ECE/NUSRI 3+1+1 Educational Framework
FYP Proposal ID: SP01

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Magnetic signature of electric motor for the detection of flux saturation at stator
Summary (200 – 400 words)	Electric motor drive becomes the important element in the electric vehicle. The motor drive is to deliver torque according to the requirement. However, the large current for a stronger flux may cause saturation of the stator, which will reduce efficiency, increase the temperature and cause electric faults. This project aims to use the high-sensitivity magnetic sensors to fetch the flux information around the electric motor, and to detect the flux saturation. The developed system will also be able to pin-point the exact location of stator flux saturation. The project scope includes: (1) Literature review of using magnetic sensor to obtain magnetic signature; (2) hardware study using microcontroller to process captured data and for software processing; (3) Study of simulation software for motor flux computation; (4) Integration of hardware and software for the final system. Students are expected to develop the following skills (**learning outcome**): • To understand magnetic sensor and hardware design process. • To be familiar with hardware and software integration. • To be skilled at microprocessor programming. • To be skilled at software data analysis. The achievable outcomes by the FYP students are: (1) To design a magnetic sensor system to acquire the flux signature of a motor. (2) To process the data and form the signature plane. (3) To detect the change in flux saturation and locate the exact position. Interaction with Prof. Wang of ETS will be made via zoom meetings. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	YC Liang and Charlie Wang (ETS, Canada)
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Final functional system with complete hardware and software, demonstration of the system capability.

FYP Proposal ID: SP02

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of a smart cushion system for sitting posture recognition
Summary (200 – 400 words)	With the continuous improvement on the life quality of human being over the past decades, there is a significant surge of health awareness worldwide. With recent developments in medical and health sciences and the accessibility of information about health, more and more people are aware of the importance of good activities in keeping personal well-being such as through the adoption of healthy dietary choices and exercising. This project aims to develop a smart cushion system which is able to achieve real-time sitting posture recognition and prolonged sitting monitoring. The system will be integrated with pressure sensors and sensor array to sense the different pressure distribution with different seating postures. The data collected will be sent to the sensing circuit and PC/smartphone for further data processing and analysis. Machine learning algorithms will be used to recognize the sitting posture recognition. The project scope includes: (1) Literature review on the sensors and functions for the smart cushions. (2) Hardware study using microprocessor to process captured data, sensors to detect sitting posture, wireless communication for data record and storage; Software study with data analysis and machine learning algorithms; (3) Integration of hardware and software for the smart cushion for sitting posture recognition. Students are expected to develop the following skills (**learning outcome**): • To understand basic knowledge of different types of sensors and semiconductor devices; • To be familiar with hardware and circuit design; • To be skilled at microprocessor programming and ML algorithms; • To be familiar with hardware and software integration. The achievable outcomes by the FYP students are: (1) To design and implement pressure sensors/array integrated into the smart cushion for sitting posture recognition; (2) To improve the device and system design based on user testing. **Prior experience of software and hardware implementation is a must.**
Supervisor	Zhu Chunxiang
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Integration of smart cushion with hardware and software systems for sitting posture recognition

Proposal ID: SP03

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of 3D printed sensors for measuring fingertip forces
Summary (200 – 400 words)	The examination of pressure distribution maps on fingers is a useful tool in stroke rehabilitation and upper limb function research that helps doctors diagnose problems of the balance system. In this project, we aim to first fabricate capacitive pressure sensors using 3D printing technology and then to develop a system using the 3D printed pressure sensor to measure the interaction force between fingertip and external environment. In doing so, a system consisting of sensors, actuators, microprocessor, advanced communication technologies will be required. The 3D printed pressure sensors will be used to measure the forces between the fingertip and external object, the data collected will be sent to sensing circuit and PC/smartphone for further data processing and data analysis. The project scope includes: (1) Literature review on the sensors and functions for 3D printed sensors and especially for capacitive pressure sensors; (2) Hardware study using microprocessor to process captured data, sensors to detect forces/prssures, wireless communication for data record and storage; (3) Software study with data analysis and ML algorithms; (4) Integration of hardware and software for 3D printed sensor system for measuring interaction forces on fingertips. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of different types of sensors and semiconductor devices; (2) To be familiar with hardware and circuit design; (3) To be skilled at microprocessor programming and ML algorithms; (4) To be familiar with hardware and software integration. The achievable outcomes by the FYP students are: (1) To design and implement 3D printed pressure sensors for measuring interaction forces of fingertips on external environment; (2) To improve the device and system design based on user testing. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhu Chunxiang
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Integration of system consisting of 3D printed pressure sensors for measuring the interaction forces between the fingertip and environment

FYP Proposal ID: SP04

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of a smart walking stick system for the elderly
Summary (200 – 400 words)	With the continuous improvement on the life quality of human being over the past decades, there is a significant aging issue worldwide. This imposes significant demands in public healthcare, in particular huge demands for the cost-effective health monitoring systems. The system should be affordable, smart and easy for the elderly to use. A typical health-care monitoring system usually consists of sensors, actuators, microprocessor, advanced communication technologies and provides the elderly the opportunity to live on his/her own instead of in expensive health-care facilities. These systems will monitor the physiological signs of the elderly people in real time, help assess their health-conditions and will send the feedback to the doctors if necessary. This project aims to develop a smart walking stick integrated with various sensors to monitor the physiological signals like heart rate and others. The project scope includes: (1) Literature review on the sensors and functions for the elderly, especially on smart walking stick for the elderly; (2) Hardware study using microprocessor to process captured data, sensors to detect physiological signals during walking, wireless communication for data record and storage; (3) Software study with data analysis; (4) Integration of hardware and software for smart walking stick for the elderly. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of different types of sensors and semiconductor devices; (2) To be familiar with hardware and circuit design; (3) To be skilled at microprocessor programming; (4) To be familiar with hardware and software integration. The achievable outcomes by the FYP students are: (1) To design and implement different types of sensors integrated into the smart stick for health care monitoring during walking; (2) To improve the device and system design based on user testing. **Prior experience of software and hardware implementation is a must.**
Supervisor	Zhu Chunxiang
Laboratory Work	Bench-top instruments
N0. of students	2
CA1	Preliminary prototype with hardware and software development
CA2	Integration of smart stick for the elderly with hardware and software systems

FYP Proposal ID: SP05

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of a smart walking stick for the blind
Summary (200 – 400 words)	With the continuous improvement on the technology, the life quality of human being has been improved over the past decades, in particularly for the disabled. For those who are blind or visual impaired, they are often facing difficulties in their daily life. A system, which can detect obstacles/stairs, waters/oils on the roads, etc., will greatly help them walking safely. Such a system typically consists of sensors, actuators, microprocessor, advanced communication technologies. These systems will monitor the surroundings in real time, assess the signals and send alerts to the blind in real-time when necessary. This project aims to develop a smart walking stick system integrated with various sensors to monitor the surroundings such as obstacles/stairs, waters/oils on the roads etc. The data collected will be assessed and the blind will be alerted in real-time when necessary. The project scope includes: (1) Literature review on smart sensing systems, especially on smart walking stick for the blind; (2) Hardware study using microprocessor to process captured data, sensors to detect surroundings during walking, wireless communication for data record and storage; (3) Software study with data analysis and ML algorithms; (4) Integration of hardware and software for smart walking stick for the blind. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of different types of sensors and semiconductor devices; (2) To be familiar with hardware and circuit design; (3) To be skilled at microprocessor programming; (4) To be familiar with hardware and software integration. The achievable outcomes by the FYP students are: (1) To design and implement different types of sensors integrated into the smart stick for the blind; (2) To improve the device and system design based on user testing. **Prior experience of software and hardware implementation is a must.**
Supervisor	Zhu Chunxiang
Laboratory	Bench-top instruments
N0. of students	2
CA1	Preliminary prototype with hardware and software development
CA2	Integration of smart walking stick for the blind with hardware and software systems

FYP Proposal ID: SP06

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Simulation and design of enhancement mode Ga_2O_3 MOSFET with trench gate
Summary (200 – 400 words)	Over the past decade, b-phase gallium oxide (β- Ga_2O_3) has received extensive research as one of candidates for next generation ultra-wide bandgap semiconductors for power device applications due to its high breakdown field of 8 MV/cm and large Baliga's figure of merit (BFOM). However, the lack of p-type doping makes it hard to implement conventional enhancement mode n-channel MOSFETs. In this proposal, we aim to simulate and design an enhancement-mode Ga_2O_3 MOSFETs using trench gate. The simulation will be carried out using TCAD software. Various device and structure parameters such as trench gate depth, channel doping concentration, and drift layer doping concentration and thickness will be investigated to understand their influences on MOSFET performance including the on/off current ratio, on-current density, specific on-resistance, and breakdown voltage. Finally, an optimized enhancement-mode Ga_2O_3 MOSFET will be designed to achieve a higher breakdown voltage and a lower on-specific resistance. The project scope includes: (1) Literature review of power devices and Ga_2O_3 power MOSFETs; (2) Modeling and simulation of conventional Ga_2O_3 MOSFETs using TCAD software; (3) Modeling and simulation of enhancement mode Ga2O3 MOSFETs with trench gate; (4) Design and optimization of the device performance by varying different design parameters. Students are expected to develop the following skills (**learning outcome**): (1) To develop a good knowledge on semiconductor physics; (2) To be familiar with semiconductor device fundamentals and in particular Ga_2O_3 power semiconductor devices; (3) To be skilled at TCAD simulation. The achievable outcomes by the FYP students are: (1) To complete modeling and simulation of Ga_2O_3 MOSFETs with trench gate; (2) To vary different device parameters and understand their influences on device performance; (3) To complete the design and simulation of enhancement mode Ga_2O_3 MOSFETs with trench gate. **Prior knowledge of basic semiconductor physics is a must.**
Supervisor	Zhu Chunxiang
Laboratory Work	TCAD software
N0. of students	2
CA1	Modeling and simulation of Ga_2O_3 MOSFET with trench gate
CA2	Design and optimization of enhancement mode Ga_2O_3 MOSFET with trench gate

FYP Proposal ID: SP07

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Simulation and design of enhancement mode Ga_2O_3 MOSFET with heterojunction p-NiO/n-Ga2O3
Summary (200 – 400 words)	Over the past decade, b-phase gallium oxide (β- Ga_2O_3) has received extensive research for next generation ultra-wide bandgap semiconductors for power applications due to its high breakdown field of 8 MV/cm and large Baliga's figure of merit (BFOM). However, the lack of p-type doping makes it hard to implement conventional enhancement mode n-channel MOSFETs. To fabricate E-mode b- Ga_2O_3 MOSFETs, different approaches have been researched. In this proposal, we aim to simulate and design an enhancement-mode Ga2O3 MOSFETs using heterojunction p-NiO/n-Ga_2O_3. Various device and structure parameters such as doping level, thickness and defects of p-NiO, channel doping concentration, and drift layer doping concentration and thickness will be investigated to understand their influences on MOSFET performance including the on/off current ratio, on-current density, specific on-resistance, and breakdown voltage. Finally, an optimized enhancement-mode Ga2O3 MOSFET will be designed to achieve a higher breakdown voltage and a lower on-specific resistance. The project scope includes: (1) Literature review of power devices and Ga_2O_3 power MOSFETs; (2) Modeling and simulation of conventional Ga_2O_3 MOSFETs using TCAD software; (3) Modeling and simulation of enhancement mode Ga_2O_3 MOSFETs with heterojunction; (4) Design and optimization of the device performance by varying different design parameters. Students are expected to develop the following skills (**learning outcome**): (1) To develop a good knowledge on semiconductor physics; (2) To be familiar with semiconductor device fundamentals and in particular Ga_2O_3 power semiconductor devices; To be skilled at TCAD simulation. The achievable outcomes by the FYP students are: (1) To complete modeling and simulation of Ga2O3 MOSFETs with heterojunction p-NiO/n- Ga_2O_3. (2) To vary different device parameters and understand their influences on device performance. To complete the design and simulation of enhancement mode Ga_2O_3 MOSFETs with heterojunction p-NiO/n- Ga_2O_3. **Prior knowledge of basic semiconductor physics is a must.**
Supervisor	Zhu Chunxiang
Laboratory Work	TCAD software
N0. of students	2
CA1	Modeling and simulation of enhancement Ga_2O_3 MOSFET with heterojunction p-NiO/n- Ga_2O_3
CA2	Design and optimization of enhancement mode Ga_2O_3 MOSFET with heterojunction p-NiO/n-Ga_2O_3

Proposal ID: SP08

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Developing an Interactive Upper Limb Training Device for Arm Stretching and Reaching Exercise
Summary (200 – 400 words)	In order to restore muscle strength, a person with arm disability should adhere to regular and intensive rehabilitation exercises, especially visually guided or voice-guided movements. Most of these people are very passive when using traditional tools for these repetitive training. With the intention to support training exercises actively, the project is to develop an upper limb rehabilitation device, which can guide patients to do arm-stretching and reaching exercise. This project aims to design an interactive training device consisting of both hardware and software to motivate children for rehabilitation exercise. Compared with the traditional training methods, the game would enhance the fun of training through interactive forms such as visual feedbacks and voice instructions. The project scope includes: (1) Literature review of interactive rehab device design and relevant technologies; (2) hardware study using microprocessor to process captured data, sensors to detect motion during arm stretching exercise, wireless communication for data record and storage. (3) Software study with data analysis and game design. (4) Integration of hardware and software for interactive training exercise. The achievable outcomes by the FYP students are: (1) To design games associated with the existing device to motivate patients for rehabilitation exercise. (2) To enhance the fun of training through interactive forms such as visual feedback and voice instructions. (3) To improve the device design based on user testing. (4) To analyse training data to obtain the performance in rehab exercise. **Prior experiences of software and hardware are important.** If there are two students to work on the project, each student should carry out different parts, and achieve the mentioned outcomes.
Supervisor	YC Liang and J Sun (Students are to meet Prof. Sun (jie.sun@xjtlu.edu.cn) for interview.)
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Interactive Upper Limb Training Device with hardware and software systems

Proposal ID: SP09

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Developing an Interactive Lower Limb Training Device (walking carpet) for Stepping and Walking exercises
Summary (200 – 400 words)	In order to restore muscle strength, a person with lower limb disability should adhere to regular and intensive rehabilitation exercises, especially visually guided or voice-guided movements. Most of children are very passive when using traditional tools for these repetitive training. With the intention to support training exercises actively, the project is to develop an lower limb rehabilitation device such as the walking carpet, which can guide patients to step and walk. This project aims to design an interactive walking carpet consisting of both hardware and software to motivate children for rehabilitation exercise. Compared with the traditional training methods, the game would enhance the fun of training through interactive forms such as visual feedback and voice instructions. The project scope includes: (1) Literature review of interactive rehab device design and relevant technologies. (2) hardware study using microprocessor to process captured data, sensors to detect motion during arm stretching exercise, wireless communication for data record and storage. (3) Software study with data analysis and game design. (4) Integration of hardware and software for interactive training exercise. The achievable outcomes by the FYP students are: (1) To design games associated with the device to motivate patients for rehabilitation exercise. (2) To enhance the fun of training through interactive forms such as visual feedback and voice instructions. (3) To improve the device design based on user testing. (4) To analyse training data to obtain the performance in rehab exercise. **Prior experiences of software and hardware are important.** If there are two students to work on the project, each student should carry out different parts, and achieve the mentioned outcomes.
Supervisor	YC Liang and J Sun (Students are to meet Prof. Sun (jie.sun@xjtlu.edu.cn) for interview.)
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Interactive Lower Limb Training Device with hardware and software systems

Proposal ID: SP10

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Autonomous Vehicle for mail and parcel delivery
Summary (200 – 400 words)	Most of the hotels and offices use autonomous robots or vehicles for delivering items from one location to another location within the building. This is to avoid human to human contact and to save delivery manpower. This project aims to design and implement autonomous vehicles for mail and parcel delivery on campus in the outdoor environment. For the outdoor environment, there exist many disturbances, such as human traffic, uneven road surface, etc. For an autonomous vehicle to use optical sensing and GPS function to plan the fastest and safest route for the delivery, this poses engineering challenges. Fundamental knowledge of motor drive, sensing and artificial intelligence is important in implementing the project. Students will be working within a team on vehicle development. The project will be co-supervised by Prof. Sun at the XJLU university. The project scope includes: (1) Literature review of autonomous vehicle and relevant technologies. (2) Image processing for environmental analysis and navigation control. (3) Be able to plan the shortest and safest route in motion. The achievable outcomes by the FYP students are: (1) To develop an autonomous vehicle with motion capability. (2) To implement hardware and software to do environmental sensing and navigation function. (3) To implement motor drive and be able to travel in a smooth motion for parcel delivery. **Prior project experience of hardware on robotic or similar is important.** If there are two students to work on the project, each student should carry out different parts, and achieve the mentioned outcomes.
Supervisor	YC Liang and J Sun (Students are to meet Prof. Sun (jie.sun@xjtlu.edu.cn) for interview.)
Laboratory Work	Hardware and software
No. of students	2
CA1	Motor function and environmental sensing
CA2	Autonomous motion with AI function

Proposal ID: SP11

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	LED lighting effect on indoor farming application
Summary (200 – 400 words)	This project aims to design and implement a dimmable LED lighting system which can set the lighting intensity from 0 to 100% continuously. The system should also be able to vary the composition of light at different wavelength (UV, visible and infrared) to best stimulate the germination of seeds. The project scope includes: (1) Literature review/thesis reading of LED dimming control system. (2) Design and implement the hardware DC-DC converter circuit. (3) Design and Implement the PWM switching on multiple branches. (4) Investigate the influence of lighting towards the rate of germination in terms of intensity and wavelength at various stages. (5) Use of microcontroller to control and to do data recording. Students are expected to develop the following skills (learning outcome): (1) Be able to understand the LED dimming circuit and its fundamental. (2) Be able to design a proper circuit/usage of microcontroller for specific function of DC/DC converter and PWM switching. (3) Be able to find out the influence of LED lighting for indoor farming needs on different seeds. Outcomes to be achieved: (a) Be able to adjust the light intensity from 0 to 100%, for UV, visible and infrared individually and observe the seeds germination. (b) Be able to mix two or three different wavelengths at different duty cycle to achieve better germination. (c) Collect data and give sensible conclusion on the influence of lighting with the rate of germination. If there are 2 students; each student should work on different part of the project with clear outcome from each student.
Supervisor	YC Liang
Laboratory work	Bench-top equipment, PCB circuits
No. of students	2
CA1 requirement	Demonstrate of LED lighting system, the DC-DC converter, the dimmable features
CA2 requirement	Complete research data on the LED influence on indoor farming for different seeds at different stages of growth

Proposal ID: SP12

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Multiple-coil wireless power transfer system for high power efficiency
Summary (200 – 400 words)	This project is to design a wireless power transfer system, containing a specially designed high-Q inductor, to extend its transfer distance and power rating. Students will learn how to use power MOSFET devices to construct such an inverter system with PLL-based auto-frequency tracking circuit. The inductor coil is to have a high-Q for large resonant response, Q factor to be at least 800 at resonance. The secondary coil is to follow the similar resonant frequency to obtain a better transfer efficiency. The primary coil can be extended to a resonant array to cover a wider working space for wireless power transfer. The user interface will also need to be developed to control/monitor the power transfer. The project scope includes: (1) Literature review/thesis reading of resonance wireless power transfer system; (2) Design the hardware inverter circuit for the resonance. (3) Design and produce the high-Q inductor. (4) Design the indicating circuit for amount of power transfer. (5) Measure the power transfer efficiency Students are expected to develop the following skills (learning outcome): (1) Be able to understand the wireless power transfer and its fundamental. (2) Be able to design a proper circuit/usage of microcontroller for specific function. (3) Be able to build high-Q resonant coil and coil array for multiple charging units. If there are 2 students; one student will focus on the circuit hardware/microcontroller system design and implementation. The second student will be on the high-Q coil formation and the coil array (minimum 2) with selective switching on the usage of coil.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Single coil system to be functional
CA2 requirement	Multiple coil system with high power efficiency

Proposal ID: SP13

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	SiC Power MOSFET DC Circuit Breaker for Over-Current Protection
Summary (200 – 400 words)	The electronic circuit breaker used in DC microgrids are required to work within their safe operating areas bounded by temperature, voltage and current limits. Traditional approach managed to protect these switches through rapid current cut-off operations at over-load or fault situations, but failing to avoid the disturbance induced by transient current surges or noises which are not harmful to the grid operations. Aiming to increase the quality of circuit breaker operations and furthermore improve its reliability, this paper proposed a SiC MOSFET based DC circuit breaker based on the variable time-delay protection scheme. The cutoff operations only take place after proper delay time, which are precisely catered according to the transient thermal properties of SiC devices and the properties of DC loads. Students will implement the designed scheme with hardware prototype and to experimentally verify under different fault situations. The project scope includes: (1) Literature review on SiC DC circuit breaker. (2) Design and implement the hardware for the SiC circuit breaker including the current sensing circuit and SiC gate drive. (3) Design and implement the trip current setting circuit to preset the maximum delay time before tripping. (4) Combine the feature of Low leakage current sensing to protect high impedance ground fault. Students are expected to develop the following skills (learning outcome): (1) Be able to understand the current sensor and SiC power MOSFET devices. (2) Be able to design a proper circuit/usage of microcontroller or ICs for specific function of the circuit breaker. (3) Be able to provide adjustable trip time/trip current setting and to trip under the high impedance ground fault. (4) Able to filter any line noise and be precise in current detection. If there are 2 students; one student will focus on the hardware/microcontroller system design and implementation for SiC circuit breaker on adjustable trip time and current limit. The second student will be on the high impedance fault protection and intelligent features. ***All experiment setups must be verified by the supervisor before implementation.**
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic function on SiC circuit breaker to be implemented
CA2 requirement	All functions, trip current setting, trip time setting, high impedance ground fault are to be implemented and demonstrated

