Postgraduate Research in Electrical & Electronic Engineering at Stellenbosch University

The following is a list of topics available in 2023 for the research MEng and PhD programmes in Electrical & Electronic Engineering at Stellenbosch University. The research activities in our department are led by individual supervisors. For a student to be considered for postgraduate studies, you first need to find a supervisor that is willing to take you on. So if you are interested in a particular topic listed below, please email the supervisor of the topic directly to arrange a meeting. Note that this is not an exhaustive list of available topics; you can also directly contact a potential supervisor if you think there is a good alignment in interests (even if they aren't listed here).

More details about the application process for our postgraduate research degrees can be found on our postgraduate website.

Signal Processing & Machine Learning

Automatic fluorescence microscopy sample processing pipeline

In the image analysis of microscopy data, one major challenge that exists is that there are many ways to pre-process the data for analysis, and depending on how well this is done, it can produce quite different analysis results, leading to potentially incorrect (and dangerous) conclusions.

The main objective of this project is, therefore, to develop a method that generates an automatic image pre-processing pipeline, using methods such as parameter exploration, aimed at optimising the clarity of specific structures in a sample (e.g. mitochondria, autophagosomes, microtubulin, etc.) with a specific goal in mind (e.g. binarization of structures, determining colocalization, etc.). To achieve this could involve the use of neural networks, but this is not necessarily required.

This system should be designed in such a way that it can be given to a moderately experienced biologist (who might not know how to write code or choose the best pre-processing parameters). They would then simply need to specify the type of data and what they would like to achieve, and the pipeline must be generated for them.

Another aspect of this project that can be envisioned is to develop a type of visual scripting tool (such as this: https://ryven.org/), where this pipeline can be made up using modular blocks (with tunable parameters), and the output of the sample at each stage can be investigated.

Supervisor: Dr Rensu Theart (rptheart@sun.ac.za)
Level: PhD or Masters
Funding: Pending

Virtual Reality-based collaborative microscopy sample interaction

Microscopes, such as confocal microscopes, generate large z-stacks of data. These z-stacks can easily be in the order of several Gigabytes. This limits the sharing of the data as well as collaboration on image analysis between researchers that are far apart.

Since these samples are inherently three-dimensional, visualising them in virtual reality creates the best intuitive understanding of the data. Furthermore, this type of data is best visualised using direct volume rendering techniques. These methods, however, require a significant amount of processing power to generate the visualisation.

This project is therefore aimed at addressing both of these problems in a single solution. Therefore, to create a collaborative VR environment, where people can join locally and remotely, with the purpose of visualising and analysing microscopy samples together, where a host would control the sample being looked at, as well as how it is being processed. The most challenging part to solve is how everyone will share the same direct volume rendering (preferably without having to download the sample on every local computer).

Note that initially the analysis could be limited to things like applying some pre-processing to the samples and thresholding the background away, but it should be built in a modular way to allow future expansion.

Supervisor: Dr Rensu Theart (rptheart@sun.ac.za)
Level: Masters
Funding: Pending

A markerless motion capture system for therapeutic use

Currently it is required to use an expensive marker-based system such as Vicon to accurately track human body movements. However with advances in neural net-based markerless pose estimation algorithms, it is starting to become possible to achieve similar accuracies with a cheaper and more mobile solution.

This project involves the development of a high-performance multi-view system for markerless motion capture of humans. This system should use relatively high-speed hardware-synchornized cameras. To add another layer of information, this camera system can be coupled with an IMU system (which will require initial calibration). Processing should preferably happen in real-time, for which a power PC might be required.

In collaboration with the Department of Sport Science and Division of Orthopaedic Surgery at the Faculty of Medicine and Health Science, this system will then be applied to detect key points of interest to medical and health researchers. This could involve the application of the system to track locomotion of patients with injuries and/or physical disabilities.

Supervisor: Dr Rensu Theart (rptheart@sun.ac.za)
Level: Masters
Funding: Pending

Listening to discovered acoustic units

Zero-resource speech processing involves discovering linguistically meaningful representations and patterns directly from unlabelled speech audio. This is in contrast to the standard supervised approach used in current speech recognition systems (e.g. in Siri or Google Search) where models are trained on large amounts of transcribed speech audio. In our recent work, we have been developing an unsupervised approach that can automatically discover and segment acoustic units that make up an unknown language. One issue is that it is difficult to evaluate the discovered units. An interesting idea is to try and re-synthesize speech from the discovered units: if we can build a model that takes discovered units as input and can output intelligible speech, then we would know that this is a reasonable set of units. This project will involve training speech synthesizers on increasingly lower bit-rate acoustic units, and evaluating intelligibility. The candidate will learn about unsupervised machine learning with neural networks, in particular applied to the area of speech processing.

Supervisor: Prof. Herman Kamper (kamperh@sun.ac.za)
Level: PhD or Masters
Funding: Pending

Deadline for application: 31 August 2022
Notification of decision: 30 September 2022

Compositional few-shot speech classification using acoustic word embeddings

Imagine a smart home system is shown a number of actions, each paired with a spoken command, e.g. "turn on lights", "turn off kettle", "close door", "open cupboard", potentially in a language that the system does not know. From only these examples, could the system learn to execute commands such as "open door" or "turn on kettle" -- commands that the system has never seen explicitly before? Over the last few years, a number of neural-network-based acoustic word embedding methods have been proposed that map variable-duration speech segments to embedding vectors in a fixed-dimensional space, allowing for efficient comparisons between segments. Given a trained acoustic word embedding model, one question is whether the resulting embedding representations capture the type of compositional properties required to solve the few-shot task illustrated above. Given a small number of examples, it is possible to train a model on top of embeddings which is able to predict the constituents that make up a novel speech example? Or is it necessary to explicitly train the acoustic word embedding model to be tailored toward compositionality? How could a system be developed to deal with ambiguity, e.g. that "light shine" and "light on" refers to the same thing? The project will involve looking at the type of machine learning models that can be used to solve this problem. The candidate will learn about low-resource machine learning with neural networks, in particular applied to the area of speech processing and few-shot classification.

