Saha Dhrubo | **Mobile No.: 9395 5206** | **Email: DHRUBO001@e.ntu.edu.sg** |
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DOCTORAL OBJECTIVE

I am a university graduate with considerable coursework and research experience in Artificial Intelligence, especially in Multimodal AI. I finished among the top of my cohort at one of the top 10 engineering universities in the world and received several academic and research awards along the way. I am eager to pursue a PhD in areas such as Computer Vision and Multimodal Learning for Robotics and Autonomous Systems.

EDUCATION

Nanyang Technological University, Singapore Aug 2019 – May 2024 (took a gap year)
QS Global Rank 2022: 4th in Engineering
Bachelor of Engineering (Aerospace Engineering)

- **Degree Classification:** Honours (Highest Distinction)
- **Specialization:** Autonomous Systems
  - AI courses (A/A+): Introduction to Data Science and AI, Machine Intelligence, AI/ML for Engineering Applications, Autonomous Driving, Introduction to Data Analysis
- **Dean's List:**
  - Year 3 (AY2022-2023): Ranked as the best student in Aerospace Engineering with a 5.00/5.00 YGPA
  - Year 4 (AY2023-2024): Ranked as the best student in Aerospace Engineering with a 5.00/5.00 YGPA
  - My Aerospace Engineering cohort was the 3rd most competitive across all NTU degree programs (NTU IGP 2019).
- **Final Year Project:** FYP on Multimodal Deep Learning, selected as a *Global Undergraduate Award Finalist*

FINAL YEAR PROJECT (FYP) RESEARCH

Advanced Materials Synthesis Lab, NTU, Singapore Apr 2023 – Jul 2024
Referee: Professor Lai Changquan, Principal Investigator of the lab and supervisor of my Final Year Project
Award: My Final Year Project thesis was honoured as a *Global Undergraduate Award Finalist* in the Engineering category. Out of thousands of submissions, only the top 13 were selected as finalists.

Phase 1 Project Title: An Efficient Algorithmic Framework for Generating High Phase Fraction Microstructures
Research Gap: Existing microstructure generation software could produce only simple microstructures with phase fractions being capped at 60%. To address these limitations, I:

- **Developed a software solution** that used multi-dimensional arrays to accurately represent spatial configurations. It used Monte Carlo methods for probabilistic particle placement, Gaussian methods for phase fraction computations, and optimal algorithms for rapid searching.
- **Achieved remarkable results:** The tuned algorithms reduced the overall time complexity to polynomial order. This made it possible for the software to generate microstructures with complex particle shapes and phase fractions up to 80%. This tool was successful in generating high-quality microstructural datasets for training machine learning models.

Publication: Manuscript currently under peer review in *SoftwareX*.

Phase 2 Project Title: A Hybrid Deep Learning Paradigm for Multimodal Prediction of Composite Materials
Research Gap: Traditional hybrid models lacked interpretability and required large datasets to process image and numerical data simultaneously. To tackle these challenges, I:

- **Developed neural network architectures** for tasks such as super-resolution, object detection, and segmentation. These were designed to quantify image data from composite microstructures. I also implemented Multi-Layer Perceptrons (MLPs) for data processing of concatenated numerical data. This project went beyond applying existing neural network architectures. It involved novel modifications and a smooth integration of all the developed components into a comprehensive deep learning framework.
- **Achieved outstanding results:** This framework reached an R^2 accuracy between 90-99% across various mechanical properties. It accomplished this feat using less than 10% of the data used by previous models, reducing training times considerably. Moreover, the framework offered enhanced interpretability which overcame the "black-box" nature of traditional hybrid neural networks. Therefore, this interpretability provided valuable insights into the mathematical relationships governing composite material behavior.

Publication: Manuscript currently under peer review in *Advanced Materials*.

OTHER RESEARCH EXPERIENCES

Computer Aided-Engineering Lab, NTU, Singapore Aug 2022 – Jan 2023

Project Title: Design of Optimal Functional Gradings for Materials under Axial Loading

Research Gap: Previous research has found good functional gradings for axially loaded structures, but these are not the optimal ones. To fill this gap, I:

- **Conducted a literature review** to formulate partial differential equations (PDEs) for modelling the mechanics in inhomogeneous structures. Subsequently, I numerically solved these PDEs by writing Wolfram Mathematical code. This is how I examined the effects of 42 different functional gradings on the mechanical responses of various structures.
- **Achieved great results:** One of my key findings was a functional grading that could reduce axial deflections in structures by 3%. These findings had positive implications on the design and weight of axially loaded structures, and consequently contributed to enhanced safety.

