Westfälische Hochschule

University of Applied Sciences
Gelsenkirchen Bocholt Recklinghausen

Research and Development at the Westphalian University

Research Report 2018 – 2021

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Content

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Foreword

Research at the Westfälische Hochschule (2018 – 2021)

It gives me great pleasure to present the English-language version of our latest research reports.

With greater clarity than almost any year before, the year 2020 has shown us the vital importance of effective research. The coronavirus pandemic had us firmly in its claws and is still continuing to impose significant restrictions on us in many areas.
In a previous Westfälische Hochschule Research Report, I once chose as a heading: "Research at the service of people". Now, while we may not be at the heart of vaccination research, it nevertheless becomes clear from many contributions to this publication that already today, our researchers are devoting themselves intensively to the needs of people – also and in particular those who are forced to live with handicaps – or the requirements for building a secure and sustainable future.

Through the steps that have been undertaken in the "ruhrvalley" research profile field, we, together with our partner universities in Bochum and Dortmund and the many partner business enterprises involved, are now able to still further intensify our concerted efforts in working towards a liveable, secure and sustainable future. I am firmly convinced that the "ruhrvalley" alliance will enable us to discover and develop many areas in which we can work together with even greater effectiveness, and with the power of our pooled knowledge make our contributions even more holistically. We can be sure that, to this end, the scientists and researchers at our university will be open and responsive to the colleagues at the other universities and their ideas.

There are now a number of people in the office of the "ruhrvalley" university alliance in Herne whose focus is to support the introduction and matching process. They are also tasked with assisting the processes of both multi-university and individual research applications. The aim is to make use of this possibility to develop a new dimension for our research activities.

I would also like to take this opportunity to express the sincere thanks and gratitude of the Presidium to the scientists and researchers at our university for their enormous discipline and creativity in keeping their research going even through the time of the pandemic! You really have done a fantastic job, also in face of the heavy pressures you were additionally subjected to through the new forms of teaching. Many, many thanks for all of that!

I hope that we can now start looking out for better working conditions once more, and look forward very much to joining with you in approaching the challenges of the coming years.

So let's get to work together...

Prof. Dr. Michael Brodmann
Vice-President

For the executive board of the Westfälische Hochschule (Westphalian University of Applied Sciences)

Michael Brodmann
Vice-President Research and Development

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„ruhrvalley“ Mobility & Energy for Metropolitan Change – A joint research profile field with Hochschule Bochum and Fachhochschule Dortmund

Today, solutions are being developed in the Ruhr metropolitan region to meet the core challenges of the mobility and energy transition and the digital transformation, which in the medium term will achieve system relevant character for our society. The focus is thereby on security, the move towards sustainability, and the networking of mobility and energy supply on a metropolitan scale. The “ruhrvalley” research profile ranges from information and communication technologies for embedded and cyber-physical systems, through IT security, electromobility, geothermal energy and energy systems technology, all the way to the relevant areas of the economic and social sciences, in particular applied innovation research.

Core idea
Making mobility and energy sustainable and fit for the future – this is the goal that links the partners in “ruhrvalley”. One thing that clearly emerges from the broad academic and public discussion surrounding the issues of climate change, energy transition, mobility and digital transformation is this: In order to manage these fundamental challenges, we need networked, system-spanning solutions on a metropolitan scale. The Ruhr region, as a metropolitan area with one of the highest densities of universities in Europe and a growing business start-up scene, is ideally placed for developing the application of innovative technologies and driving them forward. Since 2017, in the initiative “Starke Fachhochschulen – Impuls für die Region”, partners from universities, research institutes and business enterprises have been working together, with financial support from the Federal Ministry of Education and Research, across disciplinary boundaries to build secure, networked technologies that enable the coordination and intelligent use of different forms of energy and thus generate value for the people and life in metropolitan regions.

Foundation of “ruhrvalley”
In 2016, “ruhrvalley“, a collaborative undertaking encompassing three major universities of applied sciences based in Germany’s Ruhr region, seven university institutes, 20 spin-off enterprises, and a whole range of other business enterprises, including several well-known major enterprises operating in the energy, mobility and IT sectors, emerged as one of ten winning clusters from the BMBF competition “FH-Impuls”. The BMBF [Federal Ministry of Education and Research] has been providing funding support for the innovation partnership since 2017 and, following a positive interim evaluation in 2020, will continue to do so until 2024 with a volume of altogether 10.8 million euros. A further 2.7 million euros are being invested by the universities themselves and 3.4 million euros by the business enterprises in the build-up and expansion of the research and innovation partnership.