Supervisor: Prof. Herman Kamper (kamperh@sun.ac.za)
Level: PhD or Masters
Funding: Pending
Deadline for application: 31 August 2019
Notification of decision: 30 September 2019

Electrical Energy Systems

Real-time energy resource optimisation

There is a growing trend to install large batteries and solar at residential estates. Given the three available energy sources of ESKOM, solar and a large battery bank, machine learning can be used as an adaptive agent to manage energy resource allocation. This is especially useful for scenarios where we have time-of-use electricity tariffs. This project would involve training machine learning models for an optimised decision making strategy that ensures that we provide electricity at the lowest cost to people in this ever-changing environment.

Supervisors: Dr Armand du Plessis (armandd@sun.ac.za)

Level: Masters

WRSG 5th Harmonic Field Supply

In this study a wound rotor synchronous wind generator (WRSG) drive is considered whereby the large generated 5th MMF stator harmonic is used to generate induced voltage in a winding on the rotor, which when rectified is used to supply the field winding of the rotor. In this way no brushless exciter or brushes and slip rings are used on the rotor. The study includes finite-element-based design optimization, current control, and lab building and testing.

Supervisor: Prof. MJ Kamper (kamper@sun.ac.za)
Level: Masters
Funding: Pending

Passive-Rotor Synchronous Condensers

This study is a follow-up study of a current master study on passive-rotor synchronous condensers (PRSCs). SCs are again widely used today to stabilise inverter-based renewable energy power grids. PRSCs is a new low operation-and-maintenance cost SC. The study will focus on different pole-slot combinations for higher kVAR-density.

Supervisor: Prof. MJ Kamper (kamper@sun.ac.za)
Level: Masters
Funding: Pending

EV-Bus Power Drive Train

As part of the EV Ecosystem program in the Western Cape, this study considers wound rotor synchronous motor drive technology for differential EV busses. The study includes finite-element based design optimization, maximum efficiency current control, and build and retrofit EV-bus tests.

Supervisor: Prof. MJ Kamper (kamper@sun.ac.za)
Level: Masters
Funding: Pending

EV-Corsa Power Drive Train

As part of the EV Ecosystem program in the Western Cape, this study considers reluctance rotor synchronous motor drive technology for a retrofit geared EV Corsa car. The study includes finite-element based design optimization, maximum efficiency current control, and build and retrofit EV-Corsa car tests.

Supervisor: Prof. MJ Kamper (kamper@sun.ac.za)
Level: Masters
Funding: Pending

Two-Speed Slip Synchronous Geared Wind Generator System

Slip-synchronous (SS) wind generator systems are a new kind of wind energy system that provides, amongst others, grid strength. The proposal is to develop a two-speed SS wind generator, because two-speed wind generator drives can harvest almost the same annual energy from the wind compared to variable speed wind generator drives. The study includes stator design options, hybrid rotor design investigation, complete design optimization, and build and practical wind site tests.

Supervisor: Prof. MJ Kamper (kamper@sun.ac.za)
Level: Masters
Funding: Pending

Measurement of network impedance for improved power quality and power system modelling.

The recent increase in energy demand and the global environmental degradation concerns have led to an accelerated rise in renewable energy sources particularly wind and solar. These decentralised power sources are integrated to the main power grid by use of power electronic converters. Due to the switching behaviour of power electronics converters, the quality of the electrical power delivered suffers deterioration due to harmonic distortion. For this reason, the grid connection of renewable energy systems is therefore subject to minimum compliance standards in terms of the harmonic current emissions and harmonic voltage distortion allowed at the point of common coupling (PCC). Grid impedance is one of the parameters used to evaluate this distortion.

This project aims to develop a methodology for invasive real-time grid impedance measurement, considering non-ideal grid conditions such as fundamental frequency variations, voltage unbalance, presence and variation of harmonics and inter-harmonics.

Supervisor: Dr FM Mwaniki (fmmwaniki@sun.ac.za)

Level: Masters/ PhD

Funding: Pending

Parameter Estimation of a Wound-Rotor Synchronous Generator using Pseudo-Random Impulse Sequence Perturbation.

The overall accuracy of power system modelling depends, in practice, on the accuracy of the model topologies and parameter values used for the various system components such as transformers, cables and generators. Accurate models of these components can be used for stability studies, grid integration studies and for simulation purposes.

This project will focus on system identification and parameter estimation of a wound-rotor synchronous generator. Wound rotor synchronous machines are attractive for wind generation systems due to the ability to control flux and thus its reactive power when directly connected to the grid. The methodology will involve perturbing the generator terminals with a pseudo-random impulse sequence excitation to obtain wide-band frequency responses that can be used in a parameter estimation procedure.

Supervisor: Dr FM Mwaniki (fmmwaniki@sun.ac.za)

Co-supervisor Mr JC Bekker (neliusb@sun.ac.za)

Level: Masters

Funding: Funded

Electronics & Electromagnetics

Superconducting field-programmable gate array

Superconductor digital electronics have ultimate clock frequency above 120 GHz. Such systems, cooled to 4 Kelvin for cryogenic operation, are energy efficient and inherently have low noise.

Superconductor digital circuits are used as the interface electronics to quantum electronics operating in the 20 mK to 100 mK range. When used adiabatically, superconductor circuits can dissipate as little as 1E-21 Joule per bit switch, making these circuits ideal for close operation to quantum electronics.

In order to improve flexibility and reprogrammability of quantum systems, as well as to provide system redundancy, rerouting and repurposing in a cryogenic environment without breaking vacuum or heating a system up, a Field-Programmable Gate Array (FPGA) architecture can be developed with superconductor electronics.

The project needs the development of design methods and software for single-flux quantum superconductor FPGA (SPGA) design that includes logic, switch block and programming fabric. Programming tools must also be developed to programme the SPGA.

The project will develop integrated circuit design and layout skills.

Supervisor: Prof. Coenrad Fourie (coenrad@sun.ac.za)
Level: Masters / PhD
Funding: Pending
Deadline for application: 30 November 2022
Notification of decision: 10 December 2022

Homomorphic Computing Utilising Superconductor Electronics

Superconductor digital electronics have ultimate clock frequency above 120 GHz. Such systems, cooled to 4 Kelvin for cryogenic operation, are energy efficient and inherently have low noise. It is well documented that superconductor electronics (SCE) provides two-to-three orders of magnitude energy efficiency gain at the same performance as CMOS.

