School of Information Technology

2022 Research Projects

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Next Generation AI for Adversarial Networks

Supervisor: Dr Adnan Anwar, adnan.anwar@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

In the age of Internet-of-thing, the enormous amount of data attracts cyber attacker to launch various types of cross-site scripting, ransomware, SQL injections, email spoofing, audit-train-falsification not only through the traditional internet, but also based on weak security measures of the smart devices and IoT protocols. The amount of data and the velocity has made it challenging for the traditional security systems to detect an attack and cyber threat efficiently and accurately. Advanced Machine Learning (ML) based models and techniques can be a viable solution to mitigate security threats. ML algorithms can update the models in real-time as per the requirements; mine and process big data efficiently and effectively; and detect attack with veracity. Lightweight property is another key aspect. On top of that, a machine learning model itself could be vulnerable by new types of adversarial attacks. This domain is known as adversarial machine learning (AML). This project has two phases: i. Develop a lightweight but accurate ML model for cyber-threat detection, ii. Protect the model against adversarial attacks.

This project will help the students to enhance their skills and experience in the area of machine learning and artificial intelligence. Outputs from this project will help to understand some industry practices on cyber threat analysis. Students will also develop hands-on experience in advanced machine learning models and implementations.

Curious to know what is AML?

Keywords: IoT, cybersecurity, ML, AI, Adversarial ML

Necessary Skills:

- Python (or similar) coding at least basic level (and interest to learn more)
- Analytical mindset
- Passion in machine learning

NFTs as a service

Supervisor: Dr Alessio Bonti, a.bonti@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The current trend of trading non-fungible tokens (NFTs) has become worldwide. People are trading digital assets at the value of thousands of dollars. Sport stars and artists are releasing their own NFTs to connect with their fans and promote themselves to the audiences. On the other hands, fans are also able to support and express their loyalty by buying and trading the NFTs released by their idols.

That was to show how NTFs and blockchain technology together can increase people engagements to an entity. We would like to look at a different field where improvements of people engagements are critically important

Blockchain can be used in universities to issue digital badges which is achievable and collectable to their students with some certain criteria and expectations. It can also be used to manage digital profiles of the students where all achievements, contributions and even references are kept in one place. The profile is known to be secured and private as it is backed by the blockchain technology. Therefore, it can be used as a trusted record to any parties want to verify.

NFTs are also able to be implemented within the universities thanks to the availability of the blockchain network. They can be used to attract students attending workshops, events and expos. NFTs can also be used similarly to how they are used by the artists in this scenario.

In this project, you will explore how the University and education environment can benefit from creating NFTs , you will work in both development and research.

Necessary Skills:

- Software Development
- Knowledge of blockchain is a plus

AI and computer vision for smart agriculture

Supervisor: Dr Alessio Bonti, a.bonti@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

You get to play with Drones!

The era of technology and innovations is rapidly transforming our lives today. The advent of advanced technologies such as computer vision is contributing enormously across industries. Among several industries, the agriculture industry is one such sector that has started incorporating computer vision in their mode of operations. As the world is engulfed with human-like capabilities, the sub-branch that is computer vision aims to train computers for interpreting and understanding the visual world. The agricultural industry has witnessed several contributions of computer vision-artificial intelligence (AI) models in areas such as planting, harvesting, advanced analysis of weather conditions, weeding and plant health detection and monitoring.

In recent years, drone technology has captured a massive chunk of the market due to its autonomous flying capabilities. Drones have become an essential factor in precision agriculture and farming. With the ability to fly and cover a significant distance, they can capture vast amounts of data through a pre-installed camera and other sensors. There are critical problems that can be addressed using this data whether it be monitor crop health, yield analysis or livestock management. At the university we would really want to explore this imagery data using current SOTA AI/computer vision techniques and expand to its full potential. This step towards innovation in agriculture not only creates direct impact on the industry but also enables us to publish quality work from a research standpoint.

The group has already secured 10K worth of hardware, including drones and Lora sensors.

Necessary Skills:

- Applied knowledge of Ai and machine learning
- Computer vision a plus

Job shop scheduling problem; Discrete differential evolution algorithm, Simulated Annealing, Tabu Search

Supervisor: Dr Atabak Elmi, atabak.elmi@deakin.edu.au **Associate Supervisor:** Dr Dhananjay Thiruvady

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This research will investigate solving the job shop scheduling problem (JSP), with and without sequence dependent setup times between the jobs. The job shop scheduling problem is among the hardest combinatorial optimization problems. Not only is it NP-hard, but even among the members of the latter class it appears to belong to the more difficult ones. The JSP consists in scheduling N different jobs (1,2,...,N) with given processing times on a set of M machines (1,2,...,M), where the processing sequence of jobs on the machines are different. Each job has exactly one operation to be processed on each machine. It is assumed that each job can be processed on at most one machine at a time and that each machine can process at most one job at a time. JSP determines the processing sequence of jobs on machines. The objective of the problem is minimising the makespan which is the completion of operation for all the parts. Due to the complexity of the problem, exact methods are not efficient in solving the problem in a reasonable time. Therefore, the Discrete Differential Evolution algorithm, Simulated Annealing and Tabu Search methods will be investigated for solving the problem.

Necessary Skills:

- C++ programming
- Mathematical modelling

IoT-enabled Discrete, Outdoor Deployable Gait Monitoring System le

Supervisor: Dr Anuroop Gaddam, anuroop.gaddam@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Walking is crucial to maintaining health and wellbeing in older age. A decline in community ambulation (walking for transport or recreation) is associated with loss of independence for community-dwelling older people and is a predictor of residential care admission and mortality. Key components of ambulation are gait speed, the ability to walk while performing concurrent cognitive and motor tasks and the ability to negotiate unpredictable terrain. The decline in mobility increases risks of frailty via reductions in strength, power and muscle mass with major negative implications on psychological health. Unfortunately, gait is usually measured on a specially designed walk path, which has to be done at clinics or health institutes. Wearable tracking services using an accelerometer, or an inertial measurement unit can measure the gain for a certain time interval, but not all the time, due to the lack of a sustainable energy source, and inconvenience to the elderly user. To tackle these shortcomings, this research develops an IoT framework and a prototype that can be embedded in outdoor landscapes to monitor individuals' gait and identify patterns of gait change. The sensorized landscape would be positioned in an area frequented by target users to improve data collection opportunities. To create a gait profile for the individual and estimate the individual's fall risk from the spatial-temporal data collected by the sensors, the research also needs to be focused on developing machine learning / AI techniques. This project involves collaborating with multi-disciplinary research teams.

Keywords: Internet of Things, Cyber-security, Machine Learning, Python Programming

Necessary Skills:

- Moderate understanding of wireless sensors and Internet of Things design
- Cybersecurity aspects that are relevant to IoT's
- Moderate to good knowledge of machine learning or Python language
- A willingness to learn new technical concepts in WSN, IoT, electronics, signal processing and health informatics

Detecting Sensor Faults and Anomalies in Internet of Things

Supervisor: Dr Anuroop Gaddam, anuroop.gaddam@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Over the past few years, the Internet of Things (IoT) has gained significant recognition to become a novel sensing paradigm to interact with the physical world. The sensors within the Internet of Things are indispensable parts and are the first port to capture the raw data. As the sensors within IoT are usually deployed in environments that are harsh, which inevitably make the sensors venerable to failure and malfunction. Besides sensor faults and malfunctions, the environment where the sensors are usually installed could also make the sensor fail prematurely. All of these will make the sensors within the IoT generate unusual and erroneous data, often known as outliers. Outliers detection is very crucial in IoT to detect the high probability of erroneous reading or data corruption, thereby ensuring the quality of the data collected by sensors.

The scope of the project includes developing models to provide the highest accuracy in detecting sensor faults and outliers in the IoT context.

Keywords: Internet of Things, Cyber-security, Machine Learning, Python Programming

Necessary Skills:

- Moderate understanding of wireless sensors and Internet of Things design
- Cybersecurity aspects that are relevant to IoT's
- Moderate to good knowledge of machine learning or Python language
- A willingness to learn new technical concepts in WSN, IoT, hardware, electronics, signal processing

Enhancing Privacy and Security of Blockchain Envisioned Internet of Things for Health Infomatics

Supervisor: Dr Anuroop Gaddam, anuroop.gaddam@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

One of the major applications of the Internet of things (IoT) are in the field of healthcare. The Health - Internet of Things (H-IoT) is, therefore, the IoT system deployed for healthcare applications. The H-IoT is a subset of a generic IoT system. There is a massive potential for these IoT systems to track the health progress of the users. The patients that are connected to the network can be tracked for the change in their health parameters such as vital signs and biometric information for better diagnosis and quality of delivered medical care. Many architectures to facilitate the exchange of information between the various participating entities are designed and developed. The centralised architecture where a central server provides services to clients on the network has downsides of high maintenance costs, poor interoperability and single point of failures from security threats. A decentralised architecture on the other hand will eliminate the disadvantages of centralised architecture. A rising decentralised management platform for IoT is blockchain. By design, the blockchain network operates in a decentralised fashion where network nodes can communicate in a peer-to-peer fashion. Blockchain and Internet of things integration will strengthen the security of the future Internet as this integration will incorporate the security features of blockchain. Although being a very powerful technology, Blockchain has a number of technological limitations as well as non-technological limitations. Some of the major problems that hinder blockchain integration with the Internet of things are scalability, interoperability, inefficient consensus algorithm, security, privacy, governance and regulations. This research will mainly focus on two of the main issues that hinder blockchain integration with the Internet of things - security and privacy.

The purpose of this research is to develop methods, approaches to automate the number of IoT based services and devices that must be vetted for security and privacy vulnerabilities in the health informatics context. The study aims to design and develop innovative security architecture for the detection of a system under attack and intensifying protection mechanisms.

Keywords: Internet of Things, Cyber-security, Machine Learning, Python Programming, Blockchain

Necessary Skills:

- Moderate understanding of blockchain and Internet of Things design
- Cybersecurity aspects that are relevant to IoT's
- Moderate to good knowledge of machine learning or Python language
- A willingness to learn new technical concepts in WSN, IoT, hardware, electronics, signal processing and health informatics

Optimising Drone Delivery Planning

Supervisor: Dr Azadeh Ghari Neiat, azadeh.gharineiat@deakin.edu.au **Associate Supervisor:** A/ Prof Xiao Liu

Campus: Melbourne Burwood, Cloud

Start: Trimester 1

Project Description:

Using drones in delivery services is a fast-growing industry that gained a lot of commercial attention from companies such as Amazon, DHL, and Google. Because of the nature of drones, uncertainty is an intrinsic part of drone delivery environment. Uncertainty may be caused by payload limitations and real-time variation of weather condition like wind and visibility. Uncertainty presents fundamental challenges in terms of availability of drones. In this project, we focus on developing efficient techniques for the selection of the best drone delivery services under a range of requirements. In particular, we will find an optimal set of drone delivery services and robots from a designated take-off station (e.g., a warehouse rooftop) to a delivery station by selecting and composing drone and robots providing the best quality of delivery service in terms of payload, time and cost under a range of dynamic environmental factors such as battery life and weather conditions.

Keywords: Drone Delivery, IoT, Machine Learning, Python Programming

Necessary Skills:

- Experience in Python programming and Machine Learning is a must
- Statistical and Graphical Analysis of Data

Deep Learning Approaches to Detect Malware

Supervisor: Dr Atul Sajjanhar, atul.sajjanhar@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 2, Trimester 3

Project Description:

Cybersecurity attacks have increased several folds in recent years. Malware attack is one category of cybersecurity attacks caused by malicious software. Malware is used by perpetrators to execute unauthorized actions on the victim's system causing harm to computer hardware, computer network and other resources. In this project, you will use deep learning approaches to detect malicious software by examining binaries and identifying anomalies. These techniques can be used to pre-emptively warn users of potential threats from software. The expected outcomes are:

1. functioning code (in Python) using a deep learning framework to detect anomalies in software binaries;
2. compare and evaluate effectiveness of deep learning models to detect malware using publicly available malware datasets.

Keywords: Cybersecurity, Deep Learning, Python Programming

Necessary Skills:

- Python programming
- Experience in deep learning frameworks

Context Service discovery, composition, and chaining for IoT platform CoaaS

Supervisor: Prof Arkady Zaslavsky, arkady.zaslavsky@deakin.edu.au **Associate Supervisor:** Dr Alireza Hassani

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

During the last several years, we have witnessed a huge rise of the IoT market. More and more ordinary objects are converted into smart things and are connected to the internet. These smart connected objects are capable of providing real-time information about entities and their environment through internet-based services, which is refer to as Context Service. Internet of Things is set to dominate every aspect of our life and bring about transformation in nearly every industry (private and public). An important aspect of IoT is the data and, in particular, the ability to understand and contextualize such data in order to use it effectively. However, the metadata required to make sense of this data is mostly inaccurate, incomplete and, in many situations, only human interpretable. To address this challenge, it is required to classify, annotate and semantically enrich IoT data-streams/services. Context-as-a-Service (CoaaS) IoT platform has been developed under Prof A Zaslavsky leadership as part of EU Horizon-2020 project biotope. It allows near real-time processing of incoming and historical context for serving multiple concurrent context queries serving various IoT applications, which will enrich observed and sensed data to provide more accurate validated data for decision support. CoaaS prototype is running in the SIT research cloud. Context provisioning is a critical component of CoaaS.

