Semester 7 and BeCreative projects

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PREFACE

THIS book contains all the projects offered in Distributed Sensor Systems (DSS) for engineering students. In general, DSS has large projects, which we have divided into smaller projects that are suitable for approximately four students..

(June 20, 2023) CHRIS LEE

CONTENTS

Chapter 1

Battery management sytems (BMS) & modeling

CONTENTS

INTRODUCTION

THE urgency posed by global warming to transform our fossil fuel-dependent society into one based on intermittent renewable energy sources (such as solar and wind) creates grand technological challenges. A major one is energy storage, which is key to stationary applications as well as for mobility. Electricity storage in batteries is widely acknowledged as the answer to light- and medium-weight transport and provides solutions also for medium-scale short and medium term stationary storage. However, massive usage and adoption of batteries are hampered by problems associated with the present battery technologies, such as high battery weight, short lifetime, long charging time and limited safety.

The BatteryNL consortium, specifically building on Dutch scientific and technological strength to overcome a key hurdle for more efficient next generation batteries, strongly believes that it is urgent and well-timed to address these issues. With the growing demand in Europe for renewable electricity

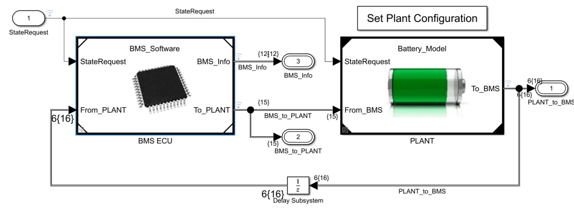

Figure 1.1 Matlab/Simulink's standard BMS model

and its storage, further delay in addressing the limitations in the current Li-ion battery technology will widen even more the gap between Europe and Asia, leaving unique opportunities unexplored for next-generation batteries with enhanced performance.

Fontys Engineering's role in BatteryNL is in the development and optimisation of battery management systems (BMS). We will create a generic model for the development of a battery management system (BMS) so as to increase safety of individual cells and battery packs for the implementation in consumer electronics, electric vehicles and utilities. This will take place in close interaction with the rest of the consortium—especially Hogeschool Rotterdam and TU-Delft—as these aspects depend in detail on the battery assembly and material design, where post-mortem analysis can bring up important aspects for improvements, as well as important input parameters for the development and validation of the model, test cells and BMS.

Objectives

- Identify the relevant safety issues related to Li-ion batteries.
- Create a generic model to be used for the development of a BMS.
- Translate kinetic data from consortium partners into the BMS model.
- Develop the electronics for the BMS.
- Analyse commercial batteries and project cells for input data for the above objectives as well as for the validation of those.

Fontys Battery Research

Our aim is to develop a chemistry flexible BMS that creates optimal charge and discharge conditions for commercial and project systems, both on cell and pack level. This research inherently includes work on safe operation of these batteries.

BMS development strongly depends on simulation models of the target battery cells, battery pack and the BMS itself. In addition to adequate modelling of the battery pack and BMS, acquiring hands-on experience with related hardware is needed for e.g. model validation and the verification of research outcomes using actual systems.

We plan to starting three student projects in September 2023:

- Investigation of existing battery cell and pack simulation models (focus on Matlab / Simulink)
- Investigation of existing BMS models (focus on Matlab / Simulink)
- Investigation of existing hardware for BMS development

These are Semester projects, that are expected to be continued for several subsequent semesters.

1.1

Battery cell and battery pack simulation models

Company Details		Fontys Engineering Details	
Company	Various	Project duration	20 Weeks
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Required Students							
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Table 1.1 Project Organisation

BACKGROUND

Batteries and battery packs can modelled at many different scales: from the chemical reactions at the electrodes, through to highly abstracted performance models. Each of the published approaches has advantages and disadvantages, depending on what information is required. However, one disadvantage of the current modeling approach is that each battery pack and chemistry requires a different model, and, as a result battery management systems require tuned models for specific packs and chemistry.

Creating a generic model that can be used for many different packs, chemistry, and loads would shorten development times and reduce costs.

OVERALL GOALS & CURRENT STATUS

The batteryNL project has just started. In order to model a BMS, we require inputs that correspond to the load and the battery. However, models for these are not general. Thus, every new battery requires a new model. The end goal of this theme is to develop a more abstract model that can cope with different pack geometries and different chemistry without directly modelling the chemical interactions. Project approach:

- Investigate existing state-of-the-art battery simulation models
  - At battery cell level
  - At battery pack level
  - Including safety aspects
- Investigate model requirements of the new developments
- Gap analysis between existing models and future requirements
- Extension of models and/or development of new models

YOUR GOALS

During your time in this project, you must develop an understanding of existing state-of-the-art battery simulation models, and identify a way to make the models more generic. A rough implementation of the model should be created and tested against a commercial cell under a fixed load. The following deliverables are expected

- Research report on
  - Findings on existing state-of-the-art simulation models
  - Requirements of future simulation models
  - Gap analysis
  - Recommendations for new or extended simulation models
- An executable simulation model for simulating existing battery packs
- A new or extended simulation model that supports future requirements

Initial task (starting September 2023):

- Investigate existing state-of-the-art simulation models in Matlab/Simulink
  - At battery cell level
  - At battery pack level

Suggested follow-up tasks (may change based on initial findings):

- Investigate simulation tools: e.g. Comsol or Python.
- Study the effect of charging and discharging rates on SOC, SOH, lifetime
- Study the effect of temperature on SOC, SOH, lifetime

SUPPORT

Since this project is part of the Dutch Battery research project BatteryNL, additional budget and support are available. You will have access to experts from the Centre of Expertise HRTech of the Hogeschool Rotterdam (HR) to discuss technical findings and engineering choices to be made. They have a battery testing setup that allows validation of battery models against actual battery performance. You will also be in contact with fellow students from HR who are working on a battery related project.

1.2

Battery Management System (BMS) simulation models

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Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 0	BeCreative: 5

Table 1.2 Project Organisation

BACKGROUND

The key to battery powered devices lies in the battery management system (BMS). At present, hardware is often customized, depending on the pack configuration and the battery chemistry. On top of that, the software, which depends on the models discussed in Section 1.1, is also often customised.

NXP is in the process of developing a software defined BMS. The generic hardware is intended to be appropriate for a wide range of pack configurations and battery chemistry types. The software must be smart enough to adapt a generic model to the specific application.

However, a software defined BMS requires a good model of BMS functionality. This model must be abstract enough to not depend on hardware implementation, while also being detailed enough to provide optimal charge/discharge for a wide range of battery packs and loads.

OVERALL GOALS & CURRENT STATUS

The batteryNL project has just started. In order to model a BMS, we need a better understanding of the state-of-the-art of BMS technology, modeling, and simulation.

YOUR GOALS

In this project, your goals will be perform research on state-of-the art BMS models. You will identify the barriers to creating an adaptable model, and the requirements for an adaptable BMS model. You will begin to develop an adaptable BMS model.

The expected deliverables are:

- Research report that document the current state-of-the-art, future requirements, presents a gap analysis
- An executable simulation model for simulating existing BMS
- A new or extended simulation model that supports future requirements

SUPPORT

Since this project is part of the Dutch Battery research project BatteryNL, additional budget and support are available. You will have access to experts from the Centre of Expertise HRTech of the Hogeschool Rotterdam (HR) to discuss technical findings and engineering choices to be made. They have a battery testing setup that allows validation of battery models against actual battery performance. You will also be in contact with fellow students from HR who are working on a battery related project.

