Bachelor Integration Project
Industrial Engineering & Management

Symposium Booklet Semester 1 2021/2022

Introduction

The Integration Project Bachelor of Industrial Engineering and Management (IEM)is the completion of IEM as a multidisciplinary study. A memorable time, unfortunately not only because of the final project of your Bachelor, but also due to Covid-19 virus.

I hope that you, your family and friends have stayed healthy. The university decided to continue degree programs and fortunately we also were able to pursue your Ba IPs, though sometimes adjusted in topic and methods. However, it took additional efforts from you and the supervision. A thesis project primarily performed at home is usually not what is envisioned in our degree program, in which many students perform experiments, work close to daily supervision and are used to share ideas during coffee breaks. Thanks for your loyalty and endurance to continue, mostly in solitary conditions.

At the start of the semester, most of the projects were only loosely defined, with very little guidance on what needed to be done. The past few months you gave direction to your own projects. What is the exact problem that needs to be solved? How do I incorporate requirements in my design? What techniques do I use for my design? Today we see the results, presented at the IEM bachelor symposium.

The subjects of the IEM Bachelor IP fit into the core purpose of the IEM programme: “Innovate with technological solutions for business problems.”
Central to this is the design of technological solutions in a business context. In the integration project, we want you to approach this goal as closely as possible. In most cases, there is a managerial issue or an organisational or social need that forms the basis of the integration project. The analysis and the solution you have applied are based on the methods used within IEM, such as the design cycle. For other projects, the subjects clearly have a more scientific context.

Introduction

The bachelor IP is a test of your competences. After the courses and projects in the bachelor program, it is now up to you to show you can use the knowledge and skills you have acquired. You have applied techniques to get to your design. Many of these techniques are based on physical and mathematical principles. You will often need knowledge of materials and underlying chemical or physical principles. But aside from that you need to be able to come up with a design that provides a solution for the problem at hand. Sometimes emphasis is on the context of design and sometimes more on the context of technology, in both cases it is up to you to show that you have come up with your own well motivated solution.

The motivation and validation of your solution of your project is an important aspect of IEM as an academic study. Conclusions should always be based on well founded (preferably quantitative) data or results that have been achieved in a transparent, verifiable and reproducible manner. This is obviously an important general basis of the scientific method. For IEM this means that you must be able to interpret data and knowledge from both the natural sciences and the social sciences. Here you can show how you can deal with the multidisciplinary character of IEM.

In this booklet you will find summaries of the projects that have been done this semester and the program of the final presentations and the rest of the day. Today you will see a number of IEM subjects, each with their own goal, challenges, problems and solutions. For you and for us as staff this is the completion of the bachelor programme. For IEM as a study programme in general, it gives a nice overview of where and how people work in the various disciplines. Your projects show how IEM as a multidisciplinary programme works in practice, and I think that is a beautiful image to finalize your studies with. I wish good luck and a lot of fun during the IEM Bachelor symposium!

Gerald Jonker
Deputy Programme Director Bachelor IEM

Preface Organisation

The past few months everybody has been working hard on their bachelor projects, and today the results of the hard work can be seen. IP candidates present the outcomes of their bachelor integration projects. The projects, done within one of the two IEM specializations, production technology and logistics (PTL) and product and sustainable process engineering (SPE), give a wonderful overview of the multifacetedness of IEM as an educational program.

This year, due to the measures taken as a result of Covid-19, the symposium will be replaced by online presentation sessions. Most sessions will take place in the week of January 31st. Please make sure you are on time, as the schedule is very tight. There is also a possibility to join presentations of fellow students through the meeting links.

To have the day go as smoothly as possible, we ask you to adhere to the following rules:

- Stick to the times in the schedule. Please be on time and manage the times for the presentations properly.
- If you plan to attend a session (other than yours), try to be present there from the start of the session.
- Mute your microphone during presentations unless you are the presenter. After the presentations there will be opportunity for questions.

In this booklet each student provides a summary of his/her research, resulting in a kaleidoscope of interesting topics and outcomes. Hopefully these will arouse your interest. The posters of the projects are also posted on Nestor. This is a great opportunity to see what fellow students have done. The closure and poster award plenary session will be held at 12:30 on 10th of June and will be visited by the program directors of the IEM bachelor and master, Dr. Gerald Jonker and Prof. dr. Antonis Vakis. Here you are all asked to present your poster in smaller breakout groups. So please keep your poster ready to present in this session in blackboard collaborate. We wish the IP candidates the best of luck and we hope it will be an interesting
and informative day for everyone!
Gunn Larsen
Joris Molijn
Betsy van Rooij-Oldenboom

Presentations

Session 1
Supervisors: dr. ir. Vos, drs. Ree, ir. Kousemaker

Student	Presentation
Robert Bakker	Investigation and Analysis of MEMS Flow Sensor for IV Infusion Flow Monitoring
Ishita Moloye	Health Monitoring Employing Flexible Sensors: A Technical Business Case
Sriyesh Joshi	
Dries van Meerwijk	Mechanical structure of the spring system to improve a flexible piezoelectric sensor

Session 2
Supervisors: PhD Acuautla Meneses, dr. Kottapalli, PhD Taheri

Student	Presentation
Maik van Rijn	Presenting life cycle assessment results concisely to a non-technical audience
Karlijn de Vries	CO2 Reduction of Flight Travel
Wicher Heeres	The sustainability of sharable e-mopeds within the Netherlands
Veerle van Citters	A comparative life cycle analysis of the environmental footprint of disposable versus reusable surgical instruments in general practices

Presentations

Session 3
Supervisors: prof. dr. Picchioni, prof. dr. ir. Heeres, prof. dr. Euverink, prof. dr. van der Maarel, dr. ing. Kloosterman

Student	Presentation
Kris Schoeman	Usage of a blend of reclaimed car tire rubber and polys tyrene in filament for Fused Deposition Modeling
Victor Schop	Commercial pyrolysis plant for rigid polyurethane waste
Tobias Mooy	Usage of a blend of reclaimed car tire rubber and polys tyrene in filament for Fused Deposition Modeling
Mariska van der Hoek	Portable Near Infrared for Honey Control

Session 4
Supervisors: prof. dr. ir. Cao, dr. ir. Jonker, Demmink, ir. Kousemaker

Student	Presentation
Wouter Diebels	The role of network structures in time-varying behavioral responses in epidemics
Ilona Doornbos	Validated game-theoretic model to incentivize social change
Sebastian Weijers	Evolutionary Game Theory in Vaccination Process Covid-19
Hugo Vaartjes	A sustainability assessment of ExxFire's solution for the industrial fire suppression industry

Session 5
Supervisors: prof. dr. Scherpen, dr. Larsen

Student	Presentation
Allard Lubbers	Performance comparison between a PID-controller and PI-PBC on a two-degree-of-freedom planar manipulator
Yannick van der Veen	An Energetic Analysis of Multi-Pump District Heating System Operations
Tijmen de Rijcke	Hydraulic Flow Estimation in District Heating Systems
Maxim Houwink	Using JSON to express Function Block Diagrams

Session 6
Supervisors: dr. Bosch, prof. dr. Bauso

Student	Presentation
Pierre Palazzi	Aggregating Smallholder Organic Farms in Developing Countries
Mia Choi	Coalition Aggregation of Distributed Energy Resources
Michiel Vries	Solving the joint replenishment problem with capacity constraints using algorithms
Brendan Dijkstra	Profit sharing in coalitional wind games

Session 7
Supervisors: prof. dr. Pei, dr. ir. Jonker

Student	Presentation
Brechje Smits	Abrasion-resistant dielectric films for ultra-durable triboelectric nanogenerator
Noud van der Wal	Stabilizing the Lithium metal battery with a dia mond-like carbon artificial solid electrolyte interface
Celine Lohmeijer	Laser metal deposition of a low alloy steel: microstruc tural evolution and mechanical properties
Victor Iwens	Additive manufacturing of high entropy alloy: micro structure and mechanical properties

Presentations

Session 8
Supervisors: dr. Cherukuri, dr. Larsen, prof. dr. Vakis, Mohebbi

Student	Presentation
Harm Schipper	The effect of varying demand in traffic networks on Braess's Paradox
Rico van Til	Improving efficiency in traffic networks via partial routing
Thomas Davids	Determining the impact of scour development on the ocean battery
Jeroen Franssen	Biodeterioration/Biodegradation on Ethylene Propylene Diene Monomer

Session 9
Supervisors: PhD Munoz Arias, PhD Taheri, prof. dr. ir. Jayawardhana

Student	Presentation
Alexander Sherwood	Design and Investigation of Wing Venation Patterns, using Centroidal Voronoi Tessellation
Ruben van de Ven	
Joris Schuuring	

Session 10
Supervisors: dr. Monshizadeh, dr. ing. Hubl, prof. dr. De Persis

Student	Presentation
Harald Rensink	Data-driven control of an experimental aircraft
Pieter Canon	The Design of Finding an Optimal Mapping System: Multi-Robot Transfer Learning
Rick Groen	The optimization of peer to peer electricity network ba sed on a Multi-Bilateral Economic Dispatch using a game theory approach

Usage of a blend of reclaimed car tire rubber and polystyrene in filament for Fused Deposition Modeling

Kris Schoeman

The number of car tires which are being landfilled or incinerated is still substantially high, both disposal methods come with their own detrimental effects on the environment. Therefore, recycling car tires is a subject which is studied intensively to see whether the materials inside car tires can be reused. Recycling the rubber which is present in the tires is by far the most complex task, as the mechanical properties of the rubber are being altered when recycled, making it less suitable for reusage.
A rubber recycling technique was found which does not cause much degradation in the rubber networks, retaining a large part of the mechanical properties. This recycled rubber was mixed with polystyrene, one of the most produced polymers in the polymer industry. A technology which has developed rapidly is 3D-printing, this might be a technology where such a blend of materials can be used, being both technically and economically feasible.

The aim of this research is to investigate whether the recycled rubber combined with the polystyrene can be used as a feedstock material for 3D-printing technology. This is done by analyzing the properties of the material which are of importance in 3D-printing, trying to put it through a 3D-printer and analyzing what the costs are connected to producing such a material.