The student will have to investigate, design, and implement an automatic approach to discover available context services based on incoming requests from users written in CDQL. An important aspect of Service discovery is service composition and chaining, which means sometimes it is required to combine several services in order to respond to an incoming request. The student will build the prototype tool for PoC and integrate with CoaaS.

Necessary Skills:

- Distributed computing
- Java
- Python
- Software engineering
- Computer science literacy

User-centric interface for smart context provider registration in Context-as-a-Service IoT platform

Supervisor: Prof Arkady Zaslavsky, arkady.zaslavsky@deakin.edu.au **Associate Supervisor:** Dr Alireza Hassani / Dr Alexey Medvedev

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

Context-as-a-Service (CoaaS) has been developed under Prof A Zaslavsky as part of EU Horizon-2020 project biotope. It allows near real-time processing of incoming and historical context for serving multiple concurrent context queries serving various IoT applications, which will enrich observed and sensed data to provide more accurate validated data for decision support. CoaaS prototype is running in the SIT research cloud. Context provisioning is a critical component of CoaaS and it requires registration of context providers/consumers in the CoaaS platform.

The students will have to explore and analyse existing GUI tools for service registration, write a detailed critical literature review, followed by proposing, designing, implementing and demonstrating the prototype that will also be integrated with CoaaS IoT platform. Students would be asked to consider using open-source software. Considerations should be given to automatic discovery of relevant context providers and context-based automatic registration in CoaaS. The student will build the prototype tool for PoC and integrate with CoaaS.

Necessary Skills:

- Distributed computing
- Java
- Python
- Software engineering
- Computer science literacy

CASE tool for developing SLAs between context providers and Context-as-a-Service IoT platform

Supervisor: Prof Arkady Zaslavsky, arkady.zaslavsky@deakin.edu.au **Associate Supervisor:** Dr Alexey Medvedev

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

Context-as-a-Service (CoaaS) has been developed under Prof A Zaslavsky as part of EU Horizon-2020 project biotope. It allows near real-time processing of incoming and historical context for serving multiple concurrent context queries serving various IoT applications, which will enrich observed and sensed data to provide more accurate validated data for decision support. CoaaS prototype is running in the SIT research cloud. Context provisioning is a critical component of CoaaS and in many cases it requires a Service Level Agreement (SLA) between context providers/consumers and the CoaaS platform. The issues that need to be addressed include:

- Complex SLA definition. How to bill for complex queries?
- SLA representation. How to model SLAs?
- Create a visual tool for SLA development
- When the caching policy tells to use more or less resources, allocate/deallocate these resources in cloud and make sure that CoaaS uses the resources and meets the SLA requirements

The students will have to explore and analyse existing CASE tools for service level agreements (SLA), write a detailed critical literature review, followed by proposing, designing, implementing the algorithm and demonstrating the prototype that will also be integrated with CoaaS IoT platform. Students would be asked to consider using open-source software. The student will build the prototype tool for PoC and integrate with CoaaS.

Necessary Skills:

- Distributed computing
- Java
- Python
- Visualisation
- Software engineering
- Computer science literacy

Context-as-a-Service IoT platform performance dashboard

Supervisor: Prof Arkady Zaslavsky, arkady.zaslavsky@deakin.edu.au **Associate Supervisor:** Dr Alexey Medvedev

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

Context-as-a-Service (CoaaS) has been developed under Prof A Zaslavsky as part of EU Horizon-2020 project biotope. It allows near real-time processing of incoming and historical context for serving multiple concurrent context queries serving various IoT applications, which will enrich observed and sensed data to provide more accurate validated data for decision support. CoaaS prototype is running in the SIT research cloud. Context provisioning is a critical component of CoaaS and in many cases it requires a Service Level Agreement (SLA) between context providers/consumers and the CoaaS platform. The performance dashboard will have to address the following features:

- Measuring and visualising performance and resource consumption in CoaaS
- Resource planning
- Optimization hints
- Applying ML/deep learning to performance logs

The students will have to explore and analyse existing performance dashboards, write a detailed critical literature review, followed by proposing, designing, implementing the performance dashboard software component and demonstrating the prototype that will also be integrated with CoaaS IoT platform. Students would be asked to consider using open-source software.

Necessary Skills:

- Distributed computing
- Java
- Python
- Visualisation
- Software engineering
- Computer science literacy

Smart Context Definition Query Language Editor V2

Supervisor: Prof Arkady Zaslavsky, arkady.zaslavsky@deakin.edu.au **Associate Supervisor:** Dr Alireza Hassani

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

Context-as-a-Service (CoaaS) has been developed under Prof A.Zaslavsky as part of EU Horizon-2020 project biotope. It allows near real-time processing of incoming and historical context for serving multiple concurrent context queries written in CDQL – language developed as part of CoaaS. CDQL Editor V1 allows interactive formulation of context queries and IDE-like execution of these queries. We see the need for more complex and sophisticated context queries development and hence the project proposal which will address such issues as:

- Support of packages
- Support of cross-referencing
- Debugging
- Schema exploration
- Other functionality typical to query IDEs

The students will have to explore analyse and compare existing context query languages and IDEs and write a detailed critical literature review, followed by proposing, designing, implementing and demonstrating the prototype of CDQL V2. Smartness should be expressed as on-the-fly hints, predictive query formulation and user personalisation.

Necessary Skills:

- Distributed computing
- Java
- Python
- Visualisation
- Software engineering
- Computer science literacy

Emotion detection using facial expression

Supervisor: Dr Bahareh Nakisa, bahar.nakisa@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Mental disorders can affect a person's thoughts, behaviours, feelings, and sense of well-being. At present, negative emotional states like anxiety are highly prevalent worldwide causing burden and disability for individuals, families and society. Accurately estimating and evaluating the level of negative emotions has very broad application prospects. Within the past several years, various models have been investigated for negative emotional state from behavioural observations. There are several ways to recognize emotions. Facial expression is the most significant physical modality that conveys significant communication signals related emotional states. Most of the studies used traditional machine learning techniques (shallow architecture) to recognize negative mental states. However, to increase the robustness of negative emotional state recognition, deep learning techniques has emerged as an alternative to such models.

This research project is going to develop a machine learning model to recognize negative emotional states using facial expression. There is a public dataset consist of human emotions by facial expression. In this project, we need to propose a framework based on deep learning techniques to recognize negative facial expression.

Keywords: Affective computing, machine learning, deep learning

Necessary Skills:

- Machine learning
- Image processing
- Python Language programming skills

Human identification using biometrics data

Supervisor: Dr Bahareh Nakisa, bahar.nakisa@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

As far as security is concerned human identification is the most challenging and critical tasks, on the other side it is very important to recognize the person. Security is an important issue in many fields. Human identification is performed through one of the biometric authentication techniques such as palm, finger, facial points, iris, ID cards, pin number, passwords etc. Single human identification techniques sometime may be unable to identify the person due to this the person belief in the identification techniques will be reduced. The ID may be tampering or hack so it may be unpredictable. It can be easily stolen. To overcome these problems, one can use the multiple features in biometrics image processing techniques.

The study will collect and understand the facial points/Palm vein template from the participants who enrolled into our data collection at Deakin, Burwood campus. In this study, you need to analyze facial points/Palm vein template collected from our dataset or any public dataset using image processing and machine learning models. You need to develop a model which can identify person using their facial points/Palm vein template based on machine learning models.

Keywords: Affective computing, machine learning, deep learning

Necessary Skills:

- Python Language programming skills
- Machine learning
- Image processing

Manufacturing the next generation Palm Vein Biometric Scanning Solution.

Supervisor: Dr Bahareh Nakisa, bahar.nakisa@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

The study will understand the usefulness of biometric authentication system like palm vein reader in self-service coffee machine using a big data collection at Deakin, Burwood campus. In this study, you need to participate in the part of data collection as well as data analysis with other RAs in the team.

This study will utilize two versions of palm vein reader integrated into coffee machine and will run two phase of data collection (Phase 1 and Phase2). In each phase, people who participate in this project would need to use their palm vein template to get access to the self-service coffee machine and provide us with their thought and idea about this new technology.

In this phase (phase 1), we only capture palm vein from participants by hovering their hand over the scanner. In this study, we want to understand how people perceive the usefulness and ease of use of this device by recording their experiences with the system by responding to some questions. So, in this study, we will collect the participants' palm vein template to register them with the machine, their ideas and thoughts on the machine, and successful rate of the system.

Keywords: Affective computing, machine learning, deep learning

Necessary Skills:

- Writing skills
- Participate in the process of our data collection

Text classification using Generative Adversarial Networks

Supervisor: Dr Bahadorreza Ofoghi, b.ofoghi@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1

Project Description:

Generative Adversarial Networks (GANs) have shown great performances in image data analysis and reproduction. Specific versions of GANs (e.g., AC-GANs) have also been proposed for image classification. This project is concerned with the study of GANs as a classification tool to be utilized on textual data, where there is little prior work that has been done by researchers in the domain. The expected outcome of this project will be a good understanding of the domain including GANs and its several variants, and more importantly, a prototype system that shows the efficacy of GANs for text classification on a given data set relevant to natural language question answering. Having solid python programming skills is a must.

Keywords: Machine Learning, Deep Learning, Natural Language Processing, Python

Necessary Skills:

- Excellent python programming skills (knowledge of keras and tensorflow)
- A good understanding of natural language processing and deep learning concepts
- Excellent research and research writing skills

Passage ranking for question answering using BERT

Supervisor: Dr Bahadorreza Ofoghi, b.ofoghi@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1

Project Description:

Fact-seeking Question Answering (QA) is an automated natural language processing application that extracts exact answers to natural language questions. As part of the QA processing pipeline, relevant passages of text are retrieved and ranked in response to a given question, from within which, answers are extracted. This project will focus on the development of deep learning solutions to answer passage retrieval and ranking using state-of-the-art models, including Bidirectional Encoder Representations from Transformers (BERT). Ranking loss functions will be studied as part of this research. The student will use their research abilities to carry out several experiments and enhance an existing python solution to answer passage ranking.

Keywords: Machine Learning, Deep Learning, Natural Language Processing, BERT, Python.

Necessary Skills:

- Excellent python programming skills (knowledge of keras and tensorflow)
- A good understanding of natural language processing and deep learning concepts
- Excellent research and research writing skills

Human-factorised and Self-adaptive Software Trustworthiness System

Supervisor: Dr Chetan Arora, chetan.arora@deakin.edu.au **Associate Supervisors:** Dr Frank Jiang, Dr Kevin Lee, Prof Jean-Guy Schneider

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Self-adaptability in software systems (SASS) is considered an important feature in software development in many modern complex scientific and engineering fields. It is regarded as the ability of the software system to change its behavior whenever the system requirements cannot be achieved. However, it may lead to the unexpected system behavior and consequently leads to failure and/or uncertainty. The heterogeneity, multi-dimensionality of the Internet of Things (IoT) sourced data streams set barriers to the conventional software trustworthiness system, and hence present great development opportunity for utilizing the SASS attributes. The goal of this research project is to gather all possible sources of context data, highlight more details on SASS systems, develop a next-generation self-adaptive and human-factorised software system to address the uncertainty, trust and privacy issues such as intelligently detecting the source of uncertainty on the ability of the software system to fulfill the objectives, obtaining fine-grained access control with acceptable granularity in the IoT infrastructure.

The human-factorised context traditionally include multi-dimension information on behaviour, personality, organization, demography, culture et al. In this project, we concentrate on the contextual information, based on previous behavioral history reinforcement. The capture of human-factorised information in the IoT environment is done when the user is identified and accesses a software application till the time when he closes it. Based on the evidence of records, the system will establish if it can trust the user or not. According to the user behavior, levels of trust are released to access the application. We take the IoT system as a case study to define uncertainty in layers of IoT stacks, and classify the multiple sourced data streams (e.g., sensory data, software behavioural data, social data, sentimental data) related to the software/applications, facilitating the smart decisions for software trustworthiness, by mitigating the source of uncertainty.

The expected outcome of this research includes:

- Develop a scalable and resilient theoretical framework to facilitate the discovery of the uncertainty and untrustful modules or anomalies from multi-source real-time data streams;
- Create a new context-aware application with human-factorised input features: a scalable and adaptable decision-making facility using semantic reasoning in the inference engine;
- Investigate the novel theory and practical inference engine as well as models/algorithms with human-factors, in the large-scale IoT edge/fog environment, more importantly, with the promising capabilities of early fault detection and diagnosis.
- Conducting the experiment on the test case, verification and validation

Keywords: Self-adaptivity, Software trustworthiness, Uncertainty, Classification

Necessary Skills: Scripting language and a willingness to learn new technical concepts in software engineering

Applications of Natural Language Processing in Software Engineering

Supervisor: Dr Chetan Arora, chetan.arora@deakin.edu.au **Associate Supervisor:** Dr Mohamed Reda Bouadjenek

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This research project aims to apply NLP on software engineering artefacts to extract relevant information and build a Question Answering based model or a chatbot on software artefacts, e.g., API documentation. Software engineering artefacts such as API documentation are hefty, and stakeholders often find it challenging to navigate through such documents. This project aims to help such stakeholders by allowing them to navigate through the documents in a palatable form and query the documents to get accurate answers.

