



Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences



2024
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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Prof. Andreas Habegger
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 Student*innen 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 Leser*innen 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 Student*innen, 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.

Aux autres lecteurs et lectrices, le Book du MSE offre un aperçu captivant des projets palpitants qui ont été traités avec engagement, créativité et persévérance.

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 2024!

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 2008 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. Hinzu kommt, 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 arbeiten an Projekten aus der Praxis. Die

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 2008, 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 since 2008 – 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, the students are assigned a research unit

- 4 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

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

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Titel/Abschluss

Master of Science (MSc)

Studienform

Vollzeitstudium (3 Semester) oder
Teilzeitstudium (7 Semester)

Unterrichtssprache

Englisch, Deutsch und 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 Forschungseinrichtungen in enger Zusammenarbeit mit einem Advisor absolviert wird.

Abschlussarbeit

Die Praxisorientierung des Studienganges ist zentral: Studierende werden in Forschungsprojekte 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 Kontaktaufnahme!

+41 31 848 50 46
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 et 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 31 848 50 46
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 covers 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.

+41 31 848 50 46
mse@bfh.ch (faculty office)

Web

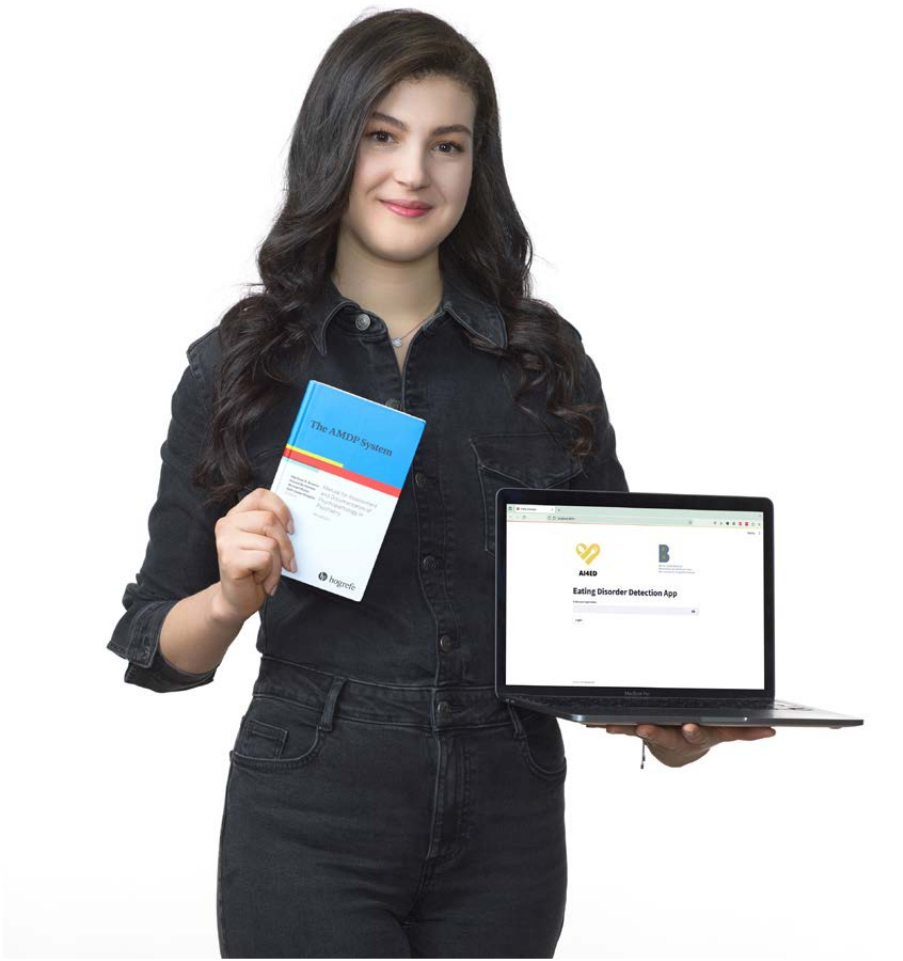
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Interviews mit Studierenden

Interviews d'étudiant-e-s

Interviews with students

6



Ghofrane Mehrbene

Why did you choose this degree programme?

During my Bachelor in Computer Science with a specialisation in Data Engineering, I developed a deep interest in the field. However, I felt that my understanding was only scratching the surface of the vast field of data engineering and data science. Pursuing a Master of Science in Data Science was a logical progression in my academic journey. It offered me the opportunity to delve deeper into these subjects, enriching my knowledge and expertise.

What did you like best?

One aspect I particularly cherished about the programme was its diverse range of modules in Data Science. The blend of theoretical foundations with practical applications made the learning experience really stimulating. It struck a good balance, making the studies less monotonous and more dynamic.

What was your daily schedule like during your studies?

Thankfully, the programme structure was accommodating. I never had more than three days of lectures per week. This flexibility allowed me to craft my schedule efficiently, dedicating time to both attending lectures and working on semester projects without feeling too overwhelmed.

Did you work during your studies? (during the semester / holidays)

Yes, I continued working part-time as an assistant in the Applied Machine Intelligence research group at BFH, a position I held since my bachelor. This role was immensely enriching, contributing significantly to my passion for data science and research.

What were the biggest challenges during your studies?

One of the significant challenges I encoun-

tered was maintaining organisation and managing the workload effectively. Balancing academic responsibilities with work commitments required careful planning and discipline.

What are your plans after graduation? What is your current occupation?

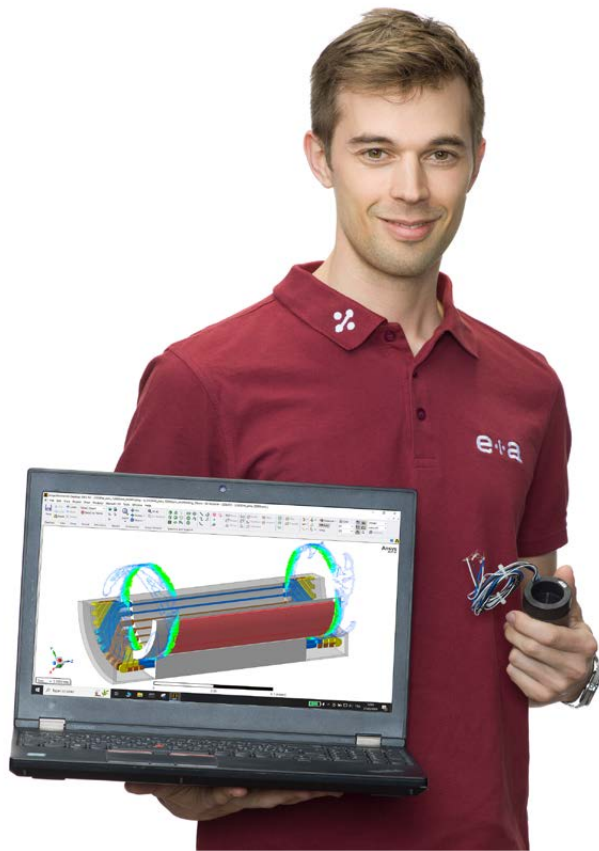
My career aspirations lean towards pursuing a Ph.D. in Data Science, inspired by my experiences with the Applied Machine Intelligence research team at BFH. Research has ignited a profound passion within me, and I envision myself contributing to the advancement of knowledge in this field.

How could you leverage what you have learned during the programme?

The knowledge and skills acquired during the programme are already instrumental in my professional endeavours. I continuously apply these insights to my day-to-day work, contributing to projects and initiatives with a refined understanding of data science principles and methodologies.

What is your advice for prospective students?

I would advise them to approach their journey with enthusiasm, dedication, and a willingness to explore and innovate. Especially, don't hesitate to engage with peers, professors, and industry professionals. Collaborative learning fosters a deeper understanding of concepts and opens doors to new perspectives and ideas. And remember, data science is a rapidly evolving field, so stay abreast of the latest developments, tools, and methodologies, and always stay open and be adaptable to change.



Lucien Porta

Pourquoi avez-vous choisi cette filière d'études ?

À la suite de mon Bachelor en Mécanique, le Master in Electrical Engineering représentait pour moi l'occasion d'élargir mes compétences. De plus, mon intérêt pour les entraînements électriques m'a naturellement orienté vers cette filière. Finalement, les compétences dans ces deux branches se complètent bien et apportent des connaissances pluridisciplinaires qui sont très utiles dans certains domaines tels que les entraînements électriques, la mécatronique ou la conception de systèmes.

Qu'est-ce qui vous a particulièrement plu dans la formation ?

La flexibilité du parcours d'études est un vrai plus au niveau master. Cela permet de se construire un cursus personnalisé et orienté vers ses propres intérêts et objectifs. Le rattachement à un institut de recherche et à un mentor est également un élément important, puisque c'est par ce biais que les expériences concrètes sont acquises avec différents projets.

À quoi ressemblait votre emploi du temps ?

Par moments, mon emploi du temps était relativement chargé. Les études de master sont flexibles, mais demandent aussi une plus grande autonomie dans l'organisation de son travail et de son cursus. Cela m'a permis de répartir la majorité des cours théoriques sur la première année, ce qui mène à des périodes d'exams intenses, tout en présentant l'avantage de pouvoir dédier la seconde partie du master aux projets.

Avez-vous travaillé en parallèle, pendant le semestre ou les vacances ?

Oui, j'ai effectué mon master en cours d'emploi au sein du même institut de recherche auquel j'étais rattaché pour mes études. Cela s'est avéré très complémentaire, et m'a donné du temps et un environnement propice pour développer des compétences et tisser un réseau professionnel dans mon domaine. De plus, mon mémoire de master a été effectué à plein temps avec une entreprise spécialisée. J'ai moi-même pu mettre en place cette collaboration qui a finalement été bénéfique pour les trois parties

prenantes, soit la BFH, l'entreprise et l'étudiant-e.

Quels défis avez-vous dû relever durant vos études ?

Personnellement, le passage du bachelor au master a représenté un grand défi, notamment au début, quand beaucoup de connaissances ont dû être acquises. Toutefois, les compétences fondamentales acquises avec le bachelor et un peu de motivation rendent un tel parcours possible, et cela se traduit rapidement par des qualités intéressantes et une satisfaction personnelle.

Quels sont vos projets ? Que souhaitez-vous faire après vos études et que faites-vous aujourd'hui sur le plan professionnel ?

Après ces études, je souhaite poursuivre mon parcours en ingénierie dans le domaine des entraînements électriques, de l'électromagnétisme ou de la simulation. J'espère pouvoir contribuer à des solutions innovantes qui ont un impact positif sur la consommation d'énergie et de ressources, et mener à bien le développement de systèmes et de projets complexes. J'ai trouvé une place de travail en entreprise sans trop de difficulté, directement après mon master, qui plus est dans le domaine recherché.

