Kaichen Ouyang

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Education Background

2020.09 – 2024.06   **University of Science and Technology of China**   **China**
- Degree: Bachelor
- Major: Mathematics and Applied Mathematics, GPA 82.04/100, Talents Class

2024.09 – 2027.06(Expected)   **University of Science and Technology of China**   **China**
- Degree: Master
- Major: Physics

Research Interests: AI & Dynamical Systems

• **Dynamical Systems of AI:** Understanding AI through the lens of dynamical systems, including analyzing training dynamics of optimizers such as SGD and Adam, as well as interpreting training dynamics from the perspectives of statistical physics and neural evolution.

• **Dynamical Systems for AI:** Designing AI algorithms inspired by real-world dynamical systems, such as evolutionary computation, swarm intelligence, diffusion models, and flow matching.

• **AI for Dynamical Systems:** Solving complex dynamical system problems with AI, including simulation, prediction, and optimization (e.g., graph neural networks, physics-informed neural networks, physics-informed evolution, and more).

Publications

- Ouyang, K., et al *Learn from Global Correlations: Enhancing Evolutionary Algorithm via Spectral GNN* AAAI 2026,Poster--**First Author**
- Ouyang, K., et al *Wasserstein Evolution: Evolutionary Optimization as Phase Transition*, IJCAI 2026,Under review--**First Author**
- Ouyang, K., et al *Physics-Informed Evolution: An Evolutionary Framework for Solving Quantum Control Problems Involving the Schrödinger Equation*, PPSN 2026,Under review--**First Author**
- Ouyang, K., et al *Consciousness as a Jamming Phase* (Arxiv)-- ICLR 2027,In Progress--**First Author**
- Ouyang, K., et al *Rethinking Over-Smoothing in Graph Neural Networks: A Perspective from Anderson Localization* (Arxiv)--ICLR 2027,In Progress--**First Author**
- Ouyang, K., et al *Graph Learning Metallic Glass Discovery from Wikipedia* AI for Science--**First Author**
- Ouyang, K., et al. *Dynamic Graph Neural Evolution:An Evolutionary Framework Integrating Graph Neural Networks with Adaptive Filtering.* 2025 IEEE Congress on Evolutionary Computation (CEC 2025),Oral--**First Author**
- Ouyang, K.,et al. *Escape: an optimization method based on crowd evacuation behaviors.* Artificial Intelligence Review. (JCR Q1, IF:13.9)--**First Author**
- Ouyang, K., et al *Beaver Behavior Optimizer: A Novel Metaheuristic Algorithm for Solar PV Parameter Identification and Engineering Problems* Journal of Advanced Research (JCR Q1, IF:13.0)--**First Author**
- Ouyang, K., et al *Multi-objective Red-billed Blue Magpie Optimizer: A Novel Algorithm for Multi-objective*

