Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

2023
Abschlussarbeiten
Travaux de fin d'études
Graduation Theses

Master of Science in Engineering

▸ Technik und Informatik
▸ Technique et informatique
▸ Engineering and Computer Science

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Editorial

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Leiter Master of Science in Engineering
Responsable du domaine Master of Science in Engineering
Head of Division Master of Science in Engineering

Liebe Leserin, lieber Leser
Mit dieser Ausgabe des MSE-Books endet für die Studierenden des diesjährigen Abschlussjahrgangs ein interessanter, lehrreicher und wichtiger Lebensabschnitt. Ich gratuliere ihnen zum Diplom und wünsche ihnen alles Gute, viel Erfolg und grosse Freude bei ihrem zukünftigen Wirken. Für die übrigen Leserinnen und Leser ist das MSE-Book ein interessanter Einblick in die spannenden Projekte, die mit viel Engagement, Kreativität und Hingabe bearbeitet wurden.

Der Master of Science in Engineering ist ein Kooperationsmaster aller acht Schweizerischen Fachhochschulen. An der BFH bilden wir spezialisierte Fachkräfte in elf Profilen aus. Die Studierenden, die dieses Programm absolvieren dürfen, zählen in der Schweiz zu den qualifiziertesten Talenten. Sie werden durch unsere Dozierenden und wissenschaftlichen Mitarbeitenden praxisnah, zukunftsgerichtet und mit vielfältigen Kompetenzen ausgestattet und auf die kommenden Herausforderungen in der Berufswelt vorbereitet.

Von grosser Bedeutung sind für uns die Kooperationen mit der Wirtschaft. Ich freue mich daher, dass es auch in diesem Jahr wieder möglich war, zahlreiche Master-Arbeiten gemeinsam mit Industriepartnern sowie Forschungseinrichtungen durchzuführen. Der Transfer von angewandter Forschung in die praktische Anwendung ist für uns zentral.

Viel Spass bei der Lektüre der diesjährigen Abschlussarbeiten!

Chère lectrice, cher lecteur,
Cette édition du Book du MSE marque la fin d'une période de vie intéressante, enrichissante et essentielle pour les étudiant-e-s de cette volée. Je les félicite pour leur diplôme, leur adresse mes meilleurs vœux et leur souhaite beaucoup de succès et de joie dans leur future activité. Pour les autres lecteurs et lectrices, le Book du MSE offre un aperçu captivant des projets palpitants qui ont été traités avec force engagement, créativité et ardeur.

Le Master of Science in Engineering est un programme d'études proposé conjointement par l'ensemble des huit hautes écoles spécialisées suisses. La BFH forme des professionnel-le-s spécialisé-e-s dans onze profils. Les étudiant-e-s qui ont la possibilité de suivre ce programme comptent parmi les talents les plus qualifiés de Suisse. Nos enseignant-e-s ainsi que nos collaborateurs et collaboratrices scientifiques leur transmettent une vaste palette de compétences axées sur la pratique et orientées vers l'avenir, les préparant ainsi aux défis professionnels de demain.

La coopération avec les milieux économiques revêt une grande importance à nos yeux. Je suis donc très heureux qu'il ait été possible, cette année encore, de réaliser de nombreux travaux de master en collaboration avec des partenaires industriels et des instituts de recherche. Le transfert de la recherche appliquée vers l'application pratique nous tient tout particulièrement à cœur.

Je vous souhaite une agréable lecture des travaux de fin d'études 2023!

Dear Reader
This issue of the MSE Book marks the end of an interesting and important educational period in the life of the students in this year's graduating class. I would like to congratulate them on gaining their degree and wish them all the best, every success and much joy in their future work. For the rest of the readers, the MSE book is an interesting insight into the exciting projects that were worked on with no end of commitment, creativity and dedication.

The Master of Science in Engineering is a cooperative master's programme run by all eight Swiss universities of applied sciences. At BFH, we train specialised professionals in eleven profiles. The students who are privileged to pursue this programme are among the most qualified talents in Switzerland. Our lecturers and research associates provide them with the diverse industry-relevant, future-oriented skills required to prepare them for the challenges that lie ahead in the professional world.

Collaboration with industry is extremely important to us. So I am all the more pleased that this year it was once again possible to carry out numerous master's theses in conjunction with industrial partners and research institutions. The transfer of applied research into practical application is a key priority for us.

We hope you enjoy reading this year's graduation theses.

Master of Science in Engineering an der BFH
Le Master of Science in Engineering à la BFH
Master of Science in Engineering at BFH

An der Berner Fachhochschule BFH wird anwendungsorientiert gelehrt und geforscht. Das Zusammenspiel von Lehre, Forschung und Entwicklung sowie Weiterbildung gewährleistet am Departement Technik und Informatik Praxisnähe, innovative und zukunftsgerichtete Lösungen, gepaart mit unternehmerischem Spirit.

Der Master-Studiengang Master of Science in Engineering (MSE) ist ein gemeinsames Bildungsangebot aller Schweizer Fachhochschulen. Das MSE-Diplom ist der höchste akademische Abschluss, den die Fachhochschulen im Bereich Technik und Informatik, Life Sciences sowie Bauwesen vergeben. Das Studium steht nur den besten Abgänger*innen der Bachelor-Studiengänge offen. Entsprechend hoch ist auch die Anerkennung dieses Mastertitels, der seit fünfzehn Jahren mit grossem Erfolg angeboten wird.

Internationale Ausrichtung
Mit der zunehmenden Internationalisierung steigt die Vergleichbarkeit der Studiengänge. Der internationale Austausch ist ein wichtiger Aspekt dieser Master-Ausbildung: Einerseits sind Studienaufenthalte im Ausland möglich, andererseits bieten mehrere Vertiefungen (Profile) auch eine Mitarbeit in internationalen Forschungsprojekten an. Hinzukommt, dass die Mehrzahl der zentralen, gesamtschweizerisch organisierten Lehrveranstaltungen in Englisch durchgeführt werden. Dies bringt den Student*innen nebst Kontakten mit Gleichgesinnten aus dem In- und Ausland auch sprachlich einen deutlichen Mehrwert.

Hoher Praxisbezug
Die theoretische Grundausbildung wird von den Schweizer Fachhochschulen gemeinsam an den zentralen Standorten in Lausanne, Zürich und Lugano angeboten. Parallel zum Besuch der Theoriemodule werden die Studierenden von Beginn an in eine Forschungseinheit eingebunden und

L'enseignement et la recherche à la Haute école spécialisée bernoise BFH sont axés sur les applications. Au sein du département Technique et informatique, l'interaction entre les cours, la recherche et le développement, et la formation continue garantit une proximité avec la pratique, des solutions innovantes et orientées vers l'avenir, le tout couplé à l'esprit d'entreprise.

Le programme de Master of Science in Engineering (MSE) est une offre de formation conjointe de l'ensemble des hautes écoles spécialisées suisses. C'est le diplôme le plus élevé décerné par les hautes écoles spécialisées dans les domaines Technique et informatique, Life Sciences et Génie civil. Seul-e-s les meilleur-e-s diplômé-e-s des filières d'études de bachelor y ont accès. La reconnaissance de ce titre de master, qui rencontre un grand succès depuis quinze ans, est d'autant plus élevée.

Orientation internationale
Avec l'internationalisation croissante, il est de plus en plus facile de comparer les filières d'études. L'échange international est un aspect important de cette formation de master : des séjours d'études à l'étranger sont possibles et plusieurs orientations (profils) proposent une coopération à des projets de recherche internationaux. En outre, la majorité des cours centraux organisés à l'échelle nationale se déroulent en anglais, ce qui permet aux étudiant-e-s d'entrer en contact avec des personnes de Suisse et de l'étranger partageant les mêmes idées et apporte une véritable valeur ajoutée sur le plan linguistique.

Forte orientation pratique
La formation théorique de base est proposée conjointement par les hautes écoles spécialisées suisses sur les sites centraux à Lausanne, Zurich et Lugano. Parallèlement

Teaching and research activities at Bern University of Applied Sciences BFH place a strong focus on application. At the School of Engineering and Computer Science, the fusion of teaching, research and development and continuing education – coupled with an entrepreneurial spirit – guarantees practice-driven, innovative and future-oriented solutions.

The Master of Science in Engineering (MSE) degree programme is run jointly by all Swiss universities of applied sciences. The MSE degree is the highest academic qualification that these universities can award in engineering, information technology, life sciences and civil engineering. It is only available to the best graduates from the bachelor's degree programmes. This master's degree – which has now been available in this form for 15 years – enjoys an excellent reputation.

International orientation
Increasing internationalisation makes it easier to compare degree programmes. This explains why international exchange is also a key element of this master's programme. Study periods abroad are available and several specialisations (profiles) offer the opportunity to collaborate on international research projects. Furthermore, most of the lectures organised centrally for the whole of Switzerland are held in English, which is of great benefit to students linguistically, as well as giving them the opportunity to meet like-minded peers from Switzerland and abroad.

High degree of practical application
The theoretical foundation courses are provided jointly by the Swiss universities of applied sciences at the central locations in Lausanne, Zurich and Lugano. While undertaking the theory modules,

arbeiten an Projekten aus der Praxis. Die Abschlussarbeiten sind alle direkt an Fragestellungen aus der Wirtschaft gekoppelt.

Gute Marktchancen

Studienabgänger*innen qualifizieren sich mit dem Master of Science in Engineering für eine Karriere in Forschungs- und Entwicklungsabteilungen, in der Produktion, Logistik, in der Beratung, in der Wirtschaft oder in öffentlichen Institutionen. Oder sie übernehmen Verantwortung bei der Leitung interdisziplinärer Projekte. Weil sie meist schon für ihre Abschlussarbeit eng mit einem Unternehmen zusammengearbeitet haben, sind ihre Aussichten, anschliessend in der Wirtschaft Fuss zu fassen, exzellent.

Das Weiterbildungsangebot richtet sich an Ingenieur*innen und angehende Manager*innen, die ihre Kompetenzen erweitern oder ergänzen wollen. Nebst den Tätigkeiten in den Bereichen Lehre und Weiterbildung wird anwendungs- und marktorientierte Forschung betrieben, um den Wissenstransfer in die Wirtschaft und die Nähe zur Industrie zu gewährleisten.

Erfahren Sie mehr über

> den Master of Science in Engineering: bfh.ch/mse
> das Departement Technik und Informatik: bfh.ch/ti
> Forschung an der BFH: bfh.ch/forschung
> Weiterbildungsangebote am Departement Technik und Informatik: bfh.ch/ti/weiterbildung
> ein Bachelor-Studium: bfh.ch/ti/bachelor
> ein TI-Master-Studium: bfh.ch/ti/master
> die Zusammenarbeit mit der Industrie: bfh.ch/ti/projektidee
> Entrepreneurship an der BFH-TI: bfh.ch/ti/entrepreneurship

au suivi des modules théoriques, les étudiant-e-s sont intégrés d'entrée à une unité de recherche et travaillent sur des projets pratiques. Les travaux de fin d'études sont tous liés directement aux défis du monde économique.

Bonnes opportunités sur le marché

Avec le Master of Science in Engineering, les diplômé-e-s sont qualifié-e-s pour une carrière dans des départements de recherche et développement, dans la production, la logistique, le conseil en entreprises ou dans des institutions publiques. Ils et elles peuvent aussi assumer la direction de projets interdisciplinaires. Ayant souvent déjà collaboré étroitement avec une entreprise dans le cadre de leur travail de fin d'études, leurs perspectives de s'insérer dans le monde économique sont excellentes.

L'offre de formation continue s'adresse aux ingénieur-e-s et aux futur-e-s managers qui souhaitent étendre ou enrichir leurs compétences. Outre les activités dans la formation et la formation continue, le cursus propose des activités de recherche axées sur le marché et la pratique, garantissant ainsi le transfert des connaissances dans l'économie et la proximité avec l'industrie.

En savoir plus sur

> le Master of Science in Engineering : bfh.ch/fr-mse
> le département Technique et informatique : bfh.ch/ti
> la recherche à la BFH : bfh.ch/recherche
> l'offre de formation continue du département Technique et informatique : bfh.ch/ti/fr/formationcontinue
> les études de bachelor : bfh.ch/ti/fr/bachelor
> les études de master TI : bfh.ch/ti/fr/master
> la collaboration avec l'industrie : bfh.ch/ti/idee-projet
> l'entrepreneuriat à la BFH-TI : bfh.ch/ti/entrepreneurship

the students are assigned a research unit right away and work on application-oriented projects. The graduation theses are all directly linked to issues from industry.

Good market opportunities

Master of Science in Engineering graduates are well qualified for careers in research and development departments, production, logistics, business consulting and public institutions. Some assume responsibility for the management of interdisciplinary projects. As most have already worked closely with a company on their graduation thesis, they have excellent prospects when it comes to launching a career in industry.

The continuing-education programmes are aimed at engineers and prospective managers who wish to extend or enhance their skills. In addition to our activities in teaching and continuing education, we conduct application-led, market-oriented research to ensure an efficient knowledge transfer and close ties to industry.

Learn more about

> the Master of Science in Engineering: bfh.ch/en-mse
> the School of Engineering and Computer Science: bfh.ch/ti
> research at BFH: bfh.ch/research
> continuing education courses at the School of Engineering and Computer Science: bfh.ch/ti/continuingeducation
> Bachelor studies: bfh.ch/ti/en/bachelor
> TI Master studies: bfh.ch/ti/en/master
> cooperation with the industry: bfh.ch/ti/projectidea
> entrepreneurship at BFH-TI: bfh.ch/ti/entrepreneurship

Steckbrief
Fiche signalétique
Fact Sheet

Titel/Abschluss
Master of Science (MSc)

Studienform
Vollzeitstudium (3 Semester) oder
Teilzeitstudium (7 Semester)

Unterrichtssprache
Englisch/Deutsch oder Englisch/Französisch

Vertiefungen
Der Master of Science in Engineering
umfasst eine breite Palette an fachlichen
Kompetenzen. Diese sind schweizweit in
fünfzehn Profile gegliedert. Der MSE kann
an der Berner Fachhochschule in elf Profilen
erworben werden:
• Business Engineering
• Civil Engineering
• Computer Science
• Data Science
• Electrical Engineering
• Energy and Environment
• Information and Cyber Security
• Mechanical Engineering
• Mechatronics and Automation
• Medical Engineering
• Photonics and Laser Engineering

Das gewählte Profil ermöglicht eine beinahe
massgeschneiderte fachliche Vertiefung,
welche an einer unserer Forschungseinrich-
tungen in enger Zusammenarbeit mit einem
Advisor absolviert wird.

Abschlussarbeit
Die Praxisorientierung des Studienganges ist
zentral: Studierende werden in Forschungs-
projekte einbezogen und schreiben ihre
Abschlussarbeit (im Vollzeitstudium ein, im
Teilzeitstudium zwei Semester) in der Regel
in Zusammenarbeit mit einem Unternehmen.

Kontakt
Haben Sie Fragen zum Master-Studiengang
MSE? Wir freuen uns auf Ihre Kontaktauf-
nahme!

+41 32 321 62 37
mse@bfh.ch (Sekretariat)

Web
bfh.ch/mse
bfh.ch/book-mse
bfh.ch/registration-mse

Titre/Diplôme
Master of Science (MSc)

Forme des études
Études à plein temps (3 semestres) ou
à temps partiel (7 semestres)

Langues d'enseignement
anglais/allemand ou anglais/français

Orientations
Le Master of Science in Engineering
englobe une large palette de compétences
techniques réparties sur quinze profils en
Suisse. La Haute école spécialisée bernoise
propose onze profils de MSE :
• Business Engineering
• Civil Engineering
• Computer Science
• Data Science
• Electrical Engineering
• Energy and Environment
• Information and Cyber Security
• Mechanical Engineering
• Mechatronics and Automation
• Medical Engineering
• Photonics and Laser Engineering

Le profil choisi offre un approfondissement
presque sur mesure des connaissances
techniques dans l'une de nos unités de
recherche, en étroite collaboration avec un-e
mentor-e.

Travail de fin d'études
L'orientation pratique du cursus joue un rôle
central : les étudiant-e-s sont impliqué-e-s
dans des projets de recherche et rédigent
généralement leur travail de fin d'études
en collaboration avec une entreprise
(sur un semestre pour les étudiant-e-s à
temps plein, sur deux semestres pour les
étudiant-e-s à temps partiel).

Contact
Avez-vous des questions sur la filière
d'études de master MSE ?
N'hésitez pas à nous contacter !

+41 32 321 62 37
mse@bfh.ch (Secrétariat)

Web
bfh.ch/mse
bfh.ch/book-mse
bfh.ch/registration-mse

Title/degree
Master of Science (MSc)

Mode of study
Full-time study (3 semesters) or
part-time study (7 semesters)

Language of instruction
English/German or English/French

Specialisations
The Master of Science in Engineering cov-
ers a wide range of specialist skills. These
are divided into fifteen profiles throughout
Switzerland. The MSE can be obtained
in eleven profiles at Bern University of
Applied Sciences:
• Business Engineering
• Civil Engineering
• Computer Science
• Data Science
• Electrical Engineering
• Energy and Environment
• Information and Cyber Security
• Mechanical Engineering
• Mechatronics and Automation
• Medical Engineering
• Photonics and Laser Engineering

The chosen profile enables candidates
to undertake an almost custom-made
specialisation, which is completed at one
of our research institutions under the close
supervision of an advisor.