1.3

Design and testing of hardware for BMS development

Company Details		Fontys Engineering Details	
Company	Various	Project duration	20 Weeks
Contact Person	See BNL documents	Fontys Coach	Harold Benten
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Required Students			
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Table 1.3 Project Organisation

BACKGROUND

Battery management system (BMS) testing can be quite hazardous. Modern batteries store a lot of energy, and, if they catch fire, can be difficult to extinguish. On the other hand, an insufficiently tested BMS respresents a hazard to users and the environment.

The solution is to emulate the battery and the load, so that testing can be completed under a wide range of conditions without taking excessive risks.

OVERALL GOALS & CURRENT STATUS

The batteryNL project has just started. In order to develop the hardware of a BMS, we first require a flexible battery emulator that behaves like an actual battery but is safe under conditions outside the 'normal' operating conditions. The goal of this project is to design, realize and test such a battery emulator. The next step is to use the outcomes of the modelling projects to develop circuits for a hardware implementation of a flexible BMS.

YOUR GOALS

In this project, your goals will be to design a programmable hardware system that presents the BMS with a “battery” and a “load.” The hardware system should, in the first iteration, be able to emulate a battery with a specific lithium-ion chemistry and capacity. However, the hardware should be flexible enough to require only software changes to emulate a battery with a different chemistry, a different capacity, and a different cell topology.

Likewise, it should be possible to emulate different loads: from electronics through to motors under varying load.

The main deliverables are:

- Tested prototype of a battery emulator circuit.
- Research report on existing hardware emulators, and the requirements for future emulators

SUPPORT

Since this project is part of the Dutch Battery research project BatteryNL, additional budget and support are available. You will have access to experts from the Centre of Expertise HRTech of the Hogeschool Rotterdam (HR) to discuss technical findings and engineering choices to be made. They have a battery testing setup that allows validation of battery models against actual battery performance. You will also be in contact with fellow students from HR who are working on a battery related project.

Chapter 2

Electronic devices for physiotherapy and orthotics

CONTENTS

INTRODUCTION

PHYSIOTHERAPY and orthotics (the design of custom shoes and insets) remains a labour intensive healthcare intervention. In both physiotherapy and orthotics, the practitioners do not have many diagnostic or treatment aids to help them. The upshot is that orthotics does not take an evidence-based approach to treatment, while physiotherapy only has limited evidence-based practice.

It should be noted that it is not that the practitioners are unwilling to take an evidence-based approach, but that the existing evidence is both sparse and equivocal, meaning that it is difficult to derive best-practice from the data. Thus, a long-standing goal is to develop devices that can measure and quantify practices that are currently not measured or quantified.

Furthermore, both practices are highly personalised: revalidation after a stroke or other serious injury requires constant supervision. This is not only expensive, it also limits the quality of care. For instance, in large countries with a limited health care system, clients may have to travel extensively for

Figure 2.2 Position sensing smart glove used to map the shape of a foot.

treatment. This problem was brought home by the pandemic, during which home therapy with remote supervision became necessary. Although the success of remote supervision was limited, it may be substantially improved if clients are supplied with assistive devices.

2.4

Effort estimation for hand revalidation

<table>
<tr><th colspan="4">Company Details</th><th colspan="4">Fontys Engineering Details</th></tr>
<tr><td colspan="2">Company</td><td colspan="2">Fontys Paramedical School</td><td colspan="2">Project duration</td><td colspan="2">20 Weeks</td></tr>
<tr><td colspan="2">Contact Person</td><td colspan="2">Fred Holtkamp</td><td colspan="2">Fontys Coach</td><td colspan="2">Qin Zhou</td></tr>
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<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">Research support</td><td colspan="2">Liz Gonzalez Carabarin</td></tr>
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<tr><th colspan="8">Required Students</th></tr>
<tr><td>Elec. Sys.:</td><td>2</td><td>Emb. Sys:</td><td>2</td><td>Inn. Eng.:</td><td>0</td><td>BeCreative:</td><td>5</td></tr>
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Table 2.1 Project Organisation

BACKGROUND

During the pandemic, a lot of physiotherapy was performed via video call. However, it was very difficult to determine if the client was doing the exercise correctly.

- Exercise form and execution difficult to judge
- Client effort and fatigue difficult to judge
- No indication of pain and/or over extension

OVERALL GOALS & CURRENT STATUS

Resistive training devices with electronic feedback are not new (you will find them in every gym). However, here we aim to develop specialised devices for physiotherapy that address the issues raised above. The first target is specifically hand revalidation.

Currently, Fontys paramedical school (FPH) is investigating several commercial virtual reality devices with a view to modifying existing hardware. However, it is expected that unique hardware and software will have to be used to optimise the revalidation process.

Electrical engineering has previously worked on a glove-based hand revalidation tool. Prototype hardware and software are available from that project. A team from mechatronics will continue the development of the resistive training hardware.

A second electrical engineering project, related to muscle activation for the resistive training device will also be working in parallel. **It is important that all three projects result in compatible modules.**

YOUR GOALS

This team will develop the effort sensing hardware and software to quantify the amount of effort that the client is exerting.

You will need to perform literature research to determine which physiological parameters are (a) related to effort and (b) most appropriate to measure. You should then develop a prototype sensor system that will allow you to measure the chosen parameters.

It is important that the physiotherapist gets a measure of “effort” and not just the raw data. Indeed, for an independent device, the measure of effort will be used as a control signal. Thus, a model that translates between raw data and measure of effort must be developed

The Fontys team is expected to develop the following:

- Prototype sensor system for effort measurement
- A model linking raw data to a general “effort” scale
- A research report summarizing the literature research
- A summary project report
- Design documents

SUPPORT

FPH will provide expertise, and there is additional budget available.

2.5
Muscle activation sensing for hand revalidation

Company Details		Fontys Engineering Details	
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Required Students			
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Table 2.2 Project Organisation

BACKGROUND

A resistive trainer that is responsive to physical movement and effort of the client requires a set of sensors and a software stack that can accurately interpret the sensor data and feed a signal back to the mechanical hardware. Thus, the system must be able to do the following:

- Detect muscle activation
- Correctly interpret the type of activation (e.g., fist clenching or unclenching)
- Estimate strength of muscle activation and provide feedback signal

OVERALL GOALS & CURRENT STATUS

Resistive training devices with electronic feedback are not new (you will find them in every gym). However, here we aim to develop specialised devices for physiotherapy that address the issues raised above. The first target is specifically hand revalidation.

Currently, Fontys paramedical school (FPH) is investigating several commercial virtual reality devices with a view to modifying existing hardware. However, it is expected that unique hardware and software will have to be used to optimise the revalidation process.

Electrical engineering has previously worked on a glove-based hand revalidation tool. Prototype hardware and software are available from that project. A team from mechatronics will continue the development of the resistive training hardware.

A second electrical engineering project, related to effort estimation will also be working in parallel. **It is important that all three projects result in compatible modules.**

YOUR GOALS

This team will develop the muscle activation sensing and hardware and software. In the end, this should provide real-time feedback to the mechanical hardware so that the force vs extension curve takes into account the actions of the user.

You will need to develop/implement an electromyography sensor system (or an alternative with similar functionality) to detect muscle and nerve activity. You will need to develop a model to interpret the data and and output a control signal. This will require significant research.

You are expected to develop the following:

- Prototype sensor system for muscle activation
- A model that interprets muscle activation
- A control signal for use by the mechanical hardware team
- A research report on the model and sensing research
- A summary project report
- Design documents

SUPPORT

FPH will provide expertise, and there is additional budget available.

