hendrik baier
artificial intelligence researcher

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research interests

I am fascinated by *artificial intelligence* and *games*.

Decision making is a basic activity in our lives, and an essential feature of intelligent autonomous agents. I am interested in creating agents that are able to succeed in a wide range of complex decision-making tasks, in order to help human users solve real-world problems. To achieve this, my research focuses on *planning*, required for acting towards long-term goals; on *learning*, required for acting in unknown environments; and on the *explainability* of planning and learning, required for successful human-AI collaboration.

In order to tackle these challenges, I use the unifying framework of reinforcement learning - of learning by trial and error - and aim at pushing its boundaries in a variety of traditional and digital games as testbeds. I then transfer game AI technology to non-game domains in collaborative projects with industry, in sectors such as logistics and transportation, smart manufacturing, and sustainable energy.

research experience

2022 – present	**Eindhoven University of Technology**	Eindhoven, The Netherlands

Assistant Professor
Information Systems Group
Developing learning, planning, and explainable AI techniques in collaboration with industry partners from sectors such as logistics, energy, and manufacturing

2018 – 2021 and 2023 – present	**Centrum Wiskunde & Informatica**	Amsterdam, The Netherlands

Researcher
Intelligent and Autonomous Systems Group
In collaboration with industry, took a leading role in applying AI and machine learning to the optimal management of energy producers and consumers on future energy markets with an increasing share of renewable energy; developed a related research vision for explainable search-based AI

2016 – 2018	**University of York**	York, United Kingdom

Research associate in artificial intelligence and data analytics
Digital Creativity Labs
Explored the integration of search algorithms and machine learning in increasingly complex commercial video games; explored ethical and societal issues around AI in interdisciplinary workshops

2015 – 2016	**European Space Agency**	Noordwijk, The Netherlands

Research fellow in artificial intelligence
Advanced Concepts Team
Worked on "blue sky" research with potential future impact for the space sector, as well as serving as an internal science consultant for the European Space Research and Technology Centre

2010 – 2015	**Maastricht University**	Maastricht, The Netherlands

PhD researcher
Department of Knowledge Engineering
Improved sequential decision making based on Monte Carlo Tree Search both in adversarial as well as single-agent environments

education

2007 – 2010	**M.Sc. Cognitive Science**	Universität Osnabrück, Germany

Grade: "excellent with distinction"
Specialization: artificial intelligence and linguistics
Thesis title: "Adaptive Playout Policies for Monte-Carlo Go"

2006 – 2007	**Linguistics**	Universität Leipzig, Germany

2001 – 2006	**B.Sc. Computer Science**	Technische Universität Darmstadt, Germany

Grade: "very good", ranked top 2%
Thesis title: "Der Alpha-Beta-Algorithmus und Erweiterungen bei Vier Gewinnt"

teaching experience

2022 – present **Eindhoven University of Technology** Eindhoven, The Netherlands
Lecturer
MSc course "Decision making with artificial and computational intelligence"
My course redesign in 2023, part of my Dutch University Teaching Qualification, led to this course achieving the highest student evaluation in the study program.

2022 – present **Jheronimus Academy of Data Science** Tilburg, The Netherlands
Lecturer
MSc course "Prescriptive Algorithms"

2021 **Utrecht University** Utrecht, The Netherlands
Guest lecturer
Introductory class on reinforcement learning in games

2013 – 2014 **Maastricht University** Maastricht, The Netherlands
Teaching assistant in computer science
Taught "skills class LaTeX" for undergraduates

2011 – 2013 **Maastricht University** Maastricht, The Netherlands
Teaching assistant in computer science
Introduction to data structures and algorithms for undergraduates

2009 – 2010 **IDF Language School** Osnabrück, Germany
English teacher
Grammar and conversational courses for individuals and groups

2004 – 2005 **Technische Universität Darmstadt** Darmstadt, Germany
Teaching assistant in mathematics and computer science
Introduction to logic for second-year students, and programming for first-year students

project management

2023 – present **Project ``PEER''** Horizon Europe project no. 101120406
Work package leader of WP3: "Human-AI collaboration on sequential decision-making tasks" (229 person-months total)

2022 – present **Project ``ALIGN4Energy''** Dutch Research Agenda, NWO-ORC project NWA.1389.20.251
Work package co-leader of WP3: "Aligning human preferences, choices and technical systems" (132 person-months total)

supervision experience

phd students

2023 – present	**Bart von Meijenfeldt**	Eindhoven University of Technology

"Human-centric, collaborative sequential decision-making"; role: *supervisor*

2023 – present	**Gao Peng**	Centrum Wiskunde & Informatica

"Sequential Decision-making for Multi-Agent Interest Alignment in Sustainable Energy Investments"; role: *co-supervisor*