Graduation thesis
The practical focus of the degree programme
is essential: students participate in research
projects and generally write their graduation
thesis – which takes an entire semester on
the full-time programme and two entire
semesters on the part-time programme – in
collaboration with a company.

Contact
Do you have any questions about the MSE
master's degree programme?
We look forward to hearing from you.

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Web
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bfh.ch/book-mse
bfh.ch/registration-mse

Interviews mit Studierenden
Interviews d'étudiant-e-s
Interviews with students

Nasser Diouri

Why did you decide to do this programme?
After finishing my Bachelor in Mechanical Engineering in London, I was interested in learning more about the business side of engineering. A lot of people asked me if a wanted to do an MBA. Business engineering is a multi-disciplinary field that blends engineering principles with business management and technology processes. After conducting thorough research, I came across the MSE with a specialisation in Business Engineering. While going through the programme curriculum, I realised that it encompasses a wide range of skills, including project management, process improvement, data analysis and problem-solving. The main reason why I chose this programme is because such a set of skills can be applied across multiple industries, giving me a strong base for future career prospects. In addition to the skill set, what I found really interesting is the possibility to attend classes throughout Switzerland, in Lugano, Zurich or Lausanne.

What did you like best?
The flexibility and the teaching method. The programme gives you the opportunity to choose classes in line with your professional needs and interests. Additionally, the teaching methodology is designed to include real-life applications, which enhances the learning experience and prepares you for your future work environment.

How was your daily schedule during your studies?
In my case, I used to begin my day by taking the train from Bern to Zurich at 7am. I would meet up with my fellow students at 8.30am for a morning coffee before attending our first class, which ran from 9.10am to 11.45am. After a short lunch break, we would attend our second class at 1.10pm. Once the afternoon session was over, I would catch the 5pm train back to Bern. During my train ride, I was able to attend the first half of the evening class and would arrive home just in time for the exercise part of the lecture. What is important to remember is that each semester, you have the possibility to choose your classes based on your personal and professional needs. Therefore, you have a high degree of flexibility when it comes to managing and scheduling your time.

Did you work during your studies? (during the semester / holidays)
Yes, during the first 4 semesters, I was working up to 80% as a car mechanic at Garage Steinmann AG. (I seize this opportunity to thank Daniel, the owner of the company, for his flexibility and support during my studies). In my 5th semester, I was working part-time at BFH as an assistant.

What were the major challenges during your studies?
I called my study journey «The Fight», because one of the primary challenges was keeping up with my studies while taking care of personal and professional obligations. Did I ever think about giving up? Yes I did! Sometimes you might feel overwhelmed by situations. However, with the right mindset and a fighter spirit, any type of challenge can be overcome.

## What is your career plan after graduation? What is your current occupation?
Currently, I work as a junior technical project manager at Schindler in the CRD department. It has not been long, but I am already using some of the skills developed during my studies. In regard to future career plans, I cannot say a lot. All I know is that I am looking forward to taking the knowledge and skills gained at BFH around the world to support my personal and professional growth.

How could you leverage what you have learnt during the programme?
Overall, the MSE equips students with a diverse set of skills that can be leveraged to excel in various industries and roles, from engineering to business development and management. For instance, the ability to analyse and interpret data can be used to make informed decisions and recommendations, particularly in roles that require strategic planning or data-driven insights.

What are your recommendations for future students?
Your future is in your hands! The decision you make today will affect your future tomorrow. If you decide to attend the MSE, irrespective of the chosen specialisation, you will open up a world of opportunities much larger than you think! And remember: it is not meant to be easy. The key is to never give up!
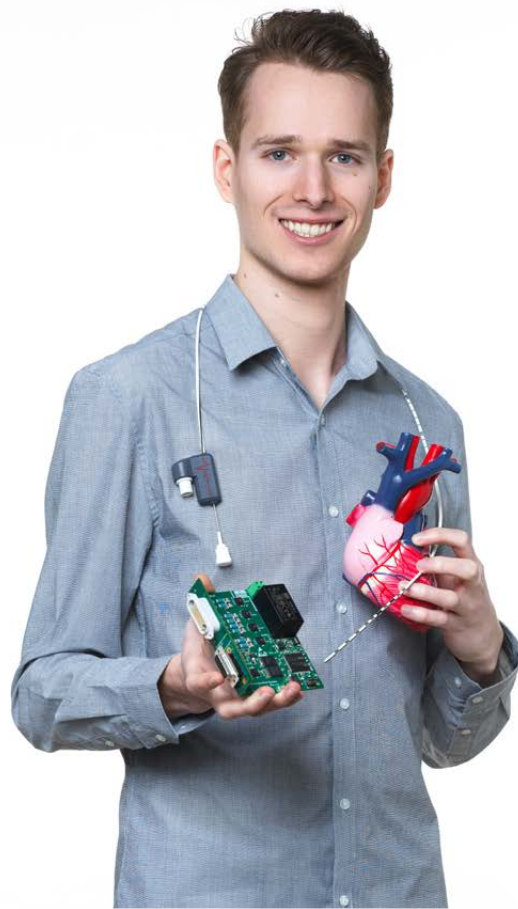
Bruno Stucki

Why did you decide to do this programme?

My bachelor studies piqued my curiosity and left me motivated to continue learning about and specialising in the exciting field of electronics. I got the chance to pursue a Research Fellowship that guaranteed financial stability, so it was a self-evident decision for me to pursue an MSE. Furthermore, a well-recognised master's degree future-proofs my intentions of working in an international environment.

What did you like best?

The scope of the studies and working with great, passionate colleagues. I focused on embedded systems and electronics engineering, but my project work allowed me to apply this know-how in a medical setting. Besides studying computing architectures and signal processing, I could profit from talking to colleagues and learnt a lot about heart anatomy and physiology, which in the end became the topic of my master's thesis. All of this comes together in an actual product that is about to be commercialised and will contribute to health care and help actual patients. I am very glad to have been given the opportunity to work on a project with such a sustainable impact and meaning, in accordance with my ethical values.

How was your daily schedule during your studies?

In the first two semesters, I was in Zurich for two days of lectures per week. Also, for some time the supplementary courses were taught locally at BFH and scheduled favourably for students. This way, the assignments and exams were separated from central module exam periods. In the remaining time, I worked on project tasks, either at the office or from home. After finishing my individualised lecture curriculum, I worked full-time in the last two semesters, with 50% on tasks assigned by my advisor and 50% on the master's thesis.

What were the major challenges during your studies?

Surely to manage the increased workload (compared to a BSc degree). Also, schedules with lectures, assignments, project work and leisure represented a challenge. But coming from an industrial working background, the adaption to a research environment posed the greatest challenge for me. Everything is much more agile and you are given responsibility for managing your project tasks, your time and engineering decisions, which can sometimes be difficult. Meanwhile, your advisor, team and colleagues support you with their know-how and experience. So in the long run, the programme is a great way of specialising in your field of choice while growing as an engineering professional and materialising your potential.

What are your recommendations for future students?

Go for it! While you will still be able to switch projects or topics during your studies, I recommend getting in touch with many potential advisors early on and learning about their research and opportunities in order to find a setting that best matches your preferences and skills. Or find support and pursue your very own ideas! And definitely take advantage of courses from other profiles to broaden your knowledge. The studies pass all too quickly, so I recommend talking to former students and planning your modules in advance to get the most out of the programme.

Interviews mit Studierenden
Interviews d'étudiant-e-s
Interviews with students

Clara Vaerst

Pourquoi avez-vous choisi cette filière d'études ?

Après avoir réussi mon Bachelor en Ingénierie de gestion industrielle, j'ai travaillé à l'étranger dans le secteur spatial pendant 2 ans. À mon retour en Suisse, j'ai voulu reprendre des études et un Master en Ingénierie s'inscrivait dans la suite logique de mon parcours académique. Dans le but de m'orienter vers un domaine qui place davantage l'humain au centre, l'option « Medical Engineering » a tout particulièrement attiré mon attention.

Comment était votre emploi du temps pendant vos études ? Qu'est-ce qui vous a le plus plu / passionné tout particulièrement ?

Mon emploi du temps était réparti entre les modules théoriques et les projets d'approfondissement. J'ai eu l'opportunité de suivre les modules à Lausanne (en francais) ou à Zurich (en anglais). Le projet d'approfondissement m'a le plus plu, car je pouvais travailler sur un projet concret en laboratoire et directement appliquer les contenus transmis dans les modules théoriques à un contexte particulier.

La Summerschool « Swiss Biodesign » m'a également spécialement plu. C'était un cours interdisciplinaire qui réunissait des étudiant-e-s de différents domaines (Ingénierie, Business et Santé). En parallèle à la théorie sur les processus d'innovation dans les technologies médicales, nous avons été amené-e-s à développer un concept d'appareil médical innovant.

Avez-vous travaillé en parallèle ?

Non, j'ai effectué la première année à temps plein, sans travailler en parallèle, pour pouvoir me concentrer exclusivement sur mes études. Ensuite, j'ai décidé de passer à temps partiel pour réaliser mon mémoire de master et pour intégrer le monde professionnel à un taux d'occupation de 50 % . Cela me permet d'avoir une certaine diversité dans mon quotidien.

Quels sont vos projets d'avenir ? Que souhaitez-vous faire après vos études ? Ou que faites-vous aujourd'hui sur le plan professionnel ? Dans quelle mesure pouvez-vous tirer profit de vos études ?

Après mes études, j'ai l'opportunité d'intégrer diverses entreprises industrielles ou de services. La qualité et l'amélioration continue m'intéressent tout particulièrement, étant donné que ce sont des fonctions transversales qui intègrent à la fois des aspects techniques, méthodologiques et humains. À plus long terme, je vise une position dans le management ou une création d'entreprise. Grâce à ce master, j'ai pu approfondir mes compétences techniques et ai appris à faire face à des défis et à gérer des situations difficiles avec beaucoup de recul et de sang-froid, afin de trouver la meilleure solution à tout problème.

Que diriez-vous à quelqu'un qui aurait envie d'entreprendre ce genre d'études ?

Ces études combinent parfaitement la théorie et la pratique. Le savoir acquis durant les cours théoriques peut directement être appliqué aux projets d'approfondissement, ce qui rend l'apprentisage plus concret. De plus, on peut choisir parmi un grand nombre de modules différents. Ceux-ci offrent l'opportunité de créer un plan d'études adapté à ses intérêts et à ses aspirations professionnelles.

Zusammenarbeitsformen
Formes de collaboration
Collaboration

Neue Erkenntnisse gewinnen, Synergien schaffen, Praxisnähe erfahren: Die Berner Fachhochschule arbeitet in der angewandten Forschung und Entwicklung eng mit der Wirtschaft und der Industrie zusammen. Dadurch wird die Verknüpfung von Forschung und Lehre gestärkt, und es fliesst neues Wissen in den Unterricht ein. Dies führt zu einer qualitativ hochwertigen und praxisnahen Lehre. Damit Unternehmen bereits heute die Spezialistinnen und Spezialisten von morgen kennenlernen oder sich an eine Thematik herantasten können, besteht die Möglichkeit, Projekt- oder Abschlussarbeiten in Zusammenarbeit mit Studierenden durchzuführen. Als Wirtschaftspartner können Sie Themen vorschlagen. Werden Themen gewählt, bearbeiten Studierende diese alleine oder in kleinen Gruppen in dafür vorgesehenen Zeitfenstern selbstständig. Dabei werden die Studierenden von ihrer Fachperson sowie einer Dozentin oder einem Dozenten der Berner Fachhochschule betreut. Die Rechte und Pflichten der beteiligten Parteien werden in einer Vereinbarung geregelt.

Möchten Sie Themen für studentische Arbeiten vorschlagen und mehr über eine mögliche Zusammenarbeit erfahren? Kontaktieren Sie uns und überzeugen Sie sich vom Innovationspotenzial unserer Studierenden.

bfh.ch/ti/projektidee

Acquérir de nouvelles connaissances, créer des synergies, découvrir la pertinence pratique : dans le domaine de la recherche appliquée et du développement, la Haute école spécialisée bernoise travaille en étroite collaboration avec l'économie et l'industrie. Le lien entre la recherche et la formation est ainsi renforcé et l'enseignement profite des nouvelles connaissances. Il en résulte une formation de grande qualité, axée sur la pratique. Pour que les entreprises puissent faire aujourd'hui déjà la connaissance des spécialistes de demain ou aborder un sujet particulier, elles ont la possibilité de réaliser des projets ou des travaux de fin d'études en collaboration avec des étudiant-e-s. En tant que partenaire économique, vous pouvez proposer des thèmes. S'ils sont choisis, les étudiant-e-s les traitent ensuite de manière autonome, seul-e-s ou en petits groupes, dans les créneaux horaires prévus à cet effet. Ils et elles sont encadré-e-s par votre spécialiste ainsi que par un-e enseignant-e de la Haute école spécialisée bernoise. Une convention régit les droits et obligations des parties au projet.

Souhaitez-vous proposer des thèmes pour des travaux d'étudiant-e-s et en savoir plus sur une éventuelle collaboration ? Contactez-nous et laissez-vous convaincre par le potentiel d'innovation de nos étudiant-e-s.

bfh.ch/ti/idee-projet

Gain new insights, create synergies, experience practical relevance: Bern University of Applied Sciences BFH works closely with business and industry in areas of applied research and development. This strengthens the link between research and education, allowing new knowledge to flow into our teaching, which leads to high-quality and practice-oriented degree programmes. In order for companies to meet our future specialists or to explore a topic, they can carry out projects or theses in cooperation with our students. As a business partner, you can suggest topics. Once these topics are selected, the students work on the projects independently, either individually or in small groups, within designated time frames. They are supervised by both your specialist and a BFH lecturer. The rights and obligations of the parties involved are set out in a written agreement.

Would you like to suggest topics for student projects and find out more about a possible cooperation? Contact us and convince yourself of the innovation potential of our students.

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Studentische Arbeiten | Travaux d'étudiant-e-s | Student projects
Das Modell einer flexiblen Zusammenarbeit mit Industrie und Wirtschaft wird in studentischen Arbeiten erfolgreich umgesetzt:
La flexibilité du modèle de collaboration avec l'industrie et l'économie se concrétise avec succès dans les travaux d'étudiant-e-s:
The model of flexible cooperation with industry and business is successfully implemented in student projects:

Semesterarbeiten, Bachelor-Thesis, Master-Thesis
Travaux de semestre, travail de bachelor, mémoire de master
Semester projects, bachelor thesis, master thesis

Wochen bis Monate
De quelques semaines à plusieurs mois
Several weeks or months

Kostenbeitrag zulasten des Auftraggebers
Frais à charge du donneur d'ordre
Costs are at the expense of the client

Auftragsforschung und Dienstleistungen | Recherche sous contrat et prestations de service | Contract Research and Services
Wir bieten Auftragsforschung und erbringen vielfältige Dienstleistungen für unsere Kundinnen und Kunden (inkl. Nutzung der BFH-Infrastruktur sowie des Forschungsnetzwerkes). | Nous effectuons des recherches sous contrat et fournissons une vaste palette de prestations de services à nos clientes et clients – y compris l'utilisation des infrastructures BFH et du réseau de recherche. | We carry out contract research and provide a wide range of services for our clients, such as exclusive use of the BFH infrastructure and the research network.

Planung, Coaching, Tests, Expertisen, Analysen;
durchgeführt von Expertinnen und Experten
Planification, coaching, tests, expertises, analyses par des expert-e-s
Planning, coaching, tests, expertise, analysis: done by experts

Wochen bis Monate
De quelques semaines à plusieurs mois
Several weeks or months

Marktübliche Preise
Prix du marché
Prevailing prices

F&E-Kooperationen | Coopérations R&D | R & D Collaboration
Die BFH-TI erbringt Leistungen im Bereich der angewandten Forschung und Entwicklung:
La BFH-TI fournit des prestations de service dans le domaine de la recherche appliquée et du développement:
BFH-TI provides services in Applied Research and Development:

Kooperationen mit Fördermitteln – mittlere und
grössere Projekte mit:
Coopérations bénéficiant de subventions – projets de moyenne
et grande envergure avec:
Public Aid – medium and large-sized projects with:

Innosuisse, SNF / FNS / SNSF, EU / UE

Monate bis Jahre
De quelques mois à plusieurs années
Several weeks or months

Teilfinanziert durch
öffentliche Fördergelder
Financement partiel par
des subventions publiques
Partly public funding

Industriepartner
Partenaires industriels
Industry partners

Eine enge Zusammenarbeit mit Industrie-
partnern ist uns äusserst wichtig. Zahlreiche
Abschlussarbeiten sind in Kooperation mit
Firmen aus der ganzen Schweiz entstanden.
Wir bedanken uns bei diesen Firmen für die
fruchtbare Zusammenarbeit!

bfh.ch/ti/projektidee

À nos yeux, une collaboration étroite avec
des partenaires industriels est extrêmement
importante. De nombreux mémoires se font
en partenariat avec des entreprises de toute
la Suisse. Nous remercions ces entreprises
pour cette fructueuse collaboration !

bfh.ch/ti/idee-projet

A close cooperation with industrial
partners is very important to us. Numerous
bachelor's theses have been produced
in cooperation with companies from
Switzerland. We thank these companies for
the fruitful collaboration!