Quels bénéfices tirez-vous de vos études ?

Je tire un grand profit personnel de l'élargissement de mes compétences et de l'expérience accumulée dans les mondes académique et professionnel. Outre les acquis techniques, le master MSE offre également une ouverture sur la Suisse grâce aux nombreuses collaborations entre les hautes écoles spécialisées, et il permet de tisser un réseau diversifié, source d'épanouissement.

Que diriez-vous à quelqu'un qui envisage de telles études ?

Je lui conseillerais de bien soupeser ses propres motivations et objectifs, car l'envie d'effectuer ce master devrait être guidée par un intérêt pour un domaine particulier. Cela permet de choisir l'institut de recherche approprié et de construire un cursus cohérent et motivant. En cas de doute ou d'envie particulière, il ne faut pas hésiter à effectuer un stage ou une expérience professionnelle entre le bachelor et le master, histoire de mieux cerner ses intérêts.

Interviews mit Studierenden

Interviews d'étudiant-e-s

Interviews with students

8



Yan Scholl

Warum haben Sie sich für dieses Studium entschieden?

Nach meinem Bachelorstudium stellte ich mir die Frage, ob ich ein Masterstudium antreten oder in einer Firma arbeiten möchte. Da ich mein Wissen in Mechatronik und Automation vertiefen wollte, habe ich mich für diesen Studiengang entschieden. Durch das breite Modulangebot konnte ich mir diejenigen aussuchen, die mich am meisten interessierten. Darüber hinaus konnte ich mit dem Research Fellowship Programm bereits während des Masterstudiums Arbeitserfahrungen sammeln.

Was gefiel Ihnen besonders gut an diesem Studium?

Nebst dem Studieninhalt der Module lernte ich vor allem die Selbständigkeit und die Freiheiten des Studiums zu schätzen. Insbesondere die freie Auswahl von Modulen sowie das selbstständige Arbeiten an Projekten, in welchen gelerntes Wissen umgesetzt werden konnte, waren ein grosser Mehrwert. Das Fellowship Programm am Institut gab mir die Möglichkeit, die Projektarbeiten im Rahmen von Forschungsprojekten durchzuführen. Dadurch waren alle Arbeiten sehr praxisorientiert und kreierten einen unmittelbaren Mehrwert.

Wie sah der Studienalltag aus?

Während dem ersten Studienjahr hatte

ich zwei Tage pro Woche Vorlesungen in Zürich oder online. Die restlichen Tage beinhalteten praktische Arbeit an den Projekten oder am Institut. Während dem zweiten Studienjahr fokussierte ich mich auf meine Masterarbeit. Diese Kombination war für mich sehr abwechslungsreich. Der Austausch mit anderen MSE-Studierenden und den Angestellten des Instituts gefiel mir sehr.

Was waren die grössten Herausforderungen im Studium?

Was mir besonders gefallen hat, ist zugleich die grösste Herausforderung: Die Selbständigkeit und Freiheiten, welche das MSE-Studium bietet. Dies erfordert gute Organisation und ein strukturiertes und konsequentes Vorgehen bei den Projektarbeiten, Vorlesungen und der Spezialisierung am Institut. Ich konnte mich jedoch immer auf die Unterstützung meines Advisors und der MSE-Administration der BFH verlassen.

Was möchten Sie nach dem Studium machen und was machen Sie heute beruflich?

In meiner Masterarbeit entwickelte ich ein Maschinenkonzept für ein neuartiges Polierverfahren. Meine Masterarbeit kann ich dank der First Ventures Förderung der Gebert RUF Stiftung weiterführen und umsetzen. Mit der Unterstützung von Gebert RUF und der BFH kann ich so mein

eigenes Spin-Off starten: Swiss Plasma Polishing

Inwiefern können Sie von Ihrem Studium profitieren?

Im Studium konnte ich mir viel Fachwissen im Bereich Mechatronik und Automation aneignen. Ein Grossteil des Studiums besteht aus Projektarbeiten. Diese Projektarbeiten halfen mir dabei, das erlernte Wissen praktisch umzusetzen. Zudem lernte ich während des Studiums wissenschaftliches Arbeiten im Team.

Welchen Tipp haben Sie für jemanden, der dieses Studium in Betracht zieht?

Wenn jemand sein Wissen in einem der vielen Profilen vertiefen möchte, ist dies das perfekte Studium. Durch die grosse Anzahl an wählbaren Modulen kann so für alle das passende, individuell zugeschnittene Studium zusammengestellt werden. Durch den grossen Anteil der Projektarbeiten ist eine strukturierte Arbeitsweise und eine gute Zeiteinteilung wichtig. Um die Projektarbeiten umzusetzen, gibt es an der BFH viele Advisors in unterschiedlichen Fachrichtungen und Forschungsprojekten, so werden alle ein passendes Thema für ihre fachliche Vertiefung finden.



Zusammenarbeitsformen

Formes de collaboration

Collaboration

10 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.

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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.

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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
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Auftragsforschung und Dienstleistungen | Recherche sous contrat et prestations de service | Contract Research and Services

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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



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Marktübliche Preise
Prix du marché
Prevailing prices

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Monate bis Jahre
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Teilfinanziert durch
öffentliche Fördergelder
Financement partiel par
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Industriepartner

Partenaires industriels

Industry partners

12 Eine enge Zusammenarbeit mit Industriepartnern 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!

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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 !

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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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Bachmann Engineering AG, Zofingen
BFH-AHB, Biel
Criva AG, Renens
Cendres+Métaux SA, Biel
CSEM, Alpnach
e+a Elektromaschinen und Antriebe AG, Möhlin
Impedans Ltd., Dublin
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Liste der Studierenden

Liste des étudiant-e-s

List of students

14 Im Folgenden präsentieren wir Ihnen die Zusammenfassungen der Abschlussarbeiten des Jahres 2024.

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.

Ci-après, nous vous présentons les résumés des travaux de fin d'études de l'année 2024.

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

Ils et elles 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.

On the next pages, we have summarised the 2024 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.

Bähler Florian	15	Landolt Fabian Levin	21	Schmid Thomas	28
Binz Bastien	16	Liechti Jonas	22	Schmutz Yannis Valentin	29
Dick Yanick	17	Louzada Wisniewski Viviane	24	Scholl Yan	30
Falise Jonathan	18	Merhbene Ghofrane	25	Temple Caley Ambler	31
Gomez Lucas María José	19	Porta Lucien	26	Theurillat Benjamin	32
Kicev Marjan	20	Rankwiler Leander	27	Watzek Malte	33

Towards Sustainability in Procurement Through AI

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Ulrich Fiedler
Expert : Dr. Andreas Ritter (Inpeck AG)

The urge for fast action on climate change brought the question of sustainability to the table of many companies. Assessing a company's processes and product' impact on global warming potential is complex and needs significant investments. Making more sustainable strategic decisions based on an sustainability framework tackles long-term reduction of emissions. This work, in contrast, aims to provide short-term feedback on operative business processes in procurement.

Approach

The Literature research for sustainability strategies and frameworks applicable to a Swiss SME in the manufacturing industry has focused on the pillars of economic, environmental and social sustainability. The market evaluation defined the ML and AI solution, enabling the following added values for an employee working in corporate procurement: calculating equivalencies, finding alternatives, consolidating orders, rating suppliers/products, suggesting sustainable practices, categorizing products, and predicting future demand. A cloud application enhances transactional and master data from an SAP ERP System with sustainability data. The application integrates the generative AI model of GPT-4 and additional ML models for product emission assignments and supplier evaluations. A mobile application for purchasers links business processes and data with enhanced generated content.

Results

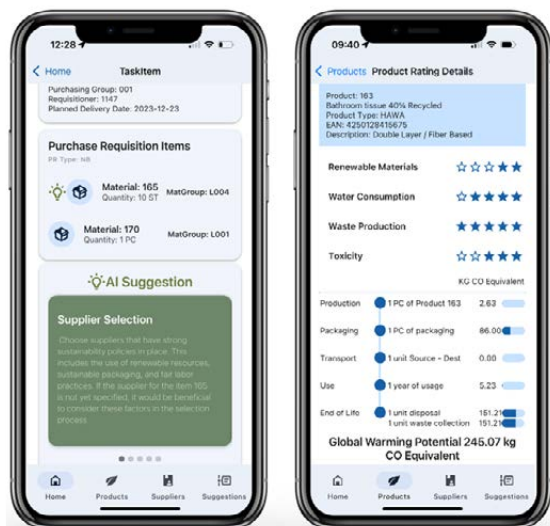
By leveraging Machine Learning (ML) and Generative Artificial Intelligence (AI), the work realized a proof of concept solution to challenge behavior and practices, empowering companies with an SAP ERP System to make sustainable procurement decisions. The scope of operative business processes, such as procurement of material, supplier returns, and one-time supplier evaluation, opened a wide range of opportunities for integrating AI features. Out of the feedback from user acceptance tests, it follows that purchasers gain valuable insights regarding sustainability while processing their daily tasks and reinforcing their learning towards more sustainable practices.



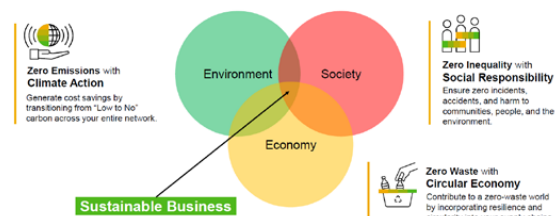
Florian Bähler
florian.baehler@agilita.ch
Computer Science

Conclusion

The architecture proves the realization of the solution and guarantees flexibility and extensibility for further exploration of applying AI features to business use cases. AI capabilities may help procurement employees to think outside the box of their usual practices and methods. Viable long-term results can significantly impact the quest for a more responsible business world. The used models have not been trained to be context-specific; therefore, they shine most on general suggestions and assessing habits in this application. The generative AI output in multiple use cases is neither transparent nor accurate or complete to rely solely on it in business context. Integrating different ML models can improve the solution's intelligence, primarily in assessing material data and perform supplier evaluations.



Mobile View on iOS for Procurement AI App



The three pillars for sustainable Business

Classifying Defect Types on High-Precision Metal Parts using Semi-Supervised Anomaly Clustering

Degree programme : Master of Science in Engineering

Thesis advisor : Prof. Dr. Gabriel Gruener

Expert : Dr. Sandro Lombardi

Industrial partners : Criva AG, Renens ; Cendres+Métaux SA, Biel

Visual inspection of machined parts requires a high level of concentration but is repetitive and monotonous. Current state-of-the-art solutions to automate this task use anomaly detection, but they only classify parts as defective, not the defect type. A semi-supervised method to predict the type of defect is being developed with Criva AG on a Cendres+Métaux SA use case.

