List of IC@N Research Projects and Supervisors

School of Electrical & Electronic Engineering (EEE)

Name of Supervisor	Research Project Description
Prof Alex Kot Chichung EACKOT@ntu.edu.sg	**Exposing Image Forgery through Statistical Detection of Image Inconsistencies** (Undergraduate Level) To restore the traditional trustworthiness on digital photos, scientific means to expose the common image forgeries is urgently needed. Since making an image forgery often involves mixing signals from different image sources, this would destroy the original statistical harmony inside a photo and lead to many underlying forms of detectable inconsistencies. In this project, the student is required to implement part of our statistical detection framework on image inconsistencies, compare different types of statistical image regularities, and improves the existing detection framework based on the experimental findings.
	Making Content Adaptive Image Forensics Decision (Postgraduate Level) To restore the traditional trustworthiness on a digital photo, digital image forensics has recently become a booming research area to identify the image source and detect possible image forgeries. Some possible solutions are through detection of various image statistical regularities and apply state-of-art pattern classification techniques to make forensics conclusions. However, the common statistical regularities detected are easily affected by the different image contents and the large variations on the statistical features can degrade the forensics performance. In this project, the student is required to address the above issue and propose valid solution to improve forensics performances by making content adaptive forensics conclusions. A student with good knowledge background on image processing and pattern classification is preferred.
	Real-Time Object Detection with NVIDIA Deep Stream SDK Object detection on images/videos is computationally intensive. Real-world surveillance applications need to run on resource constrained platforms with power, memory, and compute (CPU/GPU) restrictions. This project aims to develop an efficient object detection framework using NVIDIA Deep Stream SDK for real-time applications [https://developer.nvidia.com/deepstream-sdk] (based on SSD and/or RFBNet algorithm). The framework will be tested on vehicle/person detection in surveillance videos. Project Duration: 2 - 5 months

	Efficient Object Detection in C++ for Surveillance Videos Object detection on images/videos is computationally intensive. Real-world surveillance applications need to run on resource constrained platforms with power, memory, and compute (CPU/GPU) restrictions. This project aims to develop an efficient inference engine in C++ for object detection (based on SSD and/or RFBNet algorithm). PyTorch 1.0+ C++ API will be used for development. The framework will be tested on vehicle/person detection in surveillance videos. Project Duration: 2 - 5 months
	AI for Human Re-ID across Cameras The aim of this project is to develop human Re-identification API to re-identify a Person of Interest (POI) from one camera in another different camera, among a set of multiple non-overlapping cameras. Re-identification is based on the POI's clothing and other visual attributes. The project will construct two datasets for person Re-ID using surveillance cameras on NTU campus and develop a front-end and back-end Person Re-ID API. Applicant's role in this project is to do data processing, pedestrian detection, and identification from video; CNN model training and testing on available datasets. Python, Pytorch and Linux will be used for development. Project Duration: 2 - 5 months
	Counterfeit Detection This project aims to develop a state-of-the-art counterfeit detection and recognition system that can work well to differentiate a fake and real product with similar characteristics. Automating the detection of counterfeit events for products is challenging due to the ambiguity of how such events are defined. The problem is approached by learning different methods e.g. Barcodes, QR codes, material verification etc. that can identify real product using limited supervision. We propose end-to end systems that are able to predict the counterfeit events. The applicant will be responsible for the development (implementation, training, and test) of the system on GPU server with 1 GPU. Project Duration: 2 - 5 months
	Anomaly action detection in surveillance video This project aims to develop a state-of-the-art anomaly action detection and recognition system that can work well in the wild in unconstrained operating conditions. Automating the detection of anomalous events within long video sequences is challenging due to the ambiguity of how such events are defined. The problem is approached by learning generative models that can identify anomalies in videos using limited supervision. We propose end-to end system based on 3DCNN networks that are able to predict the evolution of a video sequence from a small number of input frames. The applicant will be responsible for the

	development (implementation, training, and test) of the system on GPU server with 1 GPU. Project Duration: 2 - 5 months
Assoc Prof Ali Iftekhar Maswood EAMASWOOD@ntu.edu.sg	**Isolated DC/DC Converter with MPPT Extraction for DC motor Application** (Postgraduate Level) This project is about photovoltaic power extraction from solar panels. The project includes discussion on different types of dc-dc converter and types of maximum power point tracking system (MPPT). Study and understanding of dc-dc converter and MPPT are done in order to select the best alternative for the project requirement. An isolated dc-dc converter is used for this project, and its simulation is carried out in PSIM/MatLab software. For the maximum power extraction on solar panels, a MPPT technique is selected, and its simulation is carried out. The converter is to run a DC motor in the most optimal manner. Project Duration: 2 - 4 months
	Sine Pulse Width Modulation (SPWM) scheme in Wind Turbine Inverter System for Harmonic Reduction (Postgraduate Level) Fossil fuel is depleting over the years and there are many research into renewable resource. One of them is using wind turbine system. However, most wind turbine system uses a popular and common form of modulation technique which Sinusoidal Pulse Width Modulation (SPWM). This is due to simplicity and less complex. However, it generates high total harmonics distortion (THD). In power system, harmonics leads to losses and high THD leads to very high losses, and this is deem very inefficient. The problem is handled at its rectifier. Vienna Rectifier is a three-phase topology using only three switching device and investigated to study its properties. Simulations is done to provide analysis on how different types of Vienna Rectifier is used to improve its THD. In these study, two methods is used mainly Pulse Width Modulation (PWM) and Hysteresis Current Controller . PWM uses a fixed frequency to generate the voltage for the switching device. Hysteresis Current Controller is use to generate the modulation method based on the its phase input, voltage, output capacitor voltages. While this study aims at harmonics reduction, Vienna Rectifier provide additional characteristics of a unity power factor. Consequently, it provides a more efficient and reliable power system. Project Duration: 5 months
Asst Prof Amal Chandran achandran@ntu.edu.sg	**Satellite technology enablers for IoT applications** Singapore's smart nation initiative will utilize data from a multitude of sensors. A space based Low-Earth-Orbiting Equatorial constellation of 6 small satellites can provide a continuous efficient back up system for data relay in the event of failure of the terrestrial network. This space platform

