Edwin Goh

Data Scientist @ NASA Jet Propulsion Laboratory (JPL)
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Research Focus

Multidisciplinary design and optimization (MDAO) of aircraft and spacecraft subsystems is frequently bottlenecked by the computational complexity of the underlying simulation models, which hinders its adoption in industry. My research interests lie at the intersection of deep learning and the physical sciences, combining neural networks with physics-based models to accelerate the most compute-intensive parts of a simulation. Parallel developments in reinforcement learning (RL) as a generalized optimization approach under complex constraints and stochastic environments have made it a viable alternative to heuristics-based optimization algorithms. My research aims to combine the efficiency of state-of-the-art physics-informed DL techniques with the human-like creative capabilities afforded by RL to develop novel frameworks that *learn strategies* rather than search a parameter space. This research has diverse applications in the areas of operations research, planetary/earth science, and energy.

Work Experience

NASA Jet Propulsion Laboratory — California Institute of Technology **Pasadena, CA**
Data Scientist Feb 2020 – Present

🌎 *Semi-supervised Learning from Images of a Changing Earth (SLICE; Principal Investigator):*

- PI on a $1M NASA research program to develop self-supervised Earth science foundation models
- Attained breakthrough 0.1°C accuracy in reconstructing satellite sea surface temperature measurements under cloud obstruction by applying large-scale, physics-informed masked image modeling on a 5PB dataset
- Leveraging neural operator learning with NVIDIA Modulus (Makani) to develop an ocean digital twin
- Communicated findings to program managers from NASA HQ and NASA science stakeholders

🚀 *Contrastive Learning for Onboard Vision-Enabled Robotics (CLOVER; Principal Investigator)*

- Won a competed proposal to investigate self-supervised learning for planetary science and robotic exploration
- Managed a team of 7 researchers to execute multi-node contrastive pretraining experiments on Mars imagery
- Reduced required labels by 10x and doubled inference throughput on Mars terrain segmentation

📡 *Automated Scheduling of NASA's Deep Space Network (DSN):*

- Pioneered automated DSN communications scheduling with deep reinforcement learning (RL)
- Implemented OR-inspired RL baselines and published a benchmark dataset for satellite scheduling (SatNet)
- Developed benchmark problem set used by Microsoft collaborators for quantum annealing-based scheduling
- Scaled up agent training to > 200 CPUs and 16 GPUs on AWS instances and NASA supercomputers
- RL agent generated feasible candidate solutions orders of magnitude faster than baseline LP approach

🌑 *ShadowNav (Co-Investigator):*

- Developed a stereo perception pipeline for absolute rover localization on the far/dark side of the Moon
- Compared stereo and edge-detection algorithms and quantified their impact on localization accuracy

💼 *Business Development*

- Served 14 stakeholders across JPL, NASA, USGS, DHS, and DARPA
- Co-authored 11 research grant proposals in Earth/planetary science, robotics, operations research, and ML
- Awarded ~$1.5M in grant funding

Ben T. Zinn Combustion Lab — Georgia Tech **Atlanta, GA**
Graduate Research Assistant — DOE Optimized Low-NOx Staged Combustor Development 2016 – 2020

- Developed simulation suite in Python and MATLAB for preliminary combustor design and optimization
- Elucidated key effects of non-ideal flow conditions on NOx formation and combustor design
- Investigated recurrent neural networks to develop surrogate models for compute-intensive chemical kinetics
- Interfaced simulation suite with constrained optimization frameworks (ANSYS ModelCenter and Dakota)
- Mapped Pareto frontier for combustor design variables that maximized efficiency while minimizing emissions
- Implemented the Non-Dominated Sorting Genetic Algorithm II (NGSA II) in MATLAB to design an optimal satellite constellation that maximized coverage and minimized cost as part of an optimization capstone project
- Developed a CUDA-based Lattice Boltzmann Method (LBM) for fluid dynamics simulations as part of a Parallel Computing course, improving throughput by over 90% compared to a CPU-based simulation

United Parcel Service (UPS) **Atlanta, GA**
Data Science Co-op May 2019 – Nov 2019

- Formulated MILP problems in Gurobi to optimize UPS' last-mile delivery network in the EU (Belgium)
- Enabled 2X speedup of a shortest-path network optimization subroutine through parallelization in the cloud
- Reported on the feasibility, strengths, and weaknesses of using reinforcement learning to optimize UPS' network

Education

Georgia Institute of Technology, Atlanta, GA **2012 – 2020**
B.S., M.S., and Ph. D. in Aerospace Engineering

