NUS National University of Singapore

College of Design and Engineering

Summer Engineering Research Internship for US Students

SERIUS 2025

PROJECT CODE	TITLE	PROJECT SUPERVISOR
BIOMEDICAL ENGINEERING		
BME1	Fine-tuning and Evaluation of Large Language Model (LLM) for Protein Engineering	A/Prof Poh Chueh Loo
BME2	Designing new materials for coral reef growth and regeneration	Dr Andrew W. Holle
BME3	Extracellular matrix mechanobiology in aging	Dr Jennifer Young
CIVIL AND ENVIRONMENTAL ENGINEERING		
CEE1	How do volatile organic compounds affect urban $PM_{2.5}$ and air quality?	A/Prof Yu Liya E.
CHEMICAL AND BIOMOLECULAR ENGINEERING		
ChBE1	Converting CO_2 to fuel using cyanobacteria	Prof Tong Yen Wah
ChBE2	Carbon capture and storage via clathrate hydrates	Prof Praveen Linga
ChBE3	Hydrogen storage via clathrate hydrates	Prof Praveen Linga
ChBE4	Converting CO_2 into methanol by hydrogenation	Prof Ning Yan
ChBE5	Self-Powered Bioelectronic Device for Medical Diagnosis & Treatment	Dr Yamin Zhang

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ECE2	Develop digital twin of interacting systems in complex sea scenarios	Prof Sam Ge Shuzhi
ECE3	Domain-specific Computing using Emerging Electronic Device Technologies	Dr Kelvin Fong Xuanyao
ECE4	Memory-centric Data Processing Hardware	Dr Kelvin Fong Xuanyao
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ECE6	Non-volatile Mem-ristive Memories	Dr Kelvin Fong Xuanyao
ECE7	Machine Learning Applied to Intelligent Farming	Dr Kelvin Fong Xuanyao
ECE8	AIoT for Aquaponics	Dr Kelvin Fong Xuanyao
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ENGINEERING DESIGN AND INNOVATION CENTRE		
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EDIC2	Intelligent Surgical Tool Checker using Vision Based and AI Based Methods	Dr Tang Kok Zuea
EDIC3	Using Deep Learning for Environmental Monitoring	Dr Tang Kok Zuea
EDIC4	Using AI for Integrating Autonomous Mobile Robots	Dr Tang Kok Zuea
EDIC5	Using AI for Effective Waste Collection	Dr Tang Kok Zuea
EDIC6	Decoding the Brain	Dr Yen Shih-Cheng

MECHANICAL ENGINEERING		
ME1	Multiphase Flow in Pipelines and Multiphase Equipment Development	A/Prof Loh Wai Lam
ME2	3D Printing Enabled Urban Farming	Dr Sing Swee Leong
ME3	3D Food Printing for Sustainability	Dr Sing Swee Leong
ME4	Exploration of light-field-based control methods for light-driven robots	Dr Tan Yu Jun
ME5	From Kombucha Tea to sustainable wearable electronics	Dr Tan Yu Jun
ME6	Fabrication of a self-healing optoelectronic device	Dr Tan Yu Jun
ME7	Fabrication of a Flexible, Self-healing Material for Electronics	Dr Tan Yu Jun
ME8	Control of a Hexapod Robot for Visual Tasks	Dr Guillaume Sartoretti
ME9	Reinforcement Learning-Based Decentralized Multi-Agent Pathfinding	Dr Guillaume Sartoretti
ME10	Decentralized Traffic Signal Control for Urban Mobility	Dr Guillaume Sartoretti
ME11	Visibility-Based Mobile Target Localization and Tracking with Robots	Dr Guillaume Sartoretti
ME12	4D metal printing	Dr Tan Xipeng
ME13	High-throughput design and fabrication of soft magnetic materials	Dr Tan Xipeng
ME14	Improving tribological properties of 3D-printed biomedical alloys	Dr Tan Xipeng
ME15	3D printing of high-performance alloys via direct ink writing	Dr Tan Xipeng

Project BME1

Supervisor **A/Prof Poh Chueh Loo**
https://engbio.syncti.org/

Fine-tuning and Evaluation of Large Language Model (LLM) for Protein Engineering

Large Language Models are revolutionizing protein engineering by enabling rapid prediction and optimization of complex sequence-function relationships, essential for applications in enzyme design, drug development, and biomanufacturing. Despite these advances, achieving accurate and reliable predictions with LLMs in protein engineering still requires specialized fine-tuning and rigorous performance evaluation, given the complexity of sequence-function features. This project focuses on systematically fine-tuning pretrained models using existing protein databases that provide rich annotations on protein sequences, structures, and functions, and rigorously evaluating the model predictive performance from structural and functional perspectives. Students involved will gain hands-on experience in protein data extraction and processing, model fine-tuning, and performance evaluation, equipping them with cutting-edge skills in protein engineering.

Maximum no. of participants: **1**

Project Learning Outcomes
Students will develop skills in fine-tuning LLMs specifically for protein engineering and learn to analyse and interpret results (sequences and functions) to ensure model reliability and accuracy.

Nature of Project
Model Development

Relevant Majors
Biomedical Engineering, Electrical Engineering, Computer Engineering, Computer Science, Chemical Engineering, System Engineering

Name and Address of Lab that participants will be attached to
Engineering Biology Lab
E6-04, 5 Engineering Drive 1, Singapore 117608

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Programming skills (Python)

Project BME2

Supervisor **Dr Andrew W. Holle**
https://www.mbi.nus.edu.sg/andrew-holle/

Designing new materials for coral reef growth and regeneration

Despite worldwide attention to the plight of coral reefs due to climate change, there has been little focus on the role of mechanobiology for supporting the attachment, growth, and development of coral planulae. This project will use biomaterial techniques to fabricate hydrogel substrates with different stiffnesses, then test the ability of these scaffolds to remain functional in seawater-mimicking media. Next, isolated stable coral cell lines will be plated on these substrates to determine the degree to which coral cells can sense the stiffness of their mechanical microenvironment. Substrate chemistry will also be controlled in order to enhance the binding of symbiotic algal species to which coral cells have been shown to interact. Finally, these substates will be tested with live budding coral species to determine if seeding efficiency is affected as a function of substrate stiffness and surface chemistry. Ultimately, these findings may lead to new designs for coral-enhancing materials that can be placed in situ to encourage coral regeneration.

Maximum no. of participants: **2**

Project Learning Outcomes
1. An understanding of hydrogel synthesis
2. Connections between mechanobiology and marine biology
3. Surface modification techniques

Nature of Project
Laboratory Investigation

Relevant Majors
Biomedical Engineering, Materials Science, Biology

Name and Address of Lab that participants will be attached to
Confinement Mechanobiology Lab
T-Lab Level 10, 5A Engineering Drive 1, Singapore 117411

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA

Project BME3

Supervisor **Dr Jennifer Young**
https://www.mbi.nus.edu.sg/jennifer-young/

Extracellular matrix mechanobiology in aging

Aging results in drastic tissue alterations, yet the role of specific tissue properties in regulating age-related dysfunction is poorly understood. Thus, this project aims to quantify how extracellular matrix (ECM) deregulation directly affects cellular function. To do this, we will design biomaterial systems mimicking tissue properties for studying the role of individual ECM components (stiffness, composition, organization). Young vs. aged cells will be cultured on these materials and monitored for functionality using imaging-based and expression assays.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Design, fabrication, and characterization of hydrogels
2. Cell culture and biological assays
3. Data analysis and presentation of project findings

Nature of Project
Laboratory Investigation

Relevant Majors
Biology, Biomedical Engineering, Materials Science

Name and Address of Lab that participants will be attached to
Soft Nano-Biomaterials Lab, Mechanobiology Institute
T-Lab Level 9, 5A Engineering Drive 1, Singapore 117411

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Some background knowledge in biomaterials and meat alternatives should be acquired before commencing the program. Specific literature will be given to the student(s) once assigned to the project.