	can also thus an efficient technology enabler for disaster recovery and for IoT hubs for remote areas/ocean-based buoys or autonomous exploration devices. This project aims to conceptualize and prototype the ground and space segment for this space based IoT enabler. Project Duration: 2 months
	Development of low cost subsystems for student satellites (Undergraduate Level) The Satellite Research Centre at Nanyang Technological University is embarking on a series of student satellite programs where select undergraduate students will get the opportunity to build cubesats and small satellites. A Cubesat is a miniaturized self-contained small satellite built in scalable multiples of 10 cm x 10 cm x 10 cm (1 Unit) weighing no more than 1.33 kg per Unit. A cubesat contains all the sub-systems of a larger spacecraft. Students will get the opportunity to develop, build and test spacecraft sub-systems and integrated satellites. Project Duration: 6 months
Assoc Prof Anamitra Makur eamakur@ntu.edu.sg	**Compressed Sensing and its Applications** (Postgraduate Level) This project involves algorithm development in the area of compressed sensing, a new area of research in signal processing community. Compressed sensing involves taking measurements of a sparse signal using random basis functions and reconstructing the signal from these measurements. Many reconstruction algorithms such as basis pursuit family and matching pursuit family have been proposed. In this project the objective is to apply compressed sensing to new scenarios such as reconstruction in presence of noise, or reconstruction of joint sparse signals, etc. Matlab knowledge and love of mathematics is desirable for this project.
Assoc Prof Arokiaswami Alphones EAlphones@ntu.edu.sg	**Composite Right Left handed Metamaterials for Microwave Circuits** Multi band filters/ Leaky wave phenomenon from the composite right/left-handed transmission lines (CRLH TLs) is a very interesting and promising topic in recent times. The most important advantage for the CRLH TLs is that they can be used to design leaky wave antennas which can radiate backward in the left-handed (LH) mode and forward in the right-handed mode. With the development of the CRLH TLs, one important property has been found that the structure can support the backward radiation when it is working in LH region, and it exhibits negative permeability and negative permittivity. The structure can be realized by introducing the series capacitance. The transverse slots etched in the upper side of the waveguide create series capacitance, while the solid inductive posts in the rectangular guide create the shunt inductance. Besides the posts at the side walls, additional posts are introduced at the centre of the waveguide with one

	and three posts alternatively. These contribute the LH property of the SIW, which is necessary to support a backward radiation.
	Modelling of Photonic Crystal Fibre Photonic crystal fibers (PCF) are promising fiber structures. Their applications in nonlinear optics, supercontinuum generation, soliton propagation, and photonics signal processing are some examples of the improved performance of PCF. Despite the known benefits of those fibers, the modelling has attracted much interest in the last few years. Finite difference methods have the general advantages of their simplicity, the ease of implementation, and the possibility of including several additional effects without relevant modifications. On the other hand, they have some drawbacks, as other method of analysis, related to memory requirements as the photonic crystal structure becomes large. Some of those problems can partially be alleviated by the use of sparse matrices and advanced eigenvalue calculation methods. In this work a comparative study between the spectral Fast-Fourier transform (FFT)-MS method and the central finite difference methods of high order has to be performed to conclude on the numerical methods of PCF models.
	Wireless Energy Harvesting In this project, a wireless power transfer (WPT) that is adaptive to change in coil separation will be attempted. For analytic design of the WPT system, a new design method which does not require calculating the voltages and currents in the system is to be explored. The proposed design method may allow us to have perfect impedance matching theoretically for the WPT system using capacitor circuits connected to the sending and receiving coils. Closed-form design equations are to be derived for straight-forward application of the new design method. In order to compensate the variation of the mutual coupling between the two coils due to the change in separation, a new switchable capacitor array circuit need to be attempted. For verification of the new design method and the new switchable capacitor array circuit, fabricate and measure a WPT system operating at lower frequency.
Assoc Prof Boon Chirn Chye eccboon@ntu.edu.sg	**Virtual Reality RFIC** (Postgraduate Level) Candidate will engage in state-of-the-art research in RFIC. Technology node for fabrication in our group is TSMC 40nm. Chance to use advance testing equipment up to 325Ghz. Candidate will engage in either analog baseband, Mimo Antenna, IC controlling software stack or RF front-end for VR applications. Strong interest and background in IC or baseband software stack will help in your PhD.
	In-Band-Full-Duplex Transceiver's Component IC Design A new paradigm for future wireless communication. In-Band-Full-Duplex Transceiver's allows for 2 x throughput with the same wireless spectrum.

