Zhizhuo Yang

PhD Candidate · Computing & Information Science

Rochester Institute of Technology, 1 Lomb Memorial Dr, Rochester, NY 14623

zhizhuoyang@mail.rit.edu | https://www.linkedin.com/in/zhizhuo-yang/ |

https://scholar.google.com/citations?user=OA2-BIsAAAAJ

Education

Rochester Institute of Technology *Rochester, NY, USA*

PhD Computing and Information Sciences *08/2017 - present*

- Advisor: Dr. Alexander G. Ororbia II
- Co-Advisor: Dr. Reynold Bailey

Beijing Institute of Technology *Haidian, Beijing, China*

MS Virtual Reality and Augmented Reality Technology *09/2014 - 06/2017*

- Advisor: Dr. Dongdong Weng

Beijing Jiaotong University *Haidian, Beijing, China*

BS Optical Information Science and Technology *09/2010 - 06/2014*

Professional Experience

09/2023 - 12/2023 **Part-time Student Researcher at Meta** Continuation of AI research internship. Analyzing new data and writing a research paper for submission to IROS 2024.

05/2023 - 09/2023 **AI Research Scientist Intern at Meta** Researched the end-to-end gradient-based EKF learning method for sensor fusion. Developed a neural network-based residual pose learning algorithm to improve tracking accuracy. Processed 1.35 TB of data using Python, C++ executable, and Bash scripts. Implemented the method in PyTorch and trained on cluster. Reduced mean tracking error by 39.76% and standard deviation by 12.68% respectively. Analyzed the raw data and results, generated plots and animation using pandas, scikit-learn, seaborn and plotly.

05/2020 - 08/2020 **Research Intern at Facebook** Developed and tested a real-time statistical filtering algorithm in C++ to improve Asynchronous TimeWarp technology used in Quest 2 by reducing visual artifacts. Learned to work with Android developer toolkit quickly and read about ARM NEON API. Improved team working efficiency by building efficiency tools in Python and writing informative Wiki pages in the company.

05/2019 - 08/2019 **Software Engineering Intern at Facebook** Developed a deep learning-based algorithm which extrapolates frames using adjacent frames and motion vectors to increase rendering frame rate and save GPU resources on VR headsets. Implemented it in Tensorflow and PyTorch and trained on clusters with Horovod and Slurm. Iterated on ideas and made rapid implementation by working closely with engineers and researchers from different teams.

Publications

Published

Yang, Z., Diaz, G.J., Fajen, B.R., Bailey, R. and Ororbia, A.G., 2023. A neural active inference model of perceptual-motor learning. *Frontiers in Computational Neuroscience*, 17, p.1099593.

Rakshit, K., **Zhizhuo, Y.**, Kanan, C., Bailey, R., Pelz, J. B., & Diaz, G. J. 2020. Gaze-in-wild: A dataset for studying eye and head coordination in everyday activities. *Scientific Reports*, 10(1),1-18.

Nair, N., Kothari, R., Chaudhary, A. K., **Yang, Z.**, Diaz, G. J., Pelz, J. B., & Bailey, R. J. 2020, September. RIT-Eyes: Rendering of near-eye images for eye-tracking applications. In *ACM Symposium on Applied Perception* 2020 (pp. 1-9).

Yang, Z., & Bailey, R. 2019, June. Towards a data-driven framework for realistic self-organized virtual humans: coordinated head and eye movements. In *Proceedings of the 11th ACM Symposium on Eye Tracking Research & Applications* (pp. 1-3)

Kothari, R., **Yang, Z.**, Binaee, K., Bailey, R., Kanan, C., Pelz, J., & Diaz, G. 2018. Classification and Statistics of Gaze In World Events. *Journal of Vision*, 18(10), 376-376.

Yang, Z., & Weng, D. 2016, December. Passive haptics based MR system for geography teaching. In *Proceedings of the 15th ACM SIGGRAPH Conference on Virtual-Reality Continuum and Its Applications in Industry*-Volume 1 (pp. 23-29)

Yang, Z., Weng, D., Zhang, Z., Li, Y., & Liu, Y. 2016, September. Perceptual issues of a passive haptics feedback based MR system. In *2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)* (pp. 310-317). *IEEE*.

