Swathi Ganesh

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My research interests lie in Computational and Process Systems Engineering with a focus on data-driven techniques to model, predict, and control the behavior of dynamic chemical systems

Education

Indian Institute of Technology (IIT) Madras, Chennai, India [Jul '19 - Present]
B.Tech in Chemical Engineering, Minor in Systems Engineering CGPA: **9.39/10**

Publications

- A Kumar, **S Ganesh**, D Gupta, H Kodamana, "A text mining framework for screening catalysts and critical process parameters from scientific literature-a study on Hydrogen production from alcohol", Chemical Engineering Research and Design 2022, **DOI**
- **S Ganesh**, BK Kumar, A Kumar, H Goyal "Capturing mesoscale structures in multiphase CFD simulations", *In Submission*

Scholastic Achievements

- Ranked **3rd out of 86** in the Department of Chemical Engineering at IIT Madras ['22]
- Presented **3MT-Thesis** from 50+ interns at University of Alberta Research Symposium ['22]
- Awarded the prestigious **DAAD-WISE** and **MITACS Globalink** scholarships to pursue summer research internships at TU Munich, Germany, and UofA, Canada ['21]
- Recipient of the Young Research Fellowship (YRF) among 200+ applicants from IIT Madras ['21]
- Among **top 3 percentile** in JEE Advanced 2019 among 1.2M+ candidates across India ['19]

Research Experience

- **Chemical Reaction Networks (CRNs) for Computation** [Sep '21 - Present]
  Undergraduate Thesis & YRF, Guide - Prof. Nirav Bhatt, RBCDSAI, IIT Madras
  "Chemical Computers" - Physically feasible CRNs to realize different classes of computations
  - Examined the interplay between kinetics and structure of CRNs to understand complex properties such as stability, self-replication, sustenance, etc displayed by CRNs in living systems
  - Incorporated properties like reversibility and autocatalysis to redesign existing CRNs in literature (fundamental operations, log & polynomials) to make them physically realizable and implementable
  - Formulating mathematical frameworks for CRNs to further realize regressors, classifiers, activation functions and optimisation network architectures
- **Mesoscale Structures in Multiphase CFD Simulations** [Aug '21 - Oct '22]
  Guide - Prof. Himanshu Goyal, GRG Lab, IIT Madras
  Characterization of mesoscale features in fluidized beds & risers using a density based clustering algorithm
  - Identified clusters and formulated correlations for hyperparameters in beds & risers using DBSCAN algorithm; accurate identification for bubble spacing less than 1.3 times grid size
  - Verified the methodology against 2D & 3D CFD-DEM simulation data; analyzed the feature properties of clusters (centroid, chord length, area) and obtained less than 2% error
- **Attention Architectures for Chemical Processes** [May '22 - Jul '22]
  MITACS Globalink Scholarship, Guide - Prof. Vinay Prasad, University of Alberta
  Attention based mechanisms for forecasting of sequential chemical systems
  - Simulated 3 stage CSTR using DEE MATLAB to predict the concentrations for 20 time steps ahead using LSTM + Attention layers and decreased loss by 43 %
  - Performed time series analysis of 4 different Vacuum Swing Adsorption (VSA) cycles for post-combustion CO_2 capture — Forecasted for 25 steps ahead using Bi-LSTM + Multi-Head Attention architecture
  - Explored the integration of time embedded encoder architectures (similar to Transformers) to capture the behavior of spatio-temporal solid concentrations in VSA sub-units
- **Scientific Literature Mining for Optimal Process Conditions** [Jun '21 - Jan '22]
  Guide - Prof. Hariprasad Kodamana, CAPS Lab, IIT Delhi
  Text mining framework for optimal process conditions during H_2 production from alcohols
  - Extracted 6K+ full-text articles and 0.1M abstracts using Elsevier API keys, a custom-built XML parser, and ChemDataExtractor library

- Mapped articles to production categories using Latent Dirichlet allocation (LDA) and performed sentiment analysis to annotate experimental section of articles
- Developed Ex-SciBERT to perform classification followed by Named Entity Recognition (NER) for catalyst extraction; Obtained accuracy scores of 0.890 and 0.997 respectively

