Nada Abdelrahman

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Summary

Experienced Scientist with a strong track record in developing advanced computational models for neural systems and machine learning applications. Proficient in deep learning, recurrent neural networks, and Bayesian inference, with a focus on solving complex, interdisciplinary problems. Demonstrated expertise in theoretical neuroscience, and computer vision for real-world applications. Passionate about continuous learning and innovation in dynamic research environments.

Experience

Postdoctoral Scientist 08/2022 – Present
Howard Hughes Medical institute at Janelia Research Campus. *Ashburn, VA*

- I developed a computational model for spatial navigation that mimics real animal behavior and their fast learning dynamics.
- My model integrates goal learning with motion planning and execution using a Bayesian inference framework, outperforming existing Reinforcement Learning (RL) algorithms that solve the same problem.
- I drove research from theoretical conception to practical implementation resulting in a software package to simulate agents' learning to intercept hidden rewards given any environment setup.

Doctoral research assistant, Ph.D. 05/2022 – 08/2022
Engineering and Physical Sciences Research Council (EPSRC) ActiveAI project *Sheffield, United Kingdom*

- I implemented an Echo State Network model (ESN) for electromyography (EMG) hand gestures classification.
- The model serves as a benchmark for Recurrent Neural Networks (especially Echo State Networks) performance to classify real EMG data from amputees using the NinaPro public dataset.

Machine Learning Engineer 01/2018 – 08/2018
American University in Cairo (AUC) *Cairo, Egypt*

- I developed a Convolutional Neural Network (CNN) used in automated in-store inventory management.
- I trained this CNN to recognize and segment our customers' products from shelf images taken in-store by phone cameras.
- My CNN network used this extracted information along with history data in the same store to compute metrics that help this product's owners optimize their strategies for profit maximization.

Education

University of Sheffield 2018 – 2022
Ph.D., Computational Neuroscience *Sheffield, UK*
Thesis: Modeling olfactory processing and insights on optimal learning in constrained neural networks: learning from the anatomy of the Drosophila mushroom body

Nile University 2014 – 2016
M.Sc., Medical Informatics and medical Image Processing *Cairo, Egypt*

Cairo University 2009 – 2014
B.Sc., Biomedical Engineering *Cairo, Egypt*

Select Research Publications

Abdelrahman, N., Vasilaki, E., & Lin, A.C. (2021). Compensatory variability in network parameters enhances memory performance in the Drosophila mushroom body. *The Proceedings of the National Academy of Sciences (PNAS).*

Abdelrahman, N.*, Vasilaki, E., & Lin, A.C. (2020). Optimising sparse odour coding by tuning input synaptic weights in Drosophila Kenyon cells. *the 12th Federation of European Neuroscience Societies (FENS) forum of Neuroscience*

Abdelrahman, N.*, Vasilaki, E., & Lin, A.C. (2019). Optimising sparse odour coding by tuning input synaptic weights in Drosophila Kenyon cells. *Artificial and Biological Cognition Conference, University of Cambridge, Cambridge (UK).*

Abdelrahman, N., El-Rewaidy, H., & Fahmy, A.S. (2016). Low Cost System for Screening Cardiovascular Diseases in Large Populations: Preliminary Results. *IEEE International Symposium on Biomedical Imaging, (ISBI).*

Artificial Intelligence Bootcamps

Applied Generative Artificial Intelligence Specialization at Purdue University. `Dec 2024 - Feb 2025`
https://bootcamp-sl.discover.online.purdue.edu/applied-artificial-intelligence-course

Open Source Software

`Model-for-rapid-spatial-navigation-via-efficient-inference-and-exploration.m` | *Matlab*

- This code base is an implementation for the manuscript (in preparation) (A Model for rapid spatial learning via efficient exploration and inference) by [Nada Abdelrahman, Wanchen Jiang, Joshua Dudman and Ann Hermundstad].
- Developed a model that achieves the rapid learning dynamics observed in mice and animal data.
- My model learns to find **hidden** spatial targets and achieves a high reward rate in tens of trials, significantly outperforming existing reinforcement learning models, which require hundreds of thousands of trials to converge.
- I developed a modular code base that implements all the main modules in our model, which are:
  1) Trajectory planner module where our model mouse computes the required action parameters of its trajectory generative functions to weave a smooth and efficient path connecting N keypoints (which we call anchors).
  2) Bayesian inference module, that integrate the agent's past trajectories and their associated outcomes (reward/no reward) to help the agent to localize the hidden target in the polar coordinates space (R*,θ*). Candidate targets locations in the polar space, (R*,θ*), determine the input parameters of the trajectory generative functions.
  3) Sampler module, it selects the candidate target locations (*anchors*) that the agent will visit on their next run, given their current Bayesian belief about possible target locations. This module encapsulates different sampling strategies, e.g. Peak and Proportional samplers.
- Implemented an algorithm that sends a surprise-like signal to the agent if the hidden target location changes, and helps it to learn new locations rapidly.

`CompensatoryVariability.m` | *Matlab*

- Developed a biologically plausible neural network model for optimal learning in constrained neural systems.
- Implemented a firing rate neural network model of the mushroom body, the center of associative learning in fruit flies.
- Designed and implemented homeostatic plasticity rules that achieve compensatory variability, which enhances the model's memory performance and its discriminatory power given large sets of inputs.

`ESNninaProEMG.py` | *python*

- A recurrent neural network that exploits reservoir computing properties to discriminate input EMG signals from real subjects amputees.
- This network needs to learn only the output weights, thanks to the echo state property and achieves 91% accuracy on NinaPro dataset.

Technical Skills

Languages: Python (PyTorch, TensorFlow), MATLAB
Expertise: computational neuroscience, machine learning, Bayesian inference, optimization, signal & image processing, computer vision, Large Language Models, Recurrent Neural Networks, Data acquisition and processing