2022 – present	**Tim de Boer**	Centrum Wiskunde & Informatica

"Preference Elicitation for Multi-Agent Interest Alignment in Sustainable Energy Investments"; role: *co-supervisor*

2022 – present	**Luca Begnardi**	Eindhoven University of Technology

"Integration of Planning and Learning: from Online Combinatorial Optimization to Real-World Applications"; role: *co-supervisor*

2017 – 2018	**Daniel Hernandez**	University of York

"Multi-Agent Reinforcement Learning for Game AI and Robotic Control"; role: *supervision team member*

2017 – 2018	**Peter York**	University of York

"Applying Tree Search and Reinforcement Learning to Competitive and Human-Like MOBA AI"; role: *supervision team member*

2016 – 2018	**Adam Sattaur**	University of York

"The Use of Gameplay Data to Inform High-level AI Decision Making"; role: *supervision team member*

engineering doctorate, master, and bachelor students; interns

List available on request.

admin experience

2024 – present	**Jheronimus Academy of Data Science**	Tilburg, The Netherlands

Member of exam committee

2013 – 2015	**Department of Knowledge Engineering**	Maastricht, The Netherlands

PhD coordinator
Supported and represented PhD students at the department level

2011 – 2015	**PhD Academy of Maastricht University**	Maastricht, The Netherlands

Member, from 2013 board member, in 2014 chair of PhD Academy
Organized social, cultural and academic events for PhD students; funded by Maastricht University

2013 – 2014	**University Council**	Maastricht, The Netherlands

Co-founder of a group representing PhD researchers
Elected as one of six representatives of scientific staff in the University Council of Maastricht University

invited talks and research visits

| 2023 | **University of Alberta** | Edmonton, Canada |
| | Talk at the Workshop on Neurosymbolic Programming | |

| 2022 | **Leiden University** | Leiden, The Netherlands |
| | Talk at the Belgium-Netherlands workshop on Reinforcement Learning (BeNeRL) | |

| 2022 | **Dutch Institute for Emergent Phenomena (DIEP)** | Amsterdam, The Netherlands |
| | Talk at the DIEP seminar | |

| 2019 | **Queen Mary University of London** | London, United Kingdom |
| | Talk at the game AI group seminar | |

| 2017 | **Lancaster University** | Lancaster, United Kingdom |
| | Talk at the PACTMAN workshop on Trust, Identity, Privacy and Security in the Digital Economy | |

| 2017 | **University of York** | York, United Kingdom |
| | Talk at the GamesLab Emerging Tech workshop (industry audience) | |

| 2017 | **University of York** | York, United Kingdom |
| | Talk at the AI group seminar | |

| 2017 | **University of Essex** | Colchester, United Kingdom |
| | Talk at the School of Computer Science and Electronic Engineering seminar | |

| 2016 | **New York University Tandon School of Engineering** | New York City, NY, USA |
| | Talk at the NYU Game Innovation Lab seminar | |

| 2013 | **University of Alberta** | Edmonton, Canada |
| | Talk at the AI group seminar | |

| 2012 | **Reykjavik University** | Reykjavik, Iceland |
| | Research visit to the Center for Analysis and Design of Intelligent Agents; funded by the Netherlands Organisation for Scientific Research (NWO) | |

impact and engagement

| 2023 | **Vanderlande Tech Day** | Veghel, The Netherlands |
| | Guest talk for industry audience about human-centered, collaborative learning and planning | |

| 2018 | **Pint of Science Festival** | York, United Kingdom |
| | Talk about artificial intelligence and games at the "To the future... and beyond" session | |

| 2017 | **Yorkshire Games Festival** | Bradford, United Kingdom |
| | Talk about artificial intelligence and games at the "Lates: Gaming" session at the National Science and Media Museum | |

| 2017 | **Science out of the Lab** | York, United Kingdom |
| | Organized the activities of the Digital Creativity Labs at a science outreach event as part of the "York Festival of Ideas"; reached about 2000 people | |

| 2016 | **ESTEC Open Day** | Noordwijk, The Netherlands |
| | Co-organized the activities of the Advanced Concepts Team at the open day of the European Space Research and Technology Centre; reached about 9000 people | |

2013	**Career Day**	Maastricht, The Netherlands

Informed students on academic careers at the Department of Knowledge Engineering's career information day, Maastricht University

2012	**DKE Open Day**	Maastricht, The Netherlands

Represented the game AI group at the Department of Knowledge Engineering's open day, Maastricht University

other activities

2023, 2024 **International Joint Conference on Artificial Intelligence (IJCAI)**
Co-Chair of Workshop on Explainable Artificial Intelligence

2024 **European Conference on Artificial Intelligence (ECAI)**
Co-Organizer Workshop "Trustworthy Sequential Decision-Making and Optim."