Accolade: Recognized with the prestigious *NTU President Research Scholar* award for outstanding project outcomes.

Rolls-Royce @ NTU Corporate Lab, Singapore May 2022 – Jul 2022, Jan 2023 – May 2023

Projects: Completed 4 projects, outlined as follows:

- Developed Gaussian Process Regression ML software for predicting roughness of machined workpieces from key machining parameters, attaining prediction accuracies (R^2) exceeding 99%.
- Formulated the experimental method for HCAF fluid flow, showcasing MATLAB numerical analysis skills for optimizing dimensionless variables.
- Improved the cooling system in the Rolls-Royce Trent Engine, utilizing VBA algorithms for CAD model refinement to improve heat conduction rate by over 15%.
- Optimized vibratory finishing of compressor blisks, combining literature review with hands-on experimentation to achieve sub-0.25 μm surface roughness, which is about 5% lower than existing methods.

Achievements: My contributions were an accurate GPR model, efficient HCAF fluid system, cooler Trent engine, and smoother compressor blisks. These have helped reduce Rolls-Royce's production costs.

Referee: Professor Yeo Swee Hock, Principal Investigator of the lab and supervisor of my 30-week research internship

TEACHING EXPERIENCES

School of Mechanical and Aerospace Engineering, NTU, Singapore Aug 2022 – May 2024

Peer Tutor of MA3005 Control Theory and MA3705 Aerospace Control Theory

- Developed a Google Classroom platform for conducting weekly 2-hour lectures complemented by Q&A sessions.
- Created structured revision notes and compiled a series of 34 targeted practice questions and my solutions.

Achievements:

- Class size grew from less than 70 to over 200 students each semester due to positive buzz
- Average grade for this course improved from C to B within a year
- Received over 50 personal emails and messages from students who were thankful for their triumphant learning journey.

Referee: Professor Ng Bing Feng, Chair (Students) of MAE, NTU.

SKILLS

Programming Languages: Proficient in Python, C, C++, R, VBA, MATLAB, TensorFlow, Keras, PyTorch, OpenCV, PIL, Scikit-learn

Languages: Proficient in English and Bengali

PUBLICATION WEBSITE

URL: https://sites.google.com/view/sahadhrubo/home

The website provides updates on my latest research paper publications. Some papers that were previously under peer review may now be published.

Saha Dhrubo

1. My University Education

I graduated with a Bachelor of Engineering (*Honors, Highest Distinction*) in Aerospace Engineering from Nanyang Technological University, where I finished among the top of my cohort. NTU is ranked as the 4th best engineering university in the world according to QS 2022, and its aerospace cohort is the 3rd most competitive. I was awarded a place on the *Dean's List* (Top 5%) for both Year 3 (AY2022-2023) and Year 4 (AY2023-2024) for achieving perfect yearly GPAs of 5.00/5.00. I also completed a specialization in Autonomous Systems by shining in courses such as AI/ML for Engineering Applications, Machine Intelligence, Autonomous Driving, and Introduction to Data Analysis. These courses focused on Artificial Intelligence theory and applications.

2. My Final Year Project Research

2.1 Research in Algorithms and Software Development

Existing microstructure generation software could produce only simple microstructures with phase fractions being capped at 60%. My aim was to overcome these bottlenecks. I developed a software solution that used multi-dimensional arrays to accurately represent spatial configurations. It used Monte Carlo methods for probabilistic particle placement, Gaussian methods for phase fraction computations, and optimal algorithms for rapid searching. The tuned algorithms reduced the overall time complexity to polynomial order. This made it possible for the software to generate microstructures with complex particle shapes and phase fractions up to 80%. This tool was successful in generating high-quality microstructural datasets for training machine learning models. The manuscript that outlines this work is currently under peer review in the journal *SoftwareX*.