Commercial pyrolysis plant for rigid polyurethane waste

Victor Schop

Due to relatively low production costs and the broad range of applications, polymers are present anywhere in our lives. Polyurethanes, commonly used in matrasses, sponges and as insulation material ranks 6th most used polymer worldwide. 18 million tons of polyurethane is produced yearly and when at the end of their lifetime the subsequent waste is being accumulated in landfills or incinerated. Leading to soil contamination and pollution of air.

Pyrolysis technology could provide the solution. During this project, various laboratory-scale pyrolysis studies were evaluated on their suitability for scale-up. A commercial-scale plant is designed based on the most promising study. It was designed to process a waste rigid polyurethane feed stream and was aimed to retrieve the valuable chemical compound aniline, from which MDI and subsequently new polyurethane can be produced. Other products were found to be alkylbenzenes, tetrahydrofuran and naphthalene, serving as either starting material for chemical processes or having fuel value. To answer the main research question: 'Is the recycling of polyurethane waste by pyrolysis technically and economically feasible?' the project includes setting up mass balances, determining process conditions and selecting and sizing process equipment. Furthermore, an economic evaluation was conducted on the preliminary plant design by determining the required capital investments, other relevant costs and sale value of the products.

Usage of a blend of reclaimed car tire rubber and polystyrene in filament for Fused Deposition Modeling

Tobias Mooy

The project 'Examining peptides through different compound extracting steps of potato juice' was started due to Avebe, a large starch manufacturer, not being able to find peptides after the extraction of proteins out of potato fruit juice (PFJ). When extracting starch from potatoes, PFJ is the leftover waste product. However, due to a larger demand of plant-based proteins, the extraction of proteins from PFJ became financially attractive. This research followed the steps of the protein extraction from PFJ and investigated the liquid present after protein extraction. The remaining liquid was investigated using high performance liquid chromatography (HPLC), mass spectrometry (MS) and LC-MS.

The latter is a combination of both techniques. All three techniques were used to examine the presence of peptides and amino acids in the PFJ throughout the different protein extraction steps. Economical considerations of extracting peptides and amino acids from the leftover PFJ were also reviewed. A mass balance of the potatoes different properties was made to provide data on the economical considerations.

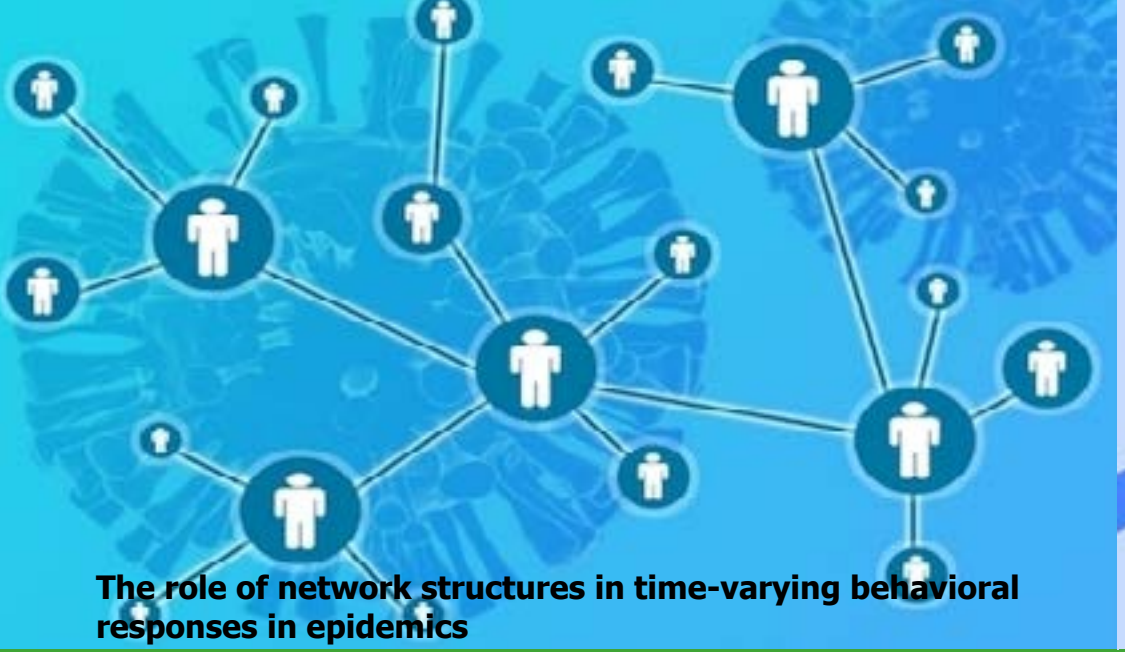
Portable Near Infrared for Honey Control

Mariska van der Hoek

Honey is a well-known, natural food product produced by the honeybee. It is mostly used as a sweetener but is also reported to having some health benefits. However, the honey that is supposed to be in the jar according to the label, might not be what is actually in the jar. Honey is the third most adulterated food product in the world. Fraud in the honey industry is performed by the addition of sugar syrups to the bees or to the honey, by illegally mixing cheap and expensive honeys, or by laundering cheaper honey via different countries.

To preserve the natural quality of honey and to withstand fraud, Western countries have set strict legislation for honey. Therefore, companies in the industry must perform quality controls. The techniques that exist to perform quality controls are generally large, stationary, and time consuming. For this reason, there is a need for portable fast detection techniques.

This thesis project was performed in collaboration with the company Trinamix GmbH. Trinamix has commercialized a portable Near Infrared spectroscopy device and is looking for more market opportunities. The portable device of Trinamix could potentially serve as a testing mechanism within the honey supply chain. The objective of the project, therefore, was to determine the technical and commercial feasibility of Trinamix to enter the honey industry with their Near Infrared device. This was done by conducting experiments, interviews, and literature research.



The role of network structures in time-varying behavioral responses in epidemics

Wouter Diebels

The outbreak of the fast emerging novel coronavirus (COVID-19) caused worldwide attention. The pandemic has led to a massive global health campaign to counter the spread of the virus by increasing hand washing, wearing masks, physical distancing, and preventing face touching. According to several studies, social and behavioral factors are critical in the response to an epidemic. The spreading of diseases in epidemics and the collective behavioral response of the population are deeply intertwined and principally manipulated by the social influence that is generated within a network.

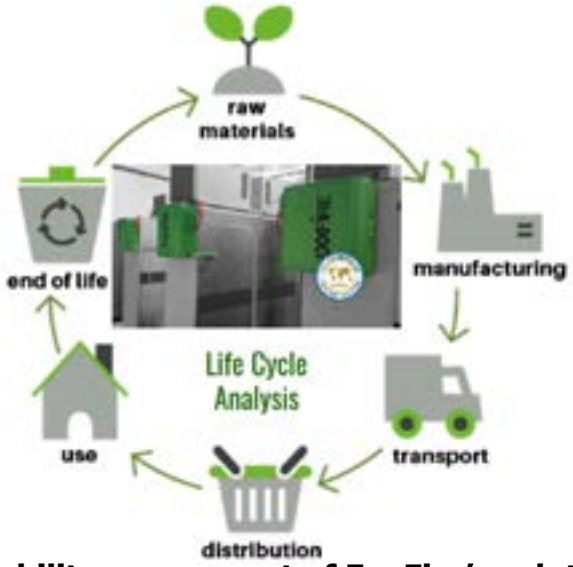
Inspired by this phenomenon, this research investigates the role of network structures in the time-varying behavioral responses in epidemics. Different network structures are implemented in a game-theoretic Susceptible-Infected-Susceptible model that can reproduce the periodic behavior and epidemic spreading representing real-world scenarios. The approach of this research represents real-world scenarios and the results should lead to improved parameterization in the models to have strong potential in explaining and evaluating the role of the real world on the time-varying behavioral response in epidemics.

Validated game-theoretic model to incentivize social change

Ilona Doornbos

Human society is an extraordinarily complex system that can be analyzed using mathematical models. Its dynamics can be modeled as a coordination game played by a network of individuals. When a company is introducing a new product, idea or behavior, the individuals in the corresponding network might change their opinion and opt for new alternatives. Incentivizing social change towards the adoption of the newly introduced alternative is based on the influence of the trend-seeking mechanism of dynamic norms and inertia. Trend-seeking is already included in the social diffusion model that captures dynamic norms. However, previous research did not take into account inertia, which represents the preference of individuals to stick to their current decision, resulting in a model not tailored to a real-world scenario.

Simulating the boundary of the probability that social diffusion of the alternative will occur, will create an overview of what is needed to incentivize this social change. As it is easier to influence the individuals with high centrality scores, centrality measures are introduced to examine their impact on the boundary of the social diffusion process. A comparison of the most optimal strategy to incentivize social change is made based on how each strategy influences the social diffusion process.



A sustainability assessment of ExxFire's solution for the industrial fire suppression industry

Hugo Vaartjes

With the imminent forecast of global warming and climate change constantly present, sustainability is becoming increasingly more important over all markets and industries. In that sense, sustainable innovation can be seen as inevitable obligation in order to remain competitive. If you look at it the other way, it can also be seen as a gateway of opportunity for companies with the right mindset and innovative capabilities, ExxFire being one of the latter.

