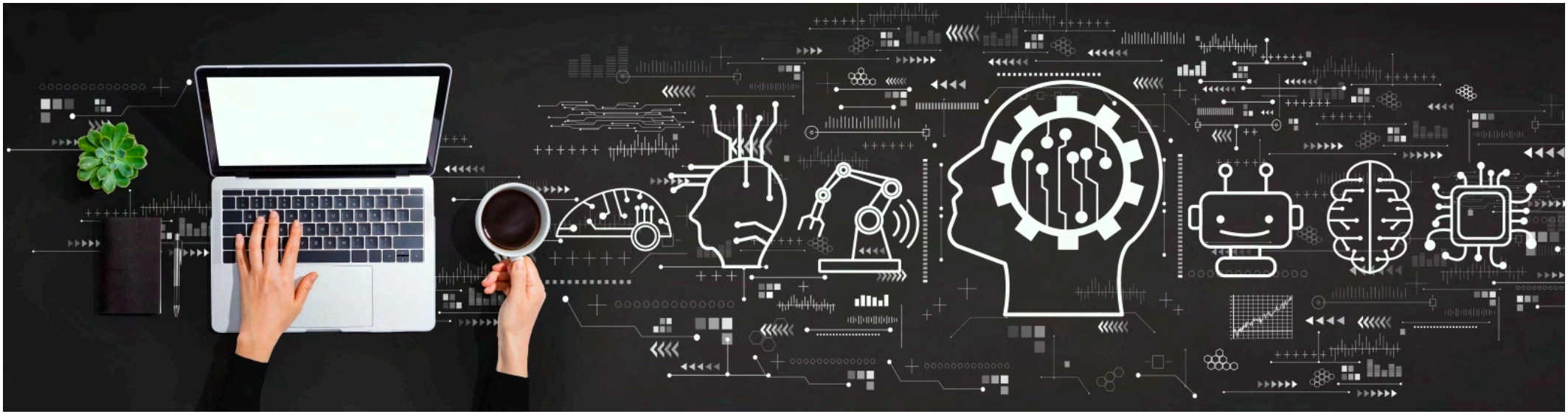
A New M.Sc in Machine Learning and Big Data
At the Open University of Israel

Prof. Elishai Ezra Tsur



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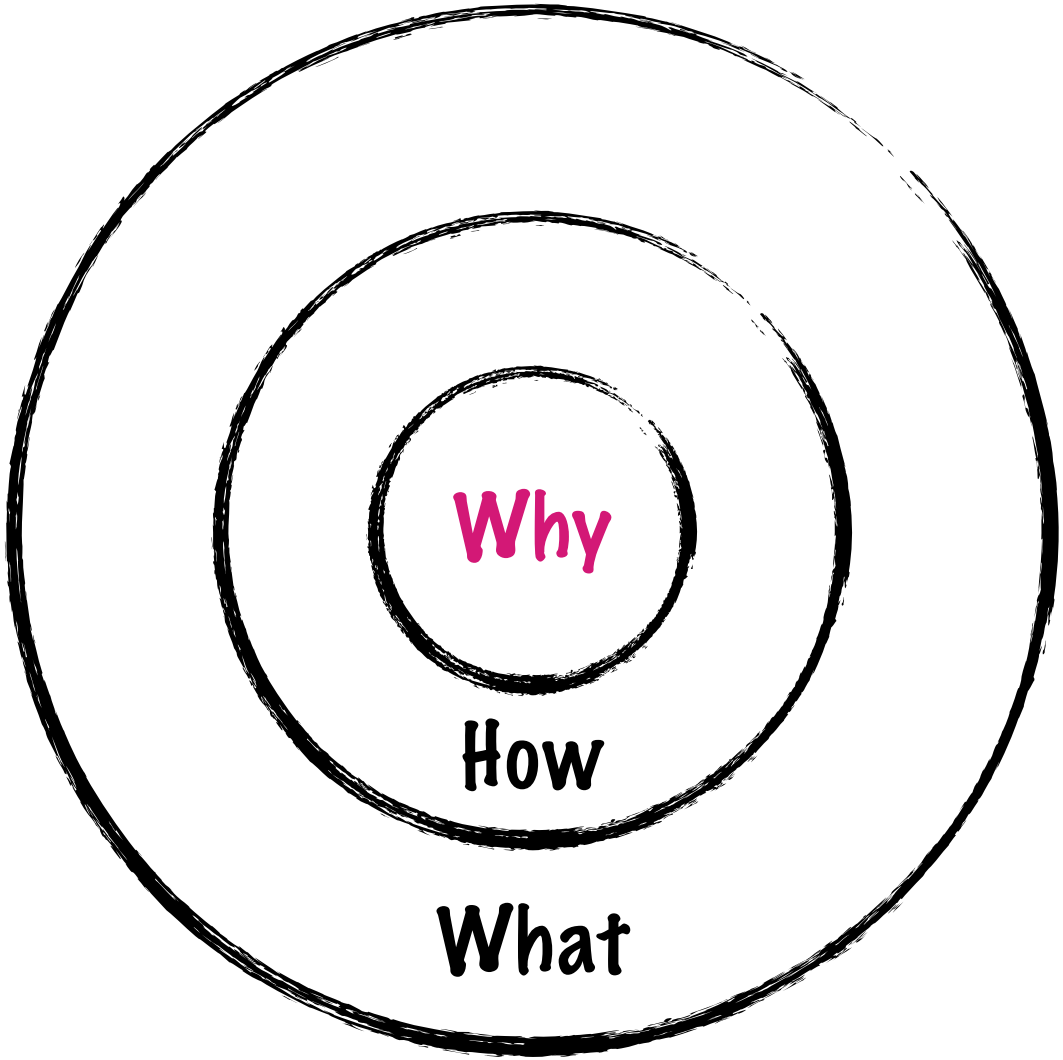
Exploring new inter-disciplinary frontiers in AI



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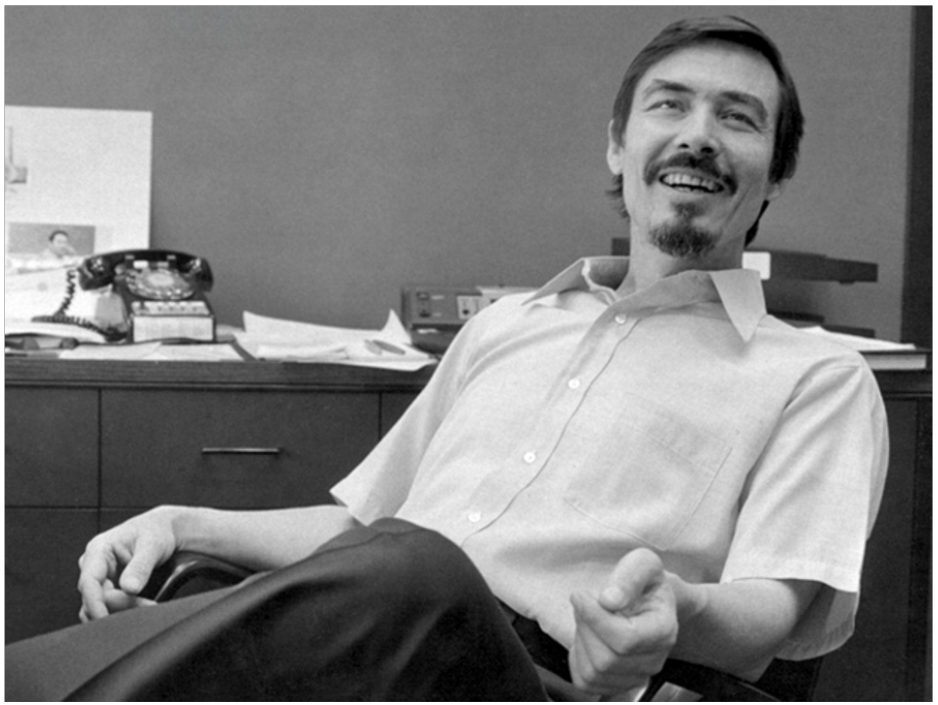
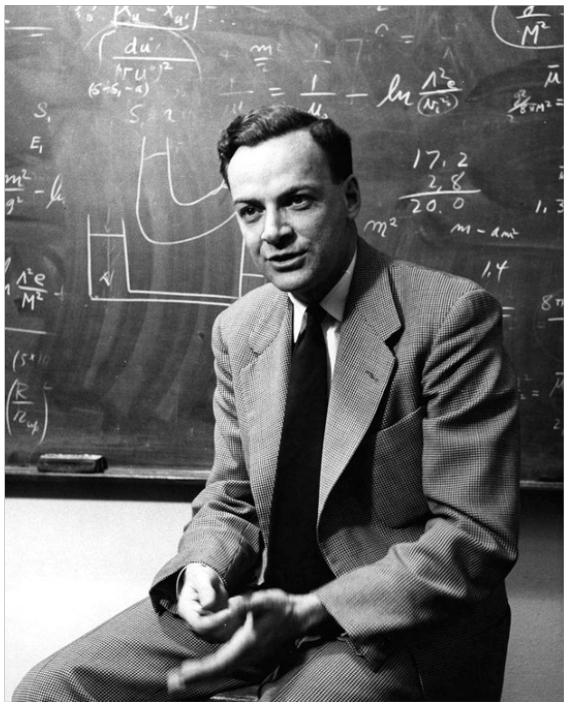
The course was called *Physics of Computation*. It was exhausting, exhilarating, and enlightening; the student were amazed, confused and overwhelmed..



Carver Mead



Richard Feynman

John Hopefield

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How we created neuromorphic engineering

Neuromorphic engineering aims to create computing hardware that mimics biological nervous systems, and it is expected to play a key role in the next era of hardware development. Carver Mead recounts how it all began.

My fascination with the nervous systems of animals as computing systems started 40 years ago. I had spent over 10 years developing an understanding of the limits that semiconductor technology places on large-scale computing systems, and how the evolution of the technology by Moore's law affects those limits. It had become clear to me that industrial practice was on a problematic path: in the race to release new product generations, it was faster to scale old designs to smaller feature sizes than to innovate at the architecture level. But where to look for inspiration, even if the industry would allow such innovation?

This was the topic of a lunch with Richard Feynman and John Hopfield, two of my favourite Caltech colleagues. We had come to the question from very different backgrounds, and decided that the best way to develop our mutual understanding was to teach a joint course on the subject. The course was called *Physics of Computation* and started in 1981. It was exhausting, exhilarating and enlightening; the students

Fig. 1 | Photograph of Misha Mahowald, who died in 1996, and Carver Mead testing Mahowald's stereo-correspondence chip in the Mead lab in the early 1990s.

