Seminar on **AutoAI**
Automating the Design and Analysis of AI Methods

Kickoff Meeting

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[2]LIACS, Universiteit Leiden, The Netherlands
[3]University of British Columbia, Vancouver, BC, Canada

5 May 2022

RWTH AACHEN UNIVERSITY

The nature of computation

Clear, precise instructions – flawlessly executed

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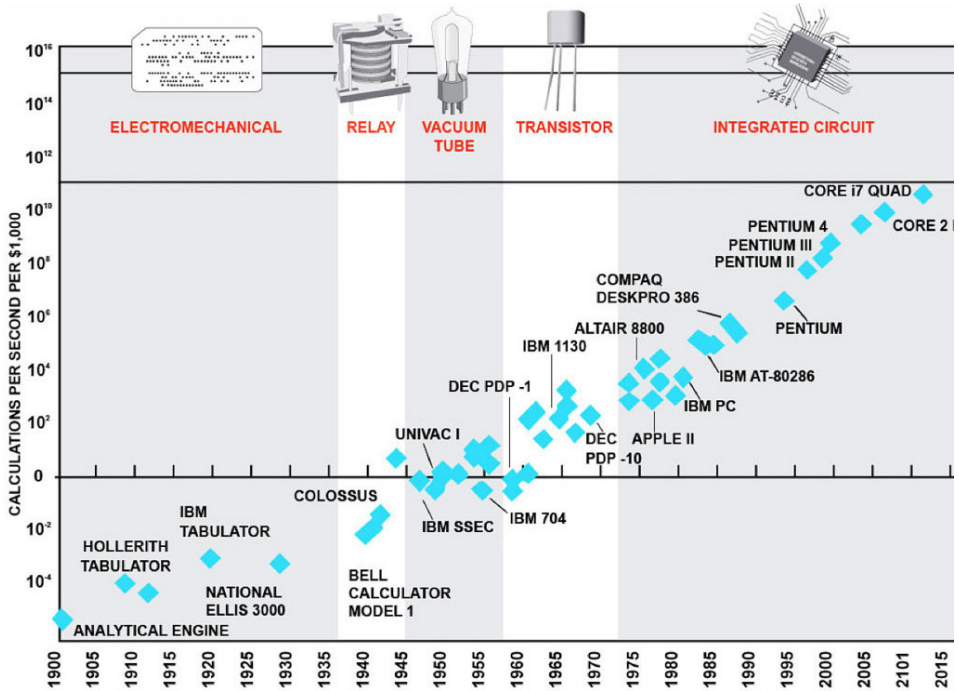
- $\rightsquigarrow$ predictable results, behaviour
- $\rightsquigarrow$ performance guarantees
- $\rightsquigarrow$ trusted, effective solutions to complex problems

Impressive progress in hardware

Exponential speed-up since 1942 ("Moore's Law")



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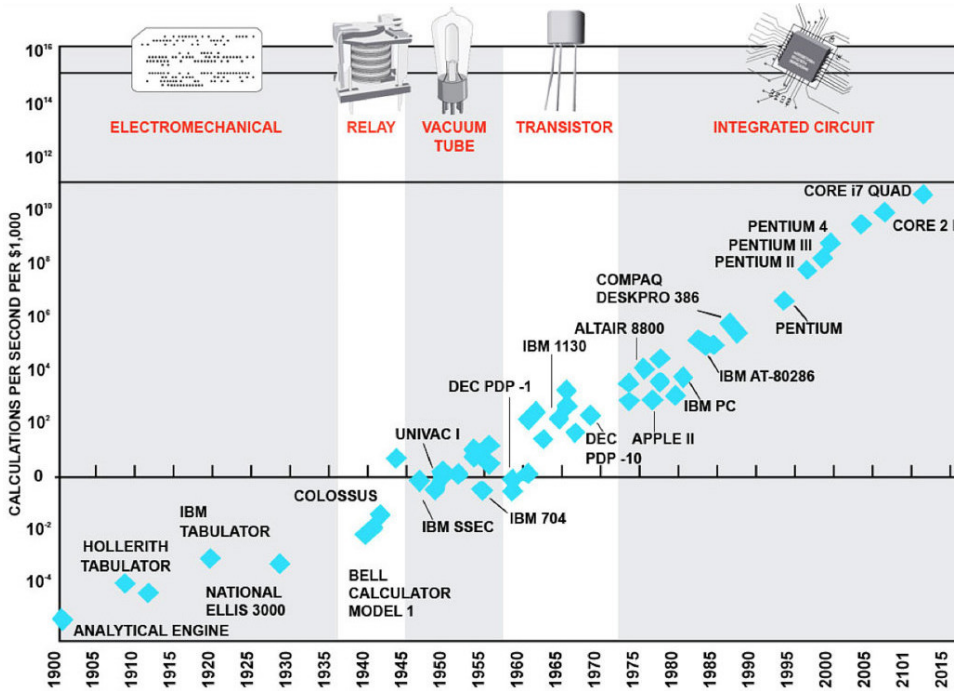