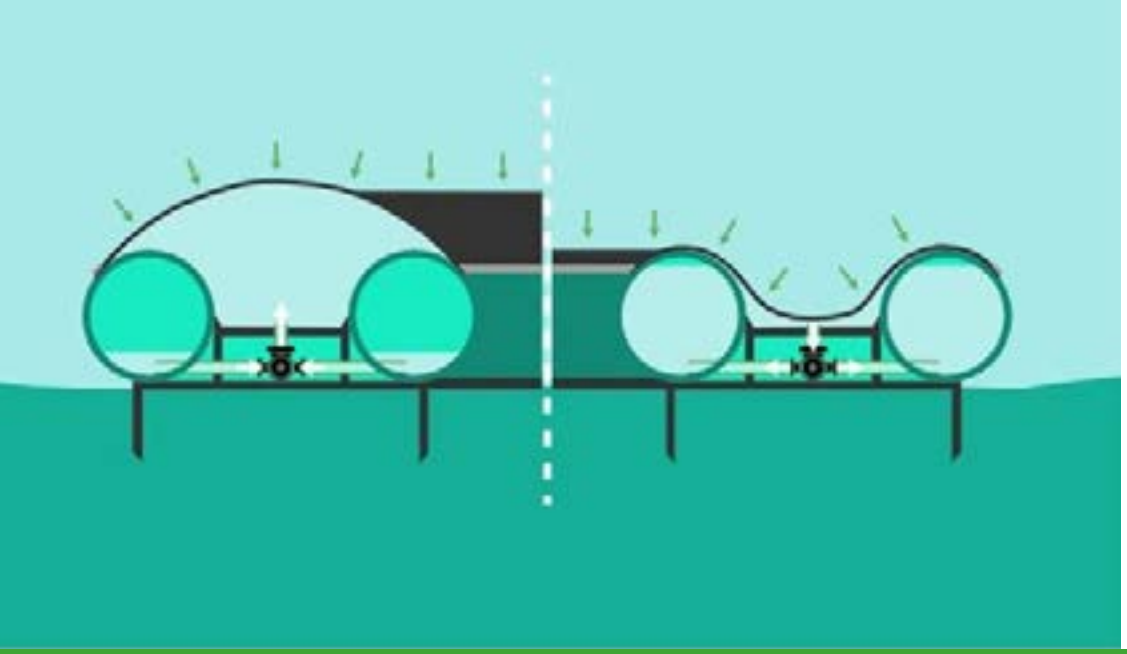
ExxFire is a company specialized in industrial fire suppression systems. Their solution, the Cool Gas Generator uses a clean extinguishing agent instead of the traditional polluting agents used in most of the market's alternative, and has already obtained a prominent sustainability label. ExxFire believes their solution is disruptive enough to obtain a large market share, as it is significantly more sustainable than all the competitors.

That is where this report comes in. This report assesses ExxFire's solution's sustainability features and compares it with the market's mainstream alternative. The main focus is the solution's environmental impact which has been thoroughly examined using a Life Cycle Analysis. The results have been displayed, compared and interpreted. Recommendations have been formulated and handed over to ExxFire so that they can competitevely enter the market by exploiting the Cool Gas Generator's significantly lower environmental impact.

Evolutionary Game Theory in Vaccination Process Covid-19

Sebastian Weijers

Covid-19 is one of the largest challenges the world has faced in a long time. It has not only hit the health of the population, but the wealth as well. Many businesses were temporarily limited or even shut down completely. As it seems now, the most promising solution is for everybody to get vaccinated. However, not everybody feels the need to get vaccinated. Some see risks in the vaccines or believe that covid-19 is not such a large problem as others believe it is to be. Before the vaccines became available, it was stated that 75% of the Dutch population was willing to take a vaccine and 8% fell under the category who were sure that they did not want a vaccine. The other 17% was unsure what to choose.
This research proposed the use of evolutionary game theory to understand how much of the other 17% would be willing to receive a vaccine after time k. The model is based on the concept that people follow the opinions of those closest to them. The results are simulated in MATLAB and can be useful to understand what the main factors are in the switch of opinions.



Joris Schuuring

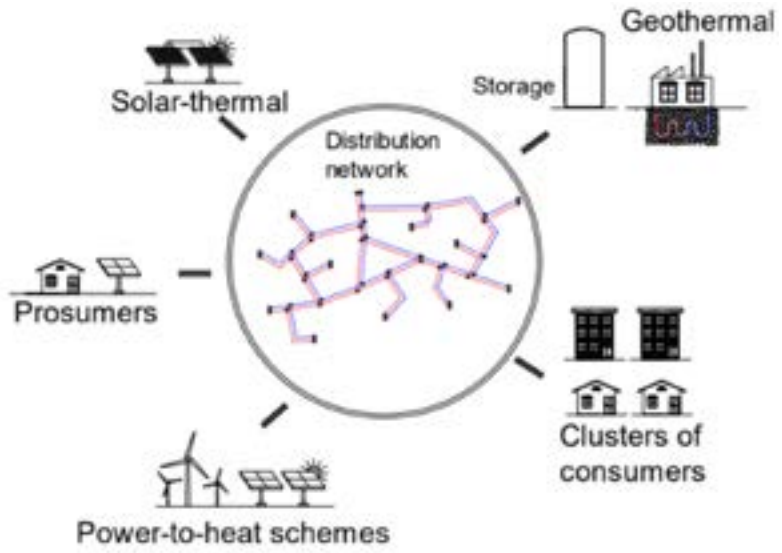
The transition in the power grid from mainly fossil fuels to greener and more renewable alternatives poses a problem in the energy market. Renewable offshore energy sources are proven to be more precarious energy producers, due to the dependence on the environment. To level the fluctuation the Ocean Grazer BV. has come up with a scalable hydro powered battery. When an access of offshore energy is produced the battery charges through pumping water in a hydro pressured bladder to store as potential energy. When a shortfall of energy occurs, the potential energy is harvested through a turbine and is added to the power net.

In this thesis a dynamical mathematical model of the pump turbine system of the Ocean battery is presented in MATLAB. The model poses as a digital twin of the system to validate real-life data and test the design

Performance comparison between a PID-controller and PI-PBC on a two-degree-of-freedom planar manipulator

Allard Lubbers

In this Bachelor Integration project, the performance of two different types of controllers is compared. The two types of controllers are a Proportional Integral Derivative (PID) controller and a Proportional Integral Passivity-Based Controller (PI-PBC). These controllers are designed for a planar manipulator robot arm, which can operate in two dimensions. These machines are used widely across different kinds of engineering fields, such as electrical engineering, medical engineering, and space engineering. Performance of the controllers in terms of robustness is examined using a sensitivity function, as well as computer simulations and real-life simulations on a planar manipulator robot arm.



An Energetic Analysis of Multi-Pump District Heating System Operations

Yannick van der Veen

Currently, a lot of the increasing energy demand and consumption are covered by burning fossil fuels, which contributes to the climate change. This problem drives the energy sector to develop a more sustainable, renewable and efficient energy network. In order to do so, a change must be implemented that shifts from fossil fuels to renewable energy sources, also called the energy transition.

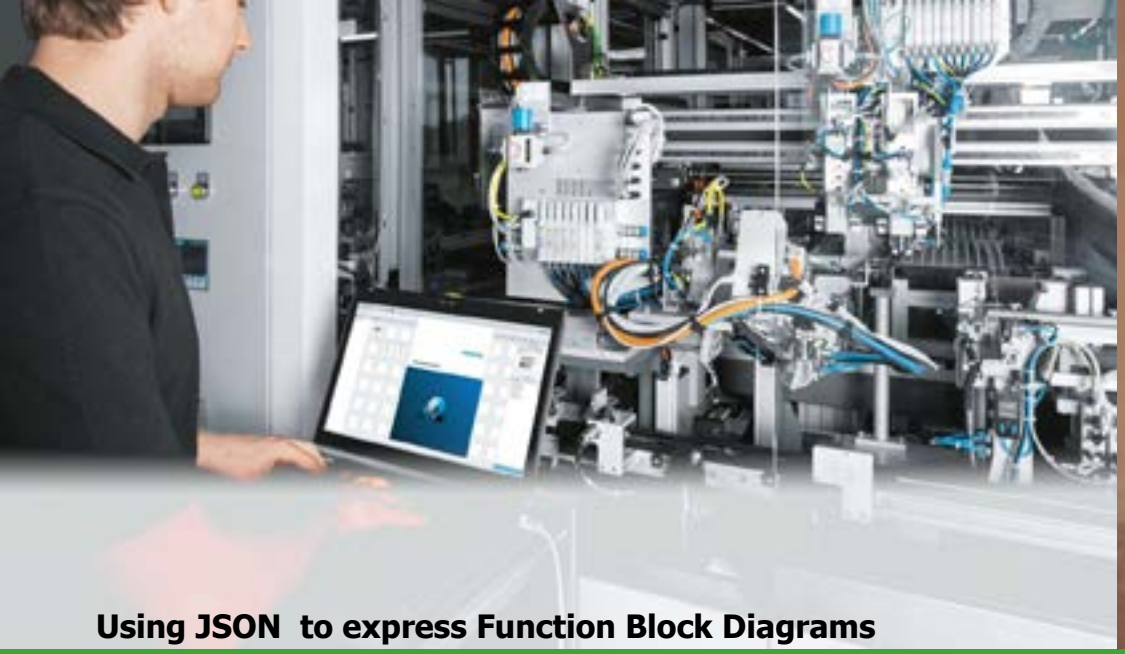
In order to improve the sustainability and predictability of heat demand of a distribution network renewable energy sources and more efficient hydraulic heat distribution devices must be implemented. In terms of achieving a more efficient energy flow in the distribution network a constant pressure difference control strategy must be implemented. This maintains the constant difference in pressure at zero pressure difference points in the network, where the distributed variable speed pumps are installed, by varying the rotation of the pumps. Using this optimal pressure control strategy, the pump power of the system is minimized under the condition of providing enough power to deliver heat to the consumers.
Therefore, a more efficient system with multiple renewable energy storage systems connected to a common heat distribution network should solve the problem of energy demand for space heating. In order to achieve this, a system with diverse hydraulic speed pumps placements and configurations must be analyzed to cover the energy consumption.