Project CEE1

Supervisor **A/Prof Yu Liya E.**
https://cde.nus.edu.sg/cee/staff/yu-liya-e/

How do volatile organic compounds affect urban $PM_{2.5}$ and air quality?

Volatile organic compounds (VOCs) (e.g., emitting from trees and household cleaning reagents) are known to be involved in photochemical smog generating compounds (such as O_3) affecting public health. How do VOCs affect ambient $PM_{2.5}$ concentrations? This study aims to address the question through simulation of chemical reactions in a warm humid city in the equatorial Asia. Field measurements data are employed as inputs and validation of computational results. Specific focus can be given to investigate effects of selected VOC species originating from biogenic sources (e.g., isoprene) and anthropogenic processes (e.g., toluene). Students who are keen to integrate programming skills (Python and R) with atmospheric chemistry will enjoy the most.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Atmospheric reaction mechanisms in warm humid urban environment
2. Applications of Python or R to atmospheric environment

Nature of Project
Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Chemical Engineering, Chemistry, Atmospheric Science, Environmental Science Engineering

Name and Address of Lab that participants will be attached to
Air quality & aerosol science lab (AQASL)
E2-05-24, 9 Engineering Drive 1, Singapore 117575
E8-02-06, 1 Engineering Drive 3, Singapore 117580

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity of Python and R will be most suitable
Strong interests in data processing and chemical reactions

Project ChBE1

Supervisor **Prof Tong Yen Wah**
https://cde.nus.edu.sg/chbe/staff/tong-yen-wah/

Converting CO_2 to fuel using cyanobacteria

Cyanobacteria have been successfully used to produce many value-added bioproducts directly from CO_2. These chemicals are high-value-added products and have been widely used in multiple fields. However, the production yields of such low molecular-weight chemicals by cyanobacteria are usually low, which is the most significant barrier against the commercialization of cyanobacterial cell factories. In this project, we are focusing on biomaterial production by engineered cyanobacterial cell factories and other CO/CO_2-utilising microorganisms. We will use a multi-physical field simulation model to help design the novel photobioreactor coupled with actual bioreactor fabrication to evaluate the most effective light absorbing photobioreactor. This is different from the traditional reactor development methods, and would help to accelerate the design and optimization processes by leveraging AI technology. Experiments in building photobioreactors and computer simulation will be coupled together in this joint project between NUS and SJTU, and the students will be able to work on bioreactor design, cell culture or product extraction.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Design and operation of bioreactors
2. Culture and growth of microorganisms
3. Analysis and testing of products

Nature of Project
Laboratory Investigation

Relevant Majors
Chemical Engineering, Environmental Engineering

Name and Address of Lab that participants will be attached to
E8-06-16/17, 1 Engineering Drive 3, Singapore 117580

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project ChBE2

Supervisor **Prof Praveen Linga**
https://blog.nus.edu.sg/lingalab/

Carbon capture and storage via clathrate hydrates

Global CO_2 emissions are currently estimated to be around 30.6 gigatons [2020] by the International Energy Agency [IEA]. To prevent the catastrophic repercussions of global warming, such as rising sea levels, melting glaciers, and rising global temperatures, the CO_2 worldwide emissions must be drastically decreased. The IEA has set a target of achieving a zero-carbon economy by 2050 and limiting global warming to 1.5 °C. Carbon capture and storage [CCS] has the potential to significantly reduce CO_2 emissions in the atmosphere. The ocean can serve as a huge pool for carbon capture and storage. However, the carbon dioxide cannot be disposed of directly into the ocean due to environmental restrictions such as ocean acidification and threat to aquatic life. The storage of CO_2 as gas hydrates in deep ocean sediments is an alternative approach. Through experimental tests and computational models, this research will conduct a fundamental morphological study on CO_2 hydrate formation kinetics in aqueous media and porous media. The successful applicant will be responsible to help with lab experiments and computational modelling.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Experimental skills
2. Technical writing and presentation skills
3. Data analysis skills

Nature of Project
Hybrid (eg. mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Chemical Engineering, Mechanical Engineering, Chemistry, Oceanic Engineering

Name and Address of Lab that participants will be attached to
Biomolecular Engineering
E8-04-06, 1 Engineering Drive 3, Singapore 117580

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
1. Background reading on CO_2 hydrates recommended
2. Skills in using Microsoft Excel and Matlab programming preferred
3. Good communication and writing skills preferred

Project ChBE3

Supervisor **Prof Praveen Linga**
https://blog.nus.edu.sg/lingalab/

Hydrogen storage via clathrate hydrates

Hydrogen (H_2) with zero-emission upon combustion is projected to play a leading role in the clean energy portfolio. Establishing the hydrogen economy necessitates the development of innovative hydrogen storage technology for both onboard and stationary applications. Hydrate based hydrogen storage enabling safe, long-term, and energy-dense storage of hydrogen molecules under moderate temperature and pressure conditions is promising for stationary storage applications in the foreseeable hydrogen economy.

This project consists of the following objectives: a) to identify thermodynamic promotors to improve the temperature and pressure conditions required for hydrogen storage by gas hydrates; b) to identify kinetic promotors to enhance the hydrogen storage speed by gas hydrates; c) Optimization of the parameters for enhanced hydrate formation kinetics.

Outcomes:
On successful completion of this project, students will be able to: a) understand the fundamental properties of gas hydrates; b) master the basic and necessary experimental skills to conducted gas hydrate-related experiments; c) understand and estimate hydrogen storage capacity and efficiency of various hydrate systems using fundamental thermodynamics concepts (Equation of state et al); d) be familiar with various chemical engineering equipment, e) understand the process design and optimization.

Maximum no. of participants: **1**

Nature of Project
Laboratory Investigation, Computing and Analysis

Relevant Majors
Chemical Engineering, Mechanical Engineering, Material Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Candidates with prerequisite knowledge in heat and mass transfer, thermodynamics, and material characterization are favorable.

Project Learning Outcomes
1. To master the basic and necessary experimental skills on gas hydrate research in the state-of-the-art gas hydrate laboratory
2. To obtain a complete understanding of the hydrate based hydrogen storage and transport process
3. Possibly achieve a breakthrough in the research area with potential collaboration on a scientific research paper

Name and Address of Lab that participants will be attached to
Linga Lab
E8-04-04, 1 Engineering Drive 3, Singapore 117580

Project ChBE4

Supervisor **Prof Ning Yan**
https://www.yan-group-nus.com/

Converting CO_2 into methanol by hydrogenation

The escalating concerns about global climate change necessitate the development of technologies that can address the excessive CO_2 levels in our atmosphere. The project "Converting CO_2 into Methanol by Hydrogenation" offers a viable solution to this challenge by converting carbon dioxide, a major greenhouse gas, into valuable methanol through hydrogenation.

