Paweł Liskowski

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Research Interest

Current neural networks, deep learning, computer vision, reinforcement learning

Past evolutionary computation, genetic programming, program synthesis

Employment

2018–present **Research Scientist**, *NNAISENSE*, Lugano, Switzerland.
Member of the Deep Learning & Intelligent Automation Team
Applying machine learning and computer vision to industrial process inspection, modeling, and control. Conducting research in neural networks and deep learning.

2018–2019 **Assistant Professor**, *Laboratory of Intelligent Decision Support Systems, Institute of Computing Science, Poznań University of Technology*, Poland.
Member of the Computational Intelligence Research Group.

2013–2018 **Research Assistant**, *Laboratory of Intelligent Decision Support Systems, Institute of Computing Science, Poznań University of Technology*, Poland.
Researched neural networks, evolutionary algorithms, and reinforcement learning.
Applied machine learning to medical imaging and computer vision problems.

2010-2013 **Software Engineer**, *NaviExpert*, Poznań, Poland.
Member of the research and development team, worked on innovative traffic technologies.

Education

2012-2018 **Ph.D. with honors in Computer Science**, *Poznań University of Technology*, Poland.
- Thesis: *Heuristic Algorithms for Discovery of Search Objectives in Test-based Problems* (advisor: Prof. Krzysztof Krawiec),
- Specialization: Intelligent Decision Support Systems.

2011-2012 **M.Sc. in Computer Science**, *Poznań University of Technology*, Poland.
- Thesis: *Co-Evolution Versus Evolution with Random Sampling for Acquiring Othello Position Evaluation*,
- Graduated with honors.

2007-2011 **B.Sc. in Computer Science**, *Poznań University of Technology*, Poland.
Thesis: *Mobile Search Engine for Sales and Promotional Offers*.

Achievements and Awards

2019 **Polish Artificial Intelligence Society Award for the best Ph.D. dissertation in Artificial Intelligence**, *Wrocław, Poland.*
Contest organized by Polish Artificial Intelligence Society. Awarded dissertation: *Heuristic Algorithms for Discovery of Search Objectives in Test-based Problems.*

2018 **Distinction of doctoral dissertation**, *Poznań, Poland.*
Awarded by Faculty of Computing, Poznan University of Technology. Awarded dissertation: *Heuristic Algorithms for Discovery of Search Objectives in Test-based Problems.*

2017 **Polish Academy of Sciences Award for the best original creative article**, *Poznań, Poland.*
Annual contest organized by Polish Academy of Sciences. Awarded article: *Segmenting Retinal Blood Vessels With Deep Neural Networks*, published in IEEE Transactions on Medical Imaging.

2016 **EuroGP Best Paper Award**, *Porto, Portugal.*
For my joint paper with Krzysztof Krawiec entitled *Surrogate Fitness via Factorization of Interaction Matrix* presented during 19th European Conference on Genetic Programming.

2015 **Award in PRELUDIUM 8 competition**, *Poznań, Poland.*
Contest organised by Polish National Science Centre for young scientist.

2012 **Polish Information Processing Society Award for the best master's thesis in computer science**, *Wrocław, Poland.*
Annual contest organised by the Polish Information Processing Society.

Grants Received

2017-2018 **Research grant for young scientists awarded by the Faculty of Computing, Poznan University of Technology**.
- Title: *Very Deep Neural Networks for Reinforcement Learning.*
- Success rate: 30%

2015-2018 **Research grant from Polish National Science Centre**.
- Title: *Heuristic Discovery of Underlying Objectives for Test-based Problems.*
- Success rate: 18%

2016-2018 **Computational grant from Poznań Supercomputing and Networking Center**.
- Title: *(Co)evolutionary Computation Framework in High Performance Computing Cluster.*

2012-2015 **Conference Grants**.
Awarded by SIGEVO/ACM for GECCO 2013, 2015, 2016, 2017.