1942: 1 year

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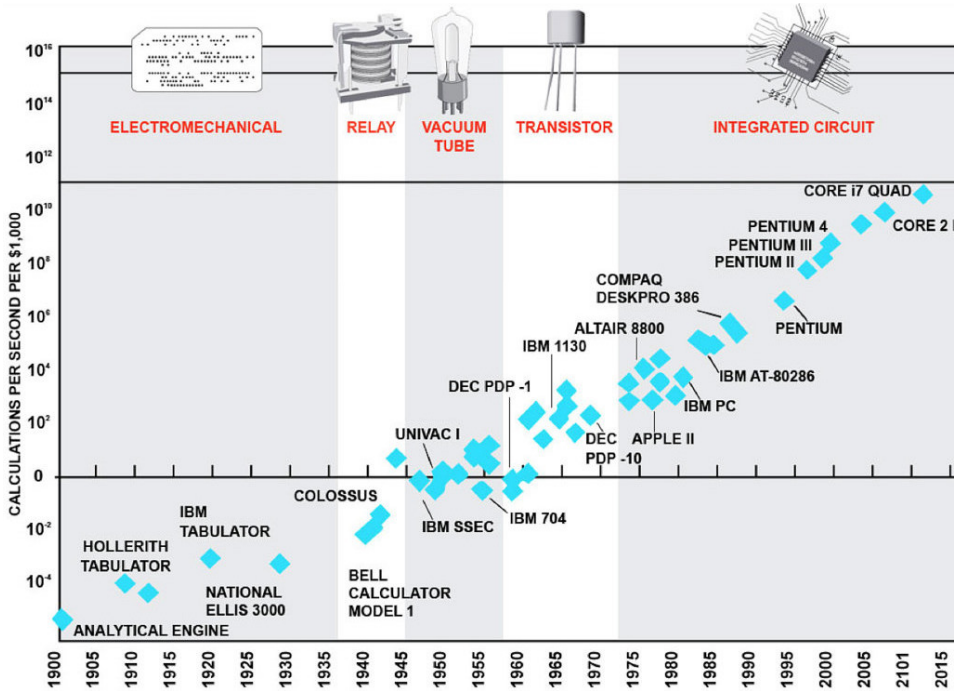
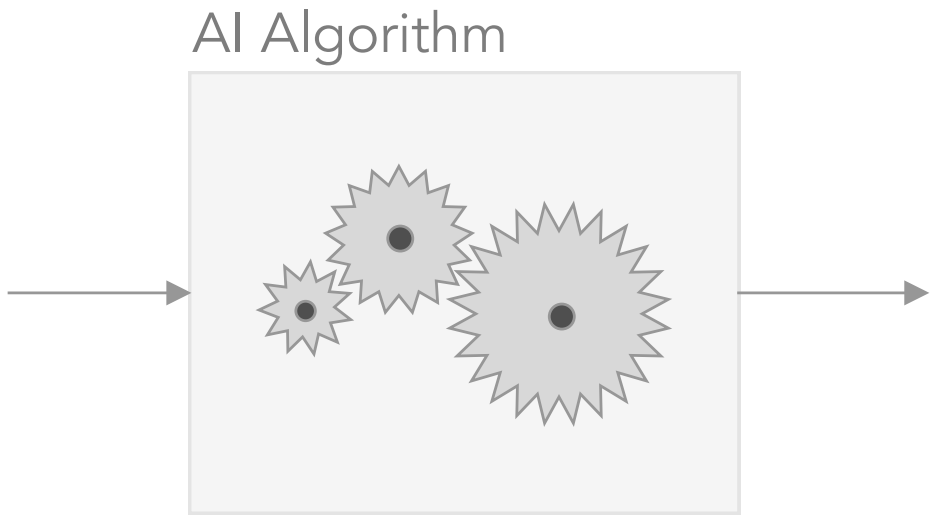
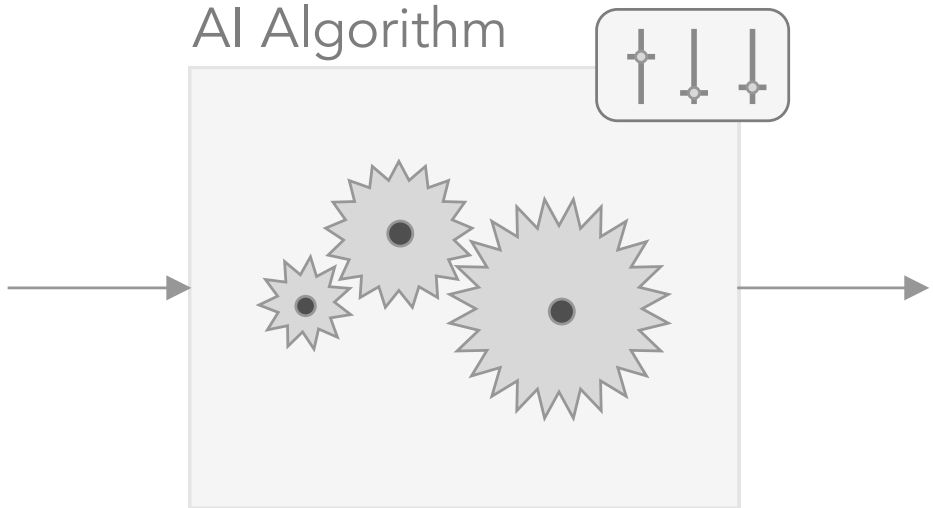