Focal research areas of “ruhrvalley”
A total of 26 joint projects – most of them of quite substantial size – are being conducted by the partners within the framework of FH-Impuls. They are concerned, for example, with the flexible and decentralised feed-in of solar and geothermal heat into existing heating grids, the development of a distributed test rig and development system for complex technical propulsion systems, the energy management in metropolitan eMobility recharging infrastructures, condition monitoring systems for technical energy installations, modular lithium ion battery systems, methods for multidisciplinary and multi-domain systems engineering, IoT and smart-service platforms, integrated sharing solutions for lightweight electrical mobility, four-wheeled pedelecs for urban logistics and commuter traffic, innovative electrolysis systems for the production of hydrogen, IoT system solutions for the monitoring of critical infrastructures, and an open development platform for vehicle component and system development.
It is intended that the projects should result ultimately in the creation of new technical system offerings, products and services, with the establishment of value creation networks in the region for their production and marketing. The initiation of business start-ups is then simply a logical consequence, with the result that “ruhrvalley” has already given rise to a constantly growing number of spin-offs.

“ruhrvalley Cluster e. V.”
In order to give the “ruhrvalley” strategic innovation partnership a permanent structure and so enable the partnership between universities, research institutes, business enterprises and other entities to continue when the period of government support ends, “ruhrvalley Cluster e.V.” was founded on 11 January 2019, i.e. as a registered society. “ruhrvalley Cluster e.V.” organises a range of specialist and network events so as to provide the members, either among themselves or in consultation with experts and decision-makers, a forum for mutual exchange and for the formation of joint projects and initiatives. The purpose of the organisation is to foster and support the performance of research, development and innovation projects, as well as knowledge transfer between science and the business sector.

Outlook
“ruhrvalley” is a place where visions, expertise and out-of-the-box thinking come together with responsibility and practical implementation forces. It provides a space and impetus for all those seeking to amalgamate their expertise and abilities across the boundaries of sectors and disciplines. In the current FH-Impuls intensification phase up to the end of 2024, it is planned to broaden the research, development and innovation activities also beyond the projects taking place hitherto. To this end, specialist and network events are held regularly, with the aim of involving additional interested parties and developing new ideas. “ruhrvalley” is open at all times for partnerships with further scientists, researchers and businesses.

Project information //
Term of project: 01.01.2017 – 31.12.2024
https://www.ruhrvalley.de/

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RS1 Mobil – An approach to achieving sustainable individual mobility in urban settings

While the last few years have seen substantial CO2 reductions in other areas of consumption, savings in the mobility sector have hitherto been more than offset through even more quickly growing traffic [1]. The mobility transition is not proceeding in the automobile sector as envisaged by the German government, whereas electric bicycles, by contrast, are experiencing a boom. This is illustrated by the continuous growth in the sales figures, with 1.4 million units sold in 2019 alone [2]. Most people, however, do not view a pedelec as the alternative to a car. It is not able to overcome the drawbacks that a large number of Germans associate with cycling: distance, dependence on the weather, amount of time taken, effort, lack of safety, and lack of cycling infrastructure [3]. In most cases, a car is the only viable mobility solution. Essential prerequisites in this case are, however, a driver's licence, sufficient financial means, and somewhere to park. If mobility is viewed socially as a possibility for participation and self-determination, "automobility" excludes a large portion of the population.

Meaningful and urgently needed alternatives that fill the gap between pedelecs and e-cars have hitherto been for the most part ignored. The mobility concept of the bike-car [German: *Fahrradauto*] combines the advantages of both categories of vehicle, such as weather protection, safety, flexibility and efficient use of space, and so represents an alternative.

Procedure

The goal of the research project was to design a mobility concept that would take on the current challenges of mobility design and implement them in an adequate manner. The development process can be divided into three phases. First, the relevant social, economic and legal framework conditions were analysed. In the course of the user-centred development process, various private and commercial user groups were segmented, surveyed empirically, and their requirements summed up on the basis of several user scenarios as personas. The results obtained were used in the second phase as the basis for development of a vehicle concept that would offer the greatest number of users the greatest possible practical and economic benefit. Following the concept phase, a visual model was created and subsequently evaluated from a technical and ergonomic standpoint. The process of selecting technically and economically suitable bought-in components was performed and a production concept for components requiring to be manufactured was drafted. The knowledge gained was integrated into the design and construction of the initial functioning prototype.