In Prep

Continual Reinforcement Learning with Episodic Memory Signature, Mid 2024, *Neural Computation*

Empirical Comparison and Evaluation between Deep Active Inference and Deep Reinforcement Learning Agents on Benchmark Cognitive Tasks, Late 2024, *ICLR*

Robust Active Inference for Continuous Partially Observable Markov Decision Processes, Mid 2024, *ICML*

Teaching Experience

Fall 2022	**CSCI-635 Intro to Machine Learning**, Graduate Teaching Assistant	*Python*
Fall 2021	**CSCI-635 Intro to Machine Learning**, Graduate Teaching Assistant	*Python*
Spring 2020	**CSCI-620 Intro to Big Data**, Graduate Teaching Assistant	*JAVA, MongoDB*
Spring 2018	**CSCI-620 Intro to Big Data**, Graduate Teaching Assistant	*MySQL, R*

Mentoring

Spring 2021	**Timothy Johnson**, Undergraduate independent study, Rochester Institute of Technology
2019-2020	**Nitinraj Rajan Nair**, Graduate capstone project, Rochester Institute of Technology
2015-2017	**Haiyan Jiang, Mo Su, Yue Li, Xingyao Yu and Yaqiong Xue**, Subsequent master students in the same research group, Beijing Institute of Technology

Research Experience

Continual reinforcement learning

Advisors: Dr. Alexander G. Ororbia II and Dr. Reynold Bailey *06/2022-present*

- Researching on techniques such as Subjective Timescale Model and episodic memory related methods to construct better representation of past experience
- Investigating efficient embedding methods and unsupervised learning to develop better exploration techniques as well as boost transfer abilities of continual learning agents
- Prototyping and testing a continual learning agent on Jelly Bean World benchmark

Empirical comparison and evaluation between deep active inference and deep reinforcement learning on cognitive tasks

Advisors: Dr. Alexander G. Ororbia II and Dr. Reynold Bailey *02/2021-present*

- Developed an Active Inference (AIF) model that approximates the Expected Free Energy using Q-learning
- Compared the performance of variations of prior preference such as global prior, local prior and empirical prior learned from demonstration
- Systematically investigated and demonstrated the effects of components of our AIF framework on agent's performance
- Comparing variants of our AIF framework with a popular reinforcement learning approach, i.e. Deep Q Network on OpenAI gym environments
- Extending the benchmark tasks from OpenAI gym to more advanced benchmarks such as Animal-AI which focus on the cognitive capabilities of the intelligent agents

Generalizing active inference to continuous state-spaces: an application to perceptual-motor learning tasks

Advisors: Dr. Alexander G. Ororbia II and Dr. Reynold Bailey *09/2020-08/2022*

- Expanded a simple AIF model under discrete state-space by Buckley and made visualizations of the agent's behavior to teach myself and our research group about Active Inference
- Scaled AIF using deep neural networks and variation inference to tackle continuous state-space problems including classic control problems in OpenAI gym
- Devised hypothesis tests and experiments for investigating human perception-motor task with deep AIF framework based on an interception task
- Proposed a novel prior function that maps original observations to a new low-dimensional and interpretable space where prior preference can be specified as a distribution

Predictive processing framework for human perception & action

Advisors: Dr. Alexander G. Ororbia II and Dr. Reynold Bailey *02/2020-06/2020*

- Attempted modeling human behaviours in visuomotor tasks with predictive coding methods to answer cognitive questions on human perception, action and decision making. Specifically, investigated a virtual ball-catching experiment with eye and head tracking data using pandas
- Proposed hypothesis tests for information sufficiency of human's catching behaviour under different frame of references
- Visualized the human subject data from previously a published study in a virtual environment using Unity3D engine
- Implemented a particular flavor of predictive coding framework called PC/BC-DIM by Spratling with TensorFlow2 and tested on the MNIST dataset

Rendering of near-eye images for eye-tracking applications

Advisor: Dr. Reynold Bailey *09/2019-03/2020*

- Collaborated with a cross-laboratory team to build a computer graphics system using blender for synthesising a photo-realistic eye-tracking video dataset, which is for training image-based eye tracking algorithms
- Evaluated and analyzed trained machine learning models

Data-driven framework for realistic self-organized virtual avatars

Advisors: Dr. Reynold Bailey and Dr. Alexander G. Ororbia II *03/2019-12/2019*

- Led a team to develop algorithms including Mixture Density Networks, Recurrent Neural Networks and Mode-Adaptive Neural Networks in PyTorch for computationally modeling coordinated human eye-head movements from synchronized motion capture and eye tracking data in order to generate realistic virtual avatar animation
- Proposed a research pathway to move from script-based eye and head movement animation to self-organized and task-driven animation using reinforcement learning
- Mentored a master student in computer science on conducting research and experiments

Event-level error metric for evaluating gaze events classification

Advisor: Dr. Reynold Bailey *06/2018-12/2018*

- Devised an window-based event-level error metric which reports categorical misclassifications (by confusion matrix) and temporal misalignment (with timing offsets and overlap ratio) of gaze events. This metric is generally applicable to evaluate classification performance for any machine learning methods at event-level
- Implemented proposed methods in both Matlab and Python and compared to other existing metrics

Event detection of human eye and head movements

Advisor: Dr. Reynold Bailey *01/2018-05/2018*

- Collected data with a collaborator using Pupil Lab's eye tracker and an IMU while participants performing daily tasks such as walking, visual searching and ball-catching
- Worked with a collaborator on designing and training the gaze event classifier with Recurrent Neural Networks in PyTorch

Enhancing password recollection performance using augmented reality with the method of Loci