One promising application of SCE digital circuits is for Fully Homomorphic Encryption (FHE) – a cryptosystem that allows an arbitrary circuit to be evaluated on encrypted data *without decryption*. A FHE system makes it possible to outsource computation and securely aggregate sensitive information.

This project will be focused on the development of the SCE circuit blocks that are required for FHE systems, and to demonstrate these circuits a highly efficient realisation of the Number Theoretic Transform (NTT).

The project will develop integrated circuit design and layout skills.

Supervisor: Prof. Coenrad Fourie (coenrad@sun.ac.za)
Level: Masters
Funding: Funded.
Deadline for application: 30 November 2022
Notification of decision: 10 December 2022

A Machine Learning Approach to Radio Propagation Modelling for Mobile Communications

1. Problem Statement, Current Methods and Algorithms

Direct Line of Sight (LOS) Received Signal Strength Level (RSSL) calculations at a receiver (Rx), from a transmitter (Tx) with known characteristics and location, are straightforward and basically follow the Friis formulation. However, when such transmissions occur over a terrestrial terrain in a Non-LOS manner, the situation is very different. RSSL is influenced by many factors, such as terrain intrusions into the Fresnel ellipsoid between Tx and Rx, the shape, severity and number of such intrusions, terrain cover (clutter) and clutter type. There are also other influences. Typically, these attenuating influences on the RSSL are captured in various Over Terrain (NLOS-OT) propagation models, such as Bullington, Longley-Rice, TIREM, ITU-R 526, R-M2474, Okamura-Hata, Egli, Multipath Reflective Ray Tracing, et al. All of these approaches represent a synthesis between theory and empiricism and have application specific advantages/disadvantages to accuracy.

2. Objectives

A large amount of work has been carried out over the last 3+ years in order to predict RSSL's between static base stations and mobile transceivers, using some of the abovementioned models combined with Digital Elevation Models (DEM's). Most of the algorithms utilize the DEM to take angular incremental terrain sections between Tx & Rx and to analyse the predicted RSSL of each section and subsequently combine all of these into a contributed area view. The objective that came to mind was to explore the possibility of increasing the accuracy of this prediction and modelling process by using the DEM information as input to a smart ML-based terrain feature recognition tool, in order to develop an enhanced path propagation algorithm. The current algorithms are quite restrictive in the type, no. of and physical characteristics of the features they utilize. Typically, depth of intrusions, roundness and roughness, are used as inputs. More detailed description and extraction of these characteristics might well be useful to enhance the accuracy of current approaches. Moreover, it would be another objective to use such refinements as a basis to develop an improved approach to the problem. To my knowledge, not much work has been done in this area.

Supervisors: Prof. R Wolhuter / Prof. Thomas Niesler (wolhuter@sun.ac.za, trn@sun.ac.za)
Level: Masters / PhD
Funding: Pending

Radar Tomography Imaging System using a Vector Network Analyzer

A Vector Network Analyzer (VNA) is a measuring device mostly used to measure S-parameters (reflection and transmission) of RF components and to characterize these two-port devices (such as amplifiers, filters, antennas, etc.). The proposed topic is to make use of a VNA in a 'radar' mode, combined with a rotating pedestal, to create a Radar Tomography system. This system will generate images of objects which are placed on the rotating pedestal, in front of the VNA measuring system, by using Inverse Synthetic Aperture Radar (ISAR) signal processing techniques. The study includes system design and implementation, experimental setup, measurements and signal processing to create an ISAR image of the scene of interest.

Supervisor: Mr LL Grootboom (llgrootboom@sun.ac.za)
Level: Masters
Funding: Pending

Biosensors

A membrane-based digital LAMP device

Nucleic acid amplification techniques and assays based on them have revolutionised the fields of biotechnology, immunology, and pathology, to name but a few. The current standard, qPCR, is well-suited to lab-based implementations, but is difficult to perform otherwise due to the complexity of temperature control necessary for such a device.

Isothermal amplification techniques, such as LAMP, are poised to change this, although several significant hurdles are still to be overcome before that can happen. One of these is the qualitative nature of LAMP, which can be overcome by converting the assay to a digital format.

The membrane-based dLAMP assay has recently been proved to be a viable candidate for this role, whereby the LAMP reaction is performed in the micropores of commercial filter membranes instead of microfabricated reaction volumes.

This project would require a student to design, build and test a device that integrates most of the processing steps necessary to perform and evaluate a digital LAMP assay.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

A multi-sine or harmonic-excitation electrochemical impedance spectroscopy (EIS) device

Electrochemical impedance spectroscopy has long been known to be a very powerful tool in evaluating biosystems and biosensors.

The common method of sequentially sweeping through a set of frequencies to perform impedance spectroscopy, while very precise, can also be very time consuming.

The use of a superimposed excitation source, with multiple excitation frequencies, can allow for the testing process to be sped up considerably, while potentially providing new information on the behaviour of the system being probed, by inspecting multiple frequencies simultaneously.

This project would require a student to design, build and evaluate a device to perform harmonic electrochemical impedance spectroscopy on a biosensor, as well as the fabrication of the biosensor in question.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

A multi-channel fluorescent spectroscopy device for evaluation of multiplexed PCR assays

PCR assays are becoming more and more common for a variety of applications, including disease tracking and diagnosis.

Multiplexed PCR assays, such as those used for TB diagnosis, simultaneously probe the sample for three to six targets, while most commercial PCR platforms can still only evaluate three probes simultaneously due to the detection technique usually employed – photodiodes with wavelength-selective filters.

However, recent advances in CMOS imaging sensors have made it possible to develop highly sensitive, low-cost tabletop fluorescent spectrometers, which can in principle simultaneously evaluate almost any number of target wavelengths simultaneously.

This project would require a student to design, build and evaluate a low-cost fluorescent spectrometer specifically for the evaluation of highly multiplexed PCR assays.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

An automated immuno-PCR device

The standard immunological test for biomarkers is the Enzyme-linked Immunosorbent Assay (ELISA), through which a colour change directly proportional to the concentration of a target analyte present in a sample is measured by a device to determine the concentration of that analyte.

The development of the ELISA assay revolutionised the world of immunology, and made all of the analytical tests we know today possible.

The next step in the evolution of the ELISA assay is to, instead of using a colour-changing enzyme to present a result, rather use fluorescent nucleotide tags that can be amplified through thermal cycling in the same manner as a PCR test, and have been shown to increase the sensitivity of such a test by up to 1000x.