Maximum no. of participants: **2**

Nature of Project
Laboratory Investigation

Relevant Majors
Chemical Engineering, Chemistry

CO_2 Hydrogenation Reactor

Name and Address of Lab that participants will be attached to
Green Catalysis Lab
E8 level 5, 1 Engineering Drive 3, Singapore 117580

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA

Project Learning Outcomes

1. Students will develop basic understanding of the principles and mechanisms behind the hydrogenation of CO_2 to produce methanol, encompassing both thermodynamic and kinetic aspects.

2. Through hands-on experience with the synthetic robot, students will acquire skills in designing, synthesizing, and characterizing various catalysts tailored for CO_2 conversion.

3. Students will become adept in setting up, operating, and troubleshooting the advanced multi-channel reactor, ensuring safety and optimal performance throughout the process.

4. By collecting and analyzing experimental data, students will gain the ability to derive meaningful insights, understand catalyst behavior under different conditions, and optimize reaction parameters for maximum methanol yield.

5. Students will be challenged to innovate and optimize the process continuously, fostering their analytical and problem solving skills.


Synthesis Robot

Project ChBE5

Supervisor **Dr Yamin Zhang**
https://yaminzhang.group/

Self-Powered Bioelectronic Device for Medical Diagnosis & Treatment

This project proposes the development of a self-powered (bioresorbable battery), miniaturized device for closed-loop cardiac pacing, designed to be fully implantable through needle injection, thereby avoiding the complications associated with traditional open-heart surgery. Utilizing cutting-edge bioresorbable materials, this device is engineered to naturally degrade within the body, eliminating the need for surgical extraction. This technology aims to enhance patient safety and comfort, by reducing the risk of myocardial injury and infection.

Maximum no. of participants: **4**

Project Learning Outcomes
1. Understand the design principal of the device.
2. Be able to fabricate and test the device.

Nature of Project
Laboratory Investigation, Feasibility/Case Studies, Design

Relevant Majors
Biomedical Engineering, Chemical Engineering, Chemistry, Electrical Engineering, Materials Science

Name and Address of Lab that participants will be attached to
Electrochem-Bioelectronics Lab

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Have knowledge on fundamental chemistry or background in materials

Project ECE1

Supervisor **Prof Sam Ge Shuzhi**
https://cde.nus.edu.sg/ece/staff/ge-shuzhi-sam/

Dynamic and Control of Mechanical System in Offshore Engineering

Offshore engineering is concerned with the design and operation of systems in harsh environment conditions. It is one of the most challenging tasks in offshore engineering. The modeling and control of such system have received increasing attention in recent years with growing energy demands extending oil and gas explorations. Offshore applications are characterized by the timevarying environmental disturbances and the sea conditions. For riser systems, vibration and deformation of the flexible structures due to the ocean current disturbances and the tension exerted at the top can produce premature fatigue problems and failures that require costly repairs. Proper control techniques are desirable for preventing damage and improving the lifespan of the structure. The problems and the proposed solutions will be of interest to the offshore engineering community, to the academic control community, and to who may be able to make even further contributions in wide range of industrial and control area.

Maximum no. of participants: **2**

Nature of Project
Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Engineering, Computing

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Python, Matlab, Control Science

Project Learning Outcomes
1. Theoretical exploration on dynamics of marine mechanical system
2. Developing advance strategies for control design of systems with guaranteed stability
3. The control design are coupled with numerical simulations to illustrate the effectiveness

Name and Address of Lab that participants will be attached to
Control and Simulation Lab
E4A-03-04, 3 Engineering Drive 3, Singapore 117582

Project ECE2

Supervisor **Prof Sam Ge Shuzhi**
https://cde.nus.edu.sg/ece/staff/ge-shuzhi-sam/

Develop digital twin of interacting systems in complex sea scenarios

In offshore operations such as FLNG offloading or rig installation, the environment envelopes are very conservative due to the high risks of explosions and environmental pollution. Operators are interested to enhance the productivity of the offshore assets through better understanding and predictability of the global performance of the coupled systems, predictability of operations and active control strategies.

In this project, students are expected to design and develop digital-twin for Offshore operations to achieve its controllability and predictability by working together with our group. During the project, students are expected to strengthen the abilities of self-motivated study, project planning , algorithm development, system integration, and academic writing.

Maximum no. of participants: **3**

Nature of Project
Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Engineering, Computing, Mathematics, Physics

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
1. Enjoy Programming and familiar unity, python
2. Enjoy Design and Development of Software or Hardware
3. Good at Math, Physics and writing and teamwork
4. Excellent learning and take challenges

Project Learning Outcomes
1. Describe the aspects of offshore robotics and technological solutions
2. Understand digital twin and apply to offshore engineering
3. Understand digital representation and marine robot motion

Name and Address of Lab that participants will be attached to
Control and Simulation Lab
E4A-03-04, 3 Engineering Drive 3, Singapore 117582

Project ECE3

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

Domain-specific Computing using Emerging Electronic Device Technologies

Future computing systems will require unprecedented levels of energy-efficiencies and can solve much more challenging problems that are beyond the capabilities of existing electronics. In this project, students will explore the mapping of challenging problems (e.g., MAX-CUT) to electronic devices that may be able to better model the atomic operations needed in algorithms to solve those problems. Students will attempt to prove their ideas using simulations and evaluate the designs.

Maximum no. of participants: **4**

Project Learning Outcomes
1. Map a computational problem to an electronic device technology
2. Demonstrate and evaluate their proof-of-concept using simulations

Nature of Project
Computing and Analysis, Design

Relevant Majors
Applied Mathematics, Applied Physics, Electrical Engineering, Computer Engineering, Electronics Engineering

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity with Python and MATLAB
Good to know the Finite Element Method and COMSOL but not required

Project ECE4

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

Memory-centric Data Processing Hardware

Future Cognitive Internet of Things will deploy data-intensive machine learning and artificial intelligence algorithms on edge devices for various applications. However, the hardware architecture needs to be designed to drastically reduce the energy consumption and meet the unique energy requirements for edge devices. Memory-centric microarchitectures have emerged as a promising solution. In this project, students will be involved in the design of a memory-centric microarchitecture based on non-volatile memory devices (e.g. ferroelectric RAM, ReRAM, STT MRAM and SOT MRAM).

Maximum no. of participants: **4**

Project Learning Outcomes
1. Be able to simulate a memory-centric microarchitecture
2. Identify key design problems in the microarchitecture

Nature of Project
Computing and Analysis, Design

Relevant Majors
Electrical Engineering, Computer Engineering, Electronics Engineering

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Knowledge of Python and MATLAB
Familiarity with concepts of memory subsystems

Project ECE5

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

Non-volatile ferroelectric transistor memory

Non-volatile ferroelectric memory is a promising technology for future non-volatile memories. In this project, we will be exploring the design of the non-volatile ferroelectric transistor using simulations. Students will work with Python libraries and COMSOL to work with the simulation tools, benchmarks and test suites. The simulation tools will also be calibrated to experimental measurements from collaborators or in the literature.