C. Mead - Nature Electronics, 2020

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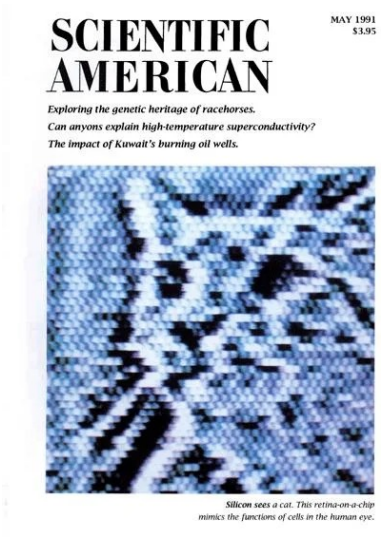
The Silicon Retina

A chip based on the neural architecture of the eye proves a new, more powerful way of doing computations

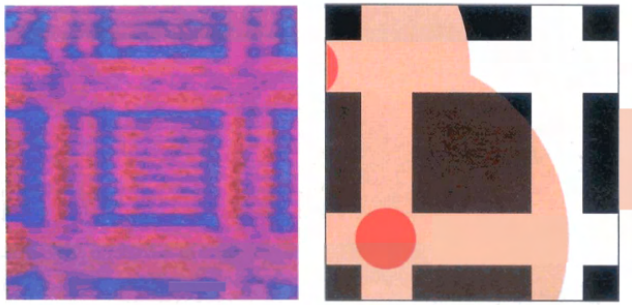
by Misha A. Mahowald and Carver Mead



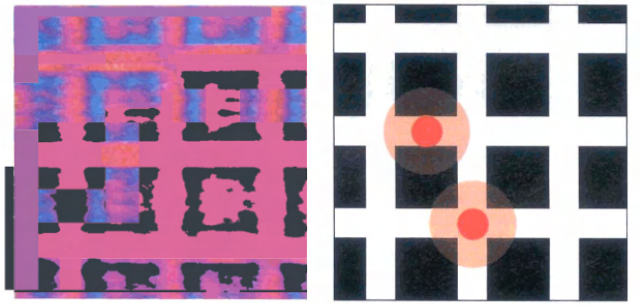
Silicon sees a cat. This retina-on-a-chip mimics the functions of cells in the human eye.

Optical Illusions and the Silicon Retina

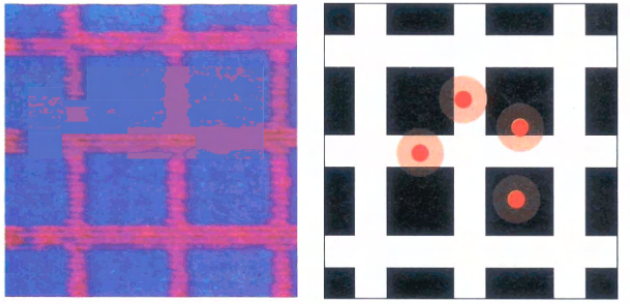
That the silicon retina is subject to some of the same misperceptions as is the human visual system suggests it has captured some essential biological principles. The Herring grid is one well-studied illusion: gray patches appear at the intersections of a grid of black squares on a white background. These patches occur because the retina's response at a given point in the visual field depends on the light intensity at nearby points. (This is the so-called center-surround effect.) The neighborhood of the intersections contains more white space and so reduces the apparent brightness of the intersection itself. A simpler example of the same effect is the illusion of simultaneous contrast (*bottom*), in which a gray square appears darker or lighter depending on the brightness of its background.



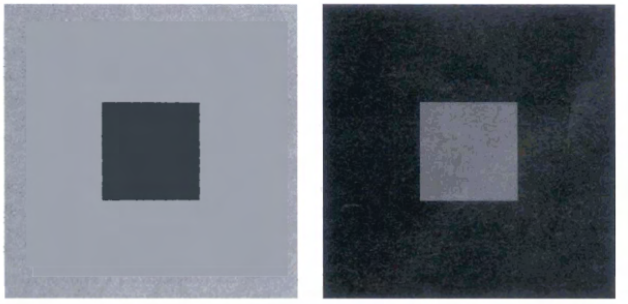
Close-up of the grid reveals no illusory brightness change because both the center and the surround of the receptive field are smaller than the space between the squares.



When the size of the center receptive field is comparable to the space between the squares, the illusion appears.



The illusion disappears again when the grid is viewed from a distance, because the average intensity registered by the surround is roughly the same everywhere.



The small squares in both of these images are the same shade of gray. The retina, however, perceives brightness in relation to an object's background, and so the small square on the right appears lighter.

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20 years later….

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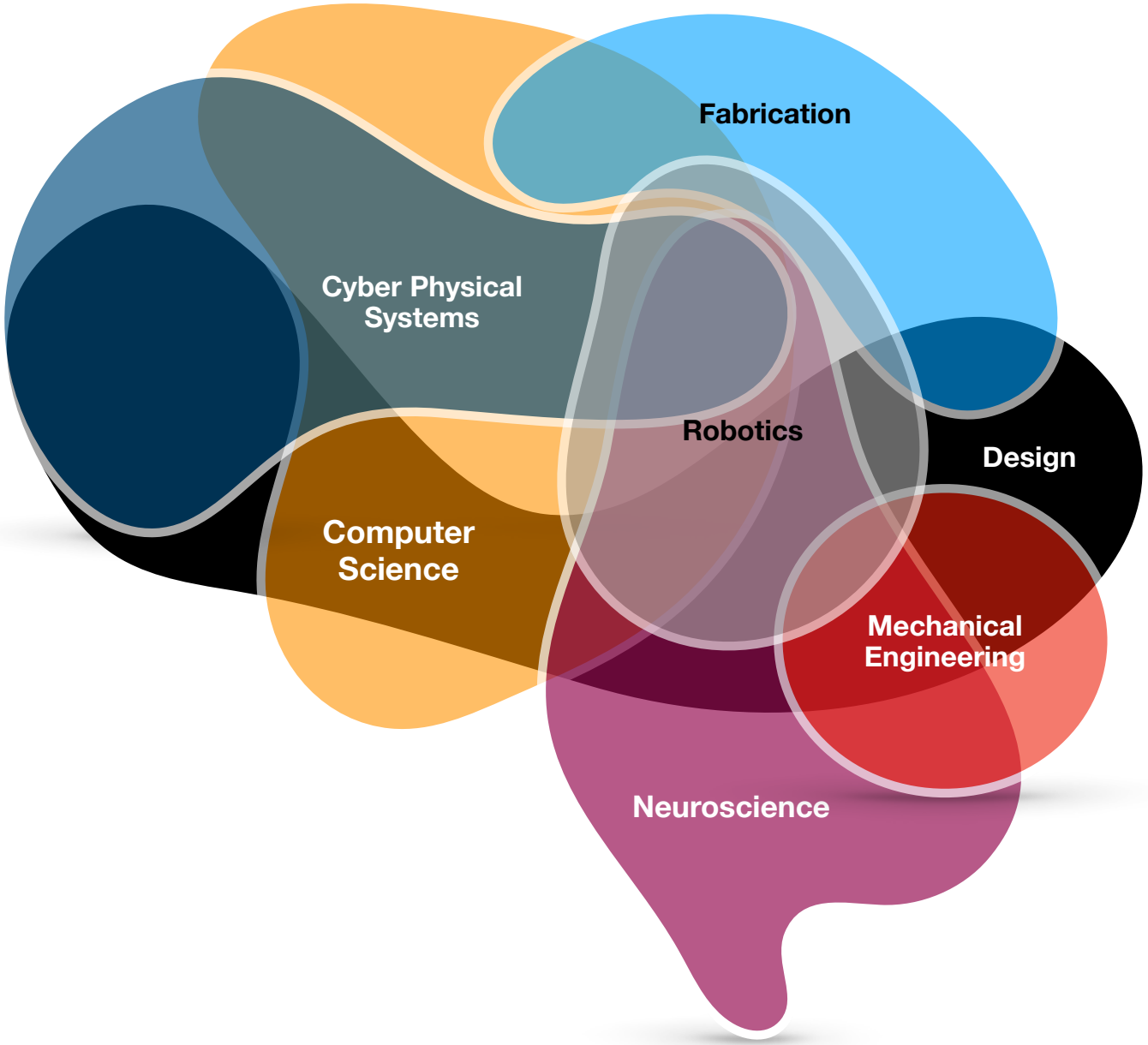
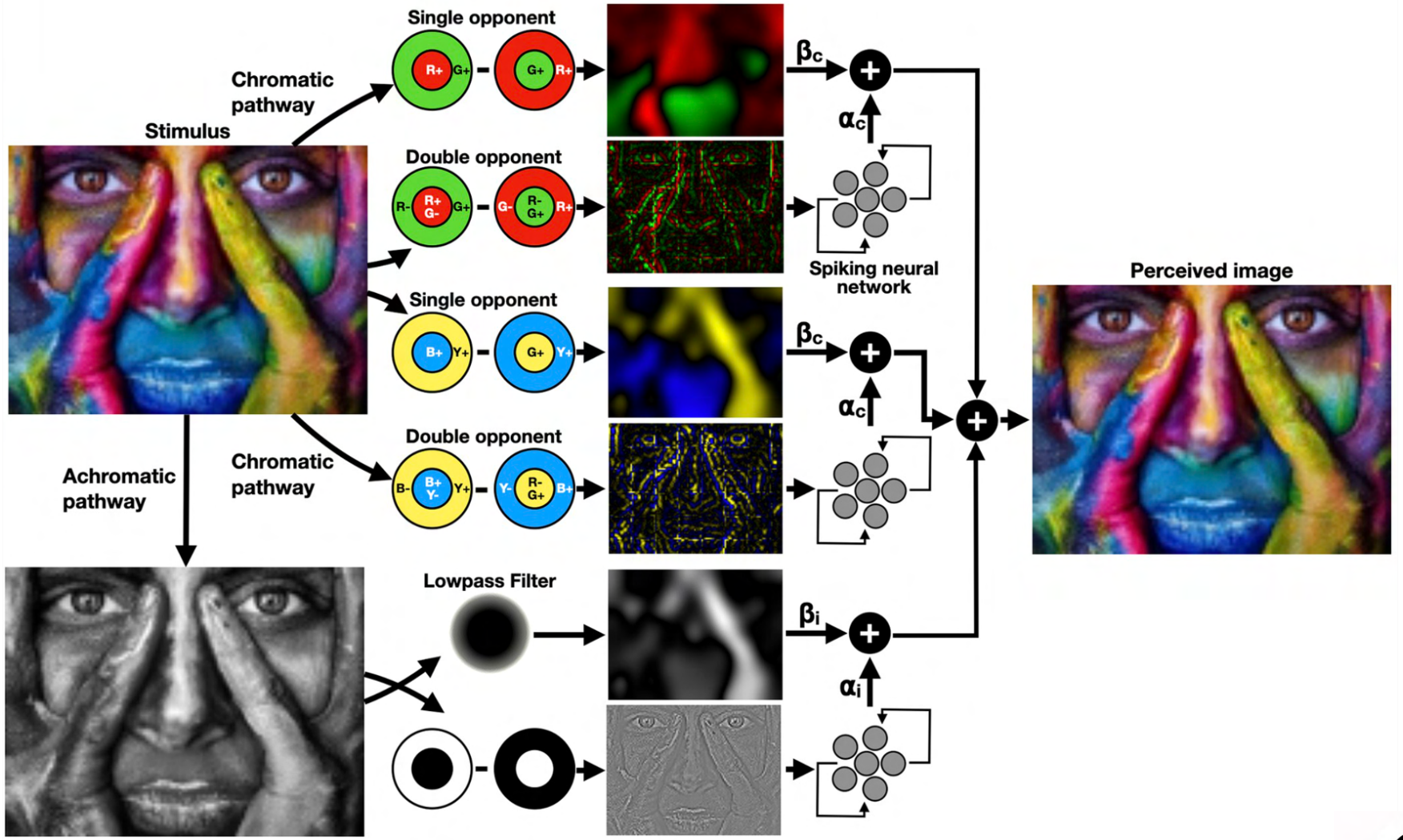


PLOS COMPUTATIONAL BIOLOGY

Hadar Cohen-Duwek[1], Hamutal Slovin[2], Elishai Ezra Tsur[1]*

Computational modeling of color perception with biologically plausible spiking neural networks