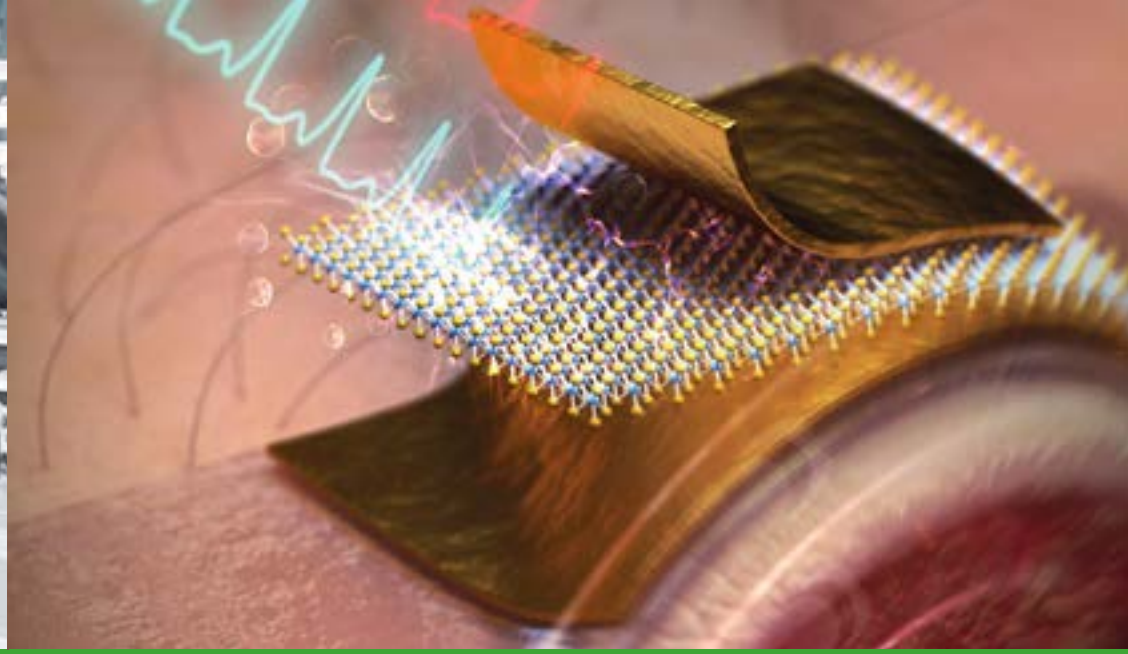
Hydraulic Flow Estimation in District Heating Systems

Tijmen de Rijcke

Today, the use of fossil fuels is becoming increasingly problematic since they are limited resources, and their use causes environmental problems, the most prominent example being climate change. One of many initiatives contributing to the energy transition to combat climate change is the emergence of district heating systems. (DH) DH systems centralize the production of heat demanded by clusters of consumers within a neighbourhood or city. The distribution network of the multi-source DH system is a network of insulated pipes which transport heated fluid. This transportation of heated fluid from the producers towards the consumer and back again, causes big variances in pressure and flows throughout the distribution network. Pressure measurements have been proven to be adequately accurate, however, flow cannot be measured accurately, causing a decrease of energy-efficiency throughout the network.

In this project, an observer is designed to estimate the flow more accurately from pressure measurements. This observer will include a combination of control design, with a linearized controller redesigned from an existing nonlinear system, and an estimation of the flows of interest. The performance of the observer is validated through numerical simulations.





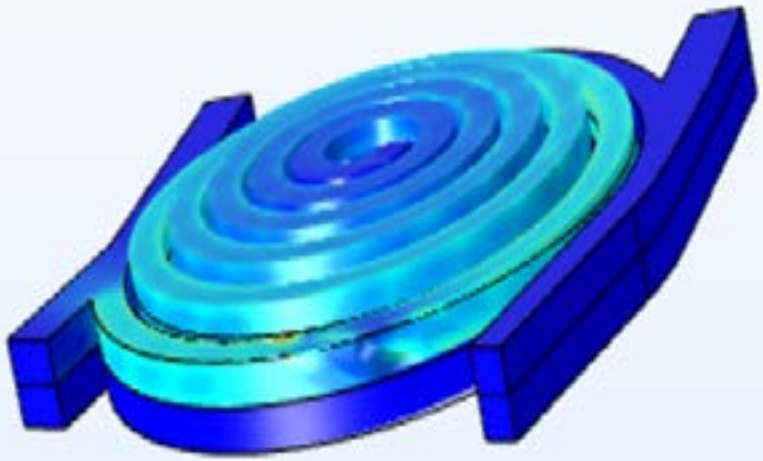
Using JSON to express Function Block Diagrams

Maxim Houwink

Sriyesh Joshi

Adaptive cruise controlled cars, self-ordering machines, autonomously controlled drones and automated manufacturing lines. At the heart of these technologies, the PLC (Programmable Logic Controller) is by far the most commonly used type of control-unit to implement and execute specific functions and operations to achieve a desired output. Whereas PLCs were orignally designed as electromechanical relay systems, modern-day PLCs feature high-performance microprocessor-based controllers in order to control their output(s) based on information or data received through their input(s). For programing PLC's, control systems can be graphically designed using Function Block Diagrams (FBDs), one of the five supported programming languages for PLCs.

This design project proposes a syntax framework for expressing FBDs using the JavaScript Object Notation (JSON) format. Although a diverse range of FBD programming applications have been developed throughout the years, including FESTO, Simulink and Codesys, data exchange among these applicatios remains restricted as each interface uses its own, proprietary file format. In addition, as most FBD programming software often requires advanced interfaces that require a strong learning curve, the framework is written using a straightforward, easy-to-learn syntax in order to ease FBD programming for users new to programming.



Mechanical structure of the spring system to improve a flexible piezoelectric sensor

Dries van Meerwijk

The piezoelectric effect was discovered in 1880's by Pierre and Jacques Curie. They found that when pressure is applied to certain crystals like quartz or ceramic, an electric voltage develops across the material.

The piezoelectric effect has been exploited in many useful applications, including the production and detection of sound, piezoelectric inkjet printing, generation of high voltage electricity, as a clock generator in electronic devices, in microbalances, to drive an ultrasonic nozzle, and in ultrafine focusing of optical assemblies.

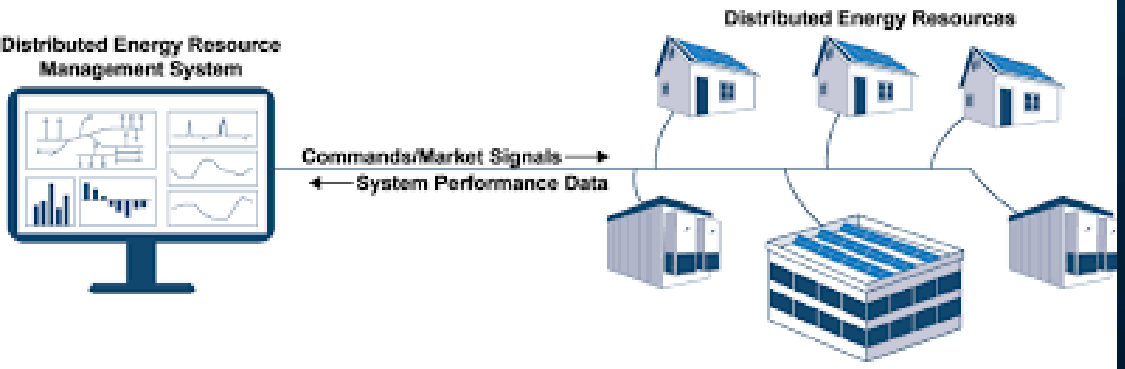
In this research, the conversion of a displacement applied on a spring system into electrical output is investigated. The piezoelectric material used is PVDF.

This integration project is focussed on improving the dimensions of a spring system containing maximum dimensions of 17 x 17 mm2 in order to maximize the output voltage relative to a fixed displacement in the y-direction of 20 mm. Simulations in the programm Comsol Multiphysics are executed in order to find the best model.

Aggregating Smallholder Organic Farms in Developing Countries

Pierre Palazzi

The desire for more sustainable strategies to fulfill the worldwide food demand has become increasingly important. In today's agriculture two main challenges arise: the increasing food demand because of the growing population and reducing negative effects on the environment. Organic farming – which is done without the usage of chemical fertilizers and pesticides – could tackle both challenges, whereas conventional agriculture will not be able to tackle the challenge of reducing emissions. Organic agriculture demands cheaper external inputs, making it ideal for smallholder farmers in developing countries. Therefore, 75 percent of the worldwide organic farmers are based in developing countries. However, they face certain challenges compared to conventional agriculture such as: risks associated with contamination, lower yields, market barriers, lack of market power and the underutilization of agricultural resources. This study provides a cooperative game model that examines the benefits of resource sharing in terms of profits made by smallholder organic farms in developing countries (SOFDCs). By examining the benefits of resource sharing and thereby possibly increasing the profits of SOFDCs, it could become more attractive for food producers all over the world to engage in the organic food supply chains.



Coalition Aggregation of Distributed Energy Resources

Mia Choi

Distributed Energy Resources (DER)s allows integration of decentralized renewable system into conventional energy grid. The unpredictable nature of renewable energy sources which makes it challenging to match the demand is covered by conventional energy plants and energy trading. The Aggregator manages the system with its own resources and interacts with the power system market. It makes profit from the gird transactions. In this project, the data in distributed energy system are gathered and calibrated. A mathematical model is developed in a viewpoint of the aggregator, where the objective of the mathematical model is to maximize the profit of the aggregator.
Mathematical model is translated into MATLAB to find the optimal decisions regarding procurement plan, storage units, energy trading. Two managerial approach is considered, Full Resource Management (FRM), where aggregator fully decides the schedule of the resources, storage level to satisfy the demand. Second is Residual Resource Management where coalition members individually decide their schedule and the aggregator only acts as the integrator. These two managerial setups, with storage decisions are simulated. The analysis on the different management options are conducted to propose a data analysis based managerial suggestion.

Solving the joint replenishment problem with capacity constraints using algorithms

Michiel Vries

For a lot of companies, restocking their inventories contributes a big deal to their total costs. Finding the optimal solution can be a complicated task, especially with random demands and little storage available. When resupplying a warehouse there are multiple costs factors contributing to the total costs, which should be minimized. Shortage penalties, storage costs and order costs should all be evaluated and optimized, with a complicated mathematical model as a result. Nowadays computers can be used to find more effective solutions for resupply times and quantities than ever before.

