gaier adam

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summary

Nomadic American researcher with a research background spanning evolutionary computation, robotics, and machine learning. Primarily works in and around biologically-inspired computation with neuroevolution, quality-diversity, and novelty-based approaches. Doctoral work centered on the integration of evolutionary and ML techniques.

Research Topics: evolutionary computation, design exploration, robotics, neuroevolution, machine learning, quality diversity

Highlights:
- Successful internship at Google Brain resulting in a **Spotlight presentation at NeurIPS 2019**
- Earned **3 Best paper awards** at top of field conferences in evolutionary computation and aerodynamics optimization
- Broad background in **evolutionary computation, robotics, and machine learning**

education

PhD | Computer Science
Inria, University of Lorraine | 2017-2020 (expected)
- **Thesis:** *Evolutionary Optimization of Aerodynamic Designs and Models through Illuminated Surrogates*
- **Research Topics:** Design Exploration, Evolutionary Computation, Bayesian Optimization, Quality-Diversity
- **Advisors:** Jean-Baptiste Mouret, Alexander Asteroth

MSc | Autonomous Systems
Bonn-Rhein-Sieg University | 2012-2019
- **Thesis:** *Accelerating Neuroevolution with Heredity-Based Surrogate Modeling*
- **Research Topics:** Robotics, Neuroevolution, Data-efficient Optimization
- **Advisor:** Alexander Asteroth

MSc | Evolutionary and Adaptive Systems
University of Sussex | 2011-2012
- **Thesis:** *Evolved Motor Primitives for Developmental Modulatory Networks*
- **Research Topics:** Biologically-inspired Computation, Insect Intelligence, Neuroevolution, Hypernetworks
- **Advisor:** Luc Berthouze

BSc | Computer Science
Richmond American International University in London | 2002-2005
- **Research Topics:** Species-conserving Genetic Algorithms for Design
- **Advisor:** Marton E. Balazs

recognition and awards

- Spotlight Presentation   2019
  Advances in Neural Information Processing Systems
- Best Paper Award   2018
  Complex Systems at the Genetic and Evolutionary Computation Conference (GECCO)
- Best Paper Award   2017
  Complex Systems at the Genetic and Evolutionary Computation Conference (GECCO)
- Best Paper Award   2017
  AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference (GECCO)
- Drive-E Studienpreis   2015
  National award for outstanding student work in the field of electric mobility
- Pegge Scholarship   2011
  Awarded to an Evolutionary and Adaptive Systems student with high potential

primary contributions

Gaier, Adam, and David Ha. 2019 *Weight Agnostic Neural Networks.* Advances in Neural Information Processing Systems (NeurIPS) ⚲

→ In this paper we question to what extent neural network architectures alone, without learning any weight parameters, can encode solutions for a given task. A search method was proposed for neural network architectures that can already perform a task without any explicit weight training. We demonstrated that our method can find minimal neural network architectures that can perform several reinforcement learning tasks without weight training. On a supervised learning domain, we found network architectures that achieve much higher than chance accuracy on MNIST (>90%) using random weights.

• Impact: Spotlight presentation (top 2.5% of submissions) at the Conference on Neural Information Processing Systems (NeurIPS), a top tier conference in the field of machine learning . Generated substantial conversation in the machine-learning community, on social media and in journal clubs in the US ⚲ and China ⚲.

Gaier, A., Asteroth, A. and Mouret, J.B., 2018. *Data-efficient design exploration through surrogate-assisted illumination.* Evolutionary computation, 26(3), pp.381-410. ⚲

→ The paper of record for the Surrogate-Assisted Illumination (SAIL) algorithm, an approach which integrates quality-diversity and Bayesian optimization with Gaussian process models to create a data-efficient method of producing large archives of diverse solutions. Building on work done in conference publications, aerodynamic problems are tackled – illustrating the techniques ability to extend the reach of quality-diversity algorithms to even computationally expensive domains.

• Preliminary work introducing the approach received the Best Paper award (Complex Systems) at the Genetic and Evolutionary Computation Conference (GECCO) 2017 – the premier conference for evolutionary computation. A paper pplying the approach received the Best Student Paper award at the AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, part of the AIAA Forum – the largest event for aerospace research.

• Impact: *Evolutionary Computation* (impact factor 2019: 3.826) is one of the top journals in the field of evolutionary computation. Since its publication one year ago this paper has been cited across a wide range of fields including robot learning, additive manufacturing, aerodynamics optimization, and procedural video game content generation.