Keywords: Software Engineering, Machine Learning, Natural Language Processing

Necessary Skills:

- Python
- Natural Language Processing (expertise in BERT desired)
- Software Engineering

Software Engineering for ML Models

Supervisor: Dr Chetan Arora, chetan.arora@deakin.edu.au **Associate Supervisor:** A/Prof Mohamed Abdelrazek

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

The aim of this research theme is to tackle specific challenges in the specification of AI-based systems, the training and testing of ML components, as well as their integration into practical software systems. Projects in this theme are as follows:

P1. Characterizing bias in training data of ML systems: Selecting the right training data is critical in the implementation of ML-components that exhibit the desired behaviour. More often than not, either consciously or not, training data selected for ML includes biases. The aim of this project is to identify novel ways to classify the key “components” of training data and detect potential bias.

P2. Resilience requirements of autonomous vehicles: The autonomous vehicles are trained on the images. These images are the basis of resilience requirements of these systems. This project will focus on resiliency aspects of the training data for autonomous vehicles by mutating the training data.

Keywords: Requirements Engineering, Software Engineering, Machine Learning, AI

Necessary Skills:

- Python
- Statistical Analysis
- Software Engineering

Supporting Emerging Internet of Things (IoT) Applications in Next-Generation Communication Networks

Supervisor: Dr Chathu Ranaweera, chathu.ranaweera@deakin.edu.au **Associate Supervisor:** Dr Jonathan Kua, Dr Imali Dias

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The fifth generation (5G) mobile technology promises higher bandwidth capacities, lower latencies and higher reliability for emerging time-sensitive and mission-critical applications. As part of the Internet of Things (IoT), it is also predicted that number of diverse connected devices will reach 500 billion by 2030, which will be significantly greater than the expected world population. Providing communication and networking support for billions of devices, along with satisfying the stringent quality of service requirements of such devices is an active area of research.

Communication technologies for 5G and beyond expect to support emerging IoT applications, such as autonomous vehicles, remote surgery, industrial automation and control, smart grid, and immersive streaming applications. Some applications such as remote surgeries will require a reliable communication that supports sub-millisecond delays and extremely low error rates whilst applications such as virtual reality require very high spectral efficiency and IoT applications will requires ubiquitous connectivity and, in some cases, power transmission efficiency. Driven by the extremely stringent constraints and diverse requirements imposed by the variety of emerging IoT applications, future networking infrastructure needs to consider the fundamental trade-offs between error-rate, throughput, deployment costs, delays, and meet the requirements through the design of innovative new techniques.

This research project aims to investigate diverse techniques that we can be used to enable cost-effective, ultra-reliable, and low-latency communication in next generation networks to support diverse emerging applications. In particular, the project aims to address the following topics:

- Characterisation of the communication requirements of different real-world IoT scenarios, ranging from backhaul optical networks to smart applications, and their impact on current networking protocols on the Internet.
- Developing integrated network protocols for low-latency communication for interactive services, IoT actuation and automation, with the application of self-learning techniques using machine learning.
- Design considerations for emerging streaming technologies, including the coding, packaging, transport and delivery of content.

Keywords: 5G, 6G, Internet of Things, Machine Learning

Necessary Skills:

- Programming e.g. Python, C++, data analysis (e.g. Matlab)
- Background in networking, and a background in data analysis and machine learning would be advantageous

Centre for Cyber Security Research and Innovation (CSRI) - Multiple projects with scholarship support

Supervisor: Assigned based on the student's preference and research interest - Contact csri@deakin.edu.au

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Research projects are available in the following areas:

- **Data security**: cryptography, digital forensics, secure communication, integrity, authentication, access control, and data erasure, Blockchain-enabled authentication and authorisation.
- **Software and system security**: security principles, static and dynamic testing, formal verification, security requirements, and threat modelling.
- **Network security**: zero trust architectures, distributed systems, cloud security, virtualisation, network services, and network defences.
- **Human security**: identity management, social engineering, security awareness, usable of security and privacy, social behavioural privacy and security.
- **Organisational security and cybercrime**: risk management, governance, cyber policy, laws, ethics, and compliance.
- **Data Privacy**: privacy-preserving technologies, data masking, anonymity, and legal aspects of privacy.
- **Security analytics**: threat intelligence, network traffic analysis, malware detection, continuous authentication, security orchestration, automation and response.

CSRI offer $10k Cyber Security CRC scholarships and $4K CSRI Summer Scholarships. They are open to both domestic and international students, including PG students.

Necessary Skills:

- A proven interest in cyber security
- Excellent written and oral English skills
- Commitment, team working, self-motivated and a critical mind
- Strong academic performance

Investigation into adversarial attacks on deep neural networks and the counter measures

Supervisor: Prof Chang-Tsun Li, changtsun.li@deakin.edu.au **Associate Supervisor:** Dr Xufeng Lin

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Advances in artificial intelligence make it increasingly easy to create visually-convincing fake contents such as images, videos and audios. The term “Deep fakes” refers to the fake contents generated by deep neural networks (DNNs), particularly generative adversarial networks (GANs), which can learn useful data statistics from the training set and generate fake contents that are hardly detectable by naked eyes. Some examples of deep fakes can be found here. Deep fakes pose huge threats to many aspects of the society. This project aims to develop effective automatic algorithms for detecting deep fakes.

In this project, you may engage in:

- Literature review on different methods of generating and detecting deep fakes.
- Implementing one popular existing deep fake detection algorithm and testing its performance.
- Designing and developing a new detection algorithm (possibly based on the implemented existing algorithm.
- Evaluating the performance of the proposed detection algorithm and comparing it with other algorithms.

Necessary Skills:

- Experience in coding in one of the following languages: Matlab, Python, and C/C++
- Basic understanding of the concepts and principles of deep learning and signal processing

Automatic Detection of Deep Fakes

Supervisor: Prof Chang-Tsun Li, changtsun.li@deakin.edu.au **Associate Supervisor:** Dr Xufeng Lin

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Advances in artificial intelligence make it increasingly easy to create visually-convincing fake contents such as images, videos and audios. The term “Deep fakes” refers to the fake contents generated by deep neural networks (DNNs), particularly generative adversarial networks (GANs), which can learn useful data statistics from the training set and generate fake contents that are hardly detectable by naked eyes. Some examples of deep fakes can be found here. Deep fakes pose huge threats to many aspects of the society. This project aims to develop effective automatic algorithms for detecting deep fakes.

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- Evaluating the performance of the proposed detection algorithm and comparing it with other algorithms.

Necessary Skills:

- Experience in coding in one of the following languages: Matlab, Python, and C/C++
- Basic understanding of the concepts and principles of deep learning and signal processing

Computer Vision Enabled Leaf Area Measurement for Plant Growth Monitoring

Supervisor: Prof Chang-Tsun Li, changtsun.li@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Leaf area is an important indicator of plant growth, but its manual measurement can be labour-intensive, intrusive, and imprecise. Fortunately, the advances in computer vision and artificial intelligence make possible the automatic leaf area measurement from digital images. An example is shown below to demonstrate the procedure of automatic leaf area measurement from an image:

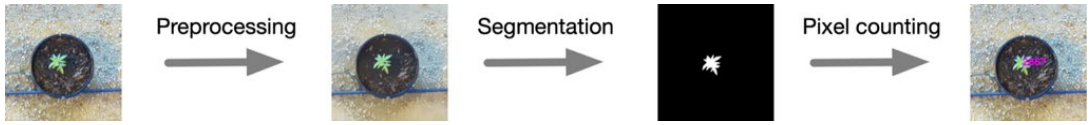


Figure 1 Leaf area measurement from an image

In Fig. 1, the original image is firstly pre-processed to mitigate the effect of background noise. The pre-processed image is then segmented into leaf and non-leaf areas. Finally, the leaf area is measured in terms of pixel number and can be converted into an area in square centimetres if other information, e.g., camera parameters and the distance between camera and plant, is available. The key step in the above procedure is image segmentation, which is arguably one of the most non-trivial tasks in computer vision. What makes the problem of leaf area segmentation even more challenging is that different colours of grow lights are often used to provide the optimal spectrum for the plants being cultivated (see Fig. 2 for some examples).

Figure 2 Plant leaf images captured in different lighting conditions.

This poses a great challenge for many image segmentation algorithms and often results in unsatisfactory segmentation results. In this project, you are required to carry out the following tasks based on a dataset of cannabis plant images collected in a greenhouse:

- Implement basic image processing algorithms to calculate the cannabis leaf area in an image captured under natural lighting conditions (see the first two images of Fig. 2).
- Implement evaluation metrics to evaluate the results of leaf segmentation and area measurement.

- Develop colour correction algorithms to correct the colour of images captured in unnatural lighting conditions (see the last four images of Fig. 2).
- Evaluate the results of leaf segmentation and area measurement on the colour-corrected images.
- Draw a plot of leaf area growth with images captured over a period of time.

Keywords: Image Processing, Computer Vision, Machine Learning, Python Programming

Necessary Skills:

- Coding experience in Python or Matlab.
- Basic knowledge of image processing, computer vision and machine learning.

Learning camera fingerprints from images

Supervisor: Prof Chang-Tsun Li, changtsun.li@deakin.edu.au **Associate Supervisor:** Dr Xufeng Lin

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

As a bullet passes through a barrel, unique markings are left on the surface of the bullet, which allow an examiner to determine whether a given bullet was fired from a particular firearm. In exactly the same vein, a camera will also produce individual and unique traces, collected from each processing component in the image acquisition pipeline, in every image it captures. These unique traces are referred to as “camera fingerprints” and can find a wide range of applications in computer forensics, such as the source tracking and forgery detection of the images shared through social networks.

Traditional camera fingerprint extraction methods highly rely on our domain knowledge about the processing components, either hardware and software, in the built-in image acquisition pipeline of cameras. As the structure of cameras becomes more complex and camera manufacturers tend to keep the technical details under wraps, hand-crafted features to represent camera fingerprints has begun to show its limitations. Recent years have witnessed a trend of favouring deep neural networks (DNNs) to automatically learn useful features from data. Therefore, this project aims to develop and evaluate new algorithms based on DNNs and existing algorithms to automatically learn representative and discriminative camera fingerprints from images. In this project, you may engage in:

- Literature review on different types of camera fingerprints and existing extraction algorithms
- Implementing functioning codes to extract meaningful camera fingerprints from images taken by different cameras.
- Evaluating and comparing the performance of different representations of camera fingerprints.

Necessary Skills:

- Experience in coding in one of the following languages: Matlab, Python, and C/C++
- Basic understanding of the concepts and principles of machine learning

Outlying aspects mining in mixed data

Supervisor: Dr Sunil Aryal, sunil.aryal@deakin.edu.au **Associate Supervisor:** A/Prof Richard Dazeley

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

While existing Outlier Detection (OD) algorithms are good at detecting outliers, they cannot explain why a data instance is considered as an outlier, i.e., they cannot tell in which feature subset(s) the data instance is significantly different from the rest of the data. Recently, researchers have started working on the problem of Outlying Aspect Mining (OAM), where the task is to discover feature subset(s) (subspaces) for a query where it is significantly deviated from the rest of the data. Those feature subset(s) are called outlying aspect(s) of the given query. OAM algorithms require a score to rank subspaces based on the outlying degrees of the given query. Existing OAM algorithms use traditional distance/density-based outlier scores as the ranking measure. Because distance/density-based outlier scores depend on the dimensionality of subspaces, they cannot be compared directly to rank subspaces. Z-score normalization of outlier scores has been used to make them comparable. It requires to compute outlier scores of all instances in each subspace. It adds significant computational overhead making OAM algorithms infeasible to run in large and/or high-dimensional datasets. Also, they are applicable to numeric/continuous/quantitative data only, it can't handle categorical/qualitative data well. In real-word applications, data has both quantitative (e.g., height, weight) and qualitative (e.g., gender, nationality) features. In this project, we would like to extend the OD methods that we developed for mixed data for OAM. We have an idea to make them dimensionality unbiased so that the raw scores can be used to rank subspaces directly. They do not require computing scores for all instances in each subspace. Also, they do not use pairwise distances. Therefore, they improve the runtimes of OAM algorithms by several orders of magnitude making them feasible even in very large datasets.

Keywords: Outlying Aspect Mining, Outlier Detection, Z-score Normalisation

Necessary Skills:

- Python Programming
- Probability and Statistics
- Linear Algebra
- Basic understanding of data mining and machine learning

Blockchain-Enabled Software Engineering

Supervisor: Dr Frank Jiang, frank.jiang@deakin.edu.au **Associate Supervisors:** Dr Chetan Arora, Dr Kevin Lee, Prof Jean-Guy Schneider

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Distributed Ledger Technologies (DLT) and Blockchain are featured with immutability, consensus mechanism and trust mechanism, particularly the blockchain enabled (BC-enabled) smart contract has attracted tremendous research interests. However, the immutability of the blocks, where the smart contracts are stored, causes conflicts with the traditional Software Development Life Cycle (SDLC), such as Waterfall Model, Spiral Method, Big Bang Model and Agile development. The immutable block scheme does not fit well for software engineers who might bring any future modification into the application, including fixing bugs or adding future enhancements. The testing and maintenance cycles cannot directly be migrated to the Blockchain-enabled smart contract applications. The aim of this project is to explore the tailor-made model and framework for blockchain-based applications. Thus, the integration, testing, verification and validation process will be orchestrated seamlessly to produce higher quality and enhanced security software applications.