2023 **17th Learning and Intelligent Optimization conference (LION)** Nice, France
Co-Organizer of Special Session "Responsible AI in Practice"

2017-2018 **IEEE Conference on Computational Intelligence in Games 2017 and 2018** New York, NY, USA / Maastricht, The Netherlands
Co-Organizer of Text-Based Adventure AI Competition

2017 **CHERISH-DE initiative of the EPSRC** Swansea/Edinburgh/London, United Kingdom
Participant of Digital Economy Crucible, a seven-day development program for young academics

2013 **Artificial Intelligence and Interactive Digital Entertainment Conference 2012** Stanford, CA, USA
Participant of AIIDE Doctoral Consortium

2011 – present **Professional Service**
Program committee member, *senior program committee member* and/or *reviewer* for conferences and workshops in the fields of game AI, general AI and related fields, such as the International Joint Conference on Artificial Intelligence, the European Conference on Artificial Intelligence, the International Conference on Autonomous Agents and Multiagent Systems, the IEEE Conference on Computational Intelligence and Games, the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, the International Conference on the Foundations of Digital Games, and the International Conference on Advances in Computer Games; as well as for journals such as the Journal of Autonomous Agents and Multi-Agent Systems, Theoretical Computer Science, Engineering Optimization, the IEEE Transactions on Games, and the ICGA Journal.

awards and funding

2023 **Horizon Europe call HORIZON-CL4-2022-HUMAN-02-01 — ``AI for human empowerment (AI, Data and Robotics Partnership)''** total €7,737,900; work package €637,450
Co-Investigator and work package leader
Project title: "PEER – hyPEr ExpeRt"

2023 **EWUU Alliance call ``AI for Preventive Health and a Circular Society''** €40,000
Co-Investigator
Project title: "TakePart: An AI-driven Game in Digital Twin Platforms for Circular Green"

2017 **Digital Economy Crucible ``Research Priming'' Award** £5000
Co-Investigator and workshop organizer
Project title: "Building Trust in AI – Designing for Consent"

publications

journal articles

Value Targets in Off-policy AlphaZero: A New Greedy Backup
D. Willemsen, H. Baier, M. Kaisers
Neural Computing and Applications 34.3. Pp. 1801–1814. 2022

The Text-Based Adventure AI Competition
T. Atkinson, H. Baier, T. Copplestone, S. Devlin, J. Swan
IEEE Transactions on Games 11.3. Pp. 260–266. 2019

Emulating Human Play in a Leading Mobile Card Game
H. Baier, A. Sattaur, E. J. Powley, S. Devlin, P. I. Cowling, J. Rollason
IEEE Transactions on Games 11.4. Pp. 386–395. 2019

MCTS-Minimax Hybrids with State Evaluations
H. Baier, M. H. M. Winands
Journal of Artificial Intelligence Research 62. Pp. 193–231. 2018

Time Management for Monte Carlo Tree Search
H. Baier, M. H. M. Winands
IEEE Transactions on Computational Intelligence and AI in Games 8.3. Pp. 301–314. 2016

MCTS-Minimax Hybrids
H. Baier, M. H. M. Winands
IEEE Transactions on Computational Intelligence and AI in Games 7.2. Pp. 167–179. 2015

The Power of Forgetting: Improving the Last-Good-Reply Policy in Monte Carlo Go
H. Baier, P. Drake
IEEE Transactions on Computational Intelligence and AI in Games 2.4. Pp. 303–309. 2010

conference articles

Deep Reinforcement Learning for Two-sided Online Bipartite Matching in Collaborative Order Picking
L. Begnardi, H. Baier, W. Jaarsveld, Y. Zhang
Asian Conference on Machine Learning 2023 (ACML 2023). Accepted.