Proposal ID: SP14

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	LoRa based soil moisture/temperature monitoring system for indoor and outdoor use
Summary (200 – 400 words)	In this Smart Agriculture Project, we will make LoRa Based Soil Moisture Monitoring System. The LoRa Soil Moisture Module is the robust, simple, and fully wireless solution to soil moisture measurement for agriculture. Reference web information: https://how2electronics.com/lora-based-soil-moisture-monitoring-on-lora-esp32-webserver/ The LoRa Soil Moisture Sensor Node is made up of Capacitive Soil Moisture Sensor PCB. The PCB Combines ATmega328 microcontroller with LoRa Module RFM95. The gateway is an ESP32 LoRa Shield that fits on MakePython ESP32 Module. This gateway uploads the data to the cloud and is capable of managing an unlimited number of wireless soil moisture sensors. The revolutionary Sensor soil moisture solution is self-sustaining, wireless, and remote. This project can be extended by adding another sensor, such as temperature sensor, to be a multisensory IoT application. Video tutorial web information: https://how2electronics.com/lora-based-soil-moisture-monitoring-on-lora-esp32-webserver/#Video_Tutorial Students are to complete the system hardware and software setup, and to provide the data display on the phone. The distance of LoRa communication is also tested and to report the longest distance possible. For indoor use, the test will be made on different floors.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic function on LoRa data communication
CA2 requirement	All functions, including the multiple sensors, longest communication distance and phone interface

Proposal ID: SP15

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	LoRa Based Wireless Weather Station
Summary (200 – 400 words)	In this project, we will build a LoRa Based Wireless Weather Station using Arduino Pro Mini & ESP32 Wifi Module. You can keep the Weather Station Node on the roof of a building or any remote location just a few kilometres away from your lab. You can use the sensor like BME280 Barometric Pressure Sensor along with a BH1750 Light sensor and also a Rain Sensor. Basically, this weather station can monitor the Environment parameters like Temperature, Humidity, Pressure, Altitude, Dew Point, Wind speed and Direction, Rainfall & Light Intensity. Using the LoRa Module SX1278/RFM95 you can monitor the data from a few kilometre distances (up to 5Km). The device operates on a 3.7V lithium Ion Battery and power consumption is low. The system needs its own power supply from the PV panel and battery. The Gateway can be placed indoors inside the lab. The gateway is made using Lora SX1278/RFM95 and ESP32 Wifi Module. The receiver collects the data from the sender or Sensor Node and uploads it to the Server. Reference web information: https://how2electronics.com/lora-based-wireless-weather-station-with-arduino-esp32/ The weather data can be displayed on a webpage, and with history data charts to make comparison on weather data. Video tutorial web information: https://how2electronics.com/lora-based-wireless-weather-station-with-arduino-esp32/#Video_Tutorial_038_Guide_Wireless_LoRa_Weather_Station Students are to complete the system hardware and software setup, and to provide the data display on the web page. The distance of LoRa communication should also be tested and to report the longest distance possible. The following must be included: Temperature, humidity, wind speed, wind direction, rainfall amount, air pressure, lightning frequency, sun rise/set time, etc.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic function on LoRa data communication
CA2 requirement	All functions, including the multiple sensors, longest communication distance and web page interface

Proposal ID: SP16

Academic Year	AY 2024/2025 (September 2023 – May 2024)
Title of Project	IoT based low-cost portable ECG system with data communication
Summary (200 – 400 words)	In this project, we will build a low-cost IoT Based ECG Monitoring with AD8232 ECG Sensor & ESP32. The ECG signal from a patient heart can be observed online. An ECG is a recording of the electrical signals in the heart. It is also called an electrocardiogram or an EKG. The ECG is used to determine heart rate, heart rhythm and other information regarding the heart's condition. ECGs are used to help diagnose heart arrhythmias, heart attacks, pacemaker function and heart failure. An electrocardiogram can be a useful way to find out whether your high blood pressure has caused any damage to your heart or blood vessels. Reference web information: https://how2electronics.com/iot-ecg-monitoring-ad8232-sensor-esp32/#What_is_an_ECG The ECG data should be displayed in real-time locally on the portable screen and be displayed on a webpage, and with history data charts to make comparison. Video tutorial web information: https://how2electronics.com/iot-ecg-monitoring-ad8232-sensor-esp32/#Video_Tutorial_Explanation Students are to complete the system hardware and software setup, and to provide the ECG data display on the local device and on the web page. For the team of two students, the project can be extended by adding an oximeter (MAX30100 Pulse Oximeter) to monitor the percentage of oxygen level in the blood and to display together.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	ECG measurement system
CA2 requirement	ECG system with user interface, data recording, oximeter for multisensory function

Proposal ID: SP17

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Radar sensor for the detection of human motion behind wall
Summary (200 – 400 words)	In this project, we will build a low-cost radar sensor system to detect human motion behind wall or any invisible objects, and to detect number of human and their physical gesture. Reference web information: https://www.youtube.com/watch?v=gU-Rrwf1vr0&ab_channel=AndreasSpiess Students are to complete the hardware circuits and to implement the software to display the outcome on the computer screen, or any display. For human facing directly with the radar sensor, i.e. not behind the wall, the image should be very clear and the software should also analyse the human gesture to issue control command for the appliance, such as to turn on and off the light by waving the arms. Other applications, such as measuring the physical distance between two humans can also be implemented, and to count the number of humans in a group. In summary, the FYP outcomes to be implemented are: (a) Detect the human gesture behind the wall (b) Use human gesture to control appliance (c) Measuring distance between two humans (d) Counting the number of humans in a group GUI should also be made to visually display the outcome on screen.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic radar sensor function for (a) and (b)
CA2 requirement	Full performance for (a) – (d)

Proposal ID: SP18

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	LoRa for Off-Grid Voice/texting/image Communication
Summary (200 – 400 words)	In this project, we will build a LoRa based communication device for off grid use. The Arduino Pro Mini & ESP32 Wifi Module can be the option to build the system. For example, using the LoRa Module SX1278/RFM95 you can monitor the data from a few kilometre distances (up to 5Km). The device operates on a 3.7V lithium Ion Battery and power consumption is low. The system needs its own power supply from the PV panel and battery. In the video below, the LoRa modules are used for the off-grid texting communication. We will extend the function to enable voice communication and sending pictures. An additional unit for voice capture and digitised into data will be needed. The data are sent to the receiving unit via the LoRa communication and converted by the Arduino module to the voice signal. Reference web information: https://www.youtube.com/watch?v=gqAsWtIjHUY&ab_channel=DIYRenewableEnergy%26Electronics https://www.youtube.com/watch?v=FwnTiNPrB8w&ab_channel=DIYRenewableEnergy%26Electronics Students are to complete the system hardware and software setup, and to provide the demonstration on texting, voice communication and sending pictures. The distance of LoRa communication should also be tested and to report the longest distance possible.
Supervisor	YC Liang
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic function on LoRa data communication
CA2 requirement	All functions, including the texting and voice communication function.

Proposal ID: SP19

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Intelligent Wheelchair System
Summary (200 – 400 words)	In this project, we will build an intelligent wheelchair which has the functions of (a) electric drive with speed and torque control, and (b) intelligent function to avoiding obstacles, emergency communication, and possible automatic functions. The project is to collaborate with XJLU, and medical equipment supplier. Students are to make the following hardware and software implementation: • Speed control with a BLDC motor which is able to drive a wheelchair under the human control. The speed control should be smooth without shaking. • Safety features to cut off the motor drive if no one is on the chair. • Able to perform extreme slow motion for small radius turning. • Able to do visual or ultrasonic detection to avoid any obstacles. • Able to have an emergency button which send call signal in case of urgency. • Able to do the auto-drive function in a low speed. Students are to complete the system hardware and software, and to provide the demonstration on its function. This project may need to handle more detailed hardware work, experience in hardware work before is essential.
Supervisor	YC Liang and J Sun (Students are to meet Prof. Sun (jie.sun@xjtlu.edu.cn) for interview.)
Laboratory work	Bench-top instruments, computer, software, microcontroller
No. of students	2
CA1 requirement	Basic function on wheelchair motor drive and motion control
CA2 requirement	All functions, including the motion control, communication, auto-drive etc.

Proposal ID: SP20

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Concept Unlearning for Diffusion Models
Summary (200 – 400 words)	The project scope includes: **(1)** Gain a comprehensive understanding of diffusion models, including their architecture, training process, and applications. **(2)** Study the concept of unlearning in machine learning models and its relevance to diffusion models. **(3)** Develop and implement techniques for removing unwanted concepts from pre-trained diffusion models, emphasizing ethical considerations. **(4)** Evaluate the effectiveness of concept removal techniques through experiments and analysis. Students are expected to develop the following skills (learning outcome): • Deep understanding of diffusion models and their training mechanisms. • Knowledge of the concept of unlearning and its application in diffusion models. • Proficiency in implementing techniques for concept removal in diffusion models. • Ability to assess and evaluate the impact of concept removal on model outputs. • Effective communication of technical concepts through documentation and guidelines. The deliverable outcome by the FYP students for the CA assessment are: (1) Detailed documentation on the principles and mechanics of diffusion models. (2) Implementation of concept removal techniques in pre-trained diffusion models. (3) Evaluation results demonstrating the effectiveness of concept removal techniques. (4) Guidelines and best practices for ethical concept removal in diffusion models. If there are two students to work on the project, they should develop a) different algorithms for effective pose-estimation methods, or b) different target diffusion models to apply concept unlearning.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	To develop effective approaches for unlearning concepts from diffusion models.
CA2 requirement	To devise strategies to transfer the unlearning framework to arbitrary diffusion models.

Proposal ID: SP21

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Automatic Attack Framework for Text-to-Image (T2I) Models
Summary (200 – 400 words)	The project scope includes: **(1)** Conducting a thorough review of existing safety checkers and attack methods in Text-to-Image (T2I) models concerning the generation of sensitive or explicit content. **(2)** Designing and implementing the Jailbreak Prompt Attack framework to bypass safety checkers while preserving the semantics of the generated images. **(3)** Evaluating the effectiveness of attacks against both online and offline safety checkers. **(4)** Documenting the methodology, results, and findings in a comprehensive report aimed at contributing to research on T2I model security and ethics. Students are expected to develop the following skills (learning outcome): (1) Understanding ethical considerations in Text-to-Image (T2I) model security. (2) Designing and implementing attack frameworks like Jailbreak Prompt Attack. (3) Evaluating attacks against safety checkers, both online and offline. (4) Analytical skills in assessing the semantic coherence and suitability of generated images for different environments. (5) Develop comprehensive documentation and reporting skills. The deliverable outcome by the FYP students for the CA assessment are: (1) Understanding the challenges and ethical implications of NSFW image generation in T2I models. (2) Developing skills in designing and implementing automatic attack frameworks for T2I models. (3) Gaining insights into the robustness of text prompts in evading safety checkers. If there are two students to work on the project, they should develop a) different attacking frameworks for attacking T2I models, or b) different thread model settings for T2I models.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	To develop effective approaches for attacking white-box T2I models.
CA2 requirement	To develop highly transferable attacks for surrogate white-box T2I models and test them under several black-box T2I models.

Proposal ID: SP22

Academic Year	AY 2023/2024 (September 2023 – May 2024)
Title of Project	Efficient Multi-Modal Large Language Models
Summary (200 – 400 words)	The project scope includes: (1) A literature review of state-of-the-art multi-modal large language models (mLLMs). (2) Understanding the basic pipelines for mLLM training. (3) Designing effective approaches for efficient mLLMs. (4) Developing practical strategies like quantization and pruning for deployment. **Students are expected to develop the following skills (learning outcome):** • Understanding the key concepts and challenges of mLLMs; • Gaining insight into the basic pipeline of mLLM training; • To be skilled at Python programming; • Developing skills to deploy mLLMs. **The deliverable outcome by the FYP students for the CA assessment are:** (1) A literature review analyzing existing multi-modal LLM architectures like LLaVA and efficiency-enhancing techniques such as KV Cache and linear attention. (2) Designing an optimized multi-modal LLM architecture incorporating RNN, Mamba, or other linear attention mechanisms. (3) Exploring deployment strategies such as quantization and 2:4 sparsity to validate the model's practical application. If there are two students to work on the project, they should a) develop different algorithms for efficient mLLMs, or b) address different efficiency problems like memory footprint or latency.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	To understand the core ideas of multi-modal large language models, and craft light-weight baseline models.
CA2 requirement	To develop and improve effective approaches for multi-modal large language models

Proposal ID: SP23

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Condense Large-Scale Datasets for Vision Tasks
Summary (200 – 400 words)	The success of deep learning models on a variety of vision tasks, such as image classification, object detection, and semantic segmentation, is largely attributed to the huge amount of data used for training. However, the sheer amount of data introduces significant obstacles for storage, transmission, and data pre-processing. Besides, publishing raw data inevitably brings about privacy or copyright issue in practice. To alleviate these problems, this project is concerned with the technique of dataset condensation, to compress a large dataset into only a few samples, so that the training effort for downstream models can be largely reduced. These samples are not from the original dataset but synthesized by condensation algorithms. They are expected to be informative enough so that the training effects for downstream models using the condensed dataset can match those using the original one as much as possible. In this project, we will focus on condensing large-scale datasets for vision tasks. For example, condense the COCO dataset into only 100 images, with which the trained downstream models can work for in-the-wild object detection. Candidates will have chance to publish their research in top-tier conference or journals. Working hours will be flexible. In summary, the project scope includes: 1. Review and reproduce state-of-the-art dataset distillation techniques for large-scale datasets. 2. Illustrate the basic pipeline of dataset distillation for object detection. 3. Review recent data-efficient techniques for object detection. 4. Continuously improve the pipeline using these techniques or with any other insights.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	Illustrate the basic pipeline of dataset distillation for object detection.
CA2 requirement	Continuously improve the pipeline using techniques from general object detection or with any other insights.

Proposal ID: SP24

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Reconstructing Visual Stimuli from Brain Recordings
Summary (200 – 400 words)	Decoding visual stimuli from brain recordings aims to deepen our understanding of the human visual system and build a solid foundation for bridging human and computer vision through the Brain-Computer Interface. However, reconstructing high-quality images with correct semantics from brain recordings is a challenging problem due to the complex underlying representations of brain signals and the scarcity of data annotations. In this project, we would like to explore using AI foundation models to facilitate the research of brain decoding, and achieve competitive results over existing state-of-the-art methods. Students in this project will learn the basic representation of human brain signals and play with multimodal generation models like Stable Diffusion. They will be required to conduct a survey on recent state-of-the-art techniques of brain decoding and write a comprehensive review of existing methods. Working schedules will be flexible. In summary, the project scope includes: 1. Review and reproduce state-of-the-art dataset distillation techniques for brain decoding. 2. Design automatic methods to effectively search and identify the optimal regression objective for brain decoding. 3. With this regression objective, train a novel brain decoding model. 4. Continuously improve the performance and/or explainability of the pipeline using existing techniques or with any other insights.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	Design automatic methods to effectively search and identify the optimal regression objective for brain decoding.
CA2 requirement	With the regression objective in CA1, train a novel brain decoding model and continuously improve the performance and/or explainability of the pipeline using existing techniques or with any other insights.

Proposal ID: SP25

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Recovering 4D world from casual videos
Summary (200 – 400 words)	The project scope includes: (1) Conducting a literature review of state-of-the-art video-to-4D methods.; (2) Summarizing the basic components and pipeline for video-to-4D recovery; (3) Gaining an understanding of the ambiguities and inconsistencies among various 2D visual priors used to supervise 4D recovery; (4) Designing effective schemes of 2D visual priors fusion and strategies for point tracking under complicated movement and occlusion within the video. Students are expected to develop the following skills (learning outcome): • To understand the challenges in the video-to-4D task; • To learn the relationship between 3D vision and 2D vision; • To be skilled in dynamic 3D reconstruction, especially 3D Gaussian splatting and camera pose estimation; • To be skilled at Python programming; • To develop a system for modelling the dynamic 3D world and camera trajectories simultaneously from casual videos; • To develop efficient schemes for data association, either within each frame or across consecutive frames. The deliverable outcome by the FYP students for the CA assessment are: (1) To illustrate the classic workflow designs for video-to-4D; (2) To develop effective approaches for 2D visual prior fusion in video-to-4D; (3) To devise point tracking strategies that can deal with complicated movements and occlusions within the video. If there are two students to work on the project, they should develop a) different algorithms for video-to-4D methods, or b) different video dynamics settings for video-to-4D tasks.
Supervisor	Wang Xinchao
Laboratory work	Python
No. of students	2
CA1 requirement	To develop effective approaches for 2D visual prior fusion in video-to-4D.
CA2 requirement	To devise point tracking strategies that can deal with complicated movements and occlusions within the video.

FYP Proposal ID: SP26

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Current measurement using TMR sensors
Summary (200 – 400 words)	Current measurement is crucial for ensuring the safe and efficient operation of electrical systems, including electric vehicles (EVs), by monitoring and controlling power flow. It helps diagnose issues, prevent equipment failures, and avoid hazards like short circuits and overloads. For both industrial settings and EVs, accurate current measurements optimize energy consumption and maintain proper functionality, managing battery health and preventing component damage. In renewable energy systems, current measurement maximizes energy harvest and ensures reliable integration with the grid, supporting EV charging infrastructure. In this project, we propose to develop a low-cost and high-accuracy current meter using a tunnelling magnetoresistance (TMR) sensor. Compared to coil-based current meters, the TMR sensor offers several advantages, including higher sensitivity, low power consumption, better linearity, and a smaller form factor. The project scope includes: **1)** Review different types of current measurement techniques, particularly TMR based current sensors. **2)** Define the requirements and specifications for the current meter. **3)** Identify and source for hardware, software, and components required for the project and finalization of overall design. **4)** Develop hardware/software for measuring system. **5)** Calibrate the prototype for accurate current measurement. **6)** Conduct extensive testing to ensure performance meets the required standards. **7)** Validate the prototype against various benchmarks and scenarios. **8)** Summarize the findings, results, and potential impact of the project. Student is expected to develop the following skills (learning outcome): 1) Understand the working principle of a wide range of current measurement techniques. 2) Design and implementation of an intelligent sensing system from devices to system and applications that cover both hardware and software aspects as well as engineering integration. 3) Advanced signal processing techniques. 4) Translational research and development.
Supervisor	Prof. Wu Yihong
Laboratory facilities to be used	Budget for purchase of electronic components, sensors, microcontrollers, and evaluation kits; Software for simulating magnetic field generated by current; Magnetic sensor characterization systems; Laptops (presumably students have their own)
No. of students	2
CA1 requirement	Preparation of technical specification and block diagram of the proposed device, design and fabrication of the sensing circuits, design and implementation of hardware and software for processing the detected signals.
CA2 requirement	Testing, evaluation and improvement of the device at system level; demonstration of current measurement using the developed device.

FYP Proposal ID: SP27

Academic Year	AY2024/2025 (September 2024 – May 2025)
Title of Project	Photoplethysmography (PPG) sensors for heartbeat and SpO_2 monitoring
Abstract (200 – 400 words)	Photoplethysmography (PPG) sensor is widely used for detecting volumetric changes in the blood in peripheral circulation. When light travels through biological tissues, it is absorbed by skin pigments, bones and the circulating blood. The change in blood flow can be detected by measuring either the reflectance or absorbance of the light using a photodetector. The resultant voltage signal from the photodetector corresponds to cardiac synchronous changes in the blood volume with each heartbeat. Using two light emitting diodes (LEDs) of different wavelength, e.g., one is in infrared and the other is in the red region, it is possible to measure the oxygen saturation (SpO_2) level, which is crucial for a human body to function properly. In this project, a two-student team will **1)** Develop a prototype PPG sensor using discrete components, test and benchmark its performance with commercial products (sub-project 1); and **2)** Develop algorithms to calculate heartrate, heart rate variability, and oxygen saturation (SpO_2) from the acquired PPG signals (sub-project 2). Scope of sub-project 1: **1)** Do a literature review on PPG sensors and prepare a block diagram for the overall detection circuitry. **2)** List out all the components that are required to build the circuit (ensure that it is within the allocated budget). **3)** Source for and purchase all the components and build the sensing circuit. **4)** Test and de-bug the circuit. Collect PPG signal and compare it with those obtained from commercial sensors. Investigate motion and skin tone effect. Scope of sub-project 2: **1)** Do a literature review on heartrate, heart rate variability, and oxygen saturation (SpO_2) measurement using PPG. Work together with the teammate to complete the PPG sensor. **2)** Develop algorithm to calculate heartrate and SpO_2 from the measured data and compared the results with those obtained from commercial devices. Through this project, students are expected to develop the following skills: 1) To learn how optoelectronic devices such as light emitting diode and photodetectors are used in clinical and healthcare monitoring. 2) To learn how to build electronic circuits that are directly related to real world applications. 3) To learn basic techniques for data acquisition and processing. 4) To learn how to deal with noise which is always present in real systems.
Supervisor	Prof. Wu Yihong
Laboratory facilities	Budget for purchasing electronic components, LEDs, photodiodes, microcontrollers, commercial PPG sensors, etc., laptops (presumably students have their own)
No. of students	2
CA1 requirement	- Prototype circuit is ready for detecting blood flow. - Basic algorithms for heartrate, heart rate variability, and SpO_2 calculations are ready.
CA2 requirement	- System level demonstration of the PPG. - Demonstration of algorithms for accurate heartrate, heart rate variability, and saturation oxygen monitoring.