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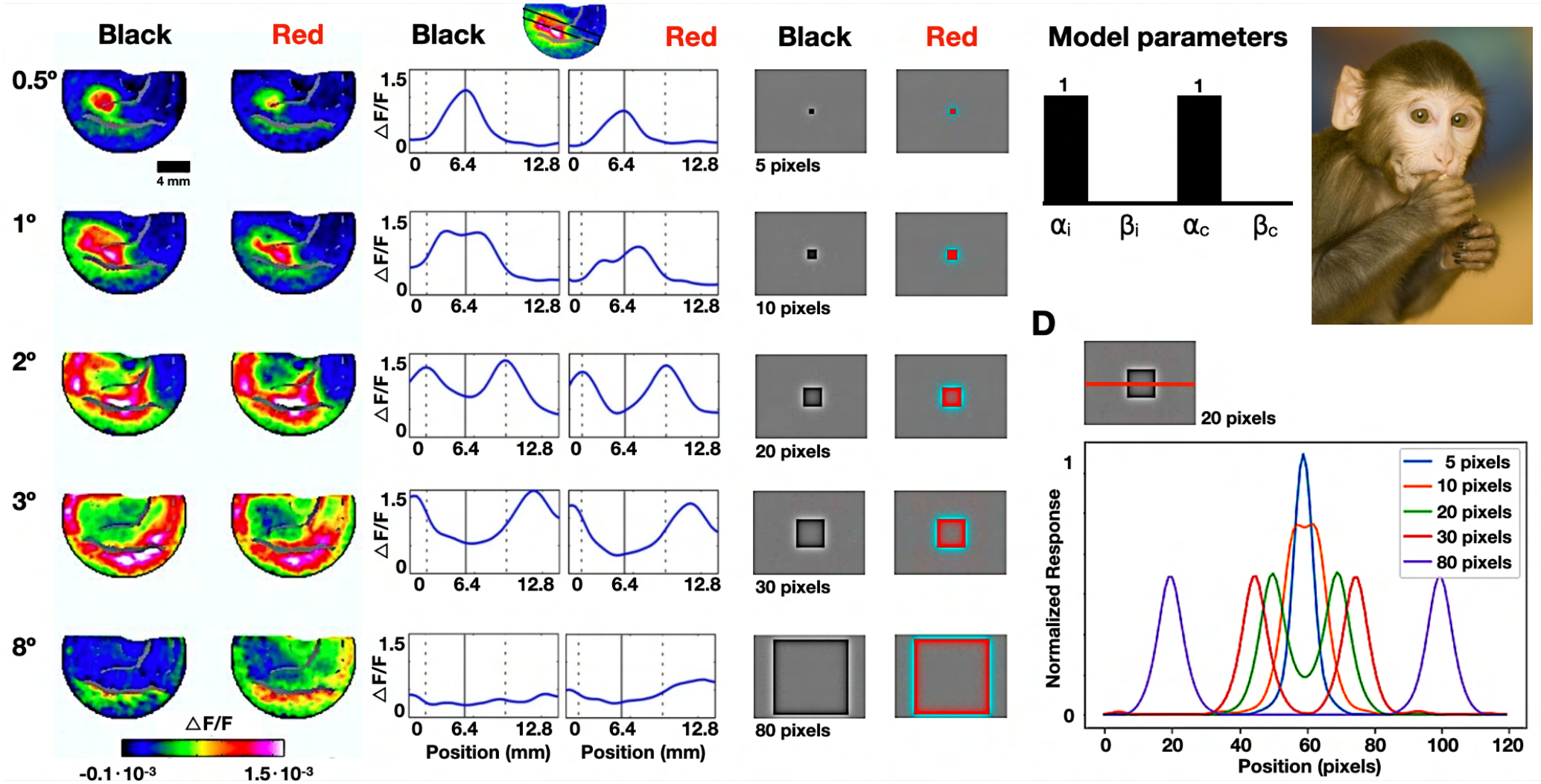
Biological Experimentation



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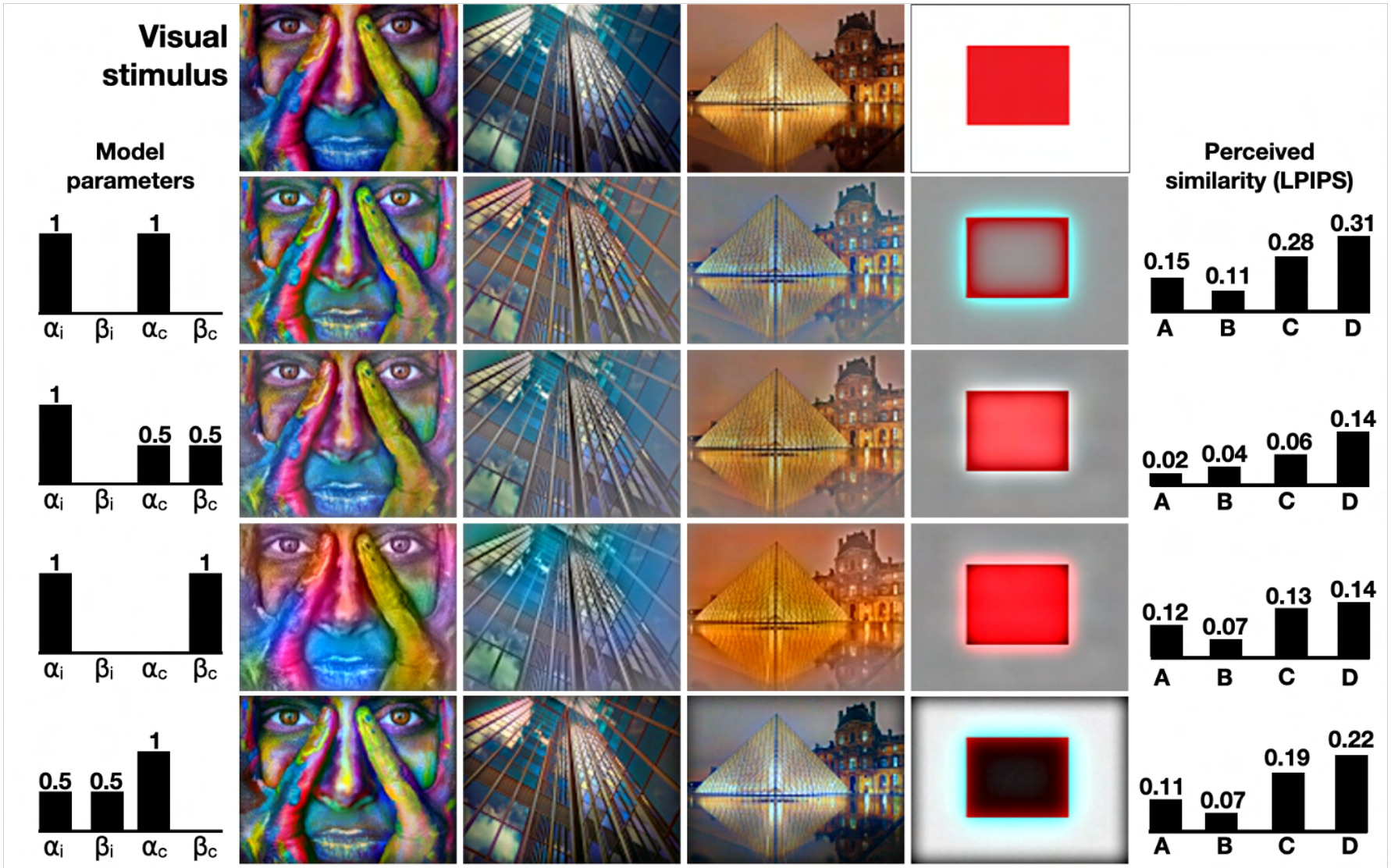
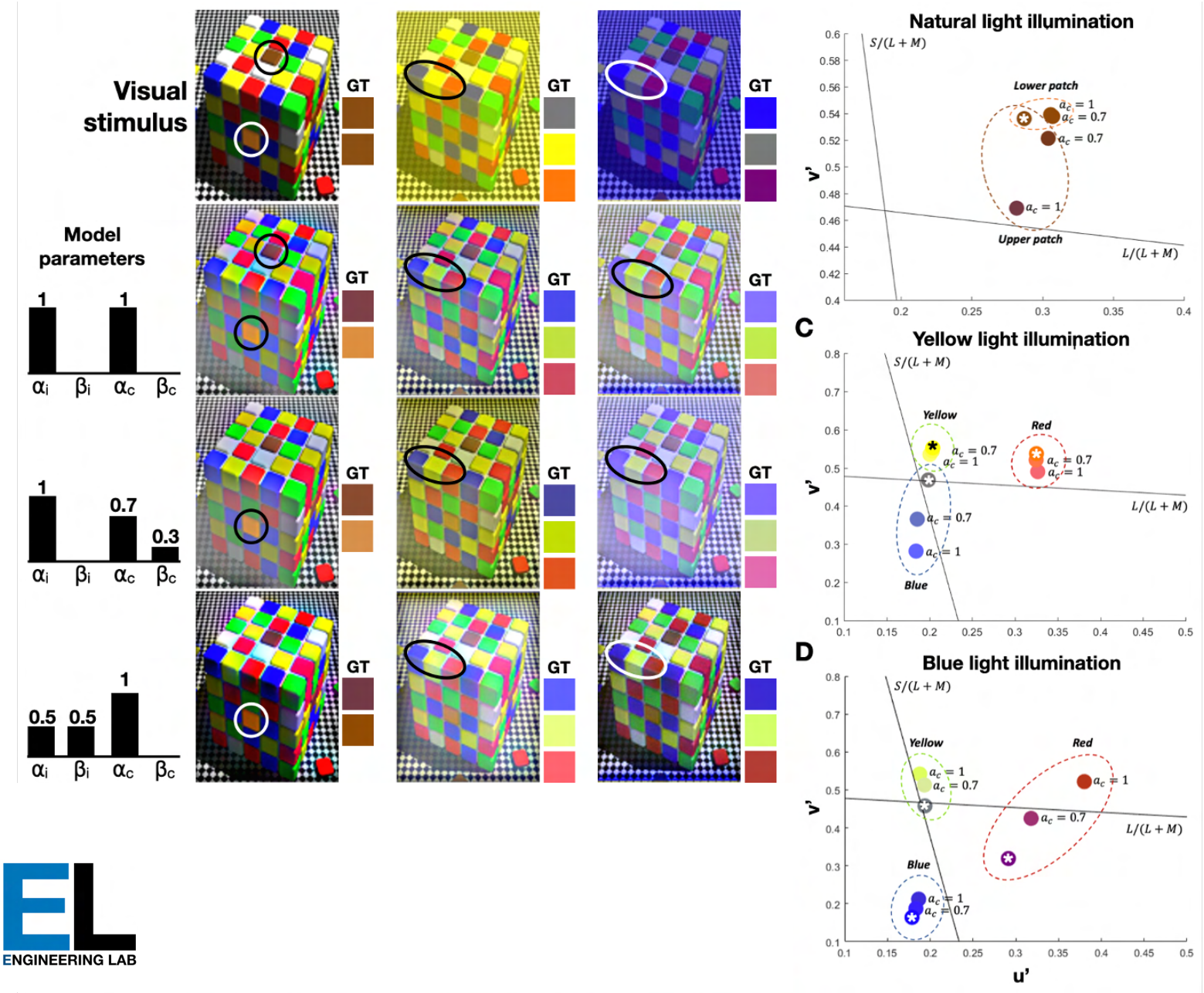
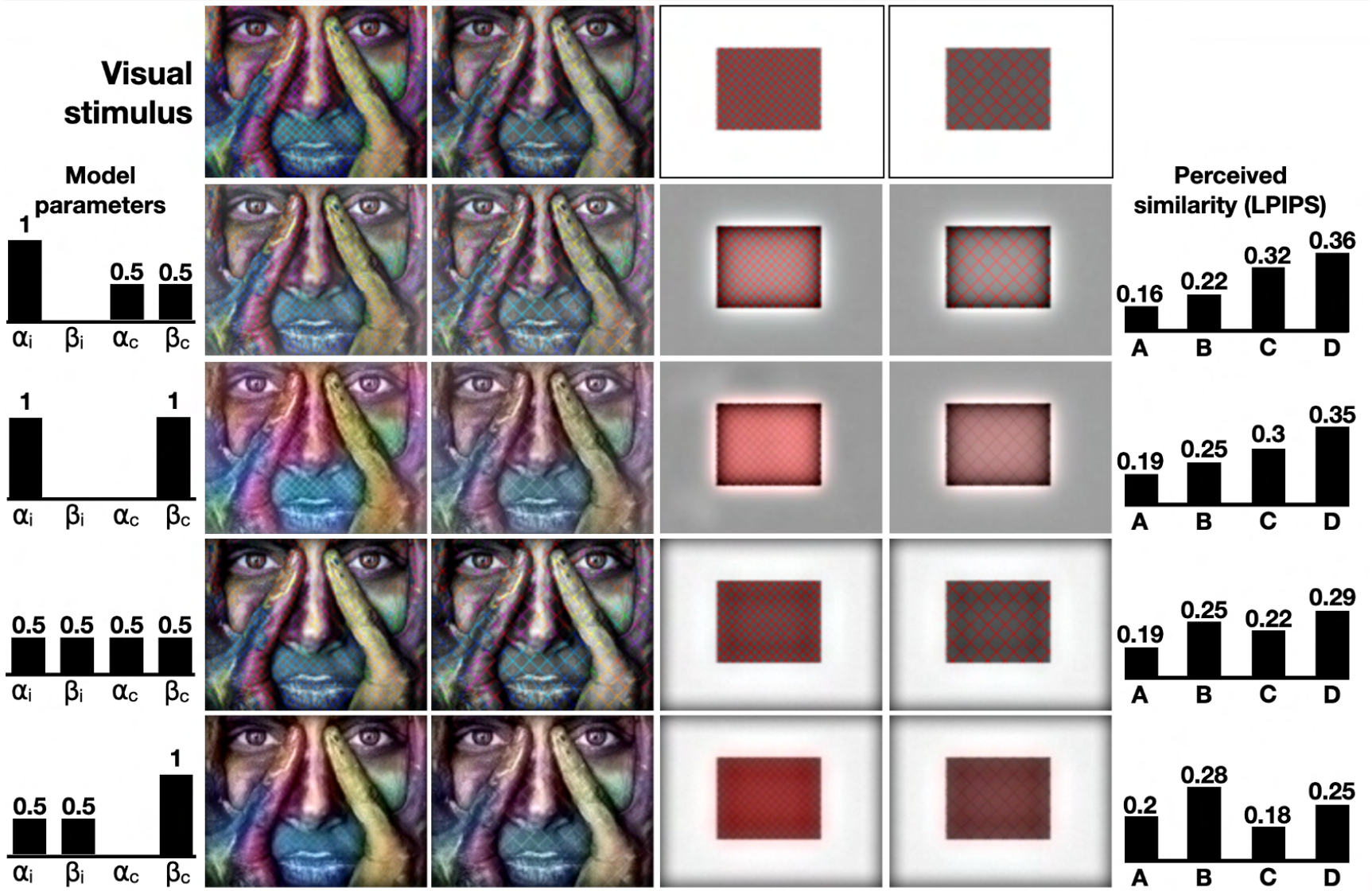
Explaining Image Reconstruction



