summer, 2012*
    - Implemented optical logic gates exploiting non-linearities in fibers.

- **Stockholm Vatten AB** Stockholm, Sweden
  Summer intern *Summer 2012*
- **Stockholm Vatten AB** Stockholm, Sweden
  Summer intern *Summer 2011*
  - Warehouse work including: collecting and delivering items; cleaning and repairing machines; contacting customers; administrative work in the supply system Agresso.

References

Available upon request.

Publications

Journals

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Asymptotically efficient identification of known-sensor hidden Markov models. *IEEE Signal Processing Letters*, 24(12):1813–1817, 2017.

Conferences

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Inverse filtering for linear Gaussian state-space systems. In *Proceedings of the 57th IEEE Conference on Decision and Control (CDC'18)*, 2018.

- Roberto G. Ramírez-Chavarría, Gustavo Quintana-Carapia, Matias I. Müller, Robert Mattila, Daniel Matatagui, Celia Sánchez-Pérez, Bioimpedance parameter estimation using fast spectral measurements and regularization. In *Proceedings of the 18th IFAC Symposium on System Identification (SYSID'18)*, 2018.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Inverse filtering for hidden Markov models. In *Advances in Neural Information Processing Systems (**NIPS'17**)*, pages 4207–4216, 2017.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Identification of hidden Markov models using spectral learning with likelihood maximization. In *Proceedings of the 56th IEEE Conference on Decision and Control (CDC'17)*, pages 5859–5864, 2017.

- Antti Siika, Robert Mattila, Bo Wahlberg, and Joy Roy. An optimal gender- specific treatment policy for abdominal aortic aneurysms constructed using a Markov decision process model. *Journal of Vascular Surgery*, 65(6, Supplement):175S, 2017. Abstracts of the 2017 Vascular Annual Meeting (VAM'17).

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, and Bo Wahlberg. Computing monotone policies for Markov decision processes: a nearly-isotonic penalty approach. In *Proceedings of the 20th IFAC World Congress*, volume 50, pages 8429 – 8434, 2017.

- Robert Mattila, Antti Siika, Joy Roy, and Bo Wahlberg. A Markov decision process model to guide treatment of abdominal aortic aneurysms. In *Proceedings of the IEEE Conference on Control Applications (CCA'16)*, pages 436–441, 2016.

- Robert Mattila, Vikram Krishnamurthy, and Bo Wahlberg. Recursive identifi- cation of chain dynamics in hidden Markov models using non-negative matrix factorization. In *Proceedings of the 54th IEEE Conference on Decision and Control (CDC'15)*, pages 4011–4016, 2015.

- Robert Mattila, Yilin Mo, and Richard M. Murray. An iterative abstraction algorithm for reactive correct-by-construction controller synthesis. In *Proceedings of the 54th IEEE Conference on Decision and Control (CDC'15)*, pages 6147–6152, 2015.

- Robert Mattila, Cristian R. Rojas, and Bo Wahlberg. Evaluation of spectral learning for the identification of hidden Markov models. *Proceedings of the 17th IFAC Symposium on System Identification (SYSID'15)*, 48(28):897–902, 2015.

Theses

- Robert Mattila, *Hidden Markov models: Identification, control and inverse filtering.* Licentiate thesis, KTH Royal Institute of Technology. Stockholm, Sweden, 2018. Supervisors: Prof. Bo Wahlberg and Assoc. Prof. Cristian R. Rojas.

- Robert Mattila, *On Identification of Hidden Markov Models Using Spectral and Non-Negative Matrix Factorization Methods.* Master's thesis, KTH Royal Institute of Technology. Stockholm, Sweden, 2015. Supervisors: Prof. Bo Wahlberg and Assoc. Prof. Cristian R. Rojas.

- Robert Mattila, *Including Bathymetric Data in Autonomous Surface Vessels' Maneuvering Optimisation Tool.* Bachelor's thesis, KTH Royal Institute of Technology, Stockholm, and Universidad Cumplutense de Madrid (UCM), 2013. Supervisors: Prof. Juan Jiménez and José María Benítez.

Other

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Method of Moments for Learning Hidden Markov models.* Poster at the 2018 Workshop of the European Research Network on System Identification (ERNSI), September, Cambridge, UK.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Inverse Filtering for Linear Gaussian State-Space Models.* Presentation at the 2018 Swedish Control Conference (Reglermötet), June, Stockholm, Sweden.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Inverse Filtering for Hidden Markov Models.* Poster at the 2018 WASP AI4X Industry, February, Stockholm, Sweden.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Inverse Filtering for Hidden Markov Models.* Poster at the 2017 Workshop of the European Research Network on System Identification (ERNSI), September, Lyon, France.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Method of Moments Identification of Hidden Markov Models with Known Sensor Uncertainty Using Convex Optimization.* Poster at the 2016 Workshop of the European Research Network on System Identification (ERNSI), September, Cison di Valmarino, Italy.

- Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy and Bo Wahlberg, *Method of Moments Identification of Hidden Markov Models with Known Sensor Uncertainty Using Convex Optimization.* Poster at Reglermötet 2016, June, Göteborg, Sweden.

- Robert Mattila, Vikram Krishnamurthy and Bo Wahlberg, *Recursive Method of Moments Identification of Hidden Markov Models using Convex Optimization.* Poster at the 2015 Workshop of the European Research Network on System Identification (ERNSI), September, Varberg, Sweden.