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Alpes Lasers SA, St-Blaise
Bern University of Applied Sciences, Biel
Bern University of Applied Sciences, Bern
E.M.S. Electro Medical Systems S.A., Nyon
ennos AG, Merzligen
Micos Engineering GmbH, Dübendorf
SCHNEEBERGER AG Lineartechnik, Roggwil
Swiss Cobotics Competence Center (S3C), Biel/Bienne
VICI AG, Schenkon

Liste der Studierenden
Liste des étudiant-e-s
List of students

14 Im Folgenden präsentieren wir Ihnen die Zusammenfassungen der Abschlussarbeiten des Jahres 2023.

Die Studierenden sind in alphabetischer Reihenfolge aufgeführt.

Die Studierenden haben die Texte – teils mit Unterstützung der betreuenden Dozierenden – selbst verfasst. Die Texte wurden vor Publikation nicht systematisch redigiert und korrigiert.

*Der Begriff «Abschlussarbeiten» ist mit Bedacht gewählt. Zum Zeitpunkt des Druckes handelt es sich um die Abschlussarbeiten von noch nicht diplomierten Studierenden. Nach Erhalt des Diploms entspricht die Abschlussarbeit der Diplomarbeit.

Ci-après, nous vous présentons les résumés des travaux de fin d'études de l'année 2023.

Les étudiant-e-s sont présenté-e-s par ordre alphabétique.

Les étudiant-e-s ont rédigé les textes de façon autonome, parfois avec l'aide des enseignant-e-s qui les encadrent. Les textes n'ont pas systématiquement été relus ou corrigés avant publication.

*Le terme «travaux de fin d'études» a été choisi judicieusement. Au moment de l'impression, il s'agit de travaux de fin d'études d'étudiant-e-s pas encore diplômé-e-s. Après l'obtention du diplôme, le travail de fin d'études correspond au travail de diplôme.

On the next pages, we have summarised the 2023 graduation theses.

The students are listed in alphabetical order.

The texts were written by the students themselves, with some support from their lecturers. They were not systematically edited or corrected before publication.

*The term "graduation theses" is carefully chosen. At the time of printing, these are the theses of students who have not yet graduated. After receiving the diploma, the thesis corresponds to the diploma thesis.

Analyse der Ermüdungslebensdauer von Wälzführungen unter verschiedenen Vorspannungen

Studiengang : Master of Science in Engineering | Vertiefung : Mechanical Engineering
Betreuer : Prof. Roland Rombach
Experte : Prof. Dr. André Lisibach
Industriepartner : SCHNEEBERGER AG Lineartechnik, Roggwil

Kompakte Profilschienenführungen sind moderne Maschinenelemente, die sich besonders durch ihre Eignung für hohe Geschwindigkeiten und Beschleunigungen im Arbeitsprozess auszeichnen. Um den hohen Beanspruchungen gerecht zu werden, ist u.a. die Kenntnis ihrer Lebensdauer von essentieller Bedeutung. Da die gängige Norm diesbezüglich nur grundlegende Einflussfaktoren berücksichtigt, bedarf es erweiterter Methoden zur Lebensdauerabschätzung.

Ausgangslage
Das Unternehmen SCHNEEBERGER AG Lineartechnik mit Standort in Roggwil bedient Erstausrüster verschiedenster Industriebranchen auf dem Gebiet der Lineartechnologie. Zur Produktpalette gehören u.a. kompakte Profilschienenführungen mit unbegrenztem Hub, die beispielsweise für die Industrie- und Laborautomatisierung zum Einsatz kommen. Dafür sind an sie u.a. hohe Anforderungen hinsichtlich ihrer Lebensdauer gestellt, welche jedoch bisher nur auf vereinfachte Weise bestimmt wird. Zurzeit basiert die Lebensdauervoraussage auf der gängigen ISO-Norm. Diese berücksichtigt jedoch keine Einflüsse, welche aus der Montage oder aus der Existenz unterschiedlicher Vorspannklassen hervorgehen.

Ziel
Das Ziel der Arbeit ist es, für eine ausgewählte Profilschienenführung die Ermüdungslebensdauer abhängig von verschiedenen Vorspannungen zu untersuchen und mit einem daraus erarbeiteten Berechnungsprozess zu ermitteln.

Vorgehen
In einem ersten Schritt erfolgte eine umfassende Literaturrecherche zur Lebensdauervorhersage von Wälzführungen. Daraus galt es, verschiedene Theoriemodelle zusammenzutragen und deren spezielle Eigenheiten in Bezug auf die konkrete Anwendung für die zu untersuchende Profilschienenführung hervorzuheben.
Der zweite Schritt befasste sich mit der Anwendung bei verschiedenen Lastfällen, um die u.a. von der gewählten Vorspannklasse abhängigen Lebensdauern zu bestimmen. Dafür kamen Simulationen basierend auf der Finite-Elemente-Methode zum Einsatz. Deren Ergebnisse konnten mit Hilfe der Lebensdauermodelle sowie Versuchsdaten verglichen und überprüft werden.

Dominik Bagaric

Ergebnisse
Es existieren statistische Methoden zur Analyse empirischer Daten, welche die Abschätzung der für die Lebensdauervorhersage relevanten Parameter auf Basis einzelner oder mehrerer, unterschiedlich grosser Versuchsreihen ermöglichen.
Weiter sind mehrere Theoriemodelle vorhanden, welche die Lebensdauerabschätzung eines einzelnen Kontaktpunktes basierend auf den vorherrschenden Schnittkräften zwischen den Wälzkörpern und den Laufbahnen bis hin zur Gesamtlebensdauer der Profilschienenführung erlauben.
Zuletzt besteht ein iterativer Berechnungsprozess, der die konkrete Anwendung der Lebensdauermodelle auf bestehende Versuchsdaten gestattet. Dieser offenbarte u.a. einen von der äusseren Belastung abhängigen Lebensdauerverlauf.

Modell der untersuchten Profilschienenführung
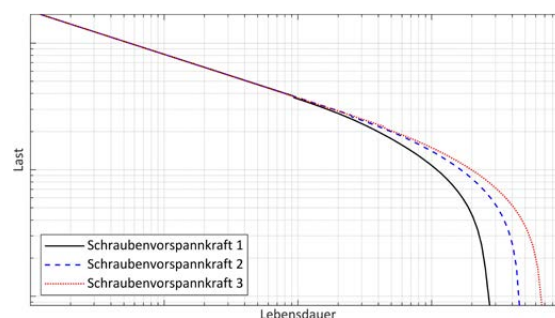
Lebensdauer in Abhängigkeit der externen Last

Data-Oriented Design: From Theory to Implementation

16

Complex, interconnected programs are ubiquitous in today's societies, as drivers and enablers of many recent technological advancements. To mitigate the difficulty of writing and maintaining such programs, paradigms of how to best develop software have emerged. This thesis investigates the data-oriented design (DOD) paradigm as an alternative to object-oriented design (OOD), which is the dominant paradigm taught and used in the software industry today.

Jan Alexander Dellsperger
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Outset
DOD advocates principles that favor clear data paths over abstraction and taking into account target hardware platforms when implementing software. This is in stark contrast to OOD, which promotes layers of abstraction and many small functions and classes that hide underlying soft- and hardware system implementations.

Method
Principles of DOD were researched and a software package, a game engine, was implemented (see fig. 1). A set of solutions to problems encountered during the project were thoroughly documented to serve as a baseline and inspiration for future work, highlighting where DOD principles guided the design.

Results and Conclusions
A series of tests was run on the DOD implementation as well as OOD comparison programs. The DOD programs consistently outperformed their OOD counterparts with considerable speedups (see fig. 2). The conclusion is drawn that DOD principles should be taught as a viable paradigm in informatics curricula and programmers should consider a more data-oriented approach when developing software.
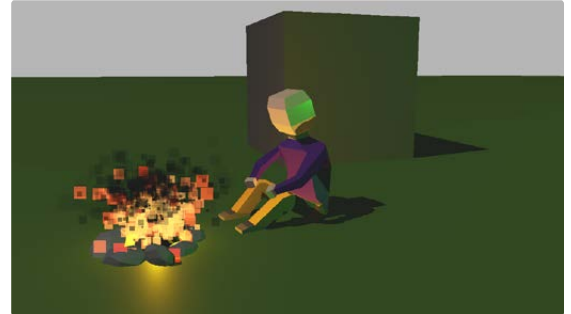

Fig. 1: A scene rendered in the custom game engine created for the thesis.
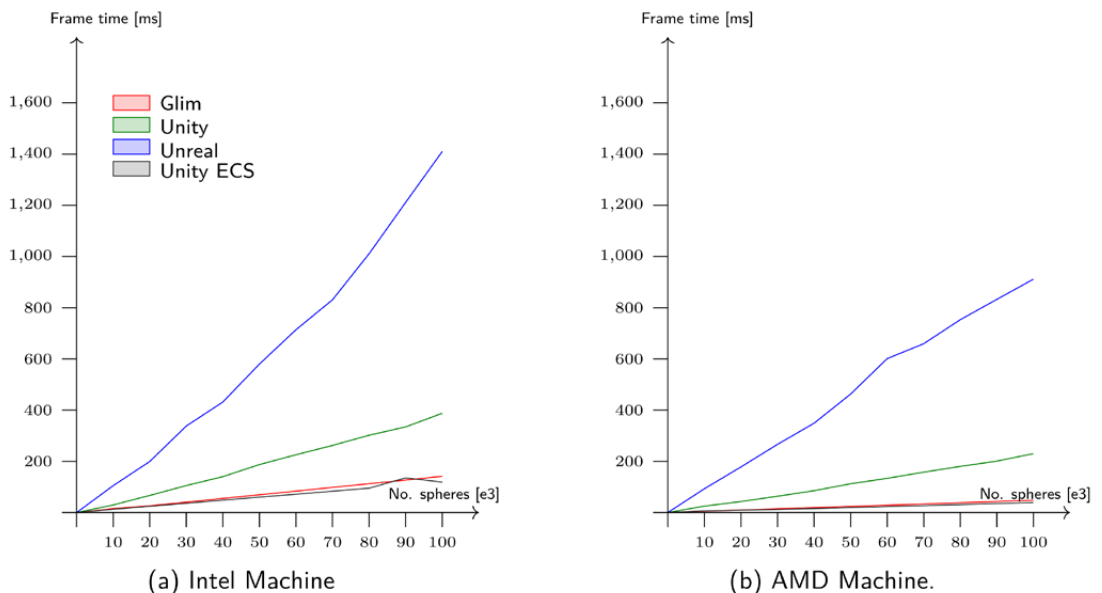

(a) Intel Machine

(b) AMD Machine.

Fig. 2: Performance measurements of a test program implemented in the custom game engine (in red) and industry standard solutions. The test was run on two different machines.

Academic entrepreneurship at BFH-TI: The case of module offerings and student attraction

Entrepreneurial activities at the Universities of Applied Sciences are becoming increasingly important to accelerate economic growth and support local communities. This research focuses on supporting the BFH-TI in improving entrepreneurial activities targeting three dimensions of academic entrepreneurship: module offering, student attraction and, the entrepreneurial ecosystem.

Introduction and Objectives

Google, Netflix, WhatsApp and Airbnb are names that we hear frequently, but do you know what these companies have in common? They belong to the most successful start-ups created by university graduates. Academic entrepreneurship holds an immense potential in transforming educational institutions into dynamic hubs of innovation, enabling students to stay ahead in a fast-changing and evolving economy. To bring new technologies from research to the market innovative ways must be explored to take academic entrepreneurship to a new level. The objectives of this research are to analyze universities of applied science(UAS) activities targeting academic entrepreneurship from a systemic perspective, create an attractive environment for BFH-TI students interested in entrepreneurial careers, and identify patterns and factors that influence the entrepreneurial ecosystem.

Research Design

The research design follows a qualitative and quantitative research method using surveys, interviews, and website analysis to address the research questions. The model built (Figure 1, left side) provides a holistic view of the universities' academic entrepreneurship landscape and identifies areas that can be recommended to improve and support the growth of entrepreneurial activities at BFH-TI. Mayring's method is used to analyze the interviews, supporting a systematic and structured approach to extracting valuable insights. Four main categories are defined: the UAS/University, student attraction, IP and spin-off regulations, and the ecosystem. Below the main categories, over twenty sub-categories are defined.

Results

BFH-TI offers classes that cover several entrepreneurial skill sets, and compared to the other UAS, the number of offerings is approximately equal or higher. A major difference is seen in the ECTS assigned to the modules. Based on the conducted interviews, having the same culture and vision shared among lecturers contributes to creating an attractive environment for students. In the student survey with 112 responses, it was revealed that entrepreneurial skills are highly valued by BFH-TI students, and word-of-mouth is the most common source of information used when choosing modules. The survey also revealed that 43% of the students are and may be interested in taking entrepreneurial modules if there is the possibility to learn a new skill set. It's important to note that 39% of the respondents did not complete this question in the survey.

Implications and Recommendations

The research concludes that potential growth is possible by improving marketing strategies, as 39% of the students either just heard or do not know about the offerings and benefits available. The recommendation is that lecturers within BFH-TI align to spread information about offerings, support, and benefits available. Another conclusion drawn from the interviews defines the importance of building inter-departmental collaboration to foster an entrepreneurial culture. Further work should review the progress of the new entrepreneurial minor available and explore partnerships with external universities for the accreditation of entrepreneurship modules to increase flexibility for students with time constrains.

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Figure 1: Ecosystem Model used to analyse Universities & Universities of Applied Science, BFH-TI Student survey results

Digital Supply Chain Transformation of SMEs: A Focus on Order Fulfilment Processes

Degree programme : Master of Science in Engineering | Specialisation : Business Engineering
Thesis advisor : Prof. Dr. Jörg Grimm

This thesis investigates the digital supply chain transformation in small and medium enterprises (SMEs) as they strive to stay competitive through digital transformation. It explores the interplay between technology, innovation, and business management. The study specifically focuses on optimizing order fulfilment processes in SMEs to develop a customized solution that addresses the challenges encountered in this aspect of the digital transformation journey.

Sandra Maria Eklund

Background

Digital supply chain transformation is increasingly crucial for businesses, particularly for SMEs. Compared to larger businesses, SMEs often face resource or knowledge limitations when it comes to implementing and managing a digital transformation, resulting in more substantial challenges. However, the research available on digital transformation is limited concerning SMEs and in-depth process-focused transformation. Hence, digital transformation is important but challenging for SMEs.

Objective

The research aimed to investigate the digital supply chain transformation process among SMEs by focusing on order fulfilment processes. Such a focus enabled a thorough investigation of the order fulfilment processes: processing, picking, packing, shipping, and tracking. Based on this investigation, a conceptual framework was developed that specifies the successful criteria for utilisation of digital transformation on order fulfilment from an SME perspective.

Methodology

The methodology utilised an inductive qualitative approach to construct a conceptual framework. This was achieved through an integrative literature review and a thematic analytical technique applied to data collected from 10 semi-structured interviews. The interview sample consists of managers selected based on their expertise and knowledge of digital transformation efforts within their respective companies. The managers selected for the study encompass a diverse range of roles within the supply chain or general business streams. These roles include positions such as head of logistics and chief operating officer, allowing the results to offer valuable insights into the digital supply chain transformation across SMEs of different sizes and industries in Europe.

Results

This study highlights the initial steps of digital transformation for SMEs, emphasizing the importance of conducting a thorough assessment of the organization and its order fulfilment processes. A conceptual framework is developed, incorporating previous strategies, and identifying critical success factors for digital supply chain transformation as identified by European SME managers. The framework addresses the selection and implementation of digital tools, leadership, and strategies while considering enablers and barriers. The research reveals the positive outcomes of transitioning from traditional to digital order fulfilment processes, accommodating limited resources and knowledge. The implications of the framework provide a structured approach for informed decision-making and highlight the role of active managerial involvement. Recommendations include comprehensive assessment, strategic planning, and continuous evaluation. By leveraging the framework, SMEs can effectively navigate their digital transformation journey, optimizing operations, gaining a competitive advantage, and ensuring sustainable growth.

Improved Robot Accuracy with Motion Capturing

Collaborative robots are advertised with good repeatability. However, in an agile production environment the absolute accuracy is the limiting factor. For example, the position error of a Universal Robot UR5e can exceed a few millimetres. Here an optical motion tracking system was used to improve the accuracy of the robot. A closed loop position controller was implemented in ROS2.

Context

Collaborative robots became very popular over the last years because they can be easily installed with a minimum of safety equipment and also easily programmed in an offline mode with teach-in methods. For that, of course, the repeatability is the important design factor. For more flexible applications where the robot receives the goal position at runtime the absolute accuracy of the robot is important.