	This is an extremely important technology for the overly congested frequency spectrum. In this work, together with post-doctoral fellows and researchers team members, you will embark on an integrated circuit design learning journey while working on a component or part of such transceiver.
Asst Prof Cuong Dang hcdang@ntu.edu.sg	**Imaging through strongly scattering media** (Postgraduate Level) The project will combine algorithm with specific hardware arrangement to do imaging through strongly scattering media. We do not implement any technique to de-scatter the structure or even understand the scattering media. We take 'seemingly random' speckle pattern image, then find out the object behind by digging into the statistic properties of these speckle with strong algorithm. Project Duration: 3 - 6 months
	Optical wave front controls for biomedical imaging (Postgraduate Level) Have you ever wanted to look or image through the skin by light wave? Skin or bio-tissues do not absorb light significantly; they scramble the light path and mesh up the spatial information of the objects behind. We will design and execute a special optical imaging system to de-scatter light. The captured images are better quality with speckles. Then we will build an algorithm to reconstruct images and reveal the high quality images of objects behind a scattering medium. The algorithm is based on the signal processing with significant knowledge about optical properties of random scattering media. The project will combine your physical experiment skills with computational coding skills.
	Full Colour Single Material Lasers (Postgraduate Level) Compact visible lasers would enable an extreme technology for many applications such as lighting, display, or visible light communication. Conventional solid state lasers based on semiconductor hetero-structures are technologically matured and ubiquitous but still cannot cover the whole visible spectrum. Colloidal semiconductor nanomaterials with full visible colour tune-ability offer a great solution for this problem. The proposed research aims to study both theoretical and experimental parts of the colloidal quantum dot lasers. The research will cover theoretically modelling/optimizing nanocrystal structures for stimulated emission, chemically synthesizing colloidal semiconductor nanocrystals, building a resonant cavity to enable a nanocrystal laser by micro-fabrication techniques, characterizing the optical gain materials and lasers.

	Optoelectronic devices with solution processed materials (Postgraduate Level) The research focuses on the optoelectronic devices such as light-emitting diodes, lasers, solar cells, or photodetectors with advanced solution processed materials. We are targeting new semiconductor materials such as perovskites, semiconductor nanomaterials, quantum dots, nanoplatelets. The research will cover theoretical modelling/optimizing novel materials, experimentally demonstrating the materials and their optoelectronic devices with high performances.
Assoc Prof Chang Chip Hong ECHChang@ntu.edu.sg	**Design of Residue Number System (RNS) Based Scalers** (Final year Undergraduate and Postgraduate Level) RNS is very attractive for designing high speed digital hardware, especially in real time process control and signal processing, due to its main advantage of being able to perform addition and multiplication without carry propagation between different moduli; Hence, exhibit smaller delay as compared to that of in Binary Weighted Number System. However, due to its non-weighted characteristic, carrying out intermodular operations, such as sign detection, scaling, etc. entice long delay and large hardware requirement. This project focuses on scaling operation that is essential in ensuring the results of preceding operations do not exceed the dynamic range of the system.
Asst Prof Christopher H. T. Lee chtlee@ntu.edu.sg	**A high-performance direct-drive motor for electric vehicles** (Postgraduate Level) This project aims to develop a high-performance motor drive with direct-drive feature for electric vehicles. A high-speed electric motor installed with mechanical gear is a typical arrangement for electric vehicles, while this setting suffers from mechanical loss and bulky size. A direct-drive motor can be a solution for this application. This project targets to develop a direct-drive motor from design, analysis and simulation. The obtained results can be fundamental elements for future projects, e.g., fabrication for concept verification. Project Duration: 6 months
Assoc Prof Fan Weijun EWJFan@ntu.edu.sg	**Design of novel GaAsBi/AlGaAs quantum well lasers** High-performance and low-cost long-wavelength semiconductor lasers operating in the 1.3 and 1.55 μm range are highly demanded in fiber optical communication, measurement, and sampling systems. In this project, we will design a GaAsBi/AlGaAs QW laser using our k.p programs. We may control Bi composition to achieve smaller fundamental transition energy (better for 1.55 um long wavelength emission) and very large band offset for both conduction and valence bands (better electron and hole confinement. The novel GaAsBi materials grown on GaAs provide us an opportunity to fabricate high-performance and low-cost 1.55 um QW laser.