Explaining the “Cube Illusion”



Explaining Color Assimilation



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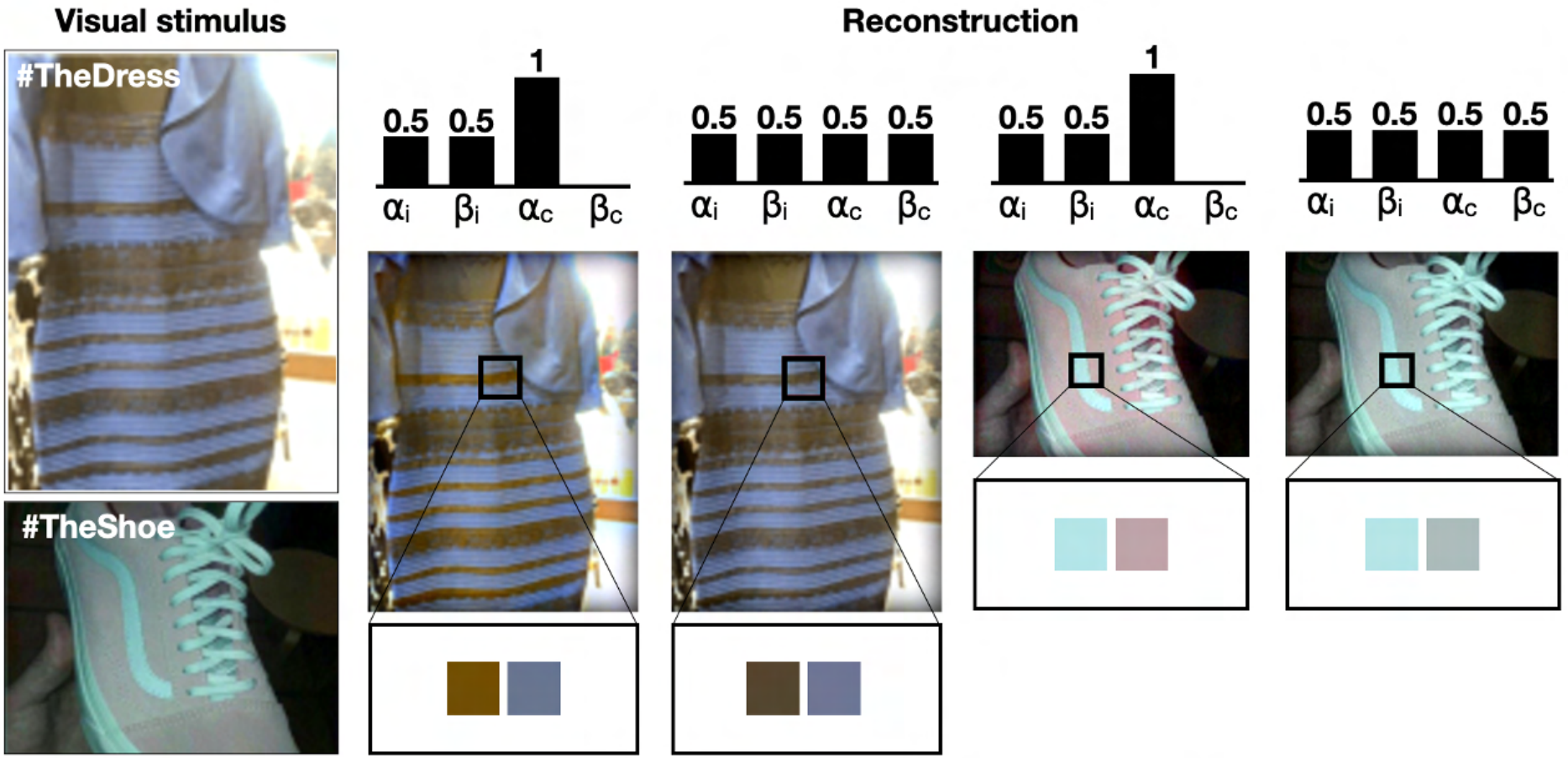
Explaining Individual Color Perception



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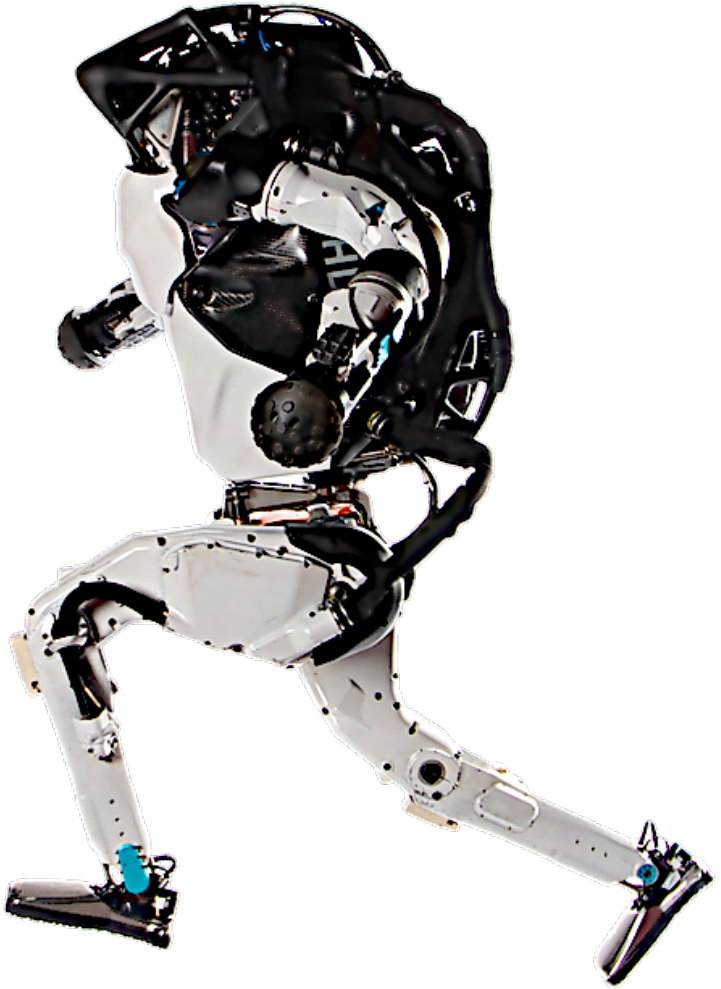
A new field emerged: Neurorobotics