Goal

The goal of this project is to improve the absolute accuracy of the robot with the help of a optical motion capturing system. A motion capturing system consists of multiple infrared cameras which track reflective markers in the three-dimensional space. A closed loop controller for the tool flange of the robot is implemented. The controller is implemented in ROS2 so it can be used in other research projects of the institute.

Method

The test setup consists of six Qualisys motion capturing cameras mounted on the ceiling of the laboratory and a collaborative UR5e robot. On the tool flange and at the base of the robot multiple markers are mounted to track the pose of the flange and the robot base. The black support to be mounted on the flange with the reflective markers can be seen in figure 1.

The cameras are connected to a Windows PC on which the software of the motion capturing system is running. The capturing software sends the poses of the robot flange and base over TCP/IP to a Linux PC and ROS2. The controller is composed of six separate P-Controllers to control all degrees of freedom and outputs the robot flange velocity in cartesian coordinates. ROS2 then calculates the joint positions of the robot and sends them over TCP/IP to the robot.

Results

To compare the implemented controller with the normal movements the robot was moved to multiple points in its workspace and the position error were measured with the motion capturing system. If the robot is operated in its normal mode, the positioning error has a median of 5 mm. The errors can be seen in figure 2, they show a dependency on the pose of the robot. The errors for different poses are indicated by a dot in the figure. Smallest errors (around 0.5 mm) are shown in blue and largest errors (around 10 mm) are shown in red. With the closed loop controller, the median error was reduced to 0.8 mm.

With the new controller the movements of the robot are way slower than with the normal mode. Furthermore, the cost of a motion capturing system is not negligible. Prices are in the same range as the robot itself.
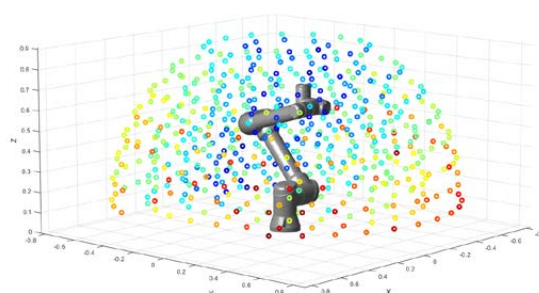

Oliver Kilian Fässler

Figure 1: Markers for Robot Flange

Figure 2: Position Errors normal Robot Movement

Development of a Hardware Accelerated Radio Direction Finder for Drone Remote Controls

Drones have become increasingly popular in recent years and so has their risk to enter into critical flight restricted zones, such as airports. To help mitigate this risk, a radio direction finder is being developed, which locates signals from within the 2.4GHz and 5.8GHz ISM bands. The research leading to these results was supported by the Swiss Center for Robotics and Drones of the Department of Defence, Civil Protection and Sport at armasuisse S+T under project No. O43-O1.

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Introduction

Drone remote controls nowadays use digital modulation schemes in conjunction with frequency-hopped spread spectrum (FHSS) to avoid channel interferences with other remote controls. These signals are usually located in the 2.4GHz ISM band and span over 80MHz. Some drones also incorporate a downlink for video (digital or analog) and telemetry data. Those are transmitted in the 5.8GHz ISM band in most cases, with a bandwidth between 6MHz to 40MHz. To process signals with bandwidths this large, a powerful software defined radio (SDR) is required. For this reason, the Xilinx ZCU111 is being used. The goal is to preprocess the large number of samples (5 x 128MHz after decimation) within the FPGA, so that the direction estimation can be done within the CPU of the ZCU111 without dropping any samples. In addition, an RF frontend will be developed to increase the sensitivity and frequency range of the receiver.

Concept and goals

The correlative phase interferometer is a robust and precise direction finder. It measures the phase difference between the antennas of a uniform circular array and compares them to a look-up table (LUT), that is being generated via measurements beforehand. The acquired samples are transformed into the frequency domain via an FFT in the FPGA. This has the advantage that multiple transmitters can be detected. To reduce the data throughput, each detected channel can be numerically integrated after the calculation of the phase difference in the frequency domain. This results in a data bandwidth in the range of kHz instead of MHz. To receive both 2.4GHz and 5.8GHz signals an RF fronted is incorporated. Each band features its own receiver, so that their sensitivity can be optimised.

Results

A digital signal processing chain was developed for the FPGA of the ZCU111, that can render the raw samples in into more compact phase differences for the direction estimation within its CPU. In the best-case scenario, it possible to reduce the throughput from 128MHz to 15.625kHz. The RF frontend was dimensioned to be as sensitive as possible, while keeping the noise figure as low as possible. Additionally, a sensor array, comprised of a GNSS receiver, accelerometer, gyroscope and compass, was included to get an absolute angle of arrival (AoA). A second PCB was developed, that interfaces with the RF fronted, to ease the measurement of its receivers.
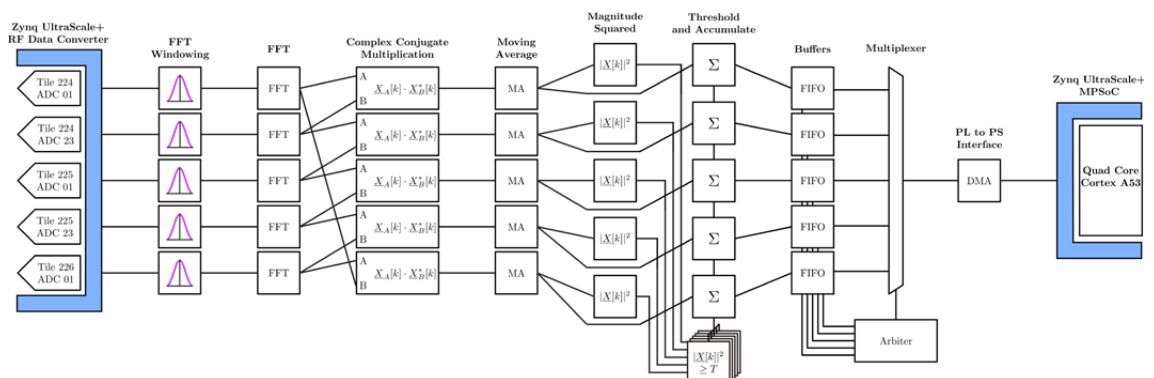
Digital signal processing chain

Intégration d'un ensemble complet de logiciels permettant la conduite autonome

Filière d'études : Master of Science in Engineering | Orientation : Energy and Environment
Encadrant : Prof. Peter Affolter
Expert : Prof. Marcus Hudritsch

La conduite autonome est un sujet qui prend progressivement de plus en plus de place tant sur la scène internationale que sur la scène suisse. Une certitude règne quant à son arrivée mais de nombreux défis demeurent encore. Comme pour tout domaine de recherche, nous pensons que la mobilisation de compétences est un élément clé à la découverte de solutions novatrices. C'est dans ce sens que l'idée d'intégrer un ensemble complet de logiciel open source nous a séduite.

Autoware est une fondation créée en 2015 qui propose un ensemble de logiciels open source autour de la conduite autonome, bien documenté et appuyé par une large communauté à travers le monde, elle possède aujourd'hui une communauté croissante construite autour du développement de logiciels pour la conduite autonome. Autoware est utilisé par de nombreuses entreprises à travers le monde et fonctionne sur plusieurs dizaines de véhicules.

Le but de ce projet est d'implémenter l'ensemble de logiciels proposé par Autoware sur notre projet sh@ttle afin qu'il soit capable de conduire de manière autonome.

Au départ de ce projet, sh@ttle, un véhicule Renault Twizy électrique entièrement d'origine, remanié par les différentes volées d'étudiants d'ingénieur en technique automobile afin de le rendre progressivement autonome. Le véhicule est passé par différentes étapes afin de pouvoir être commandé par logiciel : installation des capteurs, installation de moteurs électriques pour la commande des freins et de la direction, pose d'un ordinateur central, d'une unité de sécurité et d'un réseau de communication entre tous les éléments. Le véhicule est équipé et prêt pour l'implémentation des logiciels de conduite autonome. L'ensemble de logiciels comprend les parties suivantes : interface du lidar, localisation, perception, cartographie, planification, interface avec le véhicule et contrôle des moteurs.
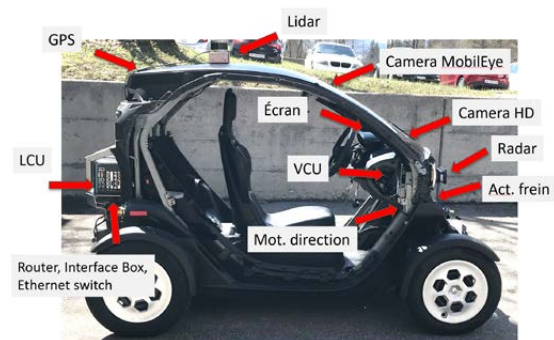
Basé sur le lidar, une carte 3D sous forme de nuages de points est créée servant de base pour la localisation du véhicule dans l'espace. Aussi, un autre type de carte est crée à des fins de planification de trajectoire appelé une carte haute-définition. Elle permet de définir le tracé des routes où le véhicule est autorisé à conduire, ainsi que d'autres informations tels que la limitation de vitesse, les feux et panneaux de signalisation et autres.

À la fin nous obtenons un véhicule capable de conduire de manière autonome dans un environnement connu, préalablement cartographié. Il possède les fonctionnalités suivantes :
– Se localiser de manière précise sur la carte
– Calculer le tracé de la trajectoire depuis sa position actuelle jusqu'à la destination choisie
– Capable de se mouvoir précisément le long de ce tracé
– Capable de s'arrêter lors de la détection d'objet sur son tracé

Le résultat final est un véhicule autonome sous la forme d'une plateforme de recherche et développement basé sur un ensemble de logiciels open source appuyé par une communauté compétente et grandissante.

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sh@ttle: écran de navigation embarqué

Supportive Auto Belay for Climbing

22

After bicycles, skateboards, SUP's and everything else that moves by muscle power, the Supportive Auto Belay "E-Climber" is now also electrifying climbing. It provides the necessary support for climbing whenever needed. It is intended to make climbing easier and make it accessible to people who are not or no longer able to climb due to an impairment. The E-Climber will be the e-bike for the climbing wall.

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Introduction

Climbing is becoming increasingly popular among the population and has established itself as a recreational sport in recent years. Climbing is a healthy sport that trains strength, endurance and coordination. It also promotes well-being, strengthens self-confidence and teaches people to remain calm in difficult situations. In addition to sport climbing, therapeutic climbing, under physiotherapists guidance, has also become more and more popular. The target groups are people with chronic illnesses, sensorimotor disorders or physical impairments. However, to be able to climb, basic physical requirements must be met. People with overweight or paraplegia, for example, usually do not meet these requirements and are, therefore, unable to climb a route using only their muscle power. In contrast to other sports, there is currently no device that can provide the necessary support for climbing.

Objective

The master's thesis is about the development of a "Supportive Auto Belay for Climbing". The focus is on designing and constructing mechanical hardware components with the additional integration of electric and mechatronic components. The overall goal is to develop a competitive device with full functionality according to the required standards.

Implementation

In previous projects, a proof of concept was made, and the requirements for the fully functional Supportive Auto Belay were defined. Based on the requirements, the mechanical design has been worked out in the first step. In the design phase, the manufacturing processes, suitable for small batches, had to be respected. Further on, all strength verifications of the critical mechanical parts were necessary and have been done. In the next step, the electrical and mechatronic components were included in the design. The challenge was to find a compromise between functionality, safety and the device's compactness. In a last step, the Supportive Auto Belay had to be tested and its safety verified. The somewhat experimental approach of the previous prototypes was professionalised and resulted in a fully developed product.

Result

The operation principle of the developed Supportive Auto Belay "E-Climber" is simple. The climber can select the desired support at the beginning of the route. This support makes the body feel lighter and therefore requires less strength and endurance for climbing. In addition to the support, the E-Climber reliably secures the climber. It has a specially developed gearbox, ensuring the climber's safety, regardless of an electrical malfunction. In the event of a fall, the built-in mechanical brake is activated, and the person is lowered slowly and safely to the ground.

Design of the Supportive Auto Belay «E-Climber»

Visual Blood Count

Blood holds a lot of information about a patient's well-being and is used to asses the health status. In particular, the blood cell count is so commenly performed world-wide, that a point-of-care application would be beneficial. This thesis describes how the values for the red blood cells, namely haematocrit, cell volume and haemoglobin content of a cell, can be calculated from a video taken from cells flowing through a microfluidic channel.

Point-of-Care Device

Reading out the amount and specifications of blood cells, a doctor can assess a patient's general health status. However, to get the blood count, a flow cytometer is needed. To make this blood test more accessible, a small, portable point-of-care microscope has been developed at the HuCE Institute. It uses a microfluidic chip, which takes a small droplet of blood and pulls it in via capillary force. A video is taken of the red blood cell stream and analysed for haematocrit, mean cell volume, and mean cell haemoglobin.

Haematocrit

The haematocrit is the volume of red blood cells relative to the whole blood volume. The channel is illuminated with blue light, which is absorbed by the haemoglobin in the cells. The pixels of the blood stream are compared to the reference background of the chip, which is proportional to the haematocrit.
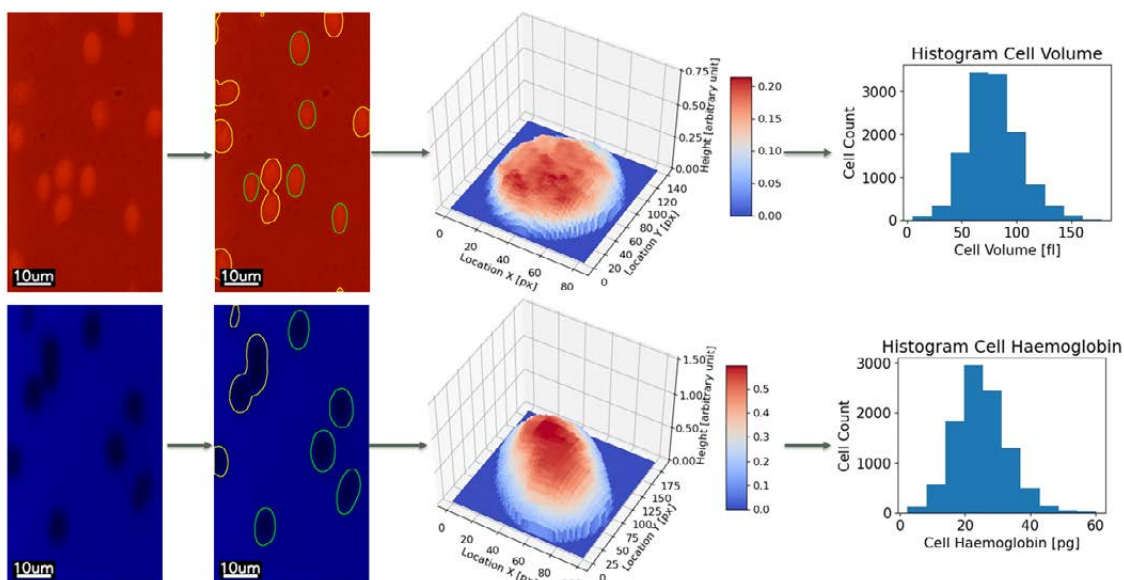
Mean Corpuscular Haemoglobin and Volume

Like the haematocrit, the haemoglobin and the volume per cell are also measured using absorption. For the cell volume calculations the blood plasma is stained blue, so that it absorbs red light, whereas the haemoglobin in the cell absorbs blue light. The background is calculated from the bloodstream to get the blood plasma reference brightness. Then the volume and haemoglobin are calculated by comparing the cell pixel intensity to the plasma pixel intensity, using the Beer-Lambert law. For multiple cells, the average is taken to get the mean cell volume and haemoglobin content.
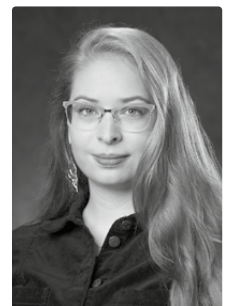
Calibration and Validation

To validate the algorithms, values were compared to those from a flow cytometer from Inselspital in Bern. Blood which has been previously analysed by the hospital was analysed with our device and the values compared. This process permitted to calibrate and validate the algorithms.

Annalena Hofer

Process of the Mean Corpuscular Volume (red) and Haemoglobin (blue) Calculations [left to right: initial frame, contour detection, individual cell height, histogram of cells]

Implementation of Control Software for the Automated Manufacturing of SmartCatheters

The manufacturing of smart catheters requires a high amount of manual labor. This amount can be reduced with a new catheter structure, based on a LCP bonded to a TPU substrate. Due to this improvement, the manufacturing process complexity gets broken down and allows automation. This automation is implemented with a system, developed at the BFH, and a programmable logic controller combined with an industrial-grade human-machine interface from B&R Industrial Automation GmbH.

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Motivation

The manufacturing of complex catheters, which implement various sensing features, is a tedious process and requires a high amount of manual labor. Unfortunately, the state-of-the-art structure of such a catheter does not allow to reduce the ratio of manual labor during the manufacturing process. So at the Institute for Human Centered Engineering (HuCE) of the Bern University of Applied Sciences (BFH) a new approach, concerning the structure of such a catheter, was pursued. By bonding a liquid crystal polymer (LCP) onto a substrate consisting of thermoplastic polyurethane elastomer (TPU) the possibility for new applications was given.