Prof Gan Woon Seng EWSGAN@ntu.edu.sg	**Subjective Study on the New Virtual Bass (Low Frequency) System** (Postgraduate Level) In this project, we will perform psychoacoustics into how human perceive low-frequency sound based on the "missing fundamental phenomenon". In this project, student will take part on an ongoing doctoral work dealing with subjective listening tests for different nonlinear devices (NLDs) used in the Virtual Bass System. Previous objective studies have shown great promise in using certain types of NLD to create useful harmonics that enhance the perceived low-frequency effect. This new subjective study will provide a correlation study on how to best design the virtual bass system that relates objective and subjective scores. The virtual bass system is now currently deployed in enhancing the bass effect for portable devices, like audio player, handphones, etc
	Implementation of a Beamsteerable Loudspeaker Array (Undergraduate Level) The target of this project is to develop a LABVIEW program that can fulfil various experiments of beam steering algorithms of an ultrasound transducer (or loudspeaker) array. A basic functional LABVIEW program without GUI is provided, together with 8 channel analog output board (PCI-6733) from National Instruments. The functions to be implemented consists of a GUI with text file operation, channel selector, weight setting for each channel, weight compensation for each channel, delay compensation for each channel, optimal update rate, and temperature compensation for sound speed. This project requires student with good experience on LABVIEW program and will provide student with an opportunity to understand basis concepts of array signal processing.
	Research into new 3D audio technology for 3D TV (Postgraduate Level) With the recent advancement and popularity of the 3D TV LCD in home entertainment, there is a strong desire to improve on the 3D audio capability and features of current TV speakers. Several research works have been on-going in the DSP Lab in NTU and the selected student is to assist the researchers in carrying out several objective and subjective measurements. There are several interesting novel works that are yet to be researched in this field. One such work involves the development of a new type of 3D audio system that is dependent on the content of multi-channel audio soundtracks in today's movie format. Several interesting research questions to be answered in this work.
	New Deployment of Directional Sound System (Undergraduate Level)

	This project investigates new deployment of the directional sound system. Student will have the opportunity to assist researchers to carry out several experiments and deployment of the directional sound system. Student will also learn the art of measurement of sound radiation pattern in an anechoic chamber using an array of microphones and binaural microphone with dummy head and torso. To make this project more interesting, student will also be involved in programming the latest embedded processor for implementing some pre-processing algorithms to drive the directional sound system.
Assoc Prof Gooi Hoay Beng EHBGOOI@ntu.edu.sg	**Optimization of Load Aggregator via Maximization of District Benefit** (Postgraduate Level) A Load Aggregator (LA) combines all Demand Dispatch (DD) and Demand Response (DR) loads of homes and buildings. Each participant will be compensated proportionally based on the half-hourly kWh contribution amount. Based on the declared DD/DR amounts or past historical measurements and performance, LA is able to schedule DD and DR loads. LA participates in the optimization of generation and demand by considering maximum demand, ToU tariff, supply and load constraints, and traditional and renewal energy sources. Optimization is performed by maximizing the overall campus benefit. DD and DR will be incorporated as an expanded version of Automatic Generation Control.
Assoc Prof K. Radhakrishnan ERADHA@ntu.edu.sg	**Gas sensing using GaN-based HEMT Structures** Gas sensing technology, where the detection of gases and air pollutants is imperative for safety of health. Common sensors suffer from limited sensitivity/lifetime, poor selectivity and high energy consumption. To overcome these shortcomings, III-Nitrides based sensors are attractive as they offer high band gap, 2-Dimensional Electron Gas (2DEG) near the surface and chemical inertness. We propose novel AlN/GaN heterostructure for NO2, CO2 and O2 gas sensing. Specific objectives are to optimise epigrowth of thin AlN (barrier), GaN (channel) and thick AlN (buffer) layers, and gas sensor demonstration. AlN/GaN heterostructure offer high 2DEG concentration due to higher spontaneous polarization, achieved by thin barrier ~5 nm. The unique feature of channel near the surface makes this sensor more sensitive and efficient. Project Duration: 6 months or longer
	GaN-based UV detectors on Silicon Group III Nitrides offer major advantages compare to conventional silicon-based UV detectors. They have direct bandgap, which confers the photodetector with improved spectral selectivity. The cut-off frequency can be engineered by changing the mole fraction in their ternary alloys, which allows for blue and white light emission or detection. Conventional GaN-based epitaxial layers are generally grown on sapphire or SiC, which are either poor thermal conductor or expensive. In this project, we aim to develop GaN-based UV detectors on Silicon using MBE growth, and fabricate detectors with low dark current, high quantum efficiency, improved responsivity, and bandwidth.

