

Swaminathan Sundar

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EDUCATION

Texas A&M University

College Station, TX

Doctor of Philosophy in Chemical Engineering; GPA: 3.7/4

Aug 2021 - today

Advisor: Dr. Efstratios N. Pistikopoulos

Relevant Coursework: Non Linear Programming, Advanced Process Optimization, Heuristics Optimization, Data Mining and Analysis, Machine Learning, Deep Learning

Carnegie Mellon University

Pittsburgh, PA

Master of Science in Chemical Engineering; GPA: 3.7/4

Aug 2019 - Dec 2020

Advisor: Dr. Debangsu Bhattacharyya and Dr. Chrysanthos Gounaris

Relevant Coursework: Advanced Process Systems Engineering, Molecular Simulations of Materials, Product and Supply Chain Optimization, Quantum Integer Programming, Data Science in Chemical Engineering

WORK EXPERIENCE

Texas A&M University

College Station, TX

Graduate Research Assistant

Aug 2021 – Present

1. Continuous Algae-based Carbon Capture and Utilization (CACCU) Project — U.S. Department of Energy (DOE)

Conducted doctoral research on the DOE-funded CACCU project, developing multi-scale modeling and decision-support frameworks to enable the scale-up of novel technologies such as algae based CCUS. Contributions include:

- **Iterative Dynamic Modeling Framework:** Built a comprehensive modeling platform integrating process dynamics, global parameter estimation, global sensitivity analysis, and model-based design of experiments (MBDoE).
- **Dynamic Feasibility and Flexibility:** Evaluated controllability, operational flexibility, and feasibility of CCUS systems under uncertainty.
- **Model Predictive Control (MPC):** Designed and tested MPC strategies for real-time process optimization and stability.
- **TEA & LCA Integration:** Developed Python-based workflows linking process design, scheduling, techno-economic analysis (TEA), and life cycle assessment (LCA) for cost–environmental trade-off evaluation.
- **Optimization Frameworks:** Implemented multi-objective optimization to assess tradeoffs between competing objectives and support decision-making for biorefinery systems.

Carnegie Mellon University

Pittsburgh, Pennsylvania

Graduate Research Assistant

Aug 2019 - Dec 2020

1. Modeling and Optimization of a Photo-Catalytic CO₂ Utilization Process

- Developed a first-principles model using Pyomo for a photo-catalytic reactor.
- Achieved 25× higher CO₂ conversion through optimization of reactor length and addition of a recycle stream.
- Integrated Langmuir-Hinshelwood kinetics, annular fluid dynamics, and empirical radiation models, validated through sensitivity analysis.

ACADEMIC PROJECTS

Vision Transformer for CIFAR-10 Classification, TAMU

Jan – May 2024

- Built a Vision Transformer model in PyTorch to classify CIFAR-10 images, incorporating hyperparameter tuning and data augmentation techniques.
- Tuned parameters included patch size (4), embedding dimension (512), number of heads (8), number of layers (8), encoder hidden dimension (768), batch size (128), and learning rate (0.0001).
- Applied data augmentations such as vertical and horizontal flipping, brightness and contrast adjustment, and Gaussian noise addition.
- Achieved a test accuracy of 56.98%, demonstrating practical skills in deep learning model development and optimization.

Classification of Yelp Reviews Using Transformer Model, TAMU

Aug – Dec 2023

- Preprocessed a dataset of 174,000 Yelp reviews using the NLTK library, followed by tokenization.
- Developed a Positional Encoding dataclass in PyTorch to provide positional information to the Transformer model.
- Achieved a validation accuracy of 83% and a testing accuracy of 82.9% using the optimal set of hyperparameters.

Metaheuristic Approach for CVRP, TAMU

Jan – May 2022

- Proposed a metaheuristic solution for Capacitated Vehicle Routing Problems (CVRP) using 2-opt and λ -interchange local searches combined with an Iterated Local Search to avoid local optima.
- Delivered near-optimal solutions for small problem instances; performance decreased with larger problem sizes.

Particle Track Reconstruction, CMU

Aug – Oct 2020

- Reconstructed particle tracks from Large Hadron Collider data using optimization techniques.
- Formulated and implemented the problem in Pyomo, successfully predicting tracks for five particles.
- Developed a QUBO formulation and applied simulated and quantum annealing; optimal solutions not achieved for multiple particle cases.