This project would require a student to develop a device with which to perform an automated immune-PCR assay and evaluate the feasibility of using such an assay as a point-of-care test.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

A miniature, multiplexed, low-cost potentiostat

The use of electrochemical measurement techniques to evaluate biosensors is increasing rapidly due to the ease, simplicity and low cost of developing such sensors.

Part of the process for developing such biosensors, however, is doing dozens or hundreds of tests to evaluate the performance of the biosensor in question, and to refine various elements of the manufacturing process.

Most commercial potentiostats, devices capable of performing the necessary electrochemical measurements, only allow for one concurrent test, which is a severe bottleneck in the biosensor development pipeline, while multichannel potentiostats are inordinately expensive.

This project would require a student to design, implement and evaluate a relatively inexpensive multichannel potentiostat for biosensor development, and to develop a simple biosensor in the process.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

A miniaturized rapid PCR device

With the rise in PCR tests being used for disease diagnosis also comes a desire to use those tests outside of the lab and bring them into wider use.

Current laboratory-based thermal cyclers used for PCR require 300-700W of power to complete a single 96-well plate of reactions, which then take upwards of 90 minutes to complete.

Part of the reason for this long duration and high energy consumption is the large thermal mass necessary to keep the temperature of the test uniform and stable. However, it has been shown recently that high-speed temperature control systems can be effectively used to reduce the thermal mass necessary to reduce fluctuations in temperature for heathers with a smaller thermal mass.

This project would require a student to design, implement and evaluate a small-scale thermal cycling device for use with PCR assays, with design goals of low-power usage and high-speed temperature cycling.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

An integrated cell-sorting and counting device using dielectrophoresis for the detection of cancer circulating tumour cells

The effective detection and interrogation of low abundance circulating tumour cells has been shown to be important for the effective diagnosis and treatment of cancer.

One of the promising methods of detecting these rare cells is through the use of dielectrophoresis (DEP) to sort the cells in a blood sample before interrogation of the cell types through a variety of methods.

Through the nature of DEP, which is the use of time-varying electric fields to manipulate particles, it is also possible to determine the electrical characteristics of a cell being sorted.

This makes the use of DEP a very attractive technique for simultaneous cell sorting and evaluation, to simplify and speed up the process of cancer diagnosis.

This project would require a student to design, simulate and fabricate a DEP device for the detection of circulating tumour cells in blood.

Supervisors: Prof Willie Perold/Prof Anna-Mart Engelbrecht (wjperold@sun.ac.za / ame@sun.ac.za)

Level: Masters

Development and evaluation of a surface plasmon resonance device for biomarker detection

Surface plasmon resonance (SPR) has been used extensively as a method of biosensor and biomarker evaluation.

SPR is at the interface of optics and electromagnetics, where light is used to excite a metal layer at the interface of two dielectric materials. The result is a highly sensitive method of measuring small changes in dielectric constant at or near the dielectric-metal-dielectric interface.

This project would require a student to first evaluate an existing SPR device, before continuing to develop their own as a biosensing platform.

Supervisors: Prof Willie Perold/Daniël Retief (wjperold@sun.ac.za / jdretief@sun.ac.za)

Level: Masters

Computers & Control

See below.

Postgraduate Research in Autonomous Vehicles 2023

FAKULTEIT INGENIEURSWESE
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Electronic Systems Laboratory (ESL) – Autonomous Vehicles

The Electronics Systems Laboratory, established in 1992, is an internationally respected postgraduate research laboratory that specialises in the automation and control of unmanned vehicles, including satellites, unmanned aerial vehicles, terrestrial robots, and autonomous underwater vehicles. The ESL is housed within the Department of Electrical and Electronic Engineering at Stellenbosch University.

The **Electronic Systems Laboratory** would like to announce the following Master's degree and PhD research projects commencing in 2023. Final year and postgraduate students in Electrical & Electronic Engineering, Mechatronic Engineering, and Mechanical Engineering are invited to apply. Some topics are also suitable for students who have completed Honour's degrees in Applied Mathematics and Computer Science.

To improve your postgraduate application, we suggest that you apply for bursaries which you qualify for. We are willing to support you in the application of external bursaries. There are several of them available with deadlines in the near future. I recommend that you investigate the options listed in: http://www.sun.ac.za/english/research-innovation/Research-Development/postgraduate-funding-support
Other bursary options are available at: https://www.sansa.org.za/bursaries/

This document provides short descriptions of the topics available in the Electronics Systems Laboratory in 2023. For more details about specific topics, please email the supervisor of the topic directly.

To Apply

Indicate your top three projects of interest and email your CV and latest academic transcript to Dr Callen Fisher (cfisher@sun.ac.za) and CC the supervisor(s) of the projects. Please add an email subject in the form of *[ESL2023] – Your name and surname*.

Closing date for applications: *26 August 2022*
Notification of application results: *16 September 2022*

Research Topics

Dr Japie Engelbrecht

1. Trajectory Planning and Collision Avoidance for an Autonomous Racing Car
2. Motion Planning and Feedback Control of a Hexapod Robot
3. Automatic Cooperative Collision Avoidance for Unmanned Aerial Vehicles
4. Trajectory Planning and Execution for a Quadrotor UAV with Swinging Payload
5. Inspection Drone: Vision-Based Flight Control and Guidance for a Quadrotor UAV
6. Formation Flight and Cooperative Target Following for Multiple Unmanned Aerial Vehicles

Dr Corné van Daalen

7. Teaching a Robot Manipulator
8. Improving the Efficiency of Large-scale SLAM

Dr Willem Jordaan

9. Fault Tolerant Control for Satellite Attitude Control System
10. Fault Detection, Isolation and Recovery (FDIR) of Nanosatellite using Probabilistic Graphical Models (PGMs)
11. Prototype Development for DockSat Mission
12. Analysis, Simulation and Measurement of a Pyramid Configuration of Reaction Wheels for High Performance Imaging Missions

Dr Arno Barnard

13. Software-Defined-Radio for Nanosatellite and Groundstation Application
14. Performance and Radiation Tolerance Testing of Vision-Processing-Units (VPUs) for Nanosatellite Application
15. Design and Implementation of Firmware (VHDL) Based Image Calibration Algorithms for Real-time On-board Satellite Image Processing