Results

The bike-car combines the necessary functions of an automobile and a pedelec and creates a novel class of vehicle. Application scenarios can be identified not only in private use (e.g. as a second car or commuter vehicle), but also in the commercial sector (e.g. for care service personnel and delivery or collection services). Additionally and in particular, people with restrictions or with no driving licence can benefit from use of a vehicle built to this concept. Mobility can be enjoyed as an important factor in social participation, and people are given the possibility of access to alternative electromobility.

The cycle and velomobile market is dominated by amateur athletes, for which reason lightweight construction is more relevant than the durability of the components. However, in order to be competitive with motor vehicles, bike-cars must also be able to meet similarly high expectations in in terms of service intervals, robustness, intuitive handling and design. The market is only developing slowly and is slow in making components available that have been specifically developed for vehicles of this type.

In order to reduce the transport requirements and logistics processes required for this implementation concept, the vehicles should be produced locally, decentrally, and under fair and transparent conditions at the place where they are intended for use. The *Diakonie* (social welfare service) in the parish of Recklinghausen has been identified as a suitable partner for this. The technical and organisational know-how is available, and there are also various implementation scenarios on hand.
The project is being continued within the scope of *START-UP Transfer.NRW*, a funding support programme, in which the production concept, together with a suitable business model, will be developed, tested and evaluated.

Fig.1: Concept for a two-track, roofed mobility solution, based on the pedelec and designed for use on high-speed cycle tracks (RS1 Mobil)

Project information //
This is a project of the "ruhrvalley" network and has been realized with funding from the BMBF [Federal Ministry of Education and Research] under the "FH-Impuls 2016" programme of funding for research at universities of applied sciences, together with Bochum University of Applied Sciences, local partners from the business sector, Green City Hub GmbH & Co. KG, and the Klostermann-Group from Gelsenkirchen.

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The FH-Impuls-project "Energy management in metropolitan 'eMobility' charging infrastructures"

E-mobility facilitates the optimisation of smart energy management among the participants in terms of the efficient integration of innovative decentralised generation structures, encompassing volatile local renewable energy systems using wind energy and photovoltaic installations and the stable, demand-driven generation capacities of the power and heat cogeneration systems, and also the temporary grid load and the stationary and mobile storage systems of the electric vehicles themselves. The charging station is the interface between the electric vehicles and the potential of the IoT (Internet of Things), with integrated energy management optimisation systems and with the security of highly sophisticated, generally utilisable billing and communication systems. (Fig. 1)

The FH-Impuls project with the name EMEL (Energy Management in Metropolitan eMobility Recharging Infrastructures) has been born out of the conviction that this complex challenge of integration and optimisation of mobility and energy-management problems cannot be resolved through isolated approaches but only through holistic system approaches. Through the authors involved here, the WEI (Westphalia Energy Institute) is one of five university institutes taking part in the project.

Intelligent charging makes the difference

In metropolitan areas in particular, the aimed-for extensive use of e-mobility is faced with the dilemma of not being accessible if, together with the high density of charging points and the high simultaneity factor needed for a charging infrastructure if it is to enjoy acceptance, there is also the challenge of decentralised generation structures.

Proceeding from the differentiable needs of the individual market participants, with proprietary island solutions for the "smart home", "smart grid" and "smart factory", the focus was placed on a general-use "smart charging" system that takes account of the technical and regulatory requirements for an integrated, market-near system solution. The development of this solution was initially based on a simulator, which, among other things, took account of the functions of the charging station. This has meanwhile been expanded for an extensive range of real-life scenarios and replaced by actual charging stations. Through the work in the laboratory of real life, it is now possible to e.g. validate the previously simulated communication flows between the vehicle and charging station and the energy systems and make provision for the "genuine surprises" arising, for instance, from vehicle-related limitations that vary from manufacturer to manufacturer.

In the laboratory of real life, the authors research the interactions on the energy side and develop near-market-ready systems around the IoT and the energy market design for application under the conditions of a metropolitan operating environment, such as the "ruhrvalley".

The IoT entities involved in the process were already standardised beforehand in terms of infrastructure on a cross-project basis. This was followed by the integration of innovative communication adapters such as the Open Charge Point Protocol (OCPP) for smart charging into the Energy Management System (EMS). The non-proprietary, licence-free OCPP communication protocol, which has become established as the worldwide standard, has been introduced through the certification programme of the Open Charge Alliance (OCA) for the EU-wide use of e-mobility. Compared to proprietary equipment protocols and modbus, the further development is constantly ongoing, guaranteeing future-proof and cost-effective planning of the charging infrastructure, free of dependence on specific manufacturers.