2.6

Hand and finger tracking for orthotic footwear design

Company Details		Fontys Engineering Details	
Company	Fontys Paramedical School	Project duration	20 Weeks
Contact Person	Fred Holtkamp	Fontys Coach	Chris Lee
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		Research support	Liz Gonzalez Carabarin
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Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 0	BeCreative: 5

Table 2.3 Project Organisation

BACKGROUND

At present, orthopedic footwear is designed on the basis of the experience and feel of the clinician who diagnoses the patient. However, approximately 20% of all orthopedic footwear fails to meet the patient's needs. It is believed that this is because the clinician is operating in a data-poor environment. Our aim is to bring evidence-based medicine to the orthopedic clinic.

The smart scan project aims to extract data during diagnosis. In this case, diagnosis is carried out by the clinician feeling and manipulating the patient's foot and/or leg. The clinician uses this to estimate where the tissue is hard or soft and what shape of footwear is required to correct the patient's foot. This feel is combined with a plaster cast to which the clinician must then apply their adjustments.

OVERALL GOALS & CURRENT STATUS

The smart scan project aims to record, as exactly as possible, the manipulation during diagnosis. The position of the hands and the fingers must be tracked, the motion of the foot and leg during manipulation must be recorded, and, when the foot is pressed into the corrected shape, that too must be recorded.

Currently, a prototype glove with wired sensors and (wireless) pressure sensors has been developed. The software to select relevant data (e.g., only data from when the hand is touching the foot) has been developed. A plugin system that allows the user to implement their own data processing has been implemented. And, the data can be exported for viewing in a CAD program.

Thus, the initial project goals have been met, and the client is able to use the glove to collect real clinical data. However, using wired sensors make the glove a fragile, user unfriendly device

YOUR GOALS

You will investigate the possibility of replacing the wired sensors with wireless sensors. The current sensors provide absolute position data, making it simple to keep track of location. There are no direct replacements for these sensors. Instead, one must consider a combination of different sensor types–cameras, combined with inertial motion sensors, for instance.

You are expected to do the following:

- Exhaustive investigation into wireless position sensors and algorithms
- A prototype glove
- **Quantitative** accuracy comparisons between new system and existing system

SUPPORT

FPH will provide expertise and access to the protoype. We are currently applying for funding for this project, thus, it is possible that the budget will increase later in the project. It is, however, more likely that the money will not arrive until the spring semester starts.

Chapter 3

eBike innovations

CONTENTS

INTRODUCTION

Until 2010, all electric bicycles were driving using hub motor. In 2010, Bosch introduced the mid-motor, which became the standard on more expensive bikes in Europe. In 2020, the popularity of the hub motor started to increase again, mainly due to appearance and cost.

The current IDbike controller solution targets hub drive systems. However, IDbike aims to generalise their controller so that it can also drive mid motors. This development is enabled by open source technologies, which IDbike both contributes to and benefits from. Our goal is to expand open source technologies so that services, such as cloud connectivity, and ride customisation are standardised and readily implementable by all bike companies.

This development is happening concurrently with an economic and security environment that makes manufacturing in Europe more attractive. As a result, bicycle manufacturers are returning production to Europe and will need components with short delivery times produced in Europe. IDbike intends to be well-positioned to participate in this emerging market. Aside from economic changes and cost-reducing standardisation, safety is also an increasing concern for eBike manufacturers. The number of bike accidents is growing fast, and the potential for injury from a bike accident is also increasing. Thus, bike manufacturers are looking for ways to enhance safety. More flexible and standardized controllers may enable more safety features.

With this in mind, we offer the following project for either semester 7 or BeCreative students.

Figure 3.3 Will the rider make it home on battery power?

3.7 Development and Production of an open source Vesc controller

Company Details		Fontys Engineering Details	
Company	IDbike	Project duration	20 Weeks
Contact Person	Bas d'Herripon	Fontys Coach	Harold Benten
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			c.lee@fontys.nl

Required Students							
Elec. Sys.:	2	Emb. Sys:	2	Inn. Eng.:	0	BeCreative:	5

Table 3.1 Project Organisation

BACKGROUND

Development and production of an Open Source VESC controller for electric bicycles and software, with interfacing possibilities to other road users, traffic systems and Artificial Intelligence functionality, directly or via the cloud.

- eBike manufacturers use various drive systems with fixed riding characteristics. They can't adapt the riding experience to their specific needs.
- Most of the drive system manufacturers are working on cloud connection, but there is no standardisation.
- Bike manufacturers have to test different systems and make a choice. There is no possibility to fine tune the system.
- Most systems are currently produced in Asia, with long lead times, transport costs, and supply insecurity.
- The production costs of electric bikes are too high.

The development of an open source VESC controller has several advantages that will partially address the problems noted above. It will significantly enhance the safety and comfort of the cyclist. Bike manufacturers will have more control and flexibility to customise bike performance to their riders. The open-source aspect will result in faster future hardware and software development.

OVERALL GOALS & CURRENT STATUS

IDbike intends to offer a system with riding software with maximal flexibility and connectivity. It will include data acquisition to test and optimise the riding experience. It also will provide a connection for a standardised cloud solution. The standardized cloud solution will allow, for example, apps integration, and Geofencing and Connection to traffic light systems. Manufacturers will be able to change the software and add functionality in the future.

The hardware will be compatible with mid-motor and hub motors, simplifying the design process.

IDbike and collaborators have already started development, and the following has been achieved

- A prototype controller has been developed, based on an existing VESC controller.
- The basic software has been developed, including IDbike's riding software
- About 100 controllers have been build as prototype, of which 50 pieces are being tested in Spiked' eBikes.
- Prototypes are being tested by Wattworld, Brompton, Infinite, Fulpra, Anywhere Berlin and Boreal Berlin

- A data acquisition system has been set up for testing, evaluation, and optimisation
- The geo-fencing functionality has been tested in cooperation with the city of Tilburg.

YOUR GOALS

The Fontys team will work together with engineers from IDbike, Monotch (Cloud environment), and Boreal Bikes (AI functionality). Your main contact will be Bas d'Herripon (IDbike) and we expect that the student team will spend between a quarter and half their time at IDbike.

The Fontys team is expected to develop the following:

- Prototype Vesc improved and footprint reduced to acceptable size
- Prototype tested in stationary bike setup
- Open specification for standardized cloud connectivity

SUPPORT

IDbike will provide the following support and service:

- budget for Vesc PCB & other hardware/software

Chapter 4

Thermal battery management & control

CONTENTS

INTRODUCTION

THERMAL batteries are designed to store and release heat over long periods of time in a controllable way. A household battery is intended to form part of a combined central heating system, allowing users to charge their thermal batteries via a heat pump when energy is cheap, and solar energy when the sun is out.

It is also intended that thermal batteries can be modularized. In this form, a large battery stores heat for a neighbourhood (∼50 houses). The storage material, a salt, is transported to and from nearby industrial centers, where they can be recharged from the waste heat. The waste heat from industrial processes in the Netherlands is large enough to provide domestic heating for the whole country.

Our task is to provide sensors to measure the charge state of the thermal battery, and to develop a control system so that heat can be discharged in a controllable way. Finally, a friendly and informative user interface needs to be developed so that homeowners can easily control the use of their thermal battery.