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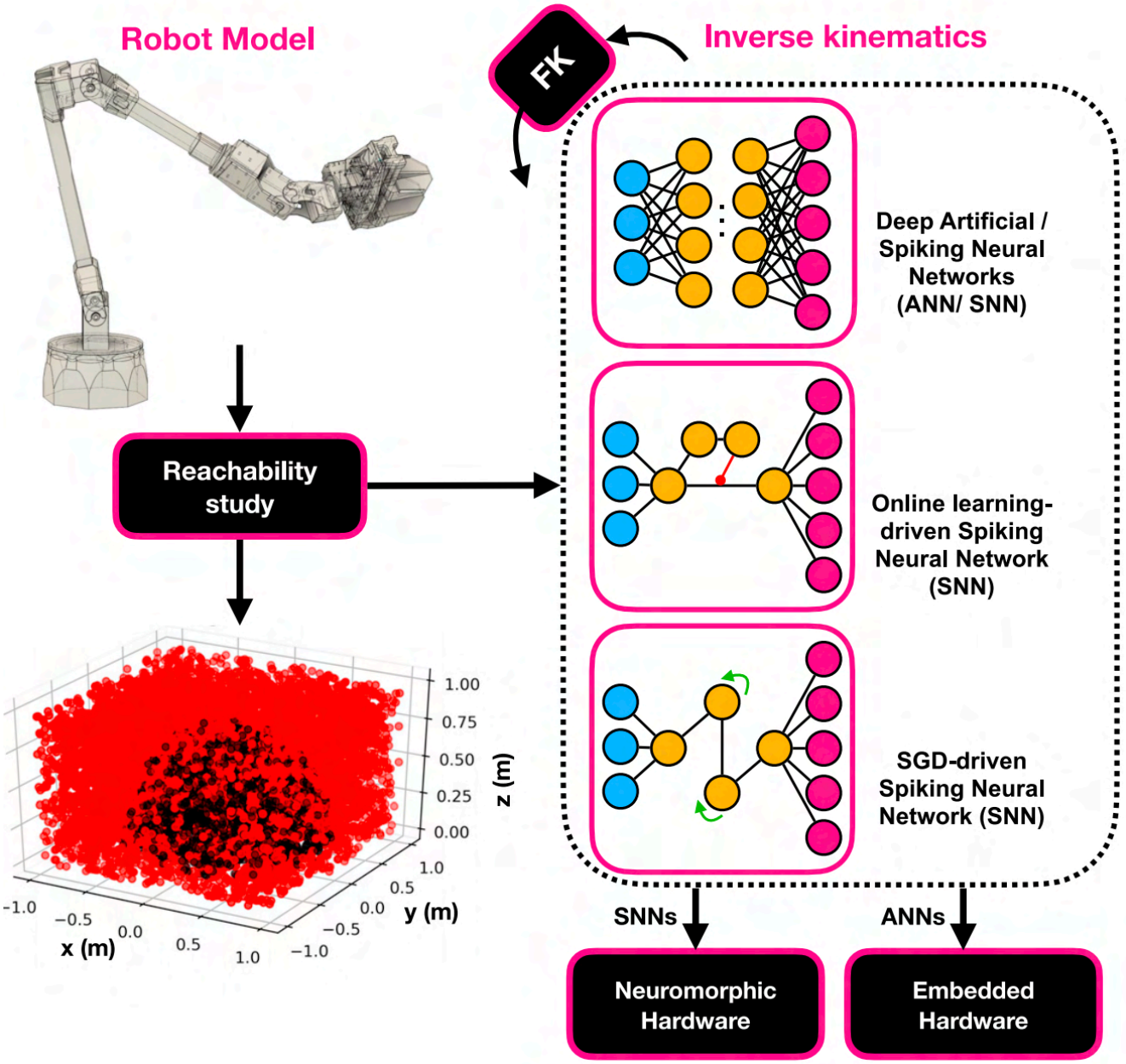
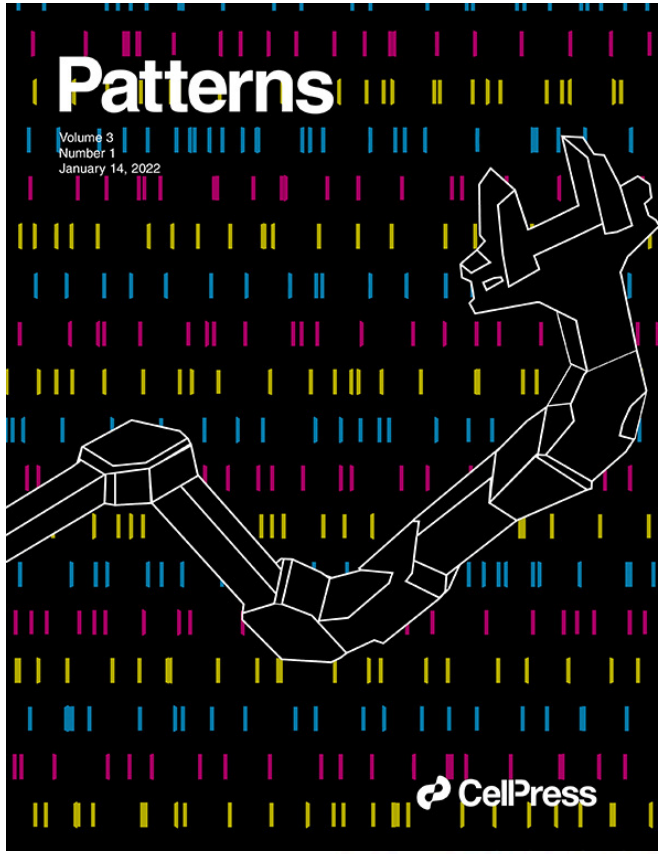
Patterns

Data-driven artificial and spiking neural networks for inverse kinematics in neurorobotics

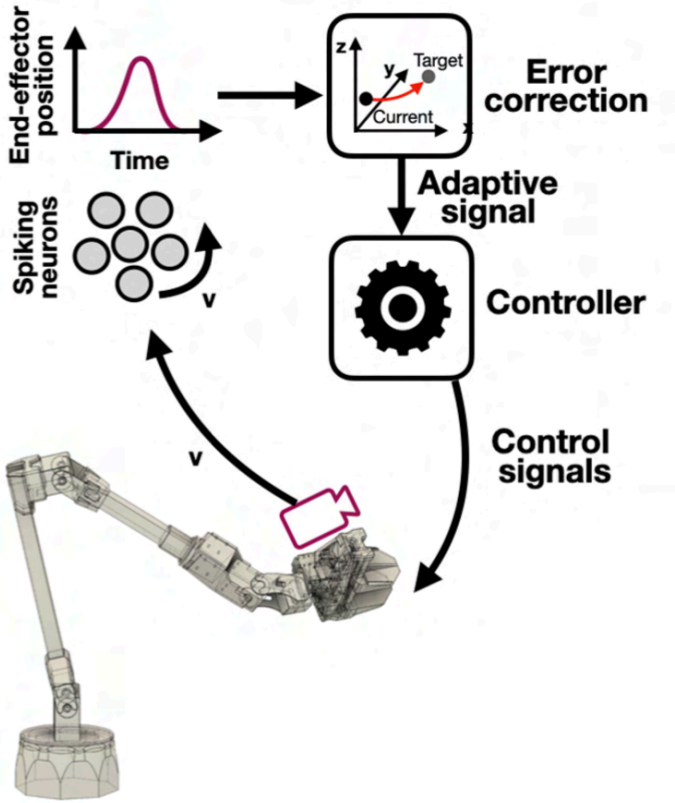




Adaptive control of a wheelchair mounted robotic arm with neuromorphically integrated velocity readings and online-learning

frontiers | Frontiers in Neuroscience

Michael Ehrlich[1†], Yuval Zaidel[1†], Patrice L. Weiss[2,3], Arie Melamed Yekel[3], Naomi Gefen[3], Lazar Supic[4] and Elishai Ezra Tsur[1*]



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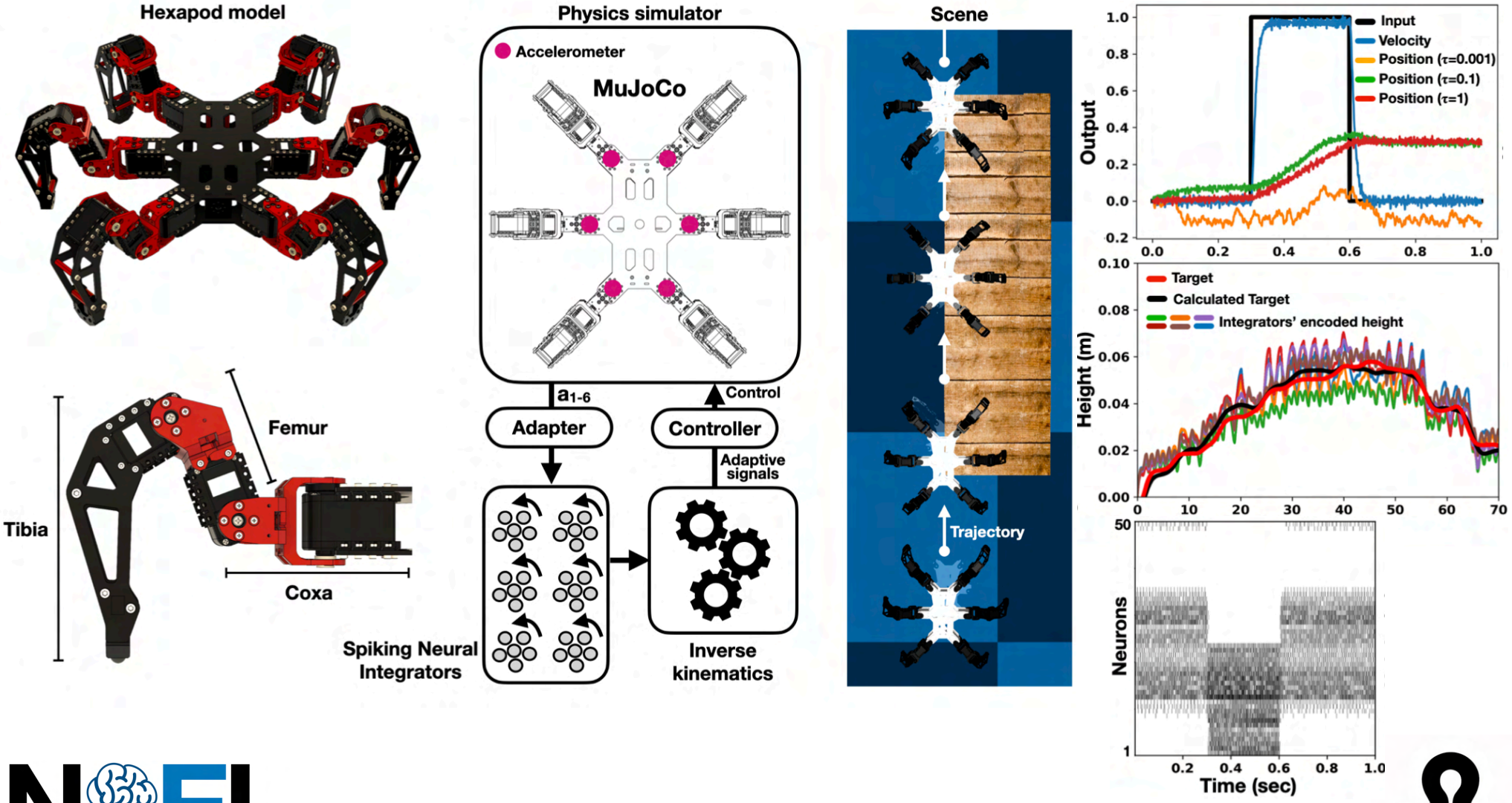
Neuromorphic Adaptive Body Leveling in a Bioinspired Hexapod Walking Robot