FYP Proposal ID: SP28

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Magnetic tracking using smartphone and standalone magnetic sensors
Summary (200 – 400 words)	A typical magnetic tracking system consists of one or more magnetic sensors and magnetic field generators. The latter can be the geomagnetic field or field generated by magnets, current coils, etc. During the operation, either the magnet or sensor will be moved around and their relative locations will be determined from the field detected in three orthogonal directions. A major advantage of magnetic tracking is that it does not require a line-of-sight between transmitter and receiver because magnetic fields can penetrate through many materials such as wall, wood, plastic, ceramic, rubber, human body, etc. In this project, a two-student team will develop a 3D magnetic tracking system to track a moving permanent magnet using either standalone magnetic sensors or built-in magnetometer in a smartphone and explore potential applications. The project scope includes: **1)** Conduct a literature review on different types of electromagnetic tracking techniques, with emphases on the use of permanent magnets as the field generator. **2)** Prepare system layout and source for electronic components and sensors required for building the tracking systems using standalone magnetic sensor (i.e., not the built-in sensors in a smartphone). **3)** Write an application software (or APP) to access the built-in magnetic sensor inside a smartphone and output the data for further processing (for detection system using smartphone). **4)** Use dipole model to calculate the 3D field generated by a permanent magnet (required for tracking using both external and built-in sensors). **5)** Prototype, test and debug individual modules and the complete system. Test the performance of the tracking systems. Demonstrate possible applications, e.g., pen movement during writing. Student is expected to develop the following skills (learning outcome): 1) Understand the working principle of a wide range of magnetic sensors and their applications in magnetic tracking. 2) Design and implement an intelligent sensing system from devices to system that both cover hardware and software design and engineering integration. 3) Design and develop smartphone-based APPs. Learn and master advanced signal processing techniques. Be familiar with translational research and development.
Supervisor	Prof. Wu Yihong
Laboratory facilities to be used	Budget for purchase of electronic components, sensors, microcontrollers, and evaluation kits; Magnetic sensor characterization systems; Laptops and smartphone (presumably students have their own)
No. of students	2
CA1 requirement	Preparation of technical specification and block diagram of the proposed tracking system, design and fabrication of the sensing circuits, design and implementation of hardware and software for processing the detected signals (sub-project 1); Demonstration of working APP which can access the built-in magnetic senor in smartphone and its application in magnetic tracking (sub-project 2); Development of algorithm for calculating the magnetic field (both sub-projects)
CA2 requirement	Testing, evaluation and improvement of the tracking system; demonstration of accurate tracking of moving magnet with potential applications.

FYP Proposal ID: SP29

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Noncontact flowmeter using magnetic sensors
Summary (200 – 400 words)	In this project, a two-student team will develop a low cost and energy-efficient magnetic flowmeter. Flowmeters are important for measuring the flow of liquid, gas and other substances and are used across industries from water supply to wastewater treatment, food, beverage, oil, gas and pharmaceutical plants. There are several different types of flowmeters including Coriolis, differential pressure, magnetic, turbine, ultrasonic and vortex meters. Each type has its own advantages and disadvantages, depending on specific applications. The objective of this project is to design and prototype an ultralow power magnetic flowmeter based on a permanent attached to a turbine and a tunnel magnetoresistance (TMR) sensor and compare its performance with commercial flowmeters. The main tasks include: Sub-task 1: i) Do a thorough literature review of different types of flowmeters and summarize their advantages and limitations, ii) understand the working principle of magnetic flowmeter, iii) determine the technical specifications of the flowmeter to be designed and prototypes in this project, iv) prepare a system level block diagram, v) prepare a detailed milestones of the project with clear timelines, and vi) purchase all the necessary components/modules for making the proposed device. Sub-task 2: Design and implement electronic circuits for signal acquisition and processing including microcontroller and wireless communication unit and develop physical models to calculate the flowrate. Sub-task 3: System level integration of hardware and software and calibration of the flowmeter using commercial device. Sub-task 4: Explore the possibility of magnetic telemetry for underground water flowrate monitoring including the estimation of workable distance, power requirement and external disturbance. Sub-task 5: Update progresses on regular basis, present findings in continuous assessment and write a thesis. Students are expected to develop the following skills (learning outcome): 1) Understand the working principle of magnetic flowmeter. 2) Design and implementation of electromagnetic and electronics systems from device to system and applications which cover both hardware and software aspects as well as engineering integration. 3) Advanced signal processing and wireless communication. 4) Translational research and development.
Supervisor	Prof. Wu Yihong
Laboratory facilities to be used	Bench DC power supply, signal generator, oscilloscope, multimeter, soldering station and accessories, wire stripper, breadboards, electronic components and modules, and simple mechanical tools to fabricate fixtures for holding the magnet and sensor (can be outsourced), and a simple water circulating system (to be built by the team).
Number of students	2
CA1 requirement	Preparation of technical specification and block diagram of the proposed device, design and fabrication of the sensing circuits, design and implementation of hardware and software for processing the detected signals. The water circulating system should be ready for testing the flowmeter.
CA2 requirement	Testing, evaluation and improvement of the device at system level; demonstration of telemetry for remote flowrate monitoring.

FYP Proposal ID: SP30

Academic Year	AY2024/2025 (September 2024 – May 2025)
Title of Project	Chair-based ballistocardiography for health monitoring
Summary (200 – 400 words)	Ballistocardiography (BCG) is a non-invasive technique used to measure the mechanical movements of the body in response to the ejection of blood from the heart with each heartbeat. These mechanical movements, known as ballistocardiographic signals, are generated by the force exerted by the heart's pumping action and the resulting recoil of the body. During each cardiac cycle, blood is ejected from the heart into the arteries, causing a series of physiological responses throughout the body. These responses include a subtle but measurable shift in the body's center of mass, as well as changes in body acceleration and deceleration. BCG captures these movements and translates them into signals that can be analyzed to assess cardiovascular function. In this project, a two-student team will develop a BCG using magnetic sensors to measure the body's mechanical movements in response to cardiac activity. The system will utilize advanced signal processing algorithms to extract and analyze ballistocardiographic signals, providing insights into cardiovascular function such as heart rate, stroke volume, and cardiac output. The goal is to create a non-invasive and portable BCG solution that can be integrated into wearable devices for continuous cardiovascular monitoring in various environments. The main tasks include: 1) Do a literature review of different types of BCG devices. Propose designs for chair-based BCG that can capture ballistocardiographic signals efficiently using magnetic sensors. 2) Develop robust signal processing algorithms to accurately extract and analyze ballistocardiographic signals from the sensor data. Design and rigorously test a prototype BCG system to ensure its accuracy, reliability, and usability in diverse environments. 3) Create an intuitive user interface for the BCG system, enabling real-time visualization and interpretation of cardiovascular data. Validate the BCG system against clinical standards, iteratively optimizing its performance based on testing feedback to enhance accuracy and functionality. Students are expected to develop the following skills (learning outcome): 1) Understanding the working principle of BCG. 2) Gain expertise in selecting, integrating, and calibrating sensors for capturing ballistocardiographic signals, along with developing and implementing signal processing algorithms to extract relevant cardiovascular data. 3) Master and apply signal processing and machine learning techniques.
Supervisor	Prof. Wu Yihong
Laboratory facilities to be used	DC power supply, signal generator, oscilloscope, multimeter, soldering station and accessories, breadboards, electronic components and modules, and simple mechanical tools to fabricate fixtures for holding the magnet and sensor (can be outsourced).
No. of students	2
CA1 requirement	Preparation of technical specification and block diagram of the proposed device, design and fabrication of the sensing circuits, design and implementation of hardware/software.
CA2 requirement	Testing, evaluation and improvement of the device at system level; demonstration of BCG functionality.

FYP Proposal ID: SP31

Academic Year	AY2024/2025 (September 2024 – May 2025)
Title of Project	Sound source localization using a microphone array
Summary (200 – 400 words)	Sound localization plays a crucial role in various applications such as surveillance, robotics, and virtual reality, where identifying the direction of sound sources is essential for situational awareness and interaction. In this technique, multiple microphones first capture sound signals emanating from the source. Then, by comparing the arrival times of the sound signals at different microphone pairs, the time differences between them are computed. Subsequently, employing the positions of the microphones and the speed of sound propagation, the source's location is calculated through triangulation or other localization algorithms. Finally, the direction of the source relative to the microphone array is determined, usually expressed in angles or three-dimensional coordinates. In this project, a two-student team will develop a sound source localization system using a microphone array. The system will be designed to accurately identify the direction of sound sources in three-dimensional space in real-time. By integrating advanced signal processing algorithms with a carefully configured microphone array setup, the team will create a versatile and reliable tool for applications such as surveillance, robotics, virtual reality, and healthcare. The main tasks include: 1) Design and implement a microphone array setup, selecting an appropriate configuration (e.g., linear, circular, or planar array). Develop signal processing algorithms for sound source localization, incorporating techniques such as time delay estimation and beamforming in combination with machine learning. 2) Realize a user-friendly interface for visualization and interpretation of localized sound sources in three dimensions. Evaluate the system's performance through comprehensive testing and validation, comparing results against ground truth data. Students are expected to develop the following skills (learning outcome): 1) Gain proficiency in signal processing techniques for audio signals, including time delay estimation, beamforming, and spatial filtering. 2) Acquire hands-on experience in integrating hardware components, such as microphones and processing units, with software systems.
Supervisor	Prof. Wu Yihong
Laboratory facilities to be used	DC power supply, signal generator, oscilloscope, multimeter, soldering station and accessories, breadboards, electronic components and modules, speakers, and simple mechanical tools to fabricate fixtures for holding the microphone arrays (can be outsourced).
Number of students	2
CA1 requirement	Preparation of technical specification and block diagram of the proposed device, design and fabrication of the sensing circuits, design and implementation of hardware/software.
CA2 requirement	Testing, evaluation and improvement of the device at system level; demonstration of sound localization functionality.

FYP Proposal ID: SP32

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Developing a high precision image-based rotation rate estimation algorithm for satellite air bearing system
Summary (200 – 400 words)	The Satellite Technology and Research (STAR) centre have developed 4 12U microsatellites. The Lumelite-4 has been launched in April 2023, while Lumelite-1 to Lumelite-3 will be launched by end of 2024. The attitude determination system (ADS) of Lumelite satellites contain sensors such as sun sensor, magnetometer, and gyroscope. Both gyroscope and magnetometer are required to properly calibrated to ensure the satellite's ADS meets the required performance specification. Because the magnetometer is susceptible to the present of magnetic field produce by any magnetic device, the magnetometer calibration is only conducted via air bearing system. Thus, its accuracy is heavily depending on the gyroscope's accuracy. Therefore, this project aims to develop a high precision image-based rotation rate estimation algorithm for air bearing system in STAR centre, to further improve the magnetometer calibration accuracy. The project is part of the continuation of capstone project from AY 2023/2024. The you only look once (YOLO) object tracking algorithm has been developed. Student will utilize the data output from YOLO algorithm to complete this project. The project scope includes: **(1)** Literature review of you only look once (YOLO) object tracking algorithm; **(2)** Literature review of sequential estimation algorithm such as Kalman filter; (3) To conduct error and covariance analysis on the centroid labelling provided by YOLO algorithm; Implement Kalman filter for image-based rotation rate estimation purpose; Students are expected to develop the following skills (**learning outcome**): • To understand YOLO object tracking algorithm; • To be familiar with error and covariance analysis method; • To be skilled at python and/or Matlab programming; • To be familiar with sequential estimation algorithm; The achievable outcomes by the FYP students are: (1) To combine all the coding module/block into one coding structure for enabling real-time prediction in the future; (2) To implement information fusion on the image data from multiple cameras for improving the overall accuracy performance; (3) To display the predicted rotation rate and the associate error covariance. **Python knowledge is a must. Matlab knowledge is optional.**
Supervisor	GOH Shu Ting
Laboratory Work	Computer work
N0. of students	1
CA1	Layout Kalman filter structure and initial error analysis of object's centroid tracking
CA2	Present the rotation rate prediction and the associate error covariance prediction.

FYP Proposal ID: SP33

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Developing a precise and scalable satellite tracking system
Summary (200 – 400 words)	The Satellite Technology and Research (STAR) centre has developed 4 12U microsatellites, which are Lumelite-1 to Lumelite-4 satellites. The Lumelite-4 has been launched in April 2023, while Lumelite-1 to Lumelite-3 will be launched by end of 2024. In recent years, the numbers of satellite being launched into low-earth orbit has been significantly increased, which results in a lower efficiency of space object tracking by ground phase array system. As a result, the ground communication radar may not able to properly track the satellite in space. Therefore, this project aims to develop a precise and highly scalable batch processing algorithm for satellite orbit prediction using GPS data. Synthetic satellite orbit data will be provided to student to verify the implemented algorithm. Student will use the real satellite GPS data, available from UCAR CDAAC to implement the coordinate conversion method, then verify the implemented algorithm. The implemented algorithm will help NUS STAR ground station to have a better efficiency performance in ground-to-space communication. The project scope includes: **(1)** Literature review of orbital mechanics of satellite; **(2)** Literature review of sequential and batch estimation algorithm; **(3)** Literature review of coordinate conversion; (4) To apply coordinate conversion on GPS data; **(5)** To select and implement batch estimation algorithm for satellite ephemeris generation; **(6)** To develop the software graphic user interface (GUI) for satellite tracking system. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with batch estimation algorithm; (2) To understand the basic of coordinate conversion; (3) To understand the basic of error analysis method; (4) To be skilled at python and/or Matlab programming; (5) To understand the orbital mechanics. The achievable outcomes by the FYP students are: (1) To apply coordinate conversion on GPS, to convert from earth-centred-earth-fixed frame to earth-centred-inertial frame; (2) To implement information fusion on the GPS data to obtain satellite orbital elements; (3) To investigate possible weighting strategy in batch estimation algorithm to improve orbit prediction accuracy. **Python knowledge is a must. Matlab knowledge is optional.**
Supervisor	GOH Shu Ting
Laboratory Work	N/A
N0. of students	1
CA1	Satellite orbital information prediction by using synthetic satellite orbit data
CA2	Satellite ephemeris data generation by using GPS data with GUI

FYP Proposal ID: SP34

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Satellite on-board payload data processing system
Summary (200 – 400 words)	The Satellite Technology and Research (STAR) centre has developed 4 12U microsatellites, which are Lumelite-1 to Lumelite-4 satellites. The Lumelite-4 has been launched in April 2023, while Lumelite-1 to Lumelite-3 will be launched by end of 2024. Typically, large amount of payload's image data is required to be downloaded to ground station before the payload data post-processing is initiated. However, the payload downlink process would result in a lower overall operation efficiency, due to the reason that the low-earth orbit satellite's ground contact period is only last for 10 to 12 minutes. In this project, student(s) to integrate camera payload, embedded hardware system and object detection and classification algorithm to develop a low-cost satellite on-board payload data processing system. Students will select and integrate the camera into embedded hardware system to demonstrate the satellite's payload subsystem. In addition, student(s) will implement the object tracking algorithm, such as you-only-look-once (YOLO) for object detection and classification on the image captured by the camera. Student(s) will also study the feasibility of integrating the object detection and classification algorithm into the embedded system. The project scope includes: **(1)** Literature review of embedded hardware system; **(2)** Literature review of camera devices; **(3)** Literature review of object detection and classification methods; (4) Integration of camera and embedded hardware system kit; **(5)** Integration of machine learning algorithm with payload data. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with c programming language; (2) To be familiar with embedded system; (3) To be familiar with object tracking algorithm; (4) To be familiar with python programming language The achievable outcomes by the FYP students are: (1) To integrate camera payload and embedded hardware system; (2) To simulate satellite payload operation via embedded hardware system; (3) To apply object detection and classification on image/video data; (4) To train the object classification and tracking algorithm. **Python knowledge is a must. Matlab knowledge is optional.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	GOH Shu Ting
Laboratory Work	Benchtop laboratory
N0. of students	2
CA1 requirement	1. Embedded hardware and Camera selection; 2. Preliminary firmware implementation; Hardware procurement; 3. Trained object tracking algorithm for at least once.
CA2 requirement	1. Integration of camera and embedded system; 2. Apply object tracking on captured image/video.

FYP Proposal ID: SP35

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of fault monitoring and detection system for satellite
Summary (200 – 400 words)	The Satellite Technology and Research (STAR) centre has developed 4 12U microsatellites, which are Lumelite-1 to Lumelite-4 satellites. The Lumelite-4 has been launched in April 2023, while Lumelite-1 to Lumelite-3 will be launched by end of 2024. Nowadays, large number of small satellites are being launched as a constellation to achieve a higher operation efficiency. For example, Starlink has launched more than 1000 satellites. However, it requires large amount of manpower to continuously monitor each satellite's health. Therefore, an intelligent system that could automatically detects satellite's fault or anomaly is highly desired. This project aims to develop an artificial intelligent (AI) based fault monitoring and detection system for satellite. In this project, student to study different fuzzy based AI or machine learning (ML) algorithm. Student will also study the feasibility of integrating two AI/ML algorithms, if required. In addition, student will study and learn the relationship between different satellite subsystems, to identify all the possible fault for algorithm training purposes. Student may obtain the relevant dataset via available resources or generate the relevant dataset for training and test purposes. The project scope includes: **(1)** Literature review of fuzzy based AI and ML algorithms; **(2)** Literature review of satellite subsystems; (3) To train the selected AI/ML algorithm; **(4)** To implement the trained algorithm on various test dataset. Student(s) are expected to develop the following skills (**learning outcome**): (1) To be familiar with different AI or ML algorithms; (2) To understand the satellite subsystem and components; (3) To be skilled at python. The achievable outcomes by the FYP students are: (1) To obtain or generate the satellite system data; (2) To implement and train the AI/ML algorithms; (3) To demonstrate the trained AI/ML algorithms using various test dataset. **Python knowledge is a must.**
Supervisor	GOH Shu Ting
Laboratory Work	N/A
N0. of students	1
CA1 requirement	1. Study and identify the fuzzy based AI/ML algorithms to be required, 2. Generate/Obtain required training dataset, 3. Train at least one algorithm.
CA2 requirement	1. Demonstrate the implemented AI/ML algorithms, 2. Report the test results of implemented algorithm.

Proposal ID: SP36

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	IoT-based Smart farming system
Summary (200 – 400 words)	Traditional agriculture is vulnerable to nature's vagaries. To meet the food security requirement, agriculture must adapt latest technology. In this project, a low-cost, and durable Internet of Things (IoT)-based smart system will be developed for cultivating short-duration vegetables, flowers, and fruits in urban terraces with minimal user attention. The proposed system can monitor environmental parameters (temperature and humidity) and control soil elements such as soil moisture and soil nutrients. The system can be deployed with pre-existing Wi-Fi infrastructure in the farmer's home with or without an internet connection. The proposed smart farming system is easy to install, scalable, robust in terms of data security, and developed on open-source platforms with a cost-effective hardware component. The project scope includes: (1) Literature review of IoT; (2) Implementation of a prototype IoT system with required sensors (3) Connection of sensors to IoT server (4) Demonstration of the remote monitoring Students are expected to develop the following skills (learning outcome): • To understand requirements for Plant growing; • To be able to do microcontroller programming to connect the sensors • To be able to implement a web-based UI; • To be able to do necessary debugging and testing The deliverable outcomes by the FYP students for the CA assessment are: (1) To complete the system design (2) To complete the necessary hardware setup (3) To do necessary webpage programming (4) To demonstrate the complete system
Supervisor	Dr. Sahoo (elesahoo@nus.edu.sg)
Laboratory work	Microcontroller programming, sensor integration, Web based UI design
No. of students	2
CA1 requirement	Literature survey, Design of hardware system
CA2 requirement	Connecting with IoT server, demonstration of the working system

Proposal ID: SP37

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	IoT-based Smart Office System
Summary (200 – 400 words)	Proper lighting and temperature control in buildings are important for a conducive work environment, and their transformation into digital, smart environments. These two also play a pivotal role in reducing the energy footprint of cities. Connected indoor lighting and temperature control systems, with embedded sensing, control, and networking technologies, can provide an attractive platform for enabling data to optimize building control operations and also improve the performance of enterprise management systems. In this project, the architectural elements of a connected indoor environment management system will be developed. The system will be a prototype for easy and scalable integration of services in a building Internet of Things ecosystem. Other applications like energy monitoring, and remote system monitoring can be added to this system. The project scope includes: (1) Literature review on smart lighting in workplaces. (2) Connection the sensors through the microcontroller (3) Programming of the controller to read the sensors and output the necessary control signals (4) Develop a mobile App to monitor and control the lighting Students are expected to develop the following skills (learning outcome): (1) To understand the requirement for indoor lighting. (2) To design the sensor network system (3) To be able to do microcontroller programming to connect the sensors (4) To be able to develop the mobile App The deliverable outcome by the FYP students for the CA assessment are: (1) To be able to design the overall lighting and control system based on indoor conditions (2) To complete the necessary microcontroller programming (3) To develop the mobile App for the system (4) To demonstrate the working system and submit the thesis
Supervisor	Dr. Sahoo (elesahoo@nus.edu.sg)
Laboratory work	microcontroller programming for connecting the sensors
No. of students	2
CA1 requirement	Literature survey, system conceptualization
CA2 requirement	Microcontroller programming, demonstration of the working system, Thesis writing

Proposal ID: SP38

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and performance analysis of EV battery charging system
Summary (200 – 400 words)	Battery use is increasing by the day. The battery is an important component in electric vehicles and the adoption of electric vehicles for clean transportation depends on the affordability of batteries. A charger is used for storing electricity in rechargeable batteries. At the heart of a battery charger is a current-controlled DC-DC converter that pushes certain currents into the battery. The charging current profile of the battery depends on the type of battery and the state of charge of the battery. Battery life will be reduced if the recommended charging profile is not followed. This project will do a MATLAB/Simulink-based model for such a battery charging system. The operation of the charger will be studied and its efficiency will be evaluated. The project scope includes: **(1)** Literature review on battery type **(2)** Literature review of battery charging infrastructure **(3)** Development of the battery charger Simulink model and control circuit **(4)** Simulation studies under different operating conditions **(5)** Report writing Students are expected to develop the following skills (learning outcome): (1) To understand the operation of the power converter for the charger (2) To be able to implement a suitable controller for the chargers (3) To be able to design a charging system for given application (4) To be able to do loss calculation and evaluation of system efficiency. The deliverable outcome by the FYP students for the CA assessment are: (1) To complete a literature survey for choosing circuit topology (2) To develop MATLAB/Simulink model (3) To conduct simulation studies under various operating conditions (4) To write a thesis based on simulation studies
Supervisor	Dr. Sahoo (elesahoo@nus.edu.sg)
Laboratory work	NA
No. of students	2
CA1 requirement	Literature survey, develop MATLAB/Simulink model
CA2 requirement	To conduct simulation studies under various operating conditions, to write a thesis based on simulation studies