The expected outcome of this research includes:

- Develop a new BC-enabled SDLC model;
- Design the internal architecture to achieve the consensus and conduct the verification and validation;
- Conduct the experiment with the publicly available third-party development platforms, such as Ethereum.

Be part of the Software Engineering and IoT team, fortnightly project meetings, development of new blockchain-based smart contract Scheme:

- Literature review on Blockchain and software applications via new SDLC
- Develop the new BC-enabled smart contract scheme for all phases in SDLC.
- Design a use-case for an IoT application development lifecycle and experiment it on the developed new scheme.

Keywords: Blockchain, Distributed Systems, Software Development Lifecycle

Necessary Skills:

- Moderate to good understanding of SDLC, OOP, OOD.
- Minimal understanding of Blockchain
- A willingness to learn new technical concepts in software engineering

Time Series Data Preparation for Tourism Demand Modelling

Supervisor: A/Prof Gang Li, gang.li@deakin.edu.au **Associate Supervisor:** Dr Ye Zhu

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

It is widely known that empty airline seats, unsold rooms in hotels and event tickets cannot be stockpiled for future use. They represent not only unrealized revenue but frequently unnecessary costs – a combination that can threaten financial sustainability. The perishable nature of the tourism industry necessitates the need for accurate forecast.

The existing tourism demand forecasting literature has primarily relied on these quantitative models which are established on strict statistical assumptions and stringent economic theories. While the existing tourism demand forecasting models can achieve acceptable predictive accuracy in different contexts, it is important to prepare quality secondary data from raw data to enable efficient and quality models constructed from the available data. In other words, data preparation generates quality secondary data, which leads to quality tourism demand forecasting models. Thus, the development of data-preparation methods in the context of tourism demand forecasting is a challenging and critical task.

In this project, students will develop better techniques that efficiently utilise and process the raw data. The goal of this project is to improve the quality of the collected data in order to maximise the performance of the tourism demand modelling. Students will need to evaluate existing machine learning methods with proposed data processing techniques on the real tourist datasets for demand forecasting and anomaly detection.

Keywords: Data Science, Machine Learning, data processing, forecasting

Necessary Skills:

- Python/R/Matlab Programming
- Basic Machine Learning and Data Science Background

Developing and Efficient Zero Trust Software

Supervisor: A/Prof Gang Li, gang.li@deakin.edu.au **Associate Supervisor:** Dr Shiva Pokhrel

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

The anticipated zero trust software is a type of network security and identity management solution used to implement the zero-trust security model. As opposed to traditional network security systems, which provide a castle-and-moat system for granting access into a network, the zero-trust model assumes every individual, both internal and external, is a potential threat until they are verified.

Corporates and industries have adopted the zero-trust security model since decentralized business models and IT systems have made it significantly more complicated to ensure proper access controls are in place across multiple networks and physical locations. Zero-trust software solutions shall allow corporates to continuously monitor activities and user behaviour to adapt action and authentication requirements on an individual basis. Verified individuals behaving abnormally or attempting to violate their permissions will need to be prompted to provide further authentication. Data is to be collected from access points, behaviours, and traffic logs to perform learning and provide in-depth network security analytics capabilities.

This project aims to develop a zero-trust software to utilize similar authentication methods as risk-based authentication software but is specifically for network access control. Risk-based authentication can be broader, and its methods can be applied to accessing a network, application, database, or any other privileged information.

To qualify for inclusion in the intended Zero Trust Software, a product must:

i) utilize adaptive authentication to continuously verify user permissions
ii) allow for network segmentation to simplify and broaden policy enforcement
iii) monitor traffic and user behaviour for future inspection and analysis.

Keywords: Software Engineering, Machine learning, Security, Software Testing Metrics

Necessary Skills:

- AI/ML Programming
- Project Engineering and Design
- Distributed Learning
- S/W development techniques

Integration of IoT-enabled Indoor Wireless Networks

Supervisor: Dr Imali Dias, imali.dias@deakin.edu.au **Associate Supervisors:** Dr Chathu Ranaweera, Dr Jonathan Kua

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

Indoor wireless networking technologies such as WiFi have long been used in providing many services such as day-to-day internet access and home automation. Indoor wireless networks, however, are constrained in data rates and bandwidths due to the limited availability of radio spectrum. Recent developments in diverse IoT applications and services have demanded improvements in indoor wireless networks in both data rates and latency, prompting many hardware, architecture and protocol-wise improvements on indoor wireless networks. As a result, diverse indoor wireless technologies (such as 60 GHz WiFi) are emerging to facilitate the new breed of user applications ranging from low-latency internet of things (IoT) applications such as remote education, tele-surgery and home automation to bandwidth-hungry applications including mixed reality and hologram.

Although a significant amount of research has been carried out on IoT-supportive multi-gig indoor wireless networks, research on integrating these indoor wireless networks with the rest of the network that provides access to Internet is still at its infancy. This is particularly important in guaranteeing the stringent end-to-end requirements of emerging IoT applications. As such, under this proposed research, we will investigate potential technologies and architectures that can be used to integrate indoor wireless networks with the access and core networks. The key areas addressed in this study are as follows.

- Analyse the latencies experienced by user data at different network segments along the data transmission path and implement a framework for latency-constrained data transmission.
- Incorporate machine learning techniques to predict user behaviours and allocate resources across the integrated network.
- Analyse the abilities of different communication technologies such as 5G and optical to connect indoor wirelesses networks to Internet.
- Investigate and implement secure data transmission to support IoT applications that require high-level of security such as tele-surgery.
- Analyse the trade-offs between different Quality of Service (QoS) parameters such as latency, reliability, security and energy efficiency of the proposed protocols.
- Incorporate energy-efficient data transmission strategies to minimise energy consumption.

Keywords: Internet of Things, Indoor Wireless, Wireless Communications, 5G

Necessary Skills:

- Programming: Object Oriented Programming. E.g Python, C++
- Background in networking
- Background in data analysis and machine learning would be advantageous

Exploration of Variational Quantum Algorithms

Supervisor: Hon A/Prof Jacob Cybulski, jacob.cybulski@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Quantum Computing is a new and exciting area of Science, which intersects Physics, Mathematics and Computer Science. Quantum algorithms are known to solve problems, which until recently have been considered unsolvable classically due to their inherent complexity. Typically a high-level quantum algorithm in Python generates a quantum circuit, which can be executed on a real quantum machine or a simulator. Unfortunately, quantum circuits hard-code their data, so that an application of an algorithm to new data leads to a new circuit. This means that circuits are static and cannot be trained or optimised directly. However, there exist hybrid classical-quantum techniques that can produce variational (or parametrised) circuits, which act as templates for circuit generation. Quantum machine learning algorithms take advantage of variational circuits to implement quantum-alternatives to many machine learning algorithms. In this way, quantum solutions can be both highly efficient and data rich.

This project aims to investigate a range of variational quantum algorithms, i.e. hybrid classical-quantum algorithms capable of manipulating parametrised quantum circuits.

Keywords: Quantum Computing, Quantum Machine Learning, Variational Quantum Algorithms, Python Programming, Qiskit.

Necessary Skills:

Students undertaking this project should already be familiar with Python, Data Science and have excellent knowledge of Maths. It is important that students wishing to undertake this project learn the foundations of Quantum Computing, as well as gain some experience with IBM Quantum Lab and Qiskit before the trimester start. Self-directed study will be essential, which can be supported by the supervisor.

Cooperative Smart Data Transfer in Vehicular Networks

Supervisor: Dr Jonathan Kua, jonathan.kua@deakin.edu.au **Associate Supervisor:** Prof Seng Loke

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The combination of high-capacity mobile networking technologies and the growing popularity of bandwidth-hungry applications (such as video streaming, social media applications, and emerging VR/AR application data) has tremendously increased the demand for mobile network resources.

Connected and automated driving vehicles further increase the network load, as they often require a large amount of data transfer between vehicles and remote cloud/edge computing infrastructure. In addition to bandwidth-hungry applications, the continuous collecting, maintaining, and sending and receiving of situational updates can potentially overload the vehicle-to-network (V2N) communication infrastructure. Hence, it is important to consider a cooperative method for smart data transfer among inter-connected vehicles to mitigate the load on existing V2N networks.

For example, vehicles in a vicinity can use vehicle-to-vehicle (V2V) technology to form a group, known as “vehicular micro-cloud”. Each member downloads a subset of data segments that comprise an original data content, and then exchanges those segments with other members so they can reconstruct the original content if needed. This mechanism enables a group of vehicles to collectively serve as a virtual content delivery server. This is particularly relevant as in-built infotainment systems often require real-time retrieval of video content from remote content servers.

This research project aims to design a local coordination and cooperation smart data transfer scheme for vehicular networks that achieve the following goals:

- The formation of vehicular micro-cloud that facilitates efficient data transfer and downloads.
- Coordination of micro-cloud group members to reduce redundant data download via V2N while keeping the channel resource overhead to the minimum.
- An efficient video streaming coordination data transfer scheme for in-built infotainment systems.

Keywords: Autonomous Vehicles, Connected Vehicles, Vehicular Networks

Necessary Skills:

- Programming (Python, C++)
- Scripting (e.g. Bash shell)
- Data analysis (e.g. Matlab)
- Experience with vehicular networks simulators (e.g. Veins) would be advantageous.

A Hybrid Internet of Things Network Infrastructure

Supervisor: Dr Jonathan Kua, jonathan.kua@deakin.edu.au **Associate Supervisors:** Dr Shiva Pokhrel, Mr Grishma Khadka, Prof Jinho Choi

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2

Project Description:

This project is an initiative by Deakin's Centre for Internet of Things Ecosystem Research and Experimentation (CITECORE) that aims to build a hybrid Internet of Things (IoT) network infrastructure at the Burwood campus.

This project will deploy of a range of IoT sensors and gateways across the Burwood campus, utilising Wi-Fi and IoT connectivity technologies to form a hybrid network infrastructure. We will primarily use Software Defined Radios (SDR) for performance evaluation and experimentation, and also the design of wireless communication protocols and systems. SDRs allow us to efficiently plan, design and prototype radio communication systems which are traditionally implemented in the hardware, which is advantageous for a hybrid campus-based IoT network.

This infrastructure will allow us to collect, analyse and visualise IoT situational and environmental telemetry on campus in real-time. It also serves as an enabling platform and experimental testbed for future IoT research. Some topics of interest include characterising the communication requirements of real-time IoT applications, improving IoT connectivity and access technologies for specific use cases, improving data transmission behaviours of IoT applications and evaluating their impact from the application to the physical layers, utilising machine learning techniques for large-scale IoT data analysis and anomaly detection, indoor localisation of robots, evaluating the security and privacy preservation mechanisms of IoT, and so forth.

Keywords: Internet of Things, Wireless Communications, Software Defined Radio (SDR)

Necessary Skills:

Programming, background in software-defined radio, wireless communications, sensors, embedded systems, machine learning, Matlab, Simulink would be advantageous.

An Experimental Low Power Wide Area Network (LPWAN) Testbed

Supervisor: Dr Jonathan Kua, jonathan.kua@deakin.edu.au **Associate Supervisor:** Dr Kevin Lee

Campus: Melbourne Burwood, Geelong Waurn Ponds

Start: Trimester 1, Trimester 2

Project Description:

The Internet of Things (IoT) is rapidly growing, with the prospect of billions of Internet-connected devices providing ubiquitous services in the next few years. IoT devices are increasingly being deployed in remote areas a long distance from internet connectivity. These deployment locations typically have limited physical access and limited power supply. The motivation for this project is to investigate the growing options for the connectivity of IoT devices in scenarios in which they are deployed remotely.

This project focuses on building an experimental Low Power Wide Area Network (LPWAN) testbed for evaluating new WAN radio technologies. The student will initially build a 3-tier (IoT node, Edge, Cloud) testbed based on LoraWAN wireless communications technology. These WAN technologies will then be evaluated for their suitability for building IoT applications in various use cases and remote applications.

Keywords: Internet of Things, LPWAN, Edge computing

Necessary Skills:

- Programming language experience: e.g., C/Python/Node.JS
- Experience with hardware: e.g., Raspberry Pi, Arduino, networking experience

The performance and security evaluation of Blockchain based operational networks

Supervisor: Dr Keshav Sood, keshav.sood@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Blockchain is a promising technology to enhance the security of next generation networks. Unfortunately, the impact of Network Delay on Bitcoin Mining directly results in the performance of any Blockchain enabled network and this has been recently explored by researchers. This issue can occur both in attack and non-attack scenarios. The impact of this is severe in operational networks. In this project, we aim to investigate novel approach to protect the network resources in such scenarios.