1942: 1 year $\rightsquigarrow$ 2020: 0.000 057 seconds

Algorithm configuration



Algorithm configuration



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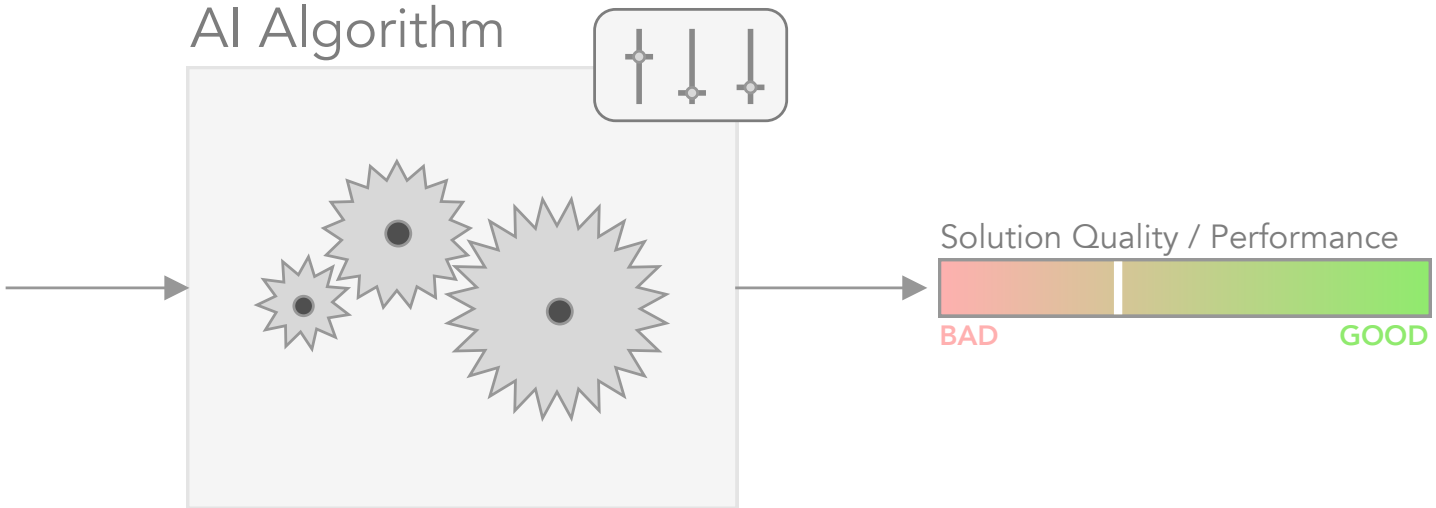