Stipends

2018 **START Scholarship of the Foundation for Polish Science**.
- START is a program for young (<30) talented researchers from Poland.
- Success rate: 11%

2014-2017 **Stipend for the best Ph.D. students**.
Awarded by Poznań University of Technology.

Scientific Activities

Selected research projects

- Scalable Metaheuristics for Automated Program Synthesis (Polish National Science Centre, DEC-2014/15/B/ST6/05205, 2015–2018).
- Interferometric Imaging Methods for Investigation of Dynamics of Biological Systems (Polish National Research and Development Center, PBS1/A9/20/2013, 2013-2016).
- Multi-criteria Methods for Designing Algorithms that Learn Combinatorial Games Strategies (Polish National Science Centre, DEC-2013/09/D/ST6/03932, 2013–2016).
- New Computational Paradigms for Explanatory Modeling of Complex Systems (Polish National Science Centre, DEC-2011/01/B/ST6/07318, 2011–2014).
- Open platform for Online Navigation, R&D project supported by Polish Agency for Enterprise Development (PARP), 2011-2012.
- Prediction of Travel Times in a Traffic Communication Network, research project for NaviExpert, a GPS navigation company, 2010-2011.

Talks and conferences participation

- Genetic and Evolutionary Computation Conference (GECCO) 2013, 2015, 2016, 2017, 2018, 2020.
- International Conference on Learning Representations (ICLR) 2019.
- Parallel Problem Solving from Nature (PPSN) 2014, 2020.
- European Conference on Genetic Programming (EuroGP) 2015, 2016.
- European Conference on the Applications of Evolutionary Computation (EvoApps) 2014, 2015, 2016.

Invited talks

- Machine Learning in Robotics and Image Processing (2018), title: *Deep Convolutional Networks Combined with Structural Prediction in Medical Ophthalmological Imaging*.
- Code4Life Scientific (2017), title: *Segmenting Retinal Blood Vessels With Deep Neural Networks*, together with K. Krawiec,
- Applied Machine Learning and and Big Data (2016), title: *Augmented Diagnosis with Deep Learning*, together with K. Krawiec.

Reviews for journals

- IEEE Transactions on Industrial Informatics, IEEE Transactions on Medical Imaging, IEEE Journal of Biomedical and Health Informatics, IEEE Transactions on Computational Intelligence and AI in Games, International Journal of Applied Mathematics and Computer Science, PLOS ONE.

Teaching

2018-2019 **Topics in Computational Intelligence**.
Responsible for the part of the course that focused neural networks and deep learning

2013-2019 **Human-Computer Interaction**.
Students evaluations:
- autumn 2014: 4.42 (2.0 – worst, 5.0 – best); Rank: 3/25 undergraduate courses in CS program.
- autumn 2013: 4.4 (2.0 – worst, 5.0 – best); Rank: 3/33 undergraduate courses in CS program.

Skills & Knowledge

Languages	Python, C++, C, Java
Frameworks	PyTorch, Tensorflow, Caffe
Software	Docker, AWS/Azure (Sagemaker, Lambda, Batch, ACI), Git, MATLAB

Languages

Polish	Native
English	Proficient
German, Italian	Basic

Publications

Journal Publications

[1] Wojciech Jaśkowski, Paweł Liskowski, Marcin Szubert, and Krzysztof Krawiec. Performance Profile: A Multi-criteria Performance Evaluation Method for Test-based Problems. *International Journal of Applied Mathematics and Computer Science*, 26(1):215–229, 2016.

[2] Paweł Liskowski, Wojciech Jaśkowski, and Krzysztof Krawiec. Learning to Play Othello with Deep Neural Networks. *IEEE Transactions on Games*, 2018 (to appear).

[3] Paweł Liskowski and Krzysztof Krawiec. Online Discovery of Search Objectives for Test-based Problems. *Evolutionary Computation*, 25(3):375–406, 2016.