Proposal ID: SP39

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Estimation of Remaining Useful Life (RUL) of electrical equipment using Machine Learning Approaches
Summary (200 – 400 words)	The remaining useful life (RUL) is the capability of the machine to function before a replacement or repair is required. Estimation of RUL is important in predictive maintenance. It helps in optimizing operating efficiency and avoiding unplanned downtime. This project is based on the detection and calculation of the RUL life of electrical equipment. For calculating the remaining useful life, parameters like temperature, current, and voltage are measured from the sensors and are given as data sets to the machine learning algorithm. The obtained data sets are trained using Machine learning algorithms like K-Nearest Neighbor (KNN), Gaussian Naive Bayes, Random Forest, and Support vector machine (SVM). The project scope includes: (1) Literature review on methods used in the prediction of RUL (2) development of DATA models (3) Testing the performance of the data models Students are expected to develop the following skills (learning outcome): (1) To understand various methods used for the prediction of RUL (2) To be able to develop data models. (3) To be able to do necessary tests on the performance of the data models The deliverable outcome by the FYP students for the CA assessment are: (1) To do a literature survey (2) To complete the necessary programming for data models (3) To do testing on the data models (4) To write a thesis based on the findings
Supervisor	Dr. Sahoo (elesahoo@nus.edu.sg)
Laboratory work	NA
No. of students	2
CA1 requirement	Literature survey, development of data models
CA2 requirement	Testing the models on standard data sets and writing the thesis

Proposal ID: SP40

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Digital twin for EV drive system
Summary (200 – 400 words)	A digital twin is a digital equivalent of a physical object or machine. Both digital and physical twins share a two-way data connection. The digital twin has both analytical as well as data-based models of the physical system. The digital twin can be used to predict the performance of the object in the future. This is useful for scheduling preventive maintenance of the system. In this project, we shall develop a digital twin for some components of an EV drive system. The project scope includes: (1) Literature review on digital twin and EV drive system (2) MATLAB/Simulink-based model of the EV drive system and its digital twin (3) Development of an Algorithm to obtain parameters of the digital twin (4) Demonstration of the overall system under various fault conditions Students are expected to develop the following skills (learning outcome): **(1)** To understand the working of the EV drive system **(2)** To be able to develop MATLAB/Simulink-based digital twin for the drive system **(3)** To identify model parameters for the digital twin The deliverable outcome by the FYP students for the CA assessment are: (1) To complete the modelling of the digital twin of the EV drive system (2) To accurately identify the model parameters (3) To simulate different faults and validate the performance of the digital twin (4) To demonstrate the overall system
Supervisor	Dr. Sahoo (elesahoo@nus.edu.sg)
Laboratory work	NA
No. of students	2
CA1 requirement	Literature survey, MATLAB/Simulink-based modeling
CA2 requirement	Completion modelling, Simulation studies, and thesis writing

Proposal ID: SP41

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	PT symmetric topological circuits for sensing applications
Summary (200 – 400 words)	In 2018, it was found that electrical circuits composed of basic components such as resistors, capacitors, inductors and op-amps, can exhibit topological behaviour. These circuits are known as topolectrical (TE) circuits. Their electrical outputs can mimic novel topological materials such as Weyl semimetals. In this project, we will analyze a dual-ring (gainy-lossy) TE circuit. The objective is to model, design, optimize and finally implement TE circuits for sensing application. The sensing circuit will be designed with the optimal PT (parity time) symmetry to achieve the highest sensitivity. We will design and characterize realistic hybrid circuits using the LTspice library which incorporates parasitic components as well as tolerance range of normally available circuit components. The project scope includes: i) Literature review of research articles covering TE circuits ii) Apply Kirchhoff's laws to verify the analogy between the output of TE circuits and the corresponding Hamiltonian of quantum systems iii) Study non-Hermitian TE circuits and the PT symmetry of the such circuits iv) Modelling of the TE circuits with circuit simulation software e.g. LTspice. v) Study and optimize the eigenspectrum of the TE circuits under different PT symmetry vi) Study and quantify the sensitivity of the sensing circuit Students are expected to develop the following skills (learning outcome): i) Realistic circuit simulations using simulation packages such as LTspice ii) Analytical and numerical programming skills with Mathematica or Matlab iii) Able to design and implement INIC which is required for non-Hermiticity and gainy/lossy behaviour. iv) Able to design and analyze PT symmetry-based TE circuits v) Able to design the PCB of PT symmetry based TE circuit for sensing application The deliverable outcome by the FYP students for the CA assessment are: i) General design and characterization of PT-based TE circuits ii) Actual PCB design and implementation of PT-based TE circuits If there are two students to work on the project, each student should take charge of different aspects of the circuit design, PCB design and circuit implementation.
Supervisor	Mansoor Bin Abdul Jalil
Laboratory Work	Matlab, Mathematica and LTspice software, PCB design and circuit characterization
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	General theory and implementation of basic TE circuits
CA2 requirement	To achieve the goals set out in Deliverables (i) and (ii).

Proposal ID: SP42

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Non-Hermitian topological ring sensor
Summary (200 – 400 words)	In 2018, it was found that electrical circuits composed of basic components such as resistors, capacitors, inductors and op-amps, can exhibit topological behaviour. These circuits are known as topolectrical (TE) circuits. Their electrical outputs can mimic novel topological materials such as Weyl semimetals. In this project, we will analyze a non-Hermitian TE ring circuit with non-reciprocal coupling. The objective is to model and design a sensor circuit based on the changes to the terminal coupling capacitance. The sensing circuit will be designed with the optimal circuit component values to achieve the highest sensitivity. The circuit design will be carried out using the LTspice library which incorporates realistic parasitic components as well as tolerance range of normally available circuit components. The circuit output will be characterized as a function of various parameters, e.g. terminal coupling, system length, degree of non-reciprocity. The project scope includes: i) Literature review of research articles covering basic TE circuits ii) Study of basic Hermitian TE circuits such as the SSH circuit iii) Study of basic non-Hermitian TE circuits such as the Hatano-Nelson circuit iv) Study the non-Hermitian ring sensor circuit. v) Modelling of the TE ring circuits with circuit simulation software e.g. LTspice. vi) Study and optimizing the output of the TE ring sensor circuits vii) Characterizing the sensitivity of the sensing circuit as a function of various circuit parameters Students are expected to develop the following skills (learning outcome): i) Realistic circuit simulations using simulation packages such as LTspice ii) Analytical and numerical programming skills with Mathematica or Matlab iii) Able to design and implement INIC which is required for non-Hermiticity and gainy/lossy behaviour. iv) Able to design and analyze ring-based TE sensor circuits v) Able to design the PCB of ring-based TE circuits for sensing application The deliverable outcome by the FYP students for the CA assessment are: i) General design and characterization of ring-based TE sensor circuits ii) Actual PCB design and implementation of ring-based TE sensor circuits If there are two students to work on the project, each student should take charge of different aspects of the circuit design, PCB design and circuit implementation.
Supervisor	Mansoor Bin Abdul Jalil
Laboratory Work	Matlab, Mathematica and LTspice software, PCB design and circuit characterization
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	General theory and implementation of basic TE circuits
CA2 requirement	To achieve the goals set out in Deliverables (i) and (ii).

Proposal ID: SP43

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	LC Electrical circuits for quantum gate implementations
Summary (200 – 400 words)	In 2020, it was found that electrical LC circuits composed of basic components such as capacitors and inductors can be used to implement universal quantum gates such as the phase shift gate and CNOT gate. In this project, we will design LC electrical circuits to emulate all the universal quantum gates (Hadamard, CNOT and phase shift). We will determine the optimum time evolution of the circuit components to achieve the best quantum outputs. We will compare the outputs with the publicly available IBM Quantum Computing tool. Finally, we will design and characterize realistic LC quantum gate circuits using the LTspice library which incorporates parasitic components as well as tolerance range of normally available circuit components. The project scope includes: i) Literature review of research articles covering LC circuits emulating quantum gates ii) Learn the basics of quantum gate operations iii) Apply Kirchhoff's laws to verify the output the LC circuits emulating quantum gates iv) Optimizing the time evolution of the LC circuits v) Modelling the LC circuits with circuit simulation software e.g. LTspice vi) Extending beyond the basic quantum gates, e.g. to non-unitary quantum gates Students are expected to develop the following skills (learning outcome): i) Realistic circuit simulations using simulation packages such as LTspice ii) Analytical and numerical programming skills with Mathematica or Matlab iii) Able to design and implement quantum gates based on LC circuits The deliverable outcome by the FYP students for the CA assessment are: i) General design and characterization of LC-based quantum gate circuits ii) Optimization and verification of quantum gate operations iii) Implementation of LC telegraph circuit if there is time If there are two students to work on the project, each student should take charge of different aspects of the circuit design, circuit optimization and LT Spice simulation.
Supervisor	Mansoor Bin Abdul Jalil
Laboratory Work	Matlab, Mathematica and LTspice software
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	General theory and study of basic LC based quantum gate circuits
CA2 requirement	To achieve the goals set out in Deliverables (i) and (ii).

FYP Proposal ID: SP44

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Deep Learning-Assisted Terahertz Reconfigurable Metasurface Design based on MEMS Technology
Summary (200 – 400 words)	Terahertz metamaterials play important roles in electromagnetic wave manipulation for wireless communications. Traditional metamaterial structure design usually requires expert guidance, geometry fine-tuning, parameter sweeping, and iterative optimization. This procedure is highly time-, labour-, and resource-consuming especially when faced with complicated structures. Recently, deep learning techniques have been developed for simplifying and accelerating the design process, while most studies investigate one-dimensional parameter optimization with fixed geometry structure or two-dimensional geometry pattern design with low diversity and quality. To address these limitations, this project will develop advanced deep learning frameworks to realize automatic, fast, and high-free-of-degree design for MEMS-based terahertz reconfigurable metasurface with beam-steering functionalities. The project scope includes: (1) Literature review of terahertz metasurface based on MEMS and relevant technologies. (2) Investigation on basic deep learning techniques and related applications. (3) Software study with Lumerical FDTD simulation, Python coding, and data analysis. (4) Hardware study with the fabrication of terahertz metasurface. (5) Integration of hardware and software for interactive training exercise. Students are expected to develop the following skills (**learning outcome**): • To understand device design process of terahertz reconfigurable metasurface based on MEMS. • To be skilled at deep learning model design and data analysis. To be skilled at simulation and programming. To be familiar with hardware and software integration. The achievable outcomes by the FYP students are: (1) To design terahertz metasurface for beam steering. (2) To design digital switch based on MEMS integrated into the terahertz metasurface; (3) To develop deep learning models to optimize the metasurface design process. (4) To achieve reconfigurable beam steering functions on the terahertz metasurface. **Prior experience of software or hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Chengkuo Lee
Laboratory Work	Device measurement
N0. of students	2
CA1 requirement	Literature review on related technology and preliminary prototype with hardware and software development
CA2 requirement	Terahertz reconfigurable metasurface device for beam steering with complete hardware and software systems

FYP Proposal ID: SP45

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	CMOS Infrared metamaterial-based Bound states in the continuum (BICs) for ultrasensitive sensing applications
Summary (200 – 400 words)	The mid-infrared (mid-IR) spectrum is essential for sensing because of the presence of characteristic molecular absorption fingerprints originating from the intrinsic vibrational modes of chemical bonds. Mid-IR spectroscopy allows direct characterization of molecular structures with chemical specificity unique to this spectral range, and is therefore widely recognized as the gold standard for chemical analysis. However, because of the mismatch between mid-IR wavelengths and dimensions of molecules, the sensitivity of mid-IR spectroscopy is limited when detecting signals from nanometer-scale samples, biological membranes, or low numbers of surface-bound molecules. Recently, nanophotonics based on BIC (Bound state in the continuum) can overcome this limitation. When the resonance is spectrally overlapped with the absorption fingerprints, the enhanced molecule-resonator coupling can lead to a change in either the frequency or the strength of the resonance, from which the molecular fingerprints can be extracted. In this project, the students are required to do the simulation of IR metamaterial-based BICs for ultrasensitive sensing applications. The project scope includes: (1) Literature review of IR plasmon and BIC technologies and functional metamaterials; (2) Simulation study using Lumerical-FDTD to design plasmon and BICs in IR region; (3) Optimization of the proposed design for sensing applications; Students are expected to develop the following skills (**learning outcome**): • To understand the basic knowledge of metamaterials and BICs; • To be familiar with Lumerical-FDTD and the whole metamaterial design process; • To think systematically, and understand the basic knowledge of device fabrication and characterization process; The **deliverable outcome** by the FYP students for the CA assessment are: Student 1: To complete the metamaterial design and simulation; To optimize the Q resonance of the **metal plasmonic** BIC phenomenon; To optimize the design and achieve ultra-high sensitivity; To demonstrate ultrasensitive vibrational spectroscopy. Student 2: To complete the metamaterial design and simulation; To optimize the design and achieve ultra-high Q **tunable** BIC resonance; To numerically model the sensing materials. To demonstrates highly responsive sensing applications based on changes in complex permittivity.
Supervisor	Chengkuo Lee
Laboratory Work	Lumerical-FDTD
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review of IR metamaterial-based BICs and numerical study using simulation tools
CA2 requirement	Design, simulation, and optimization of IR metamaterial-based BICs for ultrasensitive infrared sensing applications

Proposal ID: SP46

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Machine-learning augmented mid-infrared VOC spectroscopy using nanoantenna-enhanced piezoelectric IR detector array
Summary (200 – 400 words)	High-performance infrared (IR) detectors are key components for optical sensing applications. Recently, metamaterial, which can resonantly enhance the IR light absorption and thus provide selectivity to the sensing analytes, is rising as a heated topic with numerous stunning characteristics. Surface acoustic wave (SAW) or lamb wave, featuring high sensitivity to the temperature produced by IR light absorption, is promising for the design of high-sensitivity infrared detectors. In this project, the student is required to design and optimize a metamaterial-integrated infrared detector based on SAW or lamb wave and, finally, demonstrate the VOC detection for potential healthcare diagnosis. The project scope includes: (1) Literature review of the current infrared detector and the metamaterial with sensing demonstration. (2) Metamaterial design and optimization for the resonant absorption of infrared light. (3) Evaluation of frequency shift of SAW/lamb wave caused by the light absorption. (4) Analysis of the sensing performance based on the proposed infrared detector. Student is expected to develop the following skills (learning outcome): (1) To obtain a basic knowledge of metamaterial, SAW/lamb wave, and infrared detectors. (2) To be familiar with metamaterial design and optimization through simulation. (3) To be familiar with frequency shift-based infrared sensing mechanism. (4) To be enabled with infrared detector performance analysis through theoretical calculation and numerical simulation. The achievable outcomes by the FYP student are: (1) To complete the design and optimization of metamaterial with absorption resonance to the specific infrared wavelength range. (2) To complete the evaluation of the frequency shift of SAW/lamb wave caused by the light absorption. (3) To analyse the performances of the designed metamaterial based infrared detectors, and the demonstration of sensing applications. Reference: (1) https://www.ece.nus.edu.sg/stfpage/elelc/Publication/2020/ACS%20NANO_20V14_9_Nanometer-Scale%20Heterogeneous%20Interfacial%20Sapphire%20Wafer%20Bonding%20for%20Enabling%20Plasmonic-Enhanced%20Nanofluidic%20Mid-Infrared%20Spectroscopy_Jikai%20XU.pdf (2) https://www.nature.com/articles/ncomms11249
Supervisor	Chengkuo Lee
Laboratory work	Advanced Microelectronic Centre, NUSRI Software: COMSOL, MATLAB, Lumerical
No. students	2
CA1	design and simulation of surface acoustic wave and metamaterial for infrared detection.
CA2	Infrared detector performance analysis.

Proposal ID: SP47

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Photonic neural network design and optimization for machine learning acceleration
Summary (200 – 400 words)	The increased demand for machine learning on vast datasets and the growing demand of AI services on the cloud has driven a resurgence in custom hardware designed to accelerate MAC computations—the fundamental mathematical element for matrix-vector multiplication (MVM) operation. Although various custom silicon computing hardware—that is, field-programmable gate arrays (FPGAs), ASICs and graphics processing units (GPUs)—have been developed to improve computational throughput and efficiency, they still depend on the same underlying electronic components, which are fundamentally limited in both speed and energy by Joule heating, electromagnetic crosstalk and parasitic capacitance. Photonic neural network (PNN) benefit from high bandwidth and parallel data process ability, which have led to the ubiquity of photonic integrated circuits for information transfer and machine learning acceleration. In this project, the students are required to design and optimize the PNN for machine learning acceleration. The project scope includes: (1) Literature review of basic optical devices and principles. (2) Literature review of photonic synapses and photonic neuromorphic computation technology. (3) Photonic synapse design and optimization based on optical simulation. (4) Performance characterization of photonic synapse, such as weight tunability and robustness (5) Performance analysis of the designed photonic neural network. Student is expected to develop the following skills (learning outcome): (1) To obtain basic knowledge of artificial neural network and neuromorphic computing. (2) To be familiar with photonics devices design (e.g. waveguide, ring resonator, Mach-Zehnder interferometer etc.) and optimization through simulation. (3) To be familiar with commonly used deep learning neural networks. (4) To be familiar with some basic neural network optimization algorithms The achievable outcomes by the FYP student are: (1) To complete the design and optimization of photonic synapses. (2) To complete the integration of photonic neural network based on simulation. (3) To analyse the performance of the designed network and find way to further improve it.
Supervisor	Chengkuo Lee
Laboratory facilities to be used	Software: Lumerical, COMSOL, Python, Matlab
Number of students	2
CA1 requirement	Design and simulation of photonic synapse including weighting and robustness.
CA2 requirement	Complete the design of the integrated photonic neural network.

Proposal ID: SP48

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Tactile Sensors for E-Skin in Cognitive Robots
Summary (200 – 400 words)	Tactile perception is instrumental in the evolution of future cognitive and intelligent robotics and wearable devices, as it allows them to comprehensively and closely explore their surroundings, achieve more versatile functions (such as healthcare monitoring and object recognition), and become the nexus for human-machine interactions. Emulating the human somatosensory system, researchers have investigated numerous techniques to build tactile sensors with multimodal sensing capability to replicate the functions of skin sensory neurons. To achieve a comprehensive tactile sensor with multimodal sensing capability, students are required to do a comprehensive paper review and design and fabricate the tactile sensor using multiple principles to achieve proposed specific applications. The project scope includes: (1) Literature review of tactile sensors (2) Fabrication of tactile sensors with basic hands-on ability (3) Output measurements of designed tactile sensors through an oscilloscope (4) Practical measurements tactile sensors and analyzed with machine learning Students are expected to develop the following skills (learning outcome): • To understand basic knowledge for various kinds of sensing principles, • To learn methods to use commercialized tactile sensors • To learn basic program to analyze sensor signals with artificial intelligence • To be skilled at 3D mechanical drawing software, • To be familiar with basic circuit design; • To be skilled at the usage of basic measurement equipment like the oscilloscope. The achievable outcomes by the FYP students are: (1) To complete the sensor design and fabrication; (2) To use artificial intelligence to analyze sensors' output signals; (3) To apply the sensor in several specific practical applications;
Supervisor	Chengkuo Lee
Laboratory facilities to be used	Software: Solidworks, AutoCAD, Matlab, Python Equipment: Oscilloscope
Number of students	2
CA1 requirement	Paper review, design, and fabrication of tactile sensors regarding proposed specific application scenarios.
CA2 requirement	Measurements of sensors, AI analysis of sensors, advanced applications achieved through AI and multimodal tactile sensors

FYP Proposal ID: SP49

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Intelligent Robotic manipulators with multi-modality perception ability
Summary (200 – 400 words)	Recent developments in robotics increasingly highlight the importance of sensing technology, especially tactile perception, in enabling robots to effectively engage with their environment and interpret physical interactions. Triboelectric nanogenerators (TENGs) have become a good choice for robot perception due to their high flexibility, high stretchability, low cost and self-powered property. Between, MEMS-based piezoelectric micromachined ultrasonic transducers (pMUTs) also show the potential to enable the remote perception with low power consumption. This project is to design a multi-modality smart sensing system consisting of TENG sensors for tactile sensing, e.g., pressure, strain, etc., and pMUT sensors for remote perception, to realize a multi-modal robotic sensing system. The project scope includes: (1) Literature review of state-of-art sensors for robots, especially based on pMUT and triboelectric mechanism; (2) Structure design and fabrication of TENG sensors with SolidWorks platform and 3D printing technology. Simulation and test of the pMUT sensors, and the system integration. (3) Signal processing and fusion of fabricated multi-modality sensors with deep learning technologies; Demonstration for advanced perception tasks, i.e., object recognition, and human-machine interactions. Students are expected to develop the following skills (**learning outcome**): (1)To understand basic knowledge of pMUT and triboelectric mechanism; (2)To be equipped with the ability to design the structure of some simple flexible sensors with SolidWorks and 3D printing. (3) To be capable of doing the simulation and optimization of the pMUT sensor. (4)To be skilled at C and Python programming; (5)To be familiar with the deep learning enabled data fusion; (6)To be skilled at system integration and the construction of human-computer interaction interface. The achievable outcomes by the FYP students are: (1) To complete the device design and fabrication; (2) To optimize the sensor design to achieve desirable stability and sensitivity. (3) To optimize the signal fusion algorithm to enhance the performance of the multi-modal sensory system. (4) To implement the system integration and realize the machine learning enabled perception tasks for practical application. If there are two students to work on the project, one student focus on the sensor design and data fusion algorithm, and another student focus on the soft robot design and system integration.
Supervisor	Prof. Chengkuo Lee
Laboratory work	Oscilloscope, 3D printer, SolidWorks, COMSOL, Python, Arduino
No. of students	2
CA1 requirement	Complete the sensor design and fabrication, and system integration.
CA2 requirement	Demonstration for advanced perception tasks, i.e., object recognition, and human-machine interactions.