Context

Cendres+Métaux SA (CMSA) is a contract manufacturer of complex titanium medical components. Their products must meet high standards, so a 100% visual inspection is performed by experts. CMSA wants to automate the visual inspection to cope with increased production and to reduce subjectivity. Criva AG's anomaly detection-based software could be a solution. However, this solution does not yet provide the type of anomaly, which is important for manufacturing quality management, as repeated occurrences of similar defects may indicate a production issue.

Motivation

Supervised learning would be the best approach to classify the defects into categories like burrs, dust, scratches, etc. However, it requires a significant number of labeled images. Furthermore, all possible defects must be predefined, since it can only classify defects correctly that are present in the training dataset. Therefore, a semi-supervised method based on anomaly clustering requiring few labeled images is explored.

Implementation

For benchmarking, the clustering algorithm was initially implemented on the popular MVTec dataset to compare

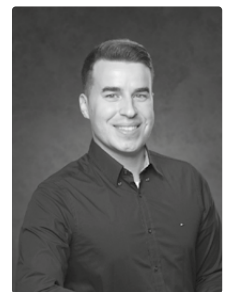
it with state-of-the-art methods and to ensure that the extracted features provide enough information to form valid clusters. First, Criva's software is used to extract per-patch features for each image, as shown in Figure 1. These features are processed into weighted average feature vectors. Then, using hierarchical clustering with ward linkage, anomaly clustering can be performed to group similar vectors. This clustering algorithm is then applied to images of CMSA components.

Results and Conclusion

The clustering algorithm achieves similar results compared to state-of-the-art methods on the extracted features of the MVTec dataset. The same approach did not work as well on the CMSA dataset because the images often contain more than one defect type. In addition, the ratio of anomalous pixels to the total number of pixels is smaller than in the MVTec set.

Outlook

To improve performance on CMSA images, clustering should use regions around the defects, as shown in Figure 2. Anomaly detection features can be used to localize defects and create the regions. The proposed solution must be validated using more images of known defects for real-world performance.



Yanick Dick
yanick.dick94@gmail.com
Mechatronics and Automation

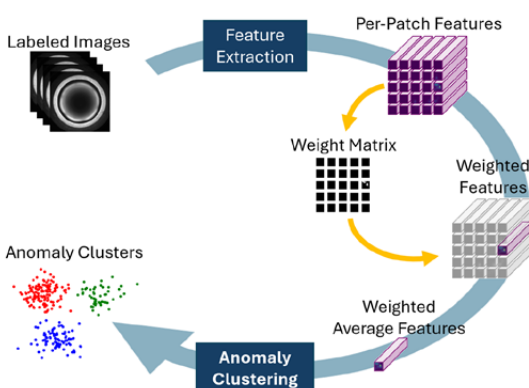


Figure 1: Clustering algorithm

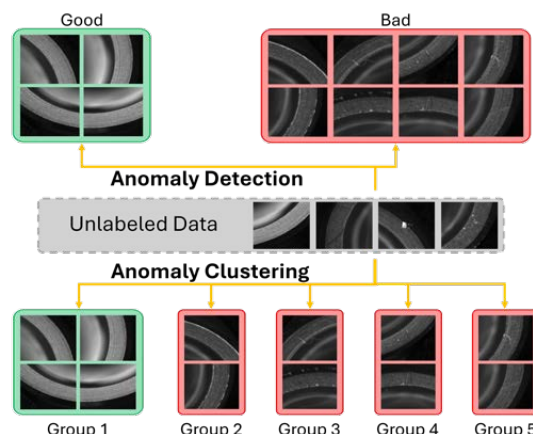


Figure 2: Difference between anomaly detection and clustering

Intelligent Machining Cell for CFRP Mast: Case study, Roadmap & Initial proof of concept

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Norman Urs Baier

18

This thesis explores integrating an automated machining cell at Hall Spars to address workforce challenges and cost reduction goals. It identifies other automatable operations, evaluates scanning methods to improve the digital twin, and assesses marking solutions to reduce human error. A prototype software also demonstrates the feasibility of this project.



Jonathan Falise
078 698 31 93
Mechatronics and Automation

Context

Hall Spars is a well-established Dutch designer and producer of sailboat carbon fibre-reinforced plastic (CFRP) mast and rigging. Working in the high-end market, it operates in a high-mix low-volume model. Therefore, Hall's manufacturing process is exclusively manual and faces challenges in finding the workforce. Hall aims to solve these challenges through automation.

The manufacturing process starts by having the mast laminated and cured, then moves to the pre-assembly, where all the various openings and part fitting are manually made. Then, the mast goes through a sanding and painting stage before having all the rigging and electronics installed and checked. The pre-assembly stage is the most critical and time-consuming stage of the manufacturing process, requiring experienced and skilled workers.

Goal & Approach

This master's thesis investigates how an automated intelligent machining cell can be implemented as a first step in that direction. The project is divided into four sections.

First, it provides a comprehensive list of manufacturing steps suitable for automation. It profiles each project by grading their complexity, ROI and added value. Secondly, it evaluates various scanning methods to acquire a valid digital twin, ensuring accurate CAD data to assist the machining process. This step is seen as a crucial part as it can offset the variability

of the manufacturing process and is the foundation of an "intelligent" system. Thirdly, this thesis compares and grades different marking solutions to establish references on the mast. The goal is to reduce human error and use the new marking method as a stopgap solution before introducing a machining centre to the manufacturing process. Lastly, a prototype software processes the scanned data to extract the critical features necessary for the machining process. This is the first step to creating "intelligent" software that adjusts the machining operation according to the actual part.

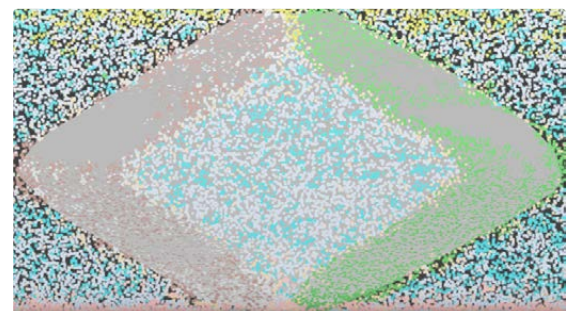
Results

My work highlights the benefits of a scanning solution using a laser tracker and a structured light scanner. It also suggests a two-stage deployment, starting only with the laser tracker, offering more time to gain experience with the new tool. My analysis also elaborates on the probable unnecessary aspects of the marking meant as a stopgap. Lastly, the trial data processing software I developed convincingly recognises the critical features for machining.

In conclusion, my work outlines an overarching roadmap with four distinct steps to introduce a state-of-the-art machining solution. The first two steps will have the most significant impact, reducing costs and bringing new capabilities to the company. The last two steps are more optimising and minimising the manhours through some automated processes.



All of the parts are made of carbon fibre-reinforced plastic, and the manufacturing process is manual.



Outline of a reinforcing patch given by the prototype software.

Standardization of Testing Services at the Swiss Cobotics Competence Center (S3C)

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

The new Swiss Robotics Competence Center (S3C) bridges research and industry to boost robotic applications in Swiss manufacturing. The S3C's main service shall be testing on Cobotic Base Cells (CBCs), validating industrial process with cobotic solutions. In this work, the S3C testing processes and the generated documentation have been designed and validated.

Motivation

The S3C facilitates collaboration between academic and industrial partners, enabling testing of manufacturing processes with adaptable CBCs. It designs and conducts tailored tests based on customer-specific needs, processes, and workpieces

Objectives

The goal of this project was to develop and refine S3C testing processes, specifically tailored for industrial cobotic applications. Templates and documents were to be developed to structure the testing process from input to output. These tools were to be iteratively enhanced through industry-inspired test cases, optimizing both methodologies and outcomes.

Methodology

The current S3C testing process follows an Input-Process-Output (IPO) model. To enhance this structure, Lean Robotics and PDCA methodologies have been integrated (Fig. 1). Lean Robotics optimizes robot integration in manufacturing, while PDCA offers a structured approach to process improvement. The Input stage, encompassing the Prepare and Design steps, establishes key parameters such as project scope and metrics, and defines both manual and

robotic tasks. The Process stage includes the steps Integrate, Operate, and Check. During the Integrate step, the CBC to be used is defined, and pre-testing is done. In the Operate step, the process is initiated, monitored, and data is collected. The Check step involves evaluating the results. Finally, the Act step of the Output stage focuses on process improvement, proof-of-concept, conclusions, and recommendations.

Results and Outlook

Implementing this methodology resulted in two templates and three reports: a customer input form, a process form to guide the testing, and a comprehensive report detailing each phase with insights. These templates were validated with two use-cases inspired by packaging (Fig. 2) and assembly tasks, helping as a roadmap for the entire process from cobotic cell selection at the S3C facilities to test monitoring. This approach guarantees optimization through iterative improvements, ensuring added value for the customer and facilitating process analysis for tangible results at the S3C.



María José Gomez Lucas
 076 543 67 24
 majitogomez240@gmail.com
 Mechatronics and Automation

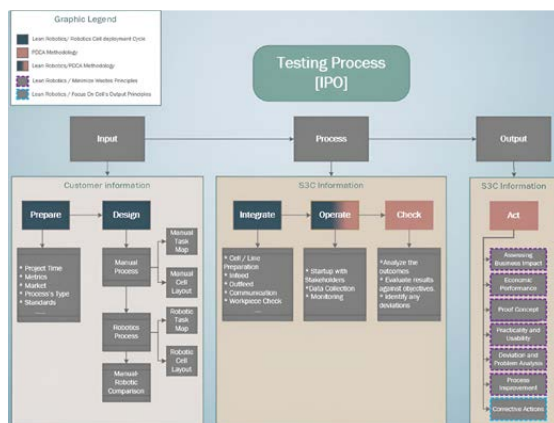


Fig.1 Proposed methodology

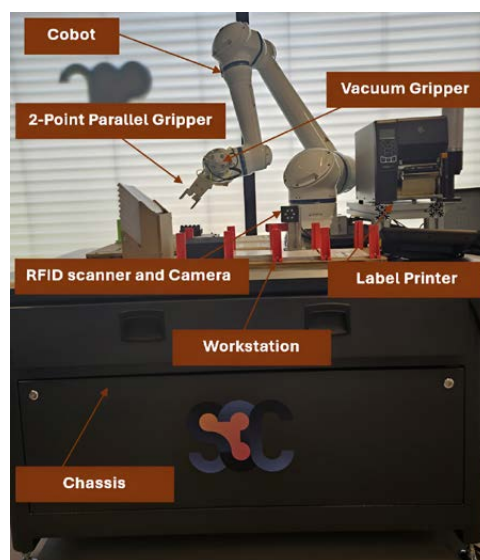


Fig. 2 Cobot cell used in the packing process

Development of a System for Multiplexed High-Resolution Multimodal Signal Acquisition

Degree programme : Master of Science in Engineering
Thesis advisors : Prof. Dr. Thomas Niederhauser, Prof. Andreas Habegger, Nishant Gupta

20

The Institute for Human Centered Engineering has developed a multiplexed multimodal miniaturized catheter. However, there is no commercially available device that allows measurement and control of the device under tight time constraints. In this thesis the requirements were evaluated and a dedicated modular front-end was developed. By using a high speed analog front-end, a system on chip, and multiplexed drive circuits, minimal settling and measurement times were achieved.