The result of this is that system states can be made available to the users in real time, in the form of animated symbols on card applications – PC or mobile phone – or in tabular form in the shape of lists with all necessary information, through to the billing of electrical charging transactions. At the present time, interfaces are being de-veloped that will transmit the energy figures from the energy management system to the third-party systems of the research partners in real time.

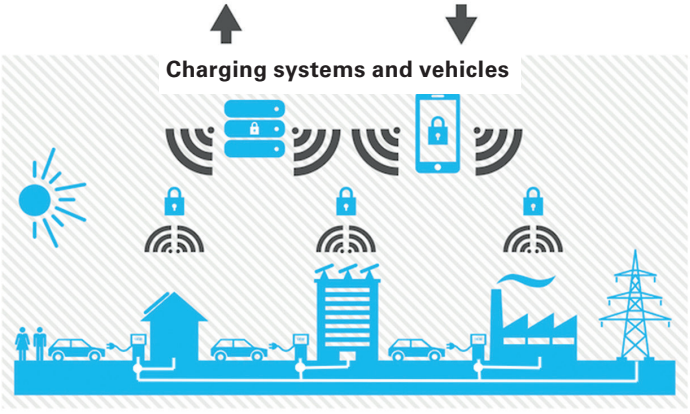

Fig. 1: Hardware and software integration relating to charging stations points in the IoT.

Energy management and consumers

Another focus is on the integration of demand-side management (DSM). This makes use of the extensive experience from former electromobility projects such as "SyncFuel" and "eMobility Scout".

Matching of the parties with the goal of smart energy management optimisation through developments in DSM based among other things, on the factors of timing, availability and network load and supported through the framework of sustained utilisation, takes place today on the basis of the communication solutions developed.

The principal parties involved in this process - consumers – mains operators – generators – are already project participants through the grid operators involved in the project.

For the current project, data for a demand side response (DSR) have become available from the laboratory of real life are flowing constantly into further optimisation.

Due to the considerable complexity and dependencies within the DSM and the increase in the volume of usage, AI strategies are being investigated. An interface to artificial intelligence (AI) has been prepared with the developed software framework.

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Connect Emscherlippe – Digital impulses for the Emscher-Lippe region

The collaborative project with the title "connect.emscherlippe/smart" is a strategic research, development and innovation initiative of the Westfälische Hochschule. Together with partners from the business sector and society, its aim is to generate new impulses for the Smart-Region Emscher-Lippe. In nine subprojects, the collaborative project concerns itself with digital team methods, the exploitation of technology potential, innovation-oriented work networking between students and business enterprises, the exploration of digital possibilities in the field of building management, the creation of a regional information system, digital business models in (geriatric) care, and rehabilitation as a means of preventing disability or the need for long-term care.

The common goal is the promotion of innovation, technology transfer and knowledge-based business start-ups in the Emscher-Lippe region.

The subprojects

The subprojects "futureWork", "smartreha" and "blockchain" focus respectively on the topics of working in the future, rehabilitation and blockchain, and deal with them for users in the region. It is intended that the results obtained from them should be used to generate impulses for further projects in the region.

The projects "3Dmapping", "digibusiness", "I-Care" and "openregio" offer an explorative opening to the new subject fields of building management, digital business models, care activities and open data. In the course of the project to date, concrete applications have in some cases been developed and implemented.

The "scouts" project has the aim of rendering existing technology potential visible for business enterprises. The task of "Digitization Scouts" is to establish contact between science and the user and trigger communication between them. Discussions and workshops thereby provide a basis for initiating joint projects.

The "students" project has involved the creation of a cooperative internet platform known as X-Challenger. The website sees itself as a project platform for bringing businesses and students together. It allows both parties to look for creative minds for solving their digital challenges, and for such people to seek and take on challenges of this kind. An editorial team encompassing several people provides support with drafting the challenges and also establishes targeted contacts. Further information on X-Challenger can be found on the website *x-challenger.de*.

The nine subprojects are each handled by a different unit of the Westfälische Hochschule, e.g. by the Computer Science Group ("Fachgruppe Informatik") or the Institute of Work and Technology. The broad-based support for innovation, technology transfer and knowledge-based business start-ups aims to foster the further development of digital skills and capabilities in the region. In this context, the creation of strategic networks, which should continue to exist beyond the end of the project, are intended to play an important role in sustainably strengthening the region.