[4] Paweł Liskowski and Krzysztof Krawiec. Segmenting Retinal Blood Vessels with Deep Neural Networks. *IEEE transactions on medical imaging*, 35(11):2369–2380, 2016.

[5] Paweł Liskowski and Krzysztof Krawiec. Adaptive Test Selection for Factorization-based Surrogate Fitness in Genetic Programming. *Foundations of Computing and Decision Sciences*, 42(4):339–358, 2017.

Refereed Conference Publications

[1] Wojciech Jaśkowski, Paweł Liskowski, Marcin Szubert, and Krzysztof Krawiec. Improving Coevolution by Random Sampling. In *Proceedings of the 15th annual*

conference on Genetic and evolutionary computation, pages 1141–1148. ACM, 2013.

[2] Wojciech Jaśkowski, Marcin Szubert, and Paweł Liskowski. Multi-criteria Comparison of Coevolution and Temporal Difference Learning on Othello. In A. I. Esparcia-Alcazar and A. M. Mora, editors, *EvoApplications 2014*, volume 8602 of *Lecture Notes in Computer Science*, pages 301–312. Springer, 2014.

[3] Wojciech Jaśkowski, Marcin Szubert, Paweł Liskowski, and Krzysztof Krawiec. High-dimensional Function Approximation for Knowledge-free Reinforcement Learning: A Case Study in SZ-Tetris. In *Proceedings of the 2015 Annual Conference on Genetic and Evolutionary Computation*, GECCO '15, pages 567–573, New York, NY, USA, 2015. ACM.

[4] Krzysztof Krawiec and Paweł Liskowski. Automatic Derivation of Search Objectives for Test-based Genetic Programming. In Penousal Machado, Malcolm I. Heywood, James McDermott, Mauro Castelli, Pablo Garcia-Sanchez, Paolo Burelli, Sebastian Risi, and Kevin Sim, editors, *18th European Conference on Genetic Programming*, volume 9025 of *LNCS*, pages 53–65, Copenhagen, 2015. Springer.

[5] Paweł Liskowski. Quantitative Analysis of the Hall of Fame Coevolutionary Archives. In *Proceedings of the 15th annual conference companion on Genetic and evolutionary computation*, pages 1683–1686. ACM, 2013.

[6] Paweł Liskowski, Iwo Bładek, and Krzysztof Krawiec. Neuro-guided Genetic Programming. In *Proceedings of the 2018 on Genetic and Evolutionary Computation Conference*, GECCO '18, pages 1–8, New York, NY, USA, 2018. ACM.

[7] Paweł Liskowski and Wojciech Jaśkowski. Accelerating Coevolution with Adaptive Matrix Factorization, (nominated to Best-paper Award). In *Proceedings of the Genetic and Evolutionary Computation Conference*, GECCO '17, pages 457–464, New York, NY, USA, 2017. ACM.

[8] Paweł Liskowski and Krzysztof Krawiec. Discovery of Implicit Objectives by Compression of Interaction Matrix in Test-based Problems. In *Parallel Problem Solving from Nature–PPSN XIII*, pages 611–620. Springer International Publishing, 2014.

[9] Paweł Liskowski and Krzysztof Krawiec. Non-negative Matrix Factorization for Unsupervised Derivation of Search Objectives in Genetic Programming. In *Proceedings of the 2016 on Genetic and Evolutionary Computation Conference*, GECCO '16, pages 749–756, New York, NY, USA, 2016. ACM.

[10] Paweł Liskowski and Krzysztof Krawiec. Surrogate Fitness Via Factorization of Interaction Matrix (Best-paper Award winner). In Malcolm I. Heywood, James McDermott, Mauro Castelli, and Ernesto Costa, editors, *EuroGP 2016: Proceedings of the 19th European Conference on Genetic Programming*, volume 9594 of *LNCS*, pages 65–79, Porto, Portugal, 30 March–1 April 2016. Springer Verlag.