	GaN-based High Electron Mobility Transistors It is proposed t investigate the growth and fabrication of lattice matched InAlGaN/GaN HEMTs on Si by Molecular Beam Epitaxy (MBE) technique to demonstrate higher frequency performance compared to conventional AlGaN/GaN devices. Extensive characterization techniques such as Hall, mercury probe CV, SEM, TEM, XRD, AFM, Raman spectroscopy, etc will be used to study the electrical, structural, optical, stress and surface morphology properties of the grown layers. Further, DC and RF characterization of the fabricated HEMTs will be studied and compared.
	Electrical and Structural Characterization of GaN based semiconductor layers GaN-based semiconductors are important for high-power, high-frequency and high-temperature electronic applications due to wide bandgap, high saturation velocity and high breakdown electric field. Devices based on these materials are promising for applications in radar, satellite, wireless base stations, etc. Materials growth and their properties play a vital role in the performance of these devices. Surface, optical, electrical and structural characterizations are important to understand the crystalline quality, composition, thickness, defects and carrier mobility of the material. In this project, characterization of GaN based semiconductors will be studied using Hall, CV, AFM, X-ray diffraction, and Photoluminescence. Results will be correlated with epitaxial growth parameters.
Assoc Prof KIM Tae Hyoung, Tony THKIM@ntu.edu.sg	**Design of Robust Sub-threshold Circuits for Highly Energy Efficient Microwatt Systems** (Postgraduate Level) In recently emerging battery-powered applications such as mobile electronics, wireless sensor nodes, RFID Tags, and implantable biomedical devices, energy efficiency concerns surpass traditional emphasis on performance. Sub-threshold circuits are attracting interests since the minimum energy consumption to maximize the battery lifetime can be achieved in the sub-threshold region. However, various challenging issues including frailty sub-threshold operations, high process-voltage-temperature (PVT) variation sensitivity and difficulties in designing analog and mixed-mode circuits exacerbate the utility of sub-threshold circuits in real applications. The goal of this research is to develop sub-threshold circuit design techniques for microwatt applications with operation robustness and high energy efficiency in nano-scale technologies.
	Design of Robust Sub-threshold Circuits for Highly Energy Efficient Microwatt System (Final Year Undergraduate Level)

	In recently emerging battery-powered applications such as mobile electronics, wireless sensor nodes, RFID Tags, and implantable biomedical devices, energy efficiency concerns surpass traditional emphasis on performance. Sub-threshold circuits are attracting interests since the minimum energy consumption to maximize the battery lifetime can be achieved in the sub-threshold region. However, various challenging issues including frailty sub-threshold operations, high process-voltage-temperature (PVT) variation sensitivity and difficulties in designing analog and mixed-mode circuits exacerbate the utility of sub-threshold circuits in real applications. The goal of this research is to develop sub-threshold circuit design techniques for microwatt applications with operation robustness and high energy efficiency in nano-scale technologies.
Asst Prof Leong Wei Lin wlleong@ntu.edu.sg	**Novel materials and device structures for printed electronics** Organic and printed electronic devices such as solar cells, transistors and memories are under intense research due to their potential to enable production of flexible, stretchable, and low-cost devices. This project proposes to fabricate and test these printable electronics. Candidates for this project are preferably those with interests in electronics and materials characterization.
Assoc Prof Ling Keck Voon EKVLING@ntu.edu.sg	**J-Park Simulator** J-Park simulator is a project under the Cambridge Centre for Advanced Research and Education in Singapore (Cambridge CARES). The simulator models the manufacturing activities in an industrial park, their carbon footprints, electricity usage, etc. It will display every object in 3D for data visualisation and user interaction. You will be expected to contribute to the coding effort of project. Candidate is expected to have extensive coding experiences, especially in C#, XML, and 3D modelling.
	Accelerating Model Predictive Control This project aims to accelerate computation of Model Predictive Control (MPC), a form of constrained optimisation to be carried out online and in real-time, on special purpose hardware such as FPGA or GPU. Experiences in digital circuit and system design, MATLAB would be useful. Predictive Control Knowledge is desirable but not necessary.
	Model Predictive Control (MPC) on a Chip The purpose of this project is to implement the MPC algorithm (a Quadratic Program which need to be solved in real-time at every sample) on a FPGA. The candidate should have the necessary mathematic background, e.g., linear algebra, as well as MATLAB and FPGA (Xilinx ISE) coding experiences. Model Predictive Control knowledge is desirable but not necessary. One area of interest is to investigate how one could optimise or trade-off speed vs resource usage to fit the demand of specific application.

Asst Prof Luo Yu luoyu@ntu.edu.sg	**Ultrasensitive metadevices for biosensing** (Postgraduate Level) The demand for new chemical and biological sensing methods for the effective detection of small amounts of molecules has been continuously growing for diverse purposes such as health care, food monitoring, environmental science, and national security. In particular, there is an increasing concern for health risk originating from screening to detection of bio-molecules. One element in strategy to address these concerns is to develop rapid, easy to use, sensitive detection methods which are the objective of this project. The localized surface plasmon resonance (LSPR) supported by noble metal nanostructures provides a powerful platform for sensitive structural detection of a single or a small number of bio-molecules. In this project, the student will be guided to design compact, non-invasive, and cost-effective meta biosensors capable of detecting specific protein at the single molecule level.
	Negative refraction in metamaterials (Undergraduate Level) When light is incident upon the interface of two different materials, it will be bent and refracted at the interface. Normally, the refracted and incident light beams lie on different sides of the surface normal. Nevertheless, recent theoretical and experimental developments show that artificially structured metamaterial can support negative refraction, where the refracted and incident light beams appear on the same side of the surface normal. However, most of the previous designs are metal based, where large dissipation losses strongly deteriorate the performance of devices under design. In this project, we will explore a new approach by using all dielectric resonators to achieve low-loss negative refraction. Project Duration: 6 months
	Invisibility cloak designed with a genetic algorithm (Undergraduate Level) Invisibility cloak is a fictional device which can make objects invisible to outer detection. Recent years, invisibility cloak has become a hot research topic. However, previous invisibility schemes provide less ability to characterize the performance of a multi-layered cloak in practice. In this project, the student will be guided to model the performance of a multi-layered invisibility cloak. A genetic algorithm will be applied to diminish the intrinsic scatterings caused by discretization and simplification. The goal is to design a 'quasi-perfect' invisibility device with only a few layers of artificially structured materials, that can be easily implemented in practice. Project Duration: 6 months