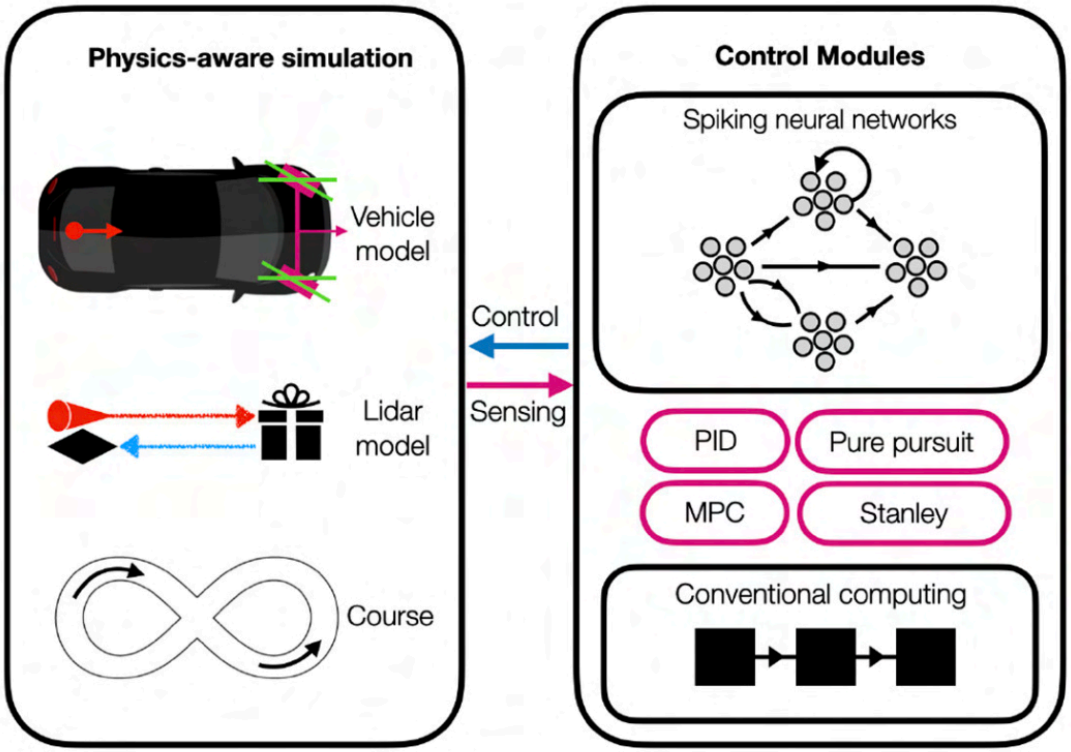
Michael Ehrlich and Elishai Ezra Tsur

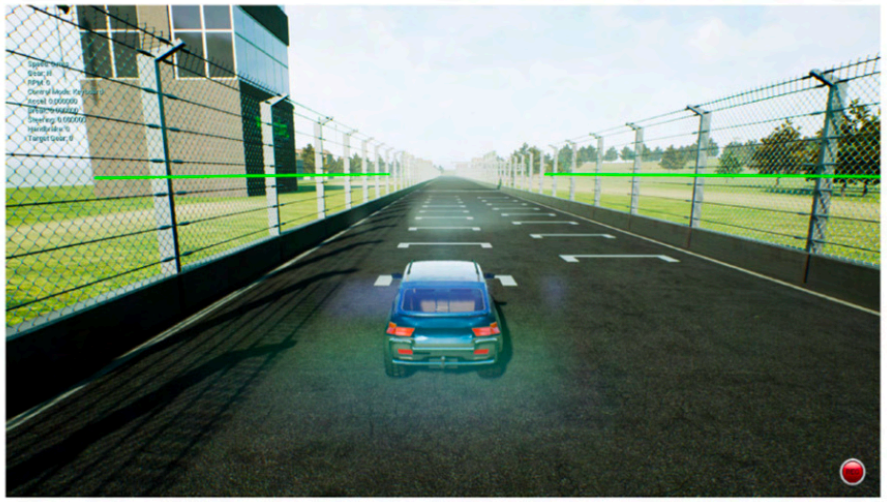


Autonomous driving controllers with neuromorphic spiking neural networks

Raz Halaly and Elishai Ezra Tsur*

frontiers | Frontiers in Neurorobotics





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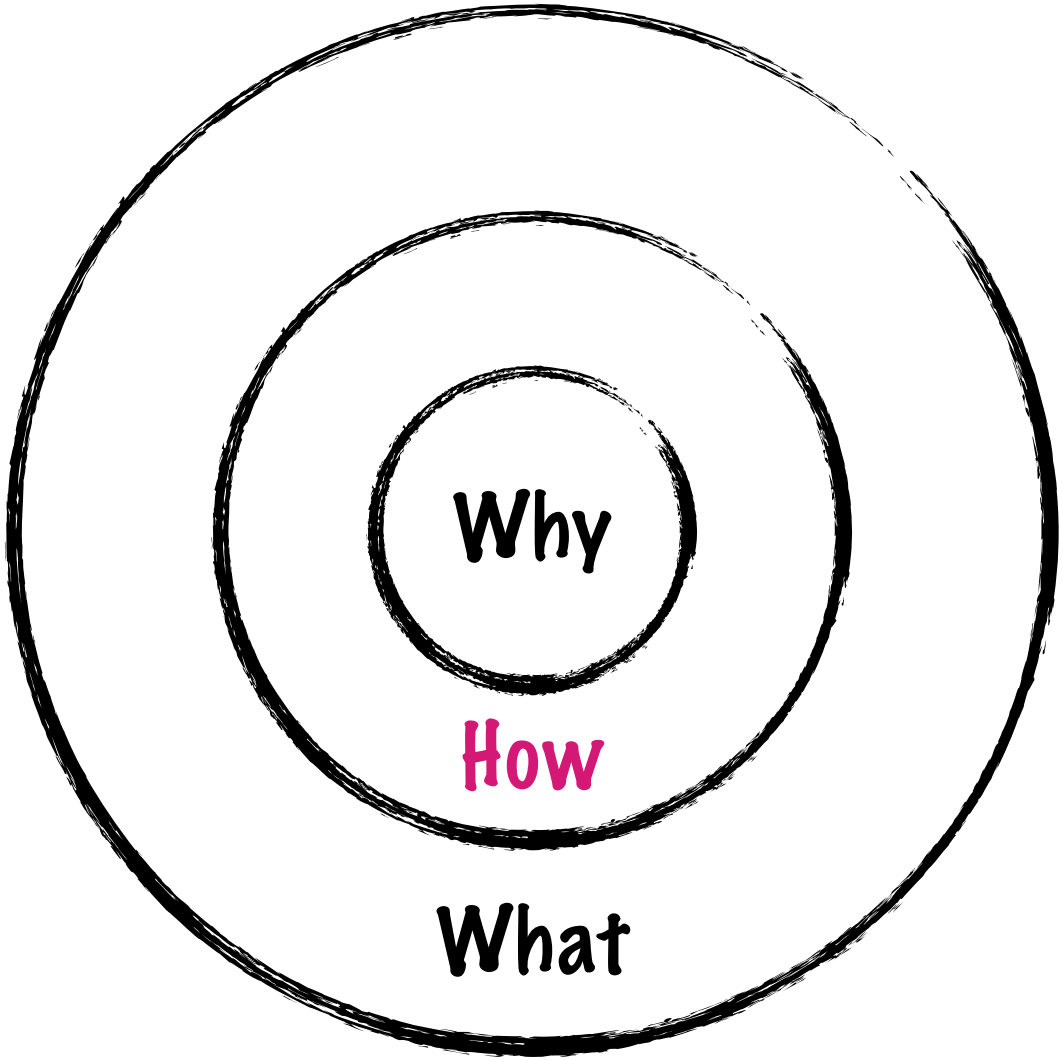
Building a common language



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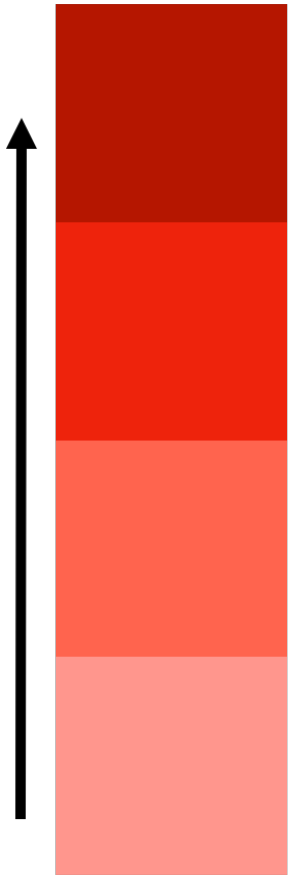
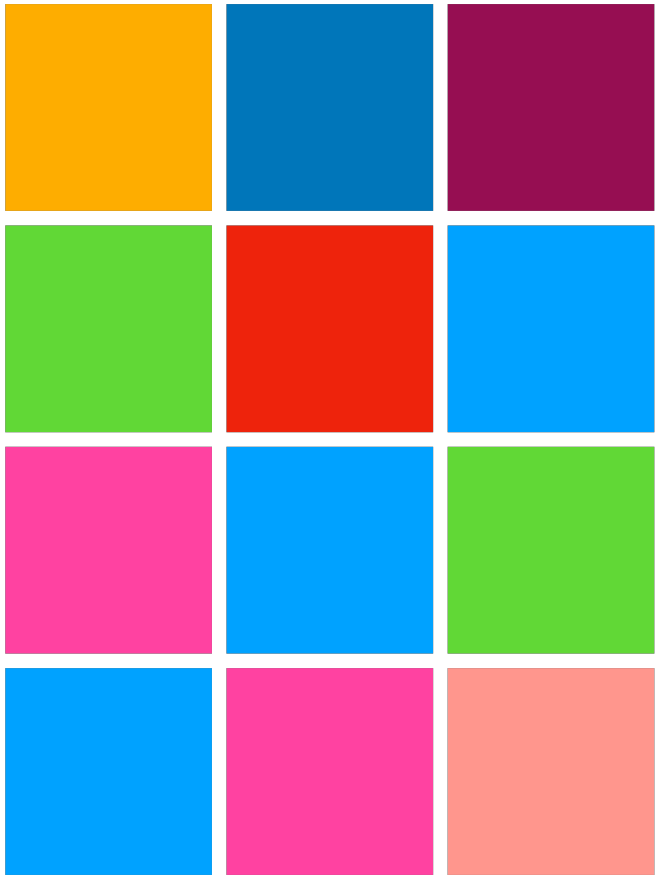
Linear learning



Combinatorial learning



Remember?

… It was exhausting, exhilarating, and enlightening; the student were amazed, confused and overwhelmed..

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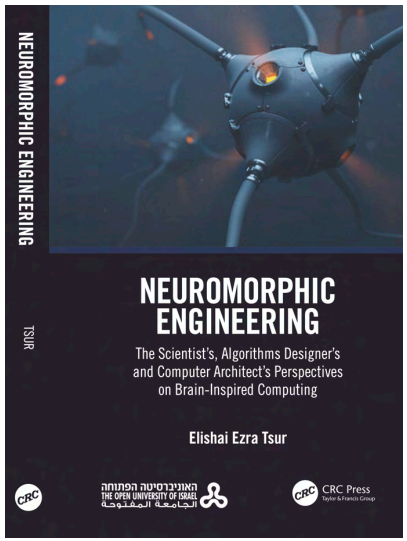
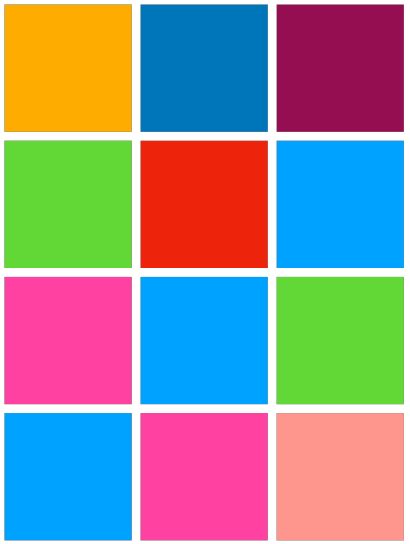
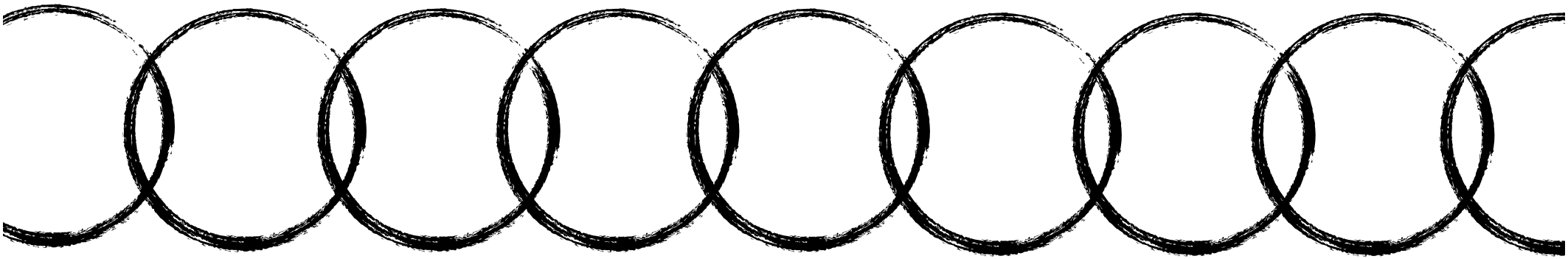
About me…