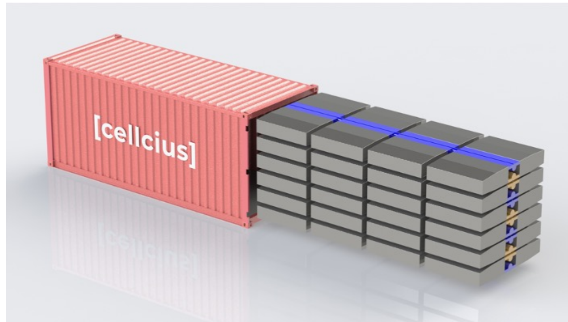

Figure 4.4 Neighbourhood thermal battery concept. One battery can provide heating to ∼50 houses

4.8
Development of setup for accelerated sensor lifetime testing

Company Details		Fontys Engineering Details	
Company	IDBike	Project duration	20 Weeks
Contact Person	Bas d'Herripon	Fontys Coach	Harold Benten
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Required Students							
Elec. Sys.:	2	Emb. Sys:	2	Inn. Eng.:	0	BeCreative:	5

Table 4.1 Project Organisation

BACKGROUND

Development and production of an Open Source VESC controller for electric bicycles and software, with interfacing possibilities to other road users, traffic systems and Artificial Intelligence functionality, directly or via the cloud.

- Ebike manufacturers use various drive systems with fixed riding characteristics. They can't adapt the riding experience to their specific needs.
- Most of the drive system manufacturers are working on cloud connection, but there is no standardisation.

- Bike manufacturers have to test different systems and make a choice. There is no possibility to fine tune the system.
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OVERALL GOALS & CURRENT STATUS

iDBike intends to offer a system with riding software with maximal flexibility and connectivity. It will include data acquisition to test and optimise the riding experience. It also will provide a connection for a standardised cloud solution. The standardized cloud solution will allow, for example, apps integration, and Geofencing and Connection to traffic light systems. Manufacturers will be able to change the software and add functionality in the future.

The hardware will be compatible with mid-motor and hub motors, simplifying the design process.

IDBike and collaborators have already started development, and the following has been achieved

- A prototype controller has been developed, based on an existing VESC controller.
- The basic software has been developed, including IDBike's riding software
- About 100 controllers have been build as prototype, of which 50 pieces are being tested in Spiked' eBikes.
- Prototypes are being tested by Wattworld, Brompton, Infinite, Fulpra, Anywhere Berlin and Boreal Berlin
- A data acquisition system has been set up for testing, evaluation, and optimisation
- The geo-fencing functionality has been tested in cooperation with the city of Tilburg.

YOUR GOALS

The Fontys team will work together with engineers from IDbike, Monotch (Cloud environment), and Boreal Bikes (AI functionality). Your main contact will be Bas d'Herripon (IDBike) and we expect that the student team will spend between a quarter and half their time at IDBike.

The Fontys team is expected to develop the following:

- Prototype Vesc improved and footprint reduced to acceptable size
- Prototype tested in stationary bike setup
- Open specification for standardized cloud connectivity

SUPPORT

IDBike will provide the following support and service:

- on location work place for students
- active support for hardware and software development
- budget for Vesc PCB & other hardware/software

4.9
Capacitive sensors for thermal battery management

Company Details		Fontys Engineering Details	
Company	Cellcius	Project duration	20 Weeks
Contact Person	Pim Donkers	Fontys Coach	Ralph Goes
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Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 0	BeCreative: 5

Table 4.2 Project Organisation

BACKGROUND

Applied physics has developed a capacitive sensor to directly sense the state of charge of a thermal battery. The sensor forms part of an oscillator, and the change in resonance frequency is measured to determine the state of charge of the thermal battery.

The basic system has been developed, but the applied physics students do not have the right knowledge and skills to complete the work.

OVERALL GOALS & CURRENT STATUS

In developing the sensor system for the thermal battery, we had two goals. One was to develop an effective sensor, and the second was to show that the sensor might be reasonably expected to last for five years.

We have developed one sensor system that has been verified to work. This sensor measures the input and output relative humidty and temperature. From this data, a simple model can be used to calculate the state of charge of the battery. The sensors seem to be robust against noise and integration errors. However, we have not performed life-time tests. Thus, we cannot be sure that the sensor system will meet the life-time requirements.

The capacitive sensor, developed in applied physics, represents an alternative. In the end, the choice will come down to accuracy, life-time, and cost. Thus, we need to complete the development of the capacitive sensor in order to perform a fair comparison.

Thus, one project will focus on creating a life-time testing set up, and this project will complete the development of the sensor described above.

YOUR GOALS

The Fontys team will work together with students from applied physics and engineers from Cellcius to complete the development of the capacitive sensor. The sensor system should be robust, with the electronics protected against the environment.

The Fontys team is expected to develop the following:

- A pre-production prototype sensor that fits within the volume specified by the client
- Calibration measurements and a calibration
- A report on the sensor design with full design documents
- real test data from Cellcius' test set up
- a comparison (and recommendation) between the two sensor modalities

SUPPORT

Cellcius and Applied Physics will provide the following support and service:

- Applied Physics will provide a group of students and guidance to help complete the calibration
- Cellcius will provide access to a test set up
- Cellcius will provide expertise on the sensor mechanical requirements

Chapter 5

Fusion plasma sensing & control

CONTENTS

INTRODUCTION

Fusion energy makes use of nuclear fusion (the combining of two nuclei to create a heavier nuclei) to generate energy. The sun, which provides all our energy, is powered by fusing hydrogen ions to create helium. On Earth, controlled fusion is regularly achieved in the lab, but only at the *cost* of enormous amounts of energy. A fusion reaction that generated more energy than it uses is expected to be achieved in the ITER tokamak, and will be followed by DEMO. DEMO is being designed to generate energy.

One of the many unsolved engineering problems on the road from ITER to DEMO is sensing. DEMO will have far more limited access for current sensor technology, and new sensing modalities will have to be developed. Our current focus is developing sensors for the diverter.

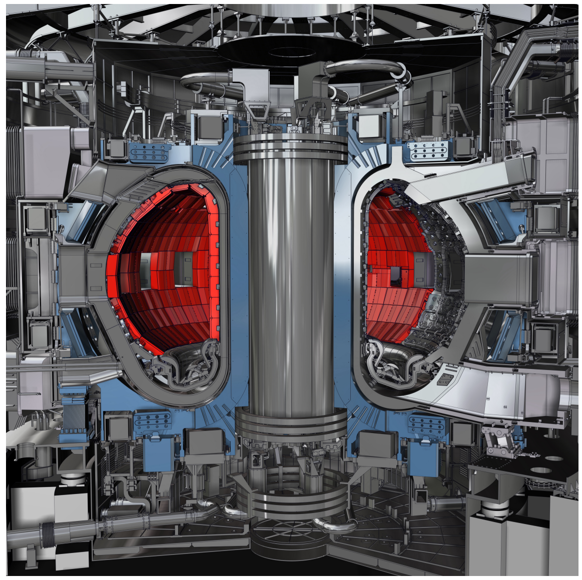

Figure 5.5 ITER: a tokamak fusion reactor under construction in the south of France.

5.10

Radar system for plasma boundary detection

Company Details		**Fontys Engineering Details**	
Company	DIFFER	Project duration	20 Weeks
Contact Person	Marco de Baar	Fontys Coach	Chris Lee
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		Research support	TBD
			TBD
Required Students			
Elec. Sys.: 3	Emb. Sys: 1	Inn. Eng.: 0	BeCreative: 5

Table 5.1 Project Organisation

BACKGROUND

The diverter is a part of the tokamak where the fusion plasma is allowed to interact with the wall. The confining magnetic field of a tokamak is such that charged particles will escape to the wall. If uncontrolled, the particle flux and energy will destroy the wall material. Hence, the diverter is designed from materials (tungsten monoblocks) that are resistant to high heat loads, while active control of the plasma-surface interaction keeps the energy load within the limits of the tungsten monoblocks.

Active control of the plasma-surface interaction is achieved through neutralisation and collisional cooling. The electron density of the plasma is expected to have a rather flat profile (1019 /m3) that decreases sharply at the boundary. A neutral hydrogen gas collisionally cools the plasma to keep the heat load on the diverter wall manageable.