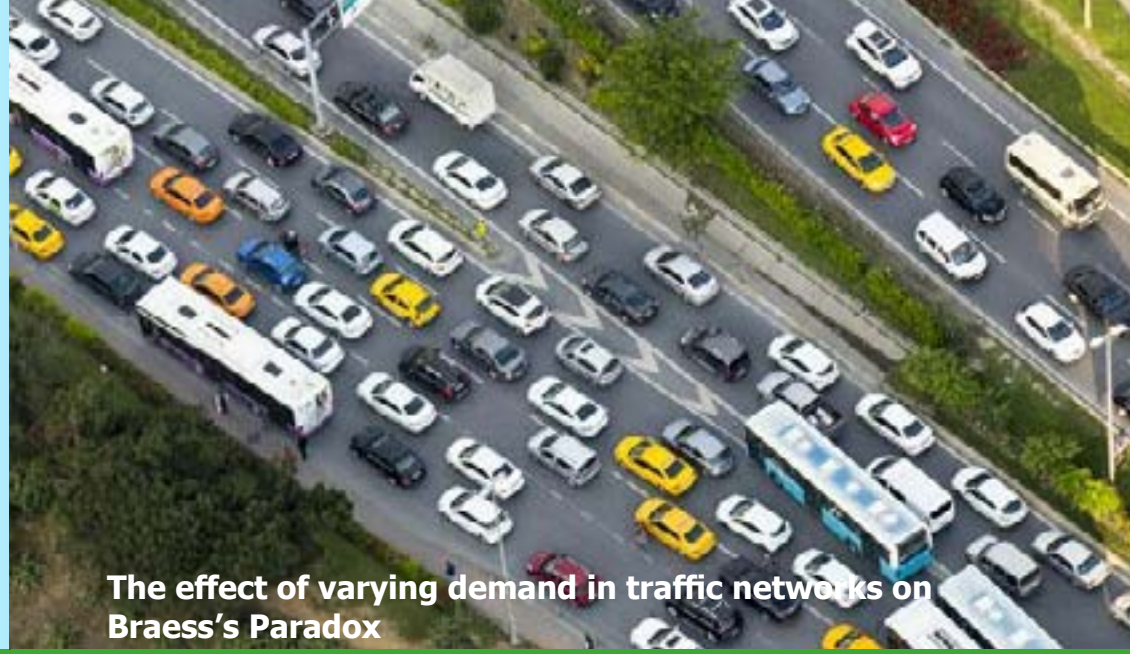
In this thesis such a mathematical model is solved with usage of a MATLAB algorithm capable of determining optimal order sizes and quantities for a warehouse of any size. Three possible mathematical models are analysed and compared based on their final resupply costs, shortages and resupplies. In addition to the costs an overview of the inventories generated by the algorithms will be shown and evaluated to create a better understanding of how the algorithms function.

Profit sharing in coalitional wind games

Brendan Dijkstra

Wind power producers are penalized for the uncertainty the wind causes on their output. By forming coalitions, and thus leveraging geographic diversity between multiple wind farms, the total value among producers increases. In the work of Baeyens et al. (2011), it is proven that the core of this coalitional game is nonempty, which indicates that fair and beneficial profit allocations for the members of the coalition do exist. In their work, the authors propose a profit allocation method by minimizing the worst-case excess.

In this research project, I propose multiple methods to solve this linear program and ways to evaluate the payoff allocations. Many different games with various coalitional properties have been simulated, checked and analyzed. The simulations have been performed using random uniformly distributed variables to cover a broad spectrum of possible scenarios. Moreover, the property checks have been designed with zero margin for error, resulting in high accuracy. Lastly, the analyses show a clear increase in profit for each of the aggregating players. Therefore, the methods used to assign profit evidently disincentivize coalitional split-up.



The effect of varying demand in traffic networks on Braess's Paradox

Harm Schipper

Traffic networks play an essential part in everyday life and are therefore frequently used. This usage is known as demand and can introduce inefficiencies in a traffic network. One of these inefficiencies is called Braess's paradox, where the presence of a road in a traffic network makes the network less efficient in terms of travel time. Analyzing whether Braess's paradox is present in a traffic network can therefore be used to make the network more efficient by removing inefficient roads. Analyzing Braess's paradox might even be more important when planning to build a new road for a traffic network; determining beforehand whether the new road improves traffic network performance can prevent spending significant capital on a useless road.

This research lays out the key concepts to understand Braess's paradox and presents a MATLAB model to detect it in any given traffic network with a single origin-destination pair. As demand plays an important role in the presence of Braess's paradox, a numerical analysis with the MATLAB model is done on the relation between Braess's paradox and varying demand. As varying demand resembles the use of real-life traffic network best, the numerical analysis is used to draw conclusions on traffic network design decisions.

Improving efficiency in traffic networks via partial routing

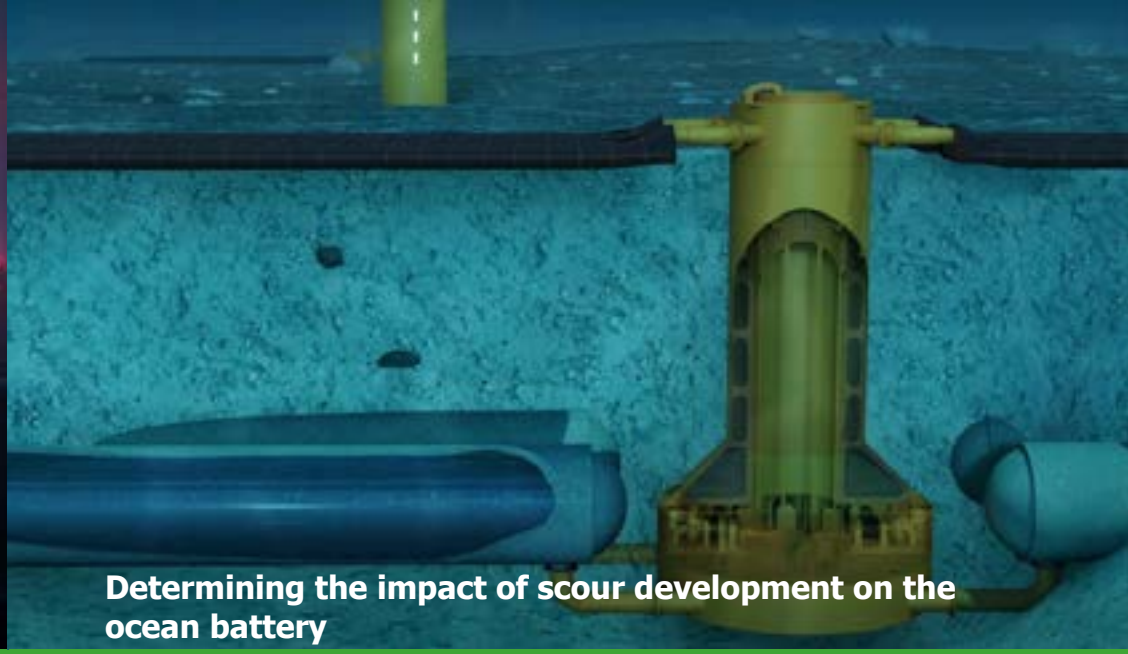
Rico van Til

Road users spend billions of kilometers on the road each year. On Dutch roads only, road users, excluding motorcycles and mopeds, drove 151.8 billion kilometers in 2019. The traffic networks on which road users travel these kilometers are subject to various forms of inefficiency, resulting in congestion. Nearly every morning and evening, when people travel to work or back home from work, traffic jams occur.
These inefficiencies are usually unpredictable, or computationally expensive, to prevent and detect with current methods.

When choosing what route to take to get to their destination, road users make their decisions based on what they think gives themselves the lowest travel time. One might selfishly choose a certain road over another because it is said on the radio that the other road is congested. This selfish behaviour is considered inefficient and suboptimal.
A proposed solution to mitigate these inefficiencies is by giving efficient routing recommendations to part of the population.

When part of the population would cooperate during their commute through traffic, would the system end up in an improved situation in which total average traffic time is reduced?

This research will investigate the potential benefits of such partial routing strategies by presenting a numerical analysis of a model of several generic road networks.



Determining the impact of scour development on the ocean battery

Thomas Davids

An historical agreement was made at the Paris climate conference in 2015 to limit the global temperature rise to 1.5° Celsius. This in turn highlighted the global need for renewable energy, including wind energy. excess energy needs to be stored for later use to improve the reliability and usability of wind energy.

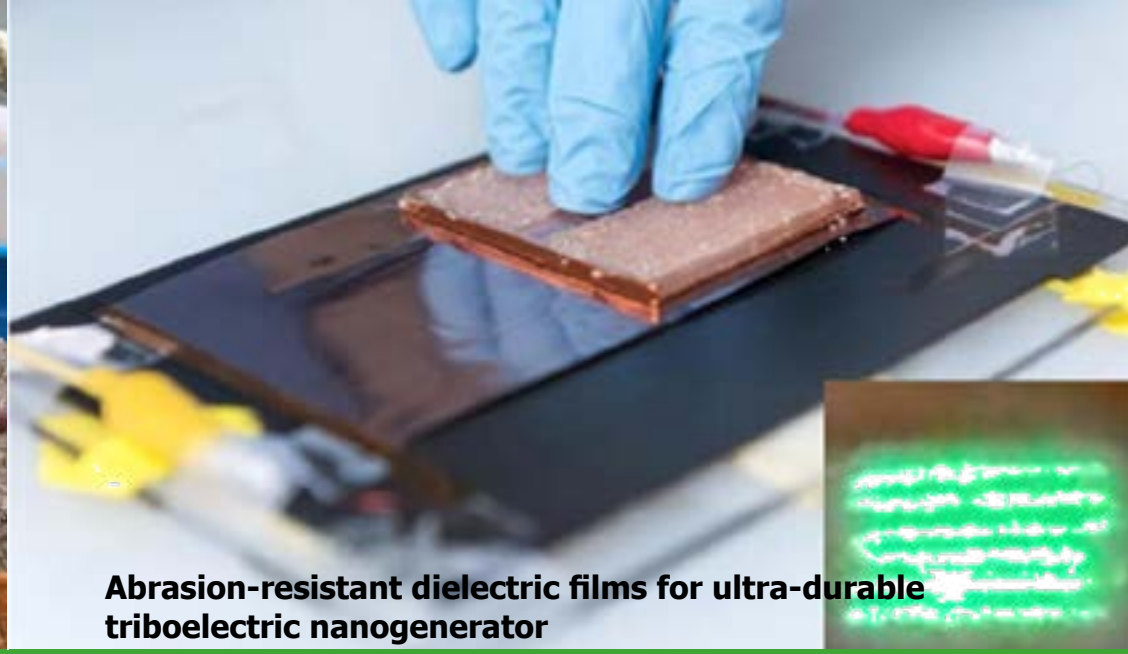
The Ocean Battery is a battery that is capable of storing excess energy with an eco-friendly solution. It is installed on the bottom of the sea, which results in several challenges. This research focuses on the impact that scour development can have on the installed Ocean battery.

Scour development is a process where sand grains are transported by a turbulent flow of water, often caused by a structure situated on top of the sea bottom. This process can result in large holes of several meters deep, which can be harmful for a structure like the Ocean battery. Simulations on scouring have been done in combination with predictive calculations to find out where the scouring takes place and how deep it is. With the obtained data, recommendations have been made for scour mitigation strategies and scour protection methods.

