IoT Edge Device and Digital Twin for Mechatronics Laboratory

Reference	: AHB1
Supervisor	: Prof Anton Basson
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
Building information management (BIM) is an area where the Internet of Things (IoT) has the potential to play a significant role. A university campus can act as a "laboratory" for the development of these technologies. One element of this is to develop "digital twins" for various spaces. There are normally few sensors in such spaces.
This project focusses on the mechatronics laboratory. This project's objective is to develop an IoT edge device that will sense and transmit data that is relevant for venue's digital twin. The data could include occupancy, lighting, ambient conditions, use of equipment, etc. The project relies on a structured design approach to define the roles and requirements for the digital twin. The project also includes the development and testing of a concept demonstrator, which is likely to involve a small microcomputer or microcontroller and software to store and display the data.

Control of a Prosthetic Hand

Reference	: SI1
Supervisor	: Mr Shival Indermun
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical and/or Mechatronic
Required elective	: None

Description:
The hand is arguably the limb that defines a human's independence. Prosthetic replacements for amputees or those suffering with birth defects has seen rapid development due to the aid of additive manufacturing and non-profit communities. Focus has been primarily aimed on the sensory integration of prosthetic hands, for improved functionality. Apart from the sensory response to actuate the prosthetic arm, the motion and grip strength are key factors in the pursuit of identically replicating the function of the hand. The action of gripping common items, such as a pen, requires minimal force. However, actuators controlling the hand, do not cater for specific forces but are binary – full force or stop. Furthermore, hand motion is not rapid, but fluidic. Therefore, to replicate the grasping of a hand, the prosthetic needs to cater for the amount of force required to hold an object and the acceleration at which the item is gripped. Given a servo-actuated prosthetic hand, the student must design and develop a method of controlling the amount of force require to grasp small items and a method of smoothening the acceleration of hand while performing basic gestures.

Optical Pitch and Squareness Measurement of a Wire Panel

Reference	: KS1
Supervisor	: Prof Kristiaan Schreve
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
This project was initiated by Clifford Machines & Technology (https://www.cliffeng.com/). This company develops machines that makes large wire panels that are used for example for fences. An optical system is needed to measure the critical dimensions of such panels. The measurements will be used to tune the machine parameters so that the panels are manufactured accurately. A previous project investigated a basic optical measurement system for the welded wire panel. This must now be extended to measure critical dimensions of the 6 m long wire panel, such as the overall pitch between the wires and the overall squareness. The measurement system must be designed so that the measurements can be done in real time. Therefore, image stitching must be investigated. The real time measurement must be demonstrated by showing that the measurements can be done fast enough and accurately enough. Also investigate the effect of travelling speed, and speed variance, on the measurement accuracy. Have a look at the company's website to see more about the machines they design and manufacture.

Automated infant length and weight measurement

Reference	: KS3
Supervisor	: Prof Kristiaan Schreve
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
A crucial activity in nutrition surveillance is growth monitoring and promotion to timeously identify and treat children who are malnourished or at risk for malnutrition. It is estimated that 45% of deaths in children under 5 years are linked to malnutrition. In a hospital and clinic environment, these measurements are often taken under severe time pressure resulting in errors or complete neglect of taking these measurements. This is partly due to the fact that the measurements are time consuming, require multiple devices and require great care to be accurate. In this project, an existing design concept must be fully developed, built and tested. The design uses a camera with a back light to measure the infant's length while at the same time also taking a weight measurement. The measurements must be taken digitally and captured in a format that can quickly be made available to the clinicians needing the data. The system's accuracy must be tested.

Hunting Bow Testing Device

Reference	: GV5
Supervisor	: Prof Gerhard Venter
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical and/or Mechatronic
Required elective	: None

Description:
This project will develop a testing device with corresponding testing procedures to test hunting bows. A high end bow will be provided for testing.
The testing will consists of fatigue type tests where the bow will be loaded/unloaded for a high cycle count to ensure that it is safe to use. Typical parameters are a maximum force of around 500 N and a travel of around 600 mm. The bow must be loaded and unloaded in a controlled and safe manner and the device should account for the fact that the bow string may break during testing. Safety is of the utmost concern.
The developed device will be dedicated to testing bows and should be easy and efficient to use. The idea would be to specify basic parameters like the cycle count, travel and a maximum force in a user interface and have a micro-controller that executes and monitor the test while recording data. The physical test frame and all the electronics required to control the test will have to be developed and provided as a finished product that can be used by industry to test newly developed bows.