To ensure that the gas impinging on the diverter is within safe limits, the following parameters should be measured: the temperature gradient, and mechanical deformation of the monoblock, the distance from the diverter surface to the plasma edge, and the temperature and density of the neutral gas between the diverter and the plasma. It is our goal to develop microwave imaging and spectroscopy sensors to measure each of these parameters.

Access to the environment around the diverter, however, is extremely limited, making it difficult to place sensors. In addition, the harsh environment will destroy most materials, meaning that the sensor must be a part of the monoblock. Thus, the challenge is to identify sensor modalities that are compatible with the current monoblock design. Furthermore, the sensor and its signal conditioning must be able to cope with the immense electromagnetic noise generated by the plasma and associated wall currents.

OVERALL GOALS & CURRENT STATUS

Our current approach is to build a radar system that reflects of the plasma boundary (similar to the way short wave radio signal reflect off the ionosphere). We have designed a proof of principle radar system, based on a low frequency ($\sim$1-6 GHz) software defined radio (SDR) system. The radar measures the phase and frequency shift of the return signal to determine speed and relative position.

In general, it has been discovered that the chosen SDR is unsuitable for this application for two reasons: the frequency is too low and the frequency stability is poor. As a result, the measured distance is often inaccurate. Furthermore, several limitation of GNURadio were discovered, which should be taken into account in future work.

The second part of the project is to design a method to inject the microwave signal into the diverter (through the monoblocks). A surface waveguide has been designed, modelled in COMSOL, and printed in stainless steel. At the time of writing this guide, we hope to characterise the printed waveguide, both in terms of print quality and whether it works as a waveguide.

YOUR GOALS

In this project, our initial goal is to change the operational frequency to ∼70 GHz. There are two options available: automotive radar from suppliers such as NXP, and backward wave oscillators that are available at DIFFER. The NXP devices are all controlled via an embedded system, and it is, as yet, unknown if the system provides enough control to change the way the radar operates.

It will be important for you to understand the basic principles of operation of different types of radar and interferometry systems. You should also build up a basic understanding of plasmas and how radar signals are transmitted and reflected by them.

Thus, you will need to familarize yourself with high frequency radar technology. Some of you will need to develop an understanding of wave propagation, interference, and impedance matching. For the NXP devices, you must be prepared to learn a new embedded system, and to be open to calling NXP support to ask questions. At the end of the project, the following should be achieved

- A microwave reflectometer at the target frequency
- Tests in a non-plasma environment
- A research paper on radar options
- A research paper that leads to requirements and specifications for the radar
- (if applicable) waveguide tests and comparison to model results

SUPPORT

DIFFER will provide the following support and service:

- Access to high frequency sources and measurement equipment
- Expertise in working high frequency sources
- limited budget
- Fusion and plasma expertise

We are in the process of applying for additional funding for this project. Thus, it is possible that there will be additional budget available late in the project. However, you should not depend on that.

Chapter 6

Anxiety recognition & warning system for caregivers in elderly care

CONTENTS

INTRODUCTION

PEOPLE with dementia often have difficulty communicating their feelings and needs to their caregivers. This can result in increased frustration, anxiety, and stress that is, ultimately, expressed through violent outbursts. Dealing with unexpected and sudden outbursts is also a cause of stress for caregivers and is one of the reasons for high staff turnover in the industry.

We aim to improve the quality of care and, therefore, the quality of life of people with dementia by alerting caregivers to the rise in anxiety and stress before the client becomes agitated or violent.

This project is just the first stage in a longer term ambition to develop sensing technology for a wide range of situations where communication is difficult and/or the information is subjective. Our next target is to monitor pain for hospitalized people. Pain reporting is highly subjective and is also influenced by the biases of the doctors. This can result in sub-optimal care.

Figure 6.6 Sock that measures skin conductivity.

In each case, our task is similar. First, we use scientific literature to understand how the reported qualitative symptom (pain, or anxiety in the examples above) are related to quantitative and measurable physiological parameters. We then develop a sensor system to measure the relevant parameters, and model to translate the data into a scale that represents the qualitative symptom (e.g., how anxious a person is feeling). We do this work in collaboration with a company (Mentech innovations) as well as researchers from Lieden University Medical Center, and practitioners in elderly care.

6.11

Cloud-connected Anxiety detector: hardware and software development

Company Details		**Fontys Engineering Details**	
Company	Mentech Innovations	Project duration	20 Weeks
Contact Person	Reon Smits	Fontys Coach	Chris Lee
Contact Details	reon.smits@mentechinnovations.eu		c.lee@fontys.nl
		Research support	Liz Gonzalez Carabarin
		l.gonzalezcarabarin@fontys.nl	
Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 0	BeCreative: 0

Table 6.1 Project Organisation

BACKGROUND

Mentech Innovations has developed a sensor system that, with the help of cloud-based machine learning, can recognise anxiety in people with dementia with an accuracy of about 80%. These devices measure a number of physiological parameters—heart rate and perspiration (EDA) mainly—from which the level of emotional arousal is determined. This is then translated into a stop-light based warning system that caregivers can use to provide early intervention.

The community response has been largely positive. However, the device is not accepted by all potential clients. And, the watch-like device is subject to motion artifacts and low sensitivity to changes in EDA that result in sub-optimal performance.

The development of a garment that incorporates the sensors and electronics will provide improved sensor performance. Additionally, a garment is not readily identifiable (one of the reasons for non-acceptance) as a sensor system, increasing acceptance.

OVERALL GOALS & CURRENT STATUS

Over the last two years a new sensor system, with hardware and software has been developed. The new sensor system is woven into a sock and can measure skin conductivity (directly related to perspiration) with good reliability and longevity. A new pre-processing signal processing algorithm has been developed, allowing the signal quality to be better understood and the machine learning model to be trained on a better quality data set.

The prototype, based on the new sensor and old hardware and software, is being prepared for clinical trials. However, we must still complete the development of the improved hardware and software.

YOUR GOALS

The new hardware incorporates a four probe measurement technique. The initial design has been completed, but must be tested on a (large scale) PCB and then shrunk to fit in a wearable (watch form-factor). The software for measuring the implementing the four probe measurement must be completed and incorporated with Mentech's existing software stack.

The hardware and software must be tested, both in artificial conditions with known conductances and in real-life conditions.

The Fontys team is expected to develop the following:

- Working large prototype
- Working watch form-factor prototype
- Software integrated into Mentech's stack
- Test results with analysis
- full design documents

SUPPORT

Mentech and Saxion will provide the following support and service:

- Place to perform real-life tests
- Software development support
- Sensors for testing
- Components

6.12

Localized machine learning for anxiety detection

Company Details		Fontys Engineering Details	
Company	Mentech Innovations	Project duration	20 Weeks
Contact Person	Reon Smits	Fontys Coach	Liz Gonzalez Carabarin
		l.gonzalezcarabarin@fontys.nl	
Contact Details	reon.smits@mentechinnovations.eu		c.lee@fontys.nl
		Research support	Chris Lee
			c.lee@fontys.nl
Required Students			
Elec. Sys.: 0	Emb. Sys: 4	Inn. Eng.: 0	BeCreative: 0

Table 6.2 Project Organisation

BACKGROUND

Mentech Innovations has developed a cloud based anxiety sensor (see Sec. 6.11 for more details). However, connectivity to the cloud is not always possible. furthermore, the power consumption, due to connectivity, is high compared to the cost of computation. Since it is likely that more sensors will be added, the power drain due to communication is likely to increase rather than decrease.