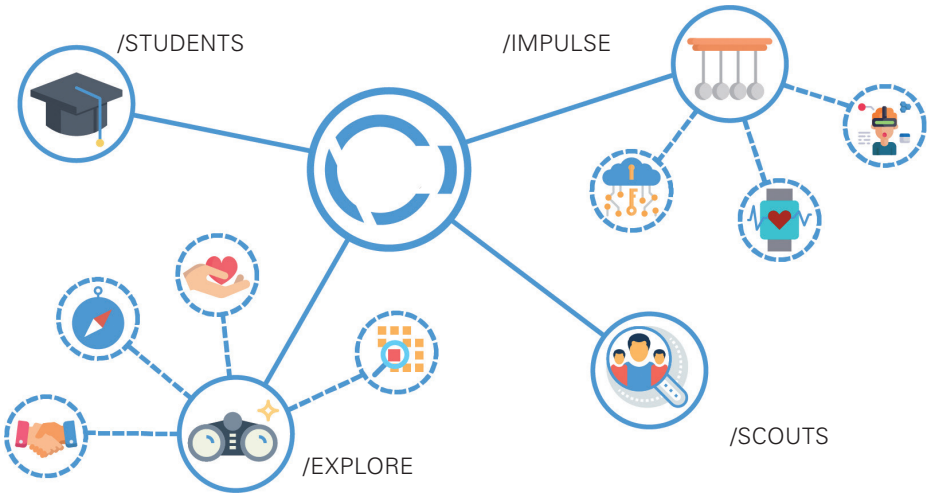

Fig.1: The collaborative project headed "connect.emscherlippe" is made up of 9 subprojects, each of which is handled by a different area of WH.

Results of the collaborative project

One of the key features of the collaborative project is that the results of the subprojects are published very quickly. This means that all parties involved in the Emscher-Lippe region can play an active role in shaping the research. A range of information channels are available for the exchange of information.

Besides the project website, on which all information relating to the digital aspects of the subprojects is presented, a special format named "Digitaler Kaffee" ("Digital Coffee") format has also been created as part of the project. "Digitaler Kaffee" is a podcast that provides listeners with timely insight into the projects. It also introduces interesting personalities from the Emscher-Lippe region who play an active role in the digitalisation process. The explorative mission of the collaborative project is driven forward by a live broadcast called "Digitaler Kaffee TV". This is a forum where representatives from business, science and society meet regularly and talk about digital topics affecting the Emscher-Lippe region. For further information on "Digitaler Kaffee", go to *digitaler-kaffee.de*.

Workshops are held as a means of stimulating the application of new digital technologies in the region. Topics have included, for example, potential applications for Long Range Wide Area Networks, internet security, digitalisation in the sphere of building management, and future technologies in the field of care.

connect. emscherlippe

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen

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3D-Mapping – Moving digital innovation forwards

The use of a digital twin of buildings potentially opens up many possibilities, such as virtual tours of inspection by interested visitors or indoor navigation by a local customer. A range of applications are also conceivable in relation to the operation of existing buildings, e.g. the enrichment of special data points with relevant information, scan-based measurements, translation into BIM models (Building Information Modelling) etc.

These possibilities and others were the subject of the explorative research project entitled "3D-Mapping", which forms part of the collaborative project "connect.emscherlippe". The aim was to promote digital innovation and knowledge transfer between business enterprises in the Emscher-Lippe Region. The first step towards this was to examine the existing 3D laser scanning technologies. Next, a use case was carried out which involved the mapping of the Westfälische Hochschule Gelsenkirchen by means of a 3D scanner.

Survey on the use of 3D mapping technologies

Additionally, use cases for the implementation of digital 3D mapping and visualisation technologies were developed in workshops with the users for various application contexts and building utilisation purposes, such as universities, hospitals and municipal buildings. It is often the case that the users are not involved in the implementation of digital innovations, or no account is taken of their environment. Therefore, within the scope of the project, an online survey was also conducted, aimed at identifying both corresponding potential and, conversely, barriers or obstacles.