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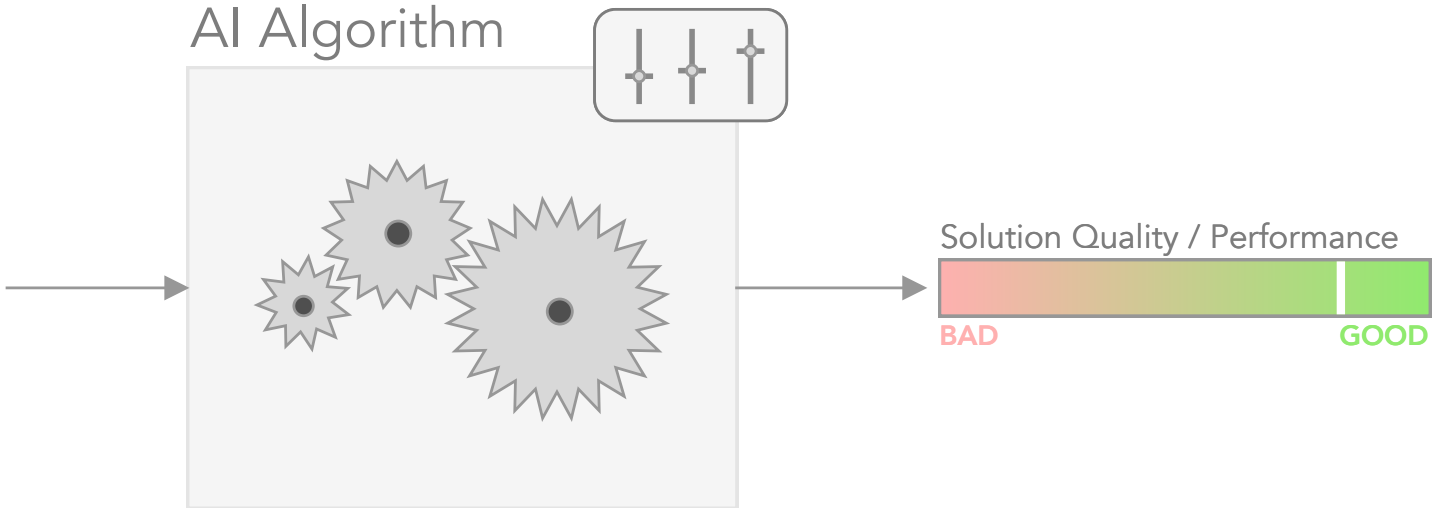
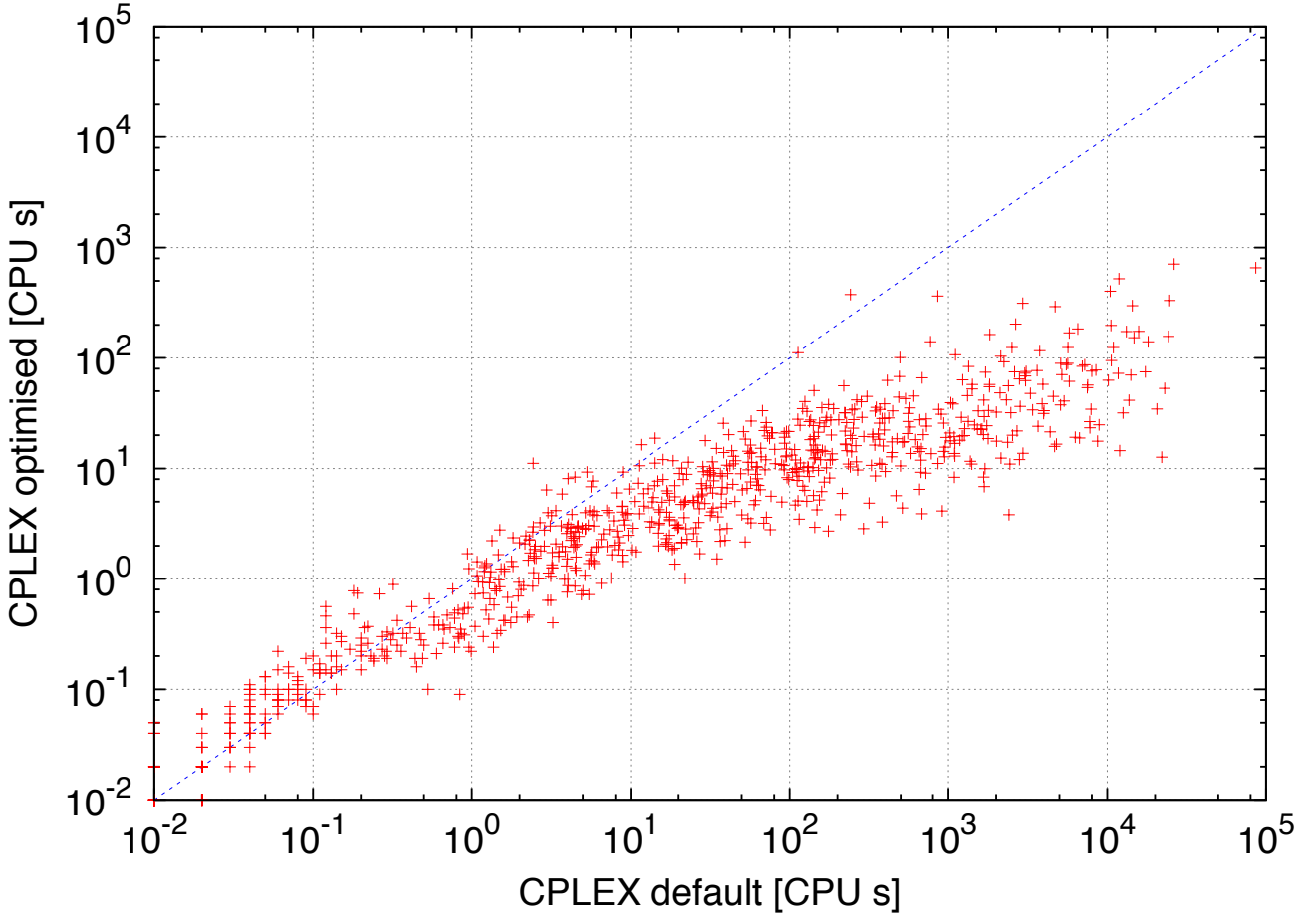