As a result, we would like to explore the possibility of running a simplified version of the machine learning model on local, low cost, low power hardware. By performing the bulk of processing locally, we may increase the battery lifetime of the device. More importantly, if the device cannot connect to the cloud, it will still function, and can communicate via local networks with the caregiver's device. This will allow for the development of a more robust system.

Another potential advantage is that model personalisation maybe easier to implement on local hardware than on a cloud.

OVERALL GOALS & CURRENT STATUS

At present, almost all the data processing is done in the cloud. Pre-processing is done locally (e.g., filtering), and battery lifetime is optimized by having a low data rate (indeed most IoT services have restricted message rates).

A literature search, and some preliminary work on model pruning (reducing the size of a machine learning model to fit on a system with limited resources) has been done.

YOUR GOALS

This is an exploratory project. You will be expected to learn and document the process for deploying a machine learning model on an example SoC (including making use of the on-board FPGA). You are expected to compare and document performance: power consumption, and model accuracy for a number of different model implementations and hardware configurations.

If possible, you may be able to incorporate the sensor system hardware developed by the team working on project 6.11.

The Fontys team is expected to develop the following:

- Working machine learning algorithms on low power SoCs
- Performance benchmarks on recorded data
- Full documentation of software and hardware designs
- If time allows, tests with live data inputs

SUPPORT

Mentech will provide the following support and service:

- Place to perform real-life tests
- Data sets for testing
- Models

We are currently in the process of applying for additional funding for this project. Thus it is possible, though highly unlikely, that additional budget will be available near the end of the project period.

Chapter 7

Waste & material sorting for recycling & up-cycling

CONTENTS

INTRODUCTION

Reuse, repair, recycle is a current trend in both consumer and industrial products. However, reuse and recycling requires that different "raw" materials are separated from each other. A modern consumer product is made from many different metals, plastics, and other materials (e.g., fiber glass). If the device cannot be repaired, then to reuse or recycle product must be taken apart, and the individual parts separated into different materials that can then be put through a process for reuse.

This same problem occurs at all different scales: when we manufacture a product, there are waste materials that, if we want to recycle, must be kept separate from each other. When we renovate or tear down a building, huge volumes of waste are generated, and a waste separation process must be introduced. Even household waste, and waste that is illegally dumped (and then removed) must be processed so that valuable materials can be recovered.

Unfortunately, if the separation process is unreliable, then the waste is often not recycled, but down-cycled. For instance, mixed plastic waste gets turned into traffic signs or roading material, while unmixed plastics may be reprocessed for reuse as if they were freshly produced.

Figure 7.7 Can you spot the polycarbonate? No one else can either

7.13

Sensor systems to separate plastics for recycling

Company Details		Fontys Engineering Details	
Company	Vink Plastics	Project duration	20 Weeks
Contact Person	Bas Gepkens	Fontys Coach	TBD
Contact Details bas.gepkens@nl.vink.com			TBD
		Research support	Chris Lee
			c.lee@fontys.nl
Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 6	BeCreative: 5

Table 7.1 Project Organisation

BACKGROUND

Plastic is one of the greatest forms of waste. Even when it is recycled, it is often “down cycled” from high value, long lived products to low value, short lived products. This is because each plastic type requires its own recycling process, thus, a small amount of contamination can result in strong reduction in desirable properties, such as strength.

Vink is an industrial plastics distributor. Companies, such as ASML, purchase plastic from Vink, process it into their products, and return the waste plastic to Vink. By obtaining agreement between end user, and suppliers, such as Mitsibushi chemicals, Vink has set up a circular supply chain, where the end user agrees to sort the waste plastics on site. Vink delivers the sorted plastics to a third party that reworks the plastic back into the original product (often plastic sheets). Because the plastic is well sorted, the reworked product has properties that are indistinguishable from plastic that has not gone through the recycling process.

Vink faces a number of challenges, but for this project, we want to focus on a single part of the process. Vink, in partnership with the Circular Plastics Factory, have a process for fully recyclying polycarbonate. Polycarbonate is often used in place of glass: it is very strong, and highly transparent. But, polycarbonate also scratches easily (compared to glass). To prevent scratches, polycarbonate is often coated with an anti-scratch layer. This layer is impossible to directly see, and is enough to contaminate the recycling process.

At the moment, the Circular Plastics Factory will only recycle polycarbonate that has a protective film (the same type of film that is placed on appliances to protect from damage) that contains information about the coating. If the end user has removed the entire protective film from a sheet, that plastic cannot be recycled into a new polycarbonate sheet and must be downcycled.

OVERALL GOALS & CURRENT STATUS

Our job is to develop an industrialised measurement system prototype that can detect the presence of the anti-scratch layer. A team of students in the BeCreative minor have identified two relatively simple methods to distinguish polycarbonate with and without a hard coating.

- The reflectivity of polycarbonate in the near UV and in the green is different for polycarbonate with and without the coating (it is also different in other areas of the spectrum, but these are the largest differences)

- When the hard coating is scratched, it looks and sounds different to uncoated (or UV coated) polycarbonate.

Both of these methods are being tested under a range of conditions, and some initial design work for a *path to commercialisation* is being done.

YOUR GOALS

On the one hand, the work that is being done now should be completed. The current workflow at the circular plastics factory should be observed, and a device that fits with the current workflow should be designed and tested. We expect that, near the end of the project period, work floor tests can be performed.

This means that the sensor design needs to be made fast and robust. In practice, this probably means that the sensor design should incorporate a commercial embedded system that provides very simple user interface for the user and is similar to (or is combined with) the sensors that are currently used.

On the other hand, Vink has more plastic separation issues. Thus, it may be possible to split the group so that one sub group works on completing the prototype and the other works on a sensor for a different separation problem.

The Fontys team is expected to develop the following:

- A prototype that is tested on the work floor
- An analysis of the prototypes performance
- A complete set of design documents

SUPPORT

Vink will provide the following support and service:

- Samples of relevant plastics
- Access to the circular plastics factory
- budget for equipment

7.14

Sensor and control systems optimisation for waste separation

Company Details		**Fontys Engineering Details**	
Company	Renewi	Project duration	20 Weeks
Contact Person	Piet Hein Brewsma	Fontys Coach	TBD
Contact Details	Piet.Hein.Breeuwsma@renewi.com		c.lee@fontys.nl
		Research support	Jeedella Jeedella
			j.jeedella@fontys.nl
Required Students			
Elec. Sys.: 0	Emb. Sys: 0	Inn. Eng.: 6	BeCreative: 5

Table 7.2 Project Organisation

BACKGROUND

Industrial waste is sorted automatically. During sorting, a number of sensors, coupled to a programmable logic controller (PLC) try to estimate the success of the sorting process. However, in the end, human inspection is required to ensure that the PLC settings are correct.

If the waste is not well sorted, then control system is re-tuned to improve sorting. The tuning is based on experience and implicit knowledge, rather than on directly measurable parameters.

The development of an additional feedback loop or process optimisation, or sensors that makes the control system more robust against day-to-day variation would lead to a number of advantaged. For example, there would be less time lost in reprocessing waste, and the process would be less dependent on human judgement.

OVERALL GOALS & CURRENT STATUS

This is a new project for us, therefore, one of the jobs of the student team is to determine the current status. They should observe the current practice and find out what solutions have been attempted.

The goal, in the end, is to fully automate the control system for waste sorting. To do this, it is necessary to understand how and why the current control system goes wrong. This knowledge should be used to develop potential improvements to the current system. Eventually, the proposed improvements should be prototypes and tested.

YOUR GOALS

As this is the start of the project, we anticipate a lot of preparatory work. Thus, we expect that the student team will perform observational research at the waste sorting plant to understand the process and functioning of the system. The students will analyse the data logged by the PLC to pull out correlations between sensor input/output and the quality of waste.