Maximum no. of participants: **2**

Nature of Project
Computing and Analysis, Software Development

Relevant Majors
Applied Mathematics, Applied Physics, Electrical Engineering, Computer Engineering, Electronics Engineering, Materials Science

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity with Python
Good to know the Finite Element Method and COMSOL but not required

Project Learning Outcomes
1. Create a test suite to test their simulation programs
2. Calibrate the simulation programs to experimentally measured device characterization data
3. Perform an analysis of the non-volatile ferroelectric transistor

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

Project ECE6

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

Non-volatile Mem-ristive Memories

Non-volatile mem-ristive memory devices exhibit stochastic behavior that increases the complexity of models and analysis methodologies that are needed for design. In this project, we will be exploring the Fokker-Planck based simulation framework to study emerging mem-resistive memories. Students will work with Python libraries and COMSOL to work with the simulation tools, benchmarks and test suites. The simulation tools will also be calibrated to experimental measurements from collaborators or in the literature.

Maximum no. of participants: **3**

Nature of Project
Computing and Analysis, Software Development

Relevant Majors
Applied Mathematics, Applied Physics, Electrical Engineering, Computer Engineering, Electronics Engineering, Materials Science

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity with Python
Good to know the Finite Element Method and COMSOL but not required

Project Learning Outcomes
1. Create a test suite to test their simulation programs
2. Calibrate the simulation programs to experimentally measured device characterization data
3. Analyse one novel device concept using the developed simulation framework

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

Project ECE7

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

Machine Learning Applied to Intelligent Farming

Climate change will severely impact the global land availability for agricultural activities. High tech farming techniques may provide a solution that is labor and cost efficient. In this project, students will explore the application of machine learning techniques for diagnostic activities on an aquaponics system. One aspect of the project is to explore the generalizability of machine learning models, where publicly available datasets are used for training models, which are then deployed in an aquaponics system. Students will then address the generalizability issues by developing novel solutions.

Maximum no. of participants: **2**

Project Learning Outcomes
Students will learn to apply machine learning concepts on an engineering project, and create software tools that can be applied.

Nature of Project
Computing and Analysis, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Applied Mathematics, Computer Engineering, Computer Science, Computing, Electrical Engineering, Biology

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity with Python and at least one machine learning framework (e.g., PyTorch, Tensorflow)

Project ECE8

Supervisor **Dr Kelvin Fong Xuanyao**
https://blog.nus.edu.sg/seeder

AIoT for Aquaponics

Climate change will severely impact the amount of land available for agricultural activities. High tech farming can be a promising solution to transform the agricultural industry. Artificial Intelligence Internet of Things (AIoT) is a potential pathway towards improving the labor and cost efficiency for future high tech farming. In this project, students will leverage existing tools/software/hardware to implement AIoT solutions for an aquaponics system. They will work with a local startup to conduct research on prototypes of AIoT solutions for an aquaponics system.

Maximum no. of participants: **4**

Project Learning Outcomes
Students will learning about aquaponics and IoT for aquaponics. The project will also provide participants with experience working on an engineering project.

Nature of Project
Design, Feasibility/Case Studies, Product Development, Software Development, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Biology, Computer Engineering, Computing, Electrical Engineering, Engineering Science, Environmental Engineering, Robotics

Name and Address of Lab that participants will be attached to
Computational Nanoelectronics & Nanodevices Lab
E4-07-12, 4 Engineering Drive 3, Singapore 117583

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Experience working with Arduino or Raspberry Pi will be a plus.

Project ECE9

Supervisor **Prof Aaron Thean**
https://sites.google.com/atresearchgroup.net/at-research-group/about-us

AI Chips that rewire themselves

We are working on new semiconductor device technologies that may allow chips to learn and reconfigure themselves. The devices are oxide-based semiconductors with ferroelectric memory that can be integrated into the interconnect wirings of advanced chips. Here, in this project, we would like to explore the design and integration of circuit components for novel neural network on 3D chip applications. Interested students will have a choice to work on the system design, circuit design, or material development/integration.

Maximum no. of participants: **5**

Nature of Project
Laboratory Investigation

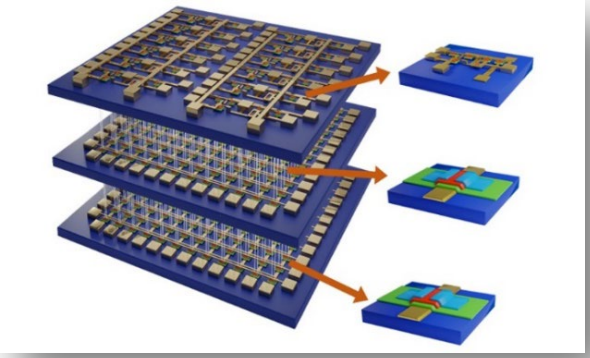
Relevant Majors
Electrical Engineering, Materials Science

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Basic semiconductor device theory and processing.
Basic electronic circuit concept.

Project Learning Outcomes
1. Student to learn basics of semiconductor processes
2. Student to learn the basics of AI chip architecture
3. Student to learn about memory device material

Name and Address of Lab that participants will be attached to
E6Nanofab
E6-05-03, 5 Engineering Drive 1 Singapore 117608



Project EDIC1

Supervisor **Dr Tang Kok Zuea**
https://cde.nus.edu.sg/edic/staff/tang-kok-zuea/

Development of an Edge-AI Virtual Reality System

This project aims to develop an algorithm for visual field testing to be performed on a virtual reality (VR) wearable device. Visual field testing remains the most important investigation for the diagnosis and monitoring of various eye conditions, like glaucoma, a leading cause of blindness worldwide and in Singapore. The current method of visual field testing requires the patient to sit in front of a large, expensive machine in a darkened room, and pressing a button each time light of varying intensity is presented at different points of his visual field. This test is time-consuming, frequently performed unreliably, lacks real time feedback to the patient on test performance, and occupies too much space on precious hospital real-estate. The developed VR visual field test will be relatively inexpensive, easier to perform, produce more reliable results (in part through provision of real-time feedback on test performance) as compared to current methods. Patients will also be able to perform these tests at their own time in the comfort and familiarity of their own homes, reducing unnecessary waiting times in the hospital, and freeing up precious space within hospital grounds for other patient care activities. Ultimately, it is envisaged that this project will translate into more accurate and timely detection of eye diseases and their progressions, thus reducing the incidence of more serious and irreversible conditions. This project involves software development.

Maximum no. of participants: **4**

Nature of Project
Software Development, Design, Product Development

Relevant Majors
Electrical and Computer Engineering, Mechanical and Product Development Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Understand and appreciate the various components in an Edge-AI VR system
2. Develop skills and experience related to using Unity for App development
3. Develop skills and experience related to developing an edge computing board
4. Proof-of-concept development for the integrating the various components in the proposed approach

Name and Address of Lab that participants will be attached to
Engineering Design and Innovation Centre (EDIC)
E2A, #04-05, 5 Engineering Drive 2, Singapore 117579

Project EDIC2

Supervisor **Dr Tang Kok Zuea**
https://cde.nus.edu.sg/edic/staff/tang-kok-zuea/

Intelligent Surgical Tool Checker using Vision Based and AI Based Methods

An article in the Outpatient Surgery magazine has written that an instrument processing department in the US has to process 900 trays of instrument per day. Due to this high volume of surgical tools, hospitals are facing a challenge of reducing the number of missing tools in their inventory as well as incomplete surgical sets in operation theatre. The problem also lies on the close similarities between 2 different tools, which are difficult to be noticed by a human's naked eye. Hence, this project aims to develop an intelligent system to reduce the number of human errors occurred in the hospital using vision based methods and artificial intelligence (AI). The scanner should be able to identify the tool placed on the platform and tally it with the reference toolset. As such, if there is any missing or wrong tool placed on the platform, the software will be able to warn the user about the error before the tool set is being out processed which in turn reduce the occurrence of missing tools in their inventory as well as incomplete surgical sets in operation theatre.