Dr Callen Fisher

16. Contactless heart rate and respiration rate monitoring system of multiple, moving subjects
17. Desktop robotics: Develop a testing platform for legged robotics
18. Ab/adduction, is it really required in legged robotics?
19. Improving the existing SLAM based rover and adding an autonomous manipulator

Dr JC Schoeman

20. Developing a model-based reinforcement learning framework for autonomous driving
21. Autonomous F1TENTH racing on an unknown track
22. The degenerate Kalman filter
23. Gaussian belief space planning using probabilistic graphical models
24. “Diplomacy” using reinforcement learning

Mr Benjamin Evans

25. Safe Autonomous Racing at the Performance Limits
26. Head-to-head Autonomous Racing using Safe Reinforcement Learning

1) Trajectory Planning and Collision Avoidance for an Autonomous Racing Car

A planning, guidance, and control system for an autonomous racing car must be designed, simulated, implemented and practically demonstrated. An optimal trajectory planner must be designed to plan the optimal path for the autonomous racing car around the race track while avoiding collisions with competitors. A control system must be designed to control the heading and speed of the racing car, and a guidance system must be designed to follow the planned optimal trajectory. The planning and control must include collision prediction and avoidance functions to avoid collisions with competitors. The trajectory planning and control system must be verified in simulation and with practical tests.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)

2) Motion Planning and Feedback Control of a Hexapod Robot

A motion planning and feedback control system must be designed and implemented for a hexapod robot. The motion planning algorithm must use the leg kinematics to plan the trajectories of the hexapod legs to enable the robot to move at a given forward speed in a given direction. A feedback control system must be implemented to control the hexapod speed and heading while compensating for external disturbances and parameter uncertainty. The motion planning and feedback control system must be implemented and verified in simulation and with practical tests.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)

3) Automatic Cooperative Collision Avoidance for Unmanned Aerial Vehicles

The purpose of this project is to design and verify multi-aircraft path planning algorithms for autonomous collision avoidance of unmanned aerial vehicles (UAVs). One of the key enabling technologies for the eventual integration of UAVs into commercial airspace, is collision/conflict prediction and avoidance, also called “Sense and Avoid”. A semi-cooperative collision avoidance system will be developed where all UAVs broadcast their position, velocity, and intent on a communications network, and where multi-agent path planning and re-planning is used for globally optimal conflict resolution. The collision avoidance system is semi-cooperative because it assumes most air vehicles are cooperating, but that some air vehicles are unresponsive or not following instructions. The performance of the collison avoidance system will be verified in simulation for specific conflict scenarios and will also be verified statistically using Monte Carlo simulations. The system must preferably also be validated with practical tests.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)

4) Trajectory Planning and Execution for a Quadrotor UAV with Swinging Payload

A feedback control system to perform flight control of a quad rotor with a swinging payload must be designed, simulated, implemented and practically demonstrated. A trajectory planning problem must be

formulated and solved to guide the quadrotor and its swinging payload through a confined space consisting of horizontal and vertical tunnels. A mathematical model for the quadrotor-cargo system must be derived. Feedback control loops must be designed to control the quadrotor while stabilising the swinging cargo. Path planning algorithms must be applied to perform trajectory planning. The performance of the trajectory planning and flight control system must be verified in simulation, and if possible, with practical flight tests.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)

5) *Inspection Drone: Vision-Based Flight Control and Guidance for a Quadrotor UAV*

The purpose of this project is to design and verify a vision-based flight control and guidance system for a quadrotor inspection drone relative to a known inspection target. The inspection drone must autonomously navigate itself around the circumference of the inspection target. A vision-based localisation system will be used to identify visual features on the inspection target and to use these features to accurately determine the relative position and orientation of the inspection drone relative to the target.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)
Co-Supervisor: Prof. Herman Engelbrecht (hebrecht@sun.ac.za)

6) *Formation Flight and Cooperative Target Following for Multiple Unmanned Aerial Vehicles*

The aim of this project is to design, simulate, implement, and practically demonstrate guidance and flight control systems for multiple unmanned air vehicles to fly in formation and to cooperatively follow and view a moving ground target. The two unmanned aircraft must perform cooperative trajectory planning to follow the moving target while providing optimal camera coverage from both sides. Both aircraft must also implement cooperative collision prediction and avoidance functions to avoid colliding with each another, and to avoid static and dynamic obstacles in the environment. The cooperative target-following system must be verified in simulation and with practical flight tests.

Supervisor: Dr Japie Engelbrecht (jengelbr@sun.ac.za)

7) *Teaching a Robot Manipulator*

One of the problems that prevent effective interaction between humans and robots is that they "speak different languages" -- humans use high-level, abstract concepts, whereas robots use low-level, concrete concepts. For specifying a robot manipulator task such as "take this component and insert it into that slot such that it clicks into place", one would ideally want to tell or show the manipulator what to do. Instead, programming a robot manipulator in practice to reliably perform such a task can take an expert many painstaking iterations over several days to get right, and some simple tasks are still not possible to program reliably.

The goal of this project is to develop techniques that would allow a user to demonstrate a task by manually moving the manipulator, and then for the robot to extract an action sequence such that the task can be performed reliably -- this would allow the user to specify a task in a quick and intuitive way. This will be done by using probabilistic graphical models (PGMs) to build high-level, abstract concepts (e.g. "click into place") from low-level, concrete concepts (e.g. location or force profile), and giving the robot the ability to reason about these concepts. The project involves theoretical development of the solution, implementation in software, demonstration on a simulated manipulator, and final demonstration on an actual manipulator.

Supervisor: Dr Corné van Daalen (cvdaalen@sun.ac.za)

8) *Improving the Efficiency of Large-scale SLAM*

Simultaneous localisation and mapping (SLAM) is a robotics technique that measures static points -- or landmarks -- in the vicinity of a robot, and uses these measurements to simultaneously determine the location of these landmarks as well as the pose (position and orientation) of the robot. The landmark positions and robot pose are usually described in a single reference frame, with the robot's starting pose at the origin. The accumulation of errors in this formulation prevents the application of SLAM to large-scale environments. A solution is to divide the map into smaller regions -- or submaps -- each with its own reference frame. However, there are several challenges to overcome: the pose of neighbouring

submaps should be estimated relative to each other, the robot pose should be transformed from one reference frame to another when the robot crosses over to another submap, and loop closure -- when the robot returns to a previously observed region -- would be difficult to perform. Nevertheless, this approach promises significant improvement in the scalability of SLAM.