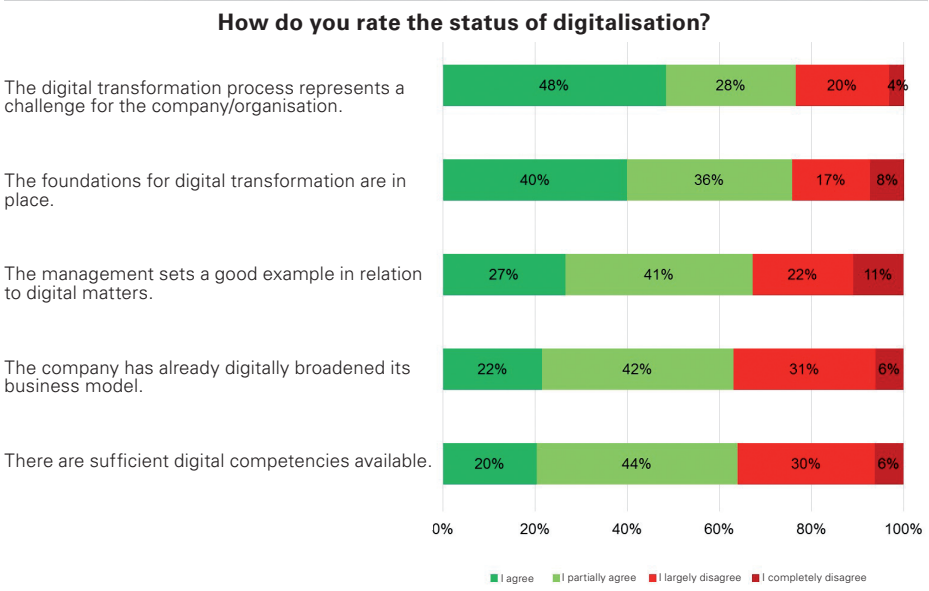

Fig. 1: How do you rate the status of digitalisation in your business/organisation? (n = 62, figures in percent)

The quantitative survey took place in October 2020. Of the 79 participants, 36% were from the Emscher-Lippe region. 48% of the participants stated that digital transformation represented a challenge. While 40% of the respondents stated that the foundations for digital transformation were in place, the questions about the example set by the management (27%) and the broadening of the business model (22%) elicited increasingly poor responses. The lowest level of agreement was found in response to the question about the digital competencies available in the company (20%).

More than half (56%) of the respondents indicated that personnel resources with the necessary skills for the implementation and utilisation of digital technologies were not present within the company. The responses following in second and third place (43%) were to the effect that the technical prerequisites were not in place and that excessively high investment costs were an obstacle. In fourth place (42%), the respondents rated the benefits as overestimated, followed by the view that the data protection requirements were very high (36%), and that a rapidly changing building would be an obstacle.

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen

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Blockchain – A method for certifying research data

As long ago as 2013, a Bitcoin-based implementation of a proof-of-existence (PoE) service for digital documents was developed and published. The approach it adopted was to store a cryptographic hash of a document on a public ledger. This public notarisation service proves the existence of a document at a certain time, without revealing the content of the document itself. [1] A similar approach was proposed for the secure, tamper-resistant storage of clinical study data, special attention being drawn to the potential for improving the general quality of clinical research in terms of traceability and security of automation. [2]

In addition, blockchain and DLT-based approaches were discussed for addressing problems in the field of intellectual property and copyright – e.g. for a trustworthy system for the submission of manuscripts with a time stamp for peer reviews [3] and an auditable platform for collaborative design thinking and open innovation. [4]

On the basis of this knowledge and the requirements of the scientific community, we have developed a software library for the integration of the MATLAB computing environment with bloxberg, a blockchain infrastructure that is geared to academic need and enables the seamless integration of proof-of-existence of research raw data into existing scientific processes.

Bloxberg

The bloxberg infrastructure is a global blockchain that is administered and operated by an international consortium of scientific organisations. The purpose of the infrastructure is to offer the academic community a public blockchain as a service and thus promote cooperation between scientists and institutes. [5]

Specific aspects make the bloxberg network an ideal infrastructure on which to build up academically focused blockchain applications. One such application that already exists is Certify-dApp.

Certify-dApp

Certify-dApp is a prototypical decentralized application (dApp), which is operated within the bloxberg network. It can be used to verify the existence of any data file, e.g. one containing generic research data, at a specific time, without revealing the content of the file itself.

Certify-dApp can be used by users as a genuine dApp in conjunction with wallet software (e.g. MetaMask). It is, however, also possible to interact with the application online without a wallet. Access is possible via a web application that acts as a proxy or intermediary vis-à-vis the bloxberg network and publishes transactions through a custodial wallet.