Marjan Kicev
marjankicev@msn.com
Mechatronics and Automation

Motivation

The continued miniaturization of transducers, in combination with advancements in flexible printed circuit board technologies, has enabled the fabrication of smart catheters that integrate multiple sensing modalities on a single device. As a result, it is now possible to simultaneously acquire bio-signals from several vital organs, locations, and modalities at a suitable orifice (such as the esophagus). To facilitate multi-modal signal acquisition, the Institute for Human Centered Engineering (HuCE) is seeking a versatile interface that can acquire bio-signals with a novel, flexible, liquid-crystal polymer (LCP)-based catheter integrating multiple multiplexed sensors (e.g., electrodes for bio-potential/impedance, pressure, oximeter and temperature sensors).

Goal

The focus of this thesis is the development of a dedicated front-end design for the acquisition of high-resolution, time-multiplexed, multimodal biosignals with a single system. By supporting a wide range of modalities and short switching and measurement times, quasi-simultaneous data should be available. A modular design should allow for easy modification and expansion.

Results

A common analog interface optimized for multiple sensor types has been developed. By using a System on Chip (SoC), multiple channels can be measured simultaneously. Parallel pipelined filtering allows simultaneous use of averaging and lock-in amplifiers that include a signal decimation stage. This allows low-frequency and high-frequency signals to be separated in the same measurement. A dedicated digital processing path records the raw data and the corresponding filter position, allowing timing optimization. A multiplexer, combined with a direct digital synthesizer (DDS) and two digital-to-analog converters (DAC), allows multiple sensing modalities to be driven with minimal setup time.

High-speed, pipelined analog-to-digital converters (ADCs) reduce measurement time and enable high-frequency excitation signal acquisition. 16-bit resolution allows low gain operation for reduced settling time and noise. Settling times of less than 1 μ s maximize usable measurement time. By selecting a pin-compatible family, the sampling rate can be increased from 25 MSPS to 125 MSPS, allowing higher frequency measurements such as ultrasound.

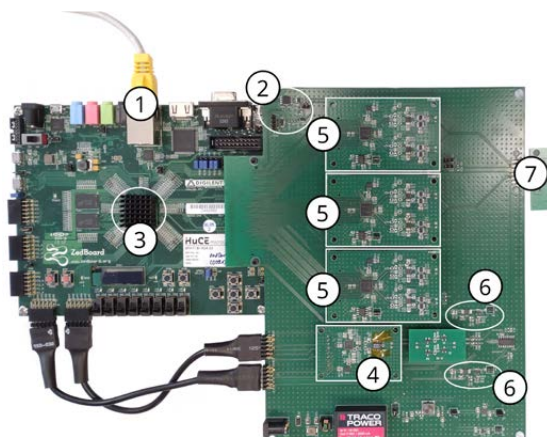
With 10 sensor nodes, a maximum sampling rate of 650 Hz with catheter response time and 2 kHz without can be achieved.

A TCP/IP server allows data and configuration exchange. It is also possible to measure raw data without any digital processing.

Outlook

By sharing resources such as dividers and magnitude calculations between processing pipelines, logic cell and DSP usage can be further reduced and silicon efficiency improved.

This, combined with a reduction in the number of lanes used in the LVDS interface, would allow an increase in the number of parallel sensor acquisitions possible.



Overview: 1) TCP/IP 2) Node selection and detection unit
3) Zynq SoC 4) DDS 5) Analog Frontend 6) DAC 7) Catheter

Collaborative Mobile Manipulator Solution for CNC Machine Tending and Intralogistics Tasks

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Gabriel Gruener
Expert : Dr. Francesco Crivelli (CSEM)
Industrial partners : Bachmann Engineering AG, Zofingen ; BFH-AHB, Biel

Switzerland's machining industry need for automation has increased due to labor shortages and high costs. This is being addressed by a collaboration between BFH, Bachmann Engineering AG, vonRickenbach.swiss AG, and Weinig Holzher AG. An integrated solution is being developed combining Autonomous Mobile Robots (AMRs) and Collaborative Robots (Cobots) for CNC machine tending. This project improved system precision and created a no-code, friendly interface.

Context

Collaborative Robots and Autonomous Mobile Robots are increasingly popular in various industries due to their potential to improve automation and efficiency. However, their adoption in smaller enterprises is slow due to the complexity of programming and operational challenges. Addressing this is essential to enable smaller enterprises to use this technology effectively.

Motivation

Simplifying programming interfaces for cobotic systems is crucial to enable automation technologies for small and medium enterprises. The goal is to simplify programming and solve the complexity with the interaction of mobile robots. If the time required for reprogramming intralogistic tasks is reduced, it will increase profitability.

Approach

Collaborative mobile manipulators must be reliable and precise to load CNC machines. The process involves employees working alongside cobots, guiding them to approximate positions, after which onboard vision systems and tags handle the precise fine-tuning and adjustments. The process is tested and enhanced to achieve simplicity while maintaining flexibility for operations.

Result

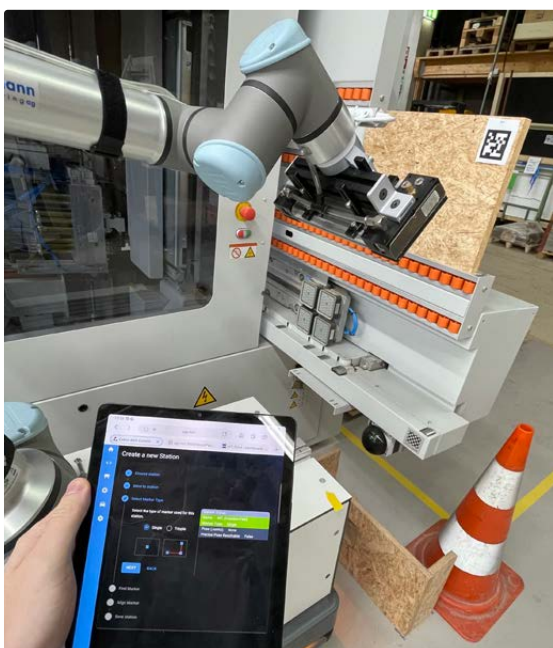
A method using multiple markers at defined positions is used to improve the precision of the calibration. A Universal Robot, a MIR platform, and an Intel RealSense Camera are combined in a cobot-AMR set-up to showcase a real solution. An application running on a web browser controls the cobot-AMR through a tablet. This interface greatly simplifies task reprogramming, reducing the time and technical skills required, making automation simpler and more practical for SMEs.

Outlook

In the future, the application can be adapted to suit a broader range of industrial scenarios. This will involve enhancing the block programming functionality and developing specialised interfaces. Introducing an automated scheduler will enhance task management and overall system efficiency.



Fabian Levin Landolt
fabian.landolt@hotmail.com
Mechatronics and Automation



Demonstration of station setup via Web-App



Cobot-AMR system loading a CNC-Machine

Collecting and Analyzing Spam E-mails Through Simulating an Open Mail Relay

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Bruce Nikkel
Expert : Sylvain Hirsch

22

Spam e-mails are an annoyance to many people in the 21st century. To better understand and analyze, a service to collect large amounts of spam e-mails was designed and implemented. Compared to traditional spamtraps, this system actively coerces spammers into sending e-mails, therefore collecting a greater volume of messages.



Jonas Liechti
Computer Science

Introduction

In the online world, spam emails are a major annoyance and security issue for regular users. Kaspersky estimates that more than 55% of global email traffic is unsolicited email. The most common way to study how spammers acquire email addresses and use them in their spam campaigns is to use so-called spamtrap addresses - email addresses specifically designed to receive spam. This project took a different approach: instead of spamtrap addresses, an SMTP server was implemented that simulates an open mail relay. It accepts any email for any address, while pretending to deliver it to the destination.

Implementation

A virtual machine in the BFH Cyber Lab with public IP addresses was provided to handle the incoming traffic. The design of the service is based on a microservice architecture using Docker containers. Each microservice has its own responsibility for the different topics. This allows parts of the system to be changed independently, while the rest can continue to operate unaffected. The main parts consist of the mail server container, which receives all incoming messages and stores them in the local file system. As a

secondary step, the received emails are analysed and enriched with additional data in a separate container and finally stored in the database. Using the web interface and API, users of the system can browse the acquired dataset and search for specific domains or IP addresses. For deeper analysis, a JupyterLab instance is also provided to programmatically interact with the data.

Result

After the initial test emails were forwarded to the spammers' mailboxes, the number of spam emails increased dramatically. In total, over 180 million emails were received during the project. This shows that spammers are still actively looking for ways to abuse open mail relay servers. The dataset shows that more than 80 percent of the spam emails received were sent from countries in Europe, with the Netherlands being the top destination followed by France and Germany. This suggests that spammers have a bias towards choosing an Open Mail Relay closer to their own location.