FYP Proposal ID: SP50

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Research and development of deployable antennas for small satellites
Summary (200 – 400 words)	The objective of the project is to research and develop concepts for deployable antennas for application in small satellites. Small satellites typically have a low volume and relatively low weight. At the same time, radio antennas are relatively large for communication and remote sensing applications. To realize applications with such antennas requires the development of antennas that can be compactly stowed and deployed once the small satellite in space. Various concepts have been proposed in literature and this project aims to build and improve on that. The project scope includes: (1) Literature review of deployable antennas for small satellites; (2) Review of planar array antennas and parabolic dish antennas; (3) Conceptual design of the innovative deployable antenna; (4) Implementation and demonstration of the design, including deployment mechanism. Students are expected to develop the following skills (**learning outcome**): • To understand small satellites and their constraints; • To be familiar with planar antennas and parabolic antennas; • To be familiar with mechanical design tools and fabrications tools; • To be able to develop an innovative deployable antenna concept. The achievable outcomes by the FYP students are: (1) To develop the concept for an innovative, compact, and deployable antenna; (2) To implement the concept as a demonstrator, including the deployment mechanism; **Prior experience of software and hardware implementation is a must.** This project requires two students to work closely together to achieve the outcome.
Supervisor	Koen Mouthaan
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Literature review, development of several competing concepts
CA2 requirement	Selection of the concept, and implementation in a demonstrator

FYP Proposal ID: SP51

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Stable scatterers in Sentinel I synthetic aperture radar data
Summary (200 – 400 words)	The objective of the project is to explore the publicly available Sentinel I synthetic aperture radar (SAR) images to identify stable scatterers I urban environments. The synthetic aperture radar (SAR) images of the Sentinel I satellite are made publicly available by the European space agency (ESA). The SAR images are at C band with a reasonable resolution. The objective of this project is to analyze a longer tern time series to determine scatterers with highly stable scattering performance over time in a build environment. A similar effort is ongoing at the research group in Singapore and some guidance will be provided. The project scope includes: (1) Literature review on SAR imagining and ESA's sentinel I; (2) Familiarization and application with SNAP (Sentinel Application Platform); (3) Identification of an urban environment with sufficient scatters; (4) Research of time series of selected scatterers; (5) Statistical assessment of stability of scatterers. Students are expected to develop the following skills (**learning outcome**): • To understand radar scattering mechanisms; • To understand synthetic aperture radar (SAR) imaging; • To be familiar with Sentinel Application Platform; • To apply SNAP for the identification of stable scatterers; • To apply statistical processing to determine the time series stability of stable scatterers. The achievable outcomes by the FYP students are: (1) To identify stable scatterers in an urban environment, such as a large city in China; (2) To determine the stability of the stable scatterers through statistical data processing of time series of Sentinel I data; . This project requires two students who are keen to work together to learn more about SAR imaging and statistical processing of SAR data.
Supervisor	Koen Mouthaan
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Literature review, familiarization with SNAP
CA2 requirement	Selection of urban area, identification of stable scatterers.

FYP Proposal ID: SP52

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Low-cost and lightweight corner reflectors for SAR calibration and verification
Summary (200 – 400 words)	The objective of the project is to develop and test low-cost and lightweight corner reflectors for SAR calibration and verification. Synthetic aperture radar (SAR) on satellites is used make SAR (radar) images of parts of Earth. An example of such a SAR satellite is Sentinel I, with its SAR images made publicly available by the European space agency (ESA). So-called corner reflectors (CR) are used to test the quality of the SAR images and several permanent corner reflectors are placed around the world for that purpose. A typical CR for Sentinel I can be about 2-3 meters at its base. A drawback of corner reflectors is that they are heavy and costly due to the metal parts used in the construction of the corner reflectors. This makes it cumbersome to transport corner reflectors in case of measurement campaigns. The objective of this project is to develop and test low-cost and lightweight CR that can be easily folded and transported. This may require the use of lightweight materials to be coated with thin metallic layers. The project scope includes: (1) Literature review on SAR imagining and ESA's sentinel I; (2) Develop an understanding of the principal operation of CR; (3) Development of concepts for lightweight and low-cost CRs; (4) Construction of CRs; (5) Measurement of CR response using Sentinel I data. Students are expected to develop the following skills (**learning outcome**): • To understand radar scattering mechanisms; • To understand synthetic aperture radar (SAR) imaging; • To understand the principal operation of CRs; • To develop novel concepts for low-cost and lightweight CR;; • To fabricate and test CRs. The achievable outcomes by the FYP students are: (1) Development of several concepts of lightweight and low-cost CRs; (2) Fabricated and tested lightweight and low-cost CR; (3) Possibly a conference contribution. This project requires two students who are keen to work together on the development of innovative and low-cost corner reflectors.
Supervisor	Koen Mouthaan
Laboratory Work	Bench-top instruments
N0. of students	2
CA1	Literature review, familiarization with SAR images, and corner reflectors;
CA2	Selection of CR concept, fabrication, and testing.

FYP Proposal ID: SP53

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Innovative application of low-cost radar modules
Summary (200 – 400 words)	The objective of the project is to develop innovative applications of low-cost radar modules. Low-cost radar modules typically cost a few dollars up to a few hundred dollars. An example of a low-cost radar module is the HB-100, and an example of an application of the HB-100 is the SEN0192 module. The HB-100 uses the Doppler effect to detect movement. These modules can be used, for example, to detect moving people and automatically open a door, The objective of this project is to develop innovative applications of the low-cost radar modules. An example could be a music instrument in which the movement of hands is translated into sound. The project scope includes: (1) Literature review of radar principles, including the Doppler effect; (2) Review of low-cost radar modules; (3) Development of several innovative concepts using low-cost radar modules; (4) Selection of concept for development; (5) Development and demonstration of an innovative application. Students are expected to develop the following skills (**learning outcome**): • To understand radar scattering mechanisms and the Doppler effect; • To understand the functional behavior of the selected radar module; • To apply (Doppler) radar signal processing; • To develop innovative concepts for applications of radar modules; • To fabricate and test an innovative application. The achievable outcomes by the FYP students are: (1) Development of several concepts of innovative applications of radar modules; (2) Fabricated and tested application of radar modules; (3) Possibly a conference contribution. . This project requires two students who are keen to work together on the development of innovative applications of low-cost radar modules.
Supervisor	Koen Mouthaan
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Literature review, familiarization with low-cost radar modules, testing of radar module;
CA2 requirement	Selection of concept, demonstration of innovative application of radar module.

FYP Proposal ID: SP54

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Real-Time Object Detection for Home and Office Environments Using Resource-Limited Hardware Platforms
Summary (200 – 400 words)	Object detection is essential for various applications in home and office environments, such as security, automation, and smart assistance. Deploying real-time object detection on resource-limited hardware platforms (like ESP32 and low-cost microcontrollers) enables localized processing, ensuring privacy, and reducing dependency on cloud services. This project aims to develop and implement an efficient and accurate real-time/low-latency object detection system that leverages machine image/video processing tools and learning models, optimized for resource-limited hardware. The resulting system will enhance automation and security applications, and the insights gained will be valuable for future developments in resource-constrained environments. The project scope includes: (1) Literature review of existing methods for object detection, edge AI frameworks and packages; (2) Hardware study using ESP32 microprocessor to capture image and process information, data record and storage wirelessly; (3) Select and train machine learning model on a server or cloud platform; (4) Optimize the model to fit in the resource-limited platform. (5) Develop a mobile app to communicate with the hardware, display the detection results and provide feedback. Students are expected to develop the following skills (**learning outcome**): • To be familiar at the object detection methods; • To be skilled at the microprocessor programming; • To be able to select and train suitable machine learning model for the application; • To be able to develop mobile app for data display and communications; The achievable outcomes by the FYP students are: (1) To design an object detection solution suitable for resource-limited platform; (2) To implement and optimize the image processing and machine learning model on the resource-limited hardware; (3) To improve the implementation based on testing results; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	A working real-time object detection system with improvement from the preliminary prototype.

FYP Proposal ID: SP55

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Hand Sign and Gesture Recognition System
Summary (200 – 400 words)	In recent years, gesture recognition technology has gained significant attention due to its applications in various fields such as human-computer interaction, virtual reality, and healthcare. This project aims to develop a robust hand sign and gesture recognition system using either motion sensors or cameras to interpret and respond to hand movements accurately. By combining hardware expertise with advanced algorithms, the system aims to enhance user interaction in various technological applications. The successful implementation will contribute to the growing field of gesture recognition and its practical applications. The project scope includes: (1) Literature review of hand sign and gesture detection methods; (2) Hardware study using microprocessor to interface with motion sensors and camera; (3) Develop mobile app to show the recognition results and provide feedback; (4) Evaluate accuracy and response speed of the prototype. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with algorithms for hand sign and gesture detection; (2) To be skilled at the microprocessor programming; (3) To be able to identify a suitable algorithm for the application; (4) To be able to develop mobile app for result display and provide feedback; The achievable outcomes by the FYP students are: (1) To design a hand sign and gesture recognition system; (2) To extract key features for the recognition from signals; (3) To implement and optimize the prototype system on the accuracy and response speed; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	A working real-time hand sign and gesture recognition system with improvement from the preliminary prototype.

FYP Proposal ID: SP56

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Augment Data Set for Smart Farming for Plant Growth Stages and Health
Summary (200 – 400 words)	The agricultural sector is increasingly leveraging advanced technologies to enhance productivity and sustainability. A critical component of these technologies is the use of machine learning and computer vision to monitor plant health and growth stages. However, the effectiveness of these models relies heavily on the availability of high-quality, diverse datasets. This project aims to augment existing datasets by creating a comprehensive, enriched dataset that covers various plant growth stages and illnesses, thereby supporting the development of robust smart farming solutions. This proposal outlines a detailed plan to augment the dataset for smart farming applications, providing a robust foundation for developing advanced agricultural technologies. The project scope includes: **(1)** Literature review of data set augmentation for machine learning; **(2)** Select a suitable machine learning model for plant growth stages and illness detection; (3) Collect and identify available data for plant growth stages and health; (4) Explore method for data set augmentation to improve the model performance; Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with machine learning models and training methods; (2) To be able design and train machine learning models for applications; (3) To be able to apply suitable methods for dataset augmentation; (4) To be able to develop metric to measure the improvement due to data augmentation; The achievable outcomes by the FYP students are: (1) To design and train a machine model for the application; (2) To develop algorithms for data augmentation; (3) To compare the effectiveness of different data augmentation approaches; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1 requirement	Identify available data sets and design a suitable model for the application. Propose augmentation methods for data set augmentation.
CA2 requirement	Augment the data sets identified and compare the model performance with the data generated with different augmentation methods.

FYP Proposal ID: SP57

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Error-correcting codes with Deep Learning Methods
Summary (200 – 400 words)	Error-correcting codes (ECC) are essential in ensuring the reliability of digital communications and data storage. Folded Reed-Solomon (FRS) codes and Block Product Codes (BPC) are two advanced types of ECCs known for their robustness and error correction capabilities. Traditional decoding methods for these codes, such as list decoding and iterative decoding, are often complex and computationally intensive. In practical applications, the code length are relative short and transitional code design methods cannot ensure their performance. The advent of deep learning has opened new avenues for solving complex problems in various domains. This project proposes to explore the application of deep learning methods to decode Folded Reed-Solomon codes and Block Product Codes. The aim is to develop deep learning models that can potentially offer more efficient, adaptable, and accurate decoding mechanisms compared to traditional methods. The project scope includes: (1) Literature review of iterative decoding of error-correcting codes by deep learning; (2) Understand Folded Reed-Solomon codes and block product codes and their traditional design and decoding algorithms; Design novel decoding algorithm based on deep learning for Reed-Solomon codes and product codes; Compare the performance with the traditional method and the method based on deep learning. Students are expected to develop the following skills (**learning outcome**): (1) To understand the iterative decoding of the folded Reed-Solomon codes and product codes using the traditional methods; (2) To understand the deep leaning models to be applied in the decoding; (3) To be able to develop and implement decoding algorithm based on deep learning; (4) To be able to compare the performance of the decoding algorithms; The achievable outcomes by the FYP students are: (1) To implement the traditional iterative decoding algorithms for folded Reed-Solomon codes and block product codes; (2) To develop novel decoding algorithms based on deep learning; (3) To compare the decoding performance and identify the factors of the performance; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1 requirement	Implementation of the traditional iterative decoding algorithm for folded Reed-Solomon codes and block product codes. Propose the algorithms based on the deep learning.
CA2 requirement	Implement the algorithms based on deep learning and improve their performance. Compare the performance and identify the performance factors.

FYP Proposal ID: SP58

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Fast GPS Spoofing using Software-defined Radio
Summary (200 – 400 words)	Global Positioning System (GPS) is an essential technology in modern navigation and timing applications. However, its signals are vulnerable to spoofing attacks, where a malicious actor transmits fake GPS signals to mislead the receiver. This project aims to explore and develop a method for fast GPS spoofing using Software-defined Radio (SDR) technology. This project aims to provide a comprehensive approach to understanding and demonstrating GPS spoofing using SDR. The results will contribute to the body of knowledge on GPS vulnerabilities and help in developing robust countermeasures to enhance the security of GPS-dependent systems. The project scope includes: (1) Review existing research on GPS signal structure and spoofing techniques; (2) Develop algorithms to generate GPS L1 C/A signals using SDR software; (3) Ensure the spoofed signals are synchronized correctly with the genuine GPS signals to deceive the receiver without raising alarms; (4) Use software tools such as GNU Radio and MATLAB for signal processing and SDR control. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with GPS signal format; (2) To be familiar with SDR hardware and software tools; (3) To be skilled at SDR software programming; (4) To be able to fast spoof GPS signal; The achievable outcomes by the FYP students are: (1) To prepare a comprehensive review of existing GPS spoofing techniques and SDR technologies; (2) To develop a fully functional software package for generating and transmitting GPS spoofing signals using the selected SDR platform; (3) To suggest effective anti-spoof methods; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1 requirement	A comprehensive review of existing GPS spoofing techniques and SDR technologies and a spoofing platform based on precious work.
CA2 requirement	A fast spoofing system including an implemented software package and SDR hardware configuration.

FYP Proposal ID: SP59

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Object detection using mm-Wave Radar
Summary (200 – 400 words)	The final year project is a critical component of undergraduate education, often determining students' preparedness for professional careers. Predicting student performance in these projects can help in identifying students who may need additional support and in improving educational outcomes. This project aims to develop a data-driven model to estimate student performance in their final year projects using various academic and non-academic data. The estimation can be based on data from the same student or data from previous students. By leveraging data analytics and machine learning, this project aims to provide a predictive model that estimates student final year project performance. This tool can aid educators in identifying at-risk students and enhancing their support strategies, ultimately improving educational outcomes. The project scope includes: (1) Gathering data from academic records, attendance, participation in extracurricular activities, demographic information, and other relevant sources; (2) Identifying significant predictors of project performance through statistical analysis and machine learning techniques; (3) Building predictive models using techniques such as linear regression, decision trees, random forests, and neural networks; (4) Creating an application or dashboard for educators to use the model in real-time. Students are expected to develop the following skills (**learning outcome**): (5) To understand the predicting model and the principle behind; (6) To be skilled at data pre-processing and exploratory data analysis; (7) To be skilled at model development and evaluation; (8) To be skilled at user-friendly interface development; The achievable outcomes by the FYP students are: (1) To produce a comprehensive dataset that includes all relevant factors influencing final year project performance; (2) To develop a robust predictive model capable of estimating student performance with high accuracy; (3) To develop an interactive tool for educators to use the predictive model in real-time; **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Zhang Jianwen
Laboratory Work	Bench-top instruments and desktop computer
N0. of students	2
CA1	Data collection and analysis, model design and validation.
CA2	Refined model and interface development, evaluate the results.

FYP Proposal ID: SP60

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Ultra-low power wake-up receiver
Summary (200 – 400 words)	RF transceiver for data transmission consumes significant amount of power budget. Hence, it is not viable to have an always-on transceiver. In order to ensure low latency and reliable communication, wake-up receiver becomes indispensable block. Its always-on feature demands ultra-low power consumption, which keeps monitoring the call for wake-up. Once wake-up signal is received, it will proceed to activate the normal transceiver for normal data transmission. This helps prolong the battery life of the system. The key challenge in wake-up receiver is on the ultra-low power consumption as well as high sensitivity comparable to the normal receiver in order to maintain the communication range. The project scope includes: (1) Literature review of various wake-up receiver architecture; (2) Design and simulate the low power wake-up receiver; (3) Evaluate the performance of the designed wake-up receiver and benchmark with other wake-up receiver; Students are expected to develop the following skills (**learning outcome**): (1) To understand the various wake-up receiver architecture; (2) To develop EDA tool usage skill set; (3) To develop schematic design and circuit simulation skill; (4) To be able to evaluate wake-up receiver performance; The achievable outcomes by the FYP students are: (1) A completed wake-up receiver architecture containing detailed transistor level schematic; (2) A complete simulation results to evaluate the wake-up receiver performance. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different architecture, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Need desktop and access to EDA tools such as Cadence. Alternatively can use LTSPICE or Dolphin SMASH.
N0. of students	2
CA1 requirement	Understand the various wake-up receiver architecture. Learn the usage of EDA tools
CA2 requirement	Completed schematic of the implemented wake-up receiver, and detailed simulation results of the wake-up receiver.

FYP Proposal ID: SP61

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	N-path receiver
Summary (200 – 400 words)	Nowadays, RF transceiver needs to deal with multiple wireless standard occupying different frequency spectrum. It is expensive to employ multiple external SAW filter to select the desired band and reject the unwanted interference. N-path architecture provides an integrated solution to achieve high-Q RF bandpass filtering by simply varying the carrier frequency. In this project, student will investigate and implement the state-of-the-art N-path receiver architecture The project scope includes: (1) Literature review of various N-path receiver architecture; (2) Design and simulate the N-path receiver; (3) Evaluate the performance of the designed N-path receiver and benchmark with other N-path receiver; Students are expected to develop the following skills (**learning outcome**): (1) To understand the various N-path receiver architecture; (2) To develop EDA tool usage skill set; (3) To develop schematic design and circuit simulation skill; (4) To be able to evaluate N-path receiver performance; The achievable outcomes by the FYP students are: (1) A completed N-path receiver architecture containing detailed transistor level schematic; (2) A complete simulation results to evaluate the N-path receiver performance. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different architecture, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Need desktop and access to EDA tools such as Cadence. Alternatively can use LTSPICE or Dolphin SMASH.
N0. of students	2
CA1 requirement	Understand the various N-path receiver architecture. Learn the usage of EDA tools
CA2 requirement	Completed schematic of the implemented N-path receiver, and detailed simulation results of the N-path receiver.

FYP Proposal ID: SP62

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Bioimpedance measurement platform
Summary (200 – 400 words)	Human body can be modelled as bioimpedance consists of resistance and capacitance. We can make use of the bioimpedance measurement to characterize some of the health metrics of our body. For example, it can be used for respiration rate monitoring or lung imaging through electrical impedance tomography. In this project, a wireless bioimpedance measurement platform will be developed. The collected data will be transferred wirelessly to remote device for further processing and display. The project scope includes: (1) Literature review of various bioimpedance measurement IC; (2) Design and prototype a wireless bioimpedance measurement platform; (3) Demonstrate the functionality of the platform through either respiration rate monitoring or EIT; Students are expected to develop the following skills (**learning outcome**): (1) To understand the principle of bioimpedance measurement; (2) To develop the prototype of wireless bioimpedance measurement platform; (3) To demonstrate its functionality using either respiration rate measurement or lung imaging. The achievable outcomes by the FYP students are: (1) A completed wireless bioimpedance measurement platform prototype; (2) Demonstration through respiration rate monitoring or lung imaging. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different part of the project, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Choosing appropriate bioimpedance measurement IC and components to develop the prototype. Complete the schematic design. Understand the wireless communication protocol and GUI to interface with the device.
CA2 requirement	Completed hardware prototype and software GUI

FYP Proposal ID: SP63

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Smart edge AI platform
Summary (200 – 400 words)	The advent of AI has resulted in new human-machine interface. Voice or gesture can be used to control device without the constraint of keypad or button. In this project, we will develop a universal edge AI platform that can either recognize voice command or gesture command and perform the corresponding control. The key challenge is the trade-off between the complexity of model that can be fit into the energy-aware edge AI and the resulting accuracy. The project scope includes: (1) Literature review of various model suitable for either command or gesture recognition; (2) Design and prototype an edge AI platform and demonstrate the control of different device; Students are expected to develop the following skills (**learning outcome**): (1) To understand the principle of voice or gesture recognition using AI model; (2) To develop the prototype of edge AI platform to achieve the control of various device. The achievable outcomes by the FYP students are: (1) A completed wireless edge AI platform prototype; (2) Demonstration device control through voice or gesture recognition. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different part of the project, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Bench-top instruments
N0. of students	2
CA1 requirement	Choosing appropriate components and MCU to develop the prototype. Complete the schematic design. Understand the model and develop the GUI to interface with the device.
CA2 requirement	Completed hardware prototype and software GUI

FYP Proposal ID: SP64

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	BLE Back Scattering for low power wearable
Summary (200 – 400 words)	Back Scattering is actively used for low power communication. By eliminating the power hungry power amplifier, and relying on modifying the electromagnetic field through modifying the antenna load impedance, it can achieve very low power wireless communication. In this project, software defined radio will be employed to provide the carrier transmission, while the BLE receiver available on mobile device will be used for receiving the message sent by the low power wearable tag. The low power sensor wearable tag will be developed to demonstrate the feasibility of wireless communication through back scattering. The project scope includes: (1) Literature review of back scattering for BLE and software defined radio; (2) Evaluate hardware components needed to develop the low power sensor prototype; (3) Develop the flowgraph for the software defined radio to provide the transmission and reception at mobile devices based on back scattering; (4) Develop the low power sensor prototype and demonstrate the transmission of data through BLE back scattering. Students are expected to develop the following skills (**learning outcome**): (1) To understand the BLE back scattering principle and operation of software defined radio; (2) To understand the components selection and hardware prototype; (3) To develop PCB design skill and firmware programming through the development of hardware prototype; (4) To develop the flowgraph for the software defined radio; The achievable outcomes by the FYP students are: (1) A hardware prototype for low power sensor prototype; (2) A flowgraph to control the software defined radio to enable back scattering communication. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Bench-top instruments
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Choosing of components to develop the prototype. Complete the schematic design. Understand the back scattering and software defined radio principle.
CA2 requirement	Completed hardware prototype and the flowgraph for software defined radio to enable back scattering data communication

FYP Proposal ID: SP65

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Wireless energy harvesting sensor tag
Summary (200 – 400 words)	Wireless energy harvesting provides an alternative to provide energy source to device without the need of battery. In this project, we will use software defined radio to provide the RF carrier as wireless energy source. We will develop circuit to harvest such RF energy to power the sensor tag, collecting the data, and transmitting back the sensor information. The project scope includes: (1) Literature review of wireless energy harvesting; (2) Evaluate hardware components needed to develop the wireless energy harvesting sensor tag prototype; (3) Develop the flowgraph for the software defined radio to provide the transmission and reception; Students are expected to develop the following skills (**learning outcome**): (1) To understand the wireless energy harvesting principle and operation of software defined radio; (2) To understand the components selection and hardware prototype; (3) To develop PCB design skill and firmware programming through the development of hardware prototype; (4) To develop the flowgraph for the software defined radio; The achievable outcomes by the FYP students are: (1) A hardware prototype for wireless energy harvesting sensor prototype; (2) A flowgraph to control the software defined radio to provide the RF energy source and receiving of data from sensor tag. **Prior experience of software and hardware implementation is a must.** If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Heng Chun Huat
Laboratory Work	Bench-top instruments
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Choosing of components to develop the prototype. Complete the schematic design. Understand the wireless energy harvesting and software defined radio principle.
CA2 requirement	Completed hardware prototype and the flowgraph for software defined radio to power up the wireless energy harvesting sensor tag and collect its data.