Necessary Skills:

- Moderate to good understanding of network design
- Minimal to moderate understanding of cyber security issues
- Good knowledge of machine learning or Python language
- A willingness to learn new technical concepts in Blockchain 5G, SDN and IoT networks

Adversarial attacks on medical machine learning

Supervisor: Dr Lei Pan, l.pan@deakin.edu.au **Associate Supervisor:** Dr Daniel Ma, Dr Sutharshan Rajasegarar, Dr Chandan Karmakar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Medical practitioners and researchers are developing and even deploying many AI-driven systems to aid medical diagnosis, treatment, and even insurance claims. But adversarial attacks, as a new form of attacks against machine learning and deep learning models, become an emerging threat to the medical field. There are several papers with high impact, for example:

- Science Vol 363, Issue 6433, article Adversarial attacks on medical machine learning
- arXiv.org, article Understanding Adversarial Attacks on Deep Learning Based Medical Image Analysis Systems
- Nature Machine Intelligence Vol 2, article Secure, privacy-preserving and federated machine learning in medical imaging
- Nature Medicine Vol 26, article Deep learning models for electrocardiograms are susceptible to adversarial attack

In this project, students will evaluate the performance of adversarial attacks against medical machine learning systems. The attacks are made under different settings with respect to attackers' knowledge (zero knowledge, limited knowledge, or perfect knowledge), attackers' capability (poisoning attacks, or evasion attacks), and alike.

The thesis consists of three major parts: The first part of this project is to conduct a critical literature review on the currently published literature. Then the students are expected to implement the algorithms mentioned in some papers. The final part is the benchmark results of running these algorithms with respect to a few datasets.

Keywords: Medical Images, Adversarial Machine Learning, Python Programming.

Necessary Skills:

- Python machine learning skills
- Preferably deep learning skills

Analysis of blockchain transactions using deep learning-based anomaly detection algorithms

Supervisor: Dr Lei Pan, l.pan@deakin.edu.au **Associate Supervisor:** Dr Sutharshan Rajasegarar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Anomaly detection is a topic underpinning machine learning practice in expert systems and many other industrial systems. Due to its wide applications, anomaly detection proposals with graph-based neuron networks become more and more popular in blockchain transactions. For example, there are research papers recently published on anomaly detection conducted on blockchain systems, such as the following papers:

- Chen, T., Zhu, Y., Li, Z., Chen, J., Li, X., Luo, X., Lin, X. and Zhange, X., 2018, April. Understanding ethereum via graph analysis. In IEEE INFOCOM 2018-IEEE Conference on Computer Communications (pp. 1484-1492). IEEE.
- Chen, T., Li, Z., Zhu, Y., Chen, J., Luo, X., Lui, J.C.S., Lin, X. and Zhang, X., 2020. Understanding Ethereum via Graph Analysis. ACM Transactions on Internet Technology (TOIT), 20(2), pp.1-32.
- Patel, V., Pan, L. and Rajasegarar, S., 2020, November. Graph Deep Learning Based Anomaly Detection in Ethereum Blockchain Network. In International Conference on Network and System Security (pp. 132-148). Springer, Cham.

The project consists of three major parts:

The first part of this project is to conduct a critical literature review on the currently published literature. Then the students are expected to implement the algorithms mentioned in the relevant papers. The final part is the benchmark results of running these algorithms with respect to standardized datasets, and propose an improved algorithm.

Keywords: Blockchain Transaction Analysis, Anomaly Detection, Machine Learning, Python Programming

Necessary Skills:

- Machine learning (especially deep learning) in python
- Knowledge of GCN and/or GNN will be desirable

Blockchain-based Data Analytics with Energy Trading Data

Supervisor: Dr Lei Pan, l.pan@deakin.edu.au **Associate Supervisor:** Dr Sutharshan Rajasegarar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Blockchain is becoming a new platform where real-world data is stored. Due to privacy and security concerns, DApps store encrypted and privacy preserving data on the public blockchain networks. In particular, individual energy traders like the owners of rooftop systems or electric vehicles can bid and sell electricity on blockchain-powered energy markets. This project investigates the security and privacy of such energy markets with the support of data analytics.

The project consists of three main components. The first component is a literature review of the recent research proposals and implemented solutions. The collected information will be aggregated, compared, and analyzed to build a proof-of-concept platform for research. The end product of the project will be empirical studies and their results to investigate various performance metrics of security and privacy mechanisms before ranking them.

Keywords: Ethereum, Decentralized Applications (DApps), Energy Trading, Data Analytics

Necessary Skills:

- Data analytics
- DApps development skills (ideally completion of SIT728)

IOT network traffic analysis with deep learning

Supervisor: Dr Lei Pan, l.pan@deakin.edu.au **Associate Supervisor:** Dr Sutharshan Rajasegarar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Industry control systems (ICSs) are the important for our daily lives because they control critical infrastructure like power grid, water treatment, gas pipes. However, security attacks like false data injection, replay attacks, and DoS attacks greatly endanger the safety and security of ICSs. Contemporary approaches employ machine learning and deep learning algorithms to detect these attacks at the next work level. For example, this link contains a few datasets and several research papers.

The project consists of three major parts:

The first part of this project is to conduct a critical literature review on the currently published literature. Then the students are expected to implement the algorithms in the reviewed papers. The final part is the benchmark results of running these algorithms with respect to one or two datasets, and propose improved algorithms.

Keywords: Internet of Things, Network Traffic Modelling, Machine Learning, Python Programming.

Necessary Skills:

- Python programming in machine learning, ideally completion of SIT744 and SIT720/SIT719

Quantum Machine Learning

Supervisor: Dr Lei Pan, l.pan@deakin.edu.au **Associate Supervisor:** Dr Sutharshan Rajasegarar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Quantum computers are becoming a reality in our life with giant companies like Google, Microsoft and IBM experimenting prototypes. The advantages of the quantum computers and quantum algorithms are obvious in superb performance. However, the quantum algorithms have not been fully investigated in the context of machine learning algorithms. Existing studies only present primitive ideas, such as

- Biamonte, J., Wittek, P., Pancotti, N., Rebentrost, P., Wiebe, N. and Lloyd, S., 2017. Quantum machine learning. Nature, 549(7671), pp.195-202.
- Schuld, M., Sinayskiy, I. and Petruccione, F., 2015. An introduction to quantum machine learning. Contemporary Physics, 56(2), pp.172-185.
- Saggio, V., Asenbeck, B.E., Hamann, A., Strömberg, T., Schiansky, P., Dunjko, V., Friis, N., Harris, N.C., Hochberg, M., Englund, D. and Wölk, S., 2021. Experimental quantum speed-up in reinforcement learning agents. Nature, 591(7849), pp.229-233.
- Liu, N. and Rebentrost, P., 2018. Quantum machine learning for quantum anomaly detection. Physical Review A, 97(4), p.042315.

The project consists of three major parts:

The first part of this project is to conduct a critical literature review on the currently published literature. Then the students are expected to improve one QML algorithms in the reviewed papers with novel contributions. The final part includes empirical evaluation and theoretical analysis of these algorithms.

Keywords: Quantum computing, machine learning

Necessary Skills:

- Python programming in machine learning

Dream Big – Avatars and Professional Identity

Supervisor: Laura Taubino, laura.t@deakin.edu.au **Associate Supervisors:** Dr Kerri Morgan, Dr Guy Wood-Bradley, A/Prof Andrew Cain

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The Dream Big project is developing a web application to scaffold students growing professional identity. This entails guiding students to gain a realistic view of industry requirements and to increase their awareness of the attitudes, skills and knowledge they have, or need to obtain. The central goal is to improve their employability.

In this project, the student will implement an interactive avatar aligned with a user's growing professional identity. This avatar will be integrated into the Dream Big Project web application.

This project has two components.

- The student will research different types of gamification strategies to identify the best methods for the avatar to interact with the user to accurately reflect the student's growing professional identity, and to encourage engagement with the tool.
- The student will also implement (and possibly test) some of these strategies.

Keywords: User Experience, Gamification, Web Development, Educational Technology

Necessary Skills:

- Programming skills, web development.
- Critical and design/creative thinking
- Good communication skills – students are expected to be able to perform a literature search and communicate a summary of the results with recommendations
- Although the team will be there to guide the student and make suggestions, the student must be able to work independently and proactively

Reinforcement learning with non-monotonic rewards using scalarised multiobjective non-linear decomposed rewards

Supervisor: A/Prof Richard Dazeley, richard.dazeley@deakin.edu.au **Associate Supervisors:** Dr Francisco Cruz, Dr Sunil Aryal

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Reinforcement Learning typically assumes an agent aims to maximise its reward. However, there is evidence that humans/animals do not aim to maximise a reward and instead simply aim to reach a level of reward that satisfies its requirements. For example, people stop eating when full even if there is still food available. Furthermore, people can even have a negative reward for an action that used to be positive. For instance, the pleasure of eating chocolate becomes a negative once you have had too much. This type of reward represented a non-monotonic reward which current RL methods can not learn.

This project aims to develop an approach that can learn to optimise for a non-monotonic reward. This will be accomplished through reward decomposition over multiple objectives. Each objective is itself non-linear but still monotonic. These monotonic functions can then be linearly scalarised into a single non-monotonic function. An agent then aims to maximise this scalarised combination of objectives to find the optimal point of maximal reward. Such an agent can automatically moderate its behaviour to not overindulge. Such an agent is key to the development of self-rewarding agents based on curiosity-based learning and can provide an approach to soft-thresholding for non-linear multiobjective problems.

Keywords: Reinforcement Learning (RL), Multiobjective Reinforcement Learning (MORL), Machine Learning, Programming

Necessary Skills:

- Strong Python Programming
- Machine Learning knowledge

Reward is not enough, empirically disproving Silver's assertions

Supervisor: A/Prof Richard Dazeley, richard.dazeley@deakin.edu.au **Associate Supervisors:** Dr Francisco Cruz, Dr Sunil Aryal

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

David Silver at Google's Deep mind was the lead researcher on the Alpha Go project that defeated the Go world champion Lee Sedol. Silver along with key senior Reinforcement Learning researchers, Satinder Singh, Doina Precup, and Richard Sutton claimed in 2021 that "Reward was Enough". This claim centred around the idea that a single scalar reward is sufficient to learn all underlying complex behaviour of intelligent creatures.

This project aims to contest this position and provide empirical evidence that using multiple objectives allows an agent to find more intelligent and nuanced behaviours than what is possible to find with just a single scalar reward. In particular, this project will use reward decomposition to produce a pareto set of policies. A single objective meta-agent will then learn to switch between these pareto optimal policies allowing an agent to find a better solution than an agent simply using a scalar reward.

Necessary Skills:

N/A

Safely exploring with Rule-based Multiobjective Reinforcement learning

Supervisor: A/Prof Richard Dazeley, richard.dazeley@deakin.edu.au **Associate Supervisors:** Dr Francisco Cruz, Dr Sunil Aryal

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Reinforcement learning (RL) agents learn through trial-and-error. However, most work is based on the idea that the error is not catastrophic or even particularly damaging. However, in the real world there are many things an agent can do that could present a disaster. For example, we do not want an agent learning to drive crashing a car multiple times before learning to turn. Current approaches to RL cannot learn without making mistakes preventing their widespread application in real world domains.

Multiobjective reinforcement learning allows us to place constraints on an agent through secondary, tertiary, or nth objectives. These objectives can be safety aligned to restrict an agent from exploring in dangerous places. However, it still must know where those unsafe areas are and the degree to which they are unsafe. Developing such a reward mechanism during design is generally too difficult for non-trivial tasks.

In this project you will design an algorithm that uses an incrementally built knowledge-based system that allows a user to easily identify unsafe situations and instruct the agent. The agent using these rules to define safety thresholds on an auxiliary objective will learn to solve a driving task such that it never has an accident even while learning.

Keywords: Reinforcement Learning (RL), Multiobjective Reinforcement Learning (MORL), Impact Minimisation, Safe RL, Ripple Down Rules, Simplified Autonomous Vehicles, Machine Learning, Programming

Necessary Skills:

- Strong Python Programming
- Machine Learning knowledge
- Understanding of Knowledge Based Systems preferred but not essential

User Controlled Q-Steering in multiobjective reinforcement learning using parallel coordinates

Supervisor: A/Prof Richard Dazeley, richard.dazeley@deakin.edu.au **Associate Supervisors:** Dr Francisco Cruz, Dr Sunil Aryal

Campus: Melbourne Burwood, Geelong Waurn Ponds

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Multi-objective reinforcement learning (MORL) aims to find a policy or set of pareto optimal policies that offer a trade-off between multiple conflicting objectives. There are two classes of MORL approaches: single-policy and multi-policy. In multi-policy approaches the aim is to learn the full convex coverage set usually in parallel. As an agent discovers this coverage set offline actions still need to be selected that optimise online performance that meet the requirements of the user. Q-steering is an approach that allows a user to guide an agent to switch between policies to find a mixture policy that best meets the users need.

This project will develop an interface for a Q-steering agent using an interactive Parallel Coordinate plots available as a python library. This will allow real-time interactivity with an agent during training. The student will develop a user interface that uses the parallel coordinate plot as a visualisation they can interact with to select their preferred Pareto policy. The student will also develop a test environment and run a user study to validate the tools useability and effectiveness.