Design, build and test a walking soft robot

Reference	: MPV4
Supervisor	: Dr Martin Venter
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical and/or Mechatronic
Required elective	: None

Description:
Soft robots are an interesting new branch of robotic relying on large scale deformation of soft materials rather than traditional hinged joints for articulation. Some benefits of this technology are that they are cheap to produce and have robust damage-resistant construction, which makes them an ideal complement for several applications in fields as diverse as medicine and space exploration.
In this project, the researcher will be required to design, build and test a soft robot capable of walking on a flat plane. The robot should be designed with a feedback controller that allows a user to set and steer the robot as it walks. The robot should be designed with speed and accuracy in mind.

Redesign and test the driving system for a centrifugal particle receiver

Reference	: JEH7
Supervisor	: Prof Jaap Hoffmann
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical and/or Mechatronic
Required elective	: None

Description:
Particle receivers are an attractive proposition in the concentrated solar thermal energy sector. Concentrated sunlight is aborbed directly by the particles. If designed correctly, the particles shield the structural components from high temperature. Design, build and test a centrifugal particle receiver for isothermal (cold) tests with coarse sand particles. The receiver rotational speed and inclination angle should be variable in order for particles to adhere to the wall. Your objective is to get an almost uniform particle distribution on the walls. Earlier work suggests that the rig is very sensitive to shaft misalignment. It leads to vibration and kicking particles away from the wall. It is postulated that the vibrations are caused by the current drive system. The aim of this project is to modify/improve on the existing design in order to reduce/eliminate vibrations.

High density fluid based pumped storage

Reference	: CM2
Supervisor	: Prof Craig McGregor
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical and/or Mechatronic
Required elective	: None

Description:
The company RheEnergise (https://www.rheenergise.com/) has proposed a novel concept for storing renewable electricity, such as wind and solar PV. Their concept is based on pumped hydro energy storage (PHES), where water is pumped to a high elevation to store electricity, and used to drive a hydro turbine (generator) when energy needs to be discharged.
In the RheEnergise concept, the water in a standard pumped hydro storage scheme is replaced with a high density (2.5x water), but low viscosity, fluid that allows the same energy to be stored in a smaller volume, or allows for much smaller elevation to store the same amount of energy. I suspects that the high density fluid is in fact a high concentration slurry of a very fine powdered solid suspended in water. Hence the idea is based of the science of RHEology.
There are limited opportunities in South Africa to deploy PHES because of the the specific geography that is required - a large lake at the top of a mountain connected via a hydro electric scheme to a large dam at the bottom of the same mountain. Since PHES is over an order of magnitude cheaper than battery energy storage, this idea would allow for cheaper renewable energy deployment in South Africa.
The project consists of at least the following two components: (1) some laboratory work to examine the rheology of various slurries, to propose a potential storage fluid (2) the concept design and economics of a high density pumped hydro scheme
Outside of this the student has a lot of flexibility to consider other aspects of the system. For example, some of the detailed design questions could also be addressed, such as the configuration of the hydro turbine.

Design of a unique device for honey extraction

Reference	: JVDS1
Supervisor	: Prof Johan van der Spuy
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechanical
Required elective	: None

Description:
The extraction of honey from beehive frames using centrifugal forces is an acceptable standard in the beekeeping industry. Such a honey extractor can however be bulky and difficult to store and transport. It therefore requires a relatively permanent installation that is not always available.
The student is required to design an alternative honey extraction mechanism. The mechanism must be compact and easy to store and transport. It should have sufficient capacity to handle two standard size bee frames. It is known that the viscosity of honey is highly sensitive to heat and that the addition of heat might simplify the extraction process considerably. The concept should therefore have the ability to incorporate natural irradiation from the sun. To prevent damage to the wax, however, the amount of irradiation should be controllable.
The concept should be designed, constructed and shown to operate using a mock-up set-up if original bee frames are not available.

High voltage resistors for impulse testing application

Reference	: JCB2
Supervisor	: Mr Nelius Bekker
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
Impulse generators are used in industry to test electrical equipment, i.e. transformers, surge protective devices, etc., to establish their response to, or ability to withstand, the effects of lightning strikes. Respective standards require different impulse waveshapes to test the respective equipment and characteristics. The waveshape of the impulse is adjusted by changing the resistance in the electrical circuit, i.e. the rise-time and the tail time resistors. These resistors need to be able to endure exposer to high voltages and currents. You are tasked with researching, designing, constructing and testing high voltage resistors for impulse testing applications.