FYP Proposal ID: SP66

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and Simulation of Lidar System Based on Silicon Photonic Chips for Autonomous Vehicles
Summary (200 – 400 words)	Light detection and ranging (Lidar) is an emerging technology to visually acquire the 3-dimensional position and speed information of an object, which shows great potential in automobile industry. A solid-state lidar eliminates the possibility of a mechanical failure by removing all the moving parts. Silicon photonics is one of the promising technologies with all the required components available, such as detectors, modulators, beam splitters, grating couplers, and optical phase array. In this project, the students are required to design and simulate the essential components and eventually a solid-state lidar system based on silicon photonic chips. The project scope includes: (1) Literature review of photonic lidar systems. (2) To acquire some basic knowledge about detectors, waveguide and photonic components. (3) To design essential photonic components such as grating coupler, modulator, and optical phase array. (4) To design a solid-state lidar system based on silicon photonic chips. Students are expected to develop the following skills (**learning outcome**): (1) To understand the basic knowledge of the guide wave optics. (2) To acquire the basic knowledge about photonic components. (3) To be familiar with FDTD photonic simulation and matlab data processing. (4) To write good technical reports and possibly submit papers to international conferences or journals. If there are two students to work on the project, two students should work on design and simulation of different the photonic components. They should work together to analyse and debug.
Supervisor	Dr. Gong Xiao
Laboratory work or facilities to be used	Matlab and FDTD simulation software
NO. of students	2
CA1 requirement	Design of basic photonic components and the basic control logic
CA2 requirement	Design and simulation advanced performance metrics of different photonic components

FYP Proposal ID: SP67

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Understanding and Simulation of Advanced Transistors for High Performance Computing
Summary (200 – 400 words)	Advanced transistors at cryogenic temperature are playing an important role for high performance computing. These transistors could employ various high mobility channel materials to further push the device performance in addition to the Si channel. There have been many research efforts trying to study the transport property of the advanced transistors. Understanding the electrical characteristics of these devices at low temperature is important. This project aims to understand, simulate, analyze the electrical characteristics of advanced transistors at low temperatures and benchmark the performance with different materials systems. The project scope includes: **(1)** To understand the physics of advanced transistors by literature review. **(2)** To understand the basics of high performance computing and periphery circuits. **(3)** To simulate some basic electrical characteristics of the transistors using TCAD. **(4)** To extract various key device parameters that are strongly correlated to the electrical performance of the transistors, such as source injection velocity. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge and device physics of advanced transistors. (2) To be skilled at Matlab programming. (3) To be skilled at TCAD simulation such as Sentaurus. (4) To be able to extract various key device parameters. (5) To write good technical reports and possibly submit papers to international conferences or journals. Two students will be mainly focused on the simulation of the transistors having two different channel materials and various device dimensions.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Matlab, TCAD Sentaurus
NO. of students	2
CA1 requirement	To understand device physics at various temperatures and simulate the electrical characteristics of the advanced transistors
CA2 requirement	To fit the simulation data and extract various key device parameters, and benchmark with different materials systems

FYP Proposal ID: SP68

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and Simulation of Strained SOI Technology for 5G Applications and Beyond
Summary (200 – 400 words)	5G communication heralds the beginning of an era of connected intelligence, with 5G enabling IoT networks, Tactile Internet, automated vehicles, and more. RF devices with very high cut-off frequencies are required for mmWave technology, and the fully-depleted (FD) silicon-on-insulator (SOI) platform is one of the most promising for realizing such devices with fT and fmax of a few hundred GHz and for driving increased RF performance with transistor scaling. SOI performance can be further enhanced by introducing strain into the thin Si film to form strained SOI (SSOI). Strain increases carrier mobility, giving higher transconductance gm and hence higher fT and fmax. This project aims to explore the use of ultrathin-body-and-BOX (UTBB) FD-SSOI as the ultimate platform for 5G or even 6G mixed-signal system-on-chip applications. This project is a collaboration with SOITEC which is the world's leading company of providing the SOI substrate. The project scope includes: (1) To understand the physics of the MOSFETs using SOI substrate by literature review. (2) To simulate the current-voltage and capacitance-voltage relationships of SOI-based MOSFETs using TCAD. (3) To optimize the device architectures to improve various key parameters for logic application. (4) To optimize the device architectures to improve various key parameters for RF application, such as fT and fmax. (5) To study the effect of back bias on the DC and RF characteristics. Students are expected to develop the following skills (**learning outcomes**): (1) To understand basic knowledge of MOSFETs using SOI substrate. (2) To be familiar with device physics including both DC and RF operations. (3) To be skilled at Matlab programming. (4) To be skilled at TCAD simulation such as Sentaurus. (5) To write good technical reports and possibly submit papers to international conferences or journals. If there are two students to work on the project, one student will focus on improving the device performance and the other student will focus on understanding the impact of strain and defects.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Matlab, TCAD such as Sentaurus
NO. of students	2
CA1 requirement	Simulation of MOSFETs using SOI substrate focusing on DC performance
CA2 requirement	Simulation of MOSFETs using SOI substrate focusing on RF performance

FYP Proposal ID: SP69

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	In-Memory Computing using Static Random-Access Memory (SRAM)
Summary (200 – 400 words)	In-memory computing shows great potential in the next generation neuromorphic computing technology, which mitigates the large power consumption and latency induced by the "memory wall" in conventional Von-Neumann computer architecture. Static random-access memory (SRAM) is a promising candidate used for computing to break the memory wall due to its very fast speed, high stability, and low static energy-consuming, which make it stand out among some other competitors. So far, a lot of studies have been done showing the huge feasibility of the potential of SRAM. In this project, the students are required to design and simulate an in-memory computing system based on SRAM that can perform a simple task. The project scope includes: (1) Literature review of in-memory computing system. (2) To acquire basic knowledge neural network. (3) To design an in-memory computing system based on SRAM in Matlab platform, Cadence, or in Verilog-A with the SPICE tools. (4) To design a simple task for the system, and use it to demonstrate the function and performance of the system. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of the neuromorphic computing system. (2) To acquire the basic knowledge about neural network. (3) To be familiar with Simulink/Cadence or be skilled at Verilog-A programming in SPICE tools. (4) To be familiar with the basic circuit design and tools, such as Cadence. (5) To write good technical reports and possibly submit papers to international conferences or journals. If there are two students to work on the project, one student should finish the device design and crossbar array. The other student should focus on the peripheral control circuit and application. They should work together to analyse and debug.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Matlab, Verilog-A, SPICE tools, Cadence
NO. of students	2
CA1 requirement	Design of in-memory computing system based on SRAM
CA2 requirement	Complete a simple image processing task with the system by simulation

FYP Proposal ID: SP70

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Computer Vision and its Application for Automatic Control based on Raspberry Pi and Microcontroller
Summary (200 – 400 words)	Computer vision enables computers and systems to derive meaningful information from digital images, videos, and other visual inputs — and take actions or make recommendations based on that information. With the development of the embedded system, the implementation of computer vision brings many benefits to human lives leading to the epoch of IoT. In this project, students are required to use computer vision and deep learning techniques to identify objects using Raspberry Pi and its peripherals. Moreover, with the design of a hardware system, the advanced control based on computer vision could enable a machine to solve complicated problems more smartly. The project scope includes: (1) Build deep neural networks using industry-standard tools like Tensorflow and visualize the neural networks. (2) Build the computer vision development environment on a computer and then on a Raspberry Pi with a normal camera device. (3) Produce meaningful analytics and pattern information using the deep learning tools and data relayed back by the camera or other imaging devices. (4) Build a hardware platform to apply the computer vision and deep learning model to realize a practical function. Students are expected to develop the following skills (**learning outcome**): (1) To learn the basic concept and practical application of deep learning techniques. (2) To be familiar with Linux or Linux-like systems and be good at programming with Python. (3) To be familiar with Raspberry Pi and microprocessor with the software design on them. (4) To be familiar with the simple hardware design and the system configuration. If there are two students to work on the project, one student should mainly focus on the hardware design on the embedded system. The other student should mainly develop the deep learning model and the algorithm optimization.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Raspberry Pi and its peripherals like Pi Camera, Microprocessor development kit such as Arduino or STM32 development board
NO. of students	2
CA1 requirement	Realize the implementation of the deep learning model on the computer and the embedded system; Finish the building of the hardware platform.
CA2 requirement	Complete the control of the hardware system; Combine deep learning model and computer vision to realize the specific function.

FYP Proposal ID: SP71

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Using Machine Learning to Accelerate the Analysis of Defects' Impacts on Advanced Transistors for High Performance Computing
Summary (200 – 400 words)	We are approaching the end of Moore's law and the transistor gate length has scaled to less than 20 nm. Extensive research efforts have been made to use high mobility channel materials to further push the device performance for future high performance and low power logic applications as well as ultra-high frequency RF applications. Several promising channel materials have been proposed, such as strained Si, SiGe, Ge, etc. This project aims to simulate, understand, and analyze the impact of defects on electrical characteristics of advanced transistors using machine learning approach The project scope includes: (1) To understand the physics of advanced transistors by literature review. (2) Understand the basics of machine learning. (3) To simulate some basic electrical characteristics of strained Si or Ge-based transistors using TCAD. (4) To analyse the current-voltage performance of the transistors. (5) To analyse the capacitance-voltage performance of the advanced transistors. (6) Using machine learning approach to understand the impact of defects on electrical characteristics of advanced transistors. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge and device physics of advanced transistors. (2) To be skilled at Matlab programming. (3) To be skilled in using certain machine learning software. (3) To be skilled at TCAD simulation such as Sentaurus. (4) To be able to extract various key device parameters and provide guidance for further experiment to improve the device performance. (5) To write good technical reports and possibly submit papers to international conferences or journals. One student will be mainly focused on the simulation and the other one will be focused on analysis of the data using machine learning method.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Matlab, TCAD such as Sentaurus, Python
NO. of students	2
CA1 requirement	Literature review and simulation of the electrical characteristics of basic transistors using TCAD.
CA2 requirement	Understand the impacts of defects on the electrical characteristics of advanced transistors using machine learning approach.

FYP Proposal ID: SP72

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design of Robotic Platform Based on Embedded System and Deep Learning Techniques
Summary (200 – 400 words)	Search and rescue operation during the aftermath of disasters/accidents is a race against time. Hazardous obstacles, e.g., falling debris, high temperature, radiation leak, etc., pose a significant hindrance to human rescuers. The unique challenges give rise to the increasing wider deployment of robotic platforms. In this project, students are required to build a robotic platform capable of scanning, mapping, and exploring an unknown environment through either self-or remote-controlled navigation. Moreover, through deep learning techniques, the robotic platforms should be able to identify objects in the environment and enable human operators or even themselves to make decisions and respond. The project scope includes: (1) Design and build circuits using various sensors (ultrasound, infrared, Lidar, temperature, light, humidity, etc.), actuators (motors, sound, light, etc.), and microcontrollers. (2) Design and build a self-navigating robot using sensors, actuators, and microcontrollers. (3) Build secure network links over the cloud to control the robots and to relay back sensor and image data. (4) Build deep neural networks using industry-standard tools like Tensorflow and visualize the neural networks. (5) Produce meaningful analytics and pattern information using the deep learning tools and data relayed back by the robots. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with the microprocessor and the software design on it. (2) To learn basic concept and practical application of deep learning. (3) To be good at programming with C or Python. (4) To be familiar with simple hardware design and the system configuration. (5) To improve the practical skills and learn to write a technical report. If there are two students to work on the project, one student should mainly focus on the hardware design and controlling the platform with MCU. The other student should mainly develop the deep learning model.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	Raspberry Pi and its peripherals, Microprocessor development kit such as Arduino or STM32 development board, open-source deep learning model.
NO. of students	2
CA1 requirement	Finish the building of the hardware platform and its motion control, realize the implementation of the deep learning model individually on the computer.
CA2 requirement	Complete the combination of the software and hardware parts to realize some specific function using the remote control and the deep learning model on embedded system.

FYP Proposal ID: SP73

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Simulation and Understanding of Power Devices Using Wide Bandgap Materials for Electrical Vehicles
Summary (200 – 400 words)	Power devices are becoming more and more important and have widespread applications, such as electrical vehicles. Wide bandgap materials have superior material properties than Si in terms of figure-of-merit for power applications. Depending on different applications, power devices would employ different device structures. Also, in these devices, different defects would affect the electrical characteristics significantly. This project aims to simulate, understand, and analyze the electrical characteristics of power devices with different difference device structures, including the effect of different types of defects. The project scope includes: **(1)** To understand the physics of power devices in literature review. **(2)** To design and simulate some basic electrical characteristics of power devices using TCAD. **(3)** To analyse the current-voltage performance of the power devices fabricated, including the drive current, trans-conductance, contact resistance, etc. **(4)** To understand the effect of various defects on the electrical performance of the transistors and guide future experiments to achieve better device performance. Students are expected to develop the following skills (**learning outcomes**): (1) To understand basic knowledge and device physics of power devices. (2) To be skilled at Matlab programming. (3) To be skilled at TCAD simulation such as Sentaurus. (4) To be able to extract various key device parameters and provide guidance for further experiment to improve the device performance. (5) To write good technical reports and possibly submit papers to international conferences or journals. Two students will work on two different device structures or two different materials of power devices.
Supervisor	Dr. Gong Xiao
Laboratory work or facilities to be used	Matlab, TCAD such as Sentaurus
NO. of students	2
CA1 requirement	Literature review and simulation of the basic electrical characteristics of power devices.
CA2 requirement	Simulation of advanced device structure and analysis of the effect of defects on the electrical characteristics of the devices.

FYP Proposal ID: SP74

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design of Test Platform for NAND Flash Memory Chips based on MCU/FPGA
Summary (200 – 400 words)	NAND flash memory has been widely used for data storage due to its high density, high throughput, low cost, and low power. However, as flash memory manufacturers scale to more advanced process technologies and store more bits per cell, the reliability and endurance of flash memory are decreasing. In this project, the aim is to design and implement a test platform for quick, accurate, and comprehensive characterization of flash memories. The project scope includes: (1) Literature review of NAND flash memory development and working principle. (2) To understand the datasheet of NAND flash and design an algorithm to achieve efficient read and write operations on flash and block erase operations. (3) To propose an error patterns detection method and a bad block management policy based on real error patterns, which can improve the lifetime of NAND flash. (4) To design a method to quickly detect the endurance of NAND flash, and study the variation law of the number of original error bits, erase time, and programming time as the number of program/erase (P/E) operations increases. Students are expected to develop the following skills (**learning outcome**): (1) To understand the basic working principle and advantages of NAND flash memory. (2) To be familiar with the method to read and write memory chips. (3) To be skilled at MCU/FPGA programming. (4) To be familiar with basic circuit design. (5) To be skilled at PCB design. If there are two students to work on the project, Student 1 and Student 2 cooperate to complete the task 1 and 2, while Student 1 completes the task 3 and Student 2 completes the task 4, respectively to achieve the above mentioned outcomes.
Supervisor	Dr. Gong Xiao
Laboratory work or facilities to be used	Bench-top instruments, computer and software to support simulation
NO. of students	2
CA1 requirement	Review of NAND flash memory development and working principle and design an algorithm to achieve efficient read and write operations on flash and block erase operations.
CA2 requirement	Propose an error patterns detection method, a bad block management policy based on real error patterns and design a method to quickly detect the durability of NAND flash.

FYP Proposal ID: SP75

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and Simulation of High Speed Photonic Modulators for Future Data Communication
Summary (200 – 400 words)	In the big data era, high speed and high bandwidth data communication is highly demanded. Si photonics is going to play a critical role. One of the main photonic components is the modulator, which is the core of applications like optical communication, quantum information, and sensing. Intensity modulators are commonly constructed using Mach-Zehnder Interferometers (MZI) and micro ring resonators (MRR). In this project, the students are required to design and simulate optical modulators based on MZI or MRR array. The project scope includes: (1) Literature review of optical modulators. (2) To acquire some basic knowledge about photonic components. (3) To design a modulator based on MZI or MRR. Students are expected to develop the following skills (**learning outcome**): (1) To understand the principles of modulators based on MZI or MRR. (2) To acquire the basic knowledge about photonic components. (3) To be familiar with optical simulation platforms and be skilled at modeling using Matlab or Python. (4) To be able to analyze the performance of the simulated model in engineering application. (5) To write good technical reports and possibly submit papers to international conferences or journals. The achievable outcomes for the FYP students are: (1) To complete the MZI and MRR design. (2) To demonstrate the function of an intensity modulator. (3) To analyse and benchmark the performance of the model by simulation. If there are two students to work on the project, one student should simulate the optical devices and implement the photonic circuits using MZI. The other student work on MRR. They should work together to analyse and debug.
Supervisor	Gong Xiao
Laboratory work or facilities to be used	FDTD simulation tools and Matlab or Python
NO. of students	2
CA1 requirement	Simulation and design of an optical modulator based on MZI or MRR
CA2 requirement	Analyse the device performance in practical cases considering different modulation schemes.

FYP Proposal ID: SP76

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Automated Evaluation of Digital Design Laboratories with Feedback
Summary (200 – 400 words)	Hardware description languages (HDLs) are essential in the digital design of integrated chip designs. Amongst the various types of HDLs, Verilog and VHDL are the two most widely used and accepted IEEE standard HDLs. It has also become a default component of many digital design courses at the undergraduate and postgraduate level in many universities. With the popularity and increasing complexity of modern electronic circuits, supporting students in their learning of these languages is crucial. However, the evaluation or assessment process is time-consuming and prone to misjudgement, taking time away from more formative processes. This work aims to address this need by developing an automated assessment tool with feedback process to support students in the assessment and learning of Verilog and FPGA implementations. The project scope includes: (1) Literature review of automated evaluation tools and feedback systems in FPGA labs; (2) To define and propose the architecture and features of the proposed automated evaluation and feedback system; (3) Sub-system implementation of hardware and software components in system; (4) To design, implement, and optimize the performance of automated evaluation and feedback system with user-friendly GUI through user testing. Students are expected to develop the following skills (**learning outcome**): • To be familiar with knowledge of FPGAs and Verilog coding; • To be familiar with Python and Raspberry Pi based implementations; • To be aware of best practices in evaluation of and feedback processes involved in FPGA implementations in education. The achievable outcomes by the FYP students are: (1) To design, implement, and optimize the performance of automated evaluation system for FPGA based assignments. (2) To design, implement and optimize a feedback system with user-friendly GUI. (3) To improve the system design based on user testing; If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Chua Dingjuan
Laboratory Work	Bench top Instruments (Digilent Basys 3, Raspberry Pi) Software (Verilog, Xilinx Vivado, Python)
N0. of students	2
CA1	Preliminary prototype with hardware and software development
CA2	Automated evaluation and feedback system with user-friendly GUI for Digital Design FPGA-based laboratory assignments

FYP Proposal ID: SP77

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Plagiarism Detection in Verilog based on Machine Learning Methods
Summary (200 – 400 words)	Hardware description languages (HDLs) are essential in the digital design of integrated chip designs. Amongst the various types of HDLs, Verilog and VHDL are the two most widely used and accepted IEEE standard HDLs. It has also become a default component of many digital design courses at the undergraduate and postgraduate level in many universities. With the shift to online learning and reduction of face to face evaluations, plagiarism amongst students is inevitable. Plagiarism detection has become an increasingly important consideration in the automatic evaluation or assessment process, but is time-consuming and prone to misjudgement. In this work, we seek to explore the use of machine learning models to enhance plagiarism detection in Verilog coding assignments. The project scope includes: (1) Literature review of Verilog code plagiarism detection methods; (2) Literature review of Machine learning methods applicable to plagiarism detection; (3) To implement machine learning methods to provided data set for plagiarism detection; (4) To optimize and achieve high degrees of accuracy in plagiarism detection in provided data set. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with basic knowledge of Verilog codes and typical code structures; (2) To understand code plagiarism detection methods ; (3) To understand machine learning methods suitable for phrase or code identification; (4) To implement machine learning methods for plagiarised code detection ; The achievable outcomes by the FYP students are: (1) To complete the literature review of plagiarism detection in Verilog codes and suitable machine learning methods; (2) To implement machine learning on provided Verilog code datasets. (3) To implement plagiarism detection based on machine learning. If there are two students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Chua Dingjuan
Laboratory Work	Software
N0. of students	2
CA1 requirement	To implement machine learning on provided Verilog code datasets.
CA2 requirement	To implement plagiarism detection based on machine learning.