The goal of this project is to improve the scalability of SLAM through the use of submaps. The idea is to combine classical SLAM techniques for estimation within submaps with probabilistic graphical models (PGMs) -- a statistical machine learning technique used for probabilistic reasoning -- for estimation between submaps. The project involves theoretical development of the solution, implementation in software (C++ in Linux), and demonstration on simulated and/or real-world datasets.

Supervisor: Dr Corné van Daalen (cvdaalen@sun.ac.za)

9) Fault Tolerant Control for Satellite Attitude Control System

Satellites are highly integrated systems with each subsystem having a considerable influence on the final system's performance. The attitude determination and control system (ADCS) is one such subsystem which consists of many distributed actuators, sensors, and processing units. Actuator and sensor failures, and the presence of unknown disturbances may disrupt the performance of the ADCS. Fault tolerant control (FTC) is controllers that can tolerate faults or uncertainties and keep the control performance in the ideal range. This project entails the investigation and implementation of new adaptive and fault tolerant controllers as applied to the ADCS. Modern data-driven and optimization methods will be considered such as concurrent learning-based model reference adaptive control (MRAC) and adaptive model predictive control (AMPC). These techniques are to be implemented within simulation and compared to current traditional implementations within in-depth simulations. Hardware-in-the-loop (HIL) evaluations will also evaluate the practical feasibility of these solutions on practical hardware.

Supervisor: Dr Willem Jordaan (wjordaan@sun.ac.za)

10) Fault Detection, Isolation and Recovery (FDIR) of Nanosatellite using Probabilistic Graphical Models (PGMs)

The current trend in nanosatellites are large satellite constellations (> 100 satellites), which results in the increased need for automation. Managing such a large constellation of individual satellites, especially during commissioning, places large pressure on the ground support team. This project aims to reduce this load by working on a fault detection, isolation, and recovery (FDIR) system onboard the satellite that can provide diagnostic information and insight about the current state of the nanosatellite and any errors that might have occurred. A probabilistic graphical model (PGM) is a probabilistic model where the conditional dependencies between random variables are described. There are then inference algorithms which can reason about the values of certain random variables given some measurements in the model. For FDIR in satellites, we might e.g., want to infer whether a star camera is malfunctioning given that the pointing accuracy of the satellite has degraded by a certain degree. The aim is to investigate the feasibility and effectivity of using a PGM for FDIR and develop tools which would improve the automatic detection and recovery of faults on nanosatellites within a large constellation.

Supervisor: Dr Willem Jordaan (wjordaan@sun.ac.za)
Co-Supervisor: Dr Corné van Daalen (cvdaalen@sun.ac.za)

11) Prototype Development for DockSat Mission

DockSat is an internal satellite project of the Electronic Systems Laboratory and entails the development of a mission which demonstrates the docking and undocking of a 1U and 2U CubeSat sized satellites. The aim of this satellite project is the design of the mission, the development of necessary components, the construction and launch of the satellite and the operation of the mission. This specific project entails the general system design of the 1U and 2U satellites and the analysis of the mission parameters such as mass, volume, power, link, and data budgets for varying configurations. This will include the initial definition of the major components given the requirements identified from the analysis. The next step is to construct an engineering model of the satellites, built from either engineering versions or virtualized versions of the chosen components of the two satellites. Hardware-in-the-loop (HIL) evaluation of the proposed system will also necessitate the initial development of the main flight software.

Supervisor: Dr Willem Jordaan (wjordaan@sun.ac.za)
Co-Supervisor: Dr Arno Barnard (abarnard@sun.ac.za)

12) *Analysis, Simulation and Measurement of a Pyramid Configuration of Reaction Wheels for High Performance Imaging Missions*

Reaction wheels are the most versatile and useful actuator for precise pointing and stability of an imaging telescope. However, typical non-ideal characteristics of these types of wheel actuators are static and dynamic unbalance, torque ripple, zero crossing stiction, bearing friction noise and speed measurement noise. These non-ideal parameters must be determined, and a simulation model constructed to evaluate typical nanosatellite reaction wheel performance in a pyramid configuration of wheels with biased speed. A Kistler table setup must be constructed to measure the frequency response of the wheel torque disturbances. A practical test must also be implemented on a 3-axis air bearing to validate the pointing and stability performance to be expected on a low-earth orbiting (LEO) CubeSat.

(Funding is attached to this topic, subject to final approval of candidate by the funder)

Supervisor: Dr Willem Jordaan (wjordaan@sun.ac.za)
Co-Supervisor: Prof Herman Steyn (whsteyn@sun.ac.za)

13) *Software-Defined-Radio for Nanosatellite and Groundstation Application*

One of the critical components in nano-satellite systems is the communication channel. To allow for reliable and optimal communication over the lifetime of a satellite, new generation systems must be flexible enough and be adaptable to changing communication architectures and protocols. These systems need to be reconfigurable via software and are known as software defined radios. This project's focus is to design a software-defined-radio (SDR) for application on nanosatellites and port the design to FPGA firmware to compare power consumption and speed trade-offs. The typical application would be for nano-sat telemetry and control to a ground station or inter-satellite communication. Development kits will mostly be used for the work to try and limit the hardware development of the project, and thus it is not required that any RF front-end development be done. Functional testing and verification will be ground based, including adapting, and using the Electronic Systems Laboratory ground station for the tests. The core skills that would be developed include SDR, digital signal processing (DSP), software (C/C++), firmware (VHDL) programming, and communication system architectures.

(Funding is attached to this topic, subject to final approval of the candidate by the funder)

Supervisor: Dr Arno Barnard (abarnard@sun.ac.za)

14) *Performance and Radiation Tolerance Testing of Vision-Processing-Units (VPUs) for Nanosatellite Application*

Satellites are required to operate in the harsh environment of space, where amongst other effects ionizing radiation is a major contributor to system errors and failures. At the same time satellite missions require increased performance to handle increasing user requirements. This project aims to test VPU systems that is aimed for satellite application and to characterize the performance and ionizing radiation tolerance of the VPU system(s). The work will include choosing and implementing representative benchmark software and algorithms to exercise the system during testing. The aim is to include both Total Ionization Dose (TID) testing as well as Single Event Effect (SEE) testing of the VPU system to identify possible vulnerabilities. Core skills that would be developed include VPU configuration and software programming, TID/SEE test preparation and execution, and test data analysis.