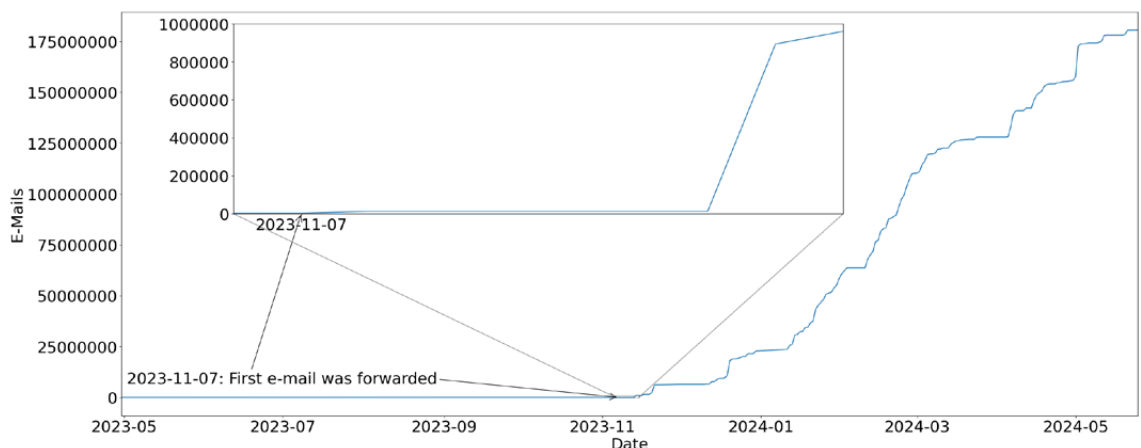
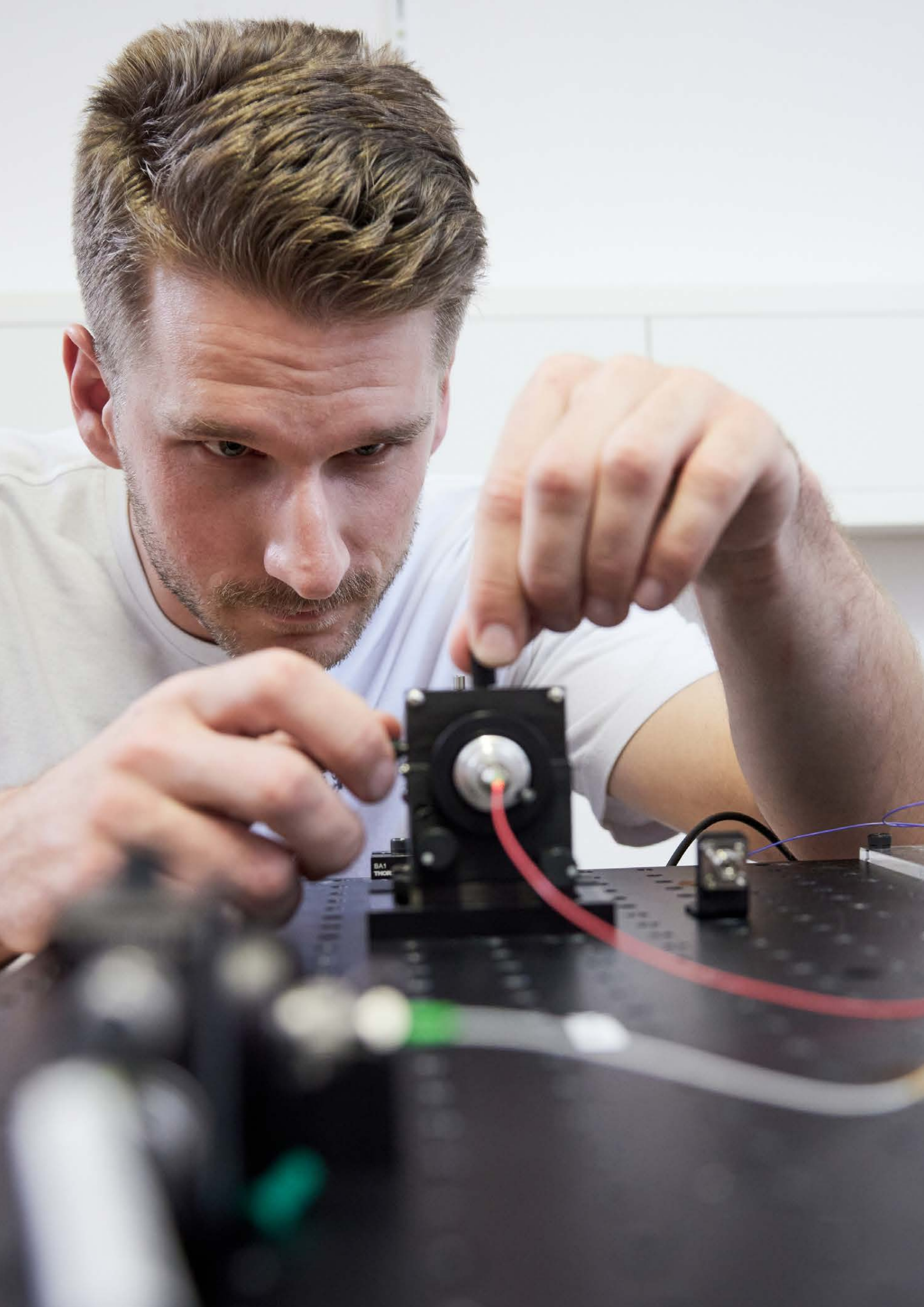


Figure 1: Number of received e-mails increased after actively forwarding the first test e-mails



Design and Control of a 800 W Single-Stage PFC Active Clamp Flyback with GaN Semiconductors

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Sébastien Mariéthoz
Expert : Dr. Maxime Moreau

24

Motivated by the goal of decreasing the charging times of electric bicycles battery packs and, thus, helping popularize the product, we present in this thesis the study, design, implementation and testing of a 800 W PFC ac-dc converter. By employing a flyback with GaN semiconductors, we expect to increase the converter efficiency while reducing its size and keeping a low parts count, resulting in a superior yet affordable charger.



Viviane Louzada Wisniewski
Energy and Environment

Introduction

E-bikes require consumers to plan their use carefully to avoid having to charge their batteries at undesirable times. A search through some manufacturers' websites shows that 4 to 6 hours are needed to refill the most common battery packs, and the most powerful versions display an average charging power of only 187 W. The appealing idea of having shorter charging times by means of a more powerful converter is the main motivation behind this work.

Concept

The architecture of choice is a synchronous, single-stage PFC flyback converter. The use of GaN FETs allows for high-frequencies of operation, and with their low parasitics, it is possible to obtain a high-efficiency converter. The challenge of scaling up the power rating to 800 W, despite the well-known intrinsic limitations, is tackled with the use of an active clamp on the primary FET, which protects it from dangerous voltage oscillations.

Goals

This work is a follow up of a semester project, where the prototype was designed from scratch and minimally tested. In order to reach the concept described above, the subsequent tasks were outlined:

- Verify experimentally that the active clamp circuit for the primary FET with an ac input voltage works
- Implement the synchronous rectification

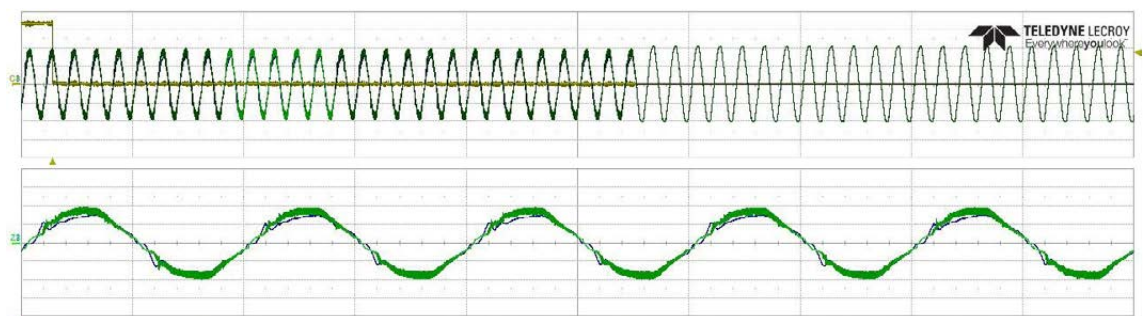
- Validate a control strategy for the single-stage PFC flyback that achieves a power factor of at least 0.98

Results

The main goal of presenting a first investigation of the proposed converter, with focus on the control and experimental investigation, was achieved. However, the results were obtained at an operating point of 115 W, as we realised that the secondary FET also needed a clamp circuit to withstand its voltage stress. Still, the feasibility of directly supplying the flyback with an ac input voltage and operating the active clamp, and attaining a high power factor of 0.9879, were validated.



The assembled flyback converter.



Grid voltage (green, 20 V/div) and grid current (blue, 5 A/div). Time scale 100 ms/div (top), 10.0 ms/div (bottom).

AI4ED: Augmented Intelligence for the Detection and Support of Eating Disorders

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Mascha Kurpicz-Briki
Expert : Dr. Elena Nazarenko

Eating disorders are a significant mental health concern. This study uses machine learning (ML) models and natural Language processing (NLP) techniques to detect eating disorders in German and French texts. Our research highlights the importance of data quality and optimization in effective model building.

Introduction

Integrating NLP and ML in clinical psychology offers advanced diagnostic tools. Traditional assessments, often based on self-reported questionnaires and clinical interviews, can overlook the emotional depth and nuances present in patients' communications. Automated text analysis, on the other hand, can significantly improve accuracy and efficiency. This study focuses on detecting eating disorders (EDs) through machine learning, analyzing German and French social media texts.

Data Collection

From YouTube, we compiled anonymized German and French YouTube comments. Using specific keywords, we identified relevant videos and extracted the associated data. Three annotators labeled the data using a six-label annotation framework based on the ICD-10.

Results

For the German dataset, using back translation and a supervised ensemble of support vector machine classifiers, we achieved an average F1-score of 0.83. For the French dataset, downsampling the majority class and optimizing hyperparameters through a grid search led to an average F1-score of 0.91.



Ghofrane Merhbene
Ghofranemer@gmail.com
Data Science

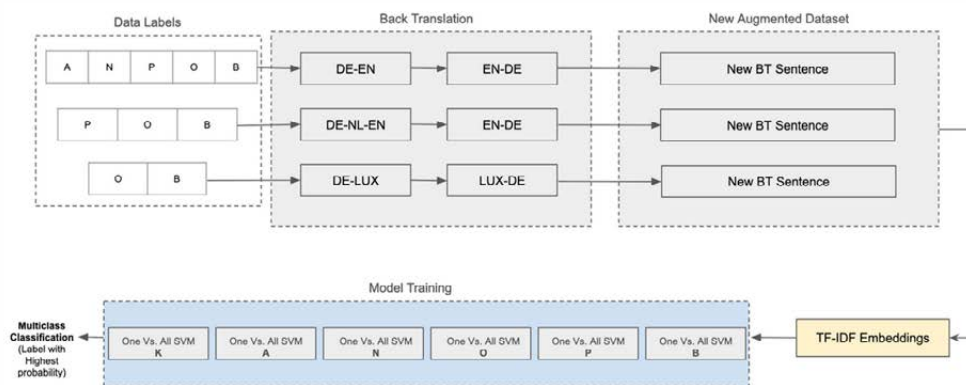


Fig. German Experimental Setup

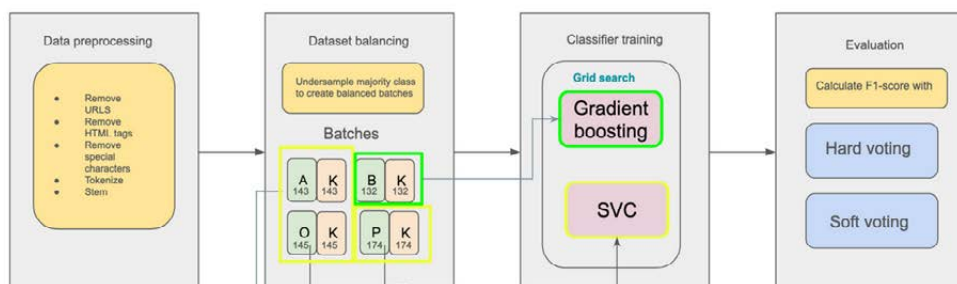


Fig. French Experimental Setup

Analysis of Eddy Current Losses in End Winding Encapsulations of High Speed PMSM

Degree programme : Master of Science in Engineering

Thesis advisor : Prof. Dr. Andrea Vezzini

Industrial partner : e+a Elektromaschinen und Antriebe AG, Möhlin

26

e+a Elektromaschinen und Antriebe AG is a Swiss company specialized in the design and manufacture of tailored, high-performance rotating electrical machines for a wide range of demanding applications. This research project focuses on the modeling, simulation and optimization of eddy current losses that are induced in the end winding encapsulations (ALKA™) of permanent magnet synchronous machines (PMSM) by implementing 3-dimensional finite element analysis (FEA).