[11] Paweł Liskowski and Krzysztof Krawiec. Discovery of Search Objectives in Continuous Domains. In *Proceedings of the Genetic and Evolutionary Computation Conference*, GECCO '17, pages 969–976, New York, NY, USA, 2017. ACM.

[12] Paweł Liskowski, Krzysztof Krawiec, Thomas Helmuth, and Lee Spector. Comparison of Semantic-aware Selection Methods in Genetic Programming. In *Proceedings of the Companion Publication of the 2015 on Genetic and Evolutionary Computation Conference*, GECCO Companion '15, pages 1301–1307, New York, NY, USA, 2015. ACM.

[13] Paweł Liskowski, Krzysztof Krawiec, and Nihat Engin Toklu. Neuromemetic evolutionary optimization. In Thomas Bäck, Mike Preuss, André Deutz, Hao Wang, Carola Doerr, Michael Emmerich, and Heike Trautmann, editors, *Parallel Problem Solving from Nature – PPSN XVI*, pages 623–636, Cham, 2020. Springer International Publishing.

[14] Paweł Liskowski, Krzysztof Krawiec, Nihat Engin Toklu, and Jerry Swan. Program synthesis as latent continuous optimization: Evolutionary search in neural embeddings. In *Proceedings of the 2020 Genetic and Evolutionary Computation Conference*, GECCO '20, page 359–367, New York, NY, USA, 2020. Association for Computing Machinery.

[15] Paweł Liskowski, Bartosz Wieloch, and Krzysztof Krawiec. Neural Estimation of Interaction Outcomes. In *Proceedings of the 2018 on Genetic and Evolutionary Computation Conference*, GECCO '18, pages 1–8, New York, NY, USA, 2018. ACM.

[16] Maciej Szkulmowski, Paweł Liskowski, Bartosz Wieloch, Krzysztof Krawiec, and Bartosz Sikorski. Convolutional Neural Networks for Artifact Free OCT Retinal Angiography. *Investigative Ophthalmology & Visual Science*, 58(8):649–649, 2017.

[17] Maciej Szkulmowski, Daniel Rumiński, Paweł Liskowski, Bartosz Wieloch, Krzysztof Krawiec, Bartosz Sikorski, and Maciej D. Wojtkowski. OCT Retinal Angiography Using Neural Networks. In *The Annual Meeting of the Association for Research in Vision and Ophthalmology*, 2016.

[18] Marcin Szubert, Wojciech Jaśkowski, Paweł Liskowski, and Krzysztof Krawiec. Shaping Fitness Function for Evolutionary Learning of Game Strategies. In *Proceedings of the 15^{th} annual conference on Genetic and evolutionary computation*, pages 1149–1156. ACM, 2013.

[19] Marcin Szubert, Wojciech Jaśkowski, Paweł Liskowski, and Krzysztof Krawiec. The Role of Behavioral Diversity and Difficulty of Opponents in Coevolving Game-playing Agents. In Antonio M. Mora and Giovanni Squillero, editors, *Applications of Evolutionary Computation*, volume 9028 of *Lecture Notes in Computer Science*, pages 394–405. Springer International Publishing, 2015.

[20] Nihat Engin Toklu, Paweł Liskowski, and Rupesh Kumar Srivastava. Clipup: A simple and powerful optimizer for distribution-based policy evolution. In

Thomas Bäck, Mike Preuss, André Deutz, Hao Wang, Carola Doerr, Michael Emmerich, and Heike Trautmann, editors, *Parallel Problem Solving from Nature – PPSN XVI*, pages 515–527, Cham, 2020. Springer International Publishing.

Theses

[1] Paweł Liskowski. *Heuristic Algorithms for Discovery of Search Objectives in Test-based Problems*. PhD thesis, Poznan University of Technology, Poznań, Poland, 2018.

[2] Paweł Liskowski. Co-evolution versus Evolution with Random Sampling for Acquiring Othello Position Evaluation. Master's thesis, Poznan University of Technology, Poznań, Poland, 2012.