BRExIt: On Opponent Modelling in Expert Iteration
D. Hernandez, H. Baier, M. Kaisers
32nd International Joint Conference on Artificial Intelligence (IJCAI 2023), pp. 3795–3802. 2023

Online Planning in POMDPs with Self-Improving Simulators
J. He, M. Suau, H. Baier, M. Kaisers, F. A. Oliehoek
31st International Joint Conference on Artificial Intelligence (IJCAI 2022), pp. 4628–4634. 2022

ME-MCTS: Online Generalization by Combining Multiple Value Estimators
H. Baier, M. Kaisers
30th International Joint Conference on Artificial Intelligence (IJCAI 2021), pp. 4032–4038. 2021

Guiding Multiplayer MCTS by Focusing on Yourself [nominated for best paper]
H. Baier, M. Kaisers
2020 IEEE Conference on Games (CoG 2020), pp. 550–557. 2020

Opponent-Pruning Paranoid Search [exceptional paper award]
H. Baier, M. Kaisers
2020 International Conference on the Foundations of Digital Games (FDG 2020), 10:1–10:7. 2020

Evolutionary MCTS for Multi-Action Adversarial Games [nominated for best paper]

H. Baier, P. I. Cowling

2018 IEEE Conference on Computational Intelligence and Games (CIG 2018), pp. 1–8. 2018

Evolutionary MCTS with Flexible Search Horizon

H. Baier, P. I. Cowling

14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE 2018), pp. 2–8. 2018

Decentralized Online Planning for Multi-Robot Warehouse Commissioning [nominated for best paper]

D. Claes, F. Oliehoek, H. Baier, K. Tuyls

16th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2017), pp. 492–500. 2017

Monte-Carlo Tree Search and Minimax Hybrids

H. Baier, M. H. M. Winands

2013 IEEE Conference on Computational Intelligence and Games (CIG 2013), pp. 129–136. 2013

Beam Monte-Carlo Tree Search

H. Baier, M. H. M. Winands

2012 IEEE Conference on Computational Intelligence and Games (CIG 2012), pp. 227–233. 2012

Nested Monte-Carlo Tree Search for Online Planning in Large MDPs

H. Baier, M. H. M. Winands

20th European Conference on Artificial Intelligence (ECAI 2012), pp. 109–114. 2012

Time Management for Monte-Carlo Tree Search in Go

H. Baier, M. H. M. Winands

13th International Conference on Advances in Computer Games (ACG 2011), pp. 39–51. 2012

Active Opening Book Application for Monte-Carlo Tree Search in 19x19 Go

H. Baier, M. H. M. Winands

23rd Benelux Conference on Artificial Intelligence (BNAIC 2011), pp. 3–10. 2011

workshop articles and extended abstracts

Decision Making in Non-Stationary Environments with Policy-Augmented Search (Extended Abstract)

A. Pettet, Y. Zhang, B. Luo, K. Wray, H. Baier, A. Laszka, A. Dubey, A. Mukhopadhyay

23rd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2024). 2024

Novelty and MCTS

H. Baier, M. Kaisers

1st Evolutionary Reinforcement Learning Workshop at GECCO (EVORL 2021), pp. 1483–1487. 2021

Towards Explainable MCTS

H. Baier, M. Kaisers

AAAI 2021 Workshop on Explainable Agency in AI. 2021

Explainable Search

H. Baier, M. Kaisers

2020 IJCAI-PRICAI Workshop on Explainable Artificial Intelligence. 2020

Value Targets in Off-policy AlphaZero: A New Greedy Backup

D. Willemsen, H. Baier, M. Kaisers

2020 Adaptive and Learning Agents Workshop at AAMAS (ALA 2020). 2020

MCTS-Minimax Hybrids with State Evaluations (Extended Abstract)

H. Baier, M. H. M. Winands

27th International Joint Conference on Artificial Intelligence (IJCAI 2018), pp. 5548–5552. 2018

A Rollout-Based Hybrid Unifying MCTS and Alpha-Beta

H. Baier

Computer Games: Fifth Workshop on Computer Games (CGW 2016), pp. 57–70. 2017

Monte-Carlo Tree Search and Minimax Hybrids with Heuristic Evaluation Functions
H. Baier, M. H. M. Winands
Computer Games: Third Workshop on Computer Games (CGW 2014), pp. 45–63. 2014

Nested Monte-Carlo Tree Search for Online Planning in Large MDPs (Extended Abstract)
H. Baier, M. H. M. Winands
24th Benelux Conference on Artificial Intelligence (BNAIC 2012), pp. 273–274. 2012

theses

Monte-Carlo Tree Search Enhancements for One-Player and Two-Player Domains
H. Baier
Ph.D. thesis. Department of Knowledge Engineering, Maastricht University, Maastricht, The Netherlands. 2015

Adaptive Playout Policies for Monte Carlo Go
H. Baier
Master's thesis. Institute of Cognitive Science, Osnabrück University, Osnabrück, Germany. 2010

Der Alpha-Beta-Algorithmus und Erweiterungen bei Vier Gewinnt
H. Baier
Bachelor's thesis. Department of Computer Science, Technische Universität Darmstadt, Darmstadt, Germany. 2006