The students are expected to propose a number of potential solutions, and, for software solutions (e.g., machine learning), test that solution against the PLC data.

The Fontys team is expected to develop the following:

- A report on the waste sorting system and its failure modes
- Proposed solutions (with system-level designs)
- If software solution is proposed, then test results and a report

SUPPORT

Renewi will provide the following support and service:

- on location support for observations
- PLC data and a system design
- support meetings for feedback

Chapter 8

Art & Entertainment

CONTENTS

INTRODUCTION

TECHNOLOGY has changed the world in many ways, and it has also brought new art forms to life. Now more than ever, art and technology are closely entwined. They don't always work in the same way, but both of them strongly influence each other. Artists, designers and engineers get inspired by technology as it gives them new ways of thinking about how to create something different. Technology also offers artists and engineers a platform to show off their skills and to share their creations with many people.

Figure 8.8 the art work 'Let's beat waste' created by Fontys students was exhibited at Glow 2022.

8.15

Glow festival

Company Details		Fontys Engineering Details	
Company	Glow	Project duration	20 Weeks
Contact Person	Tom Weerts	Fontys Coach	Harold Benten
Contact Details tom@gloweindhoven.nl			h.benten@fontys.nl
		Research support	Martijn Dekker
		martijn@gloweindhoven.nl	
Required Students			
Elec. Sys.: 0	Emb. Sys: 0	Inn. Eng.: 0	BeCreative: 5

Table 8.1 Project Organisation

BACKGROUND

GLOW is a light art festival in the public space of Eindhoven of 35 famous national and international light artists. The light artworks are connected by a walking route. Besides the light artworks created by international light artists, there are also innovative, unique works of art created by (young) Eindhoven talent and students from TU/e and Fontys (Minor BeCreative). Every edition of Glow has a specific theme which is presented to the light artists and BeCreative students to incorporate in their installation or artwork. The light art festival takes place every November, lasts for one week, and attracts over 700.000 visitors each year.

OVERALL GOALS & CURRENT STATUS

You will brainstorm, design, and realize the prototype of an interactive light installation for the Glow festival in Eindhoven in November. The installation should fit with the theme of the festival, be beautiful and fascinating for visitors. The installation must function over the entire festival period in all weather, thus robustness in design is a must.

The Glow project is multidiscplinary, requires innovative thinking, and a fearless approach to rapid prototyping and iterating to success. You must be willing to sell the project to local companies to obtain sponsoring, and to maintain excellent communication with the Glow festival organisers.

YOUR GOALS

The goals of this BeCreative project are to:

- Develop and demonstrate a working prototype of an innovative and interactive light installation.
- Upscale the size and quality of the prototype to create a light installation to be exhibited at the Glow festival.
- Involve representatives of Glow during the project to make sure that the installation will be part of the main route of the Glow festival.
- Raise sufficient funds (i.e. attract sponsors) to finance the realization of the prototype and final installation.

SUPPORT

Some of the design and artistic decisions, e.g. whether to start from scratch of build upon an existing installation, will be taken in close cooperation with the Glow organization. The Glow project will receive technical and non-technical support from the Glow organization. Technical support will be provided by experts mainly, but not exclusively, through the Glow Academy. Non-technical support may include assistance in finding sponsors for the project.

Chapter 9

Bio-inspired robotics and tools

CONTENTS

INTRODUCTION

Bio-inspired devices are an area of active research in many universities. Often nature achieves solutions in unexpected an interesting ways. The iridescent colors of butterfly wings, for example, are not due to pigments, but from the way light is reflected from tiny structures in the wing. Likewise, the abilities of fleas, crickets, and frogs to jump is due to innovative ways that energy is stored in their muscles. Thus, it is often interesting to use nature as inspiration in designing devices. Here, we work closely with companies and research universities, and aim to take fundamental discoveries out of the lab and into practice. This means that in some cases, we are developing technology proofs while still investigating if there is a potential application for the technology. In other cases, we have take specific problems from industry and investigate if bio-inspired solutions may solve their problem.

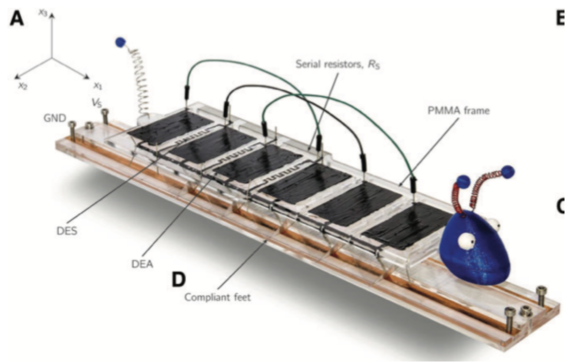

Figure 9.9 Robotic caterpillar. The actuators are made from elastomers (see https://doi.org/10.1089/soro.2017.0022 for more details.

9.16

Wireless Robotic Ants: Chemistry and Electricity in Nature

Company Details		**Fontys Engineering Details**	
Company	Helix	Project duration	20 Weeks
Contact Person	Danqing Liu Mert Astam	Fontys Coach	Chris Lee
Contact Details	d.liu1@tue.nl m.o.astam@tue.nl		c.lee@fontys.nl
		Research support	TBD
Required Students			
Elec. Sys.: 0	Emb. Sys: 0	Inn. Eng.: 6	BeCreative: 5

Table 9.1 Project Organisation

BACKGROUND

With ever-increasing interactivity between devices and human beings, compactness and mobility is a key design factor in new devices. Improving the ease of use facilitates dynamic interactions between devices and their users, offering great value for technologies such as virtual reality (VR). Wireless technology presents an opportunity to reduce device volume and enhances mobility by substituting the role of batteries or power cables. This project applies wireless systems to miniaturize devices, namely robotic ants, aiming to demonstrate the versatility of these systems by electronically mimicking the chemical communication between ants.

The demand for further convenience and interactivity in electronic devices calls for innovative ideas to improve device compactness and mobility. This is especially important for devices that need to allow controlled, yet unrestricted, user movement, such as VR technologies. Currently, such devices require the integration of a battery or power cables that restrict movement, increase device bulkiness or involve inconvenient charge times.

Finding solutions to mitigates these drawbacks would greatly increase the value of the technology. Moreover, the volume conservation brought about by such solutions would enable further device miniaturization. This would be of interest in a range of applications, from mobile phones to surveillance robots.

Wireless systems offer a solution to this compactness and mobility problem. However, the integration of wireless systems into existing products must not negatively affect its primary functions. For instance, the operable distance of a VR system must not be adversely affected by switching from cable-based power to wireless power.

Therefore, the versatility of wireless power and control must be demonstrated. This can be done through mimicking complex natural communication phenomena, such the chemical pheromone communication of ants. The notion of developing wirelessly driven and controlled electronic ants incorporates the design factors of versatility, compactness and mobility. The design of this ant-sized, wirelessly powered and controlled robot is a challenge for you and your team to solve!

OVERALL GOALS & CURRENT STATUS

The goal of this project is to two-fold: the viability of the concept needs to be demonstrated, and potential applications determined.

Last year, we demonstrated a proof of concept arm that was capable of dragging a small object along a surface. However, the full ant concept still has a long way to go. We discovered several technical challenges last year, and these need to be addressed.

YOUR GOALS

The Fontys team will have two main tasks. What are the potential applications, how big is the market, and what are the requirements. On the technical side, it is important to show a more reliable actuator. This involves the design of the mechanical and electrical aspects of the actuator and optimizing the actuation process. Here, taking inspiration from nature (how muscles are put together), especially in jumping species like frogs and crickets, will be critical to finding good solutions.