Keywords: Reinforcement Learning (RL), Multiobjective Reinforcement Learning (MORL), Machine Learning, Programming.

Necessary Skills:

- Strong Python Programming
- Machine Learning knowledge

Automated security protocol vulnerability analysis using AI

Supervisor: Dr Rolando Trujillo, rolando.trujillo@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Chess playing engines such as AlphaZero have delivered phenomenal improvements to game-playing strategies using reinforcement learning. Frameworks like the universal chess interface assist these engines in communicating with user interfaces to analyze chess variant positions and to strategize the next moves by applying discrete probabilities. The objective of this project is to apply game-theoretic AI to test security protocols. In this work, the security protocol becomes the vocabulary of the gameplay, and the reinforcement learning engine is used to exhaustively explore and evaluate all game-play variants with a view to identify and detect errors in the protocol.

A short list of references:

- Fu, M. C. (2016). “AlphaGo and Monte Carlo tree search: The simulation optimization perspective.” In: 2016 Winter Simulation Conference (WSC), pp. 659–670. doi: 10.1109/WSC.2016.7822130 (cit. on pp. 8, 9).
- Silver, David, Thomas Hubert, et al. (2018). “A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play.” In: Science 362.6419, pp. 1140–1144
- The Poulidor Distance-Bounding Protocol. R. Trujillo-Rasua, B. Martin and G. Avoine. In RFIDSec, pp. 239-257, 2010.

Necessary Skills:

- Technical: Good programming skills and capacity to understand mathematical notation. Familiarity with Python, Machine Learning and (possibly) Deep Learning
- Personality: Hard working, ambitious, and with a demonstrated capacity for self-directed learning

Robust and data-dependent kernel for practical machine learning

Supervisor: Dr Sunil Aryal, sunil.aryal@deakin.edu.au **Associate Supervisor:** A/Prof Richard Dazeley

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Kernel learning have been used in machine learning to solve various problems such as SVM classification, clustering, anomaly detection, dimensionality reduction, metric learning, manifold learning, etc. Most existing kernel functions are based of distance between data instances in the feature space. They are data distribution independent and sensitive to how data are represented. There are only a few kernel functions that consider data distribution into account, but they are not robust to how data are measured/expressed. This project builds on a robust and data-dependent kernel learning that we have been working on. In this project, the proposed kernel function will be used and evaluated in several real-world problems for dimensionality reduction. The application domain we will work on is cybersecurity, IoT and/or sensor network.

Keywords: Data-dependent (dis)similarity, Robust similarity, Kernel learning, Dimensionality Reduction, PCA, Cybersecurity, IoT and Sensor Networks

Necessary Skills:

- Python Programming,
- Probability and Statistics
- Linear Algebra
- Basic understanding of data mining and machine learning

Generating narrative from team decision making in complex environment

Supervisor: Dr Sunil Aryal, sunil.aryal@deakin.edu.au **Associate Supervisor:** A/Prof Richard Dazeley

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Generic Actual Argument Mode (GAAM) has been shown to work well in terms of modelling arguments in complex domains such as law and health. The two layered abstractions separating generic and actual argumentation provides flexibility to consider different opinions. In GAAM, knowledge is represented as a tree structure called 'Generic Argument Structure' (GAS). It captures context variables, relevant data with reasons for relevance, inference with reason(s) and claims. Each argument is an instantiation of GAS. Common underlying structure provides a basis to compare arguments in terms of Points-In-Common (PIC) and Points-Of-Difference (POD), which can be useful to reconcile conflicting opinions. This project aims to investigate the application of GAAM to represent complex decision making and generate a story line explaining a sequence of decisions made. We consider decisions made by defence forces during search-and-rescue operations in disasters simulated in a game.

Keywords: Knowledge Engineering, Argumentation, Narrative Generation, Argument Model

Necessary Skills:

- Some basic understanding of knowledge engineering and representation, machine learning, and programming

A Platform for Coordinating Internet-Connected Urban Robots

Supervisor: Prof Seng Loke, seng.loke@deakin.edu.au **Associate Supervisor:** Dr Niroshinie Fernando, Dr Amin Abken

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

We imagine a future city with robots occupying public spaces – for different purposes, from delivery, cleaning to policing. As the robots occupy shared spaces, there are issues of space contention and best use of shared spaces and resources. The project will investigate and prototype a cloud-hosted platform to allow multiple Internet-connected robots to coordinate their actions and behaviour in shared spaces. The focus of the project is not on building robots (as we will use off-the-shelf programmable robots), but on creating the mechanism that allows the robots to coordinate – the project will investigate centralized and decentralized modes of coordination in urban scenarios. Robots that we aim to work with are Temi and Vincross.

Keywords: Internet of Things (IoT), Programmable robots, Programming.

Necessary Skills:

- Very strong programming skills and a desire to learn and experiment with new things
- Mathematical maturity, and exposure to Mobile app development
- Cloud computing, AI and IoT programming will be needed

Understanding IT students' employability: Longitudinal analysis of employability traits

Supervisor: Dr Sophie McKenzie, sophie.mckenzie@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

During their time at university IT students develop their skills and employability towards their chosen career. To best support students during their studies it is important to understand the IT student experience of employability. This project will focus on analysing student employability data from 2018, 2019, 2020 and 2021 to present insights into student skill development need, and the degree of confidence they exhibit on employability traits surveyed. Preliminary literature will be provided to help define the area, with data analysis to follow a quantitative approach using statistical techniques. Outcomes of this work will include recommendations that universities can follow to continue to support students in developing their employability during their time at university. A paper publication can also be an outcome, if desired.

Keywords: Employability, Information Technology, Quantitative Analysis, Higher Education

Necessary Skills:

- Statistical analysis (descriptive, comparative, factor) skills using a desktop software package (SPSS for example)
- Microsoft office skills
- Interest in application of outcomes to teaching and learning at Deakin

Advanced Decomposition Techniques for Multi-Component Optimisation Problems

Supervisor: Dr Sergey Polyakovskiy, sergey.polyakovskiy@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Real-life optimisation problems often consist of several sub-problems of different nature. Not only do they combine several optimisation aspects into a single problem, but they also emanate from the compounded complexity of conflicting issues in numerous areas like logistics, planning and manufacturing. Solving them requires a thorough understanding of both their compounded and their individual natures. Because traditional optimisation methods may demonstrate only limited efficiency for such problems, designing advanced decomposition approaches hybridizing several algorithmic techniques to handle their specificity and non-linear behaviour intrinsic to them appears promising.

The focus of this research is on perspective decomposition methods, search strategies, and learning as a way to tune the search process at the runtime. On the application side, it aims to develop state-of-the-art solution techniques for a number of multi-component optimisation problems. For these techniques to be high-performing, it is of vital importance to be capable to adaptively select sub-problems to solve in a way that ensures fast convergence towards an optimal solution. Tuning the search process appears beneficial, but a posteriori decision-making based on a subset of test instances tends to produce ambiguous settings unsuitable for the whole set. It can ignore promising decisions as the search progresses, and thus seriously affect the efficiency of the entire search. More sophisticated decision methods using learning mechanisms during the search should guarantee advanced performance, but require designing new approaches to measure the search performance itself. Finding such techniques is a part of this research.

Keywords: Combinatorial optimisation; Discrete Optimisation problems; Mathematical Programming; Model-Based Evolutionary Algorithm; Linkage Learning

Necessary Skills:

- Advanced programming skills in Java, C#, or C++ (Essential)
- Knowledge of combinatorial optimisation techniques, e.g. meta-heuristics (Desired)
- Knowledge of mixed-integer linear programming and experience with IBM ILOG CPLEX Optimisation Studio (Desired)

Advanced Routing for a Mixed Fleet of Electric Vehicles

Supervisor: Dr Sergey Polyakovskiy, sergey.polyakovskiy@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Because the transportation was always the major contributor to pollution and climate changes, many logistic companies have nowadays become not only cost, but also CO2 emissions focused and keen to reduce them as part of their daily operations. One of the solutions to assist the positive changes is to use electric vehicles (EVs) instead of conventional vehicles. This makes the electric vehicle routing problem particularly interesting for such logistic companies. Given a fleet of EVs, a set of customers and a set of charging stations, it searches for the best possible (shortest) routes that service the customers starting and ending at the central depot. Because EVs have a limited driving range due to their battery capacities, they may need to visit recharging stations while servicing the customers along their routes. There are different variants of this NP-hard problem that may take into account the numerous characteristics of real applications, e.g. heterogeneity of the fleet, time constraints, charging infrastructure, realistic nonlinear energy consumption models, and etc., which further complicate it computationally.

Vehicle routing problems are known to be difficult for traditional optimisation techniques such as constraint programming, mixed-integer programming, and even for approximate enumerative methods that often show a limited efficiency on special cases. Finding an efficient solution in reasonable time is challenging due to a huge solution space that is intrinsic to this class of problems. New advanced approaches therefore can benefit from hybridizing several algorithmic techniques from Operations Research and Artificial Intelligence in order to handle various combinatorial and modelling aspects. This research project is inspired by the success of such approaches, especially those that are capable to explore solution space by learning the problem's model from selected solutions. They exploit different types of models exploring either no statistical interaction between decision variables, or learning pairwise dependencies, or studying higher-order interactions. They benefit from combining the strengths of traditional optimisation techniques and machine learning.

Keywords: Combinatorial optimisation; Electric Vehicle Routing; Mathematical Programming; Model-Based Evolutionary Algorithm

Necessary Skills:

- Advanced programming skills in Java, C#, or C++ (Essential)
- Knowledge of combinatorial optimisation techniques, e.g. meta-heuristics (Desired)
- Knowledge of mixed-integer linear programming and experience with IBM ILOG CPLEX Optimisation Studio (Desired)

Efficient Solution Techniques to the Two-Dimensional Guillotine Bin Packing Problem and its Variations

Supervisor: Dr Sergey Polyakovskiy, sergey.polyakovskiy@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This project deals with the class of two-dimensional bin packing problems with guillotine constraints, which asks to pack a set of small rectangular items without overlap into a minimum number of identical rectangular bins. The guillotine constraints imply that items can be cut out of the bin via a number of guillotine edge-to-edge cuts. Such problems are computationally challenging to solve in practice as the solution space has a large number of alternative solutions with many symmetric packing set ups. For example, modern approaches can find optimal solutions for instances with up to 100 items but often fail to solve instances with as few as 20 items. Solving large or difficult instances is time-consuming without any guarantee of a sufficiently good convergence to a global optimum. This is why effective approximate and hybrid matheuristics are so valuable when tackling the problem in industrial settings that include numerous applications in logistics, warehousing of goods, telecommunications as well as glass, wood, metal, and furniture industries.

Developing alternative exact and approximate approaches to the problem and its variations, e.g. the variable-size bin packing, is the primal objective of this research. It is motivated by the recent success of several new modelling techniques that are decent alternatives to more traditional mixed-integer programs (MIPs) from the literature. We expect that these techniques and the related ideas can be adopted to develop a solution approach that can be competitive with the state of the art and advance solutions to real-world examples.

Keywords: Combinatorial optimisation; Two-dimensional Bin Packing; Mathematical Programming; Heuristics; Matheuristics

Necessary Skills:

- Advanced programming skills in Java, C#, or C++ (Essential)
- Knowledge of combinatorial optimisation techniques, e.g. meta-heuristics (Desired)
- Knowledge of mixed-integer linear programming and experience with IBM ILOG CPLEX Optimisation Studio (Desired)

Design of Reconfigurable Intelligent Surface for Next Generation IoT

Supervisor: Dr Shiva Pokhrel, shiva.pokhrel@deakin.edu.au **Associate Supervisor:** Mr Grishma Khadka, Dr Jonathan Kua, Prof Jinho Choi

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The main project objective is to design and develop the experimental prototype for Reconfigurable Intelligent Surface (RIS) on computer simulation technology (CST Microwave Studio).

RIS is a massive low-cost passive element mounted on a planar surface. In general, it is composed of many controllable RIS elements made of multiple metal patches distributed uniformly. A passive system module can control the wireless propagation environment by re-engineering an electromagnetic wave. These passive elements do not need a dedicated energy source for radio frequency (RF) processing and are different from current MIMO and backscatter communication. Thus, the RIS-assisted wireless communication system, also known as software-defined surface (SDS), provides a cost-effective and energy-efficient solution for next-generation wireless technology. This project includes:

- Feasibility Study: This will be the preliminary research which includes knowledge of RIS and its implementation.
- System Design and Implementation: After a comprehensive feasibility study, the focus will be on system design, implementation, and experimental analysis using universal software radio peripheral (USRP) devices and its practical application area for IoT applications.
- Summary, Limitation and Future Implementation: This phase mainly focuses on the testing of the system, evaluation, and analysis for future implementation.

Keywords: Internet of Things, RIS, CST.

