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.

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.

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.