B.Sc.	Life Sciences
B.A.	History, Philosophy
M.Sc.	Bioengineering
M.Sc.	Computer Science
M.Sc.	Clinical Neuropsychology
Ph.D.	Bioengineering
PostDoc.	Neuroscience



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Student profile:

- Engineering Degree (Aeronautics and Space, Chemical, Electrical…)
- Bachelor degree in exact sciences (Mathematics, Statistics…)
- Bachelor degree in natural sciences (Biology, Chemistry, Physics…)
- Bachelor degree in Management and Economics
- Bachelor degree in Computer Science

With adequate mathematical background in:

- Calculus
- Linear algebra
- Statistics and Probability

Graduated with a high final grade (>80)

We plan a **new bootcamp in mathematics** for student coming from other disciplines

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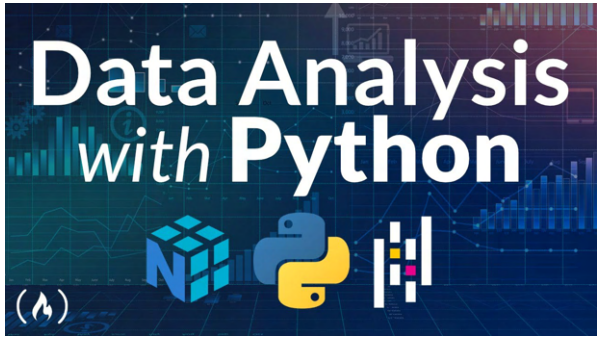
A Novel Preparation Program for student with varying backgrounds

- For students with a limited CS background
- Can be completed during the first year

New Courses



Introduction to Computer Science and Data Analysis with Python

Computer Science in a Nutshell

Algorithms
(MOOC via CampusIL)

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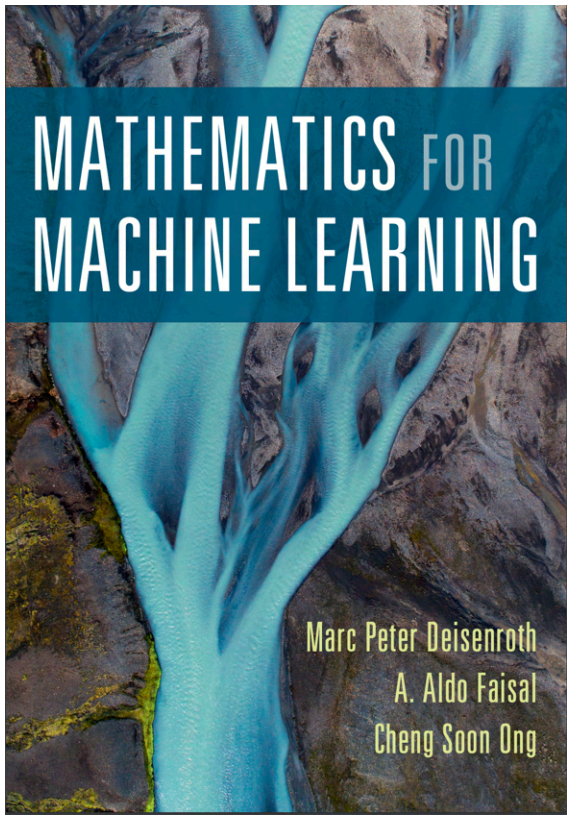
A New First Course

Mathematics for Machine Learning

- **Mandatory for all student**
- **First offering: 2025a**
- **4 credits**



- Introduction
- Abstract Linear Algebra
- Analytic Geometry
- Matrix Decomposition
- Vector Calculus
- Probability and Distributions
- Continuous Optimization
- When Models Meet Data

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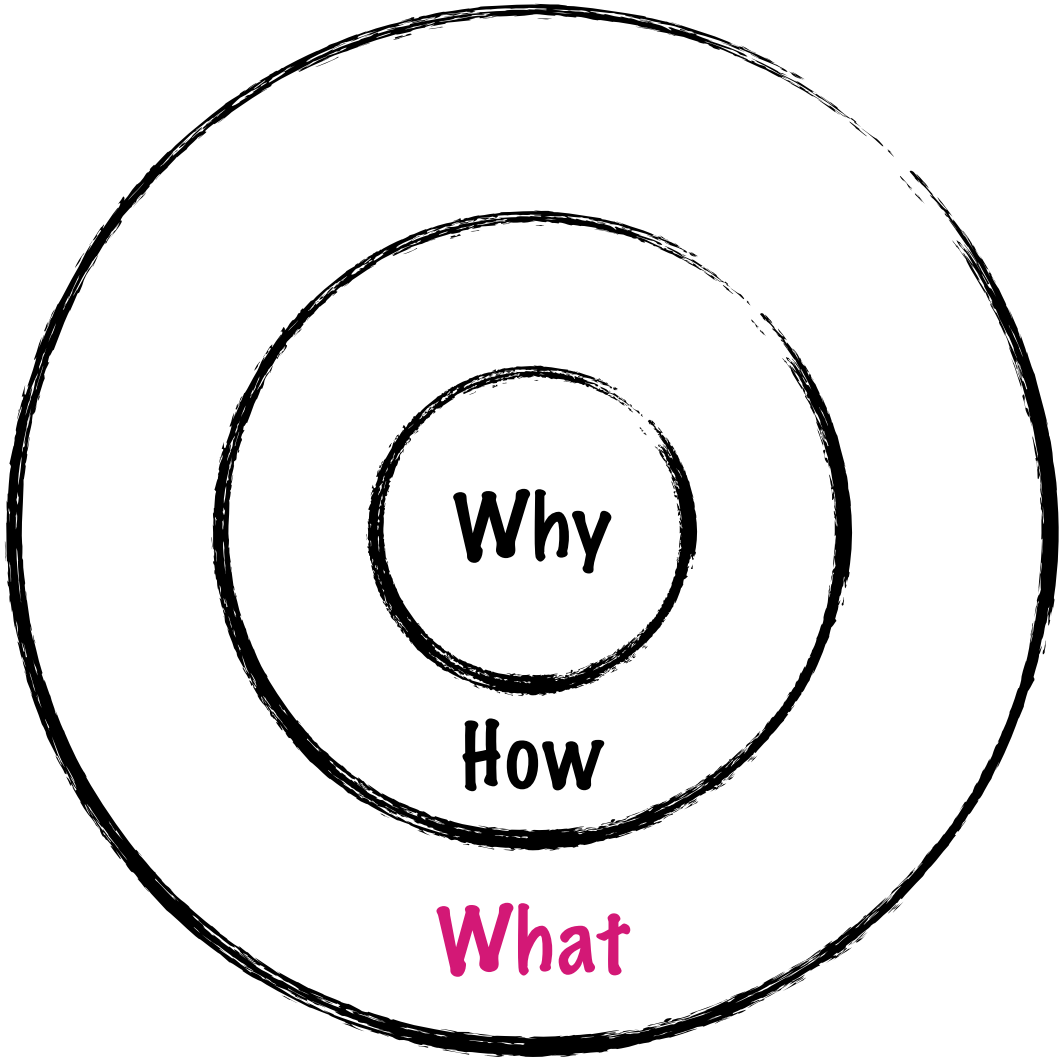
Deep Dive into Machine Learning and Big Data



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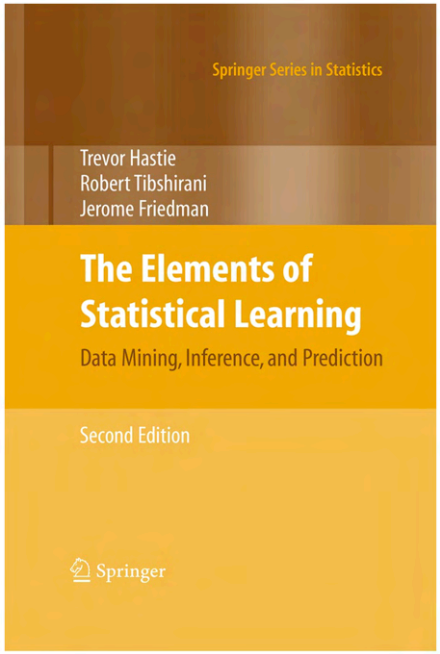
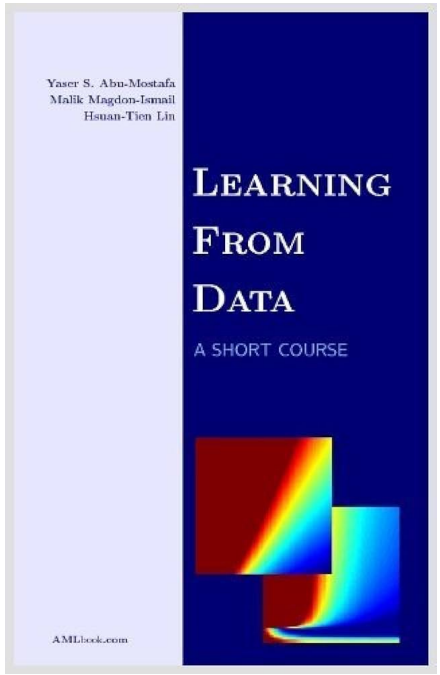
Core Courses

- **Introduction to Machine Learning**
  - Linear models for regression and classification
  - Regularization and overfitting
  - Support Vector Machines
  - Decision trees, Random Forests, Bagging, Boosting, Estimation
  - Neural Networks
  - Cluster Analysis, Maximum Visibility, Bayesian and EM parameters
  - Gaussian Mixture Model, Dimension Reduction
- **Deep Learning**
  - Building models with PyTorch
  - Deep Neural Networks
  - Convolutional Neural Networks
  - Recursive Neural Networks
  - Transformes
  - Natural Language Processing
  - Computer Vision
  - Generative Models





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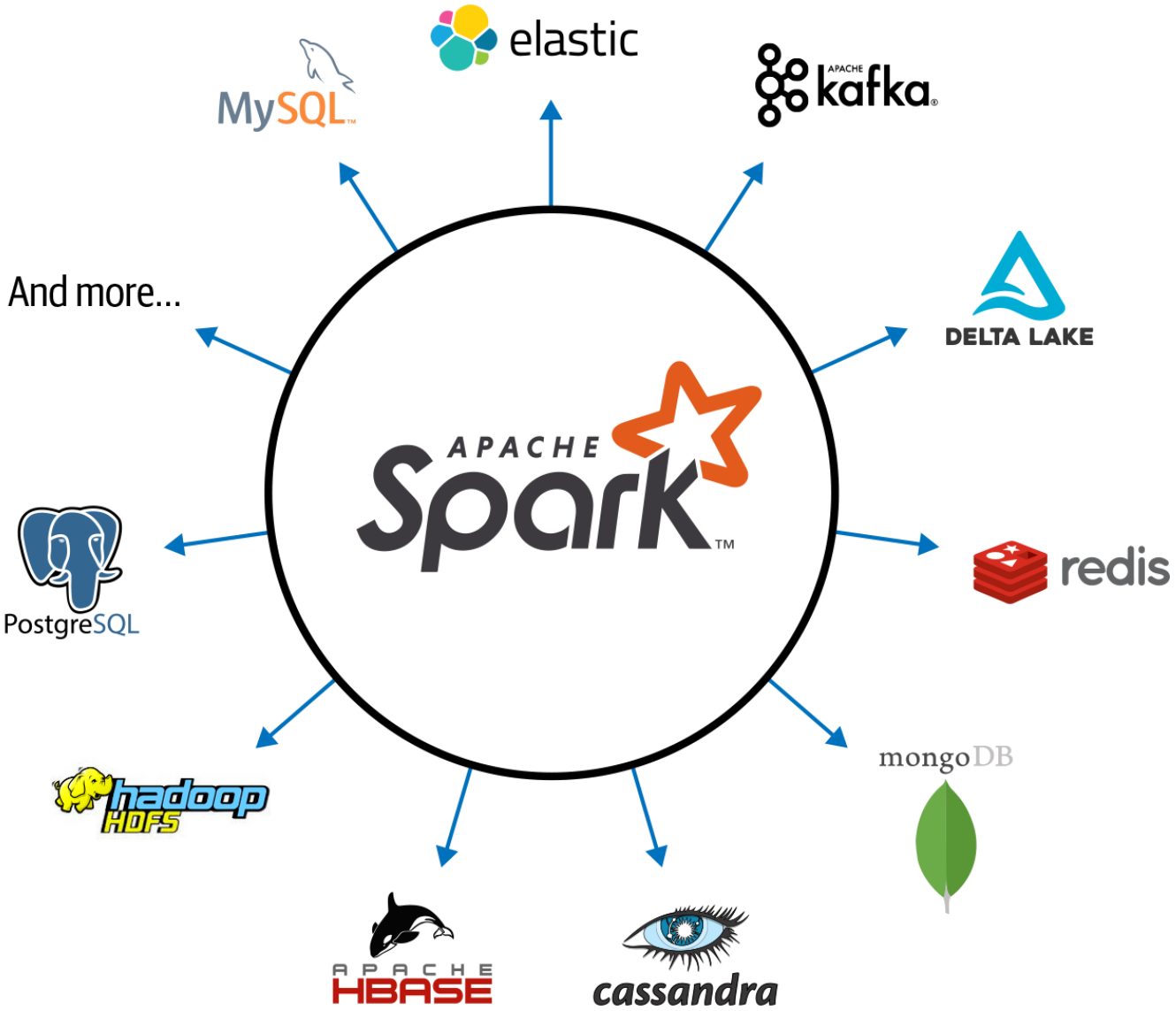
Core Courses

