Maksim Makarenko

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Summary

- **Info**: Co-founder and Chief Technical Officer (CTO) of Pixeltra™, a start-up company that develops Computer Vision solutions based on hyperspectral imaging, and Ph. D. Candidate at the Electrical and Computer Engineering department of KAUST University.
- **Current work**: Focus on the design and development of Machine Learning algorithms implemented in optical hardware for complex Imaging, Computer Vision, and Computational tasks.
- **Expertise**: Machine Learning, Computer Vision, Optimization and Optics.

Education

- **King Abdullah University of Science and Technology (KAUST)** — Thuwal, Saudi Arabia
  Ph.D in Electrical and Computer Engineering; GPA: 3.95/4.00 — *September 2018 - Present*
  Dissertation theses: *Machine learning in hardware via trained metasurface encoders: theory, design and applications.*

- **Novosibirsk State University (NSU)** — Novosibirsk, Russian Federation
  Master of Science in Quantum Optics and Computations; GPA: 4.75/5.00 — *September 2016 - May 2018*
  Dissertation theses: *Machine learning-based pulse characterization in coupled ring-cavity mode-locked lasers*

Skills Summary

- **Languages**: Python, C/C++, Mathematica, R, SQL, Bash
- **Frameworks**: Tensorflow, PyTorch, Scikit, PyMC3, JAGS, NumPy, SymPy, Pandas, Matplotlib, Seaborn, OpenCV, JAX
- **Tools**: Docker, GIT, Colab, LaTEX, Raspberry Pi, STM32
- **Skills**: Mathematics Proficiency, Complex Problem Solving, Project Management, Academic Writing.

Recent Experience

- **Pixeltra™**
  Chief Technical Officer — *Feb 2022 - Present*
  - Team lead of the small (3-5 members) group, which develops the patented Hyplex™ technology for various Computer Vision tasks, such as understanding static and dynamically changing scenes from hyperspectral videos.

- **KAUST**
  Ph. D. Student — *Sep. 2018 - Sep. 2022*
  - Theoretical and simulation study of exotic light states to design an efficient optical machine-learning hardware for complex computational and machine learning tasks. Development of the model-informed framework, which combines machine learning hardware with deep-learning software for various applications in Computer Vision.

Featured Projects

- **Hyplex™: Real-time Hyperspectral Imaging in Hardware via Trained Metasurface Encoders (Hyperspectral imaging, Machine Learning, Computer Vision, Physics-informed modeling)**: (Work in progress) Groundbreaking technology developed in our group, which allows real-time hyperspectral data processing for various computer vision tasks. This technology attracted a lot of attention in the community and is fundamental in the recently founded Pixeltra™ company. Tech: Python, Pytorch, OpenCV (November '21, Work in progress).
- **Cellular refractive index and thickness recovery via unsupervised learning framework for human colon-cancer identification. (Computer Vision, Machine Learning, Bayesian Optimization, Bio-imaging)**: Unsupervised framework for thickness/refractive index estimation of the colon-cancer cells from a single color photograph. Tech: Python, PyMC3, Scikit. (April '22)
- **Autonomous learning framework for Rule-based Evolutionary Design (ALFRED) (Optimization, Physics-informed modelling, Computer Vision, Nano-Optics)**: Development of a model-informed end-to-end optimization framework for the design of specific light-processing devices with predefined properties. Tech: Python, Tensorflow (March '20)
- **Ultrafast AI photonics chip (Machine Learning, Reservoir Computing, Nonlinear Dynamics, Time-series Data Analysis)**: Development of a model-informed end-to-end optimization framework for designing an integrated, ultrafast, optical neuromorphic processor that realizes an arbitrary Turing machine that can represent any random defined function of multidimensional space of coordinates varying with time. Tech: Python, C++, Intel oneAPI, Scikit, Pytorch, Raspberry Pi (January '22)
- **Adaptive Three-Point Compression Mechanism for Communication-Efficient Federated Learning (Optimization Theory, Federated Learning)**: Joint work with Professor Peter Richtárik's Optimization and Machine Learning Lab. Development of the new distributed compression mechanism for federated-learning setup with better theoretical and experimental properties than the current state-of-the-art in compressed distributed optimization. Tech: Python, JAX (May '22)

Honors and Awards

- **AI Initiative Fund** (100k USD). Hyplex (previously HOCULUS) granted with funds for projects that tackle important research problems in core AI and its applications - July, 2021
- **Teaching Assistant Award** (KAUST). The recipient for TA of Principles of Optics course - 2019-2020.
- **Dean Award** (KAUST). Additional allowance for talented students - August, 2018
- **Ph. D. Fellowship** (KAUST). The recipient for 4 consecutive years - March, 2018

Recent Publications (2021-Present)[1]

In review

Makarenko, M., Gassanov, E. & Richtarik, P. *Adaptive Three Point Compressors for Communication-Efficient Federated Learning* in *Advances in Neural Information Processing Systems* (eds Ranzato, M., Beygelzimer, A., Dauphin, Y., Liang, P. & Vaughan, J. W.) (Curran Associates, Inc., 2022), 4384–4396.