PV maximum power point tracking battery charger

Reference	: JBK1
Supervisor	: Dr Johan Beukes
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
In the current state of the power system in South Africa, there is a growing need for energy storage systems that can be used with renewable power generation. A PV battery charger is a high cost component in such a system and is often not reliable. Development in this area is therefore required. A buck converter needs to be designed built and tested that will convert voltage between 60 and 100 V to a nominal voltage of 48 V to charge lead acid batteries from a PV array. The power rating will be 1 kW. The device will be controlled by a DSP and a maximum power tracking algorithm will be implemented. A basic battery charging algorithm will also be implemented.

Integrated automatic target range measurement system using a Vector Network Analyzer

Reference	: LGROOT1
Supervisor	: Mr Lanche Grootboom
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
This project involves the design and implementation of a data measuring system consisting of a computer, Vector Network Analyser (VNA) and antennas to measure a scene which contains a target. The VNA will caputre data live and stream this to the computer where range profile plots are to be generated. These range profile plots will/must indicate the distance between the antennas of the the VNA measuring device and the target in the scene. This range profile plot must be updated live so that if the target moves within the scene, it's range location on the range profile plot can be observed as changing.

Smartphone application for sorting hand-written tests

Reference	: JCS1
Supervisor	: Mr JC Schoeman
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
At the Faculty of Engineering, some undergraduate modules have more than one class group due to large numbers of enrolled students. After test week, hundreds of tests need to be handed back to the students, which is often a logistical challenge. The aim of this topic is to develop a mobile application that can scan the front covers of the tests and display the corresponding class groups in real time. The system will need to perform image processing to extract information such as the student numbers and will need to query an editable database containing the matching class groups.

Geyser energy saving controller

Reference	: WS1
Supervisor	: Mr Willem Smit
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
This project will use a Siemens PLC to intelligently control the water temperarture of a geyser. The idea is to monitor hot water consumption and then use those time of use patterns to identify timeslots wherein it will be acceptable to not reheat the geyser when there is an inflow of cold water. The controller should also identify error conditions such as a broken thermostat, dry geyser or a slow water leak. The comntroller software should be designed in such a way that the system is inherently safe and from a software point of view be able to endure exteded loadshedding.

Navigation and Control of an unmanned surface vessel

Reference	: JV1
Supervisor	: A/Prof Jaco Versfeld
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
Unmanned surface vessels have many uses. In South Africa, there is a need to equip an unmanned surface vessel with acoustic sensors to detect whales and dolphins. However, usvs can be used in commercial, fishing and defence applications. The purpose of this project is to design. implement and test the navigation and control algorithms of an unmanned surface vessel. To this end, we acquired a small 2 man boat, with two thrusters (http://diamondynamics.com/en/sxtjq/qjsjgtjq/24.html).
The project is to be done in two phases. The first is to design controls so that the boat can be operated as a human-operated e-boat. This will require that the appropriate controllers is designed to control the thrusters (using PWM signals). Safety is also a main concern, so all aspects should take this into consideration.
The second phase of the project is to develop algorithms for autonomous navigation of the boat. GPS sensors should be used as input, and the appropriate navigation algorithms should be designed, implemented and tested.
If time allows, we can consider adding solar energy to the boat. Advanced sensors can also be designed to detect hazards. Real-time communications to and from the boat can also be considered.

Segmenting objects in stereo images using statistical machine learning techniques

Reference	: CVD1
Supervisor	: Dr Corné van Daalen
Can be completed in first semester	: Yes
Student already assigned	: None
Direction	: Mechatronic
Required elective	: None

Description:
Any mobile robot that should intelligently interact with its environment must be able to understand its surroundings, and to do this, it needs to distinguish different objects in its observations. The goal of this project is to take images captured by stereo cameras on a mobile robot and segment the objects in these images (i.e., it should group all pixels belonging to the same object together).
The idea of the project is to first partition the images into superpixels (regions with similar pixels), and then to group the superpixels belonging to the same object together. In order to group superpixels, one can use several relationships: superpixels belonging to the same object typically appear similar (i.t.o. colour and texture), neighbouring superpixels belonging to different objects typically have a well-defined edge between them, and superpixels belonging to the same object are at similar distances from the cameras (the distance from the camera can be extracted from stereo images); however, all these relationships are not always present. A technique used to model and reason about such uncertain relationships is called probabilistic graphical models (PGMs). The idea is to use PGMs to combine these relationships to infer (or determine) the superpixel grouping.
The work on this project involves mastering PGM and image processing concepts, designing a PGM to solve the problem, implementing it in code (a C++ PGM library is available), and testing it on stereo image datasets taken by mobile robots. This topic would be suited to a student interested in statistical machine learning techniques applied to image processing and who is not afraid of probability theory or programming.