Methods

This new structure further allows automation of the manufacturing process. By embedding the electrical circuitry and the wiring into the LCP the complexity of the catheter manufacturing can be shifted to the elaborated LCP manufacturing process. Therefore the manufacturing of the catheter can be reduced to the thermobonding process. This thermobonding process and the corresponding mechanical manipulation of the LCP and the TPU is implemented with the smartCath system. The smartCath system consists of a stepper motor-driven manufacturing machine combined with a dedicated programmable logic controller (PLC) and an industrial-grade human-machine interface (HMI) from B&R Industrial Automation GmbH.

Results

Software

The software controlling the smartCath system is implemented in C++ and conforms with the object-oriented programming (OOP) paradigms. It implements a high abstraction from the B&R software framework and therefore provides a high degree of portability. Further, it combines industrial control software concepts with object-oriented design patterns.

Digital Twin

Due to the short project timeline, a hardware/software co-design took place, to lower the risks of the commissioning near the end of the project, a digital twin (see figure 1) was implemented. This digital twin allows integration testing in the early phase of the project and reduces critical failures in the later project stages. By using Matlab/Simulink in combination with the Simscape toolbox, which is a resource already available resources at the BFH, and the Automation Studio MAT target from B&R a short implementation duration could be achieved.

Documentation

To ensure the successful continuation of the software project after the Master's thesis also the documentation needed to be considered. Therefore the source code documentation was implemented with a GitLab continuous integration (CI) and continuous delivery (CD) (CI/CD) pipeline generating Doxygen source code documentation, to make it accessible to the whole project team it is hosted on GitLab Pages. With a GitLab Wiki also the usage of the software is documented and can be reproduced.
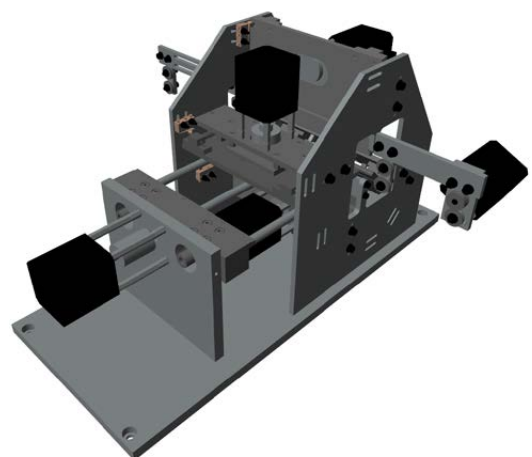

Figure 1: Digital Twin implemented in Matlab / Simulink with Simscape Multibody

Analysis of the combination of a machine learning model with a rule engine

Degree programme : Master of Science in Engineering | Specialisation : Data Science
Thesis advisor : Prof. Dr. Erik Graf
Expert : Taylor Peer

With the development of the digital world, the techniques used in Natural Language Processing (NLP) are constantly evolving. While machine learning is the main technique used today, it may be reaching its limits, especially in terms of accuracy. This is why we analyze the results of combining a machine-learning model with a rule-based classifier.

Introduction

Whether to use rules or a machine learning model depends on the use cases, the objective of the task to be solved, but also the data we have at our disposal. Each one achieves different objectives and performs more or less well depending on the application. However, each one has its own limitations and we need to look for more efficient solutions. This is why, in this work, we propose the combination of a model with a rule-based approach. We explore the concept of combining rules and machine learning models based on a real-world use case.

Context

Our use case is a Swiss start-up that supports medical and legal professionals in their administrative workflow on accidents and disease diagnosis. Their application allows to upload PDF documents and offers many tools to reduce the time spent searching for information in these files. One of the features is the classification of documents based on a complex and custom rule engine that is entirely developed in-house. The main challenge of this feature is to further improve the results of this classifier.

Objectives

This is why we propose a combination solution with a model. Our goal is to explore the potential benefit of combining the outputs of a machine learning model with the start-up's rule engine.
We explore two main approaches regarding the combination of a rule and model based method. In a first set of experiments, we investigate on how to combine both outputs. To do so, we analyze whether the model can be used to validate or correct the rule engine's predictions. Furthermore, we try to define the best method for each class and if the objective is directed towards precision or recall. In a second step, we suggest other approaches to integrate the model into the start-up's classification system.

Results

The results of the validation or correction of the outputs from the rule-based approach with those from the model are rather poor. Only a subset of the data can be considered as reliable, with a small margin of error. Then, if we group the results by label, we observe a notable difference in quality between the two methods. Therefore, we can suggest which classifier performs better for certain labels. Moreover, when the focus is on precision or recall, we also suggest one of the two approaches. This varies by class or if we look at the results as a whole.

As the fusion of the rule engine with the model is very limited, we also propose three possible applications of the model that are tools for the developer working on the rule engine. In addition to helping writing the rules, the model can make the labeling of data more efficient. Finally, it can be associated with a neural model interpretability tool, in order to better understand the keywords of a prediction.

Yael Tatjana Iseli

Applications and Capabilities of Digital Twin in Swiss Healthcare: System Dynamic Approach

European healthcare systems grapple with challenges due to aging populations, health professional shortages, disease burdens, and escalating healthcare expenditures. Digital Twin technology offers a transformative potential to enhance patient care and reduce costs. This article, among one of the first studies in Switzerland, examines the current state of Digital Twin technology and presents a model for assessing its capabilities.

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Introduction and Objectives

Digital Twin is a form of a model with a bi-directional flow of data between a digital object and a physical object, where both are fully connected and integrated. The following work first reviews the existing ecosystem of Digital Twin, then it presents its own Human Digital Twin framework. Finally, based on models of system dynamics, compares healthcare capabilities with and without an integrated digital twin and assesses the current digital maturity of the Swiss healthcare system.

Research Design

The research objectives will be achieved through a literature review and system dynamics modeling. The scope of the literature review discusses digital health services, with a special emphasis on the Human Digital Twin with its application in Swiss healthcare. Due to the lack of a common Human Digital Twin framework, the second section presents the conceptual framework of the Human Digital Twin. The last creates System Dynamics models to assess the current maturity of the Digital Twin in Switzerland. Due to the complex structure of healthcare, the modelling includes qualitative and quantitative approaches, with a 20-year perspective.

Results

The literature review presents the state of the art of Digital Twin and discusses constraints hindering further development, such as the absence of a common definition and framework for Digital Twin technology, data privacy issues, as well as a low level of digital maturity. The results of the second part present the current Digital Twin maturity and how it is changing over a given time frame. The technological capabilities of methods with Digital Twin in a given time frame at its highest point are 6 times higher in comparison to methods without Digital Twin. On the social side, the difference grows slower, reaching over 0.9 times higher during a given time. Finally, the article considers the acceptance rate among the Swiss public. The results show that the acceptance rate starts to increase in the sixth year, reaching a maximum value in the ninth year.

Implications and Recommendations

The model presented is purely conceptual and more empirical evidence is needed to validate it. This is because the Digital Twin is still mostly in the conceptual phase and therefore not enough data has been provided, making it difficult to review this technology in full detail. The shape of Digital Twin technology should be considered on different layers of application complexity. Among others, this refers to the question of how and where data-collecting sensors should be located and interconnected with each other. Moreover, social variables such as fear of missing out or automation bias should be further investigated. The research contributed to future works by providing the framework to evaluate and compare Digital Twin technology maturity.
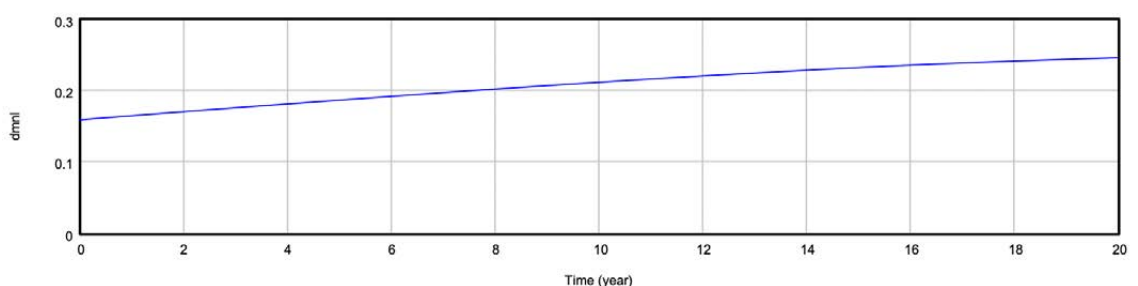
Impact of Digital Twin's current capabilities on acceptance rate

Applied Time Traveling with Temporal Data Management

Degree programme : Master of Science in Engineering | Specialisation : Computer Science
Thesis advisor : Prof. Marcel Pfahrer
Expert : Prof. Stefan F. Keller (OST Ostschweizer Fachhochschule)

Any software data application running in production for several years inevitably undergoes data modifications. Those typically come as corrections of wrongly inserted data (e.g. typos) and real-world changes that require data to evolve (e.g. population). This thesis examines how temporal data management techniques can enhance an existing software system to enable seamless navigation over several time axes. As seamless as traveling through time.

In the context of this thesis, a particular data-heavy application from the agricultural domain is under focus: RISE (abbr. Response-Inducing Sustainability Evaluation). It's an indicator-based decision support system backed by a detailed survey. During a visit to the farm, the survey is filled out with farm data and an extensive tree of calculations produces a sustainability overview of the farm according to 10 themes (from „Soil use" to „Working Conditions" via „Animal Husbandry").

These calculations use survey answers, static regional reference data (e.g. dry matter in a particular cereal), and other (sub-) calculations to produce scalar or vectorial outputs. A collection of these outputs aggregated into the 10 themes, constitutes a sustainability report that is printed and archived. As time progresses, calculation formulas are corrected and adjusted, reference data is updated and answers might be subsequently modified. These temporal changes pose a challenge in reconstructing sustainability reports to compare them. In this comparison lies the real key to quantifying sustainability.

Goals of the project

The first goal of this thesis is to transform a „single temporal" and snapshot-based data architecture into a multi-temporal one. The „single temporal" approach has the obvious disadvantage of keeping only the latest value, and the snapshot-based makes all data modifications only local to the snapshot at hand. Moving an existing application from such data-handling paradigms requires merging snapshots and data archeology to find previous values.

The second is to enable an intuitive, time-traveling approach to navigate and use that data through time. Practically, that would allow for a given survey to perfectly reproduce a sustainability report at any point in time, with the values of the reality at that time, with or without corrections. This is the part that must be intuitive and feel like time traveling.

And finally, data-managerial aspects are tackled to enable the point-in-time data modification and extension of validity time ranges to avoid gaps in time axes. This should allow users to correct data without fearing overwriting or deleting values.

The takeaway

Once this data transformation is completed, setting data changes in the future becomes possible (e.g. setting a value that will be valid only starting next year with knowledge available now). And ultimately, with enough confidence in this data architecture, sustainability assessments can be dropped from storage altogether, as the calculation formula can reproduce any calculated result in a sustainability assessment without the need for relevant data to be present in the snapshot.
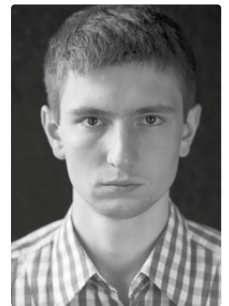
Eugene Kudryavtsev
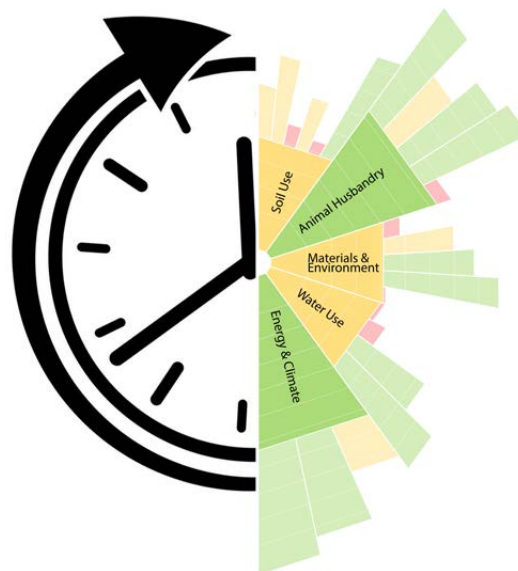
Realization of a Point of Care Hematology Analyzer

The Complete Blood Count CBC is the most performed blood test worldwide. Still, a diagnostic device that can process such a CBC directly on-site at a low cost is inexistent. This work demonstrates the feasibility of a prototype for a compact, low-cost blood cell analysis device and analyses the possibilities for mass production.

Alexander Martin Küenzi
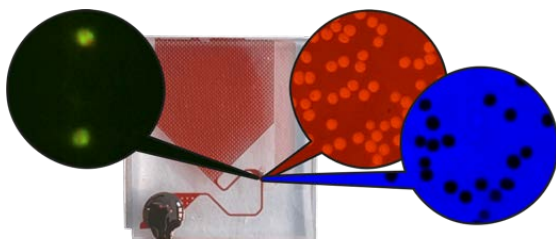alexander.kueenzi@gmail.com

Objective

The master's thesis is about developing a new point of care (PoC) device consisting of optical components and a microfluidic chip for processing and counting blood cells. This diagnostic device aims to make patients' lives easier and enables an analysis of the blood wherever it is needed.

Currently, inexpensive off-shelf components are becoming more powerful. Components such as graphical process units (GPU), and low-cost, high-performance camera chips and LED sources enable high-quality image processing through microscopy. The overall goal is to develop a competitive diagnostic device with full functionality. The point-of-care device consists of a digital fluorescence and absorption microscope. This thesis focuses on the prototypical implementation and execution of a manufacturing analysis, taking into account cost and scalability.

Implementation

The basis of this work laid my previous specialization project, which resulted in an experimental setup. By analyzing the technologies and manufacturing processes established on the market, a solution suitable for the project was developed. The mechanisms and specifications required for functionality were worked out step by step and validated experimentally. All the experience gained was used in the production of the prototype. The manufacturing processes suitable for mass production do not apply to prototyping due to high initial costs. Therefore, a conducted feasibility study analyzed the future possibilities.

The challenge is to find a compromise between optical performance and the device's compactness. The price requirements severely limited the choice of available optical elements. In this conception, the focus lies on optimizing the device's compactness to achieve high portability. Compared to the experimental setup, a reduction of the optical path by more than 50% took place.

Result

The prototype proves that manufacturing a functional blood counter with a sales price below 1'000 CHF is possible (figure 2). The microscopical setup magnifies the blood samples around 20 times. By consequent compaction of the setup, outer dimensions of 16 x 13 x 20 cm3, corresponding to approximately 4 liters at 2.5 kg, were achieved (figure 1). The elastic deformation-based frictionless Z-axis features a resolving power in the nanometer range.

Microfluidic chip with micrographs performed through reflected and incident light microscopy, illustrating white and red blood cells.

Figure 2: Design of the PoC-device «Microcyte»

Optimierung eines PEM Elektrolyse-Stacks

Ein limitierender Faktor für den breiten Einsatz von Protonen-Austausch-Membran (PEM) Elektrolyseuren sind die hohen Kosten. Diese resultieren im Wesentlichen aus den verwendeten teuren Materialien wie Titan für die Zellkomponenten und Iridium und Platin als Katalysatoren. Um die Eigenschaften von kostenoptimierten Zellen zu untersuchen, wurden in dieser Arbeit elektroimpedanzspektroskopie Messungen durchgeführt und ein Aufbau zur Messung der Stromdichteverteilung entwickelt.

Ausgangslage

Die Firma VICI entwickelt und produziert PEM-Elektrolysestacks für ihre Wasserstoffgeneratoren. Diese Wasserstoffgeneratoren haben sich für die die Erzeugung von Wasserstoff in kleinen Mengen für chemische Prozesse oder als Hilfsgas für analytische Methoden wie die Gaschromatographie durchgesetzt. Um PEM-Elektrolyseure auch ausserhalb von Laboranwendungen attraktiver zu machen, müssen die Preise deutlich gesenkt werden. VICI konnte durch Änderungen am Aufbau des Elektrolyseurs bereits eine deutliche Kostenreduktion erzielen. Wichtig ist jedoch, dass diese Änderungen das Verhalten der Zelle nicht negativ beeinflussen. Um dies zu untersuchen, wurden in dieser Arbeit Messungen an verschiedenen Zellen der neuen und alten Generation durchgeführt.

Vorgehen

Bisherige Untersuchungen beschränkten sich im Wesentlichen auf die Messung der Zellspannung und die Messung der produzierten Gasmenge in Abhängigkeit vom Strom. Diese Methoden sind relativ einfach, geben aber nur Auskunft über das Gesamtsystem. Rückschlüsse auf die Ursache von Verlusten sind auf Basis dieser Messungen nicht möglich. Um diese Einschränkungen zu umgehen, wurden im Rahmen dieser Arbeit zwei Messmethoden erprobt, die bisher noch nicht an diesen Zellen angewendet wurden.