Skills

Programming	Python, Java, C/C++
Machine Learning	Distributed PyTorch, TensorFlow, Scikit-learn, Ray, Makani, NVIDIA DALI
Parallel Computing	CUDA, MPI, OpenMP, Slurm, PBS, Shell scripting
Simulation Tools	Computational fluid dynamics (CFD), chemical kinetics solvers, finite element analysis

Professional Service/Activities

- American Institute of Aeronautics and Astronautics (AIAA), senior member
- Elected AIAA Intelligent Systems Technical Committee (ISTC) member
- Intelligent Systems Technical Discipline Lead (TDL) for the AIAA ASCEND 2024 Conference

Book Chapters

[B1] Goh, E., Didier, A., Wang, J. (2023) Deep Learning for Ocean Mesoscale Eddy Detection. Artificial Intelligence in Earth Science: Best Practices and Fundamental Challenges.

Journal Publications

[J1] Goh, E., Yepremyan, A., Wang, J., Wilson, B. (2024). MAESSTRO: Masked Autoencoders for Sea Surface Temperature Reconstruction under Occlusion. Ocean Science, 20(5), 1309-1323.
[J2] Atha, D., Swan, R. M., Cauligi, A., Bettens, A., Goh, E., Kogan, D., Matthies, L., Ono, M. (2024). ShadowNav: Autonomous Global Localization for Lunar Navigation in Darkness. IEEE Transactions on Field Robotics.
[J3] Vincent, G., Ward, I., Moore, C., Chen, J., Pak, K., Yepremyan, A., Wilson, B., Goh, E. (2023). CLOVER: Contrastive Learning for Onboard Vision-Enabled Robotics. AIAA Journal of Spacecraft and Rockets.
[J4] Guillaume, A., Goh, E., Johnston, M.D., Wilson, B.D., Ramanan, A., Tibble, F., Lackey, B. (2022). Deep Space Network Scheduling using Quantum Annealing. IEEE Transactions on Quantum Engineering, 3, 1-13
[J5] Claudet, T., Alimo, R., Goh, E., Johnston, M.D., Madani, R., Wilson, B. (2022). Δ-MILP: Deep Space Network Scheduling via Mixed-Integer Linear Programming. IEEE access, 10, 41330-41340.
[J6] Goh, E., Li, J., Kim, N.Y., Lieuwen, T. and Seitzman, J. (2021). Finite-rate entrainment effects on nitrogen oxide (NOx) emissions in staged combustors. Combustion and Flame, 230, 111-434.
[J7] Goh, E., Sirignano, M., Li, J., Nair, V., Emerson, B., Lieuwen, T. and Seitzman, J. (2019). Prediction of minimum achievable NOx levels for fuel-staged combustors. Combustion and Flame, 200, 276-285.

Conference Publications

[C1] Goh, E., Ward, I.R., Vincent, G.M., Pak, K., Chen, J. (2023). Self-Supervised Distillation for Computer Vision Onboard Planetary Robots. 2023 IEEE Aerospace Conference. IEEE.
[C2] Vincent, G.M., Goh, E., Pak, K., Wilson, B., Wang, J., Holt, B. (2023). Unsupervised SAR Images for Submesoscale Oceanic Eddy Detection. IEEE IGARSS.
[C3] Goh, E., Yepremyan, A., Wilson, B., Wang, J. (2023). Reconstruction of Sea Surface Temperature Under Clouds Using Masked Autoencoders. IEEE IGARSS.
[C4] Ward, I.R., Moore, C., Pak, K., Chen, J., Goh, E. (2022). Improving Contrastive Learning on Visually Homogeneous Mars Rover Images. European Conference on Computer Vision (ECCV) Workshop on AI4Space.

[C5] Vincent, G.M., Yepremyan, A., Chen, J., **Goh, E.** (2022). Mixed-domain Training Improves Multi-Mission Terrain Segmentation. European Conference on Computer Vision (ECCV) Workshop on AI4Space.

[C6] **Goh, E.**, Chen, J., Wilson, B. (2022). Mars Terrain Segmentation with Less Labels. 2022 IEEE Aerospace Conference. IEEE.

[C7] **Goh, E.**, Venkataram, H.S., Hoffmann, M., Johnston, M. and Wilson, B. (2021). Scheduling the NASA Deep Space Network with Deep Reinforcement Learning. 2021 IEEE Aerospace Conference. IEEE.

[C8] **Goh, E.**, Sirignano, M., Nair, V., Emerson, B., Lieuwen, T. and Seitzman, J. (2017). Modeling of Minimum NOx in Staged-Combustion Architectures at Elevated Temperatures. In ASME Turbo Expo 2017: Turbomachinery Technical Conference and Exposition. American Society of Mechanical Engineers Digital Collection.