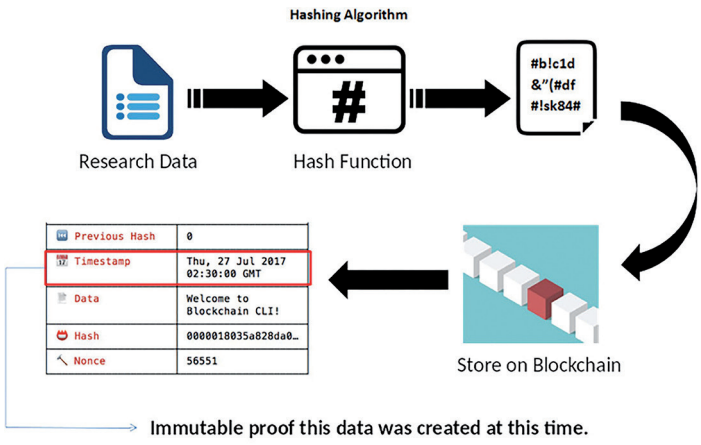

Fig. 1: Proof-of-Existence Prozess [10]

Next steps

At the present time, it is only possible to certify individual research data as atomic units. In future, however, it is intended to realise the full potential of the application by certifying the scientific process as a whole across the whole of its lifetime. As well as the interim results and final research data, this concept could also encompass artefacts such as trial designs and methods, technical test setups and hardware used (ideally in the form of cyber-physical systems), source code and software used, test persons (e.g. digital identities of humans and animals) and investigators.

At the present time, the bloxberg community is already endeavouring, in the form of bloxberg Improvement Proposals (BLIPs), to tackle the challenge of certifying a multidimensional scientific process [11]. BLIPs are aligned to established community-driven projects for the standardisation of software, such as Ethereum Improvement Proposals (EIP) [12] and JDK Enhancement Proposals (JEP) [13].

The complete results of this research project, in which scientists at Ruhr-University Bochum and the Max Planck Digital Library have been involved, are documented in detail in the academic paper "Integrating bloxberg's Proof of Existence Service With MATLAB", which has appeared in freely accessible form in the "Frontiers in Blockchain" journal [10].

Access to the bloxberg network is available to interested researchers and businesses at any time via the blockchain node operated by the Institute for Internet Security. In case of interest, please contact the Institute for Internet Security (information@internet-sicherheit.de).

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The unabbreviated original text, including all publications, can be found under https://www.w-hs.de/forschungsbericht/ in the Forschungsbericht 2020, pages 18 and 19.

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I-Care – Technical and social innovations for care of the elderly

Linking social and digital innovations makes it possible to generate sustainable impulses for nursing, care and support, as well as for ensuring the availability of qualified personnel, a modern professionalisation and attractiveness of employers. In the field of care for the elderly, however, this is still rarely the case. This problem is also the starting point for a development project by the name of I-CARE (2019 – 2021). At the core of this project is the search for creative areas and strategies that are able to empower the care organisations and care workers in the region through a combination of social and digital innovation. Based on the help of explorative analyses and regional innovation dialogues, the goal is to identify new, digitally aided solutions for resolving specific challenges and restructuring needs of the sector, initiating viable constellations of the actors, and devising new solution pathways.

Approaches and outcomes hitherto

Innovation dialogues have been conducted that focused on the one hand on the question of how to finance digital solutions (telemedicine/telecare; funding possibilities under the Care Personnel Reinforcement Law ("Pflege-Personal-Stärkungsgesetz")), and on the other on the concrete introduction of technical innovations in care homes for the elderly. It thereby emerged that the field of "job training, learning and qualification" is a key search area on the part of the care providers for digital social innovation. Given the situation amid the coronavirus pandemic, an additional ad hoc study (interviews, online questionnaire, focus groups) was initiated during the project. It proved possible to enlist the participation of around 80 decision-makers in the residential and outpatient care sectors. The results provided indications to the following areas:

- Digitalisation requires investment not only in technical infrastructures, but also in personnel development.
- Digitally aided qualification programmes and further training networks open up an opportunity to make initial and further professional training in the field of geriatric care more crisis-resistant and more attractive.
- A digitalisation strategy for the public health service should also look at more efficient information and communication concepts with the care providers on the ground.
- Digital on-the-job training programmes can provide more targeted support in the process of integrating new entrants to the geriatric care profession and additionally relieve the burden on the work teams.
- There is a need for better case-specific pooling of the care, medical and therapeutic expertise in the region so as to be able to apply the knowledge exactly where it is needed.

Fig. 1: In the workshops, innovative digital possibilities for attracting new personnel and recruiting skilled staff were presented, such as here by the company "Dein Erster Tag" [Your First Day]. (Photo: Dein Erster Tag)

Conclusion/Outlook

In the further course of the project, it is planned to hold further innovation workshops and, building on these, to conduct real-world laboratories and create collages for the "Pflegewelt Emscher-Lippe. 2040". In addition to the activities sketched in outline above, technical innovations from other sectors and their transferability to the care sector, e.g. logistical processes, will be investigated.