- **Particle Mixing Index in Drug Reactors** [Oct '21 - Dec '21]
  AbbVie Pharmaceutical R&D, *Guide - Prof. Himanshu Goyal, IIT Madras*
  Calculated the degree of particle mixing across a drug reactor using X-ray μCT frames
  - Preprocessed X-ray frames with Otsu's thresholding for 10 mixing cycles; Seperated drugs to two binary classes with unique value pixels corresponding to lighter and heavier particles
  - Calculated Lacey mixing index to obtain meaningful interpretations of mixing across the reactor. *Manuscript from AbbVie R&D under preparation*

Course and Miscellaneous Projects

- **State Estimation of Quadruple Tank Process** [Oct '22]
  Modern Control Theory (CH5120), *Guide - Prof. Kallol Roy, IIT Madras* *Report*
  - Estimated water levels in a four tank process with Kalman Filter & sequential Monte-Carlo methods. Implemented Model Predictive Control to control unmeasured states in the system
- **Sparse Identification of Nonlinear Dynamic Systems** [Mar '21]
  Guide - Prof. Himanshu Goyal, IIT Madras
  - Generated and visualised noisy data for ODEs of chaotic Lorenz System; Estimated coefficients of the system using sequential Least Squares (SINDy) & Multivariate Regression
- **Shell and Tube Heat Exchanger Design** [Jun '21]
  Heat and Mass Transfer (CH2014), *Guide - Prof. Sreenivas Jayanti, IIT Madras* *Report*
  - Designed and optimized a shell and tube HEX to meet process specifications, geometrical and cost constraints — Achieved a 4% cost reduction from baseline design
- **Impact Analysis in Shear Thicking Fluids - A Study on Oobleck** [Jun '21]
  Transport Phenomena (CH2012), *Guide - Prof. Abhijit Deshpande, IIT Madras* *Presentation*
  - Analysed compressive stress distribution of Shear Thickening fluids (Oobleck) using Added Mass Model during an impact— Modelled the dual behaviour using CMTP relations, Power Law and Fourier's Law

Technical Skills

- **Languages & Tools** - Python, C/ C++, MATLAB, Aspen Plus, Fusion 360
- **Frameworks & Libraries** - Tensorflow, Keras, Open-CV, NLTK, Sci-kit Learn
- **Miscellaneous** - Arduino IDE, Eagle EDA, LaTeX, Illustrator

Relevant Coursework

- **Chemical Engineering:** Continuum Mechanics & Transport Phenomena, Fluid & Particle Mechanics, Kinetics & Catalysis, Reaction Engineering, Thermodynamics, Heat Transfer, Mass Transfer & Applications
- **Systems Engineering:** Process Control, Process Optimization, Modern Control Theory, Data Science & Data Analytics, ML & Deep Learning (MOOCs), Process & Product Design, Introduction to CFD
- **Mathematics:** Probability, Statistics, Stochastic Process, Calculus, Linear Algebra, Operations Research

Teaching, Mentoring and Extra-Curricular Activities

- **Head**, Electronics Club, Centre for Innovation, IIT Madras [Apr '20 - Apr '22]
  - Led a team of 50+ electronics enthusiasts working on 10+ multi-disciplinary projects
  - Facilitated training of 200+ students through sessions on a spectra of electronics topics
- Volunteered at 7th International **AdCONIP** Symposium, UBC, Vancouver (1 of 7 volunteers) [Aug '22]
- **Brainly Tutor** - Provided academic mentorship to high schoolers in Mathematics & Physics [Dec '19]
- **Shaastra Mentor** - Coached top 2 teams to develop electronic prototypes for Make-a-thon [Sep '19]
- **Shaastra Trainer** - Instructed a 2-day workshop on AI & RL with 100+ participants [Jan '22]
- **Fine Arts**
  - Trained in multiple art mediums for four years under eminent artist Dr. B.S. Desai
  - Conducted a graphic designing workshop at Shaastra, IIT Madras with 100+ registrations
  - Designed an illustrative series for Mann (Mental Health Awareness campaign) by Saarang