Biodeterioration/Biodegradation on Ethylene Propylene Diene Monomer

Jeroen Franssen

A challenge for engineering underwater structures is biofouling, which is the accumulation of unwanted organisms like Mussels, Barnacles and Oysters on the surface of a material. A rubber material, Ethylene Propylene Diene Monomer(EPDM), intended for underwater usage, has been examined for biodeterioration and biodegradation due to biofouling. Scanning Electron Microscopy was used to observe eventual deterioration on the surface. A 3D Optical profilometer was used to examine eventual pits and their size. Moreover, a Universal Testing Machine was used to examine the material's mechanical properties.



Abrasion-resistant dielectric films for ultra-durable triboelectric nanogenerator

Brechje Smits

The triboelectric nanogenerator (TENG) is a novel energy harvesting technology with high efficiency, low fabrication costs, and low maintenance, is environmentally friendly and uses simple fabrication techniques. It is a promising technology based on contact electrification and electrostatic effect that can take ambient environmental energy and turn it into electricity for self-powered sensing and systems. Its durability and lifespan depend on the abrasion resistance of the triboelectric layers. This research, therefore, focuses on the ultra-durability of the triboelectric layer Si_3 N_4 deposited by pulsed DC reactive magnetron sputtering. Various depositing parameters are used when using this technique, which influences the film's properties. The effect of changing three of these depositing parameters, substrate movement, nitride flow ratio, and bias voltage, on the abrasion resistance of the Si_3 N_4 coating is examined via mechanical and electrical tests.

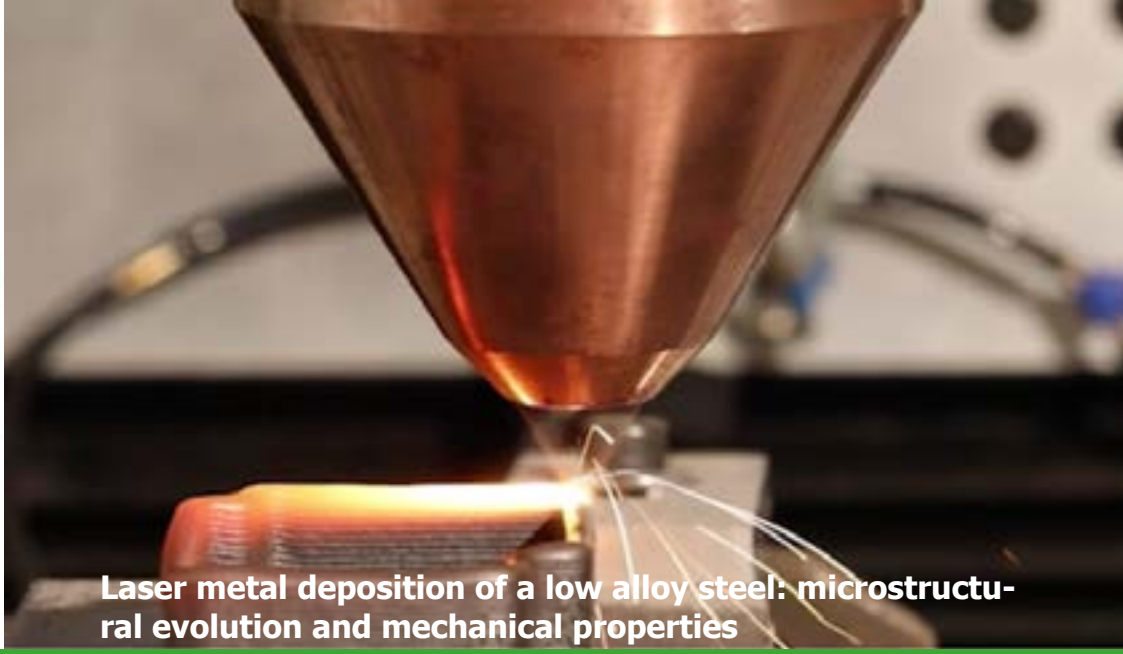
Stabilizing the Lithium metal battery with a diamond-like carbon artificial solid electrolyte interface

Noud van der Wal

Developments in high-performance, high-energy-density batteries are essential to effectively phase-out fossil fuel vehicles, and stabilize the renewable energy supply. Lithium--ion batteries use graphite as anode material, which has a theoretical energy density-the energy that can be stored in a given mass of material-of 372 mAh/g. Lithium (Li) metal has an extremely high theoretical capacity of 3860 mAh/g, low density, and has the lowest negative electrochemical potential of any metal. This gives Li-metal the potential to significantly improve both the gravimetric and volumetric capacity of rechargeable batteries.

However, the low negative electrochemical potential makes Li highly reactive. This causes Li and electrons to react with components in electrolytes inside the battery until a solid electrolyte interface (SEI) is formed. Compressive stress generation of deposited charged Li during charging cycles forms dendritic Li on the anode which breaks the SEI and grows towards the cathode. If it reaches the cathode it will cause a short circuit. This is a serious safety issue.

This integration project has engineered an artificial SEI made from hydrogenated diamond-like carbon that is electronically insulating, has sufficient modulus to suppress the Li dendrites, and high ionic conductivity to maintain performance of the battery. Making the Lithium metal battery more cyclically stable and safe.



Laser metal deposition of a low alloy steel: microstructural evolution and mechanical properties

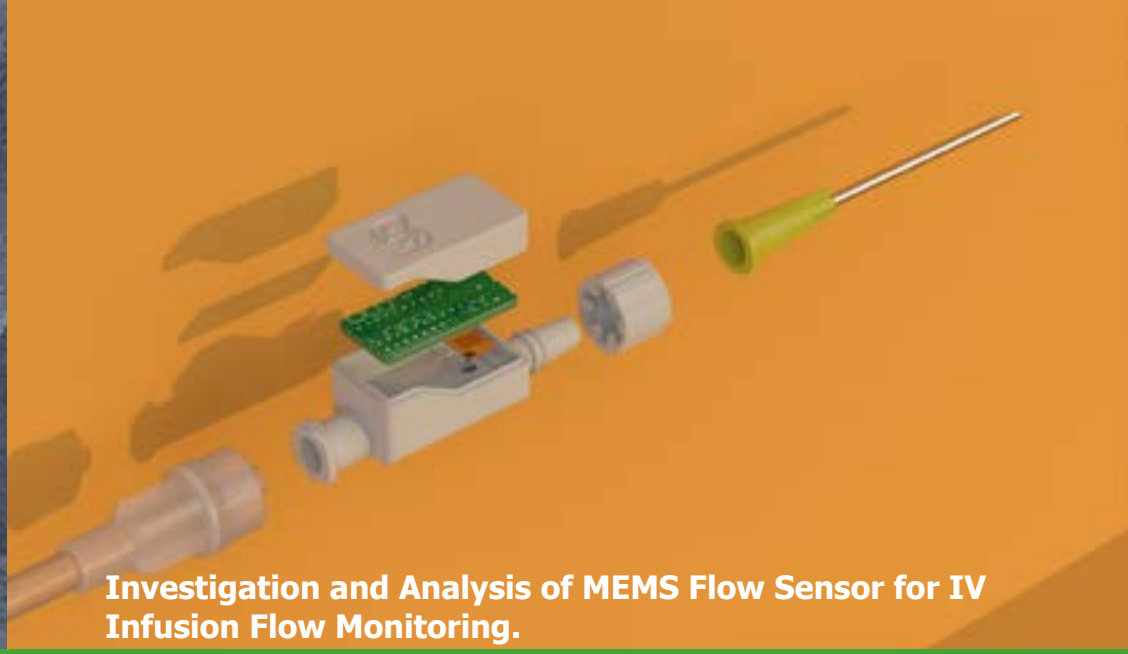
Celine Lohmeijer

The research field of additive manufacturing (AM) is increasingly growing due to its advantages regarding material usage, energy consumption and the possibility to produce complex parts. Within AM, Laser Metal Deposition (LMD) is a promising technology that is able to translate Computer Aided Design (CAD)-models to real-life 3D objects. The process consists of a laser beam producing a melt-pool in a self-supporting substrate. Metal powders are fed to a nozzle where the particles are melted by the laser and, subsequently, are deposited on the substrate to create cladded tracks. By repeating this process a 3D component is built layer by layer. The microstructure and mechanical properties of the as-printed 3D component are dependent on the following processing parameters: the laser power, the scanning speed and the powder feed rate. In addition, the overlap percentage between the different tracks is of great importance for the microstructure and the mechanical properties of the resulting 3D component. In order to enhance the knowledge on material behaviour and the effect of the LMD process on the microstructural evolution and mechanical properties, more research on different types of materials is necessary. This project focuses on the investigation of a process window for a LMD process using 8620 metal powder by producing experimental samples of single track, single- and multilayer samples. Evaluation is performed by microscopy and mechanical tests to determine the porosity rate and yield strength of the as-printed samples.

Additive manufacturing of high entropy alloy: microstructure and mechanical properties

Victor Iwens

The increase in global demand for customized products places an increasing strain on production companies to meet rapidly changing demand markets. Groundbreaking innovations in advanced production engineering have led to the manufacturing of complex geometric components for faster time to market, with larger efficiencies in material usage and less production steps by using additive manufacturing (AM).
AM expands the composition space of new materials to outperform traditional alloys implemented in mechanical designs. One such novel material is an interstitial high entropy alloy (iHEA) with elemental composition Fe49.5Mn30Co10Cr10C0.5. This material was printed using a specific AM method, called selective laser melting (SLM). SLM is a process whereby a high energy laser beam creates melting and solidification of consecutive metal powder layers in a layer-by-layer fashion. SLM with iHEA provides unique thermo-dynamic environments in the melt-pool resulting in a microstructure leading to mechanical properties of high strength and ductility simultaneously. SLM with iHEA is revolutionary as conventional production techniques result in a compromise between these properties. It would be beneficial in aerospace, nuclear and automotive industries. SLM with iHEA is still novel and requires research in optimizing the processing parameters for highest strength-ductility behaviors.
This research focused on comparing a chessboard and stripe process-scanning-strategy combined with annealing, to identify and explain differences in the material characterizations. This was done using tensile testing, nano indentation and scanning electron microscopy to clarify the effect of scanning strategies on mechanical properties.