(Funding is attached to this topic, subject to final approval of the candidate by the funder)

Supervisor: Dr Arno Barnard (abarnard@sun.ac.za)

15) *Design and Implementation of Firmware (VHDL) Based Image Calibration Algorithms for Real-time On-board Satellite Image Processing*

Satellite systems have limited downlink capability and therefore designers aim to process as much data as possible on-board the satellite. This project aims to investigate optimal implementation of image calibration algorithms on a FPGA based satellite imager platform. Analysis of the performance and resource requirements between different implementations and algorithms should be performed. The funder will provide hardware on which the work will be carried out. Core skills that would be developed include FPGA configuration and programming, python coding, VHDL coding, image processing, and system testing.

(Funding is attached to this topic, subject to final approval of the candidate by the funder)

Supervisor: Dr Arno Barnard (abarnard@sun.ac.za)

16) Contactless heart rate and respiration rate monitoring system of multiple, moving subjects

Low-cost remote monitoring has huge potential benefits for the medical field, particularly in poor regions in the world. This technology has multiple benefits, such as self-monitoring, telemedical appointments as well as multiple patient monitoring in a hospital setting. It has been proven that a respiration rate of more than 27 breaths per minute is a predictor for imminent cardiac arrest. It has also been shown that relative changes in heart rate in unstable patients is far less than the changes in respiration rate. This makes respiration rate one of the most crucial vital signs to detect early changes in the health status of critically ill patients.

The aim of the research is to develop a system, using an array of off the shelf cameras to detect vital signs in real time, as well as raise an alarm in the event of an emergency. The system can be extended to estimate blood pressure using the transient time between pulses of the photoplethysmography signals.

Supervisor: Dr Callen Fisher (cfisher@sun.ac.za)

17) Desktop robotics: Develop a testing platform for legged robotics

It is often costly and time consuming to test legged robotics, with a large research space required. Many test rigs have been developed in the past, these typically consist of a large boom arm, railing system or a support trolley. Sometimes these robots are made to run on treadmill systems as well. The aim of this research is to develop a desktop test platform to design and test trajectories on multiple monopod legs. The test rig will consist of railing system, treadmill and an array of sensors to measure parameters such as:

- GRF on the foot (horizontal and vertical)
- Reaction torque on the body (with the ability for the body to be fixed or rotate freely)
- Velocity of the foot
- All measurable states of the robot

The student will be required to develop the test rig, along with trajectory optimization inspired controllers for multiple monopod robots.

Supervisor: Dr Callen Fisher (cfisher@sun.ac.za)

18) Ab/adduction, is it really required in legged robotics?

Current research focus and state of the art platforms in the legged robotics field are focused on ab/adduction degrees of freedom. This is present in both bipedal and quadrupedal robots. Little research has been done to prove their effectiveness. Some fundamental questions need to be answered, such as:

1) How does it aid manoeuvrability? Does it only help with turning or does it help with steady-state motion? Is it used more for slow motions or higher speeds?
2) What are the requirements for the ab/adduction actuator? Must it be a high-speed actuator? Or is a low speed but powerful actuator acceptable? What angular range is required?
3) Is it required for both bipedal and quadrupedal robots?
4) Does it improve the overall stability of the platform?

These questions will be addressed in a simulation study, using trajectory optimization methods.

Supervisor: Dr Callen Fisher (cfisher@sun.ac.za)

19) Improving the existing SLAM based rover and adding an autonomous manipulator

Currently there is an autonomous rover with an array of sensors (RGB-D camera, LiDAR sensor, IMU, as well as motion sensors such as encoders and current sensors). The rover can perform autonomous locomotion and dynamic object avoidance, in real time, with on-board processing. However, the robot can only operate at a slow speed, and in a nice laboratory environment. The initial aim of this research is to improve the SLAM based system, as well as the localized controllers, to enable the rover to translate rough terrain (such as gravel and mountainous terrain).

The secondary aim of the project is to design and build a linear actuated robotic arm to attach to the rover. Using the onboard sensors, the arm must be controlled to perform tasks, such as picking up and moving objects. A large focus of this research will be on deciding if an object needs to be moved (is it blocking the path?), if it can be moved (is it a movable object?), and how to go about moving it (what orientation should the gripper be in?).

Supervisor: Dr Callen Fisher (cfisher@sun.ac.za)

20) Developing a model-based reinforcement learning framework for autonomous driving

To operate autonomously, a robotic vehicle must perform actions to successfully complete a specified task. To reliably plan for scenarios with significant uncertainty (due to factors like unknown and dynamic environments, noisy sensing, and the actions of external agents), the problem is often modelled as a sequential decision-making problem. Reinforcement learning (RL) is a popular technique from the field of computer science that can be used to solve such decision-making problems. RL has seen growing popularity in recent years; successful applications include agents capable of beating grandmaster-level human players at the games of Chess or Go.

In most of these cases, however, model-free RL techniques were used. This trial-and-error-based approach refers to algorithms where the agent learns the optimal behaviour directly from experience. Though simulation-based setups are forgiving in this regard, such naive exploration could lead to disastrous consequences and irreparable damage in practical robotic systems. A more viable approach is therefore to use model-based RL. This would enable the agent to use its experience to explicitly construct (or improve) a model of its environment. It could then use the latest model to plan and predict the outcomes of actions – something that will lead to much safer operation in practice. The aim of this project is to develop such a model-based RL framework that can be used to solve a set of autonomous driving tasks. This will first be done in simulation before applying the solution to a physical vehicle.

Supervisor: Dr JC Schoeman (jcschoeman@sun.ac.za)

21) Autonomous F1TENTH racing on an unknown track

F1TENTH is an international community performing autonomous systems research through building and racing of 1:10 scale F1 vehicles. The common goal is to race around known tracks as fast as possible – usually first in simulation and then in the real world. This provides a platform for addressing many research and systems engineering questions and solving both theoretical and practical problems. The current approaches to autonomous racing ranges from more conventional control approaches (e.g., model predictive control) to data-driven solutions involving machine learning (e.g., reinforcement learning and imitation learning).