Lucien Porta

lucien.porta@ikmail.com

Electrical Engineering

Introduction

Resin impregnation and aluminum encapsulations of the end windings (ALKA™) provides increased performance due to improved cooling, while ensuring excellent winding protection and insulation. On the other hand, aluminium encapsulations are prone to eddy currents caused by magnetic flux leakage at the machine edges, reducing the efficiency and leading to considerable heating in certain specific cases. The development of custom motors requires efficient and reproducible design and simulation capabilities. For this purpose, e+a Elektromaschinen und Antriebe AG has developed extensive experience in dimensioning its components using analytical approaches and finite element analysis (FEA). To address this specific problem, a 3-dimensional transient simulation solution is required and has to be integrated to the company's in house development tool. This Master's thesis therefore focuses on the development of an automated FEA simulation workflow to allow the subsequent analysis and optimization of eddy current losses using 3-dimensional models.

Goals

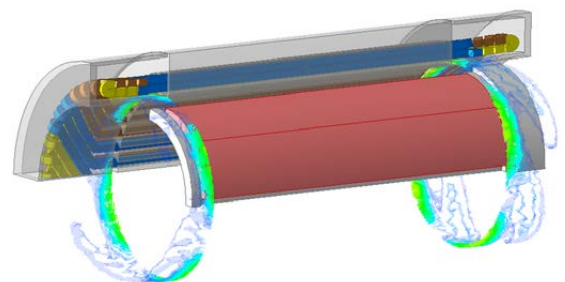
- Developing a software interface to enable a seamless and automated transfer of geometry data and operating point between the e+a in house development tool and a FEA software capable of 3-dimensional and transient simulations.
- Based on the previously developed simulation tool, a refinement of the simulation models has to be performed to match as closely as possible the laboratory measurements. Once an accurate and reliable model is obtained, the simulation tool can be used for advanced analysis of eddy current losses induced in the end winding encapsulations.
- Depending on the outcomes of the previous calculations, a range of solutions are analyzed and proposed with the aim of optimizing machine performances, providing improvement concepts for potential future implementations.

Method

Transient and 3-dimensional simulations are performed using the electromagnetic simulation software Ansys Maxwell. The interface for automatic generation of simulation models and the integration with the company's development workflow is programmed in Python, and takes advantage of the open-source library PyAEDT. Several measurements have been carried out on the test bench to check simulation results against reality, and to compare and improve the model's accuracy. Thanks to the first part of the project, the extended simulation capabilities now enable the analysis of multiple cases to better understand the sources of eddy current losses in end winding encapsulations, and to identify potential improvements.

Results

The development of the Python interface enabled full integration of Ansys Maxwell software into the company's development workflow, extending the transient simulation capabilities to 3-dimensional problems. This enabled the generation of multiple models and the refinement of parameters until reliable and accurate results were obtained, which could then be compared with test bench measurements. The eddy currents induced in the encapsulations were analyzed in detail to better understand their causes, and an example of the results is shown in the figure below. Finally, several solutions have been proposed and successfully tested in simulation, showing significant reductions in eddy current losses.



Simulation result of induced eddy currents in the end winding encapsulations of a permanent magnet synchronous machine

Exploring Bias in German and Dutch Natural Language Processing Models

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Mascha Kurpicz-Briki
Expert : Dr. Elena Nazarenko

This thesis investigates biases in German, Dutch, and multilingual natural language processing (NLP) models. It examines models commonly used in research as well as state-of-the-art models from OpenAI and voyageAI. The data used for the metrics is partly derived from workshops aimed at detecting language-specific biases in the labor market. The results show that the identified biases are reflected in almost all multilingual models, most German models, and some Dutch models.

Introduction

An unsolved issue in the domain of NLP is the perpetuation of stereotypical biases inherent in the training data. This has led to increased attention in the research community, but the focus has predominantly been on English models, often neglecting models for other languages. In order to better understand bias across languages, this thesis investigates bias in German, Dutch, and multilingual word representations. These vector representations capture semantic meaning in a numerical representation and are key components of many NLP applications.

Method

Preserved biases in word embeddings are represented by tighter vector associations between certain genders or races and their stereotypical characteristics or occupations. The Word Embedding Association Test (WEAT) is a metric that takes advantage of this fact by measuring the angle (cosine similarity) between different concepts (see figure below). For example, it measures how 'productive' relates to male & female (green in the figure below, resulting in A) and compares this to how 'unproductive' relates to male & female (blue in the figure below, resulting in B). The greater the difference between these two results, i.e. between A and B, the more likely it is that the embedding is biased towards the concepts in question. This

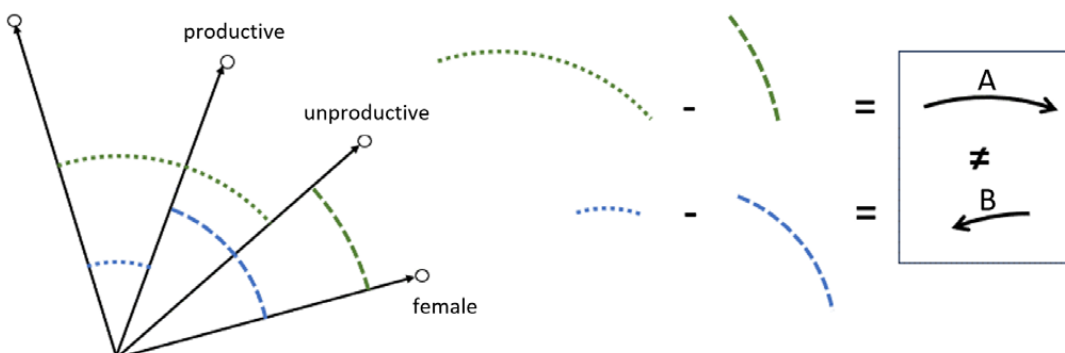
approach is used on two types of word representations: Static word embeddings, which capture the meaning of the word itself, and contextualized word embeddings, which take into account surrounding words. We use Fasttext as our pre-trained static word embedding because it is available for multiple languages, allowing us to test our German and Dutch word lists. For the contextual word embeddings, we use three different models. The Bidirectional Encoder Representations from Transformers (BERT), a widely used word representation in research, will be investigated in its German, Dutch, and multilingual versions. In addition, the state-of-the-art multilingual models from OpenAI (released January 2024) and VoyageAI (released June 2024) are considered.



Leander Rankwiler
Data Science

Data & Results

The data used for the bias metrics is partly derived from workshops conducted in the context of the EU-Project BIAS. The workshops aim to identify biases in the labor market and were held in the Netherlands to identify Dutch-specific biases, and in Switzerland to uncover German-specific biases. They involved experts from different fields, including human resources, NGOs, and machine learning. The results show that the biases identified in the workshops are reflected in almost all multilingual models, most German models, and some Dutch models.



Principle of Word Embedding Association Test (WEAT), shown in a hypothetical 2-dimensional word embedding space.

Digitaler Produktpass für CO₂-Emissionen der Herstellungs- und Nutzungsphase eines Produkts

Studiengang: Master of Science in Engineering

Betreuerin: Prof. Dr. Annett Laube

Experte: Dr. Andreas Spichiger

Industriepartner: Schweizerische Bundesbahnen SBB, Bern

28

Ein digitaler Produktpass ermöglicht den Austausch von produktspezifischen Daten. In Zusammenarbeit mit den SBB wurden in dieser Arbeit die Abbildung und der Austausch von CO₂-Emissionen beim Wareneinkauf und bei Wartungsarbeiten untersucht. Eine Architektur basierend auf Self-Sovereign-Identities wurde entworfen und deren Stärken und Schwächen beschrieben.



Thomas Schmid
Computer Science

Ausgangslage und Ziele

Die SBB haben sich zum Ziel gesetzt, bis ins Jahr 2030 klimaneutral zu sein. Um dieses Ziel erreichen zu können, werden mehr und genauere Daten zu den CO₂-Emissionen benötigt, die im Unternehmen entstehen.

Ein digitaler Produktpass kann die SBB diesbezüglich unterstützen. Er schafft die Infrastruktur für den Austausch von CO₂-Emissionsdaten und ermöglicht es dadurch, CO₂-intensive Produkte bei der Beschaffung oder während der Nutzungsphase zu identifizieren. Die Daten sollen zusätzlich für die Erstellung einer CO₂-Bilanz des Unternehmens verwendet werden können.

Umsetzung

In Zusammenarbeit mit den SBB wurde mit dem Einkauf von Bahnschienen ein geeigneter Anwendungsfall festgelegt, um CO₂-Emissionen aus der Herstellungsphase zu beschreiben. Mit der Neuprofilierung von Schienen in einer internen Werkstatt wurde ein weiterer Anwendungsfall definiert, bei dem CO₂-Emissionen während der Nutzungsphase entstehen.

Als technologische Grundlage wurden bereits im Vorfeld der Arbeit ein SSI Ansatz (Self Sovereign Identity) und entsprechende Technologien (Hyperledger Indy / Hyperledger Aries) untersucht. Ermöglicht damit eine dezentrale Datenhaltung, bei der jeder Hersteller die Hoheit über die Daten seiner Produkte in Form von Verifiable Credentials hat.

Basierend auf den ausgewählten Technologien wurde eine Architektur entworfen, die beispielhaft die Abbildung der erarbeiteten Anwendungsfälle erlaubt und

zudem die nötige Erweiterbarkeit und Flexibilität für eine breitere Anwendung mitbringt.

Im Weiteren wurde ein geeignetes Datenformat für die Abbildung und den Austausch von CO₂-Emissionen über den gesamten Lebenszyklus eines Produkts erarbeitet. Dazu wurden bestehende Standards und deren Eignung für die Verwendung in Verifiable Credentials untersucht und einbezogen.

Mit einer prototypischen Implementation wurden die Architekturkonzepte und -entscheidungen überprüft. Die definierten APIs sollen dabei die Integration in eine bestehende Systemlandschaft erlauben. Die Implementation ermöglicht zudem eine Visualisierung der Daten und die Erstellung einer einfachen CO₂-Bilanz eines Produkts.