- *UAV Path Planning* Results in Engineering (JCR Q1, IF:7.9), **--First Author**
- Ouyang, K., et al ***Newton Downhill Optimizer for Global Optimization with Application to Breast Cancer Feature Selection*** Biomedical Signal Processing and Control (JCR Q2, IF:4.9)--**Corresponding Author**
- Ouyang, K.,et al. ***Multiple Objectives Escaping Bird Search Optimization and Its application in Stock Market Prediction Based on Transformer Model***. Scientific Reports. (JCR Q1, IF:3.9)--**Corresponding Author**
- Ouyang, K.,et al. ***A Comprehensive Analysis of Digital Inclusive Finance's Influence on High Quality Enterprise Development through Fixed Effects and Deep Learning Frameworks***. Scientific Reports. (JCR Q1, IF:3.9)--**Corresponding Author**
- Ouyang, K., et al ***A Generative Adversarial Network Based Investor Sentiment Indicator: Superior Predictability for the Stock Market*** Mathematics (JCR Q1, IF:2.2)--**Corresponding Author**
- Ouyang, K.,et al ***Multi-strategy improved dung beetle algorithm and its applications in engineering optimization and bankruptcy prediction*** Neural Networks (JCR Q1,IF:6.3), *Under review*--**Corresponding Author**
- Ouyang, K., et al ***Stochastic Gradient-guided Adaptive Differential Evolution: Algorithm and Its Application in the Diagnosis of COVID-19, Influenza, and Bacterial Pneumonia*** Artificial Intelligence In Medicine (JCR Q1, IF:6.1), *Under review*--**First Author**
- Ouyang, K., et al ***Trend-Aware Mechanism for metaheuristic algorithms*** Applied Soft Computing (JCR Q1, IF:6.6)--**Second Author**
- Ouyang, K., et al ***MLLMs-MR: Multi-modal Recognition based on Multi-modal Large Language Models*** Knowledge-Based Systems.(JCR Q1, IF: 7.2)-**Second Author**
- Ouyang, K ***A novel plug-and-play meta-black-box optimization module based on video streams for non-contact physiological signal extraction*** **S**warm and Evolutionary Computation(JCR Q1,IF:8.0)-**Co Author**
- Ouyang, K ***FLNM-Net: A Frequency-Adaptive and Luminance-Noise Aware Mask Network for rPPG Signal Extraction from Video*** Pattern Recognition(JCR Q1,IF:7.6)-**Co Author**
- Ouyang, K., et al. ***Study of nonequilibrium phase transitions mechanisms in exclusive network and node model of heterogeneous assignment based on real experimental data of KIF3AC and KIF3CC motors.*** European Physical Journal Plus. (JCR Q2, IF:2.8)-**Co Author**
- Ouyang, K., et al. ***Physical mechanisms of exit dynamics in microchannels of nonequilibrium transport systems***. International Journal of Modern Physics B. (JCR Q2, IF:2.6)-**Co Author**
- Ouyang, K.,et al ***Twisted Convolutional Networks (TCNs): Enhancing Feature Interactions for Non-Spatial Data Classification*** Neural Networks (JCR Q1,IF:6.3)-**Co Author**
- Ouyang, K ***Wave Optics Optimizer: A novel meta-heuristic algorithm for engineering optimization*** Communications In Nonlinear Science And Numerical Simulation(JCR Q1,IF:3.8)-**Co Author**

Software Copyright

KC-optimizer: An Integrated Interactive Platform for Metaheuristic Algorithms for Function Optimization V1.0 (Software Copyright, Registration No. 2024SR0164438)

Research Experience

Non-equilibrium Statistical Physics & Complex Networks

Research Assistant at USTC   2021.3 – 2022.9

Advisor: Prof. Binghong Wang, Director of the Institute of Theoretical Physics, School of Physical Sciences; Head of the Theoretical Physics Division, Department of Modern Physics

- Investigated various complex network models, including the Bus Route Model (BRM), Totally Asymmetric

Simple Exclusion Process (TASEP), percolation models, jamming transition models, molecular motor models, and photonic crystals.

- Analyzed these systems using statistical physics theories, with a focus on self-organized criticality and phase transition dynamics.

Evolutionary Algorithms & Machine Learning

Research Assistant at Wenzhou University   2021.9 – Present

Advisor: Prof. Huiling Chen, Dean of the School of Artificial Intelligence and Graduate School

- Investigated single-objective and multi-objective evolutionary algorithms, proposing novel methods including Escape, BBO, NDO, WOO, MORBMO, MOEBS, GNE, and DGNE.
- Applied these algorithms to diverse real-world applications such as engineering design optimization, UAV path planning, photovoltaic parameter identification, medical feature selection, and neural architecture search.
- Research outcomes published as first author in top-tier AI conferences (AAAI, CEC) and leading AI journals (Artificial Intelligence Review, Journal of Advanced Research).

Statistical Physics & Artificial Intelligence

Bachelor and Master Student at USTC   2023.5 – Present

Advisor: Prof. Hua Tong

- Investigated structure-dynamics correlations in glassy materials and granular matter by integrating machine learning methods (graph neural networks, physics-informed neural networks) with molecular dynamics simulations, with a focus on phase transitions and self-organized criticality in glass transition and jamming transition.
- Extended research beyond physical systems by applying statistical physics perspectives to analyze the generalization, convergence, and grokking behavior of deep learning models, including Transformers and graph neural networks.
- Bachelor's thesis titled "Mechanical Self-Organization in Glass Transition Processes Based on Machine Learning" received a grade of A+.

Deep Neural Network-Based Control of Quantum Uncertain Systems

University Innovation Project at USTC   2023.3 – 2024.6

Advisor: Prof. Sen Kuang

- First proposed Physics-Informed Evolution (PIE), embedding physical constraints into evolutionary algorithms to solve control problems in quantum uncertain systems governed by the Schrödinger equation.
- Investigated three different quantum uncertain systems: state preparation in V-type three-level quantum systems, superconducting quantum circuits, and a quantum system consisting of two two-level atoms.
- Applied Kolmogorov–Arnold Networks (KAN) for quantum system control, achieving improved control precision, interpretability, and robustness compared to traditional neural network approaches.

