Yunzhe Wang

MSCS Student, Columbia University
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Research Interests

Robot Learning, Representation Learning, Computer Vision, Reinforcement Learning, Machine Learning, Artificial Intelligence

Education

Columbia University   **New York, NY**
- Master of Science in Computer Science **GPA: 3.83**   Sep 2021 – Present
    - Related Coursework: Machine Learning, Unsupervised Learning, Natural Language Processing, Reinforcement Learning, Advanced Algorithms, Introduction to Database, Computer Networks, Network and Crowds

University of Southern California   **Los Angeles, CA**
- Bachelor of Art in Applied and Computational Mathematics **GPA: 3.83**   Aug 2017 – May 2021
    - Related Coursework: Statistics, Probability Theory, Mathematical Optimization, Numerical Analysis, Applied Combinatorics, Mathematics of Machine Learning, Differential Equations, Linear Algebra, Calculus
- Bachelor of Science in Computational Neuroscience **GPA: 3.83**   Aug 2017 – May 2021
    - Related Coursework: Cognitive Psychology, Sensation and Perception, Neurobiology, Brain Architecture, Cellular and Molecular Neuroscience, General Biology, General Chemistry, Physics: Mechanics and Thermodynamics, Physics: Electricity and Magnetism
- Minor in Computer Science   Aug 2017 – May 2021
    - Related Coursework: Introduction to Artificial Intelligence, Introduction to Robotics, Algorithms and Theory of Computing, Applied Machine Learning for Games, Data Structure, Discrete Mathematics, Web Development, Blockchain

Publications

1. Yuhang Hu, <u>Yunzhe Wang</u>, Boyuan Chen, Yingke Wang, Jiong Lin, Hod Lipson
   Lip synchronization for Animatronic Robot Face
   Submitted to Nature (**Nature**), 2022
2. Yuhang Hu, Boyuan Chen, Jiong Lin, <u>Yunzhe Wang</u>, Yingke Wang, Cameron Mehlman, Hod Lipson
   Human-Robot Facial Simexpression
   Submitted to Science Robotics (**Science Robotics**), 2022
3. <u>Yunzhe Wang</u>, Nikolos Gurney, Jincheng Zhou, David V Pynadath, Volkan Ustun
   Neural Heuristics for Route Optimization in Service of a Search and Rescue Artificial Social Intelligence Agent
   Accepted to Association for the Advancement of Artificial Intelligence 2021 Fall Symposium Series: Computational Theory of Mind for Human-Machine Teams (**AAAI-FSS**), 2021

Research Experience

Robot Dynamics Representation Learning for Morphology Prediction

Creative Machines Lab, Columbia University   Jun 2022 – Present

Supervisor/Mentor: **Prof. Hod Lipson**

- Developed a multiclass-multioutput classification model that predicts the morphology of a 12-DoF quadruped robots given its dynamics, which is represented as multinomial timeseries of robot position, and joint angles. The robot's structure can be configured in countless ways.
- Experimented with various encoding architectures such as *Transformer*, *CNN*, and *PointNet*, treating data as raw timeseries, spectrograms, and independent points respectively.
- Developed a *Variational Auto-Encoder* and modeled the latent space to control robot generation.
- Employed future-prediction *Self-Supervised Learning* to pre-train representation.
- Collaborated with three mechanical engineering students to design data-collection strategies, avoiding hardware constraints.
- Applied the trained representation to *Model Predictive Control* robots with unseen morphology.
- Designed *Multi-Tasks Learning* Objectives and *Auxiliary Tasks* with tasks difficulty automatic balancing mechanism to improve performance.

Talking Face Generation for Lip-Synchronizing Animatronic Robot Face

Creative Machines Lab, Columbia University   Sep 2021 – Aug 2022

Supervisor/Mentor: **Prof. Hod Lipson**

- Developed a deep regression model, Audio2Landmark, that generates lip-synced facial landmark movements given speech audio alone. Applied the model to lip-sync a face robot.
- Self-Supervisely pre-trained a speech embedding model using *Autoregressive Predictive Coding* (APC), improving data generalization ability.
- Preprocessing of the *VoxCeleb2* Dataset (speech enhancement, landmark extraction & alignment).
- Experimented with various facial landmark normalization techniques (rotation and scaling, affine alignment, and 3D alignment by shifting viewing frustum)
- Applied Head Pose Estimation models to score training data difficulty for curriculum learning.
- Second author paper submitted to *Nature.*

Route Optimization on Graphs Using Reinforcement Learning

Institute for Creative Technologies, University of Southern California   Jun 2020 – Sep 2021

Supervisor/Mentor: **Dr. Volkan Ustun**

- Applied *Graph Transformer* models and reinforcement learning for efficiently and approximately solving route optimization problems such as the *Capacitated Vehicle Routing Problem (CVRP)*.
- Designed a *Coorperative Multi-Agent Reinforcement Learning* system where agents with different roles and capabilities use the said *Graph Transformer* models as the oracle to get approximately optimal paths and to solve a Search-and-Rescue task in a Minecraft environment.
- Developed a Markov Decision Process Semantic Graph environment to simulate search and rescue tasks and conduct deep reinforcement learning experiment with *Proximal Policy Optimization (PPO)* on the environment for route optimization.
- Devised *Mixed-Integer Programming (MIP)* Solutions.
- Proposed and applied Multi-dimentional Scaling (MDS) and Johnson–Lindenstrauss Transform (JLT) to turn pairwise distances into Euclidian points.
- First author paper accepted to AAAI 2021 Fall Symposium Series (peer reviewed)

(Py)Sigma Cognitive Architecture

Institute for Creative Technologies, University of Southern California   Mar 2020 – Jun 2020

Supervisor/Mentor: **Dr. Volkan Ustun and Prof. Paul Rosenbloom**

- Unit Testing and front-end development to the (Py)Sigma Cognitive Architecture
- Literature review on message-passing inference algorithms for probabilistic graphical models.

Chinese Part of Speech Tagging Error Correction

Institute of Computing Technology, Chinese Academy of Sciences   May 2019 – Aug 2019

Supervisor/Mentor: **Prof. Cungen Cao**

- Developed a *Rule-Based Expert System* that corrects *Chinese Part of Speech (POS)* Tagging errors made by SOTA language models.
- Systematically discovers new POS tagging rules via similarity analysis between tagging results from language models such as Stanford CoreNLP and NLPIR-ICTCLAS.

Teaching Experience

    Introduction to Natural Language Processing (Course Assistant)   Fall 2022

    Introduction to Natural Language Processing (Course Assistant)   Summer 2022

Awards & Honors

    USC Graduate with Distinction (Magna Cum Laude)   May 2021

    USC Academic Achievement Award   Spring 2021

    USC Dornsife Dean's List   Fall 2017 – Spring 2021

Technical Skills

- Expert in: Python, PyTorch, scikit-learn, NumPy, Matplotlib, PyBullet, LaTeX
- Comfortable with: C++, MATLAB, Java, TensorFlow, pandas, OpenCV, nltk, librosa, NetworkX
- Other Research Skills: presentation, Linux, video editing, web scraping, web development

References

Hod Lipson (Research Director/Supervisor)
- Professor of Engineering and Data Science
- Columbia University
- (607) 592-4383
- hod.lipson@columbia.edu

Kathleen McKeown (Course Instructor)
- Professor of Computer Science
- Columbia University
- (212) 939-7118
- kathy@cs.columbia.edu

Volkan Ustun (Research Director/Supervisor)
- Director of Cognitive Architecture
- USC Institute for Creative Technologies
- ustun@ict.usc.edu