- **Big Data Technologies (New Course, offering: 2025b)**
  - Introduction to Big Data
  - Distributed Data bases
  - Spark and Spark.ml
  - Kafka
  - Hadoop
  - NoSQL



- **Big Data Algorithms**
  - Streaming algorithms
  - Sub-linear algorithms
  - Local and distributed
  - algorithms (cluster computin

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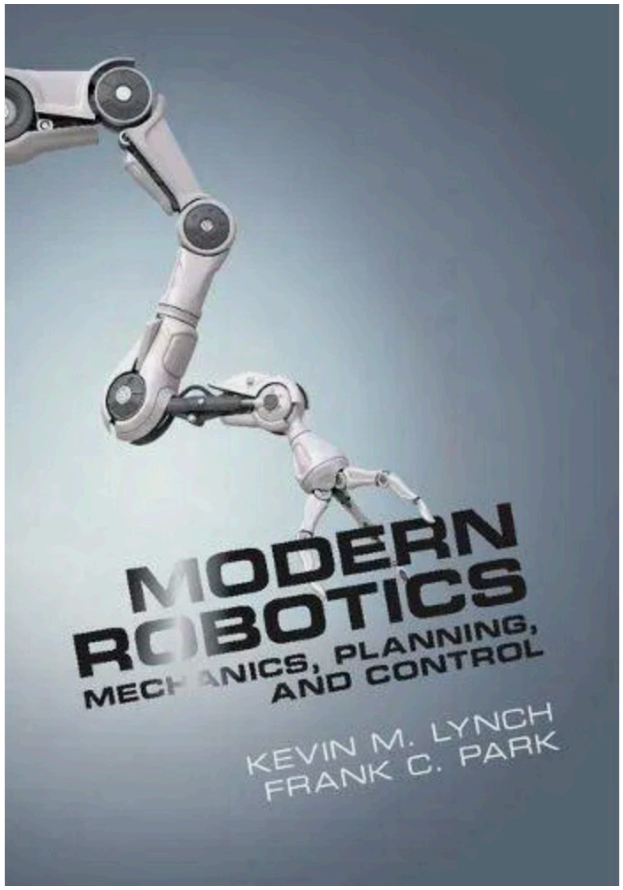
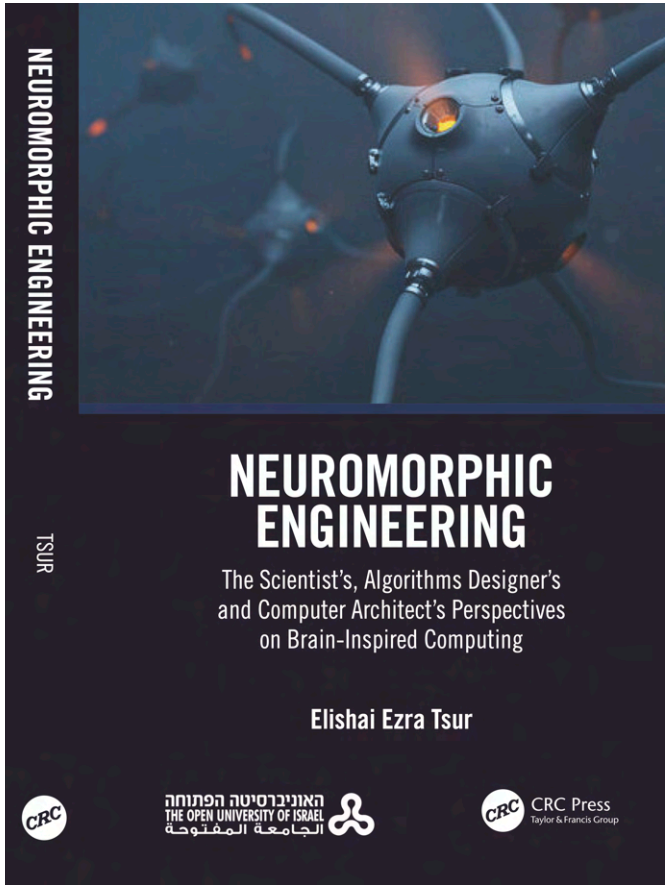
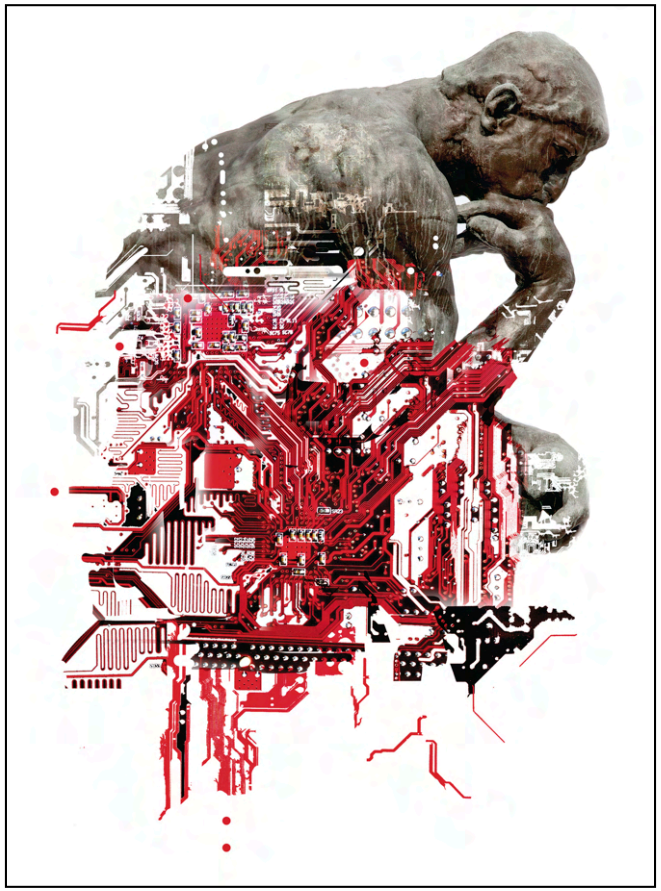
Disciplinary Courses



Algorithmic Robotics



Brain-Inspired Computing Architectures



Digital Humanities

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Seminars and Workshops

Seminars

- First-year participatory seminar in MLBD (no credits) (2025a)
- Research seminar in MLDB (2026a)

Workshops (2026b)

- Art and Machine Learning
- Machine Learning in the Service of Humanity

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Final Project / Thesis

Research Track

- 2/3 disciplinary course; waived workshop
- Finished / waived preparatory courses
- Mentorship approval from a faculty mentor
- Individual work

Final Project

- Can be performed in groups of 2-3 students
- Academic-industry mentorship
- We will strive to have a list of proposed projects for students

Recommended Time-line

Mathematical prep

Introduction to Computer Science and Data Analysis with Python

Computer Science in a Nutshell

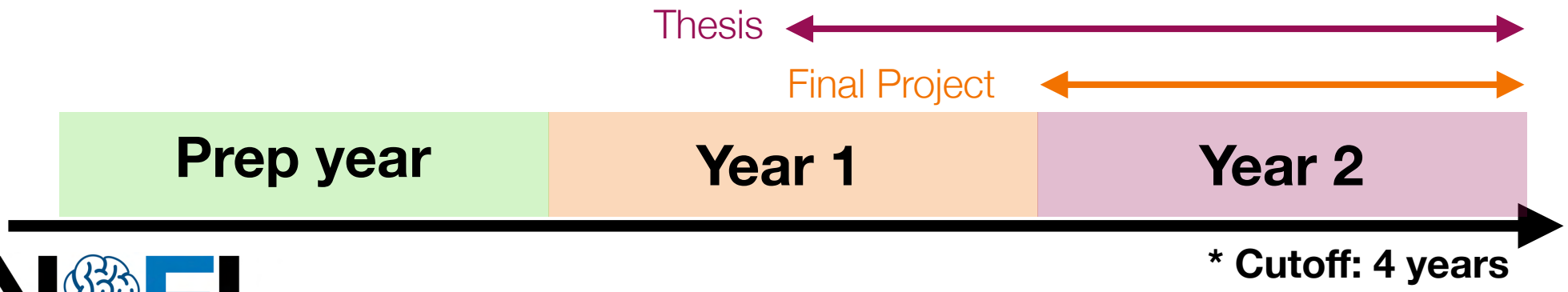
Algorithms (MOOC)

Mathematics for ML
Algorithmic robotics
Seminar

Introduction to ML
BD technologies
Brain-inspired computing

Deep learning
Algorithms for BD
Research Seminar

Digital humanities
Workshop



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MLBD or CS?

- **Bottom line:** If you are a Computer Science major, who wants to learn the broader field of Computer Science (advanced algorithms, theory, verification, graphics, cyber, geometry, communication networks, AI, ML, etc.) with other computer scientists, go for the M.Sc program in Computer Science
- With seminars and final projects as exceptions, courses can also be taken by CS students. We hope that the new MLDB program will enhance the course offerings in the CS program as well
- MLDB is a very focused program with limited to non-existent freedom of choice
- MLDB-focused research seminars (only open to MLDB students)
- A unique and a relatively short preparation program for non-CS majors, which can be taken during the first year of study
- Fellows student from a broader background (engineering, management..)
- Unique final project characteristics (as described before)

FAQ

- **Span**: 2 years (recommended) - 4 year (cutoff)
- **Language**: Hebrew. Most Learning materials are in English
- **Scholarships**: currently possible only via funded research groups
- **Attendance**: only mandatory in the seminar, workshop and as required during the final project or thesis work
- **Delivery**: Mostly online (recorded / real time)
- **Academic consultancy**: via e-mail: elishaiz@openu.ac.il
- **Study from abroad**: possible
- **Individual courses**: course are opened only to admitted students
- **Diploma Title**: מוסמך בלמידת מכונה וניתוח נתוני עתק
  M.Sc. Machine Learning and Big Data
- **PhD**: Research track graduates can carry on to any relevant Ph.D program. The OpenU currently only offers one PhD program in Education.

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