In einem weiteren Teil der Arbeit wurde die Architektur auf ihre Robustheit geprüft, indem Manipulationsmöglichkeiten eines unehrlichen Teilnehmers im System betrachtet und mögliche Gegenmassnahmen gesucht wurden.

Ergebnisse und Ausblick

Die Arbeit zeigt, dass eine Implementation eines digitalen Produktpasses mit einer SSI basierten Technologie grundsätzlich möglich ist. Insbesondere die dezentrale Datenhaltung bringt aber zahlreiche offene Fragen mit sich.

Unklarheit besteht ebenfalls bezüglich Standardisierung und regulatorischen Vorgaben. Für die Arbeit mussten diesbezüglich teilweise Annahmen getroffen werden.

Physically-Informed Video Inpainting: A Deep Learning Approach for Weather Reconstruction

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Erik Graf
Expert : Prof. Dr. Stefan Brönnimann (Universität Bern)

In the scope of this master thesis, we set out to investigate the potential of artificial intelligence for weather reconstruction. As a result, we propose a tailor-made network architecture, called WeRec3D, which has been optimized by innovative extensions of the training process to the extrapolation of daily pressure and temperature fields.

Historical weather observations are a fundamental part of improving our understanding of today's climate. However, the archival records are incomplete in both space and time. They only provide local descriptions of the weather confined to the stations immediate environment. In turn, this is insufficient to gain a comprehensive understanding of climate dynamics, including extreme weather events linked to them. Consequently, climate researchers use weather reconstruction methods to obtain a thorough picture of past conditions. Until now, mainly traditional statistical methods have been used to complete past weather patterns.

In this thesis, we investigate the potential of modern deep learning techniques for weather reconstruction applied to the heatwave of 1807. Inspired by video inpainting, we show that artificial intelligence can accurately fill historical observation gaps. This is demonstrated using meteorological temperature and pressure data. We first utilize the weather reanalysis ERA5 to train our network in a self-supervised manner and initially validate it on daily fields over Europe. In the course of this, we evaluate extensions to the training process and input to improve the reconstruction capability. As a result, an incremental pre-training, a spatially moving window, a physical soft constraint

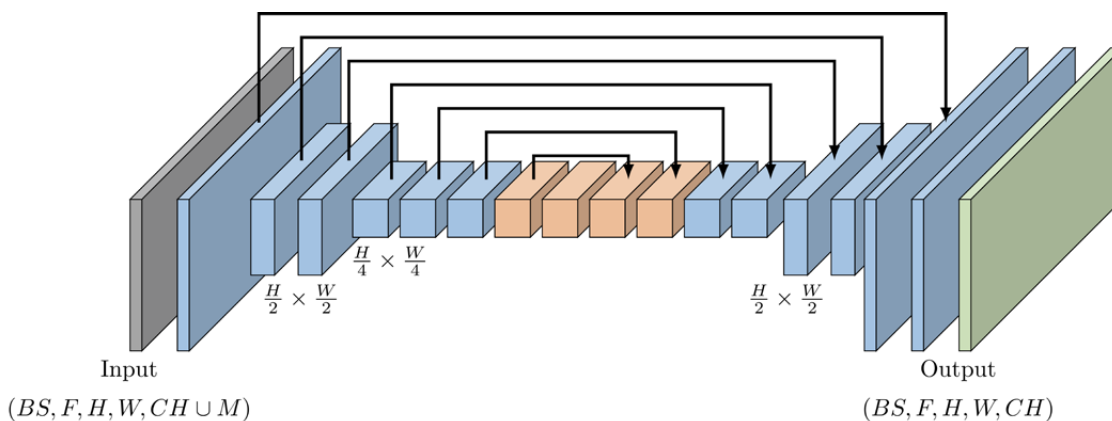
and elevation data as a further predictor revealed a positive influence. This modeling basis is then expanded again, resulting in two methods. On the one hand, an adjustment is made to the static observation locations of the target year. On the other hand, we use random cells from an analogue resampling method (ARM) to artificially increase the proportion of observed measurements. These two modeling variants are then used in parallel for the concrete weather reconstruction of the heatwave in 1807.

The inferences for the historic year show high correlation and low RMSE values in a leave-one-out procedure of the stations in space. This applies both to the model that was trained with statically missing data and to the model that was extended with ARM samples. The latter variant has an average RMSE of 1.16°C for temperature and 179Pa for pressure across all omitted stations. The normalized anomalies show a correlation of at least 0.84 and a maximum RMSE and standard deviation delta of 0.54 and 0.27 respectively.

To the best of our knowledge, this is the first study to investigate weather reconstruction using deep learning algorithms. We propose video inpainting as a new approach to reconstruct missing weather information.



Yanniss Valentin Schmutz
yanniss.schmutz@gmail.com
Data Science



Network architecture of our Three-Dimensional Weather Reconstruction Model (WeRec3D)

Plasma Electrolytic Polishing with a Jet

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Cédric Bessire
Expert : Dr. Christof Bernhard

30

Plasma electrolytic polishing is an innovative polishing technique that uses environmentally friendly salt water-based electrolytes to achieve better polishing results than traditional methods like electropolishing (EP). This thesis is about the concept of a novel machine for plasma electrolytic polishing with a jet (PEP-Jet) and the investigation of the possibilities of PEP-Jet.



Yan Scholl
yan.scholl@bfh.ch
Mechatronics and Automation

Introduction

Polishing metals is a crucial process across various industries. It helps to increase wear and corrosion resistance, decrease surface adhesion, and enhance biocompatibility and gloss. Today, the state-of-the-art surface finishing technique is electropolishing (EP), which requires toxic and harmful electrolytes. Plasma electrolytic polishing (PEP) is a new ecological polishing method that uses aqueous electrolytes and enables the polishing process to be used in a jet configuration (PEP-Jet). The PEP-Jet enables the polishing of workpieces locally and even within workpiece cavities. This new PEP-jet solution allows the polishing of workpieces partially or in areas impossible with EP.

Objectives

This master thesis has three main objectives: (1) Development of a concept for an industrial PEP-Jet machine; (2) Study and improve the polishing results of PEP-Jet in terms of homogeneity of the surface and the preservation of contours of workpieces; (3) Expanding the material range for PEP-Jet with different metals relevant in various high-end surface industries.

Results

The concept for an industrial PEP-Jet machine provides a base configuration of a machine with

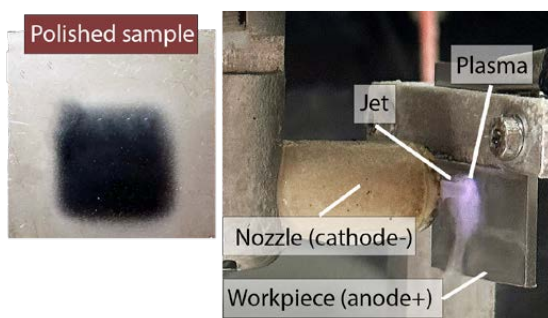


Figure 1: PEP-Jet with plasma polishing the workpiece

a manually operated jet for simple and affordable integration into current productions. It is based on customer needs from various industries that could profit from this technology and insights from previous projects. The base configuration can be expanded with automated PEP-Jet polishing using a robot or cobot. Depending on the applications, the machine can be equipped with different power options and a PEP bath.

Tests with different polishing patterns and multiple jets in different jet arrangements provided valuable insights and improved the homogeneity of the polishing area using PEP-Jet. An optimal method for maintaining workpiece contours was successfully implemented through specific approaches on the workpiece edges using the PEP-Jet.

The PEP-Jet polishing was successfully performed on different materials, including copper, various carbon and stainless steels, and even titanium and cobalt alloys. The achieved surface finishings met the hygienic standards required in medical applications.

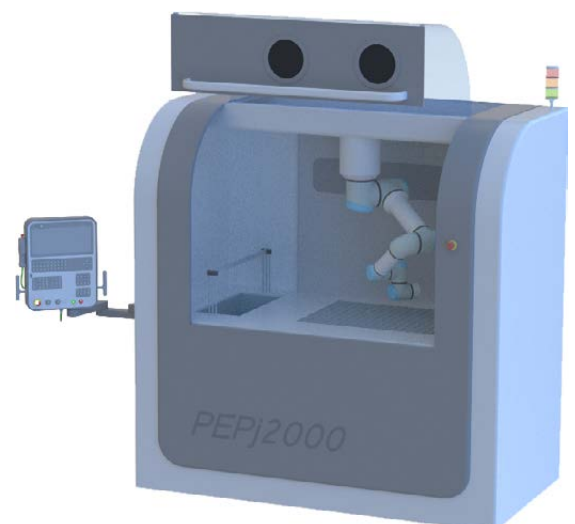


Figure 2: Visualization of the concept for an industrial PEP-Jet machine

Simple And Intuitive No-Code Robot Programming and Configuration Interface

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Gabriel Gruener
Expert : Dr. Hakan Girgin (Swiss Cobotics Competence Center)
Industrial partner : CSEM, Alpnach

In industrial automation, the development of user-friendly interfaces for robot programming is pivotal. This work introduces an innovative, no-code interface designed to make robot programming and reconfiguration accessible to workers without extensive technical skills, particularly benefiting small and medium-sized enterprises with flexible production needs.

Motivation

This work aims to empower operators by developing an intuitive, no-code interface for creating and configuring robot programs. While several no-code interfaces exist, they are usually robot and hardware dependent and not customizable. This innovation seeks to enhance the adaptability and responsiveness of manufacturing processes, reducing the need for specialized programming knowledge.

Approach

A block-based, hardware independent user interface offers blocks in several hierarchical layers (Fig. 1). Simple Primitives and Services, designed by experts, reflect the robotic cell's fundamental capabilities. Technicians can assemble these blocks into advanced Skills and Operators can create and modify complete Tasks using a touchscreen interface, adapting the manufacturing process without writing any code.

Results

The interface was successfully integrated and tested with a Cobic Base Cell (Fig. 2) at the Swiss Cobotics Competence Center (S3C), demonstrating advanced lab automation techniques. In collaboration with CSEM's VISARD interface, the cell can automati-

cally locate input racks, pick and identify vials, and determine appropriate actions. The system discards vials or places them into a centrifuge for processing and sorts them into appropriate output racks. Directly from the interface, the operator can modify the cell's workflow, calibrate equipment and key positions, and add new vial or rack types, thus enhancing the operational efficiency and adaptability of the cell.

Outlook

Future work will focus on enhancing the interface for broader applications across different settings. The goal is to refine the system based on user feedback, making Cobots' programming and configuration increasingly user-friendly and adaptable, ultimately supporting the continuous evolution of smart lab and factory automation.