	On-Chip Narrowband Thermal Emitter for Filter-Free gas Sensing at Mid-infrared frequencies (Postgraduate Level) In this project, we will design an on-chip narrowband thermal light source for mid-infrared gas sensing by combining microelectromechanical system (MEMS) heaters with metamaterial perfect emitter structures. The ultimate goal is to design a dual-gas detection in a single MPE structure. Project Duration: 6 months
Assoc Prof Ma Maode EMDMa@ntu.edu.sg	**Design of Efficient Security Schemes for Cloud-based E-Health Systems** (Postgraduate Level) Data sharing in cloud-based e-Health systems is the most popular one of the important applications in cloud computing. The data sharing will introduce the security issues of access control. To prevent the untrusted cloud server from accessing the sensitive data, particularly the patients' health information, a promising method is to encrypt the records before outsourcing. In this project, the student will design secure access control schemes applying the multi-authority attribute-based encryption with a traitor traceability method.
	Security and Performance Enhancements on 5G Wireless Networking (Postgraduate Level) The integration of heterogeneous wireless networks is one of important issues of 5G wireless technology. In this project, the student will investigate the security functionality of the heterogeneous wireless networks. Furthermore, he will evaluate the performance of the existing security schemes and design the security schemes with improved performance while enhanced security functionality for the 5G wireless network systems.
	Security Study in Cloud Computing (Undergraduate Level) Cloud computing is one of today's most enticing technology areas due to its cost-efficiency and flexibility. However, there are significant potential for the system vulnerable to various security weakness. In cloud computing, since the user's data has to be released to the cloud and thus leaves the protection sphere of the data owner. In this project, the student will investigate various security problems and their impact on adoption including data confidentiality, data safety and data privacy. The purpose of this project is to explore ways to a secure, trustworthy, reliable, and easily applicable Cloud Computing environment.

	Design and Implementation of Security Protocol for Wireless Vehicle Communications (Undergraduate Level) "Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) provide communications among nearby vehicles and between vehicles and the fixed roadside infrastructure. Vehicular networks are a cornerstone of the envisioned Intelligent Transportation Systems (ITS). Currently standards are mainly for communication purposes, and hence there is limited security for V2I and V2V communications. Thus, the project objective is to design and implement the security protocol to authenticate the vehicles and protect the exchanged messages in vehicular communications, and finally evaluate its performances.
	QoS Supports in LTE 4G Wireless Cellular Networks (Undergraduate Level) The Long Term Evolution (LTE) is the emerging technology for the 4G wireless cellular networks. Different from conventional wireless cellular networks, LTE facilitates data transmission between base station and its mobiles. In this project, the student is expected to investigate various solutions for QoS provisioning by simulation experiments in the LTE cellular networks. The student will also explore to design an efficient MAC layer protocol to support QoS in LTE networks.
Assoc Prof Poenar Daniel Puiu epdpuiu@ntu.edu.sg	**Design & simulation of micro-electromagnetic components for RF applications and bioMEMS** The goal of this research is to boost the output of a current, freshly started research project targeting to design original micro-devices for performing various RF functions useful for either RF applications, or bioMEMS using magnetic methods. The starting point is to investigate novel planar microcoils or 3D-like integrated inductors. Dependence of the magnetic field strength, RF performance on geometrical parameters, type of the substrate, and the fabrication method will be investigated. The bulk of the work will most probably be dedicated to Finite Element Analysis FEA simulations and analysis of such devices, as well as of their performance. We have available dedicated licenses for Microwave Studio which is a powerful electromagnetic simulation software. The student should be serious, hard-working, knowledgeable in basic electromagnetics and physics, as well as some knowledge of Si wafer microfabrication, and have good grades. Although not mandatory, some earlier exposure to RF design & modelling, and especially FEA simulations, would be welcome and obviously useful.
	Design & simulation of simple miniature devices for differentiation of airborne particles This project aims to investigate some methods & devices which can differentiate airborne particles in size-related categories (bins), i.e.