Elektrochemische Impedanzspektroskopie

Die elektrochemische Impedanzspektroskopie (EIS) ist eine Untersuchungsmethode, die dem zu untersuchenden System ein kleines sinusförmiges Anregungssignal aufgeprägt. Das System antwortet mit einem ebenfalls sinusförmigen Ausgangssignal gleicher Frequenz aber unterschiedlicher Amplitude und Phase. Aus dem Verhältnis der Signale wird die komplexe Impedanz des Systems berechnet. Durch die Analyse des Impedanzspektrums können z.B. die ohmschen Verluste und die Gesamtverluste getrennt untersucht werden.

Messung der Stromdichteverteilung

Die Stromdichte ist entscheidend für den sicheren und effizienten Betrieb eines Elektrolyseurs. Hohe Stromdichten führen zu eine grösseren Wasserstoffproduktionsrate, gleichzeitig korreliert die Stromdichte aber auch mit den Überspannungen (Verlusten) der Zelle. Im Idealfall sollte die Stromdichte homogen verteilt sein. Ist dies nicht der Fall kann dies zu einer schnelleren Alterung der Zelle führen. Für diese Arbeit wurden Messplatinen entwickelt, mit denen die Stromdichteverteilung im Elektrolyseur gemessen werden kann.

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Reversibler Betrieb

Eine Brennstoffzelle ist von den physikalischen Vorgängen her eine reversibel arbeitende Elektrolysezelle. Durch eine spezielle Auslegung der Komponenten und Katalysatoren ist es möglich, reversible Elektrolysezellen zu bauen, die auch als Brennstoffzelle eingesetzt werden können. Ein weiteres Ziel dieser Arbeit war es den reversiblen Betrieb mit dem aktuellen Elektrolyseurdesign zu testen.

Resultate

Die EIS-Messungen wiesen sehr unterschiedliche Ergebnisse auf. Während einige bekannte Effekte, wie die Verbesserung des Wirkungsgrades bei höheren Temperaturen, durch die Messungen bestätigt werden konnten, traten neue Effekte auf, die weiter untersucht werden sollten. Die Stromdichtemessplatinen waren in der Lage die Stromdichte aufgelöst in 36 stromdurchflossene Einzelflächen zu messen. Die Schwierigkeit bei der Auswertung besteht darin zu unterscheiden, welche Komponenten oder Prozesse für die gemessenen Stromdichteunterschiede verantwortlich sind. Die Experimente zum reversiblen Betrieb zeigten deutlich, dass dies mit dem derzeitigen Zelldesign nicht effizient möglich ist.

State of health estimation of Li-Ion Batteries and their economic value for a second-life

Degree programme : Master of Science in Engineering | Specialisation : Business Engineering
Thesis advisors : Prof. Dr. Stefan Grösser, Dr. Priscilla Caliandro
Expert : Prof. Dr. Andrea Vezzini (ennos AG)

This thesis tackles challenges in the rapidly growing lithium-ion battery sector, exploring a circular economy approach to enhance sustainability and resource efficiency. It examines existing SoH estimation as well as economic value models for second-life batteries, and presents a novel approach to calculating SoH and predicting economic value, offering significant insights for creating a sustainable, circular lithium-ion battery ecosystem.

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Introduction and Objective

Lithium-ion batteries are essential in sectors like mobility, energy, and consumer electronics. Their production presents challenges in lithium mining and recycling. Adopting a circular economy approach can address these issues, enhancing sustainability. This study aims to develop a circular lithium-ion battery ecosystem by examining existing State of Health (SoH) and economic value calculation models, creating and comparing SoH methods, and predicting the economic value of second-life lithium-ion batteries.

Research Design

A literature review was conducted to understand current SoH estimation and economic value prediction methods. The BFH-developed data pipeline validated a novel SoH estimation method using histogram data. Machine learning algorithms were tested using NASA lithium-ion dataset, which was conducted in a labratory environment, with further validation from real-world data from an electric vehicle manufacturer.

Results

The thesis provides insights into lithium-ion battery lifecycle management. A novel SoH estimation method was validated in combination with various machine learning algorithms' effectiveness. A feature importance analysis identified key factors in determining the reamaining useful life of a battery and thus its economic value at the end of the first life. A novel economic value landscape for these batteries was developed considering both internal and external elements such as the most important features resulting from the feature analysis, regulatory environments, and market needs. This integrated approach significantly contributes to a circular lithium-ion battery ecosystem and sustainable resource management.

Implications and Recommendations

This thesis supports the transition into a circular economy in the lithium-ion battery industry with:

Lack of Standardization: One significant finding is the absence of a universally accepted classification framework for SoH estimation methods. To address this, a suggested classification framework is introduced. This proposed framework could serve as a basis for creating a standardized method of assessing the SoH, enhancing the comparability of results across different studies and applications.

Differentiation between Timeseries- and Histogram-Based ML Approaches: There is currently no differentiation between timeseries- and histogram-based machine learning approaches within the SoH estimation methods. It's recommended to introduce such a differentiation, which could enhance the discussion about which SoH estimation methods are most accurate for which purpose.

Computation and Memory Requirements: The study did not investigate in detail the computational and memory requirements of different SoH estimation methods. This would be an essential aspect to ensure the practicality of the methods in real-world applications, especially in devices with limited computational resources.

Price Estimation Model for Second-Life EV-Batteries: On the economic aspect, there's currently no available model for price estimation for second-life EV batteries. The development of such a model could greatly enhance the profitability and viability of battery repurposing and recycling efforts.

Feature Importance Investigation: The feature importance investigation of the SoH estimation model can serve as parameters for the economic model. This could provide a comprehensive understanding of the factors influencing the economic value of second-life batteries, thereby enabling more accurate and effective pricing strategies.

Development of a PDMS microfluidic – paper analytical hybrid microdevice for blood processing

Degree programme : Master of Science in Engineering | Specialisation : Medical Engineering
Thesis advisor : Prof. Dr. Cédric Bessire
Expert : Prof. Dr. Olivier Guenat

By checking infection levels physicians want to know the white blood cell count as well as the human C-reactive protein concentration in the blood. These different markers react differently on the type of infection and in time after the infection. A microfluidic platform that can provide both diagnostic markers has been developed.

Motivation

Human C-reactive protein (CRP) is an acute phase inflammation biomarker. The concentration of this biomarker is used for spontaneous diagnosis of infection. At low levels of concentration (1-5 µg/ml), knowledge of cardiovascular risk can be assessed, and at greater levels of concentration (>10µg/ml), information about infections and type of infections (usually bacterial >20 µg/ml or viral <20 µg/ml) can be assessed. CRP protein is a very important biomarker in Point-of-care testing (POCT) devices. These are medical devices that can be used for diagnosis at the site of care and in short time spans. This thesis aims to show the utility of microfluidics for processing whole blood and its components for diagnostic purposes.

Objective

The project itself deals with developing microfluidic platforms for blood processing, with the ultimate aim of developing functioning POCT platforms for whole blood diagnosis. The microfluidic platform can perform white blood cell (WBC) count. The objective of the thesis is to facilitate measuring CRP concentration on the platform as well. The thesis therefore can be broken down into two integral parts – developing a biosensor for CRP measurement, and mechanically integrating this biosensor component to the microfluidic system.

Methodology

A commercially used, clinically approved CRP nitrocellulose based analytical device was used as the basis to develop this biosensor. The concentration of CRP protein in a sample is correlated to the colour intensity of the colour band that shows up on the paper strip. The key for the integration of this biosensor into the microfluidic platform is a blood cell separation membrane. A silicone microfluidic chip that takes up whole blood for enabling a WBC count was fabricated. The chip accommodates the paper analytical device for the optical CRP detection. The resultant device is a unique hybrid silicone – paper microfluidic device (see figure 1).

Results

A correlation between CRP protein concentration in a sample and colour intensity of bands was observed. This analysis was performed after images of the colour bands were taken under a microscope (see figure 2).

Kevin Nicholas
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figure 1: shows the mechanically integrated paper and PDMS microfluidic system
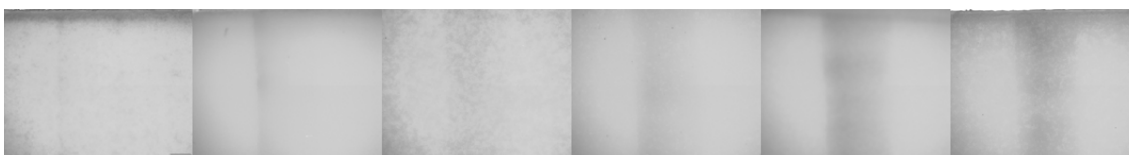

figure 2: left to right 2µg/mL to 16 µg/mL; colour intensity increasing

Experimental analysis of -100kV VM for use in automated non-destructive HV DC tests

The thesis focuses on modifying a high DC voltage power supply by replacing the ZVS resonant converter with a controllable single-phase inverter. The existing system (-100 kV, -1mA) lacks controllability, limiting its application in DC voltage supply and high voltage testing. By introducing a controllable inverter, the thesis aims to assemble a controlled high DC voltage power supply by modifying the existing system in order to perform automated high DC voltage tests.

Semir Perla

Background

Rapid improvement of power electronics and increase of voltage levels, creates a need for implementing high voltage testing techniques to verify the reliability of newly designed equipment. High DC voltage tests are usually performed in high voltage laboratories using standard high voltage equipment which is usually vast in size. The Cockcroft - Walton voltage multiplier (VM) is in fact an AC/DC converter with high output DC voltage and low output current. One was developed in the BFH power electronics laboratory with rated DC output voltage of -100kV and -1 mA current. Its small size and compactness make him a candidate to be used as a high DC voltage source for automated high DC voltage tests.

Starting point

To perform automated high voltage tests on various equipment using CW voltage multiplier, it was initially necessary to make few modifications at existing voltage multiplier circuit. Present manually operated ZVS resonant converter was not suitable for desired operation of voltage multiplier and proper surge protection in the case of short circuit needed to be designed.

Objective

Through the modifications, the thesis aims to create a controlled high DC voltage power supply that offers flexibility, controllability, and safety for various high voltage experiments and automated high DC voltage testing procedures.

Implementation

The implementation phase of the thesis involves two key modifications. Firstly, the ZVS resonant converter is replaced with a controllable single-phase GaN inverter, providing enhanced control over output voltage and frequency. This enables dynamic and flexible high DC voltage experiments with the existing multiplier circuit. The controllable inverter, originally designed for educational purposes, offers improved monitoring of input and output electrical parameters, ensuring comprehensive surveillance and control over the multiplier circuit's output voltage. Additionally, mechanisms for detecting and cutting off discharges during high voltage tests are considered, allowing the GaN inverter to be turned off to prevent unwanted circuit behavior.

The second modification focuses on the development and implementation of a measuring and protection circuit for the voltage multiplier circuit's outputs. A critical objective is to limit the discharging current to 100 μA to ensure safe operation during high voltage experiments. The thesis aims to gain proficiency in operating and controlling the power converter (GaN inverter), validate the detection of discharge events in the device under test, and enhance the protection circuit to ensure reliable and secure operation.

Results and outlook

The results of the thesis include a prototype of a coded state machine for dynamic short circuit detection in a voltage multiplier circuit. Implemented with a microcontroller and FPGA module, it generates control and modulation signals for the GaN inverter's power switches. The state machine's states are explained using a diagram, and a coded ramp test profile is described. Recorded waveforms demonstrate discharge moments and a typical response time of 150-250 μs. The state machine automates tests, detects and halts energy transfer during short circuit events, demonstrating the feasibility of using phase current as a measuring parameter for short circuit detection and mitigation.

Towards No-Code Collaborative Robotics: Intuitive Environment Calibration Method

Degree programme : Master of Science in Engineering | Specialisation : Mechatronics and Automation
Thesis advisor : Prof. Dr. Gabriel Gruener
Expert : Dr. Francesco Crivelli (CSEM SA)
Industrial partner : Swiss Cobotics Competence Center (S3C), Biel/Bienne

Manufacturing processes are becoming increasingly flexible, with shop floor workers quickly adapting to changes in production. The use of collaborative robots promises to assist workers in strenuous and repetitive tasks. While no-code interfaces are being developed to simplify programming, calibrating the cobot in a dynamic environment is still a complex and time-consuming task. Simplifying this step would greatly improve the usage of cobots in industrial settings.

Context

Industry 4.0 brings new challenges by having among its goals a production characterized by flexibility and adaptability. Shop floor workers are a very versatile resource, who adapt quickly to new processes and changes in the production line. Collaborative robots (cobots) with built-in sensors and safety features allow workspace sharing and promise to assist workers in strenuous, repetitive, or dangerous processes.

Motivation

Shop floor workers are experts in the production processes to be performed. They would be the best suited person to integrate cobots into manufacturing processes, due to their task expertise. However, their skill set lacks knowledge in robotics and programming. Innovative no-code interfaces are being developed to make cobot programming easier and more intuitive. These still require parameters derived through an accurate calibration of the cobot in its environment. This process includes defining the location of actuators, sensors, and tools to manipulate the product. It is currently a complex and time-consuming activity not suitable for novices.

Approach

Calibrating a robot's environment relates to defining a model of the real world around it. The approach used relies on manually guiding the cobot towards the objects to be calibrated. A vision-based method uses a camera rigidly mounted near the cobot's tool. This allows to estimate the position of fiducial markers attached to the objects through image processing algorithms. The model of the cobot's surroundings is thus defined at run-time.

Results

The camera parameters and main transformations matrices are calibrated within minutes. The procedure is supported by a user friendly web-browser interface, along with visual feedback on the gripper. The developed Python framework allows trajectory generation by kinesthetic teaching and displays the calibration results through augmented reality. The approach has been validated developing a watch quality control application.

Outlook

In future work, the versatility of the method developed should be evaluated by installing the system in an industrial setting and asking shop floor workers to calibrate the environment for a variety of production processes. Their feedback would be used to improve the method and to integrate it in a no-code programming interface.

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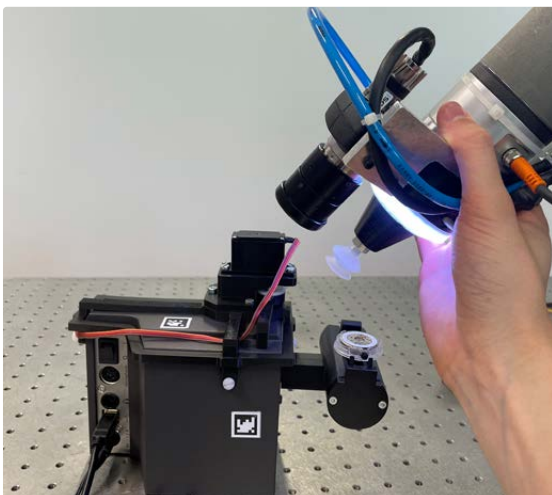
Cobot hand-guiding to a watch quality control device.
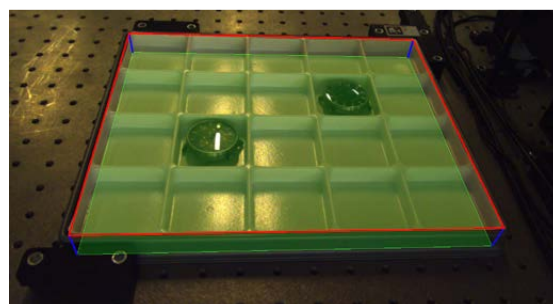
Calibration of a watch storage pallet using augmented reality as visual feedback.

Temporal pulse shaping of a nanosecond laser for tissue ablation.

Degree programme: Master of Science in Engineering | Specialisation: Photonics
Thesis advisors: Dominik Inniger, Prof. Christoph Meier
Expert: Dr. Manuel Ryser (University of Bern, Institute of Applied Physics)

Tissue ablation can be performed by pulsed, high-power laser systems such as the Master Oscillator Power Amplifier. The subsequent amplifier chain exhibits highly nonlinear characteristics, which distorts the temporal pulse shape. In an iterative optimization process, the temporal pulse shape is corrected by modulating the current of the master oscillator.

Julien Rauber

Introduction

Laser systems are widely used in material processing, industrial applications and medical procedures such as ablating tissue. It is known from material processing that ablation efficiency depends not only on the pulse energy but also on the time-resolved pulse shape. Therefore, controlling the temporal pulse shape would be desirable to optimize ablation processes.

Theory

Active fibers are used in the Master Oscillator Power Amplifier (MOPA) laser for optical amplification. The dopant atoms are optically excited into a higher energy level, creating a population inversion. A pulse travelling through the fiber can stimulate those excited atoms to release their energy as a photon, amplifying the pulse. The gain provided by the amplifier depends on the population inversion. However, a strong pulse can deplete the population inversion, resulting in a time-dependent, nonlinear gain that distorts the pulse's temporal shape.

Method

The current of the master oscillator is controlled by the computing system allowing arbitrary nanosecond pulse shapes. Two active fibers amplify these pulses, including one operating in the nonlinear regime. Typically, these nonlinearities are corrected by the Frantz-Nodvik equation with prior knowledge of the amplifiers. However, the initial pulse is already distorted due to the electro-optical response of the master oscillator resulting in inaccuracies in the equation. Hence, a pulse shaping technique is implemented using a modified particle swarm optimization (PSO). The PSO uses stochastic methods to optimize the output pulse to a desired reference shape.