Gaier, A., Asteroth, A. and Mouret, J.B., 2018, July. *Data-efficient neuroevolution with kernel-based surrogate models.* In Proceedings of the Genetic and Evolutionary Computation Conference (GECCO) (pp. 85-92). ACM. ⚲

→ We introduced a method of predicting the performance of evolved neural networks using Gaussian process models and a custom kernel which efficiently computes a hereditary distance between solutions. Integrating this model into a surrogate-assisted optimization framework we improved the data-efficiency of a state-of-the-art neuroevolution algorithm by several times.

• Impact: This work received the Best Paper award (Complex Systems) at (GECCO) 2018 – the premier conference for evolutionary computation

Gaier, A. and Asteroth, A., 2014, June. *Evolving look ahead controllers for energy optimal driving and path planning.* In 2014 IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA) Proceedings (pp. 138-145). IEEE. ⚲

→ An evolved neural network controller was presented to solve the optimal control problem for energy optimal driving of low power-to-mass vehicles. Controller computes equivalent control commands to traditional graph searching approaches, while able to adapt to varied constraints and conditions. After training, as trivial amounts of computation time and memory are required, the approach is suitable for use in embedded systems and path planning applications.

• Impact: Along with preliminary work *Evolution of optimal control for energy-efficient transport* received the Drive-E Studienpreis for outstanding student work. The Drive-E Studienpreis is national award given by the German Federal Ministry of Education and Research, the Fraunhofer Society, and the German automotive industry.

internships and summer schools

Google Brain, Tokyo (4 months)

| Worked as a research intern at Google Brain Tokyo under the supervision of David Ha ⚲

• Developed methods to evolve weight agnostic neural networks (WANN) architectures which perform with random weights

• Published tool for replication and continuation of WANN experiments ⚲

• Published general-purpose neuroevolution tool ⚲

Gaussian Process and Uncertainty Quantification Summer School (GPSS), University of Sheffield (1 week)

| A series of schools, practical exercises, and workshops aimed at understanding Gaussian process models in theory and practice. Led by Neil Lawrence, professor at University of Sheffield and Directory of Machine Learning at Amazon.

publications

Journal Publications

[1] **A Gaier**, A Asteroth, JB Mouret, 2018: "Data-efficient design exploration through surrogate-assisted illumination" *Evolutionary Computation* ⸻

[2] H Spieker, A Hagg, **A Gaier**, S Meilinger, A Asteroth, 2017: "Multi-stage evolution of single-and multi-objective MCLP" *Soft Computing* ⸻

Conference Publications

[1] **A Gaier**, D Ha, 2019: "Weight Agnostic Neural Networks" *Advances in Neural Information Processing Systems (NeurIPS)* ⸻

[2] **A Gaier**, A Asteroth, JB Mouret 2019: "Are quality diversity algorithms better at generating stepping stones than objective-based search?" *Genetic and Evolutionary Computation Conference (GECCO)* ⸻

[3] A Hagg, M Zaefferer, J Stork, **A Gaier** 2019: "Prediction of neural network performance by phenotypic modeling" *Genetic and Evolutionary Computation Conference (GECCO)* ⸻

[4] **A Gaier**, A Asteroth, JB Mouret, 2018: "Data-Efficient Neuroevolution with Kernel-Based Surrogate Models" *Genetic and Evolutionary Computation Conference (GECCO)* ⸻

[5] **A Gaier**, A Asteroth, JB Mouret, 2017: "Data-Efficient Exploration, Optimization, and Modeling of Diverse Designs through Surrogate-Assisted Illumination" *Genetic and Evolutionary Computation Conference (GECCO)* ⸻

[6] **A Gaier**, A Asteroth, JB Mouret, 2017: "Aerodynamic design exploration through surrogate-assisted illumination" *AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference* ⸻

[7] **A Gaier** 2015: "Evolutionary Design via Indirect Encoding of Non-Uniform Rational Basis Splines" *Genetic and Evolutionary Computation Conference (GECCO)*

[8] **A Gaier**, A Asteroth 2014: "Evolving look ahead controllers for energy optimal driving and path planning" *Innovations in Intelligent Systems and Applications (INISTA)* ⸻

[9] **A Gaier**, A Asteroth 2014: "Evolution of optimal control for energy-efficient transport" *Intelligent Vehicles Symposium* ⸻

teaching

Bonn-Rhein-Sieg University | Lecturer

Evolutionary Computation: Theory and Application   2015-2018
- Master's level course (8h/week)
- Designed curriculum, lectures, exercises
- 20-30 students per semester
- Top marks in department for student satisfaction

Foundations of Evolutionary Algorithms   2015
- Bachelor's level course (8h/week)
- Designed topics, lecturers, exercises

Biologically-Inspired Optimization   2013-2014
- Master's level seminar (3h/week)
- Supervised student projects on evolutionary algorithms and ant colony optimization