Caley Ambler Temple
caley.temple@gmail.com
Mechatronics and Automation

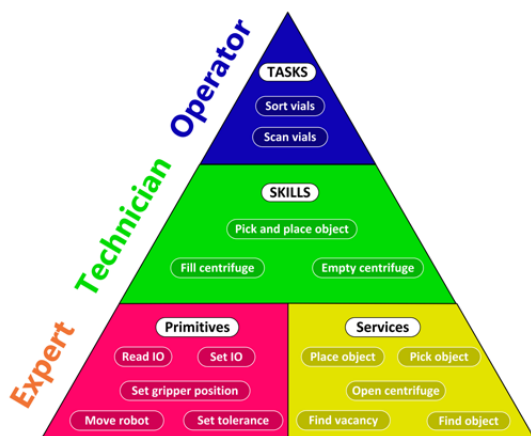


Figure 1: Developed hierarchy with some examples blocks

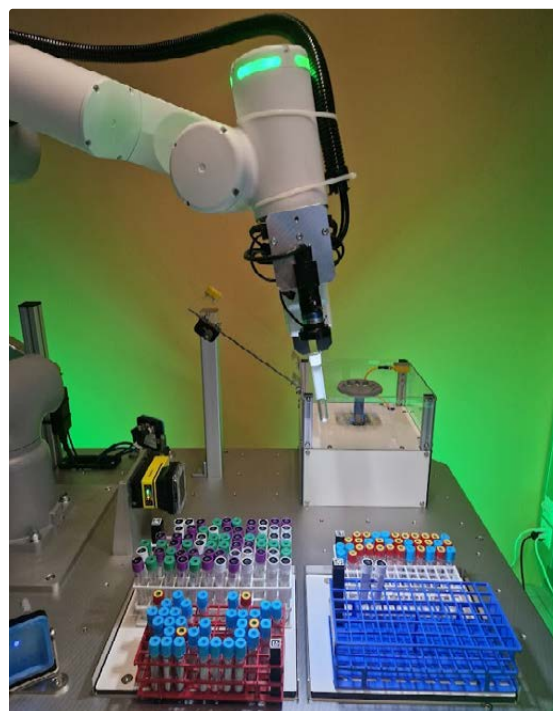


Figure 2: The cobotic cell demonstrating lab automation tasks

Implementation of a Cobotic Assembly Process for Integrated Automation of Machine Modules

Degree programme : Master of Science in Engineering
Thesis advisor : Prof. Dr. Gabriel Gruener
Expert : Hakan Girgin (Swiss Cobotics Competence Center)
Industrial partner : Rollomatic SA, Le Landeron

32

Rollomatic SA produces high-quality CNC grinding machines. The assembly and verification process of these machines is based on lean manufacturing principles and is mostly manual. The different machine models are built from modules. Some of the modules are equal between machines. Due to the difficulty in finding qualified labor and high costs, Rollomatic would like to study the integration of automatic or partially automatic processes in the manual assembly.



Benjamin Theurillat
079 266 12 92
ben_theurillat@bluewin.ch
Mechatronics and Automation

Introduction

In previous studies, subassemblies of the grinding machine GrindSmart 630XW as well as the tool palettes have been analyzed. The tool palettes are used to store cylindrical tools in Rollomatic machines (Fig. 1). They were identified as the most promising candidates for automatic assembly. There are about fifty different palettes produced each year. The aim of this work is to implement a robotic system to assemble all the palettes.

Concept

A concept was defined based on analysis and testing of palette assembly. This involves stacking the first elements of the palette using a guide, then flipping the palette to stack the last elements and tight the 4 corner screws. Flipping is needed for the robot to access both palette faces. This concept requires two grippers and a screwdriver, 31 pick-and-place operations and seven tool changes per assembly.

Implementation

Assembly tests were carried out to verify the concept. The insertion tolerance can be as low as 0.01 mm, making the task difficult for a robot. Algorithms, such as impedance or admittance control, can be used

to command the robot's joint torque in relation to external contact forces. These control techniques are interesting for many Rollomatic assembly operations since pick-and-place and screwtightening are the most recurrent tasks. As Rollomatic selected an Omron TM-5 robot, which only accepts joint position commands, these algorithms cannot be used. A palette assembly cell was implemented using only robot motion control (Fig. 2), which then required several specialized jigs.

Results and Outlook

Tests on the built cell verified the assembly concept. The cell's capacity and autonomy can be increased by adding more part-feeding supports. Impedance control would be particularly useful for inserting pins, where tolerances are tight. Admittance control would help assemble the plates, as a given trajectory must be followed for insertion. Future work shall analyze other Rollomatic assemblies and determine whether these algorithms can facilitate automation to justify acquisition of a robot that allows torque control.

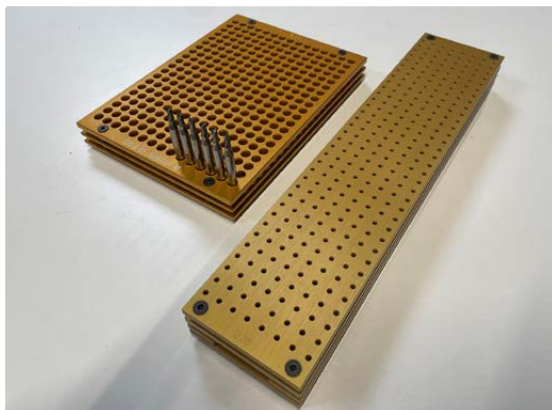


Figure 1: Tool palettes



Figure 2: Developed assembly cell

Using a retarding field energy analyser for energy resolved time-of-flight mass spectrometry

Degree programme : Master of Science in Engineering

Thesis advisor : Prof. Dr. Thomas Nelis

Expert : Dr. Thomas Gilmore (Impedans Ltd.)

Industrial partners : TOFWERK AG, Thun; Impedans Ltd., Dublin

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To measure energy resolved mass spectra and calibrate the ion flux for each species, an energy resolved orthogonal time of flight mass spectrometer (TOF-MS) can be combined with a retarding field energy analyser (RFEA). The theoretical concept was proven to work and the performance was evaluated using HiPIMS and MW plasmas as ion sources.

The properties of contemporary materials are largely influenced by their production processes. The manufacturing conditions, particularly the kinetic energy of the species involved, strongly influence the internal structure and cohesion of these layers. Therefore, the controlled and well-defined manufacturing of modern materials necessitates a comprehensive understanding of the production conditions.

A TOF-MS allows the simultaneous recording of a mass spectrum over a large range at every extraction, which reduces measurement time compared to sequentially operating quadrupole or magnetic sector based mass spectrometers. Additionally this reveals unexpected species, produced during the process. For filtering ions by their kinetic energy different designs are possible one being an electric sector

analyser (ESA) which is an energetic band-pass filter. They can provide high energy resolution of up to 0.15V. Another solution are RFEAs which are energetic high-pass filters. Their compact design in addition to the possibility to measure an absolute ion current density which then can be used to calibrate the TOF-MS and calculate the ion current density per species, makes them an interesting option. An other advantage of the RFEA is that it can be put to complete transmission mode which allows to use the MS without energy resolution.

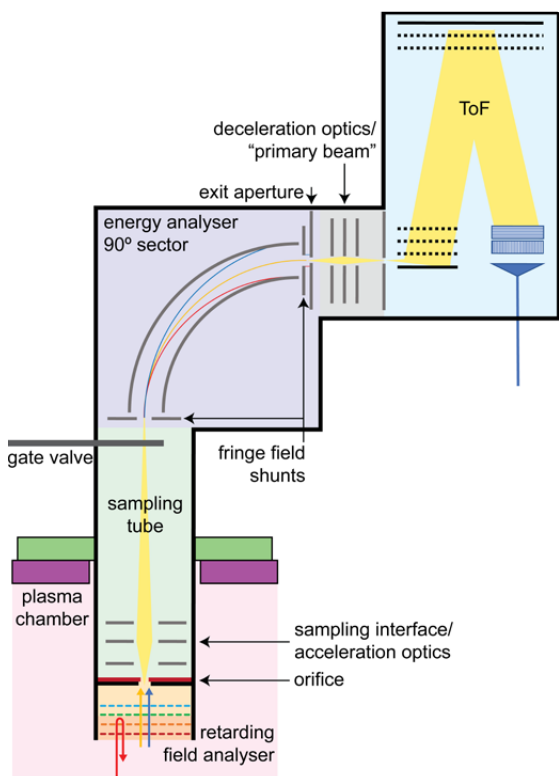
Commercially available RFEAs have a solid collector plate which doesn't allow ions to be passed to a mass spectrometer, for species identification. For this thesis such RFEAs were modified in different ways so that ions can be further analyzed with the TOF-MS after passing the RFEA. These RFEAs were then analyzed on the existing version of an energy resolved TOF-MS (E-TOFMS) [Fig 1]. The interest of this setup lies in the characterization of the energy dependent transmission of the RFEA [Fig 2] and in the application to calibrate the E-TOFMS for absolute species resolved ion current density measurements.



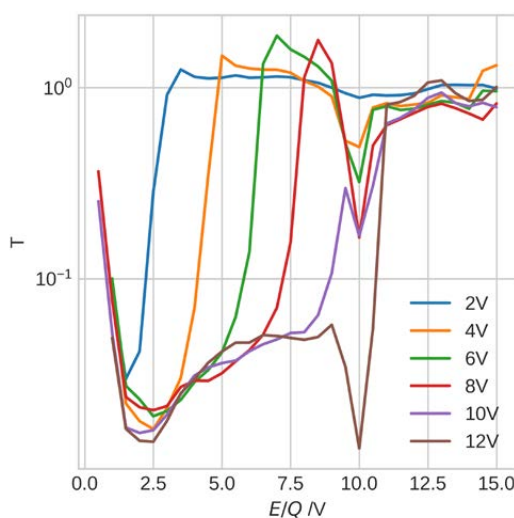
Malte Watzek

malte.watzek@bluewin.ch

Photonics and Laser Engineering



Semitransparent retarding field energy analyser mounted on an energy resolved orthogonal time of flight mass spectrometer



Transmission T in function of the energy to charge ratio for ions showing the filtering behaviour of the RFEA

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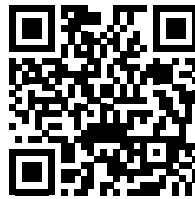


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Berner Fachhochschule

Master of Science in Engineering
Quellgasse 21
2502 Biel

T +41 31 848 50 46

E mse@bfh.ch
W bfh.ch/mse

Haute école spécialisée bernoise

Master of Science in Engineering
Rue de la Source 21
2502 Bienne

T +41 31 848 50 46

E mse@bfh.ch
W bfh.ch/fr-mse

Bern University of Applied Sciences

Master of Science in Engineering
Quellgasse 21
2502 Biel

T +41 31 848 50 46

E mse@bfh.ch
W bfh.ch/en-mse