The Fontys team is expected to develop the following:

- A proposal for an application, with market potential and requirements
- A Prototype actuator
- Design documents

SUPPORT

Helix will provide the following support and service:

- active plastics to be used as actuators
- guidance and access to equipment for characterisation and fabrication (e.g., deposition, spin coating etc)
- budget for hardware/software

9.17
Active noise cancellation for observation drones

Company Details		Fontys Engineering Details	
Company	BSS Holland	Project duration	20 Weeks
Contact Person	???	Fontys Coach	Ralph Goes
Contact Details	???		r.goes@fontys.nl
		Research support	Chris Lee
			c.lee@fontys.nl

Required Students							
Elec. Sys.:	2	Emb. Sys:	2	Inn. Eng.:	0	BeCreative:	5

Table 9.2 Project Organisation

BACKGROUND

Drones, in particular, smaller commercial drones, are playing an important role in Ukraine's defense against the Russian invasion. One important role is that of surveillance, where sensor equipped drones are used to provide intelligence.

Drones are also, unfortunately, highly vulnerable to various forms of countermeasures, including small arms fire. It is, thus, important that drones are difficult to spot.

This involves the development of drones with small radar cross sections, low visibility, and low noise. Our focus is on reducing the noise of drones

OVERALL GOALS & CURRENT STATUS

This is a new project for us. The overall goal is to reduce the amount of sound produced by drones in flight. Our task is to investigate if the nosie spectrum and amplitude can be optimized via direct control of the drone motor, and to use active noise cancellation to further reduce the apparent sound production of the drone.

Mechanical engineering and mechatronics will also play a role in this project. Mechanical engineering will focus on optimising propellor design for minimum noise. Mechtronics will investigate the feasibility of transferring knowledge from state of the art in quiet cooling fans to drones.

YOUR GOALS

In this project we will focus on understanding the frequency spectrum and directivity of the emitted sound (in a studio). The emitted sound of tethered drones will be recorded in a studio (to minimize the influence of reflections and environmental noise). These measurements will be compared to field measurements as well.

By scanning over a range of operating conditions (with direct control of the drone motors via the electronic control system), the possibility of reducing noise via direct control of the motors will be investigated. You will use classical optimisation techniques, as well as machine learning to achieve this.

This information will then be used to specify the electrical engineering requirements and specifications for an active noise cancelling system.

The Fontys team is expected to develop the following:

- A report on the sound spectrum of a drone under various operating conditions
- A report on optimisation of the sound spectrum via direct control of the drone motors
- An assessment of the noise power emitted by a drone
- A requirements and specifications document for the noise cancelling system
- A research report on noise cancelling (or reduction) systems in aircraft, ships, and other vehicles

SUPPORT

BSS Holland will provide the following support and service:

- Sample drones, drone motors, ESCs etc
- Budget for high quality sound recording in the field
- Field location for external tests

Chapter 10

Click and connect LEGO-like modules

CONTENTS

INTRODUCTION

LEGO is designs are incredibly fast and simple to assemble, yet, at the same time, very complex and highly functional designs are still possible. This is down to the modular nature of the LEGO brick—there are a limited number of brick types and designs are constructed from combinations of the bricks. By applying the LEGO principle to electronic design, we can achieve accelerated prototype development because each brick is an already tested and fully developed module (either software or hardware).

Apart from improved project planning and cost estimations, it significantly decreases the development time. For each modular part, the electronic schematic and PCB implementation is already designed. At Ventilon, the hardware module design takes advantage of the advanced functionality of the Altium design program. On the software side, we make use of Zephyr, which provides rich functionality, a tool chain that supports our goal of code modularity, and is designed to target a wide variety of microcontrollers.

The Vention "Lego-blocks" methodology is fully developed, however, the eco-system of developed modules is still under construction. Thus, we are interested in expanding our range of modules that can be used to build out client's systems as easily as building Lego houses.

10.18

Location tracker using GPS & LTE (Apple-tag like device) by practising modular design methods

Company Details		Fontys Engineering Details	
Company	Vention Technologies B.V.	Project duration	20 Weeks
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		Research support	None
Required Students			
Elec. Sys.: 2	Emb. Sys: 2	Inn. Eng.: 0	BeCreative: 0

Table 10.1 Project Organisation

BACKGROUND

For this project we will be developing an Apple-tag like tracker in its most basic function. The user can attach a power bank to a modular system that consists of a USB-C power delivery system and a nRF9160 microcontroller. The nRF9160 is capable of both GPS communication and internet connection through LTE. The user should be able to track its location through a simple (existing) web interface.

On the hardware side the USB-C power system and the nRF9160 will be designed as a modular block, on the software side the LTE code and the GPS code will be developed as modules/libraries (abstraction layers).

This example project is meant to demonstrate modular design methodology such that the students can re-use their design in the future for different use cases.

To start the project, the students will be divided into a software duo and a hardware duo:

The hardware duo will start by drawing a system architecture diagram, in which they will define which USB-C Integrated Circuit is chosen, and thus research how the USB-C power standard works. The students also have to research how the nRF9160 interfaces with the GPS LTE signal. Afterwards they will define how the subparts can be made modular by checking all functions of the subparts and defining which interfaces could potentially be accessed.

After this architecture has been made, the students can start on creating the separate electronic schematics using Altium for the nRF9160 and the USB-C chip. Subsequently, after reviewing the work the students from the hardware duo will each design one modular PCB part. Finally, the hardware duo will combine the modular PCB parts into a single PCB. The students will do this by making use of relative new feature in Altium, called Design-Reuse-Blocks. This PCB will be ordered and tested by the hardware duo.

The software duo will receive a nRF9160 Development Kit to start working on the software implementation, without depending on the hardware DUO. The development kit already supports all necessary features such as GPS and LTE. By making use of the Zephyr RTOS, the students should be able to setup a GPS interface and LTE network connection. These features are well known within Vention and have been used in the past, therefore the students can rely on the knowledge within Vention.

First of all, it is expected that the students will create a basic Zephyr template that can be ran on the nRF9160 and can be used for future developments. Since the GPS and LTE interfaces are already implemented in Zephyr, the software duo will focus on creating an abstraction layer on top of the Zephyr implementation. This abstraction layer should be made modular so the functionality can easily be enabled or disabled. It is expected that the students have some basic knowledge about C, Git and RTOS. All other necessary information will be provided by Vention.

OVERALL GOALS & CURRENT STATUS

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YOUR GOALS

The objective of this assignment is for the student to get knowledge in modular designs. The hardware duo will gain more experience in Altium, GPS LTE RF design and the USB-C standard. The software duo will gain more experience in Zephyr, RTOS, GPS and LTE networking. The objective for Vention is to gain even more knowledge in modular designs and a modular implementation for the nRF9160 so it can be used in future projects. The final aim of this project is to have an example application in which Vention can easily demonstrate the USB-C, GPS and LTE functionality to potential customers. It is expected the team will demonstrate a working system at the end of the project. From the team it is expected to provide:

- Project report including
  - List of specifications
  - System architecture diagram
  - Full set of schematics
  - Fully documented software design
- USB-C Power delivery "lego-block" design files
- nRF9160 "lego-block" design files
- Zephyr nRF9160
- Zephyr GPS sub module code
- Zephyr LTE sub module code
- Tracker example implementation using all of the above

SUPPORT

Vention will supply the following:

- USB-C PD power bank the students may use to power the hardware.
- nrRF9160 development kit
- SIM card
- LTE/GPS antenna

- documentation regarding how to design modular in Altium
- documentation regarding the software implementation in Zephyr
- regular technical assistance
- working location including office space, labs, and hardware assembly