Almost exclusively, however, current research focuses on known tracks, where the robot can either use an exact representation to plan its trajectory or can repeatedly interact with the track in simulation. This does not provide a clear and automatic way to extend these frameworks to settings where the vehicle can race on a track it has not seen before. In contrast, this would be quite natural for an expert human driver. This project therefore aims to extend the most promising algorithms (which appear to be at least partially data-driven) to F1TENTH racing on unknown tracks. This will first be done in simulation before applying the solution to a physical vehicle.

Supervisor: Dr JC Schoeman (jcschoeman@sun.ac.za)
Co-Supervisor: Mr Benjamin Evans (bdevans@sun.ac.za)

22) The degenerate Kalman filter

An important component of any autonomous robotic system is the ability to estimate its own state as well as that of its environment. This is often achieved by processing sensor measurements and control inputs in a principled way, where a common example is the Kalman filter. This well-established mathematical model can be derived from both control theory and statistics and is already widely applied in many practical systems. Without an accurate state estimator, reliable control of an autonomous vehicle is not possible.

Among other components, the Kalman filter makes use of multivariate Gaussian distributions. This means that the covariance matrix of any distribution over the robot's state needs to be non-singular (I.e., invertible) to avoid numerical errors. The implication is that there cannot exist any perfect correlation between two given states, which is an unnecessary limitation. One example application where such

linear dependencies need to be handled carefully is a ground vehicle in 3-D space navigating on a 2-D plane. This is also prevalent when working with high-dimensional, nonlinear systems where approximations are unavoidable, and singularity does occur. The aim of this project is to derive, implement and test a version of the Kalman filter that can accommodate such degenerate settings. The experiments for this project will be performed in simulation only.

Supervisor: Dr JC Schoeman (jcschoeman@sun.ac.za)

23) Gaussian belief space planning using probabilistic graphical models

To successfully perform a user-specified task, an autonomous robot must plan its future actions using predictions of the (continuous) robot and environment states. When the robot cannot observe the states directly, it represents its knowledge of the states as a belief distribution. The goal of belief space planning is then to find a policy (or mapping from belief to actions) that minimises a cost function corresponding to the specified task. Previous research efforts towards planning (e.g., motion planning and Markov decision processes) were successful in addressing either uncertainty or continuous state spaces, but not both.

A promising way to model the problem of decision-making under uncertainty is using influence diagrams – a specific type of probabilistic graphical model (PGM). PGMs are a family of statistical techniques that represent the local structure of an inference problem using directed or undirected graphs. In addition, PGMs make it easy to extend a model or make approximations. The aim of this project is to investigate the application of PGMs to the belief space planning problem. The use of Gaussian distributions would further allow planning for systems with continuous dynamics, without the traditional use of discretisation. This will aid planning for tasks like mapping an environment or avoiding collisions with static or dynamic obstacles. The experiments for this project will be performed in simulation only.

Supervisor: Dr JC Schoeman (jcschoeman@sun.ac.za)
Co-supervisor: Dr Corné van Daalen (cvdaalen@sun.ac.za)

24) "Diplomacy" using reinforcement learning

Reinforcement learning (RL) refers to a branch of machine learning that can be used to solve sequential decision-making problems. By utilising RL algorithms, an agent can learn to complete a complex task by learning which actions lead to favourable outcomes based on trial-and-error experience. A standard approach for applying RL techniques to real-world problems is to first test and study their performance on similar but easy-to-simulate problems. One such example that has received attention in the past is the popular seven-player strategy game "Diplomacy".

RL techniques are already well-studied and well-understood when applied to two-player, zero-sum adversarial games with zero cooperation. Examples of these powerful algorithms are deep Q networks (DQNs) and deep deterministic policy gradient (DDPG) methods. In Diplomacy, however, cooperation (and ultimate betrayal) is usually necessary for victory. In the "Press" version of the game, communication is further allowed between players through natural language. To date, most research efforts were focused on the simpler "No-Press Diplomacy" problem. The aim of this project is to develop a computer-controlled agent through RL that can challenge human-level performance in a software version of "Press Diplomacy".

Supervisor: Dr JC Schoeman (jcschoeman@sun.ac.za)

25) Safe Autonomous Racing at the Performance Limits

This project will extend current work in the ESL in the field of safe autonomous racing by improving the modelling of F1Tenth vehicles at high speeds. F1Tenth autonomous cars (https://f1tenth.org) are 1/10th the size of F1 racing cars that are useful for the development and testing of high-performance algorithms. The project is to model the friction limits of an autonomous (F1Tenth) race car so that a safety supervisor that operates at the edge of performance can be developed. Once an offline friction model has been derived, the parameters should be determined and refined using measurements from the physical vehicle. After the offline model has been validated, it should be converted to an online model that can use a real-time LiDAR scan to ensure that the vehicle remains within the performance limits. This application of the friction model is a supervisory safety system that monitors the planner and ensures vehicle safety, even when potentially unsafe machine learning components are used in the planning pipeline.

A candidate for this project should have an interest in physical vehicle systems with skills in applied maths and control systems.

Supervisor: Mr BD Evans (bdevans@sun.ac.za)
Co-Supervisor: Dr C Fisher (cfisher@sun.ac.za)

26) Head-to-head Autonomous Racing using Safe Reinforcement Learning

F1Tenth autonomous car racing (https://f1tenth.org) has emerged as a growing platform for developing and testing high-performance algorithms. A current challenge is head-to-head racing where two opposing vehicles race against each other. Reinforcement learning (training an agent from experience to complete a task) has been proposed as a promising approach for competitive racing.

This project entails extending current work in safe RL for autonomous racing from a single racing vehicle to head-to-head racing. The focus is on developing a learning formulation to overtake other vehicles while ensuring that the vehicle does not crash. Tasks will involve extensive simulations to develop a learning formulation for safely overtaking vehicles. Ideally, the algorithms will be validated on physical vehicles.

A candidate for this project should have an interest in machine learning, and strong mathematical and programming skills.

Supervisor: Mr BD Evans (bdevans@sun.ac.za)
Co-Supervisor: Prof. Herman Engelbrecht (hebrecht@sun.ac.za)