Mohsen Karkheiran

GitHub — LinkedIn — Streamlit — Publications

Summary

PhD in Mathematical Physics with 4 years of research experience, offering a strong foundation in mathematical modeling, computational physics and problem solving. While primarily focused on scientific research projects, many of them related to deep learning (ANNs, CNNs), I have completed multiple AI projects demonstrating my ability to tackle industry-relevant challenges using deep learning (including simple RNNs/LSTMs), reinforcement learning (Q-learning, DQN, Actions-Critic, REINFORCE) and physics-informed neural networks (PINNs). Currently leading a major Quantum AI project, developing a tensor network package that can compute MPS/MPO/PEPS, apply various algorithms on them such as compressions and DMRG, and maps tensor networks to quantum circuits (expected completion: March). Bridging my deep understanding of physics with AI methodologies to contribute effectively in interdisciplinary roles.

Education

PhD *Mathematical Physics/String Theory*, Virginia Tech, Blacksburg, USA, 05/2020
MSc *Theoretical High Energy Physics*, Sharif University, Tehran, Iran, 08/2013

Work Experience

Postdoctoral fellow *Mathematical Physics*, University of Alberta, Edmonton, Alberta 01/2023 - Now
Visiting researcher at University of Waterloo.

- Novel connections were derived between geometries and physical models using MAGMA and SageMath.
- Classified symmetries of geometrical spaces by CNNs and ANNs with an accuracy close to 98%.

Postdoctoral fellow *High Energy Physics*, Institute for Basic Sciences, 10/2020 - 11/2022
Daejeon, South Korea

- Used numerical algebraic geometry in Mathematica to link polynomial rings' linear algebra with space geometry.

AI related Projects

AI in Algebraic Geometry : With deep learning techniques such as **ANNs** and **CNNs** we classified symmetries of Calabi-Yau spaces. These spaces are characterized by matrices; therefore **image processing** algorithms are used (Finished to be published soon).

Quantum AI : A Python-based package is written to analyze **Tensor Networks**, find **MPO, MPS, PEPS** states, apply compression, and **DMRG**. It has can map tensor networks into **quantum circuits** to be used quantum machine learning problems (to appear soon in March 2025).

Finance : Simulation of market prices using **ARIMA** and **RNNs**. Simulation of volatilities using **GARCH**. Finding implied volatility and Greeks in the **Black-Sholes-Merton** model by **PINNs** based on **TensorFlow**. Compared with the known methods for **Q-learning** in **option pricing**. This project is already deployed.

Optimization with RL : An **off-policy RL** technique (Q-learning) based on **PyTorch** is used to find the shortest path in a field with arbitrary obstacles (complete, on-policy versions are being developed, will be deployed soon).

GitHub Portfolio : Many projects that use **ML** techniques such as **RandomForrests, DecisonTrees, SVM, SGD** in combination with **NLP**, **Networkx**, **deepXDE**, and unsupervised learning techniques such as **PCA, t-SNE** (Visit Github and Streamlit pages for updates).

Other Skills

Quantum Computing : PennyLane, Qiskit

Programming : Python, Julia, SQL, DataBricks, MongoDB

Mathematics : Differential Equations, Algebraic Geometry/Topology, Differential Geometry, Category Theory

Physics : Classical/Statistical/Quantum Physics and Field Theory

Other : Streamlit, NetworkX, NLTK, Pandas, Matplotlib

Certifications

- Data Science Certificate, University of Waterloo (WatSpeed): Data Science, Statistics in Data Science, Machine leanrning, Big Data Management
- PINNs course University of Alberta (Prof. V. Putkaradze)
- Data Science Certificate, University of Michigan: Machine learning, NLP, Network Analysis.

Special Mention

- Rank 2 in national entrance exam for Ph.D program in physics between 5000 applicants, Iran, 2013
- Rank 6 in national national entrance exam for M.Sc program in physics between 6000 applicants, Iran, 2011
- Rank 368 in national national entrance exam for B.Sc programs between 10^5 applicants, Iran, 2007