FYP Proposal ID: SP78

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Active Sound Control System through Vibrational Speakers for Urban Noise
Summary (200 – 400 words)	In high-rise densely-populated cities, sustainable and practical solutions for noise control or cancellation in naturally ventilated buildings is a complex problem. Erection of physical noise barriers are unsightly and impractical, leading to the reliance on façade elements in mitigation of urban noise which is difficult. An active noise control (ANC) system is an electroacoustic system, which usually comprises of a 'reference' sensor to provide advance information of the primary noise to be attenuated, an actuator driven by an adaptive circuit to produce the anti-noise, and an 'error' sensor to provide feedback to the adaptive circuit to adapt to changes in the primary noise. This work aims to address this need by developing an anti-noise system using vibrational speakers in place of conventional loudspeakers around points of noise entry such as the window, to achieve active noise control. This project also has scope for exploration of machine learning techniques to improve active noise control. The project scope includes: (1) Literature review of electroacoustic active sound control techniques in urban noise settings ; (2) To define and propose the architecture and features of the proposed active sound control system using vibrational speakers and machine learning implementations; (3) Sub-system implementation of hardware and software components in system; (4) To design, implement, and evaluate the performance of proposed active sound control system using vibrational speakers for urban noise; Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with knowledge of urban noise spectrum, sound measurement equipment (speakers and microphone); (2) To be familiar with electroacoustic techniques in sound control/ cancellation; (3) To be familiar with Python and Raspberry Pi based implementations; The achievable outcomes by the FYP students are: (1) To design, implement, and test the performance of proposed active sound control system using vibrational speakers for urban noise; (2) To explore machine learning techniques in the proposed active sound control system If there are three students to work on the project, each student should carry out different parts, and achieve the above-mentioned outcomes.
Supervisor	Chua Dingjuan
Laboratory Work	Bench top Instruments (Microphone, Vibrational Speakers, Raspberry Pi) Software (Verilog, Xilinx Vivado, Python)
N0. of students	3
CA1 requirement	Preliminary prototype with hardware and software development
CA2 requirement	Active sound control system using vibrational speakers for urban noise (involving

Proposal ID: SP79

Academic Year	AY 2024/25 (September 2024 – May 2025)
Title of Project	Object identification in large-scale images with partial information using Machine Learning for Distributed Satellite Systems
Summary (200 – 400 words)	Distributed Satellite Systems(DSS) for image processing involve a network of satellites working collaboratively to analyze and process imagery from space. By distributing computational tasks across multiple satellites, these systems can handle large volumes of data more efficiently. We attempt to employ microcontrollers (MCs) to mimic satellite nodes and process large-scale image data in a distributed fashion. Students are expected to implement tinyMLs on the MCs to aid object recognition in a distributed fashion by sharing the image via a shared memory on a central satellite node. Each student will develop an independent (i) shared memory model or (ii) a distributed memory model based strategy on his/her own constellation configuration, perform an analysis, and implement. After recognizing the objects with partial information, the nodes will send back the results for central node (could be a PC/laptop) to make complete sense of the image. The platform needs more than 5 MC nodes to mimic a DSS. Large-scale image data to be considered as workloads for training and testing the CNNs or equivalent networks. Experiments taking into other constraints, reconfigurable ability, etc., also seem feasible but needs to be explored as the project progresses. Relevant reading material, data and exact reading materials are readily available. Take this project ONLY if you are comfortable with microcontroller and ML programming. Send in your CV via email with a subject line Project ID and title. The project scope includes: (1) Literature review of ML algorithms for image recognition; (2) ML based Python packages; (3) MC programming; (4) Implementation of the distributed strategies on MCs for a specific satellite constellation configuration. Students are expected to develop the following skills (learning outcomes): • To understand basic image based ML methods; • To be familiar with tinyMLs on MCs • To be skilled at ML Python packages; • To be able to develop distributed strategies for a given constellation with practical constraints The deliverable outcomes by the FYP students are: (1) A distributed sensor/computing platform; (2) TinyML realization on MCs; (3) data communications and computing between the MC nodes; (4) TinyML deployment and performance evaluation on image recognition;
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities	Microcontrollers (5 to 6 pieces and a laptop for experiments)
No. of students	2
CA1 requirement	Familiarize microcontroller programming, identifying ML algorithms suitable for microcontrollers and setting up the platform
CA2 requirement	To design, implement, and to evaluate the performance of the implemented methods; Each student implements a different ML/DL algorithm on the microcontrollers and a distributed strategy and evaluate the performance.

Proposal ID: SP80

Academic Year	AY 2024/25 (September 2024 – May 2025)
Title of Project	Performance Evaluation Study for Distributed Satellite Constellation Systems
Summary (200 – 400 words)	The capacity to reorganize the spacecraft cluster or formation and gradually add new or upgrade older satellites in the formation has surely boosted the mission value of recent improvements in Distributed Satellite Systems (DSS). Benefits like improved mission efficacy, multi-mission capability, design flexibility, and so forth are intrinsic to these traits. When a constellation is formed the underlying available communication and computational bandwidths between the satellite nodes are not identical and not known in advance. We refer to such environments as "blind environments". Thus, we need to work with estimates of these bandwidths in order to distribute the workload for a cooperative computing. We will attempt to employ Divisible Load paradigm to distribute the load under unknown or such blind environments. *Given a satellite constellation our objective is to devise load distribution strategies that can compute the workloads based on the current estimated bandwidths and to take corrective measures as the scheduler learns the estimates over the iterations.* Each student will develop the load distribution strategy and evaluate the performance for different constellations. Relevant reading material, data and exact reading materials are readily available. There is a clear scope for incorporating machine learning approaches if students are keen and interested. Take this project only if you are comfortable in analysis & programming. Send in your CV via email with a subject line Project ID and title. The project scope includes: (1) Literature review of DLT scheduling algorithms, specifically on DLT algorithms with unknown speed parameters; (2) Python environment setting up for simulation; Use of SimPy environment must be ascertained; (3) To simulate and evaluate the performance of the strategies for a specific satellite constellation configuration. Students are expected to develop the following skills (learning outcomes): To be familiar with scheduling strategies using DLT models; To be skilled at Event-driven Simulation techniques using Python programming; To be able to develop load distribution strategies for a given constellation with practical constraints and evaluate the performance The deliverable outcomes by the FYP students are: (1) To complete the load distribution scheduling strategies using simulation study; (2) To physically scale the system and evaluate the performance via simulation; (3) To vary the node availabilities/bandwidth and evaluate the performance metrics via simulation;
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities	Multi-core machine to run VMs / GPUs; Parallel cluster set-up (SLURM) to run experiments. Python and related packages
No. of students	2
CA1 requirement	Algorithm development and simulation attempt; Students must be familiarize themselves on the event-driven simulation Python package and must demonstrate small examples and set up the MCs to form the distributed platform; Plan for SLURM set up.
CA2 requirement	To design, simulate, and to evaluate the performance of scheduling strategies for a given constellation configuration. If time permits, students can opt to implement on the chosen MCs. A SLURM based implementation may be attempted.

Proposal ID: SP81

Academic Year	AY 24/25 (September 2024 – May 2025)
Title of Project	Real-Time Workload Scheduling in AGV-based Digital Manufacturing Platforms (DMPs) using Machine Learning
Summary (200 – 400 words)	Autonomous Guided Vehicles (AGVs) are one of the key components in a Digital Manufacturing platform (DMP). In a production environment, different tasks result owing to different ways of routing the raw material among different machines in a pre-defined sequence. The throughput is severely influenced by the way tasks are injected into the system. Further, real-world dynamics must take into account of down-times of the machines and spare machine availability constraints. In this project, we will simulate such an environment and evaluate the performance of a number of scheduling strategies and analyse some of the metrics such as throughput, nett availability, efficiency, and blocking probabilities, to quote a few. We employ ML to train and attempt to suggest a processing order of the jobs to minimize the overall makespan of the workload. Take this project only if you are comfortable in python programming. Send in your CV via email with a subject line Project ID and title. The project scope includes: (1) Literature review of AGV-based scheduling systems; (2) Python SimPY environment; Simulation study using SimPy software to generate the required data, constraints defining the AGV platform; (3) To simulate and evaluate the performance of a AGV-based DMP system defined in (2) using a few scheduling strategies; Use of ML to detect a near-optimal processing sequence of jobs. Students are expected to develop the following skills (learning outcomes): (1) To be familiar with scheduling strategies using AGV based systems; (2) To be skilled at Event-driven Simulation techniques using Python programming; (3) To evaluate a given scheduling strategy and to use appropriate metrics (4) To evaluate possible ML approaches The achievable outcomes by the FYP students are: (1) To complete the AGV-based scheduling strategies; (2) To vary the design parameters and to achieve maximum throughput and minimum blocking probabilities of the tasks; (3) To vary the machine availabilities and downtimes and to show their impact on performance metrics; (4) Use ML approaches to decide on a best possible processing sequence Each student should carry out different sets of scheduling strategies for a given platform defined in (2) under the project scope above.
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities to be used	Python and related packages
Number of students	2
CA1 requirement	Project scope (1) and (2); Students must be familiarize themselves on the event-driven simulation Python package and must demonstrate small examples
CA2 requirement	To design, simulate, and to evaluate the performance of scheduling strategies using the AGV-based DMPs and implement ML approaches.

Proposal ID: SP82

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Detection of Image Steganography images using Deep Learning
Summary (200 – 400 words)	This project is an application of Machine Learning for Cybersecurity application. One technique for concealing classified information in non-secret material is steganography. Steganographic techniques are quite dangerous for consumers since malicious software can utilize them or propagate malware using them. Our study set out to determine the best automatic techniques for identifying digital steganography in jpeg images. We will look into different machine learning (ML) techniques for building prediction models that can find any dangerous stuff that is steganographically disguised and might be exploited by malware. Any system that does file scanning for security reasons, such as antimalware software, can be combined with this kind of detection. We will validate through rigorous performance evaluations and quantify the performances. Relevant data and very specific reading materials will be provided. We will also explore machine learning approaches as alternative approaches, if time permits. Take this project ONLY if you are comfortable with ML/DL programming and some signal processing concepts. Send in your CV via email with a subject line Project ID and title. The project scope includes : (1) Literature review & Use of python tools to implement the methods; (2) Preparing the training and test data on two different applications (3) To evaluate the performance of the stenographic methods and ML methods and perform a comparative study; (4) To explore novel hybrid strategies to improve performance. Students are expected to develop the following skills *(learning outcome*): To understand basic knowledge of stenographic process; ML methods; To be skilled at one of the programming tools - Python/C/C++; To evaluate ML algorithms; The *deliverable outcome* by the FYP students for the CA assessment are: (1) To identify and implement stenographic methods; (2) To evaluate the performance of different ML algorithms on certain influencing parameters and to achieve maximum quality in accuracy of prediction; (3) To attempt designing hybrid techniques to cross-validate the earlier methods. If there are two students to work on the project, each student should carry out two different applications using the methods for a given dataset and perform all-to-all comparison. Suggested applications include, data from health applications, smart city, skin texture and SAR image processing, etc, to quote a few.
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities to be used	ML/DL Python related packages
No. of students	2
CA1 requirement	Students must be familiarize themselves on the stenographic and algorithms/methods; Relevant programming tools must be learnt and must demonstrate small scale examples
CA2 requirement	To implement and evaluate the performance of stenographic methods – demonstration of a full-fledged implementation with relevant dataset; Exploring hybrid strategies;

Proposal ID: SP83

Academic Year	AY 24/25 (September 2024 – May 2025)
Title of Project	Detection of Harmful Concealed Objects using Machine Learning algorithms
Summary (200 – 400 words)	Potential threats could be in place when dangerous objects are carried in a concealed way by individuals. This is a typical of a scenario in airports and other public places. Identifying potential threat raising suspicious objects in all civilian luggage entering into an organizations' premises need scrutinized and detected via X-ray machines. However, till date, human intervention seems mandatory in identifying such objects and ML/AI based techniques are still in their infancy. In this project, we will attempt to understand the basic techniques suitable for object detection using X-ray images and evaluate the performance of certain commonly used ML and Deep Learning techniques in identifying any objects that are of threat raising concerns. We will evaluate the performance based on several metrics such as, learning rate, accuracy and number of layers/resources utilized, and efficiency of the techniques. We will attempt to compare across different techniques for a given dataset. If time permits, we will attempt to propose a hybrid method that can serve as a novel technique and a contribution to this domain. Relevant reading material, data and exact reading materials are readily available. Take this project ONLY if you are comfortable with ML/DL programming. Send in your CV via email with a subject line Project ID and title. The project scope includes: (1) Literature review of ML/AI based techniques for object detection using X-ray images (2) Using the appropriate Python tools – Pytorch, tensorfolow, etc., as needed; (3) Simulation study and performance evaluation using publicly available image datasets; Students are expected to develop the following skills (learning outcome): (1) To understand ML/AI based object detection techniques using X-ray images; (2) To be familiar with ML techniques used for X-ray images; (3) To be skilled in using simulation techniques using ML/AI based Python packages; (4) To evaluate a given x-ray data, propose a suitable algorithm and to evaluate using appropriate metrics The achievable outcomes by the FYP students are: (1) Survey of available ML/AI literature on x-ray based object detection; (2) To demonstrate the performance using the chosen ML/AI Python tools; (3) To attempt using random forest and related techniques and evaluate them; (4) To understand and evaluate Deep Learning in the problem context.
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities to be used	Python and related packages
Number of students	2
CA1 requirement	Project scope (1) and (2); Students must be familiarize themselves on data and ML techniques using the related Python packages and must demonstrate small examples
CA2 requirement	To use the chosen datasets and to evaluate the performance of ML techniques for object detection in X-ray images and to perform a comparative study across the chosen techniques.

Proposal ID: SP84

Academic Year	AY 24/25 (September 2024 – May 2025)
Title of Project	Performance Evaluation of Network Intrusion Detection Systems Based on Machine Learning
Summary (200 – 400 words)	This is a state-of-the-art project in the Cybersecurity and machine learning domain. No machine learning pre-requisite is needed, however, student is expected to follow instructions to gain knowledge in the subject. Intrusion detection systems are crucial in network security for identifying unknown threats. In this project we evaluate the suitability of machine learning-based anomaly detection algorithms in both supervised and unsupervised scenarios. We will invest some time in evaluating feature selection algorithms. We also introduce a versatile feature selection method based on association rule mining, comparing it with traditional feature selection approaches. The article includes a comprehensive analysis of experimental results, recommending combinations of models and feature selection methods for various scenarios. Finally, it provides insights into potential future research directions. Take this project only if you are comfortable with ML programming and python. The project scope includes: (1) Literature review of network security algorithms and methods; (2) Python environment and simulation study using software to generate the required data; (3) To simulate and evaluate the performance of relevant ML algorithms for network security; (4) Federated Machine learning approaches for solutions. Students are expected to develop the following skills (learning outcome): (5) Basic knowledge of ML algorithms in network security domain; (6) To be skilled at ML software packages in Python programming ; (7) Implementation of ML algorithms and evaluating them using appropriate metrics (8) Implementing federated machine learning models and evaluating them. The deliverable outcomes by the FYP students are: (1) To be able to detect malware and spurious traffic using ML approaches (2) To vary the model parameters and to achieve maximum throughput (3) To vary the dataset and evaluate the performance (4) Use of federated ML algorithms and evaluating the performance If there are two students to work on the project, each student should carry out different sets of ML algorithms.
Supervisor	A/Prof Bharadwaj Veeravalli
Laboratory facilities to be used	Python and related packages
No. of students	2
CA1 requirement	Familiarize themselves on the ML Python packages; demonstrate small examples using identical datasets; Setting up MC platform and making it to run on small examples;
CA2 requirement	To design, simulate, and to evaluate the performance of ML approaches; Using MC platforms, deploy federated ML algorithms and show the performance.

Proposal ID: SP85

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of Mobile Gait Assessment system – Vision based approach
Summary (200 – 400 words)	Mobility and walking function is a key reflector of health status. This is true to the extent that walking speed has been designated the sixth vital sign, as it accurately reflects functional status and overall health for a wide population of patients. Tools and outcome measures for the accurate evaluation of mobility and walking ability are required to aid in accurate diagnosis and targeted rehabilitation interventions for mobility function. Surrogate measures such as measures of strength and endurance, do not accurately reflect walking ability. Gait evaluation is key to guide management and rehabilitation of mobility function. The project scope includes: (1) Literature review on gait modelling and assessment; (2) To develop vision-based algorithms and solution for gait assessment Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of Telehealth and its key components; (2) To be skilled in computer vision; The achievable outcomes by the FYP students are: Development of a vision-based Gait algorithms. This project can take up to 2 students: Students 1 & 2: focus on the vision-based gait assessment. Each focuses on different vision algorithms. There are various gait parameters that we would like to extract and students can focus on different parameters. This project is suitable also for you to continue during your 1 year Master programme in NUS.
Supervisor	Arthur Tay
Laboratory Work	
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review and software development
CA2 requirement	Development of gait assessment system

Proposal ID: SP86

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of Mobile Gait Assessment system: Sensor-based Approach
Summary (200 – 400 words)	Mobility and walking function is a key reflector of health status. This is true to the extent that walking speed has been designated the sixth vital sign, as it accurately reflects functional status and overall health for a wide population of patients. Tools and outcome measures for the accurate evaluation of mobility and walking ability are required to aid in accurate diagnosis and targeted rehabilitation interventions for mobility function. Surrogate measures such as measures of strength and endurance, do not accurately reflect walking ability. Gait evaluation is key to guide management and rehabilitation of mobility function. The project scope includes: (1) Literature review on gait modelling and assessment; (2) To develop sensor-based solution for gait assessment Students are expected to develop the following skills (**learning outcome**): (3) To understand basic knowledge of Telehealth and its key components; (4) To be skilled in embedded systems; The achievable outcomes by the FYP students are: Development of a sensor-based Gait algorithms. This project can take up to 4 students: Students 1 & 2: focus on sensor-based solution. One to focus on sensor development and the other on app and algorithm extraction. There are various gait parameters that we would like to extract and students can focus on different parameters. This project is suitable also for you to continue during your 1 year Master programme in NUS.
Supervisor	Arthur Tay
Laboratory Work	
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review and software development
CA2 requirement	Development of gait assessment system

Proposal ID: SP87

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Vision-based Tele-rehabilitation
Summary (200 – 400 words)	Due to Covid-19, many patients were not able to commute to hospitals and rehab centres for their rehabilitation which is critical for their recovery. Suspension of rehabilitation services may lead to detrimental long term consequences for patients, including those who have just undergone surgery or patients with acute musculoskeletal-related pain and injury. In addition, many patients who need rehabilitation are also worried about Covid-19 transmission in hospitals and hence unwilling to travel. The ability to monitor and measure accurately, comfortably, and continuously the progress of a patient undergoing rehabilitation, without injecting cumbersome wires or boxes into their activities, has the potential to revolutionize health therapies and services. In this work, we propose to develop a vision-based tele-rehabilitation system. The project scope includes: (1) Literature review of camera-based gait and motion monitoring systems; (2) To investigate the use of camera for rehab; (3) To investigate the use of Apple iPad for rehab; (4) Development of basic rehab exercises. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of Telehealth and its key components; (2) To be skilled at computer vision; (3) To be understands the need of rehabilitation ; The achievable outcomes by the FYP students are: Development of a vision-based rehabilitation. This project can take up to 2 students: Student 1: focus on the use of camera for rehab. Student 2: focus on the use of Apple latest iPad for rehab (Suitable for student with iPad). Last year fyp students has developed preliminary prototype systems, we will continue from there. This project is suitable for continuation during Master part of the program in NUS.
Supervisor	Arthur Tay
Laboratory Work	
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review and software development
CA2 requirement	Development of vision-based rehab system

Proposal ID: SP88

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Real-time Freezing of Gait Detection/Prediction for Parkinson Diseases
Summary (200 – 400 words)	In this project, our objective is to make use of machine learning algorithms to predict the freezing of gait (FOG) in Parkinson's Disease (PD) patients. FOG is a sudden and episodic inability to generate effective stepping among PD patients. It poses a risk for falls and deteriorates a patient's quality of life. We have data of PD patients gait patterns, the objective here is to make use of machine learning algorithms to predicts these FOG episodes. The project scope includes: **(1)** Literature review of machine learning algorithms; **(2)** Literature review of Freezing of Gait; **(3)** Development of wearable sensors for measuring gait. **(4)** Implementation of FOG algorithms. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge of Telehealth and its key components; (2) To be skilled at embedded system, Arduino/Raspberry Pi; IMUs; (3) To be skilled BLE communication and App development; (4) To be skilled in machine learning algorithms; (5) To be skilled Webapp development. The achievable outcomes by the FYP students are: Development of a mobile vital signs monitoring system. This project can take up to 2 students: Student 1: Focus on FOG detection, biofeedback system. Student 2: Focus on FOG prediction, App development.
Supervisor	Arthur Tay
Laboratory Work	Embedded system (Arduino), IMUs, Biofeedback, App development.
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review and software development
CA2 requirement	Development of FOG and biofeedback system