Investigation and Analysis of MEMS Flow Sensor for IV Infusion Flow Monitoring.

Robert Bakker

Healthcare workers are under increasing pressure given the current state of the world, the time dedicated to a nursing task is a valuable resource which needs to be efficiently used. One common task, Intravenous (IV) fluid administration, is essential for the wellbeing of a patient. Accurately controlling the flow rate in the tube is a vital part of regulating and ensuring the correct dose of medicine/fluid is delivered to the patient. Current flow rate measuring techniques require the nursing staff to manually count the number of drops in a drip chamber connected to the IV tube.

The following research project investigates the calibration and design of a novel microelectromechanical system (MEMS) sensor for continuous measurement of the fluid flow rate in the IV tube. Successful development of the flow sensor can see market implementations in hospital and care institutions alleviating a common task and introducing an accurate system for early warning detection as well as remote patient monitoring.

Health Monitoring Employing Flexible Sensors: A Technical Business Case

Ishita Moloye

Gait refers to the manner in which a person walks, this varies from person to person as it is affected by both a person's locomotion and equilibrium. Calculating this human motion parameter has been proven extremely useful in devising preventive medical solutions for patients of Multiple Sclerosis and Parkinson's Disease as it not only helps in assessing the progression of the diseases but can help in predicting future hazards for the patients too. This primarily includes falls and chronic diseases. Gait is often measured using stress/strain sensors which exhibit piezoresistive properties. Piezoresistivity refers to how electrical resistance is able to change as a force is exerted on a conductor or semi-conductor. This concept becomes especially interesting when trying to characterize the movement of an individual into data.

The APE group has devised a nanomaterial composite-based sensor to collect high-precision measurements for gait-monitoring applications. The research conducted focuses on how to optimally position the sensors within a shoe sole, to aid patients pertaining conditions such as Multiple Sclerosis and Parkinson's Disease respectively. Ultimately, a technical business case was devised in order to compare the technical specifications of the sensor to similar commercially-available products on the market and hence, strategize how to best meet the consumer demands.

Data-driven control of an experimental aircraft

Harald Rensink

Controlling systems via the conventional model based way is known to be very time intensive and complex. Expert knowledge about the system is needed in order to be able to control the system at hand. Engineers have begun to favour data-driven control design. With this approach the control law can be computed with the help of the input and output data, so no expert knowledge is needed of the system.

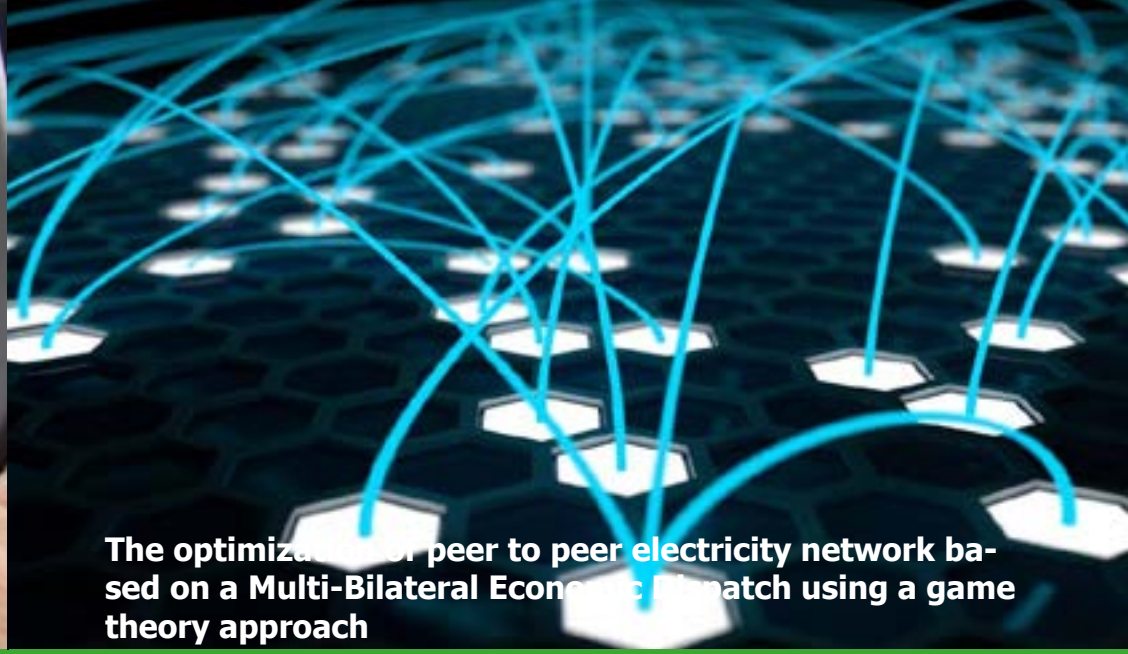
The aircraft of which its longitudinal motion needs to be controlled is the retired X-29 aircraft from the NASA and the USA airforce. This aircraft will be modelled as a discrete-time linear switched model, meaning that the system's dynamics change over time. The framework will be online meaning that the data are collected over time while the system is evolving in closed-loop, and are directly used to iteratively update the controller. The performance of this data-driven control law will be simulated with the help of MATLAB.

The Design of Finding an Optimal Mapping System: Multi--Robot Transfer Learning

Pieter Canon

Over the past decades, the development of information technology and communication has risen tremendously. The interest in the implementation of robotics in the industrial industry is growing worldwide. Imagine a factory with over a hundred slightly different robots that all perform similar tasks. It is a waste of resources to design a controller for each individual robot in order to fulfil their specific task. Multi-robot transfer learning is concerned with gathering the data by a robot that will be used by other robots and is useful to reduce the time of training and programming the dynamic systems.

The focus of this research is on the application of multi-robot transfer learning to the cruise control system of a car. A design to find the optimal transfer map that shows feasibility of one source system utilizing another target system's data for model learning is provided. An external factor of noise is exposed to the optimal mapping system to reveal the behaviour of this system more realistically without ideal circumstances. The findings of this research are grounded by the results plotted from simulations that show the difference in output (referred to as error) between both the source and target systems. An output that is closely located to zero denotes that the transfer map has successfully created a controller that is able to transfer the data of a car's cruise control system to another.

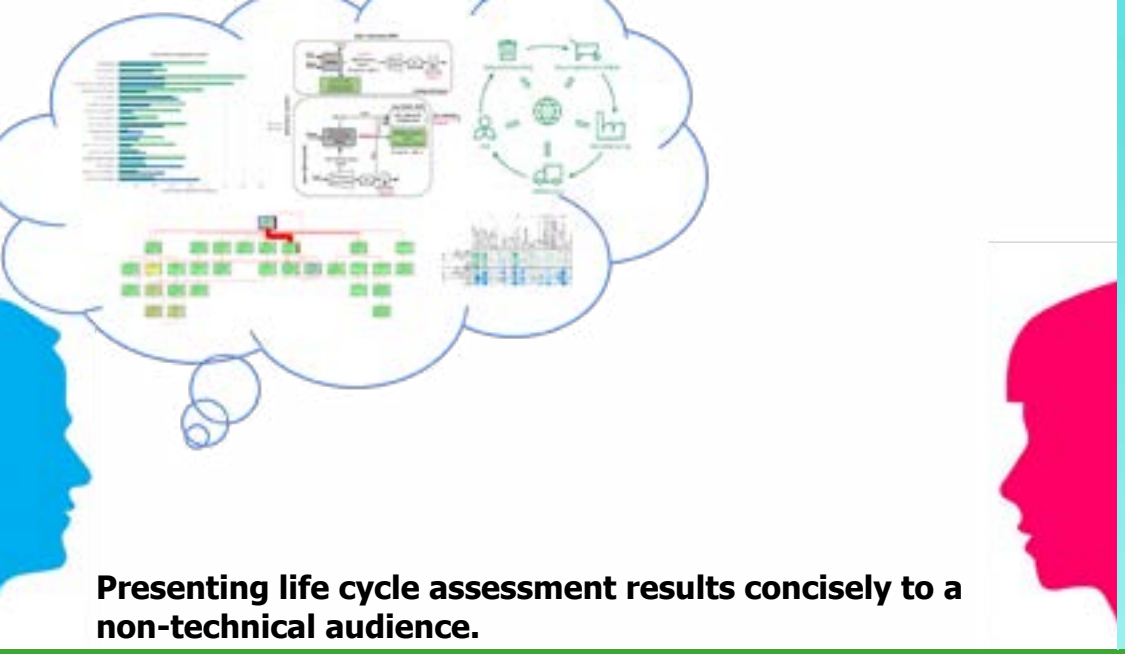


The optimiza[illegible]peer to peer electricity network based on a Multi-Bilateral Econo[illegible]atch using a game theory approach

Rick Groen

Society wants to move towards a more sustainable way of living. An aspect that can help this is peer to peer electricity trading. To make sure people find the best way to use their energy for the lowest possible costs it is important to find optimal solutions for each agent. Furthermore, computing power for these networks is a limited resource as such it is important to efficiently solve the model. This is tested by the number of iterations and the time it takes to complete these iterations. As such the model and algorithm to solve the problem are discussed.

A game theory approach is used to solve for the model. By finding the Nash-equilibrium for the model. These are the optimal solutions based on the choices for the other agents. The results of the amount of iterations and time to solve are compared and the results will be presented.



Presenting life cycle assessment results concisely to a non-technical audience.

Maik van Rijn

In an era where environmental footprints are becoming more frequently addressed, life cycle assessments (LCA) applications are becoming increasingly popular. An LCA estimates and quantifies the environmental impact of a system by life cycle modelling. This modelling logic encompasses the five life cycle stages of raw material extraction, production, distribution, use and disposal.

Even though LCAs are becoming increasingly standardized by regulatory organizations in recent years, many disparities still exist. Life cycle modelling choices are based on views and assumptions. In the same manner, environmental impact can be allocated according to a variety of methods. Many LCAs are not compatible to be compared to one another, due to different underlying assumptions and limitations. Consequentially, LCA can thus be seen as a family of assessments, not a unique method.