CPLEX on Wildlife Corridor Design

Hutter, HH, Leyton-Brown (2010)



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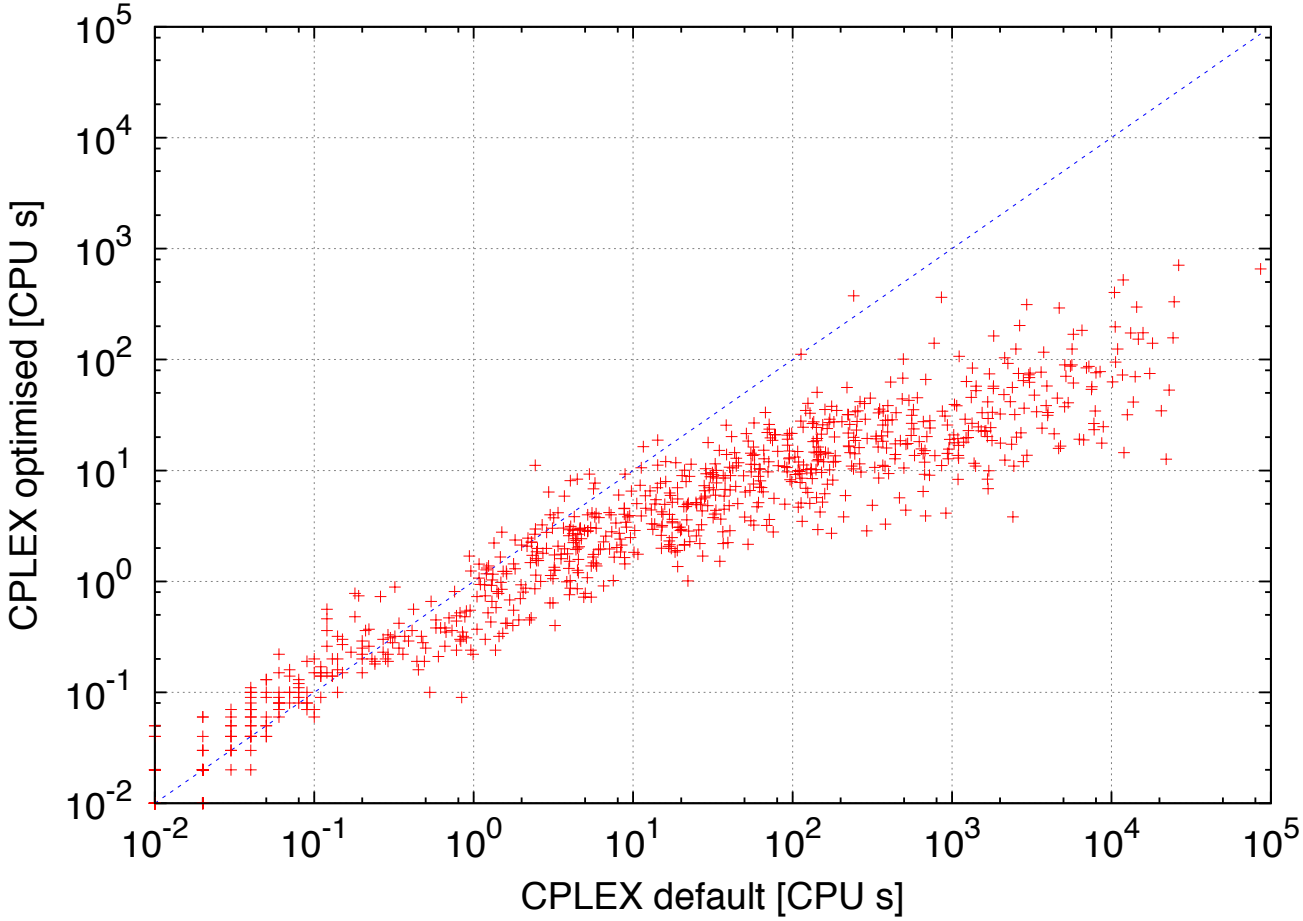

$\rightsquigarrow$ 52.3 $\times$ speedup on average!

Even more substantial progress in software/algorithms

Example: Mathematical optimisation (mixed-integer programming)

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$\sim 1.9\times$ speedup per year (*cf.* $\sim 1.4\times$ for hardware)

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1991: 1 year $\rightsquigarrow$ 2007: 18.22 minutes due to software speedup

Even more substantial progress in software/algorithms

Example: Mathematical optimisation (mixed-integer programming)

$\sim 1.9\times$ speedup per year (*cf.* $\sim 1.4\times$ for hardware)

1991: 1 year $\rightsquigarrow$ 2007: 18.22 minutes due to software speedup
$\rightsquigarrow$ 5.02 seconds on 2007 hardware

$= 6\,282\,119\times$ speedup in 16 years(!!)

Prof. Dr. Holger H. Hoos

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Research interests

- Intersection of machine learning, automated reasoning and optimisation
- Automated design and analysis of algorithms: performance prediction, algorithm configuration, algorithm selection and construction of parallel algorithm portfolios
- Iterated Local Search (ILS) algorithms
- Bio-inspired optimisation, in particular Ant Colony Optimization (ACO)
- Bioinformatics and computer music

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Research interests

- Heuristic Optimisation (in particular Evolutionary Algorithms)
- Combinatorial (Multi-Objective) Optimisation
- Evolutionary Diversity Optimisation (EDO) and Quality Diversity (QD)
- Theory of randomised search heuristics
- Sequential Model-Based Optimisation (SMBO)
- Instance Generation for Benchmarking (in particular for the TSP)
- Algorithm Selection and Configuration

Block seminar

Are you available on the following dates?

- 17 August, 2022
- 18 August, 2022
- 19 August, 2022
- 20 August, 2022
- 22 August, 2022
- 23 August, 2022

Other important dates (take note!)

- Progress update (via e-mail, bullet points are OK, but do give us some details): 10 June 2022, 18:00 CEST (hard deadline!)
- Final report due (PDF via e-mail): 29 July 2022, 18:00 CEST (hard deadline!)