	perform granulometry. Some of these methods are Field Flow Fractionation (FFF) and aerodynamic separation methods. FFF separates different particles moving through a channel by applying a vertical field (or gradient) across the channel (i.e. along the z axis) and normal to the flow along the x axis. Various types of fields can be applied: electric, thermal, flow or gravitational. Separation of particles can also be done with the so-called impactor filter or virtual impactor or using other flow-based methods. The goal is to study these separation techniques/devices, determine their performance and do simulations to optimize the performance of each. For this purpose, the student will: Perform a literature review, for introduction in topic, understanding of the theoretical principles and extraction of relevant equations, which will be used for preliminary calculations. Use a Finite Element Analysis (FEA) software (CFD-ACE) for simulations & optimizations. The optimized structures obtained at the end of the previous step will then be compared in terms of performance, and the best one(s) will be selected for the next step. 4) If time will allow, we can also investigate how the designed devices can be fabricated using simple methods such as soft lithography, or multilayer Printed Circuit Boards (PCBs) or 3D printing. The student picking up this project should easily understand the equatio ns and principles underlying the operation of the desired methods & dev ices and be able to quickly learn the FEA software. The student will collaborate wi th a Project Officer currently working in a small research project with the same topic.
Assoc Prof Soong Boon Hee ebhsoong@ntu.edu.sg	**Study and analysis of Smart Wireless Sensor Networks based on TV White** (Postgraduate Level) TV White Spaces (“TVWS”) refer to unused radio spectrum in the TV broadcast bands that could potentially be used for alternative wireless broadband communications. TVWS technology is an innovation that allows opportunistic access to the presently untapped and under-utilised source of spectrum, to meet the demand for frequency spectrum for high-speed wireless broadband Internet access, machine-to-machine communications, smart metering and outdoor environment monitoring services. The project will involved the simulation study of specialized MAC (Medium Access Control) protocols for the underground monitoring system using Matlab. Project Duration: minimum 5 months

	Wireless Power Transfer for Biomedical Implanted Devices (Postgraduate Level) Recent advances implementation of miniaturized embedded systems is not limited to biomedical applications. Implanted Micro-systems for monitoring or actuating devices are readily available in the market for environmental monitoring and other industrial applications. Wireless data and power transfer is an attractive option as it allows the full exploitation of the potential of such systems. Magnetic or inductive coupling at radio frequencies for wireless power and data transfer is a widely acknowledged solution for low power devices. Student will also benefit from building architecture and algorithm to improve wireless power transfer efficiency and apply technology to the industrial needs. In addition, the student will be working research students to provide the new applications. Project Duration: minimum 5 months
Assoc Prof See Kye Yak EKYSEE@ntu.edu.sg	**Fault Detection using Machine Learning and Statistical Data Analysis** (Undergraduate Level) Huge amount of data for rail faults detection was collected. Analysis of the collected data can reveal any deviation from the normal operation and this deviation is indicative of the system's potential malfunction or defect. The task in this project is to analyse the data and find those specific defect signals and also to identify the specific signature of the defect based on the available information. Project Duration: 2 months
	Frequency Selective Surface for Electromagnetic Interference Shielding (Postgraduate Level) The growth of wireless communications, such as GSM mobile services, wireless LAN, TV and radio broadcast, have brought us much convenience. However, it also means that our environment is occupied by a wide spectrum of electromagnetic fields, which could be an electromagnetic interference (EMI) threat to sensitive electronic devices, for example, medical electronics in hospital. Frequency selective surfaces (FSS) have been studied extensively since 1960s and been deployed in the design of randomes, Cassegrainian reflectors and reflect-array lenses, mostly for defense applications. The use of FSS in EMI suppression provides selective protection against strong electromagnetic field at specific frequency. The project aims to employ 3D full-wave electromagnetic modelling software to design and to implement a FSS that behaves as a band stop shielding at the ISM band (2.45 GHz).

Prof Shen Zhongxiang EZXShen@ntu.edu.sg	**Design of Low-profile Wide-band UHF Slot Antennas** (Postgraduate Level) Wide-band UHF antennas are extensively used in many radar and communication systems. The objective of this project is to design a low-profile slot antenna that exhibit broadband characteristics in the UHF band.
	Design of Three-Dimensional Frequency Selective Structures This project aims to investigate a novel three-dimensional (3D) frequency selective structure (FSS). The new structure consists of a two-dimensional periodic array of planar transmission lines and exhibits very attractive and unique features such as quasi-elliptic filtering performance, stable angular response, and robust design capability.
Assoc Prof Teh Kah Chan ekcteh@ntu.edu.sg	**Energy-efficient co-operative systems** (Undergraduate Level) In this project, we focus on optimizing the energy efficiency of co-operative systems. The student will first study existing methods and reproduce some of the existing results using Matlab programming. Following that, new algorithm will be proposed, and its performance will be compared with the existing methods.
Prof Tan Chuan Seng TanCS@ntu.edu.sg	**Germanium Photonics** (Postgraduate Level) There is tremendous potential for communication (e.g., chip to chip) and sensing (chemical, gas) applications at the 2 micro-meter wave-length. This is presently achieved by using compound semiconductor. To enable manufacturability, reliability and cost, semiconductor from group-IV is highly desired. Germanium based photonics is an emerging areas to fulfil this objective. There are a number of scientific and technical challenges that must be overcome before this can come to fruition. The main objective in this project is to study the effect of strain and alloying on enhancing the properties of Ge to meet the above objective. The scope includes materials growth, processing, device design/modelling, fabrication, and characterization.
Assoc Prof Tang Xiaohong exhtang@ntu.edu.sg	**Selective post-growth bandgap tuning of semiconductor quantum well structure for novel photonics devices** (Final year Undergraduate and Postgraduate Level) Post-growth bandgap tuning is very important technology for photonics integration and developing novel photonics devices. In this project, a post-growth selective bandgap tuning technology for quantum well structures will be developed and studied. The application of this technology into developing novel photonics devices will be explored.

