Master and Bachelor projects in AI/CS

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I am an Assistant Professor in the Computational Intelligence Group at the Vrije Universiteit Amsterdam. My research interest is in evolutionary and collective Intelligence.

In particular:

- Evolutionary, individual and social learning strategies,
- Neuroscience-inspired AI,
- Cumulative cultural evolution,
- AI in art, movement science and education,
- Applications to real-world/robotics.

Below, you may find several projects available for supervision as Master and Bachelor thesis. If you have any questions or topics to discuss, feel free to contact me by email.

Projects

A. Social learning strategies and cultural evolution models:
This project aims to design efficient and effective individual and social learning approaches in a population of lifetime-learning agents [1-3], and spread and evolution of cultural knowledge. Some of the key questions include:

- How to identify reliable knowledge (i.e. when, what and who to learn from) [1]? (see the blog post)
- How to design meta-learning strategies that can effectively use individual and social learning to provide optimum learning as a collective of lifetime-learners [1]? (see the blog post)
- How can a group level collective knowledge emerge and evolve to benefit the individuals in the collective system [3]? (see the blog post)

B. Learning generalist controllers: (see the blog post)
This project aims to design controllers that can generalize to various environments and tasks. Previously, we proposed approaches to learn robust/generalizable artificial neural network (ANN) based controllers to function well on a wide range of environments/tasks without need for retraining [4]. Future research aims to improve the generalizability of the controllers and efficiency of these training processes.

C. Real world embodied learning/evolution:
The behaviors learned in simulations are often not transferable to the real world due to the reality gap. To avoid this issue, it is possible to optimize the controllers directly in the real world. However, this is a very costly process. This project aims to propose efficient approaches that can be used to improve the optimization processes of controllers in the real

world. We use our modular robotic platform available in our group to demonstrate the efficiency of the proposed approaches.

D. Neuroscience-inspired AI:
This project aims to develop learning and decision-making models inspired by neuroscience to improve information processing of ANNs [5]. In particular, I am interested in following research directions:

- Lifetime learning and synaptic plasticity: How neurons change their connectivity to learn to perform certain behaviors while interacting with the environment [5]?
- How to learn spatial representations inspired by various types of cells in the brain (i.e. place and grid cells)? How to learn allocentric and egocentric representations?

E. Learning representations and evolutionary exploration in complex design spaces:
Extending on our previous work [6], this project aims to learn representations of complex design spaces such as Art images, and perform evolutionary search processes (also in collaboration with humans) to discover various kinds of designs efficiently.
(see the blog post)

F. AI in Movement Science
Anyone interested in AI and Sports? I have two topics in movement science applied to sports, in particular to Olympic Weightlifting. These topics are in collaboration with the Human Movement Science program at VU.

- Movement pattern analysis during exercise using sensors (i.e. IMUs).
- Movement pattern analysis during exercise without any sensor using computer vision.

G. AI in Education
Using AI approaches in education context for generation of more fair and effective learning environments. Involved developing technologies and platforms for logging and classifying student behavior.

Possibility of testing the algorithms in robotics:
Our group has developed Revolve2 (https://github.com/ci-group/revolve2) platform to conduct evolutionary robotics and artificial life research projects on simulation. In addition, we have a bio-inspired robotics lab (https://cs.vu.nl/ci/index.php/robot-lab/) where these projects are tested and validated in real world on hardware. Images below show some of the projects from evolvable modular robotics and swarm robotics projects. For instance, the robotics platforms we possess include Crazyflie, Thymio, Kilobot and Robobo.

Evolutionary and swarm robotics

References:

[1] Yaman A, Bredeche N, Çaylak O, Leibo JZ, Lee SW. Meta-control of social learning strategies. PLOS Computational Biology 18(2): e1009882. https://doi.org/10.1371/journal.pcbi.1009882.

[2] Yaman, A., & Iacca, G. (2021). Distributed embodied evolution over networks. Applied Soft Computing, 101, 106993.

[3] Yaman A, Leibo JZ, Iacca G, Lee SW. The emergence of division of labor through decentralized social sanctioning. 2023. (Proceedings of the Royal Society B) https://arxiv.org/abs/2208.05568

[4] Triebold, C., Yaman, A. (2024). Evolving generalist controllers to handle a wide range of morphological variations. GECCO'24. https://arxiv.org/abs/2309.10201

[5] Yaman A, Iacca G, Mocanu DC, Coler M, Fletcher G, Pechenizkiy M. Evolving Plasticity for Autonomous Learning under Changing Environmental Conditions. Evolutionary Computation. 2020. DOI: 10.1162/evco_a_00286 https://doi.org/10.1162/evco_a_00286

[6] Hall, O., & Yaman, A. (2024). Collaborative Interactive Evolution of Art in the Latent Space of Deep Generative Models. In International Conference on Computational Intelligence in Music, Sound, Art and Design (Part of EvoStar) (pp. 194-210). Cham: Springer Nature Switzerland. (*EVOMUSART best paper award*) https://arxiv.org/pdf/2403.19620