With this innovation, it will benefit a large group of people such as the instrument processing department, surgeons and patients. Packaging staffs will be able to work in a less stressful environment and more efficiently without the use of count sheets. With the reduction of human errors, it will reduce the time wastage of the surgeons and the patients. Overall, the efficiency in every aspect will be improved with the success of this innovation.

Maximum no. of participants: **4**

Nature of Project
Software Development, Design

Relevant Majors
Electrical and Computer Engineering, Mechanical and Product Development Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Understand and appreciate the various components in an Vision based AI system
2. Develop skills and experience related to developing an image processing method for identifying surgical tools
3. Develop skills and experience related to developing a vision-based AI processing method for identifying surgical tool
4. Proof-of-concept development for the integrating the various components in the proposed approach

Name and Address of Lab that participants will be attached to
Engineering Design and Innovation Centre (EDIC)
E2A, #04-05, 5 Engineering Drive 2, Singapore 117579

Project EDIC3

Supervisor **Dr Tang Kok Zuea**
https://cde.nus.edu.sg/edic/staff/tang-kok-zuea/

Using Deep Learning for Environmental Monitoring

The detection of vehicles with excessive exhaust emissions is crucial for environmental monitoring and public health around the world. Emissions from vehicles contribute significantly to air pollution, which lead to various health problems and environmental deterioration. In densely populated areas like Singapore, managing and mitigating vehicle emissions is particularly important to the government. Singapore intentionally limits the number of cars able to be driven on roads to control the number of carbon emitting vehicles out there on Singapore streets. Objectives Automatic detection of vehicles with excessive exhaust can significantly aid in enforcing environmental regulations and climate goals. Pre-existent methods of monitoring, such as manual inspection or public reporting, are often inefficient, not scalable, and quite slow. For this system to eventually be implemented at the Singapore-Malaysian Border, one of the busiest borders in the world, the system's efficiency must improve and be as stable, robust, and fast as possible without sacrificing accuracy. Advanced machine learning models, specifically designed for object detection, offer a promising solution for smart environmental monitoring.

Maximum no. of participants: **4**

Nature of Project
Software Development, Design

Relevant Majors
Electrical and Computer Engineering, Mechanical and Product Development Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Understand and appreciate the architecture of a deep-learning system
2. Develop skills and experience related to developing an image processing method for identifying vehicles
3. Develop skills and experience related to developing a vision-based AI processing method for identifying smoke
4. Proof-of-concept development for the integrating the various components in the proposed approach

Name and Address of Lab that participants will be attached to
Engineering Design and Innovation Centre (EDIC)
E2A, #04-05, 5 Engineering Drive 2, Singapore 117579

Last Updated: 8 November 2024

Project EDIC4

Supervisor **Dr Tang Kok Zuea**
https://cde.nus.edu.sg/edic/staff/tang-kok-zuea/

Using AI for Integrating Autonomous Mobile Robots

The integration of autonomous mobile robots (AMRs) into industrial and logistical operations offers significant potential to streamline processes and boost efficiency. However, effective integration requires advanced artificial intelligence (AI) techniques to address challenges such as dynamic environments, complex tasks, and real-time decision-making. This project explores the application of AI in AMR integration, focusing on areas like perception, navigation, and human-robot interaction. By leveraging AI, AMRs can become more adaptable, collaborative, and intelligent, revolutionizing the future of automation. This project is focused on software-development aspects of the project, related to robots' navigation.

Maximum no. of participants: **4**

Nature of Project
Software Development, Design

Relevant Majors
Electrical and Computer Engineering, Mechanical and Product Development Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Understand and appreciate the various components in an Edge-AI electro-mechnical system
2. Develop skills and experience related to communicating with AMRs
3. Develop skills and experience related to developing an edge computing board
4. Proof-of-concept development for the integrating the various components in the proposed approach

Name and Address of Lab that participants will be attached to
Engineering Design and Innovation Centre (EDIC)
E2A, #04-05, 5 Engineering Drive 2, Singapore 117579

Project EDIC5

Supervisor **Dr Tang Kok Zuea**
https://cde.nus.edu.sg/edic/staff/tang-kok-zuea/

Using AI for Effective Waste Collection

Efficient waste collection is crucial for sustainable urban development. This project proposes an artificial intelligence (AI) driven approach to optimize the routes of recycling trucks in urban environments. By leveraging real-time data, we aim to minimize travel distance, reduce fuel consumption, and decrease carbon emissions. The proposed solution incorporates factors such as traffic conditions, pickup locations, and vehicle capacities to generate optimal routes. Through simulations, we would like to demonstrate the significant potential of this approach to improve the efficiency and environmental impact of waste collection operations.

Maximum no. of participants: **4**

Nature of Project
Software Development, Design

Relevant Majors
Electrical and Computer Engineering, Mechanical and Product Development Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Understand and appreciate the various components in optimisation method
2. Develop skills and experience related to developing an optimisation method using MatLab or Python Language
3. Develop skills and experience related to developing an edge computing board
4. Proof-of-concept development for the integrating the various components in the proposed approach

Name and Address of Lab that participants will be attached to
Engineering Design and Innovation Centre (EDIC)
E2A, #04-05, 5 Engineering Drive 2, Singapore 117579

Project EDIC6

Supervisor **Dr Yen Shih-Cheng**
https://tinyurl.com/y26rbm9o

Decoding the Brain

The brain is the most complex structure in the known universe. Understanding how the brain performs its magic has been identified as one of the Grand Challenges for Engineering in the 21st century. This project aims to investigate place cell activity in animals (a related topic won the Nobel Prize in Medicine in 2014). The idea is to first create a virtual reality environment that an animal can be trained to navigate. Once the animals are trained, we will be able to record from their brains, as well as their eye movements, while they navigate through the virtual environment. Students can contribute to 1) modifying and extending virtual environments created in Unity, and interfacing it with an eye-tracker to track eye movements when navigating in the virtual environment; 2) developing a high-throughput data processing pipeline that will make extensive use of High Performance Computing Clusters in the NUS Computer Center to analyze responses of individual neurons as well as population of neurons.

Maximum no. of participants: **2**

Project Learning Outcomes
Write Matlab/Python code to analyze data and visualize results or to add functionality to an existing virtual environment

Nature of Project
Computing and Analysis, Software Development

Relevant Majors
Computer Engineering, Electrical Engineering, Biomedical Engineering, Computer Science, Bioengineering, Neuroscience, Psychology

Name and Address of Lab that participants will be attached to
The N.1 Institute for Health
#05-COR, 28 Medical Drive, Singapore 117456

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Familiarity with Matlab/Python, data acquisition, signal processing, and statistics, or C# and Unity for virtual environment development.

Project ME1

Supervisor **A/Prof Loh Wai Lam**
https://cde.nus.edu.sg/me/staff/loh-wai-lam/

Multiphase Flow in Pipelines and Multiphase Equipment Development

In oil & gas production, a multiphase mixture of oil, water and gas flows through a pipeline for long distances. Due to differences in densities, viscosities, and other physical properties, various flow regimes, i.e. stratified, wavy, bubbly, slug, annular and dispersed flows, can develop as a result, depending on the superficial velocities of the fluids. Different flow regimes have different effects on the pressure drop, flow pattern, etc., and ultimately on the stability of the flow. Pipeline integrity can also potentially be compromised due to force loadings from some of the flow regimes. This project looks into multiphase flow and also into the development of equipment for the oil & gas industry.