Makarenko, M., Wang, Q., Totero Gongora, J. & Fratalocchi, A. Dense and scalable universal cognitive machines break biological efficiency via topological singularities. *Nature Machine Intelligence* (Mar. 2022).

Journal papers

Makarenko, M., Wang, Q., Burguete-Lopez, A., Getman, F. & Fratalocchi, A. Robust and Scalable Flat-Optics on Flexible Substrates via Evolutionary Neural Networks. *Advanced Intelligent Systems* **3,** 2100105. https://onlinelibrary.wiley.com/doi/abs/10.1002/aisy.202100105 (2021).

Makarenko, M., Getman, F., Burguete-Lopez, A. & Fratalocchi, A. Broadband vectorial ultrathin optics with experimental efficiency up to 99% in the visible region via universal approximators. *Light: Science & Applications* **10,** 47. https://doi.org/10.1038/s41377-021-00489-7 (Mar. 2021).

Wang, Q., Makarenko, M., Lopez, A. B., Getman, F. & Fratalocchi, A. Advancing statistical learning and artificial intelligence in nanophotonics inverse design. *Nanophotonics.* https://doi.org/10.1515/nanoph-2021-0660 (2021).

Li, N., Xiang, F., Makarenko, M., Elizarov, M., Lopez, A. B., Getman, F., Bonifazi, M., Mazzone, V. & Fratalocchi, A. Large-Scale and Wide-Gamut Coloration at the Diffraction Limit in Flexible, Self-Assembled Hierarchical Nanomaterials. *Advanced Materials* **34,** 2108013. https://onlinelibrary.wiley.com/doi/abs/10.1002/adma.202108013 (2022).

Conference proceedings

Makarenko, M., Burguete-Lopez, A., Wang, Q., Getman, F., Giancola, S., Ghanem, B. & Fratalocchi, A. *Real-time Hyperspectral Imaging in Hardware via Trained Metasurface Encoders* 2022. https://arxiv.org/abs/2204.02084.

Makarenko, M., Burguete-Lopez, A., Getman, F. & Fratalocchi, A. *Learning framework for unsupervised cellular refractive index and thickness measurement* in *Frontiers in Optics + Laser Science 2021* (Optica Publishing Group, 2021), JW7A.8. http://opg.optica.org/abstract.cfm?URI=FiO-2021-JW7A.8.

Burguete-Lopez, A., Makarenko, M., Getman, F. & Fratalocchi, A. *Artificial-intelligence Assisted, Label-free Imaging of Sub-cellular Biology* in *Biophotonics Congress 2021* (Optica Publishing Group, 2021), JTu4A.19. http://opg.optica.org/abstract.cfm?URI=OMP-2021-JTu4A.19.

Patents

Fratalocchi, A., Getman, F., Makarenko, M. & Burguete-Lopez, A. *Light processing device based on multilayer nano-elements* US Patent App. 17/422,549. https://www.freepatentsonline.com/y2022/0091318.html.

Makarenko, M., Fratalocchi, A., Getman, F., Burguete-Lopez, A. & Wang, Q. *Hyplex Hyperspectral Imaging System* Provisional U.S. Application No. 63/277,741.

Fratalocchi, A., Makarenko, M., Fariborzzi, H. & Lin, R. *Ultrafast integrated artificial intelligent chip based on complex lasers* US Patent App. 24/122,372.

Certifications

- **Bayesian Statistics Specialization**
  University of California, Santa Cruz — *Mar 2022*
- **Algorithms for developers**
  Yandex — *Dec 2021*

Teaching Experience

- **Principles of Optics** — Teaching Assistant
  ECE 225, CEMSE KAUST — *Jan 2019 - Present*
- **Advanced Photonics Concepts & Application** — Teaching Assistant
  ECE 325. CEMSE KAUST — *Feb 2021*

[1] This is non-exhaustive list, full publication list is available here