Tosca Lechner

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Research Interests

Machine Learning Theory, Algorithmic Fairness, Interpretability, and Domain Adaptation.

I am interested in facilitating a better understanding of ML models and their limitations by means of a mathematical analysis. I aim to find intuitive assumptions that are meaningful in practice and lead to formal guarantees in scenarios in which common statistical assumptions break down, such as transfer learning. I believe that by developing tools that make the limitations of a model more explicit, it becomes easier to assess the trustworthiness of a model's prediction. My current research also focuses on identifying and characterizing potential sources of unfairness in automated decision making and developing new interpretable frameworks in which to address the issue of algorithmic fairness.

Education

01/2019- Present — **University of Waterloo, Cheriton School of Computer Science**.
Doctor of Philosophy (Ph.D.) in Computer Science.

- **Advisor:** Prof. Shai Ben-David.
- **Research Areas:** Machine Learning Theory, Fairness and Interpretability of ML models.
- **Relevant Courses:** ML techniques for Systems and Systems for ML, Security and Privacy for AI and ML, ML in Bioinformatics.

04/2015- 12/2018 — **Eberhard Karls University Tübingen**.
Masters in Cognitive Science.

- **Advisors:** Prof. Ulrike von Luxburg and Prof. Ruth Urner.
- **Thesis:** Domain Adaptation Under Causal Assumptions.
- **Specialization:** Machine Learning Theory.
- **Relevant Courses:** Machine Learning: Algorithms and Theory, Machine Learning Theory, Deep Neural Networks.

05/2011- 03/2015 — **LMU, Ludwig Maximilian University of Munich**.
Bachelors Degree, Major in Mathematics, Minor in Computer Science.

- **Advisor:** Prof. Christina Kuttler.
- **Thesis:** Comparison of the Hodgekin-Huxley-Model to the Fitzhugh-Nagumo-Model.
- **Specialization:** Mathematical Modeling of Biological Systems.
- **Relevant Courses:** Logic, Theory of Computation, Stochastics, Numerical Analysis, Randomized Algorithms.

Publications

Representation-Based Individual Fairness and Fair Data Representation, ***Tosca Lechner***, *Nivasini Ananthakrishnan, Sushant Agarwal and Shai Ben-David*, under review for NeurIPS 2020.
We show that the impact of an individual feature on the fairness of a presentation cannot be evaluated without considering other available features.

On Learnability with Computable Learners, *Sushant Agarwal, Nivasini Ananthakrishnan, Shai Ben-David,* ***Tosca Lechner*** *and Ruth Urner*, ALT 2020.
We introduce the notion of computable probably approximately correct (CPAC) learnability and show that there are PAC-learnable classes that cannot be properly CPAC-learned.

Ongoing Projects

Guarantees for Inherent Confidence Scores of Binary Classification Models, *joint work with Nivasini Ananthakrishnan and Shai Ben-David.*
We introduce a new confidence score i.e. a new measure, specifically to gauge the stability for general binary classification models. Along side the known *calibration criterion*, we explore the necessity of additional criteria to assess what constitutes a good notion of confidence score.

Critique of Individual Fairness, *joint work with Shai Ben-David.*
We give a literature review on current notions of individual fairness and point out the weaknesses; in particular, we criticize the focus on fairness-metrics.

Fast Tracking Algorithm for highly-dynamic Single-Molecule Localization Microscopy Data, *joint work with Marc Endesfelder, Christoph Schießl, Bartosz Turkowyd and Ulrike Endesfelder.*
We introduced a new algorithm for tracking highly-dynamic live-cell single-molecule localization microscopy by modelling the underlying probability distribution via a Bayesian network. Our algorithm has been in use in research projects at the Endesfelder Lab for and has been presented as a poster at the 4th International Conference on Physics and Biological Systems 2018.

Research Experience

09/2017-05/2018 **Research Assistant, "Domain Adaptation and Causality"**, *Max-Planck-Institute for Intelligent Systems, Tübingen, Advisors: Ruth Urner, Berhard Schölkopf.*
We analysed several formalizations of the criterion of 'Independence of Cause and Mechanism' to yield guarantees for domain adaptation. We proved lower bounds on the sample complexity of domain adaptation learners for cases with additional assumptions on the underlying causal data-structure.

06/2017-07/2017 **Research Assistant, "Theory of Machine Learning"**, *Max-Planck-Institute for Intelligent Systems, Tübingen, Advisor: Ruth Urner.*
We extended guarantees for domain adaptation from binary to multi-label classification setting.

05/2016-09/2016 **Research Internship, "Transmission of signals between prefrontal and parietal neurons involved in numerosity processing"**, *University of Tübingen, Department: Biology, Animal Physiology, Chair: Andreas Nieder.*
We analysed single cell neural data from two brain-regions involved in numerosity processing for Granger causality to detect possible top-down processing.

Teaching Experience

10/2011-Present **Teaching Assistant, "Analysis I", "Linear Algebra I & II", "Machine Learning Theory", "Logic", "Introduction to AI"**, *conducted tutorials and graded assignments and exams.*

04/2015-07/2016 **Instructor, "Mathematics and Statistics"**, *University of Applied Sciences Neu-Ulm*, gave 4 hour long lectures each week, conducted tutorials and conceived and marked exams.

Scholarships & Awards

Vector Research Grant, *Vector Institute, Toronto*, Sept 2019-Sept 2020, 6000$.

Vector Research Grant, *Vector Institute, Toronto*, Jan 2019-Sept 2019, 3000$.

Provost Doctoral Entrance Award, *University of Waterloo*, Jan-Dec 2019, 5000$.

PROMOS Travel Scholarship, *University of Tuebingen/DAAD*, Feb-Mar 2018, 750 Euro.

Deutschland-Stipendium, *National German scholarship Programm currently providing scholarships to less than 1% of German students*, May 2011-Mar 2013, 300 Euro/month.

Reviewer

Conferences **COLT 2018, IJCAI 2019, ICML 2020**.

Activities

07/2017 **Participation at Pre-Doc Summer School on Learning Systems at ETH Zurich**, *one week summer school for Machine Learning.*

04/2013-10/2016 **Establishment and Organization of the Annual Biomodels Academy, CdE e.V. (students association)**.

09/2009-12/2013 **Member of the board, Quod Erat Demonstrandum e.V. (students math association)**.

Skills

Languages **German (native), English (fluent), French (basic)**.

Programming **Python, R, Java, MATLAB, C++**.