Maximum no. of participants: **2**

Project Learning Outcomes
Students will have a better appreciation of multiphase flow in pipelines and an understanding of multiphase equipment used in oil and gas transportation.

Nature of Project
Laboratory Investigation, Computing and Analysis, Product Development, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Chemical Engineering, Mechanical Engineering, Process Engineering, Offshore Engineering

Name and Address of Lab that participants will be attached to
NUS Multiphase Oil-Water-Air Flow Loop Laboratory

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project ME2

Supervisor **Dr Sing Swee Leong**
https://cde.nus.edu.sg/me/staff/sing-swee-leong/

3D Printing Enabled Urban Farming

Urban farming has gained traction in recent years, especially for developed regions to attain self-sustainability. In this project, the feasibility of using 3D printing for design and fabrication of efficient structures for urban farming will be explored. The project aims to achieve high efficiency in urban farming via space saving and higher nutrient/water transport effectiveness.

Maximum no. of participants: **2**

Nature of Project
Laboratory Investigation, Product Development, Feasibility/Case Studies, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software), Design, Computing and Analysis

Relevant Majors
Mechanical Engineering, Civil Engineering, Materials Science, Biological Science, Bioengineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes. The designing of components can be done using open source or commonly used computer aided design (CAD) software. Analysis of performance of the designed components can also be done using numerical methods.

Any other information/requirements
Experience with computer aided design, flow analysis will be advantageous.

Project Learning Outcomes
1. Evaluate current methods in urban farming and study the design features
2. Design suitable structures for urban farming and their feasibility to be manufactured by additive manufacturing
3. Evaluate the efficiency of 3D printed structures for urban farming

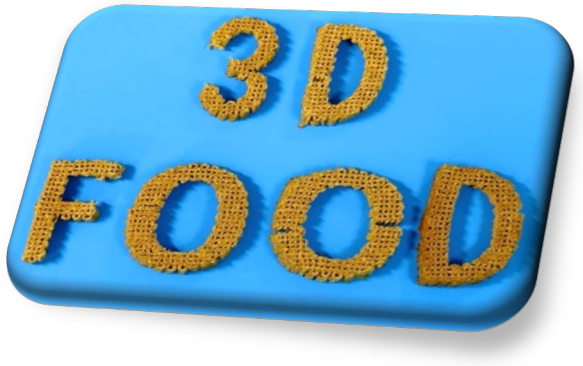
Name and Address of Lab that participants will be attached to
NUS Centre for Additive Manufacturing (AM.NUS)

Project ME3

Supervisor **Dr Sing Swee Leong**
https://cde.nus.edu.sg/me/staff/sing-swee-leong/

3D Food Printing for Sustainability

3D food printing provides the opportunity to create alternative food source using correct material combinations and print patterns that can mimic the texture of natural meat. In this project, the material combination chosen will be used to evaluation the feasibility of such technology in sustainable causes in terms of benchmarking the texture and appearance to conventional meat sources.



Maximum no. of participants: **2**

Nature of Project
Feasibility/Case Studies, Laboratory Investigation, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Materials Science, Mechanical Engineering, Chemistry, Applied Physics

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
NA

Project Learning Outcomes
1. Evaluate current development in 3D food printing
2. Study of suitable materials for 3D food printing using material extrusion technology
3. Evaluate the 3D food printing as alternative method of food production technology

Name and Address of Lab that participants will be attached to
NUS Centre for Additive Manufacturing (AM.NUS)

Project ME4

Supervisor **Dr Tan Yu Jun**
https://yujuntan.com/

Exploration of light-field-based control methods for light-driven robots

With the rise of light-driven materials such as liquid crystal elastomer (LCE), light fields are ready to produce actuation to the robot, which opened up a wide room of innovation, such as making robots as small as paramecia with remote control capability. However, current control methods for light-driven microrobots are mainly based on ON/OFF control of the light source, while other unique properties of the light field including direction, reflection, and polarization haven't been systematically utilized for robot control yet. Here, you are going to make smart use of these properties and figure out a new control strategy for light-driven robots to achieve better or novel functions. The content of the project includes (i) testing and mathematical modeling of the control method, and (ii) a robot demo to show the strength. Students with interests or skills in remote robot control, simulation, and smart materials are preferred.

To get more understanding of light-driven robots, you can refer to:
https://pubs.rsc.org/en/content/articlehtml/2020/cs/d0cs00363h
https://onlinelibrary.wiley.com/doi/full/10.1002/aisy.202000148

Maximum no. of participants: **2**

Project Learning Outcomes
1. Testing and mathematical modeling of a control method
2. Hands on skills to build a mini soft robot.

Nature of Project
Laboratory Investigation, Design

Relevant Majors
Mechanical Engineering

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02, 2 Engineering Drive 3, Singapore 117581

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
Students with interests or skills in remote robot control, simulation, and smart materials are preferred.

Project ME5

Supervisor **Dr Tan Yu Jun**
https://yujuntan.com/

From Kombucha Tea to sustainable wearable electronics

With each passing year, we blithely discard more and more electronic devices in the name of upgrading to better and more high-tech ones. The amount of global e-waste generation is estimated to be at 74 million metric tons by 2030 – which is equivalent to the weight of 247 empire state buildings! The main reason behind this is that our current electronic devices are fabricated using raw materials which are non-recyclable and non-biodegradable. To tackle this problem, scientists have successfully incorporated green materials such as cellulose into electronics and achieved great electrical properties. Cellulose is a naturally occurring biopolymer usually extracted from wood chips using a traditional process called "kraft pulping". Interestingly, cellulose can also be extracted from a simple process via fermentation of Kombucha tea. In this project, the student will learn how to extract cellulose from fermented Kombucha tea. He/she will then fabricate a flexible wearable electronic device using the extracted cellulose. Student will be challenged to program the electronic device to perform various tasks such as wireless communication.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Extraction of cellulose from Kombucha tea
2. Fabrication of a sustainable wearable electronic device
3. Programming of a sustainable wearable electronic device

Nature of Project
Laboratory Investigation

Relevant Majors
Materials Science, Mechanical Engineering

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02, 2 Engineering Drive 3, Singapore 117581

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
1. Feels strongly for a more sustainable future
2. Prior undergraduate research experience
3. Strong interest in electronics and material science
4. Prior programming experience (Arduino, Python, or relevant programming languages)

Project ME6

Supervisor **Dr Tan Yu Jun**
https://yujuntan.com/

Fabrication of a self-healing optoelectronic device

Cellulose is the most abundant naturally occurring polysaccharide which has been lauded for excellent properties like mechanical robustness, biodegradability, and biocompatibility. It has widespread use in various fields like nanotechnology, food industry, and biomedical industry but has recently found its way to the electronic industry. The main reason is because cellulose is a sustainable substitute to the raw materials used to fabricate electronical devices. Our group has synthesised a fully bio-derived material from cellulose that exhibits good physical properties and self-healing ability. In this project, the student will be fabricating an optoelectronic device using the material our group has created. He/she will then program the device to transmit light of various wavelengths.

