Akarsh Kumar

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Research Statement

I want to emerge intelligence by creating+analyzing embodied AI agents that reason+learn more intelligently in increasingly complex environments. To this end, I employ **AI-Generating Algorithms** (**meta-learning** architectures, learning algorithms, and environments) and **Open-Ended quality-diverse evolutionary algorithms**.

Education

Massachusetts Institute of Technology, *Ph.D. in CS* | *Advisor: Phillip Isola* 09/22 – 05/27

- **NSF Graduate Research Fellowship**
- Research: AI-GAs/meta-learning, Open-Endedness, exploration, curriculum learning, extrapolative generalization
- Graduate Classes: NLP, Deep RL

University of Texas at Austin, *B.S. in ECE (Honors)* | *GPA: 3.95,* ***Major GPA: 3.97*** 08/18 – 05/22

- Graduate classes: Convex Optim., Adv. Comp. Vision, Neural Computation, Probability
- Notable classes: Data Science Principles+Lab, Prob., Matrices, Discrete, Algo., Signal Proc., Img Proc., SWE II
- **Teaching Assistant** for Software Engineering (SWE) II
- **Best project** in three engineering classes

Arkansas School for Math & Science, *High School Diploma* | *GPA: 4.23/4, ACT: 35/36* 8/16 – 05/18

- **Won 1st place** in ACTM state-wide math competition
- **Won 2nd place** in national Vex robotics competition as robot lead and software lead
- Chosen as one of 24 residential community leaders and captain of basketball team

Research Publications and Presentations

1. **Akarsh Kumar** and Kevin Frans. Human-Like Open-Ended Design via Foundation Models. *EvoCraft Challenge at the Genetic and Evolutionary Computation Conference*, July 2022.

2. **Akarsh Kumar**, Bo Liu, Risto Miikkulainen, and Peter Stone. Effective Mutation Rate Adaptation through Group Elite Selection. *The Genetic and Evolutionary Computation Conference*, July 2022.

3. **Akarsh Kumar**, Aditya R. Vaidya, and Alexander G. Huth. Physically Plausible Pose Refinement using Fully Differentiable Forces. *Egocentric Perception, Interaction and Computing at the Conference on Computer Vision and Pattern Recognition*, May 2021.

4. **Akarsh Kumar**. Optimization of the Efficiency of Photovoltaic Cells for Laser Light: An Application to Laser Power Beaming. *Intel International Science and Engineering Fair*. May 2018.

Research Experience

Ph.D. Student @ Isolab w/ Prof. Phillip Isola 08/22 – now
MIT

- **Developed long-range memory mechanism for NLP Transformers** (report)
- **Won first place at the GECCO 2022 Minecraft Open-Endedness Challenge** (video)
- Learning to explore from past exploration successes/failures in Go-Explore

Undergraduate Researcher @ LARG w/ Prof. Peter Stone 05/21 – 12/21
UT Austin

- Developed a novel genetic algorithm that optimally adapts its mutation rate based on outlier statistics
- **Published first author paper at GECCO 2022** (paper)

Undergraduate Researcher @ Huthlab w/ Prof. Alexander Huth 11/19 – 05/21
UT Austin

- Developed a novel CV motion capture algorithm to reconstruct hand-object interactions from RGB-D data
- Estimated the hand-object poses and physical contact forces acting between them
- **Published first author paper at CVPR 2021 EPIC Workshop** (presentation, paper)
- Algorithm to be used in an fMRI neuroscience study on how the brain processes tactile information

Undergraduate Researcher @ VITA w/ Prof. Zhangyang Atlas Wang 09/21 – 05/22
UT Austin *Austin, TX*

- Developed a novel deep learning architecture "MLP-Shaker" for ECE Senior Capstone Project
- MLP-Shaker operates on general n-D tensors rather than MLP-Mixer's 2-D tensors

Highschool Researcher w/ Dr. Brian Monson 08/17 – 05/18
ASMSA *Hot Springs, AR*

- Discovered a novel theoretical bound on the energy transfer efficiency when using lasers and photovoltaic cells
- **Won state science fair for physics and attended Intel ISEF** (poster, paper)

AI Projects

NBA-3D | Github: nba-3d | *PyTorch*

- Reconstructed NBA players as 3D stick figures given multiple RGB videos of the scene
- Estimated camera pose using a differentiable renderer matching synthetic views and real views of the court
- **Won best project Image Processing class** (visual, presentation)

Basketball-RL | Github: basketball-rl | *PyTorch*

- Created custom end-to-end differentiable 2D basketball reinforcement learning environment
- Collected and cleaned real NBA player movement data and behavior cloned a policy
- Further fine-tuned RL agent to maximize reward

Audio Source Separation with GANs | Github: DSProject | *PyTorch*

- Developed a U-Net CNN as a GAN to distinguish noisy and noiseless spectrograms
- Used GAN as a loss function for spectrogram segmentation network (blog)

BetterKey | Github: betterkey | *Java*

- Genetic algorithm to optimize keyboard layouts: **60% reduced typos, 10% increased typing speed**, (blog)

BEVO | Github: ALD | *Tensorflow*

- Used speech-to-text and CV object detection models to assist blind people in finding everyday objects (blog)

Reimplementations of Previous Work | *PyTorch, Java*

- Implemented AlphaZero in PyTorch for Connect4
- Implemented dense NN+backpropagation from scratch in Java and reached 95% accuracy on MNIST
- Implemented NEAT (neuroevolution) from scratch in Java and solved CartPole and FlappyBird

Software Projects

Strategic Anomalies | Github: StrategicAnomalies | *Java*

- Developed online strategic board game from scratch using IO streams, sockets, Swing, and multi-threading
- Used advanced pregame lobby+gameplay and server+client software engineering paradigms (visual)

Online Chat Platform | Github: EE-422C | *Java*

- Developed a full stack (client-server) chat platform for sending texts, images, and files in an iMessage-like GUI
- **Won best project in Software Engineering II class**

CAS and Graphing Calculator | Github: LibAK-CAS | *Java*

- Parsed math strings into a syntax tree for analytical computing of expressions and their derivatives
- Extended CAS to a graphing library which allows mouse dragging and point selection (visual)

C++/OpenGL GUI API | Github: LibAKCpp | *C++*

- Developed high level window manager+GUI API (analogous to Java's Swing API) from scratch with OpenGL
- Developed a library to mimic Java's Swing library from scratch with C++ and OpenGL
- Supports windowing, rendering shapes, images, and hierarchical pane layouts (visual)

C++ Physics Simulation | Github: PhysicsSimulation | *C++*

- Developed a rigid body physics simulation to test theories on magnet behavior

Embedded Systems 3D Shooter | Github: EE-319K | *C++*

- Developed first person shooter survival game for an embedded system
- **Won best project in Embedded Systems class** (visual)

Code-Viz | Github: code-viz | *Python*

- Parsed and visualized a Python codebase in a directed graph of class/method dependencies

Work Experience

Software Intern @ Prolitfic 01/19 – 08/19
Publishing Startup

- Developed a robust customer review ranking algorithm on Django codebase **(used in production for 1 year)**

Software Intern @ Free Geek Arkansas 08/17 – 05/18
Nonprofit Hardware Company

- Developed software for tracking volunteers' hours for a nonprofit company **(used in production for 3 years)**

Technical Skills

Languages: Python, C/C++, Java, Javascript
Libraries: PyTorch, NumPy, Jax, Pandas, Matplotlib