Proposal ID: SP89

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Indoor Navigation system
Summary (200 – 400 words)	In this project, our objective is to investigate and developed an indoor localization and navigation systems for helping visitors to navigate the hospital/shopping malls etc. In terms of hardware, a few possibilities is possible, examples Bluetooth Low Energy (BLE) technologies or Ultra-Wide Bandwidth (UWB) technologies. The project scope includes: (1) Literature review of indoor localization system; (2) Literature review of navigation systems (3) Development of wireless node using Raspberry Pi/ESP; (4) Development of localization algorithms. (5) Development of mobile app for navigation. Students are expected to develop the following skills (**learning outcome**): (1) To understand basic knowledge and algorithms of localization and its key components; (2) Server and App development (3) Embedded system programming The achievable outcomes by the FYP students are: Development of a mobile vital signs monitoring system. This project can take up to 2 students: Student 1: Setting up of prototype infrastructure in lab and localization algorithms Student 2: Setting up of prototype infrastructure in lab and navigation app There is an existing hardware from past students, we will make use of that and focus more on the algorithms and software analytics for this fyp.
Supervisor	Arthur Tay
Laboratory Work	
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review, infrastructure setup and software development
CA2 requirement	Development of localization and navigation system

Proposal ID: SP90

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Vision based kinematics assessment for Gait.
Summary (200 – 400 words)	Mobility and walking function is a key reflector of health status. This is true to the extent that walking speed has been designated the sixth vital sign, as it accurately reflects functional status and overall health for a wide population of patients. Tools and outcome measures for the accurate evaluation of mobility and walking ability are required to aid in accurate diagnosis and targeted rehabilitation interventions for mobility function. Surrogate measures such as measures of strength and endurance, do not accurately reflect walking ability. Gait evaluation is key to guide management and rehabilitation of mobility function. The project scope includes: (1) Literature review on gait modelling and assessment focusing on kinematics; (2) To develop vision-based algorithms and solution for gait assessment on kinematics. Students are expected to develop the following skills (**learning outcome**): (5) To understand basic knowledge of Telehealth and its key components; (6) To be skilled in computer vision; The achievable outcomes by the FYP students are: Development of a vision-based Gait algorithms. This project can take up to 2 students: Students 1 & 2: focus on the vision-based gait assessment. The focus for this project is more on the kinematics rather than the gait parameters. Student 1 will focus on the algorithms to measure these information while student 2 will focus more on the data analytics and visualisation software. This project is suitable also for you to continue during your 1 year Master programme in NUS.
Supervisor	Arthur Tay
Laboratory Work	
N0. of students	2 (not more than 2 students for each project)
CA1 requirement	Literature review, system setup and software development
CA2 requirement	Development of gait assessment software system

Proposal ID: SP91

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Developing a Lego MechGrid for Studying Power System Stability
Summary (200 – 400 words)	An electric power grid consists of my synchronous generators that are interconnected with each other to supply the electrical loads. The grid stability is an abstract topic that is difficult to effectively visualise. That is, conventional approaches do not provide the general public with an effective, intuitive understanding of the concepts. This is one of the main obstacles in promoting the adoption of new technologies in the industry as well as training future engineers. The dynamics of a synchronous grid is similar to a spring-damper system studied in mechanical engineering. The notion of stability centres around the system inertia. To this end, this project seeks to showcase how inertia affect the synchronism of the generators under changing loads. Students will focus on developing governor (speed) controller in Lego motors using microcontrollers, e.g., Arduino. The project scope includes: **(1)** Literature review of spring-damper system and power swing equations; **(2)** Develop numerical models of the desired power grid and generator controllers; **(3)** Demonstrate all generators are capable of maintaining synchronism; **(4)** Showcase the Lego MechGrid is capable of maintaining synchronism after network disturbances. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with synchronous machines; (2) To be familiar with generator control; (3) To become competent in building simulation models in MATLAB/Python; (4) To become competent in programming micro-controller. **Expected deliverables** by the students are: (1) A hardware setup for showcasing the dynamics of droop control in power grids. The design will consist of elements imitating generators, motor loads, transmission lines, and transformers; (2) Demonstrate the Lego MechGrid capable of imitating the stability issues encountered in actual power grids.
Supervisor	Jimmy PENG
Laboratory work	Coding in micro-controller, MATLAB/Python
No. of students	2
CA1 requirement	Simulate the Lego MechGrid using MATLAB or Python.
CA2 requirement	Showcase a working Lego MechGrid, where each generator is controlled by a micro-controller.

Proposal ID: SP92

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Investigating the Interactions between Grid-forming and Grid-following Renewables in Power Systems
Summary (200 – 400 words)	Renewable resources, e.g., solar and wind, are connected to the power systems through power electronic interfaces, and are therefore termed as inverter-based resources (IBRs). Most IBR controllers operate in grid-following (GFW) mode, i.e., they operate on the assumption that system voltage and frequency are regulated by inertial sources. Such control approaches cannot guarantee system stability in low-inertia setting, and are unlikely to sustain an inverter-dominated infrastructure. In events of impending instability, renewables will need to provide regulation services, i.e., change the IBR control from GFW mode to grid-forming (GFM) mode. GFM enables the inverter to provide voltage and frequency regulation. The question is which and how many IBRs should change to GFM mode under different grid topologies. The project scope includes: **(1)** Literature review of inverters, and controller designs; **(2)** Detailed and reduced-order modelling of IBRs; **(3)** Simulation of multiple GFM and GFW inverters within a power system; **(4)** Optimize the number of GFM inverters required to maintain system stability under various operating conditions. Students are expected to develop the following skills (**learning outcome**): • To be familiar with fundamental power engineering principles; • To be familiar with linear control theory; • To be able to model inverters and construct power system models; • To be able to assess grid stability using eigenvalue analysis; • To become competent in MATLAB/Python. **Expected deliverables** by the students are: (1) Conduct a detailed literature review on the modelling and control of inverters and electric loads in power systems; (2) Demonstrate working GFW inverter (PLL based) and GFM (droop based) controllers; (3) Assess the optimal number of IBRs required and their locations to maintain grid stability.
Supervisor	Jimmy PENG
Laboratory work	MATLAB/Python
No. of students	2
CA1 requirement	Showcase working grid-following and grid-forming inverters working in a grid model.
CA2 requirement	Develop a framework/guideline to determine the grid stability under different control architectures.

Proposal ID: SP93

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Optimal Sizing of Distributed Renewable Resources within a Community Grid.
Summary (200 – 400 words)	Renewable resources, e.g., rooftop solar, and energy storage, e.g., batteries, are connected to the community power grids through power electronic interfaces. A community can be defined as a cluster of residential houses or an industrial park. To have a truly viable business solution, participants need to properly size and manage their assets while considering the interaction with the grid to which they are connected. To this end, multiple investment modes are evaluated via a two-step procedure. In the first step, the size of renewable energy sources is determined by solving an optimization problem that maximizes community welfare, considering network and investments. In the second step, an optimization problem maximizing additional community member profit with price regularisation is solved. This step shares benefits among community members. The question is how much resources should be installed and the optimal breakeven period of the investment given the latest government subsidies, e.g., in China. The project scope includes: **(1)** Literature review of optimization tools, energy management, and market mechanisms; **(2)** Develop a distributed robust optimization approach; **(3)** Devise a software for identifying the number of installed resources and their optimal sizing for a desired breakeven period; **(4)** Demonstrate the investment strategies for different clients, e.g., residential consumers and factory owners. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with optimization; (2) To be familiar with market mechanism; (3) To be able to construct energy management systems of a plant/system; (4) To become competent in MATLAB/Python. **Expected deliverables** by the students are: (1) Conduct a detailed literature review on different business models for installing rooftop photovoltaics and energy storage in residential, commercial, and industrial sectors in China; (2) Demonstrate a functioning optimization software to determine the investment size and return rate through numerical examples;
Supervisor	Jimmy PENG
Laboratory work	MATLAB/Python
No. of students	2
CA1 requirement	Development of numerical case studies and optimization tools.
CA2 requirement	Showcase the developed optimization software capable of advising the sizing of various energy resources for a community grid.

Proposal ID: SP94

Academic Year	AY 2023/2024 (September 2023 – May 2024)
Title of Project	Develop a Single-phase Fast-charging Converter for Li-ion Batteries
Summary (200 – 400 words)	Li-ion batteries are widely utilized in consumer electronics and electric vehicles. One key performance index is the charging time. However, the current practice of constant-current-constant-voltage (CCCV) method limits the charging speed. To this end, non-linear voltage charging algorithm has been recently proposed to further speed up the charging operation. The objective of this project is to build the electric circuit and power converters to reduce the charging time of consumer electronics such as smartphones. The project scope includes: **(1)** Literature review of fast charging algorithms and Li-ion battery models; **(2)** Design a charging circuit for a 5000mAh battery pack; **(3)** Implement the fast charging algorithm onto the designed circuit; **(4)** Showcase a working power bank prototype. Students are expected to develop the following skills (**learning outcome**): (1) To be familiar with fast charging algorithm for Li-ion batteries; (2) To be familiar circuit design and embedded systems; (3) To become competent in power electronics. **Expected outcomes** by the students are: (1) Conduct a detailed literature review on charging algorithm; (2) Implement the fast-charging algorithm onto DSP controller; (3) Construct a prototype charging circuit; (4) Demonstrate a working design.
Supervisor	Jimmy Chih-Hsien PENG
Laboratory work	Circuit design, C programming
No. of students	2
CA1 requirement	Present the PCB design of the charging circuit, and emulate the charging algorithm in DSP.
CA2 requirement	Showcase a working prototype equipped with fast charging algorithm.

FYP Proposal ID: SP95

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Data-Driven-Based State-of-Charge Estimation of EV Batteries
Summary (200 – 400 words)	Accurate state-of-charge (SOC) estimation of electric vehicle (EV) batteries is essential for reliable and efficient operation. It helps predict the remaining driving range, optimize battery usage, and ensure safety and longevity. This project aims to develop a novel data-driven SOC estimation method using machine learning (ML) techniques. The goal is to develop an advanced model that can accurately predict the SOC even under suboptimal conditions with few samples and noisy environments. The project scope includes: (1) Literature review of existing SOC estimation methods; (2) Datasets collection and processing; (3) Development of a data-driven method for SOC estimation; (4) Validation and testing of the method. Students are expected to develop the following skills (**learning outcome**): (1) To understand characteristics of different battery SOC estimation methods; (2) To become proficient in battery data processing techniques; (3) To develop and implement a data-driven method for accurate SOC estimation. Prerequisites: (1) Basic understanding of batteries and data analysis; (2) Experience with ML programming; (3) An interest in learning.
Supervisor	Zhao Zhenyu
Laboratory Work	Battery data analysis; ML programming; SOC estimation.
N0. of Student	1
CA1 Requirement	Completion of a literature review and processing of datasets
CA2 Requirement	Demonstration and validation of the SOC estimation model

FYP Proposal ID: SP96

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Data-Driven-Based State-of-Health Estimation of EV Batteries
Summary (200 – 400 words)	Accurate estimation for the state-of-health (SOH) of electric vehicle (EV) provides useful insights into the battery's current condition, predicts its remaining useful life, and helps in making informed decisions about battery maintenance and replacement. This project aims to develop a data-driven-based SOH estimation method that remains effective even under few samples and noisy situations. By leveraging machine learning (ML) techniques, an advanced model will be developed to accurately predict the SOH of EV batteries, even under suboptimal conditions. The project scope includes: (1) Literature review of existing SOH estimation methods; (2) Collection and processing of battery datasets; (3) Development of a data-driven method for SOH estimation; (4) Validation and testing of the method. Students are expected to develop the following skills (**learning outcome**): (1) To understand the characteristics of different battery SOH estimation methods; (2) To become proficient in battery data processing techniques; (3) To develop and implement an effective data-driven method for SOH estimation. Prerequisites: (1) Basic knowledge of batteries and data analysis; (2) Familiarity with ML programming; (3) An interest in learning.
Supervisor	Zhao Zhenyu
Laboratory Work	Battery data analysis; ML programming; SOH estimation.
N0. of Student	1
CA1 Requirement	Completion of a literature review and processing of datasets
CA2 Requirement	Demonstration and validation of the SOH estimation model

FYP Proposal ID: SP97

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Eavesdropping Risk Assessment of Computer Displays Based on EM Signal Analysis
Summary (200 – 400 words)	With the increasing dependence on digital information, unauthorized interception of sensitive data from computer displays poses significant risks to organizations and individuals. This project aims to develop an effective eavesdropping risk assessment method for computer displays by analyzing the electromagnetic (EM) emanations they generate. The primary goal is to create a reliable display information recovery method using machine learning (ML) techniques to analyze the captured EM emanation signals from computer displays, thereby assessing potential security threats. The project scope includes: (1) Literature review of existing methods; (2) Collection and processing of EM emanation signals from computer displays; (3) Development of a ML method tailored for display information recovery; (4) Validation and testing of the developed method. Students are expected to develop the following skills (**learning outcome**): (1) To understand principles and risks with EM emanations from computer displays; (2) To become proficient in data collection and processing for EM emanation signals; (3) To develop and implement a ML method for information recovery. Prerequisites: (1) Basic understanding of EM signals; (2) Experience with ML programming; (3) Interest in EM security and information protection.
Supervisor	Zhao Zhenyu
Laboratory Work	Display's information recovery; EM signal collection; ML programming.
N0. of Student	1
CA1 Requirement	Collection and processing of EM emanation signals
CA2 Requirement	Development of a ML method for information recovery

FYP Proposal ID: SP98

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	High-frequency Behavioral Modeling of Motor Drive Systems
Summary (200 – 400 words)	Motor drive systems (MDS) serve as important roles in various industrial applications like electric vehicles, renewable energy, oil and gas. This project aims to develop a novel high-frequency (HF) behavioral modeling method for MDS. Accurate HF behavioral modeling is essential for estimating several essential phenomena like conducted emissions and overvoltage ringing within MDS. This project focuses on developing a machine learning (ML)-based HF behavioral modeling method using collected impedance information, ultimately facilitating the optimal design of MDS. The project scope includes: (1) Literature review of existing HF behavioral modeling methods of MDS; (2) Processing collected impedance data from MDS; (3) Developing a novel ML-based HF behavioral modeling method; (4) Validation and testing of the developed method. Students are expected to develop the following skills (**learning outcome**): (1) To understand HF behaviors and their impact on MDS; (2) To become proficient in analyzing collected MDS's impedance data; (3) To develop and implement a ML model for HF behavioral modeling of MDS. Prerequisites: (1) Basic understanding of MDS; (2) Knowledge of circuit theory and impedance concepts; (3) Experience with ML programming.
Supervisor	Zhao Zhenyu
Laboratory Work	HF behavioral modeling; Impedance data analysis; ML programming.
N0. of Student	1
CA1 Requirement	Processing and analyzing collected impedance data
CA2 Requirement	Development of a ML-based HF behavioral modeling method

FYP Proposal ID: SP99

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and Implementation of Ultra-fast Matrix-Vector Math with Photonic Integrated Circuits
Summary (200 – 400 words)	This project involves designing and simulating Mach-Zehnder Interferometer (MZI) meshes integrated into photonic circuits for efficient matrix-vector multiplication. MZIs are utilized for their ability to manipulate and phase-shift optical signals, enabling parallel computation of matrix operations. The project will focus on optimizing the design parameters of MZIs to achieve high-speed and low-loss operations suitable for matrix-vector math applications. Simulation tools like MEEP will be employed to model and optimize the performance metrics of the MZI mesh. After MZI meshes are mastered, students will then look at more complex geometries proposed in literature which are able to accomplish ultra-fast optical computing.
Supervisor	Aaron Danner
Laboratory Work	Simulation only
N0. of students	2
CA1 requirement	Simulation results demonstrating optimized MZI mesh design parameters and initial performance evaluation metrics.
CA2 requirement	Finalized photonic circuit design incorporating MZI meshes, comprehensive simulation results validating performance metrics (e.g., speed, efficiency), and a detailed report on the feasibility and advantages of using MZI meshes versus other structures for matrix-vector math.

FYP Proposal ID: SP100

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of Photonics FDTD Simulation Library for Pedagogical Purposes
Summary (200 – 400 words)	This project focuses on developing a Finite-Difference Time-Domain (FDTD) simulation result library using MEEP, tailored for teaching electromagnetic principles and on-chip photonic design, as well as for understanding the building blocks of optical computing. The library will be designed to simulate electromagnetic wave propagation, reflection, and absorption in various media and structures, with an emphasis on complex structures that are seldom modeled. The students interested in this project should have a keen interest in learning about light propagation in photonic chip-based hardware. The project will involve coding algorithms in MEEP using either python or scheme and validating the simulation accuracy.
Supervisor	Aaron Danner
Laboratory Work	Simulation only
N0. of students	2
CA1 requirement	Initial prototype of the FDTD simulation library demonstrating basic functionalities and preliminary validation against benchmark problems. Literature survey so that there is a good understanding of what needs to be done.
CA2 requirement	Fully developed FDTD simulation library with comprehensive documentation, validation against advanced photonics problems.

FYP Proposal ID: SP101

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Photonic Simulation Using Machine Learning Techniques for Electromagnetic Wave Propagation Analysis
Summary (200 – 400 words)	This project aims to enhance the efficiency and accuracy of FDTD simulations through machine learning (ML) techniques. Specifically, ML algorithms such as neural networks or reinforcement learning will be employed to accelerate the convergence of FDTD simulations or predict electromagnetic wave behaviors in complex structures. The project will involve integrating ML models with existing FDTD codes, training them using large datasets generated from simulations, and evaluating their performance in predicting wave propagation characteristics.
Supervisor	Aaron Danner
Laboratory Work	Minimal laboratory work; computational resources for training ML models and running FDTD simulations on computers.
N0. of students	2
CA1 requirement	Developed ML models integrated with FDTD simulations, initial training results, and comparison with traditional FDTD methods.
CA2 requirement	Optimized ML-enhanced FDTD simulation framework, comprehensive performance evaluation against benchmarks, and a detailed report on the advantages and limitations of using ML in FDTD simulations.

FYP Proposal ID: SP102

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Design and Build of VCSEL-based high speed communication system for Demonstration Purposes
Summary (200 – 400 words)	This project involves designing and constructing a functional VCSEL-based fiber optic communication system suitable for use at ultra high speeds. The system will include components such as laser sources, optical fibers, modulators/demodulators, detectors. The project will emphasize understanding optical communication principles, system integration, and performance optimization. Practical considerations such as signal attenuation, dispersion, and noise mitigation techniques will be addressed through simulations and experimental validations. The key in this project is that we will push VCSELs to their maximum capabilities. Typically they are limited in speed to 1-2 GBps but through principles such as equalization or signal conditioning, we will firstly analyse the physical limitations and then try to beat them in a practical system design.
Supervisor	Aaron Danner
Laboratory Work	Yes, some laboratory work involving optical components, alignment tools, signal generators, oscilloscopes, and optical power meters.
N0. of students	2
CA1 requirement	Design of VCSEL-based communication system.
CA2 requirement	Build a VCSEL-based communication system for demonstration purposes.

FYP Proposal ID: SP103

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Development of Optical Nonlinearities for Photonic Computing Applications
Summary (200 – 400 words)	One of the keys to efficient optical information processing is the intermix of both linear and nonlinear operations. Linear optical operations such as matrix-vector multiplication are relatively easy to implement because of fundamental theorems which relate linear algebraic operations to linear optical operations. However, nonlinearities which are common in computing are less clear. In this project, we will explore what is achievable in optics. What nonlinear functions are practical and how quickly can the be carried out optically? Since linear operations can take place on dedicated optical chip-based hardware nearly 10,000 times faster than in the best nVidea chip, a key question for the future of optical computing is whether nonlinear operations can also have such a speed up. Let's explore this question in this project. The work involves literature survey, FDTD simulation, design, and speed analysis.
Supervisor	Aaron Danner
Laboratory Work	Design and simulation only
N0. of students	2
CA1 requirement	Simulation results demonstrating the feasibility of utilizing specific nonlinear optical effects for photonic computing applications.
CA2 requirement	Developed optical nonlinearities platform, experimental validation of selected nonlinear effects, performance evaluation metrics (e.g., efficiency, speed), and a comprehensive report on the potential and challenges of using optical nonlinearities in photonic computing.

FYP Proposal ID: SP104

Academic Year	AY 2024/2025 (September 2024 – May 2025)
Title of Project	Benchmarking Ising Machines for Optimization and Sampling Applications
Summary (200 – 400 words)	This project aims to benchmark Ising machines, a type of quantum annealer or analog computing device, for their performance in optimization and sampling tasks. Ising machines are specialized hardware designed to solve combinatorial optimization problems by minimizing the energy of an Ising model. The project will involve understanding the underlying principles of Ising machines, exploring their hardware architecture (e.g., D-Wave systems), and evaluating their performance metrics such as solution quality, computational time, and scalability. The project will utilize existing benchmarking frameworks and datasets to compare Ising machine performance against classical optimization algorithms like simulated annealing or genetic algorithms. Emphasis will be placed on setting up meaningful benchmarks that reflect real-world optimization problems in fields like logistics, finance, or machine learning
Supervisor	Aaron Danner
Laboratory Work	Minimal laboratory work; computational simulations and possibly access to Ising machine hardware for performance testing.
N0. of students	2
CA1 requirement	Setup of benchmarking experiments, preliminary evaluation of Ising machine performance using benchmark problems, and comparison with classical optimization algorithms.
CA2 requirement	Comprehensive benchmarking report detailing the performance of Ising machines across various optimization problems, insights into scalability and robustness, recommendations for optimizing Ising machine usage, and potential applications in real-world optimization tasks.