Discovery of Metallic Glasses Driven by Large Language Models and Graph Neural Networks

University Innovation Project at Songshan Lake Materials Laboratory   2024.2 – 2024.9

Advisor: Prof. Yuanchao Hu

- Utilized large language models to extract textual information of chemical elements from Wikipedia, generating atomic feature embeddings to construct atomic material networks.
- Developed recommendation systems for binary and ternary metallic glasses using graph neural networks including TransGNN, NGCF, and GCN.
- Successfully predicted optimal two-atom pairs for glass-forming ability given single atoms, and optimal

three-atom pairs given single or two atoms, achieving prediction accuracy exceeding 95% with results consistent with known experimental findings. Research outcomes published in AI for Science journal.

Surrogate-Driven Multi-Objective Evolutionary Design of Battery Phase Change Materials

Cooperation Project at USTC   2025.5 – Present

Advisor: Prof. Qiangling Duan

- As a collaborator, developed surrogate models using various machine learning approaches based on CFD simulation data.
- Integrated these surrogate models with single-objective and multi-objective evolutionary algorithms to design diverse battery phase change materials.
- The performance of discovered materials was validated both theoretically and experimentally. Research outcomes have been submitted as co-first author to multiple SCI-indexed journals.

Conference Experience

- 5th Amorphous Physics and Materials Symposium 2024, Attendee
- IEEE Congress on Evolutionary Computation (CEC) 2025, Oral Presentation
- The 40th AAAI Conference on Artificial Intelligence, Poster Presentation

Teaching Assistant Experience

- 2022, Mathematical Analysis B1, Teaching Assistant
- 2024, Mathematical Modeling, Teaching Assistant

Reviewer Experience

- 2024,Swarm and Evolutionary Computation (JCR Q1, IF: 8.2), Reviewer
- 2025,Knowledge-Based Systems,(JCR Q1, IF: 7.2), Reviewer
- 2025,International Joint Conference on Neural Networks (IJCNN),Reviewer
- 2025,International Conference on Intelligent Computing (ICIC),Reviewer
- 2025,AAAI 2026,Reviewer
- 2025,Computers and Electrical Engineering (JCR Q1, IF: 4.9), Reviewer
- 2025,International Journal of Computational Intelligence Systems (JCR Q2, IF: 3.116), Reviewer
- 2025,Information Sciences (JCR Q1, IF: 6.8), Reviewer
- 2025,Neurocomputing (JCR Q1, IF: 6.5), Reviewer
- 2025,Scientific Reports (JCR Q1, IF: 3.9), Reviewer
- 2025,Engineering Reports (JCR Q2, IF: 2.0), Reviewer
- 2025,Biomedical Signal Processing and Control (JCR Q2, IF: 4.9), Reviewer
- 2025,Engineering Computations (JCR Q2, IF: 1.9), Reviewer
- 2025,Cluster Computing (JCR Q1, IF: 4.1), Reviewer
- 2025,Control and Decision (Chinese Core Journals, IF:3.012), Reviewer
- 2025,ISPRS Journal of Photogrammetry and Remote Sensing(JCR Q1, IF: 12.2), Reviewer
- 2025,Results in Engineering(JCR Q1, IF: 7.9), Reviewer
- 2025,Smart Agricultural Technology(JCR Q1, IF: 5.7), Reviewer
- 2025,Optik, Reviewer
- 2025,Advanced Engineering Informatics(JCR Q1, IF: 9.9), Reviewer
- 2026, IEEE WCCI 2026, Reviewer

Honours

- 2024, Second Prize(Honorable Mention), MCM/ICM
- 2023, First Prize (Meritorious), Huashu Cup International Mathematical Contest in Modeling
- 2023, First Prize,National College Students' Mathematics Competition
- 2022, International Second Prize, Asia-Pacific Mathematical Modeling Competition
- 2020-2021, Outstanding Student Gold Award, University of Science and Technology of China

Skills

- **Language skills**: Chinese (Native), English (IELTS:7.0/9.0)
- **Computer Skills**: Microsoft Office 365, Python, MATLAB, MySQL, Java,C/C++,Lammps