Taigao Ma

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EDUCATION

University of Michigan, Ann Arbor **Ann Arbor, USA**
Ph.D. in Physics *GPA: 4.00/4.00* *Sept. 2019 – Apr. 2024 (Expected)*
Ongoing: Data Science Certificate Program

University of Science and Technology of China (USTC) **Hefei, China**
B.S. in Physics *GPA: 3.81/4.30* *Sept. 2015 – June 2019*
Honors: Outstanding Graduates

RELATED SKILLS

- Expertise in developing data-driven **deep learning**, **machine learning** and **optimization-based** models
- Strong experience in developing **Foundation Models** for **scientific** and **industrial** applications
- Programming: Python, C/C++, R, MATLAB, Wolfram Mathematica; PyTorch, Pandas, Sciki-learn
- **Graduate Courses:** Discrete Stochastics Process, Statistical Learning Theory, Reinforcement Learning Theory, Machine Learning, Statistical Regression, Predictive Analytics

WORK EXPERIENCE

PhD Intern at *Visa Research* **Austin, USA**
Foundation Models for Transaction Modelling in Payment Industry *May 2023 – Aug. 2023*

- Built up the pipeline from table-to-text generator and data preprocessing, to foundation model architecture, training and inference
- Demonstrated a PoC transaction foundation model for understanding the transaction data and predicting future transaction states

RESEARCH EXPERIENCE

Graduate Student Research Assistant at *University of Michigan, Ann Arbor* **Ann Arbor, USA**
Advisor: Prof. L. Jay Guo (guo@umich.edu)

OptoGPT: A Foundation Model for Inverse Design of Photonic Structures *May 2022 – May 2023*

- Proposed the technique of **structure serialization** to formulate a photonic structure as a sequence of tokens and introduced the novel idea of treating the inverse design problem as a **conditional sequence generation** problem
- Proposed, built up, and trained **OptoGPT**, a **GPT-type** decoder-only transformer, to solve the inverse design problem.
- Achieved remarkable capabilities on 1) autonomous global design exploration, 2) being time efficient for various design tasks, 3) the ability to output diverse designs, and 4) seamless alignment of user-defined constraints in practical applications. No previous model can achieve all these four aspects
- Revealed the physical meaning of learned embeddings in the serialized photonic structure using t-SNE

OL-Transformer: A Fast and Universal Surrogate Simulator for Photonic Simulation *May 2022 – May 2023*

- Proposed to formulate the photonic simulation in multilayer structures as **a sequence transduction** problem
- Proposed and developed **OL-Transformer**, a **BERT-type** encoder-only transformer, as a fast surrogate model for photonic simulation with **3800x** time improvement for versatile types of structures
- Revealed the hidden physical meaning of embeddings to understand the general learning ability

Reinforcement learning for Sequential Design of Sustainable Photonic Structures *June 2021 – Dec. 2022*

- Built up a customized **Gym** environment integrated with physical simulations
- Developed a deep **reinforcement learning** algorithm to design optical multilayer thin film and trained the **GRU-type RNN** using **PPO** algorithms in **PyTorch**
- Designed and fabricated multilayer thin film for sustainable applications, including environmentally friendly Cr color coatings, solar cells with pleasing colors for building-integration (with 30% energy efficiency improvement)
- Results lead to 2 published papers, 1 paper in preparation, 4 submitted patents and 1 awarded NSF proposal ($600 K)

Benchmark Multiple Deep Learning Models for Nano-Photonic Inverse Design *Jan. 2020 – June 2021*

- Built up a benchmark platform to compare different deep learning models (**tandem networks, GANs, VAEs**) for designing vectorized and pixelated photonic nanostructures using **MLP** and **CNN**, respectively
- Designed three evaluation metrics (accuracy, structure diversity, fabrication robustness), developed data analysis system and data visualization methods to compare these models' performance

PUBLICATIONS

- **Taigao Ma**, Haozhu Wang, L. Jay Guo, "Elucidating the General Design Principle for Multilayer Thin Film Structures through Explainable Sequential Learning" *(in preparation)*
- **Taigao Ma**, Anwesha Saha, L. Jay Guo, Haozhu Wang, "Reinforcement Learning-Enabled Environmentally Friendly and Multi-functional Chrome-looking Plating." *(Accepted as **Oral** by NeurIPS 2023 AI4Science Workshop)*
- **Taigao Ma**, Haozhu Wang, and L. Jay Guo. "OptoGPT: A Versatile Inverse Design Model for Optical Multilayer Thin Film Structures." *(Accepted by NeurIPS 2023 Deep Inverse Workshop)*
- **Taigao Ma**, Haozhu Wang, and L. Jay Guo. "OptoGPT: A Foundation Model for Inverse Design in Optical Multilayer Thin Film Structures." arXiv:2304.10294 (2023) [*paper*]
- **Taigao Ma**, Haozhu Wang, and L. Jay Guo. "OL-Transformer: A Fast and Universal Surrogate Simulator for Optical Multilayer Thin Film Structures." arXiv:2305.11984 (2023) *(ICML 2023 SynS & ML Workshop)*[*paper*]
- Anwesha Saha*, **Taigao Ma***, Haozhu Wang, L. Jay Guo, " Environmentally Sustainable and Multifunctional Chrome-like Coatings Having No Chromium Designed with Reinforcement Learning". ACS Applied Materials & Interfaces (2023) *(*co-first)* [*paper*]
- **Taigao Ma**, Mustafa Tobah, Haozhu Wang, and L. Jay Guo. "Benchmarking deep learning-based models on nanophotonic inverse design problems." Opto-Electronic Science 1, no. 1 (2022): 210012 [*paper*]
- Youngbum Park, Sangeon Lee, Mustafa Tobah, **Taigao Ma**, and L. Jay Guo, "Optimize optical/electrical/mechanical properties of ultrathin metal films for flexible transparent conductor applications". Optical Materials Express 13, no. 2 (2023): 304-347 [*paper*]
- Day Matthew, Mark Dong, Bradley Smith, Rachel Owen, Grace Kerber, **Taigao Ma**, Herbert Winful, and Steven Cundiff. "Simple single-section diode frequency combs." APL Photonics 5, no. 12 (2020): 121303 [*paper*]
- Niu Rui, Shuai Wan, Shuman Sun, **Taigao Ma**, Haojing Chen, Weiqiang Wang, Zhizhou Lu et al. "Repetition rate tuning of soliton in microrod resonators." arXiv preprint arXiv:1809.06490 (2018) [*paper*]

HONORS&AWARDS

- Rackham Graduate Travel Grant ($1200) *2023*
- Rackham Graduate Research Grant ($3000) *2022*
- Cyrus Tang Scholarship (10%) *2015, 2016, 2017, 2018*

ADDITIONAL INFORMATION

- **Reviewer:** AIP Advances
- **Teaching**: Physics 241 (Winter 2020, Winter 2021), Physics 141 (Fall 2020), Physics 411 (Fall 2023)
- **Mentoring:** Mentored two undergraduate students in UROP program (Fall 2023)
- **Proposal writing:** Made a major contribution to an awarded NSF proposal ($600 K) and involved in other 5+ NSF proposal writing (contact: guo@umich.edu)