Result

The implemented pulse shaping technique successfully adapts the input current to shape different output shapes. The algorithm exhibits stable convergence, typically converging to a satisfactory solution within approximately 30 iterations. In this example, the algorithm was employed on the stair pulse (see figure). The algorithm reduces the root mean square error (RMSE) by a factor of ten.
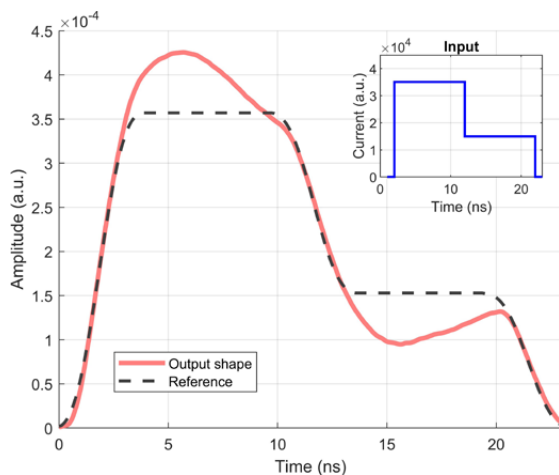
Before optimization, the RMSE is 3.3e-05 between the reference and the output shape.
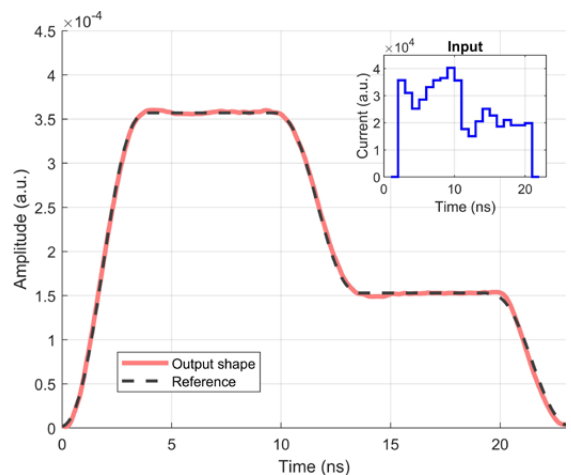
After optimization, the RMSE is improved to 2.6e-06 with the optimized input shape.

Design and implementation of flexible automated production test systems for ennos AG

An automated production test system is developed during this thesis for ennos AG, a solar water pump manufacturing company. As ennos transitioned successfully from a small spin-off to a well-known company in its market with consistent growth in production volume, the need for a new and more sophisticated production test system emerged. Since the product portfolio has also expanded, the new tester must be flexible enough to test different products with little adaptation.

Motivation

Automated testing in production offers several advantages over manual testing. Firstly, it ensures consistent and reliable test results, meeting the companies quality standards. Secondly, it minimizes the risk of human error and ensures a safe testing process. Lastly, it reduces process time, enabling faster production cycles and increased efficiency.

Goal

The aim of this thesis is to address the challenges associated with the existing semi-automated testers, which still require manual handling of data, files, and mechanical parts. This manual intervention poses risks to consistency, safety, and process time.
The thesis focuses on the design and implementation of an automated production test system comprising two test benches: one for electric motor and electronics testing, and the other for the final assembly of the solar water pump.

Implementation

Existing motor and pump test benches are extended and modified to fully functional production testers. For this purpose, measurement hardware, power supplies, human interface devices, data storages, as well as various mechanical components were installed.

A custom mechanical quick lock system for easy motor handling was developed, manufactured, and added to the motor test bench. An open-source environment called MUSCLE connects, visualizes, and controls all the hardware components and test modes. The test stands are programmed, so that the operator remotely steers the test benches through the dedicated wifi network. Also the data processing and file handling is fully automated, result reports are automatically generated, and stored online in a dedicated database.

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Result

The developed automated production test system has the potential to significantly enhance the production test process. This can lead either to shorter production time, or to a better test coverage of the production volume, which ultimately leads to enhanced product quality, and increased customer satisfaction through less warranty cases. On the motor test bench, several production test steps are combined in one automated device, which greatly facilitates the test handling, and reduces process time. Total test time was reduced by 65% for the motor tests, and 70% for the pump assembly test, which is a significant improvement in both cases. A great benefit of the test benches is also the reduction of manual intervention during tests, and automated data handling.

Motor test bench, equipped with a ennos slp2 0.5Hp motor.
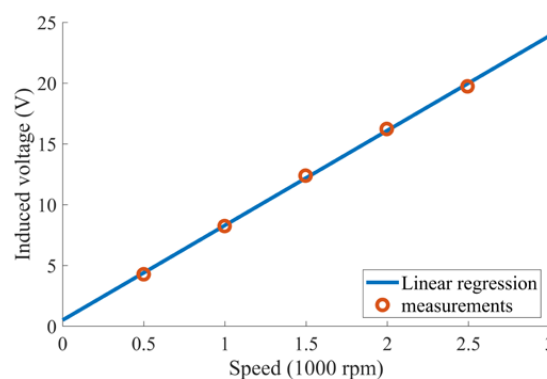
Back-EMF test result of the ennos slp2 0.5Hp motor as it is displayed on the MUSCLE user interface.

Digital Twins for plant life in an urban context

Degree programme : Master of Science in Engineering | Specialisation : Information and Communications Technologies
Thesis advisor : Prof. Dr. Annett Laube

Urban green spaces of a city are an important element not only for its citizen well-being but beneficial for the environment as well. However, green space planning is often based on purely aestethic and economic reasons. Reducing maintenance costs, including sophisticated biological expertise and integration in existing infrastructure is therefore a key aspect for modern green space planning. Digital Twins for plant life utilizing Knowledge Graphs are a promising solution.

Pascal Manuel Steiner

Unlocking greening potential

Trees have a wide range of beneficial effects on urban spaces. They provide shade, purify the air and cool the microclimate by evaporating up to 400 liters of water during a hot summer day. Moreover, they have a beneficial aesthetical effect and increase biodiversity. A lot of greening potential is still unused and could be unlocked by new and innovative ideas. Places such as roofs, walls or parking spots are increasingly considered eligible greening areas. Improving these difficult-to-reach spaces with more vegetation requires new and innovative methods. A digital solution might just help foster more green in cities.

Digital Twin meets Knowledge Graph

Digital Twin is an emerging technology paradigm focusing on real-life entities and mirroring them to a virtual counterpart. At their core, they automate data gathering, facilitate live as-is insights and use actuators based on automated decision-making. They have been widely adopted in many fields of application, including car manufacturing, airplane construction, real estate management, etc. However, surprisingly few advances in agriculture, smart farming or forestry have been made toward Digital Twins. Implementing such a Digital Twin requires the integration of cross-domain data and a multitude of devices. These requirements pose technical challenges which Knowledge Graphs can manage. Knowledge Graphs can provide a machine-interpretable harmonization of heterogeneous data sources and are able to reflect complex relationships about relevant Digital Twin information. Software „reasoners" can then scan through the Digital Twins system and infer new knowledge based on a proposed rule set. This reasoning enables tackling advanced technical challenges faced by Digital Twins and IoT.

Automated tree irrigation using Digital Twins

A Proof-of-Concept (PoC) implementation of a Digital Twin for smart tree irrigation in the city of Zurich has been implemented. Each tree is represented by its Digital Twin and the accumulated data is stored within a Knowledge Graph, giving it a small virtual presence. The Digital Twins contain advanced metainformation such as geolocation, type of tree, current health state and more. Digital Twins are automatically linked to another Knowledge Graph published by the Food and Agriculture Organization of the United Nations, making it possible to discover potential threats such as pests and diseases. This knowledge is then exploitable via API or user interface and offers advanced capabilities for data analysis. A small IoT testbed was created to assess the technical feasibility of automated decision-making based on a rule system. Machine-to-machine communication was accomplished by leveraging the new Web of Things (WoT) standard. The interplay between WoT and Knowledge Graphs enabled a more sophisticated way of defining rules for automated tree irrigation. Instead of conventionally defining actions in a rigid „chain-of-command" style, it was possible to formulate a desirable state and the system itself matches appropriate actuations to achieve it. In this case, the goal was to keep the trees saturated under consideration of current root zone humidity, temperature and weather forecast. Such a system is still slightly futuristic but nonetheless draws a new perspective on autonomous systems.

Esophageal ECG Signal Acquisition System and Left Atrium Size Estimation for EsoLive

Degree programme : Master of Science in Engineering | Specialisation : Electrical Engineering
Thesis advisors : Prof. Dr. Marcel Jacomet, Christof Baeriswyl
Expert : Emily Kathryn Thompson

A prototype version of a biopotential signal acquisition system for standard 12-lead electrocardiography (ECG) and multichannel esophageal ECG (EECG) is evaluated for its signal quality characteristics and appropriate design changes are proposed. Research and proof-of-concept investigating how the heart size can be estimated based primarily on EECG and ECG is realized. In a first step, the focus is on the left atrium (LA).

Introduction & Problem Statement

EsoLive is a novel tool for noninvasive, real-time 3D-mapping of cardiac activation. This medical device consists of an embedded biopotential acquisition system, a 3D electrode esophageal catheter and the EsoLive software. The acquisition hardware was developed in previous works and is now evaluated for its signal quality and safety requirements for use in a medical environment. Esophageal ECG (EECG) signals are acquired close to the left atrial (LA) posterior wall, implying that the height of the LA can be inferred. Together with literature research, methods to estimate the LA geometry are developed that ideally rely only on immediately available patient data.

Esophageal ECG Acquisition System

Embedded and host-PC software was refined, and the performance successfully verified. Patient leakage currents were tested according to IEC 60601-1 limits. 12-lead ECGs exhibited high levels of powerline interference, especially on precordial leads. The cause was identified as an isolation mode leakage current, together with insufficient common mode rejection in the signal path. Several improvements were proposed and tested successfully, leading to noise readings below 2.1 uVrms and making our system comparable to the baseline reference (g.HIAMP from g.tec medical engineering GmbH), at a much lower cost.

Left Atrium Size Estimation

EECG signals measure the time-varying cardiac electric field as projected in the esophagus. Hence the extent of where the esophagus 'touches' the LA posterior wall, a measure for LA height, can be assessed. Alternatively, linear mapping of the P-Wave duration, measured by utilizing a two-sided line model generated with autonomous linear state space models, gives an estimation of the LA diameter.

With known anatomical reference values, the two remaining orthogonal linear dimensions can be inferred, although significant inter-patient variability exists. With these size estimations, a simplified parametric 3D model of the LA chamber is conceived, which is in good agreement with a small number of patient recordings made in a previous clinical study.

Conclusions & Outlook

Signal quality and safety design issues were evaluated, and proposed changes are documented to enable a swift redesign and short time-to-market for a specialized, IEC 60601-1 compliant hardware at lower cost than comparable systems. Derived methods and documented limitations for LA size estimation constitute the basis for further clinical studies that shall result in a patient specific heart model, thus improving EsoLive's 3D mapping accuracy without requiring invasive and expensive imaging modalities.

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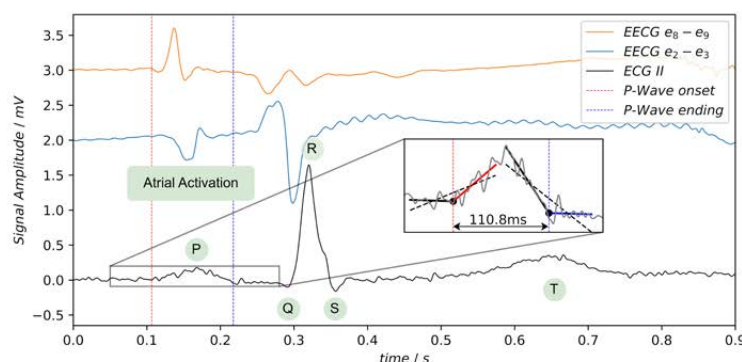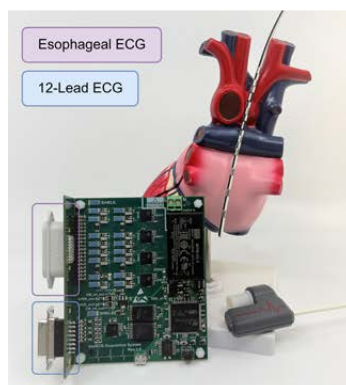
Signal Acquisition Hardware and Heart with Catheter in Posterior View | Selected EECG and ECG Signals with P-Wave Detection

Implementation of cleanliness and contamination procedures and validations on space missions

Contamination control in the space sector is of paramount importance for the success of most aerospace programs. During ground-based activities as well as exposure to the space environment, contaminants deposit themselves on all accessible surfaces of space systems and thus may impact vital space system functionalities leading to performance decrease or complete mission failure. The aim of this thesis is to implement contamination control procedures and validations.

Clara Katherine Carolin Vaerst

Introduction

With no prospect of maintenance, satellites must perform at a level of reliability greater than 99 %. To guarantee these reliability levels and to avoid or mitigate any risk of damage during launch and in-orbit operations, spacecraft systems are governed by stringent requirements in terms of design, material and process selection as well as manufacturing, assembly, integration and testing. Moreover, the materials used on a spacecraft are exposed to harsh environmental conditions including vacuum, ultraviolet and ionized radiation, extreme temperature variations, environment-induced contamination, and others.

Contamination

Surface contamination is of great concern in the aerospace industry, because of its proclivity to cause crucial instrument failure. During ground-based activities as well as exposure to the space environment, contaminants deposit themselves on all accessible surfaces of space systems. With respect to high-profile remote sensing missions, contamination on optical payload surfaces is extremely critical since it may reduce signal sensitivity due to absorption. It can also increase noise due to scattering. The consequences are performance degradation or complete mission loss. Therefore, contamination and cleanliness control is essential for the success of most aerospace programs, requiring product assurance experts. Contaminants can take numerous forms and manifest themselves in a variety of states (solid, gaseous, or liquid). Generally, two main categories such as molecular (MOC) and particulate contamination (PAC) can be distinguished. By definition, particle contamination pertains to visible µm-sized (0.001 to 100 µm) foreign matter including dust, metals, ceramics, glass, hair and fibers. Molecular contamination, either organic or inorganic, conjures to sub-microscopic dimensions (0.1 to 3 nm) such as residues from additives, oils and greases, outgassing (release of volatiles from materials) and airborne pollutants.

Results

As a means of assuring cleanliness specifications, it is of high importance to prevent or mitigate any risk of contamination along the entire supply chain, including material choices, manufacturing process selections, transportation, storage and cleanroom assembly. Clean processes, monitoring, investigation, cleaning and validation technologies are all part of contamination control used for running space missions by Micos Engineering GmbH. The objective of this thesis covers not only the stringent control of the supply chain but also cleanroom capability monitoring, as well as MOC and PAC accumulation assessments of assembled space parts after various cleaning procedures. These procedures are experimentally validated and compared with project-specific cleanliness and contamination control plans as required by customers and applicable space standards.
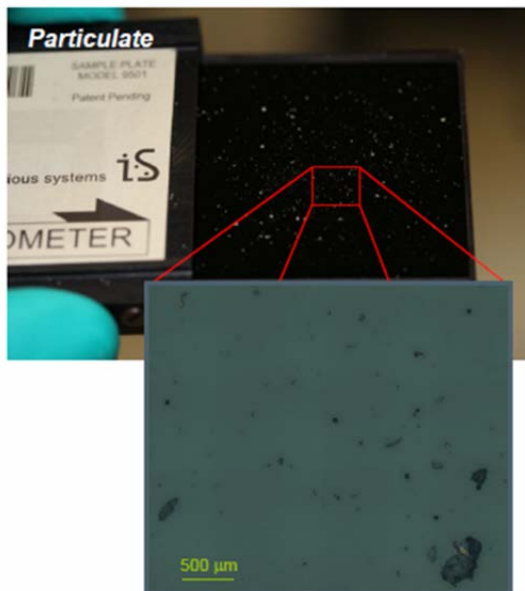

Figure 1: Particulate Contamination

Design of a Modular Platform for Controlling Piezoelectric Ultrasonic Periodontal Scalers

Degree programme : Master of Science in Engineering | Specialisation : Electrical Engineering
Thesis advisors : Prof. Dr. Thomas Niederhauser, Diego Stutzer
Expert : Dr. Giovanni Spiezia (E.M.S. Electro Medical Systems S.A.)
Industrial partner : E.M.S. Electro Medical Systems S.A., Nyon

Piezoelectric periodontal scalers remove dental calculus and plaque during therapeutic sessions through ultrasonic vibration. However, maintaining a consistent vibration intensity during use is challenging due to altering operating conditions. The new modular platform enables the integration of dedicated feedback-control algorithms that improve the overall system performance.

Background

Caries and periodontal disease count as the most common chronic disorders for humanity that emerge from dental plaque. Disease prevention in clinical settings involves removing plaque and its mineralized form, called calculus, with periodontal scalers. Our group has developed a novel piezoelectric ultrasonic scaler based on a planar transducer, targeting low manufacturing costs. Such devices must operate at resonance to efficiently reach the vibration intensities required for scaling. However, the device's characteristics, including the resonance frequency, considerably change during use due to altering operating conditions, such as varying scaling forces.