The resulting issue is that misinterpretation may occur in presenting the results of LCA studies, as experienced by Ecoras, an environmental consultancy company, as well as the main stakeholder of this project. The focus of research is evaluating where communication issues reside in executive/management summaries in LCA studies for an audience with no technical expertise in LCA.

CO2 Reduction of Flight Travel

Karlijn de Vries

The European Union has set the goal to have net zero CO2 emissions generated by flights by 2050. Every fifteen years the aviation industry doubles in air transport activities and it is expected that in 2050 alone, the aviation sector will emit 1,8 Gt of CO2. To have net zero emissions, large-scale emission reduction is necessary. Sustainable aviation fuels (SAFs) are supposed to have the biggest contribution by reducing 65% of all expected CO2 emissions in 2050. SAFs are alternative jet-fuels produced from biomass or waste resources instead of fossil resources. SAFs can be mixed with conventional jet-fuel kerosene up till 50% and require, therefore, minimal to no retrofitting of existing aircraft fleets.

In this research it is investigated whether SAFs can reduce 65% of all expected CO2 emissions in 2050. This is done by assessing the environmental impact of different types of approved SAFs, the possibility of flying on unblended SAF, and the availability of feedstocks to produce all the needed SAF in 2050. The environmental impact is assessed over the entire life cycle of the fuels. This entails, from cultivation of the biomass till combustion of the fuel in the aircraft engine.

The sustainability of sharable e-mopeds within the Netherlands

Wicher Heeres

The transport sector has a huge contribution in the worldwide global warming potential (GWP). The sector contributes as much as 15.5% to the GWP and therefore it is urgent that sustainable transportation modes arise to decrease the contribution to the GWP. The electricity powered e-moped has zero CO2 emissions during driving and doesn't produce any noise. Therefore, it might be a sustainable transportation mode but there are limitations to this statement. Other parts of the life cycle also account for the emissions of the e-moped and those can play a significant role compared to only the usage of the e-moped. The sharing concept requires extra processes that also might influence the environmental impact.
A life-cycle analysis (LCA) gives insight into the emissions the e-moped generates from the begin of its life till the end of it, a cradle to crave approach. Together with the substitution rates of other transportation modes and their environmental impact this research manages to find out whether the sharable e-moped is capable of reducing the environmental impact the transport sector has by substituting other transportation modes that would be used if there were no e-mopeds available.

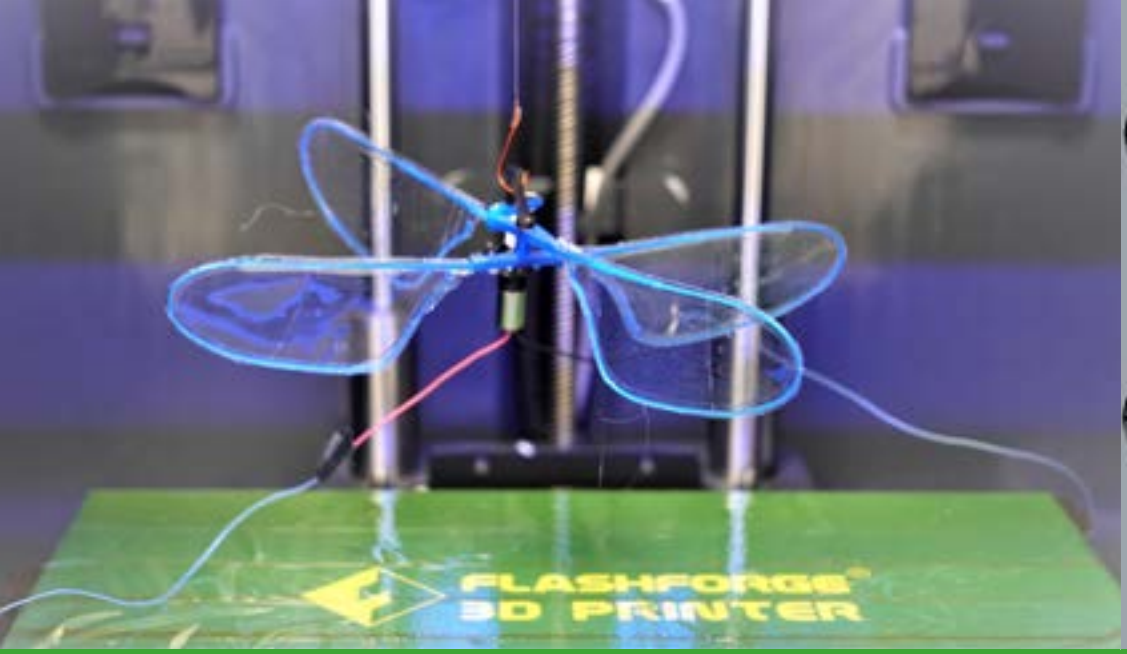
A comparative life cycle analysis of the environmental footprint of disposable versus reusable surgical instruments in general practices

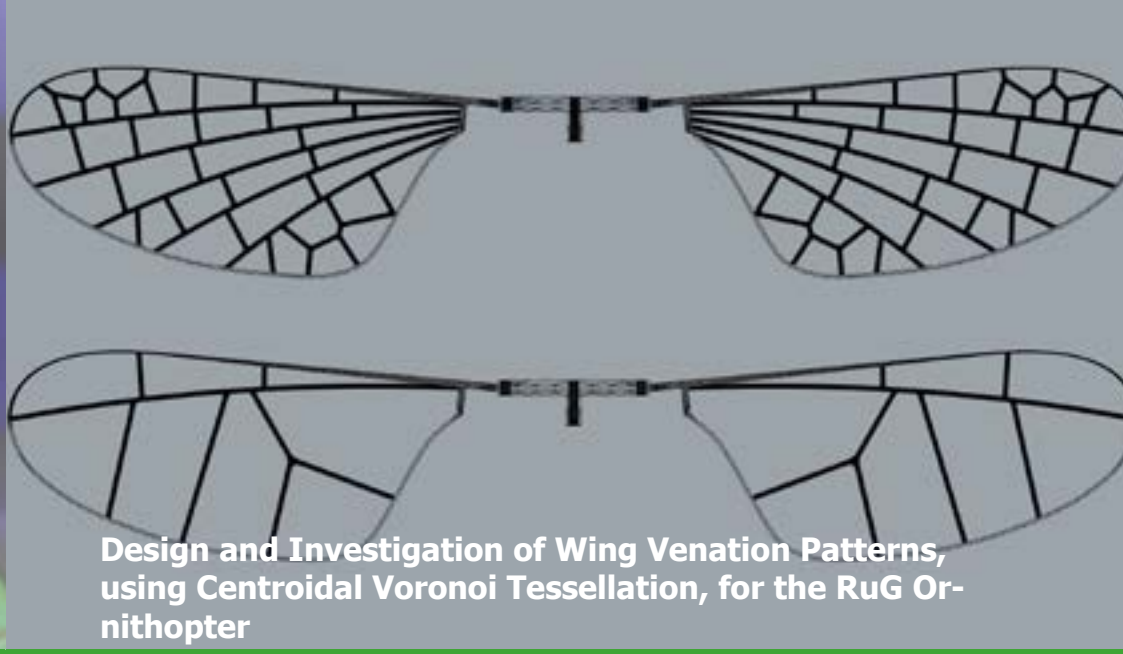
Veerle van Citters

Health care systems in the Netherlands are recognized to be unsustainable in their current design. A significant source of the negative environmental impact is the material consumption utilized during surgical procedures, including disposable and reusable surgical instruments. The healthcare pollution calls for greater transparency through medical instrument life cycles.

The usage of resources and materials have been growing rapidly over the years in which the rising use of disposable instruments, replacing reusables, contributed significantly. The consumption of medical devices contributes more to healthcare CO2 than energy use and transport combined. Moreover, the decision for a medical product often does not include environmental considerations.

Selecting instruments with a reduced life cycle could contribute to a decline of the environmental impact of general practices. Therefore, this study investigates the environmental footprint of the utilization of disposable versus reusable instruments in general practices in the Netherlands by applying life cycle assessment. In addition, it provides a design to adhere to the optimal scenario.





Design and Investigation of Wing Venation Patterns, using Centroidal Voronoi Tessellation, for the RuG Ornithopter

Ruben van de Ven

Alexander Sherwood

With the increasingly popularity of drones more applications are found for Micro air vehicles. However with the decreasing size other aerodynamic effect start to appear. To make use of these aerodynamics for small vehicles an inspiration is taken from nature and an ornithopter is created.

An ornithopter is a Micro Air Vehicle that utilizes flapping wings to generate lift. Previous iterations of The University of Groningen's ornithopter require further investigation and refinement. This project researches this derivative design iteration in the pursuit of improvement of the 3D printing process, assembly of components, and the influence of the wing sizes on the flight performances.

Of particular emphasis in this project were the interplay of wing-size and aerodynamic performance – especially in regards to lift production and wing kinematics. Small MAVs are particularly influenced by unsteady aerodynamics, as unsteady aerodynamics have a greater influence on smaller air vehicles, the size differentiation of the wings can increase the efficiency and therefore allow for more lift being generated allowing for future autonomous flight of an 3D printed ornithopter. Furthermore the process has been mapped out to be used by the second year learning communities.

Throughout the insect world, many specimens exhibit differing wing venation. These differing patterns directly influence wing kinematics and aerodynamics. By ensuring different distributions of flexion throughout their wings, venation designs can potentially reach superior energy harvesting efficiencies, angles of attack, and even lift generation when compared to those designs with no veins.

This integration project iterates the design of the RuG ornithopter, based on Richter and Lipson's mechanical insect ornithopter. The impetus for this project was a lack of systematic evaluation of venation structure in previous iterations. By investigating the effects of the shape and number of primary and secondary wing veneration, the impact of these patterns and a subsequent best-performing design were ascertained.

To accomplish this, a Weighted Centroidal Voronoi (WCV) tessellation algorithm, provided by Saito et al., was utilized to generate secondary vein patterns. These procedural patterns are biomimetic and closely mirror the vein patterns of the order Odonata – which include Damselflies and Dragonflies.

Through procedural modeling in Rhino 7 and Grasshopper, different designs were 3D printed with a Stereolithography (SLA) FlashForge Creator Pro 2. These wings were subsequently tested for lift production using a WHADDA 20kg Load Cell connected via an HX711 amplifier to an Arduino Uno.