Advisor: Dr. Reynold Bailey *10/2017-03/2018*

- Used Microsoft HoloLens to assist the famous mnemonics, the method of loci, to help user with password recollection. Voice commands and spatial mapping features of the headset were used in the project to record the 3D positions of the digits placed into the environment
- Designed experimental setup and conducted data collection. Performance Analyzed of Human Subjects Under 3 Conditions with ANOVA

Gaze-In-World (GIW) event classification

Advisor: Dr. Reynold Bailey *08/2017-12/2017*

- Trained a parallel bidirectional (Forward-Backward Window) LSTM neural network model using PyTorch with eye-tracking data such as gaze velocity, head movement data as input for GIW classification
- Developed a CNN-LSTM neural model for GIW event classification with a collaborator. Eye images and head velocity data serve as input data. A CNN model was used to extract features directly from eye images, which are then fed into the LSTM model along with head velocity data

Room-scale MR system based on passive haptics

Advisor: Dr. Dongdong Weng *10/2016–03/2017*

- Built a room-scale Mixed Reality system using Unity3D engine with passive haptic feedback from real objects. Adopted PhaseSpace active optical tracking system as the tracking subsystem for objects in the scene and the user's head. Used Perception Neuron from Noitom as tracking device for user's arms and hands

Passive haptics-based MR system for geography teaching

Advisor: Dr. Dongdong Weng *07/2016-10/2016*

- Validated the feasibility of applying MR system in geography teaching based on passive haptics with user studies
- Integrated key SDKs, including Vuforia, Leap Motion, Oculus in Untiy3D, calibrated tracking camera and LeapMotion camera, established hardware environment and programmed user study software based on passive haptics
- Recruited and selected human subjects, designed and conducted 3 experiments under different learning conditions, collected questionnaire data and recorded completion time and quiz accuracy
- Analyzed experiment results with a Friedman Test

Evaluating vehicle ergonomics with driving simulation in Virtual Reality

Advisor: Dr. Dongdong Weng *07/2015-12/2015*

- Communicated with clients to analyze their requirements, designed software architecture, drew class diagrams, wrote shooting scripts
- Measured actual vehicle space model on site and built 3D modeling with an artist
- Built the virtual scene and implemented event scripts with unity3D
- Integrated PhaseSpace optical tracking device, head mounted display, joysticks and other hardware on site, debugged the network environment and tested software

Research on motion sickness in Virtual Reality systems for automobile platform

Advisor: Dr. Dongdong Weng *04/2015-06/2015*

- Measured and recorded real-time automobile rotation data using MTx inertia measuring unit from Xsens. Collected real-time velocity through vehicle data recorder and transmitted the information to virtual reality system on a laptop
- Built a virtual environment using Unity3D, debugged and integrated with hardware
- Presented the subjects with same or different motion cues in the VR system as in the real world, while collecting statistics of subjects' dizziness through electrocardio data. Subjective questionnaires are also applied after test

Passive haptics-based Virtual Reality system for assembly tasks

Advisor: Dr. Dongdong Weng *02/2015-03/2015*

- Conducted stereo camera calibration between Leap Motion's infrared camera and a RGB tracking camera. Measured position relations of different hardware systems and subject's pupil distance to set the relations in software system accurately
- Designed and completed experiments to verify the level of consistency between vision and tactile sensory information provided by the system after calibration
- Designed a virtual assembly application and verified usability of proposed system

Outreach & Professional Development

Service and Outreach

2018	**National Technical Institute for the Deaf at RIT**, Note taker
09/2015	**International Symposium on virtual reality, augmented reality & visual computing application technology**, Volunteer
08/2011	**Being Northking Electronic Technology Development Co, Ltd**, Intern
2010 - 2011	**Undergraduate computer science association**, Committee member
2010 - 2011	**College student union**, Committee member
2010 - 2012	**College biking club**, Committee member

Development

1st International Workshop on Active Inference The first IWAI discusses current trends, novel results, real-world applications, to what extent active inference can be used in modern machine learning settings, such as deep learning, and how it can be unified with the latest psychological and neurological insights. I learned a lot about how people from different field perceive, develop and apply Active Inference, as well as richer mathematical techniques and research contexts beyond computing. I consider it to be professional development because of the inspiration and techniques I gained from this workshop given its multidisciplinary nature.

Peer Review

I reviewed for Conference on Lifelong Learning Agents (CoLLAs) 2022

Technical Skills

Libraries & frameworks TensorFlow, JAX, PyTorch, Keras, Scikit-learn, Pandas, Git, Bash, OpenCV, OpenGL, LaTex, MySQL, Plotly

Multimedia and Tools Unity3D, Noitom Axis Neuron, PhaseSpace, Xsense MT manager, LeapMotion, Microsoft HoloLens, Oculus Rift, Intel RealSense, Notion, JIRA, BUCK

Programming Languages Python, Matlab, C++, Julia, R, C#, Java (sorted by proficiency)