Necessary Skills:

- Programming
- Background in Electromagnetic compatibility (EMC), wireless communications, machine learning, Matlab, Simulink would be advantageous

Designing Decentralized and Robust Zero Trust Access Architecture

Supervisor: Dr Shiva Pokhrel, shiva.pokhrel@deakin.edu.au **Associate Supervisor:** Dr Luxing Yang, Dr Sutharshan Rajasegarar, A/Prof Gang Li

Campus: Melbourne Burwood

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This project aims to develop the first decentralized Zero Trust Access Architecture (dZTA) to efficiently facilitate remote working and collaboration for corporate networks. We will apply rigorous game-theoretic approach to analyse the robustness of the proposed dZTA control mechanism as well as the decentralized storage and analysis capabilities from distributed ledger and federated learning paradigms. Expected outcomes of this project include a robust and decentralised ZTA framework with the capacity of trust management and anomaly detection to enable secure remote working and collaboration.

The increasing trend towards remote working, working from home (WFH) and distributed collaboration has challenged previously established notions of network security, in particular, perimeter-based security. A highly distributed workforce has led to a blurring of the (physical) network boundary and exposed the weaknesses of established perimeter-based security approaches (e.g., enterprise firewalls). Perimeter-based approaches fail to: (i) effectively mitigate malicious actors located inside the network perimeter, and (ii) offer a sufficient level of protection for users and assets located outside the defined network perimeter (e.g., remote users, devices, services). Therefore, the need for security architectures that are both perimeter and location independent is much needed.

The Zero Trust Access Architecture (ZTA) has recently emerged as a promising alternative to perimeter-based security architectures (Rose et al. 2020). ZTA operates on the core principle of 'never trust, always verify', equally applied to both users and assets at a per-request level of granularity.

ZTA presents a promising vision for network security that is focused on users, assets, and resources – rather than purely on network access. However, current approaches to ZTA including the NIST framework are highly centralised, presenting both security (e.g., single point of failure, denial of service) and performance (e.g., scalability, speed) challenges. In the August 2020 National Institute of Standards and Technology (NIST) special publication (SP800-207) on ZTA, it is noted that the primary objectives of zero trust are to (i) prevent data breaches and, (ii) limit internal lateral movement. In keeping with this vision, the main aim of this project is to develop a fully decentralised and robust Zero Trust Access Architecture (dZTA) for trusted remote working and collaboration that is scalable, efficient and provably secure while limiting the opportunity for lateral movement by both malicious and non-malicious actors. To the best of our knowledge, this project is the first attempt at developing a robust and fully decentralised ZTA, which requires innovate solutions for distributed trust computation and anomaly detection.

Based on the challenges, we shall target the following tasks with associated deliverables:

Task 1. Novel Trust Computation Models. Secure and reliable trust computation is fundamental to dZTA and secure remote working and collaboration. We shall develop new algorithms for trust computation in organizational security architecture that can dynamically adapt to new contexts where the user can dynamically vary in terms of physical location, device use, network location, behaviour, etc.

Task 2. Streaming anomaly detection. Based on the established trust computation models, we will develop new scalability measures and utilise unsupervised clustering algorithms to detect new types of anomalies (e.g., zero-day attack) in streaming data.

Task 3. Robust dZTA implementation. We will take into consideration the attacking capacity of different adversaries against related machine learning algorithms and develop game-theoretic models (Yang et al. 2019) to characterise the interaction between the defensive/organisational parties and diverse types of attackers in the federal learning framework. On this basis, we shall develop algorithms approaching the optimal defensive policies

Keywords: Software Engineering, Machine learning, Security

Necessary Skills:

- AI/ML Programming
- Project Engineering and Design
- Distributed Learning
- S/W development techniques

Forecasting in Deakin Microgrid Digital Twin

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** A/Prof Vicky Mak-Hau

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This project is part of School of IT's Microgrid Digital Twin Project. Deakin University has built a Microgrid at its Geelong campus, and opened the largest solar farm on an Australian university campus. The students will become part of a research team conducting research on this important project. The Deakin Microgrid generates power from 23K solar panels from the solar farm and feeds to the Deakin Geelong buildings and main power grid along with the batteries for storage. In this project, univariate and multivariate forecasting of various measurements from the microgrid will be performed. The tasks include (i) preforming a thorough survey of the state-of-the-art forecasting/prediction methods used in powergrids/microgrids, (ii) developing novel machine learning, deep learning and AI based methods for forecasting, (iii) implementing and comparing with other existing state-of-the-art methods, and (iv) preparing report and publication on the results/work.

Keywords: Forecasting, prediction, Microgrid, Digital Twin, Energy analysis, Power analysis, Machine learning , Deep learning, Artificial Intelligence (AI), Python Programming

Necessary Skills:

- Programming skill in Python and knowledge in Machine Learning/Deep learning
- Familiarity in power/Electrical related field is an added advantage

Emotion and behaviour detection from videos

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Detecting human emotions and behaviours from videos and images

are important for monitoring purposes as well as for Artificial Intelligence (AI) applications. The challenge is to identify these different types of emotions and behaviours from in-the-wild videos and images accurately and in a timely manner. Methods, such as classical machine learning methods and deep learning methods can be used to identify the various emotions in different scenarios. The aim of the project includes, performing critical literature survey on existing emotion detection methods in various applications. Implementing and comparing some of the latest methods for detecting emotions using publicly available data. Propose novel algorithms for detecting emotional behaviours accurately. Implement those algorithms, evaluate them and empirically as well as theoretically compare with existing algorithms.

Keywords: video processing, image processing, Machine Learning, Deep learning, AI.

Necessary Skills:

- Knowledge of deep learning algorithms
- Programming Knowledge in Python
- Knowledge of image/video processing

Investigation of physical activity patterns with data analytics and wearable devices

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** Prof Maia Angelova

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

The aim of this project is to investigate patterns of physical activities using GPS and accelerometry data. The project will study the associations between different time series signals/data measured with accelerometer from the human movements. Physical activities such as running, walking, jumping, specific movements of arms and legs, etc will be investigated using physical/physiological time series. Features will be extracted from the signals and modelled using tools and methods from data analytics and machine learning/deep learning algorithms. The objectives of the project are to identify specific movements from the analysis of data and classify such movements.

Keywords: physical activity patterns, Machine Learning, Deep learning, AI, Sensors data analytics, Internet of things (IoT)

Necessary Skills:

- Programming knowledge, such as Python, R or Matlab
- Knowledge about Machine learning/deep learning algorithms

Quantum machine learning based Anomaly detection

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Detecting anomalous measurements from data is important for finding interesting events or security purposes. Quantum machine learning based methods can be used to model the normal patterns in the data and find the anomalies. The aim of the project includes, performing literature survey on existing quantum machine learning based anomaly detection methods, Implementing, and comparing some of the latest methods for detecting anomalies using publicly available data. Propose improvements to the existing methods and evaluate them.

Keywords: Quantum computing, Quantum machine learning, machine learning, deep learning, Anomaly detection, outlier detection.

Necessary Skills:

- Programming knowledge in Python
- Knowledge about Machine learning, Quantum computing

Smart Agriculture: plant disease monitoring

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Monitoring crop/plant health, such as detecting diseases, pests, and growth imperfections in crops in a timely manner is important for the agriculture industry. A challenge is how to detect the onset of health issues in plants accurately from various sensor data, such as images and videos. This will enable farmers to take necessary mitigation steps. The tasks involved in this project include:

i) performing comprehensive literature survey on the state of the art machine learning/ deep learning based methods for crop health monitoring
ii) implementing some of the latest methods and comparing their performance with various metrics
iii) propose and implement novel machine learning/deep learning based methods for highly accurate and fast detection of health issues in plants/crops and evaluate them, including comparing with other existing methods

Keywords: smart agriculture, plant disease monitoring, crop monitoring, , Machine Learning, Deep learning, AI, Internet of things (IoT), precision agriculture.

Necessary Skills:

- Python programming
- Machine learning/deep learning knowledge

Detecting shapes from hand gestures using wearable devices and machine learning

Supervisor: Dr Sutharshan Rajasegarar, sutharshan.rajasegarar@deakin.edu.au **Associate Supervisor:** Dr Chandan Karmakar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Wearable devices based on accelerometer sensors are becoming popular, and mostly used for detecting physical activities. Many of our daily gadgets e.g. smart phone also include this sensor. Recently, accelerometer sensors have been used for many applications, including medical condition diagnostic, etc. In this project, the aim is to use off-the-shelf accelerometer device to detect different shapes drawn by the user. The project involves a complete cycle of data analytic activities i.e., from data collection to train deep learning models and detecting the activities accurately from the data.

Keywords: Medical internet of things, Internet of Things (IoT), Machine Learning, Deep learning, AI, Sensors

Necessary Skills:

- Programming knowledge, such as Python, R or Matlab
- Knowledge about Machine learning/deep learning algorithms

Anomaly detection in very low frequency radio wave time series for earthquake forecasting

Supervisor: Dr Sergiy Shelyag, sergiy.shelyag@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Very low frequency radio waves from standard radio transmitters can travel vast distances around the Earth. On their way, they collect the information about the medium, through which they propagate. This information includes noise, regular variations, such as day-night, or seasonal changes, as well as the transient information on large-scale geophysical anomalies and events, such as earthquakes, volcano eruptions, tsunamis, bushfires.

A network of receivers has been created around the globe to receive those radio waves. Currently, the big question is how to understand and analyse the very low frequency radio wave propagation data in a hope to better understand and forecast geophysical hazards. In this project, we will be looking at ways to answer this big question. We will be using a variety of methods for time series analysis on already existing time series in order to find the best ways to post-predict known large-scale geophysical events, such as earthquakes. Our aim will be to find and analyse the signatures of those events in the data before they occurred at the Earth surface.

Keywords: machine learning, anomaly detection, geophysical hazards

Necessary Skills:

- Python + keras or pytorch

Animal Embodiment for Conservation using Virtual Reality

Supervisor: A/Prof Thuong Hoang, thuong.hoang@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

The disconnection between people and natural landscapes ('nature deficit disorder') is well-documented and of concern to educationalists and to governments given its impact on mental health and well-being, especially with the increasing rate of urbanisation. This second stage investigates, design, and evaluate the impact of augmented and virtual reality experiences on promoting individual and community behavioural changes for biodiversity/nature conservation as well as increasing wellbeing through connection with nature. The focus of this stage is to investigate the extent of emotional connection enabled by mixed reality technology via embodiment of endangered animals. The innovative approach of the project creates virtual reality experiences that immerses the users in a virtual natural landscape, not as human, but embodied as one of the endangered Corroboree Frog or Orange-bellied Parrot. This approach creates a powerful connection with nature by seeing through the eyes of an endangered species, which is not possible using other medium or technologies.

Keywords: Virtual Reality, Animal Embodiment

Necessary Skills:

- Unity programming

Avatar Decoder Pipeline for Multiple Simultaneous Avatar Appearances based on Trusted Relationships

Supervisor: A/Prof Thuong Hoang, thuong.hoang@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Avatars are virtual representations of users in the virtual world. Prior work has demonstrated the importance of visual representation towards user's identity, privacy, and interactions with others, in terms of self-confidence, trust and privacy.

This project explores a novel technique for avatar mesh decoder, to enable simultaneous multiple virtual representations of the same user to individual online participants, based on an established trust relationship. The focus area is a new concept in terms of identity, authentication, and privacy relating to VR devices and technologies, as well as a novel perspective on societal consideration of multiple identities and virtual representation of our avatars in virtual worlds.

Keywords: Virtual Reality, Avatar

Necessary Skills:

- Unity programming

Augmented Reality Multipresence

Supervisor: A/Prof Thuong Hoang, thuong.hoang@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Augmented reality (AR) is an interactive medium in which virtual information is overlaid on real world objects. AR visualisation can be most useful when acting as communication medium among remote users, especially for tasks guidance between an expert and novice user. Virtual instructions or interactions created by an expert located remotely can be overlaid directly on the tasks for the local user to follow. We are looking for students interested in exploring the concept of multipresence that supports seamless, natural, and engaging interactions among users that are located in multiple locations. Multipresence can be applied to various collaboration scenarios, including teaching, tasks instructions, and shared design activities. The AR multipresence platform can support the capturing and rendering of multi-sensory channels of interactions, including body movement, speech, eye tracking, haptics, touch interactions as well as exchange of 3D physical objects and environmental mapping. User can connect with the multipresence platform via virtual reality or augmented reality technologies, including mobile devices, tablet, and stand-alone VR and AR headsets.

Keywords: Augmented Reality, Mobile Technology

Necessary Skills:

- Unity programming

COVID-19 infection case forecasting using machine learning method

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Pandemic modelling is important to understand the status of the pandemic, to evaluate effectiveness of prevention and control measures and help to define and experiment with effective response strategies. Specifically, infection case forecasting can aid governments to project the changing trajectory of the spread and make appropriate decisions on precaution and control strategies (e.g., social distancing) as well as on medical resource allocation such as the provision of intensive care unit beds, ventilators, therapeutics and vaccine distribution. This project will apply machine learning methods for COVID-19 forecasting using infection case time series data.