Maximum no. of participants: **1**

Project Learning Outcomes
1. Fabrication of a sustainable optoelectronic device
2. Programming of a sustainable optoelectronic device

Nature of Project
Laboratory Investigation

Relevant Majors
Materials Science, Mechanical Engineering

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02, 2 Engineering Drive 3, Singapore 117581

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
1. Feels strongly for a more sustainable future
2. Prior undergraduate research experience is preferred
3. Strong interest in electronics and material science
4. Prior programming experience (Arduino, Python, or relevant programming languages)

Project ME7

Supervisor **Dr Tan Yu Jun**
https://yujuntan.com/

Fabrication of a Flexible, Self-healing Material for Electronics

Conventional stiff electronics generally have rigid architecture and lack the capacity for editability into desirable shapes. Therefore, it is essential and critical to develop the next generation of flexible and self-healable electronics with elastic-recovery properties. Inspired by injury organisms that can be automatically healed wounds, the self-healing function groups were introduced into the materials system to achieve high stretchability, even after damage. Besides, in order to transmit optoelectronic information, imparting the healable ability to light-emitting devices are stretch, bend and twist that can be integrated into human-machine interfaces for next-generation wearable electronics, clothing and electronic skin. Compared to conventional light-emitting devices, such device structures have advantages in flexibility, resistance to atmospheric environments and mass production, which can effectively enhance their reliability.

In this project, we will develop a self-healing material that can quickly and effectively repair the crack or damage for light-emitting devices. Specifically, the dynamic crosslinking sites in self-healing materials can be formed to stabilize the electronics from damage or disruption during ion diffusion processes. Thus, we provide a convenient and efficient approach for electronics by utilizing the self-healing property of materials.

Maximum no. of participants: **1**

Nature of Project
Laboratory Investigation

Relevant Majors
Materials Science

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Project Learning Outcomes
At the end of the program, it is expected that students can familiarize themselves with equipment in the area of materials chemistry.
Additionally, they can develop their potential in learning materials synthesis and investigating the structure and reactivity of self-healing materials.
Finally, students can independently integrate key concepts regarding the functional materials for electronics in the process of exploring self-healing mechanisms.

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02, 2 Engineering Drive 3, Singapore 117581

Any other information/requirements
This project requires students who have strong interests and foundation in material chemistry and material science. They also need to read literatures about mechanism involving with stretchable, and self-healing polymers crosslinked by dynamic bonds before materials fabrication.
Paper studies for references are as follows:

1. Tan YJ, Susanto GJ, Anwar Ali HP, Benjamin Tee CK. Progress and Roadmap for Intelligent Self-healing Materials in Autonomous Robotics. Adv. Mater. 2020; 2002800.
2. Tan YJ, Godaba H, Chen G, Tan MST, Li G, Lee PM, Cai Y, Li S, Shepherd RF, Ho JS, Benjamin Tee CK. A Transparent, Selfhealing and High-κ Dielectric for Low-field-emission Stretchable Optoelectronics. Nat. Mater. 2020; 19: 182–188.

Project ME8

Supervisor **Dr Guillaume Sartoretti**
http://marmotlab.org/

Control of a Hexapod Robot for Visual Tasks

Articulated legged robots, such as quadrupeds or hexapods, have the ability to locomote over a wide variety of uneven terrains where wheeled robots would naturally struggle, such as rock piles or rough inclines. Combining such advanced robots with onboard sensors, such as cameras/LiDARs, can increase their autonomy levels and allow complex deployments in hazardous or human-denied environments. In particular, this project will be centered around the problem of coordinating the usually large number of degrees of freedoms (DoF, actuators/motors) for these complex robots. You (the student) will first get familiar with our simulation environment and code base. Using these tools, you will devise and test your own locomotion controllers, based on different state-of-theart methods (such as Central Pattern Generators, CPGs) to allow the robot to move and integrate visual feedback from an onboard camera (e.g., for target tracking, obstacle avoidance, or gait adaptation). If successful and safe, you could then implement these controllers on a physical hexapod robot, and/or in a high-fidelity physics simulator otherwise.

Maximum no. of participants: **3**

Nature of Project
Laboratory Investigation, Software Development, Computing and Analysis

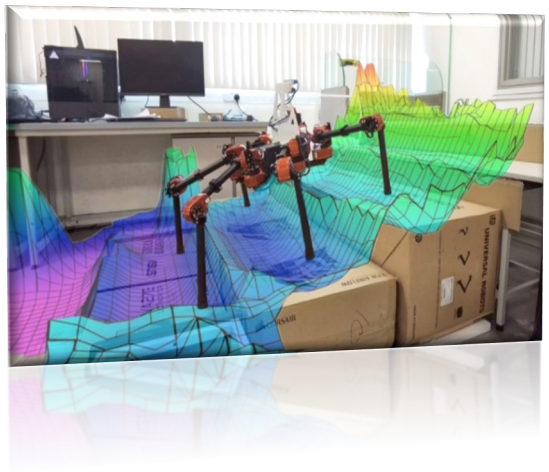
Relevant Majors
Computer Science, Robotics, Mechanical Engineering, Electrical Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Python3 (or at least Matlab) programming skills required
ROS/other simulation experience preferred
Strong mathematical background
Enthusiasm and passion for (legged) robots

Project Learning Outcomes
1. Demonstrate their simple locomotion controller in simulation
2. Develop a new hexapod locomotion controller for a visual locomotive task of their choosing
3. If possible, validate their controller on our hexapod robot

Name and Address of Lab that participants will be attached to
Control and Mechatronics Lab
E2-01-05, 9 Engineering Drive 1, Singapore 117575



Last Updated: 8 November 2024

Project ME9

Supervisor **Dr Guillaume Sartoretti**
http://marmotlab.org/

Reinforcement Learning-Based Decentralized Multi-Agent Pathfinding

Given the rapid development of affordable robots with embedded sensing and computation capabilities, we are quickly approaching a point at which manufacturing applications will involve the deployment of hundreds, if not thousands, of robots. To support these applications, significant research effort has been devoted to multi-agent path finding (MAPF), to support deployments in distribution centers, potential use for airplane taxiing and test applications to multi-agent search and rescue.

However, as the number of agents in the system grows, so does the combinatorial complexity of coordinating them. Current state-of-the-art optimal planners can plan for up to several hundreds of agents, and the community is now settling for suboptimal planners as a potential solution for even larger multi-agent systems. In this work, we will focus on pushing the state-of-the-art in reinforcement learning based MAPF (e.g., PRIMAL/PRIMAL2), to improve performance, decrease training times, and simplify implementation on real robots.

Maximum no. of participants: **2**

Nature of Project
Computing and Analysis, Software Development

Relevant Majors
Computer Science, Electrical Engineering, Mechanical Engineering, Robotics

Project Learning Outcomes
1. Get familiar with existing RL-based MAPF techniques and code base.
2. Help the team formalize and implement one of our existing concepts to improve decentralized MAPF solvers, and test its performance against some baselines in simulation, toward hardware implementation.