Assoc Prof Tay Wee Peng wptay@ntu.edu.sg	**Distributed Deep Learning for Visual Recognition** (Postgraduate Level) We analyze and investigate the use of distributed methods to implement a deep neural network learning architecture over multiple nodes in a network. Using distributed features and running in a distributed fashion, the proposed architecture is expected to achieve better accuracy and robustness compared to current machine learning methods. Project Duration: 6 months
	Hybrid Graph Signal Processing and Deep Learning Methods (Postgraduate Level) We aim to develop a robust learning framework that can handle noisy sparse labels and correlated data points, through the fusion of graph signal processing (GSP) and machine learning techniques. By leveraging on the correlation information gleaned through GSP,and combining graph features with traditional features in a machine learning model, we aim to achieve accurate learning even in the case where labels in the training set are noisy or unreliable or when not all data samples have labels. Project Duration: 6 months
	Generalized Graph Signal Processing Methods and Applications (Postgraduate Level) We develop a Hilbert space theory for generalized graph signal processing, including the concept of filtering and sampling of generalized signals on graphs. We apply this theory to various applications and study the advantages of such a framework compared to traditional graph signal processing approaches. Project Duration: 6 months
	Fusion Based Vehicular Localization Method (Postgraduate Level) Vehicular self-positioning is of significant importance for intelligent transportation applications. However, accurate positioning (e.g., with lane-level accuracy) is very difficult to obtain due to the lack of measurements with high confidence, especially in an environment without full access to a global navigation satellite system (GNSS). We develop information fusion algorithms based on a particle filter to achieve lane-level tracking accuracy under a GNSS-denied environment. This project involves both software and hardware implementations.

	Project Duration: 5 months
Prof Tay Beng Kang ebktay@ntu.edu.sg	**CVD growth and application of Sb thin flakes** (Undergraduate Level) Antimonene, an atomic layer of antimony (Sb) atoms, is predicted to be a semiconductor, and have good potential application in electronic devices. Currently, the Sb monolayers have only been demonstrated by molecular beam epitaxy, which have small size and are not suitable to device fabrication. CVD is an efficient method for 2D materials growth, however, so far, the Sb flakes grown with CVD is still thick, and further effort is necessary for thin flakes. In this project, the student will explore the CVD growth mechanism of Sb thin flakes with CVD and their application in electronic devices. Project Duration: 6 months
	Growth and application of two dimensional layers of group VA elements (Postgraduate Level) Recently, the atomic layers of other elements of group VA, including arsenic, antimony and bismuth, are predicted to be semiconductors that are stable and have high mobility, which make them promising to be applied in electronic devices. However, the preparation of such atomic layers is still challenging. In this project, the student will explore the growth mechanism of van der Waals layers of antimony and bismuth with CVD and our recently setup sputtering system, and explore the properties of such materials, including their compositions with XPS, their crystalline structure with XRD and TEM, and apply such materials in electronic devices. Project Duration: 6 months
	Advanced EM shielding through novel CNT fence wall transfer technology (Postgraduate Level) With the increase in mobile phones and smart homes, research focused on higher frequency bands. This resulted in interference between adjacent circuitries. Electromagnetic isolation has been introduced to avoid unwanted coupling from EMI. MWCNTs have shown potential due to absorption and negligible skin depth effect. In this project, the student will design and develop a novel high performance carbon based EM shield that benefit from properties such as light weight, size reduction, high aspect ratio and improved EM isolation as compared to classical approaches that are critical for the advancement of future miniaturised HF devices.

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Assoc Prof Wang Han HW@ntu.edu.sg	**Face and Eye Detection** The project is about face detection, as well as detection of eye open/close detection. We wish to develop a hardware based solution to speed up the detection process.
Assoc Prof Xiao Gaoxi EGXXiao@ntu.edu.sg	**Co-evolution of opinion and social network topology in opinion formation** In this project, we study on co-evolution of social opinion and social network topology. Students need to have some basic (not necessarily extensive) background knowledge of C++ or Matlab programming (either one of them).
Assoc Prof Zheng Yuanjin YJZHENG@ntu.edu.sg	**Design a MIMO Communication System for Wireless Ingestible Capsule Applications** Wireless capsule endoscope, also known as the pill camera was introduced in clinical medicine as a non-invasive technique for visualizing the gastrointestinal tract. Instead of having a flexible endoscope inserted through the mouth or the rectum, the patient swallows the capsule endoscope, which is equipped with lens, image sensor, transmitter and batteries. The wireless camera takes thousands of high-quality digital images within the body as it passes through the entire length of the small intestine. These images are wireless transmitted to a data recorder outside body worn like a belt by the patient while going about his or her day as usual. The student will study the dedicated wireless body channel and build the channel model. Based on the channel model, a multiple

	input multiple output wideband communication system including transmitter, receiver and synchronizer will be proposed and simulated. The proposed system, once function verified, will be mapped to integrated circuits block level for practical implementation and evaluation. The student who has strong interest on IC design and communication system are welcome to apply.