2.2 Research in Deep Learning for Multimodal Prediction

Traditional hybrid models lacked interpretability and required large datasets to process image and numerical data simultaneously. My project objective was to tackle these limitations. I developed neural network architectures for tasks such as super-resolution, object detection, and segmentation. These were designed to quantify image data from composite microstructures. I also implemented Multi-Layer Perceptrons (MLPs) for data processing of concatenated numerical data. This project went beyond applying existing neural network architectures. It involved novel modifications and a smooth integration of all the developed components into a comprehensive deep learning framework. This framework reached an R^2 accuracy between 90-99% across various mechanical properties. It accomplished this feat using less than 10% of the data used by previous models, reducing training times considerably. Moreover, the framework offered enhanced interpretability which overcame the "black-box" nature of traditional hybrid neural networks. Therefore, this interpretability provided valuable insights into the mathematical relationships governing composite material behavior. The manuscript for this project is currently under peer review in the journal *Advanced Materials*.

2.3 FYP Thesis Recognition

The two previous research projects constituted my Final Year Project (FYP) thesis, which was honored as a *Global Undergraduate Award Finalist* in the Engineering category. Out of thousands of submissions, only the top 13 were selected as finalists. (FYP Referee: Professor Lai Changquan, supervisor of my Final Year Project)

3. Other Research Experiences

3.1 Research in Machine Learning for Aerospace Manufacturing

Previous machine learning (ML) approaches were unsuccessful in predicting the roughness of workpieces after machining. This was because the high cost of machining experiments meant only small datasets could be generated. My mission was to use this limited data to develop an ML model for predicting surface roughness from key machining parameters. I conducted feature engineering to extract underlying patterns from features like feed rate, spindle speed and cutting depth. Then I determined that Gaussian Process Regression (GPR) was the optimal algorithm. GPR's ability to model non-linear relationships and providing uncertainty estimates made it ideal for the small datasets. I fine-tuned the GPR model's kernel type, regularization parameters and other hyperparameters using evolutionary optimization. The model achieved an R^2 accuracy exceeding 99%, and therefore it was a cost-effective alternative to experimentation. This model is now used by the company for producing their engines' workpieces. (Referee: Professor Yeo Swee Hock, supervisor of my 30-week research internship at Rolls-Royce @ NTU Corporate Lab)

3.2 Research in Numerical Analysis for Structural Mechanics

Prevailing research found good functional gradings for axially loaded structures, but these were not the optimal ones. My project objective was to find the optimal functional gradings of axially loaded structures for minimizing deflection and stress. I initially conducted a literature review to formulate partial differential equations (PDEs) for modelling the mechanics in inhomogeneous structures. Subsequently, I numerically solved these PDEs by writing Wolfram Mathematica code. This is how I examined the effects of 42 different functional gradings on the mechanical responses of various structures. One of my key findings was a functional grading that could reduce the axial deflection in structures by 3%. These findings had positive implications on the design and weight of axially loaded structures, and consequently contributed to enhanced safety. My work was acknowledged with the prestigious *NTU President Research Scholar* award.

4. My Teaching Experience

I have been a Peer Tutor for 2 courses on Control Theory since the beginning of my third year. I developed a Google Classroom platform for conducting weekly 2-hour lectures complemented by Q&A sessions. Additionally, I created structured revision notes and compiled a series of 34 targeted practice questions, which I taught my class. My class size grew from less than 70 to over 200 students each semester due to positive buzz about the usefulness of my teaching methods. Moreover, the average grade for this course improved from C to B within a year of my teaching endeavors. I received over 50 personal emails and messages from students who credited my class for their triumphant learning journey. (Referee: Professor Ng Bing Feng, Chair of Students at NTU)

5. My Future Aspirations

I have built a strong academic and research foundation in AI with an emphasis on Multimodal Deep Learning. Moreover, I have also developed a well-rounded CS proficiency in areas like software development, algorithm design, and numerical analysis. I am eager to pursue a PhD in areas such as Computer Vision and Multimodal Learning for Robotics and Autonomous Systems. My double skillset in Mechanical (Aerospace) Engineering and Computer Science provides a valuable multidisciplinary perspective for this field. The faculty at Columbia University are leading several research projects in my areas of interest. For example, Professor Carl Vondrick's recent work used video generation for visuomotor policy learning to successfully generalize Multimodal AI across various real-world robotic tasks. Similarly, Professor Yunzhu Li's research used his RoboPack framework for combining tactile and visual sensing in robotic systems. Besides research, I also have a fervor for teaching and am dedicated to serving as a teaching assistant. Pursuing a PhD under the mentorship of Columbia's faculty will allow me to hone both my research and teaching skills. This will prepare me for a career as a professor, which is my ultimate aspiration.