Keywords: COVID-19, forecasting, time series, machine learning, deep learning, image processing

Necessary Skills:

- Python programming
- Machine learning

Deep learning for detection of COVID-19 using radiology images

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Radiology images related to COVID-19 such as chest X-ray and CT scans are high-dimensional data that require the processing capabilities of deep learning methods in which CNN-based models are common and most suitable (e.g., LeNet, AlexNet, GoogLeNet, VGG Net and ResNet). CNNs were inspired by biological processes of visual cortex of human and animal brains where each cortical neuron is activated within its receptive field when stimulated. A CNN consists of multiple layers where each neuron of a subsequent (higher) layer connects to a subset of neurons in the previous (lower) layer. This allows CNNs to extract useful features from COVID-19 radiology images. This project will apply CNN models for detecting COVID-19. This will help to diagnose COVID-19 early and reduce the fatality risk of COVID-19 patients.

Keywords: COVID-19, radiology images, machine learning, deep learning, image processing

Necessary Skills:

- Python programming
- Machine learning

Deepfake detection using machine learning methods

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Deepfakes (stemming from “deep learning” and “fake”) are created by techniques that can superimpose face images of a target person onto a video of a source person to make a video of the target person doing or saying things the source person does. This constitutes a category of deepfakes, namely faceswap. In a broader definition, deepfakes are artificial intelligence-synthesized content that can also fall into two other categories, i.e., lip-sync and puppet-master. Lip-sync deepfakes refer to videos that are modified to make the mouth movements consistent with an audio recording. Puppet-master deepfakes include videos of a target person (puppet) who is animated following the facial expressions, eye and head movements of another person (master) sitting in front of a camera. This project will investigate deep learning methods for deepfake detection.

Keywords: machine learning, deep learning, deepfakes, forensics, image processing, video processing

Necessary Skills:

- Python programming
- Machine learning

Detecting phishing websites using machine learning methods

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

In the recent years, the world has witnessed a huge number of cybercrimes. This has made the open internet more vulnerable to threats and cyber-attacks. Phishing is also regarded as one of the most dangerous crimes all over the world. In the event of a phishing attack, the phisher forges a website to look same as an original website (a fake bank website). The fake website created by the attacker pulls the attention of the browser and makes the user to submit all their financial, personal and confidential information.

This project aims to propose machine learning/artificial intelligence methods for detecting phishing websites.

Keywords: machine learning, deep learning, phishing websites, cybersecurity

Necessary Skills:

- Python programming
- Machine learning

Machine learning for predicting functionality changes of SARS-CoV-2 mutations

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Mutations in SARS-CoV2, the virus that causes COVID-19, highlight important implications of its transmissibility and severity. A point mutation occurs when a particular point in the genomic sequence changes, resulting in a variation in the genetic code. The real concern arises when that mutation leads to a replacement in an amino acid(s) that can alter protein function. Another frequently used term, variant, refers to the combination of various mutations in the same virus. A variant is characterized as a pool of the same virus with one or more different combinations. Analysing the mutations will aid in determination of their impact on protein structure and solvent accessibility, which in turn may inform the development of more effective vaccines. This project will investigate mutations of SARS-CoV-2 that can alter protein functionality.

Keywords: COVID-19, SARS-CoV-2, genomic, protein, mutation, machine learning

Necessary Skills:

- Python programming
- Machine learning

Text mining using artificial intelligence for spam message detection

Supervisor: Dr Thanh Thi Nguyen, thanh.nguyen@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Although nowadays many different types of communication applications are getting popular but still SMS (Short Message Service) has large user base. This service is mainly used for personal and business purpose and large amount of textual data is created in this field. The main problem with SMS's nowadays is that these are extensively used for false advertisement and fraud. As a result, many times people are dragged into unnecessary trouble. Hence it is important to develop a mechanism to filter out these SPAM messages. To detect Spam, SMS text mining needs to be implemented in such a way that important messages are not marked as SPAM and vice versa. This project aims to develop a SPAM detection model using artificial intelligence technique on a selected data set which will classify the incoming message as ham or spam.

Keywords: text mining, spam message, detection, machine learning, deep learning

Necessary Skills:

- Python programming
- Machine learning

Using efficient data structure for Defence timetabling

Supervisor: A/Prof Vicky Mak-Hau, vicky.mak@deakin.edu.au **Associate Supervisor:** Vivian Nguyen, DSTG (External)

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This project is to implement an extension of the Zero-suppressed Binary Decision Diagram (ZDD) data structure designed by Nishino et al., 2021 for the complete enumeration of feasible solutions for real-life Defence scheduling problems that have been previously formulated as an Exact Cover Problem.

The aim is to implement (either in Python or Java) a newly developed algorithm that uses this data structure to obtain the complete set of solutions to the scheduling problems.

This work involves first to convert the Defence scheduling problem data into the ZDD data structure, and then to implement a particular cutting-edge solution algorithm to enumerate the full set of feasible Exact Cover solutions.

The candidate should first explore Knuth's Dancing Links (DLX), published in 2000, and understand how this is used in solving Exact Cover Problems. The ZDD and the algorithm that will be used in this project is an advancement on the DLX algorithm.

Keywords: Data Structure, Algorithms, Combinatorial Optimization.

Necessary Skills:

- Computer Science
- Programming, Python or Java

SATCOM High throughout GEO satellite dynamic resource allocation

Supervisor: A/Prof Vicky Mak-Hau, vicky.mak@deakin.edu.au **Associate Supervisor:** Dr Chetan Arora

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

With the growing irregularity in the traffic demand patterns from static and on-move satellite users such as maritime and aviation, the satellite industry is faced with several issues in meeting the demands of all the users. Satellite resources (power and bandwidth) need to be dynamically allocated to meet users' varying demands. The flexibility in both space and ground resources, e.g., digital beamforming techniques, on the one hand, make the Satcom-systems more amenable to meet these demands but, on the other hand, increase the complexity of the system by manifolds. The Honours student will work with the research team and participate in the experimentation of different mathematical optimisation techniques the team has developed for dynamic resource allocation to users via high-throughput satellites.

Necessary Skills:

- Java or Python programming
- Matlab
- Knowledge / skill in one of the following areas: 1) Optimization, 2) Machine Learning, 3) Signal processing

Project SimGrid

Supervisor: A/Prof Vicky Mak-Hau, vicky.mak@deakin.edu.au **Associate Supervisor:** Dr Sutharshan Rajasegarar

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

This project is part of School of IT's Project SimGrid. Each student will work on one component of the project alongside the R&D team. SimGrid allows users to create one or more microgrids by "building" supply modules such as of solar farms, wind turbines, roof-top solar PVs; storage modules such as batteries, electric vehicles, alkaline water electrolytes; consumption modules such as commercial and residential buildings; and a weather condition simulation module. End-users of the software (power industry, power system education, city councils) will be able to experiment with different supply, storage, demand, and weather condition to find net-zero emission solutions for best case, average case, and worst-case scenarios.

Necessary Skills:

Depending on the component the student will be working on.

- Java or Python programming
- Matlab
- Knowledge / skill in one of the following areas: 1) Optimization, 2) Prediction models, 3) Software engineering, 4) AR, 5) Software design, 6) Database

3D point cloud processing and analysis

Supervisor: Dr Zuequan Lu, xuequan.lu@deakin.edu.au **Associate Supervisor:** n/a

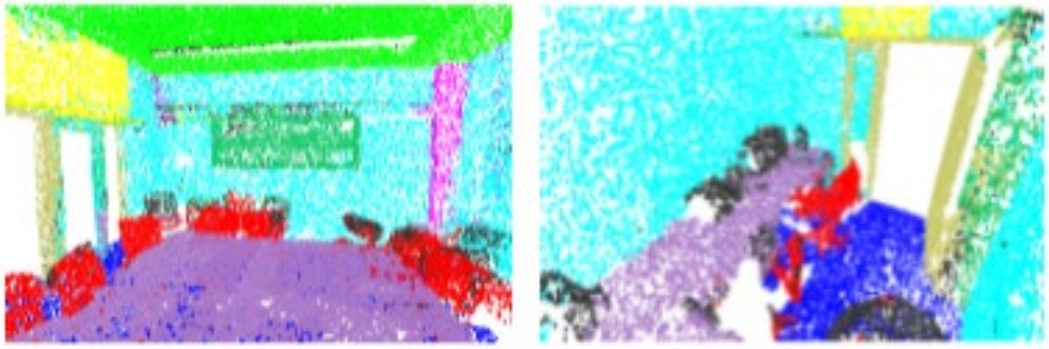
Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2

Project Description:

The computing of visual data like 3D point clouds has received remarkable attention nowadays. Recent smart techniques such as autonomous driving and robot navigation primarily rely on point cloud data. For instance, recognizing different objects is very critical for autonomous driving, and it can be achieved via point cloud segmentation (a task in point cloud processing and analysis).

In this Honours project, students are expected to focus on a few typical tasks on point cloud processing and analysis, proposing or designing feasible techniques (algorithms) to address the involved tasks under the careful mentoring of the supervisor. The research work can be submitted to prestigious conferences or journals. The following figure, from our recent work, illustrates segmentation for 3D point clouds (scenes).



Keywords: point cloud, deep learning

Necessary Skills:

- Weighted Average Score >= 75
- Should be familiar with Python.

Deepfake detection

Supervisor: Dr Xuequan Lu, xuequan.lu@deakin.edu.au

Associate Supervisor: n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1

Project Description:

Realistic face synthesis or manipulation has led to a rapid increase of deepfake images and videos which pose security and privacy threats to our society. In light of this, researchers have proposed countermeasures against face deepfake, i.e., the detection or recognition of face deepfake. It is challenging to detect manipulated faces due to the evolution of deep learning techniques for face manipulation. With technical evolution, those deepfake contents are becoming increasingly realistic and the well trained models will thus become obsolete and require retraining on new data. This project aims to design a new technique for deepfake detection, with the aid of deep learning concept. The following figure shows several examples for fake and real faces.

Keywords: deepfake, fake, real, neural networks, deep learning

Necessary Skills:

- Weighted Average Score >= 75
- Should be familiar with Python

Outlier detection in streaming data

Supervisor: Dr Ye Zhu, ye.zhu@deakin.edu.au **Associate Supervisor:** n/a

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1, Trimester 2, Trimester 3

Project Description:

Outliers are observations that are very different from other observations to arouse suspicions and are generated by a different mechanism. Outlier detection can be applied to various problems such as fraud detection, intrusion detection in computer networks, system fault detection, and unexpected error detection in databases. In recent decades, emerging technologies such as the Internet of Things (IoT) and fifth-generation (5G) cellular networks, have changed the world to connect "anything, anyone, anytime, anyplace". Unlike traditional data, the data generated from various sensors and devices require real-time analysis. How to efficiently identify outliers from these data streams becomes a major challenge for the research community.

In this project, students will perform a critical literature survey and develop new anomaly detection algorithms for data streams based on the latest isolation distribution kernel function to efficiently identify the anomalous points and groups. The baseline anomaly detection algorithms will include classic distance/density-based anomaly detectors and advanced deep learning-based anomaly detectors. Students will evaluate the performance of these methods on large real-world streaming datasets, such as network, traffic and medical datasets, and then identify the challenging issues and potential directions for further research.

Keywords: Internet of Things, Outlier Detection, Streaming data, Isolation Kernel

Necessary Skills:

- Python/R/Matlab programming skills
- Basic machine learning and data mining skills

Boosting the Convergence of Federated Learning

Supervisor: Dr Xingjun Ma, maxing@deakin.edu.au **Associate Supervisor:** A/Prof Xiao Liu

Campus: Melbourne Burwood, Geelong Waurn Ponds, Cloud

Start: Trimester 1

Project Description:

Federated learning (FL) is a type of new machine learning paradigm where there is a central server and a large number of local participants (devices). The local participants keep their private data locally, train the machine learning on their private data, then upload the local gradients to the server to do gradients/weight aggregation. FL follows a distributed learning architecture, but is different to distributed learning. In FL the local data are stored locally thus is protected, while in distributed learning, a large dataset is distributed to different devices for efficient computation. In other words, FL is for privacy while distributed learning is for efficiency. Convergence is one major issue of FL which hinders its applications with large deep neural networks (DNNs) or large-scale datasets. Materials of FL:

- Towards Federated Learning at Scale: System Design
- Federated Learning: Challenges, Methods, and Future Directions
- Federated Learning: Strategies for Improving Communication Efficiency
- On the Convergence of Local Descent Methods in Federated Learning
- Accelerating Federated Learning via Momentum Gradient Descent
- Communication-Efficient Learning of Deep Networks from Decentralized Data

In this project, students will take an optimization perspective of FL and improve the FedAvg (Federated Averaging) weight aggregation algorithm that has been the default method at the server side. Due to the nature of FL (data are stored in local devices), typical acceleration methods like momentum cannot help FL. In this project, students will explore acceleration algorithms from a structure perspective of DNNs (apply adaptive aggregation at different layers of DNNs). The thesis consists of three major parts: The first part of this project is to conduct a critical literature review on the currently published literature. Then the students are expected to implement the classic FedAvg algorithm and its improved variants. The final part is to design and test a layer-adaptive aggregation algorithm on benchmark datasets. The student is expected to submit a good paper in the end.

Keywords: Federated Learning, Local Gradient Descent, Optimization,

Necessary Skills:

- Basic knowledge of machine learning, deep learning or optimization
- Programming skills with Pytorch or Tensorflow/Keras