Methods

A feedback-control system must track the device's resonance frequency irrespective of the operating conditions and set the actuator voltage amplitude to maintain a consistent, user-settable vibration intensity, as shown in Figure 1. The system states relevant for the control system can be estimated from impedance measurements. A dedicated modular platform was developed to assist the challenging design and parametrization procedure of control algorithms by enabling tests on actual scalers in realistic settings. This platform's electronic hardware and software were designed, implemented, and extensively tested during this MSc thesis and preceding project works.
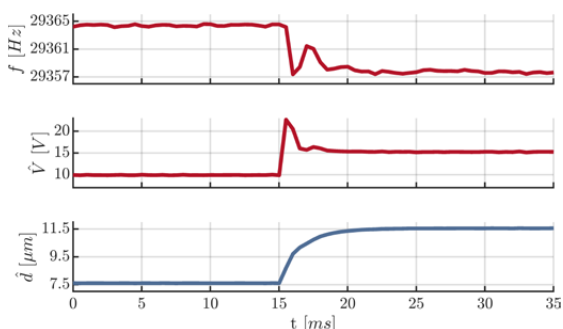
Results

The final hardware setup consists of several modules interconnected by a mainboard, as shown in Figure 2. A signal generation module synthesizes a sinusoidal signal with adjustable amplitude and frequency of up to 10V and 50kHz, respectively, and connects to standard piezo amplifiers for transducer excitation. Two sense modules measure the transducer's driving voltage and current of up to ±200V and ±500mA at low RMS noise levels of 9mV and 28μA, respectively. Essential user interaction is enabled by an HMI module. A main processor extracts the amplitudes and phases from measurement data using an LSQ-fit algorithm, estimates the required system states, applies the control law, and updates the excitation waveform accordingly. Closed-loop sampling rates close to 10kHz could be achieved.

Discussion and Outlook

Extensive circuit analysis and careful layout led to high-quality analog front-ends showing exceptional measurement quality. Its modular architecture makes the platform broadly deployable by being highly adaptable and extendable. The written software stack was profiled to identify and resolve bottlenecks using sophisticated optimization techniques, improving the system's performance significantly. The new platform is a high-end system that will greatly assist the design and verification procedure of sophisticated control algorithms applied to ultrasonic devices.
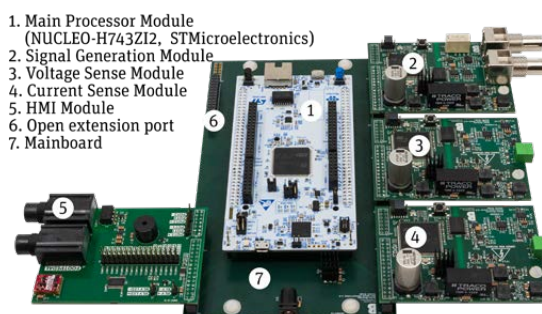
Dominik Wenger
dominik.wenger@protonmail.ch

Figure 1: Recorded controller reaction (red) and displacement amplitude (blue) during a target displacement step.

1. Main Processor Module
   (NUCLEO-H743ZI2, STMicroelectronics)
2. Signal Generation Module
3. Voltage Sense Module
4. Current Sense Module
5. HMI Module
6. Open extension port
7. Mainboard

Figure 2: Hardware setup of the new modular control platform.

MUSCLE Device Implementation on Microcontrollers

To enhance the MUSCLE project, a system to simplify controlling of laboratory equipment, we have integrated microcontrollers, thereby offering more versatility. Given the necessity for real-time capabilities, the handling of a real-time operating system is desirable, a feat previously unachievable. The objective of this thesis is to design and implement a microcontroller-based MUSCLE device.

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MUSCLE (MUSCLE Unified System for Controlling Laboratory Environment)

the system represents a versatile, self-hosted environment designed to control and monitor nearly every aspect of a laboratory setup. As a soon open source platform, MUSCLE opens up countless possibilities for controlling various technical equipment, given they have a communication interface. Additionally, this project provides the opportunity to reduce complicated devices and user interfaces (UIs) to an easy-to-use UI that can be developed for the industry, schools, research facilities and all other users. A brief system overview is shown in the figure 1.

Motivation

Previously MUSCLE exclusively supported Embedded Linux devices, the scope of its use remained limited due to certain underlying challenges such as higher costs, increased power consumption, and the inability to provide real-time responses. By integrating microcontrollers into the MUSLCE system, we aim to address these challenges and thereby unlock new potential. Microcontrollers are known for their cost-effectiveness, low power consumption, and real-time capabilities. These features can extend the reach of MUSCLE to a broader range of applications, especially those requiring real-time operation and energy efficiency.

Goal

The primary objective of this thesis is the implementation of a microcontroller-based MUSCLE device using a Real-Time Operating System (RTOS) to manage network communication, frontend device API requests, and user programming. In achieving these goals, we aim to extend the capabilities of the MUSCLE system, expand its applicability, and improve its utility in various laboratory environments. Ultimately, this work demonstrates the potential for integrating microcontrollers with an RTOS into the MUSCLE system and open the door for future development and innovation in this area.

Software Component Tasks

Network Communication: The implementation is responsible for handling the network communication. Thereby facilitating seamless interactions within the laboratory environment.

Frontend Device API Requests: By coordinating these requests from the MUSCLE frontend, the implementation ensures that all device function requests are handled properly, providing functionality between the MUSCLE system and the user program.

User Programming: Finally, the implementation takes over the user programming tasks. This gives users the ability to create custom controls and functions, further increasing the versatility and customizability of the MUSCLE system.
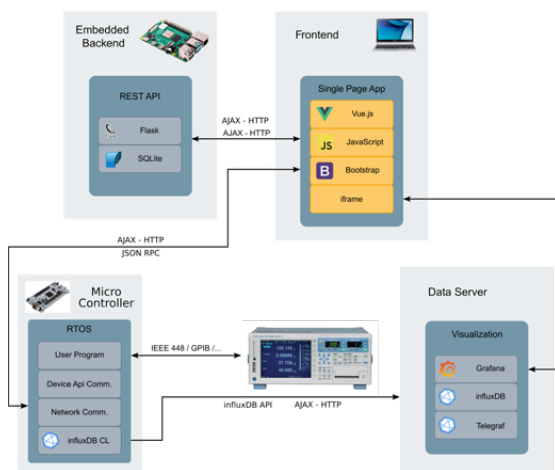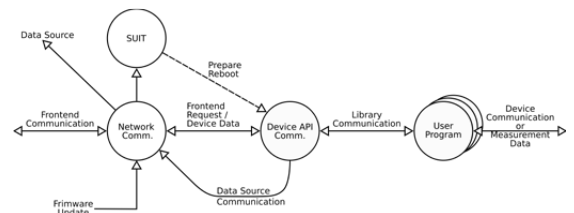

Fig. 1: MUSCLE Microcontroller Overview Concept

Fig 2: MUSCLE Microcontroller Device Software Concept

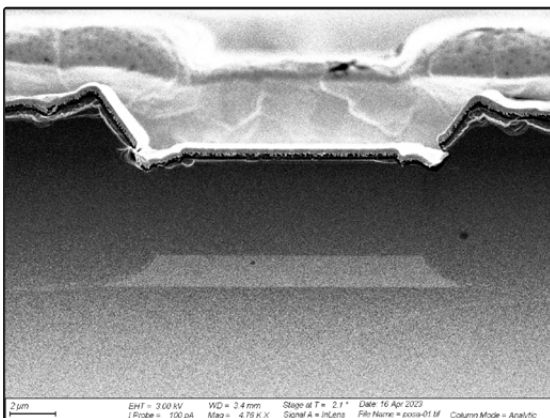# Predicting the divergence of quantum cascade lasers by simulation

The divergence of a quantum cascade laser beam strongly depends on the shape of the active region. But the divergence can only be measured at the very last stages of packaging the laser. In order to predict the divergence at an early stage, the far-field is simulated by finite element method by extracting the active region's dimensions and shape. To validate the simulation, the far-field of this same laser is measured.

Initial situation and goal

Quantum cascade laser (QCL) has the unique ability to emit at a specific narrow-band wavelength that can be selected by engineering the sequence and thicknesses of the different layers composing the active region. The typical emission wavelength is in the range of 3 to 25µm. Since many molecules have their absorption lines in this range, QCL are especially suited for spectroscopy. However, like all edge emitting semiconductor lasers, QCL has an important divergence, which is strongly dependent on the shape of the active region. The shape varies from laser to laser due to wet etching in the QCL production process. The divergence of a QCL can only be measured in the last steps of assembly, which can last several weeks, only to find out that it is out of specs. The goal of this thesis is to shorten this time-load by predicting the divergence of QCL by simulation.

Methods

This goal can be achieved if the shape and dimension of the active region are known. This is done by overlaying a binary mask over a microscope image of the front facet of the laser. The mask has in its center the approximate shape of the active region. The best fit between input image and mask is achieved when the sum of the differences between their intensities at each pixel is the smallest. This minimum is reached using a basin-hopping optimization algorithm. With the known dimensions of the active region, a 2D simulation of the electromagnetic wave equation can be run and the divergence calculated. However, this theoretical result must be compared with the real far-field of the laser. This is done with the help of a scanning detector, which moves in a spherical motion around the laser positioned in the center of the sphere.

Results

The basin-hopping algorithm in combination with a mask is very well suited for the extraction of active region dimension. With this piece of information, the measured and simulated far-field can be well compared. The final result is a precise prediction of the divergence of QCL. It means that, at an early stage, the useless and useful lasers can be separated.

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Scanning electron microscopy image of the front facet with the active region in light gray.
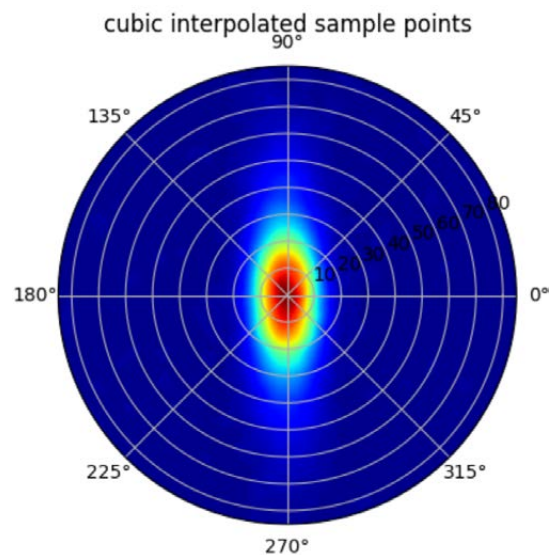
Resulting interpolated measurement of the laser's far-field.

Infoveranstaltungen
Séances d'information
Information events

Interessiert Sie ein Studium an der Berner Fachhochschule?
Wir öffnen unsere Türen: Erfahren Sie alles zu unseren Bachelor- und Master-Studiengängen, Zulassungsbedingungen, Studienbedingungen und unserer Schule. Führen Sie persönliche Gespräche mit Studierenden und Dozierenden und besuchen Sie unsere Labors in Biel und Burgdorf. Mit einer Weiterbildung auf Master-Stufe gehen Sie in Ihrer Karriere einen Schritt weiter. Unsere umfassende, interdisziplinäre Palette von Modulen ermöglicht Ihnen, Ihre Kompetenzen auf verschiedensten Gebieten zu erweitern und zu ergänzen. Informieren Sie sich in einem persönlichen Beratungsgespräch.

Jetzt informieren und anmelden:
bfh.ch/ti/infoveranstaltungen

Vous intéressez-vous à des études à la Haute école spécialisée bernoise ?
Nous vous ouvrons nos portes : obtenez des informations exhaustives sur nos filières de bachelor et de master, sur les conditions d'admission et d'études, et sur notre école. Discutez avec des étudiant-e-s et des enseignant-e-s et visitez nos laboratoires à Bienne et à Berthoud. Avec des études de master, vous posez un nouveau jalon dans votre carrière. Notre vaste gamme de modules dans diverses disciplines vous permet d'étendre vos compétences dans les domaines les plus variés. Informez-vous dans le cadre d'un entretien de conseil personnel.

Informations et inscription :
bfh.ch/ti/seances-information

Are you interested in studying at Bern University of Applied Sciences?
If so, we invite you to attend our open house events. They will give you insights into our bachelor's and master's degree programmes, our admission requirements, our study regulations and our university. You will have the opportunity to talk with students and lecturers and to visit our laboratories in Biel and Burgdorf. Completing your continuing education with a master's degree takes your career one step further. Our comprehensive, interdisciplinary range of modules allows you to expand and complement your skills in a wide variety of areas. Find out more in a personal counselling interview.

Further information and link to register:
bfh.ch/ti/information-events

Alumni*ae BFH
Alumni BFH
Alumni BFH

Alumni BFH vereint die ehemaligen Student*innen sowie die Alumni-Organisationen der BFH unter einem Dach. Als Alumni*ae sind Sie Teil eines lebendigen Netzwerkes und profitieren von attraktiven Leistungen und Benefits. Sie erhalten regelmässig den Newsletter «Alumni aktuell» und können der Community von Ehemaligen auf Facebook und LinkedIn beitreten und sich so aktiv vernetzen.

Ihr Mehrwert als Alumni*ae der BFH
Als ehemalige Student*innen sind Sie wichtige Botschafter*innen für die Berner Fachhochschule. Nach Abschluss Ihres Studiums werden Sie (kostenlos) ins fachübergreifende Alumni-Netzwerk des Dachverbands Alumni BFH aufgenommen. Wir bieten Ihnen:
– Newsletter «Alumni aktuell» (4x jährlich)
– Attraktive Angebote und Vergünstigungen
– Vielfältige Veranstaltungen der Alumni-Organisationen
– Alumni-BFH-Community auf LinkedIn und Facebook
– Karriereportal mit Jobplattform und Kursangebote rund ums Thema «Bewerben»

Als Alumni*ae sind Sie exklusiv zum grossen Netzwerk-Abend Alumni BFH eingeladen, welcher jährlich mit über 300 Ehemaligen in Bern stattfindet. Ausserdem können Sie an vielseitigen Events der Alumni-Organisationen und am Sportangebot der Universität Bern teilnehmen. Daneben erhalten Sie Vergünstigungen und Rabatte auf ausgewählte Dienstleistungen und profitieren vom attraktiven FH-Schweiz-Leistungsangebot sowie vom Weiterbildungsangebot der BFH.

Mehr Informationen zu Alumni BFH und den attraktiven Leistungen unter: bfh.ch/alumni

Alumni BFH réunit sous un même toit tou-te-s les ancien-ne-s étudiant-e-s et les organisations d'alumni de la BFH. Membre d'Alumni BFH, vous faites partie d'un réseau dynamique et profitez de prestations attrayantes. Vous recevez régulièrement l'infolettre « alumni à l'heure actuelle » et avez la possibilité de rejoindre la communauté sur Facebook et LinkedIn.

Vos avantages
En tant qu'ancien-ne étudiant-e, vous êtes une ambassadrice ou un ambassadeur important-e de la Haute école spécialisée bernoise. Une fois vos études achevées, vous rejoignez (gratuitement) le réseau interdisciplinaire de l'association faitière Alumni BFH et bénéficiez de précieux avantages :
– Infolettre « alumni à l'heure actuelle » (4 fois par année)
– Offres attrayantes et prix préférentiels
– Vaste palette de manifestations proposées par les diverses associations d'alumni
– Alumni BFH Community sur LinkedIn et Facebook
– Portail Carrière, plateforme d'emplois et offre de formations pour vous aider à postuler à un emploi

En outre, vous recevez en exclusivité une invitation à la grande soirée de réseautage qui se tient une fois par année à Berne, réunissant quelque 300 ancien-ne-s étudiant-e-s. Vous pouvez également participer aux différents évènements des associations d'alumni et profiter de l'offre sportive de l'Université de Berne. De plus, vous bénéficiez de prix préférentiels et de rabais pour certaines prestations et avez accès à l'offre intéressante de FH Suisse ainsi qu'aux formations continues de la BFH.

Plus d'informations sur Alumni BFH et l'offre de prestations : bfh.ch/alumni

Alumni BFH unites former students and BFH alumni organisations under one roof. As a member, you are part of a lively network and benefit from attractive services. You regularly receive the informative newsletter "Alumni aktuell" and can join the community on Facebook and LinkedIn.

Your benefits as a BFH alum
As a former student, you are an important ambassador of Bern University of Applied Sciences. After completing your studies, you are admitted (free of charge) in the multidisciplinary umbrella organisation Alumni BFH. Our offer:
– Newsletter "Alumni aktuell" (quarterly)
– Attractive offers and discounts
– A wide range of events set up by the alumni organisations
– The Alumni BFH community on LinkedIn and Facebook
– A career portal with a job platform and courses to help you with your job applications

As an alumni, you will be exclusively invited to the great Alumni BFH networking night, which takes place annually in Bern with over 300 former students. In addition, you can participate in the many events offered by the alumni organisations and make use of the sports facilities of the University of Bern. You also receive discounts and special offers on selected services and can benefit from the attractive offers of FH Schweiz and the BFH continuing education programme.

More information on Alumni BFH and its attractive services: bfh.ch/alumni

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