LEADERSHIP

Chemical Engineering Master's Student Association, CMU

Jan 2020 - Dec 2020

Vice President

- Represented the Chemical Engineering Master's student body and helped fellow graduate students acclimate themselves at CMU especially during COVID.
- Organized the first ever ChEMSA Research Symposium to facilitate a platform where the Master's Students can showcase their research through posters.

AIESEC, Navi Mumbai, India

Jan 2018 – May 2018

Business Development Executive

- Organized Youth Speak Forum 2018 and helped raise around ₹200k INR for the Navi Mumbai chapter

SKILLS

Programming Languages: Python(Pyomo, Gurobi, Pandas, Pytorch, Keras, Tensorflow, Scikit-learn), Matlab

Modeling Software: GAMS, Aspen Plus, Microsoft Excel

JOURNAL PUBLICATIONS

- 1 Kakodkar, Rahul, **Swaminathan Sundar**, and Efstratios Pistikopoulos. "Hydrogen-Based Dense Energy Carriers in Energy Transition Solutions." In *Handbook of Smart Energy Systems*, pp. 1-21. Cham: Springer International Publishing, 2022.
- 2 **Sundar, Swaminathan**, Rahul Kakodkar, and Efstratios N. Pistikopoulos. "Techno-economic analysis and life cycle assessment of a novel algae-based CCUS technology." *Computers & Chemical Engineering* (2025): 109409.
- 3 **Sundar, Swaminathan**, Vincent Xu, Dustin Kenefake, Yinjie Tang and Efstratios Pistikopoulos. "Model-Based Experimental Design and Parameter Estimation in Algae-Based CCUS Scale-Up" *In preparation*.
- 4 **Sundar, Swaminathan**, Vincent Xu, Dustin Kenefake, Yinjie Tang and Efstratios Pistikopoulos. "Dynamic Modeling and Control of a Photobioreactor for the Cultivation of Algae." *In preparation*.

ORAL AND POSTER PRESENTATIONS

Oral Presentations

1. **Sundar, Swaminathan**, Rahul Kakodkar, Dustin Kenefake, and Efstratios Pistikopoulos. "Scale-up of algae-based CCUS technology: a multiscale modeling and optimization framework." In *AIChE Annual Meeting*, AIChE, 2025.
2. De Sousa, Marco, Saatvi Suresh, Betsie Montano Flores, **Swaminathan Sundar**, Antonio D'Ambrosio, and Efstratios Pistikopoulos. "Achieving true carbon neutrality: integrating dynamic life cycle assessment and real-time carbon accounting within an optimization framework." In *AIChE Annual Meeting*, AIChE, 2025.
3. **Sundar, Swaminathan**, Rahul Kakodkar, Dustin Kenefake, and Efstratios Pistikopoulos. "Superstructure optimization of algae-based biorefineries for sustainable production of value-added products through carbon sequestration." In *AIChE Annual Meeting*, AIChE, 2024.
4. **Sundar, Swaminathan**, Rahul Kakodkar, Dustin Kenefake, and Efstratios Pistikopoulos. "A systems design approach for dynamic optimization of algae-based CCUS processes." In *AIChE Annual Meeting*, AIChE, 2023.
5. **Sundar, Swaminathan**, Efstratios Pistikopoulos. "From models to experiments and back: an iterative framework for scaling emerging technologies." In *Texas A&M Conference on Energy*, ERS, 2025.
6. **Sundar, Swaminathan**, Rahul Kakodkar, Efstratios Pistikopoulos. "A framework for the multiscale modeling and techno-economic assessment of the algae-based CCUS system." In *Texas A&M Conference on Energy*, ERS, 2024.
7. **Sundar, Swaminathan**, Efstratios Pistikopoulos. "Factoring dynamicity into impact characterization in energy systems modeling and optimization." In *ChEGSA Graduate Research Symposium*, ChEGSA, 2025.

Poster Presentations

1. **Sundar, Swaminathan**, Rahul Kakodkar, Efstratios Pistikopoulos. "Design of future energy systems with embedded life cycle emission considerations." In *ChEGSA Graduate Research Symposium*, ChEGSA, 2023.

OTHER ACTIVITIES

- Teaching Assistant for undergraduate and graduate-level courses, including Process Dynamics & Control, Fluid Operations in Chemical Engineering, and Advanced Process Optimization.
- Ranked among the top 20 teams globally in the 2024 Shell.ai Hackathon Challenge.
- Peer reviewer for the journal *Computers & Chemical Engineering*.
- Contributed to multiple grant proposals, including the successful \$26 million NSF grant for the CURB Engineering Research Center initiative.