Groups and topics I

AS-1 Nils Sören Eberhardt, Stefan Seiler

Topic: Algorithm selection in continuous optimization

Pascal Kerschke and Heike Trautmann. "Automated Algorithm Selection on Continuous Black-Box Problems by Combining Exploratory Landscape Analysis and Machine Learning". In: *Evolutionary Computation* 27.1 (2019), pp. 99–127. DOI: 10.1162/evco_a_00236

Groups and topics II

AS-2 Nils Christoph Baumann, Tim Tobias Bauerle

Topic: Algorithm selection for the discrete combinatorial problems

Jonathan Heins et al. "On the Potential of Normalized TSP Features for Automated Algorithm Selection". In: *Proceedings of the 16th ACM/SIGEVO Conference on Foundations of Genetic Algorithms*. New York, NY, USA: Association for Computing Machinery, 2021. ISBN: 9781450383523. DOI: 10.1145/3450218.3477308

AC-1 Yimin Zhang, Marcel Baumann

Topic: Local-search based algorithm configuration (AC)

Frank Hutter et al. "ParamILS: An Automatic Algorithm Configuration Framework". In: *J. Artif. Int. Res.* 36.1 (Sept. 2009), pp. 267–306. ISSN: 1076-9757

Groups and topics III

AC-2 Jan Philipp Kraus, Nikolas Moritz Gunz

Topic: Sampling-based algorithm configuration

Leslie Pérez Cáceres et al. "An Experimental Study of Adaptive Capping in irace". In: *Learning and Intelligent Optimization, 11th International Conference, LION 11*. Ed. by Roberto Battiti, Dmitri E. Kvasov, and Yaroslav D. Sergeyev. Vol. 10556. Lecture Notes in Computer Science. Cham, Switzerland: Springer, 2017, pp. 235–250. DOI: 10.1007/978-3-319-69404-7_17

Groups and topics IV

AC-3 Sebastian Miller, Laura-Sophie Kirchner

Topic: Model-based algorithm configuration

Jakob Bossek et al. "Learning Feature-Parameter Mappings for Parameter Tuning via the Profile Expected Improvement". In: *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO '15)*. Madrid, Spanien, 2015

PAP Aaron Berger, Alexander Mann

Topic: Parallel algorithm portfolios

Matthias König, Holger H Hoos, and Jan N van Rijn. "Speeding Up Neural Network Verification via Automated Algorithm Configuration". In: *ICLR Workshop on Security and Safety in Machine Learning Systems*. 2021

Groups and topics V

David Joshua Saam, Eric Skaliks
Topic: Hyper-parameter optimisation
Li Yang and Abdallah Shami. "On hyperparameter optimization of machine learning algorithms: Theory and practice". In: *Neurocomputing* 415 (2020), pp. 295–316. ISSN: 0925-2312. DOI: https://doi.org/10.1016/j.neucom.2020.07.061

NAS-1 Marc Flemming Thiemann, Malte Gerhard Schwerin
Topic: Gradient-Based Neural Architecture Search (NAS)
Karim Ahmed and Lorenzo Torresani. "MaskConnect: Connectivity Learning by Gradient Descent". In: *Computer Vision – ECCV 2018*. Ed. by Vittorio Ferrari et al. Cham: Springer International Publishing, 2018, pp. 362–378. ISBN: 978-3-030-01228-1

Groups and topics VI

NAS-2 Nicolas Maximilian Faber, László Dirks

Topic: Evolutionary Computation for Neural Architecture Search

Chao Pan and Xin Yao. "Neural Architecture Search Based on Evolutionary Algorithms with Fitness Approximation". In: *2021 International Joint Conference on Neural Networks (IJCNN)*. 2021, pp. 1–8. DOI: 10.1109/IJCNN52387.2021.9533986

EPM Chenhuan Gao, Miriam Kempter

Topic: Empirical performance models (EPM)

K. Eggensperger et al. "Efficient Benchmarking of Algorithm Configurators via Model-Based Surrogates". In: *Machine Learning* 107 (2018), pp. 15–41

Take-home messages

- AutoAI is the future of AI/ML
- This seminar will cover a wide range of AutoAI methods and application areas
- We're here to help – do not hesitate to contact us if you have questions