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Name and Address of Lab that participants will be attached to
Control and Mechatronics Lab
E2-01-05, 9 Engineering Drive 1, Singapore 117575

Any other information/requirements
Python3 programming required, and experience with tensorflow/pytorch very much preferred
Familiarity with GNU/Linux and command line interface
Enthusiasm and passion for multi-robot systems and coordination

Last Updated: 8 November 2024

Project ME10

Supervisor **Dr Guillaume Sartoretti**
http://marmotlab.org/

Decentralized Traffic Signal Control for Urban Mobility

Recent advances in robotics, artificial intelligence and sensing are bringing us closer to the systematic replacement of most human-driven cars by autonomous driving vehicles. However, intelligent cars will require novel intelligent traffic coordination methods, likely on the side of the infrastructure (e.g., traffic signals such as traffic lights at road junctions). Centralized approaches to traffic management are infeasible, in cities that will likely count thousands to millions of vehicles and junctions, and decentralization will be necessary. In this project, you (the student) will develop novel methods to control the traffic signals at each junction, based on that junction's traffic conditions (number and speed of incoming vehicles, queue lengths, etc.) as well as the conditions of neighboring junctions. After studying a textbook case involving a simple 4-way junction, we will look to scaling up the size of the network and consider such decentralized traffic monitoring and optimization at larger-scales in the city. We might also consider more complex cases such as vehicle breakdowns/accidents, green waves, etc. This project will be simulation-based (using an open-source traffic simulator such as SUMO).

Maximum no. of participants: **2**

Nature of Project
Computing and Analysis, Software Development

Relevant Majors
Computer Science, Electrical Engineering, Mechanical Engineering, Robotics

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes

Any other information/requirements
Python3 programming required
Familiarity with GNU/Linux and command line interface
Enthusiasm and passion for traffic optimization

Project Learning Outcomes
1. Develop a simple simulation (in SUMO) of a 4-way junction, using a state-of-the-art traffic signal controller of the student's choosing.
2. Investigate a larger-scale scenario involving many such junctions, representing a larger portion of an urban road network, for which a more advanced traffic signal controller will be devised.

Name and Address of Lab that participants will be attached to
Control and Mechatronics Lab
E2-01-05, 9 Engineering Drive 1, Singapore 117575

Last Updated: 8 November 2024

Project ME11

Supervisor **Dr Guillaume Sartoretti**
http://marmotlab.org/

Visibility-Based Mobile Target Localization and Tracking with Robots

Given the rapid development of affordable robots with embedded sensing and mobility, autonomous mobile robots may soon be able to replace humans in a variety of hazardous and repetitive tasks. Recently, much research effort has been devoted to pursuit-evasion problems, where mobile robots with limited sensing capabilities need to localize an evasive target and track/capture it. In this project, we will focus on the localization of a mobile target by an autonomous flying robot equipped with an onboard camera. The robot will reactively track the agile target that might try to escape from the pursuit of robots (e.g., TurtleBot) thereafter. This research will be carried out in simulation, but a hardware demo can be investigated if the student(s) progress(es) fast.

Maximum no. of participants: **2**

Nature of Project
Laboratory Investigation, Software Development, Computing and Analysis, Field Testing and Instrumentation

Relevant Majors
Computer Science, Robotics, Mechanical Engineering, Electrical Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
Yes. Note: Project can be conducted virtually as he experimental portion of this project can be removed in favor of more simulation work. The robot can be operated in ROS-based simulator.

Any other information/requirements
Python3 or C++ programming required, and experience with ROS/other simulation very much preferred
Enthusiasm and passion for mobile robots

Project Learning Outcomes
1. Get familiar with existing object tracking techniques.
2. Demonstrate the localization and tracking controller in simulation or real robot.

Name and Address of Lab that participants will be attached to
Control and Mechatronics Lab
E2-01-05, 9 Engineering Drive 1, Singapore 117575

Last Updated: 8 November 2024

Project ME12

Supervisor **Dr Tan Xipeng**
https://cde.nus.edu.sg/me/staff/tan-xipeng/

4D metal printing

Nickel-titanium has shown to be the most attractive shape memory alloy with many potential applications due to its outstanding capability of recovering the original shape upon heating or upon removal of the applied stress. Therefore, they can be used for biomedical and aerospace components, such as coronary stents, artificial muscle, and actuators. This project aims to design and 3D print nickel-titanium parts with shape memory properties, namely the so-called "4D printing".

Maximum no. of participants: **2**

Nature of Project
Design, Laboratory Investigation

Relevant Majors
Mechanical Engineering, Materials Science

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA

Project Learning Outcomes
1. Learn about shape memory alloys and their properties
2. Learn about metal 3D printing techniques
3. Understand how to realise 4D metal printing

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02/03, 2 Engineering Drive 3, Singapore 117581

Project ME13

Supervisor **Dr Tan Xipeng**
https://cde.nus.edu.sg/me/staff/tan-xipeng/

High-throughput design and fabrication of soft magnetic materials

Soft magnetic materials are those materials that are easily magnetised and demagnetised. The demand for next-generation, high-performance soft magnetic materials has tremendously risen in the context of sustainable and electrified world. Electrical machine design is facing challenges in terms of power densities and conversion efficiencies, thereby motivating the exploration of advanced materials and manufacturing for the future robust and ultraefficient electrical machines. The objective of this project is to explore the high-throughput design methods for discovering and developing high-performance soft magnetic materials. Advanced manufacturing technologies such as high-purity arc melting and 3D printing will be used for materials fabrication.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Learn about soft magnetic materials.
2. Learn about high-throughput materials design.
3. Gain hands-on experience in advanced materials manufacturing techniques.

Nature of Project
Design, Laboratory Investigation

Relevant Majors
Materials Science, Process Engineering

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02/03, 2 Engineering Drive 3, Singapore 117581

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA

Project ME14

Supervisor **Dr Tan Xipeng**
https://cde.nus.edu.sg/me/staff/tan-xipeng/

Improving tribological properties of 3D-printed biomedical alloys

Tribology is the science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear. Outstanding wear properties of biomedical alloys are highly sought-after particularly for orthopaedic applications. This project aims to study the wear properties of several biomedical alloys fabricated by additive manufacturing. Microstructure engineering solutions will be explored to improve wear properties.

Maximum no. of participants: **2**

Nature of Project
Laboratory Investigation, Hybrid (e.g., mixture of experiment & theoretical, or experimental and numerical/software)

Relevant Majors
Biomedical Engineering, Mechanical Engineering

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA

Project Learning Outcomes
1. Understand the importance of tribological properties in biomedical engineering
2. Hands-on experience of running tribometer and interpreting wear data

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02/03, 2 Engineering Drive 3, Singapore 117581

Project ME15

Supervisor **Dr Tan Xipeng**
https://cde.nus.edu.sg/me/staff/tan-xipeng/

3D printing of high-performance alloys via direct ink writing

Direct Ink Writing (DIW) of high-performance alloys is an additive manufacturing technique that uses a paste-like ink made of alloy powders mixed with a binder to create complex, customized structures. This technique allows for the precise deposition of material layer by layer through a nozzle, enabling intricate geometries and fine feature control. DIW is particularly advantageous for high-performance alloys, as it maintains the material's properties by reducing the need for high temperatures during fabrication. Once printed, the part undergoes sintering to enhance strength and density. DIW's flexibility and low material waste make it ideal for applications in aerospace, energy, and biomedical fields.

Maximum no. of participants: **2**

Project Learning Outcomes
1. Understand the advantages of direct ink writing in meta alloy fabrication
2. Hands-on experience in DIW 3D printing and post processing

Nature of Project
Design, Laboratory Investigation

Relevant Majors
Biomedical Engineering, Materials Science, Process Engineering;

Name and Address of Lab that participants will be attached to
Materials Lab
E3-04-01/02/03, 2 Engineering Drive 3, Singapore 117581

If the summer program needs to be suspended physically (e.g., due to COVID 19), can the project be offered and conducted virtually?
No

Any other information/requirements
NA