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Future Work

As economic and technological transformations are of increasing speed and complexity; the future world of work is characterized by a growing demand for creative problem-solving capacities.

To meet this challenge, the subproject futureWork addresses two lines of research: On the one hand, we explore how spatial and technological solutions can contribute to strengthen the output of creative work processes. On the second hand, we investigate what kind of business models are applied to operate workspaces dedicated to creative collaboration.

To root the research in concrete practices our activities are anchored in a living lab, which was set up in the artist settlement Halfmannshof in Gelsenkirchen. Here, the concrete challenges, needs, and requirements of creative professionals and artist can be conducted by qualitative methods, such as interviews and part-taking observations.

These inquiries led to the development of software prototypes by the Human-Computer-Interaction-Group. As illustrated below, those prototypes provide a starting point for further research on how creativity can be fostered by technological means.

Futurework – Mindwandering

Have you ever caught yourself in a moment where your own thoughts drift away, perhaps while sitting in a lecture, driving a car or looking out of the window of a train? Most likely you have. This phenomenon is called mindwandering and is assumed to make up 50% of our waking thoughts [1]. There are many theories as to why our mind wanders, ranging from recalibration of our brains to unconscious future planning.

Most interesting to us is recent research by Baird et al. [2] that suggests mindwandering can facilitate creative problem solving. As for inducing mind wandering, research by Smallwood et al. [3] shows a trend that mindwandering occurs more frequently in individuals performing an undemanding task.

In our current research project, futureWork, we are looking for ways to enhance creative work practices with technological solutions.

As an example, we are currently developing a lightweight application that workers can use during break times that would also provide them with a creative boost. This is where mindwandering comes in:

This project is an attempt to develop an application that promotes mindwandering and aims to foster the user's creativity in the process. Based on an extensive analysis of different mind wandering activities, we identified simple computer games as a potential source for mind wandering. By identifying mind wandering mechanics and based on an analysis of existing studies on what factors can lead to mind wandering, we propose the following model (Figure 1). This model serves as a hypothesis on future research to inform the design of mind wandering applications.

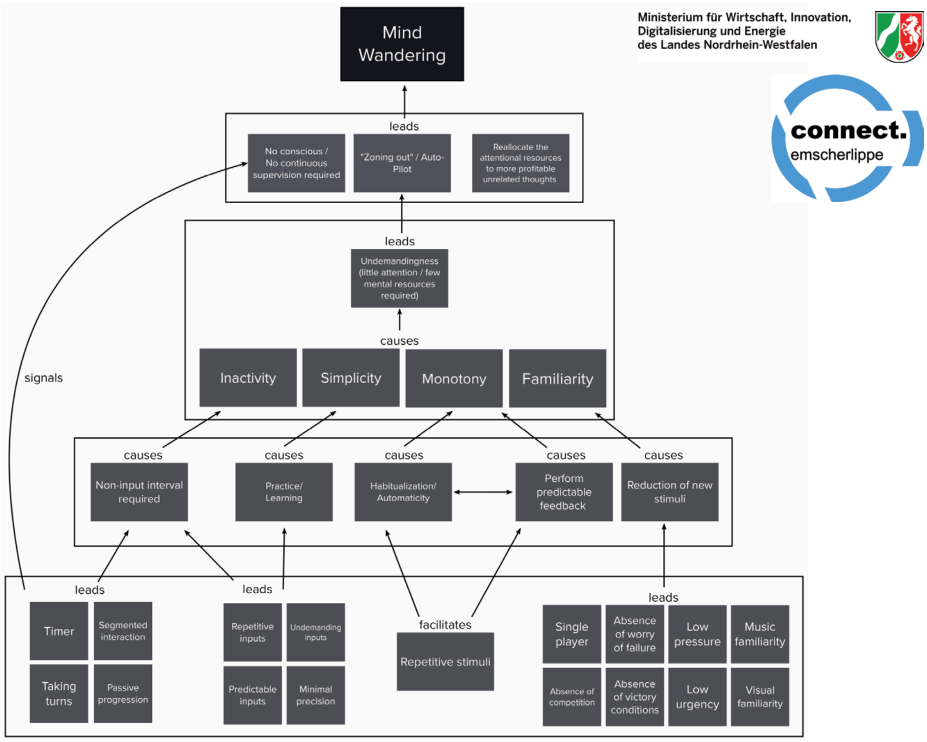

Fig. 1: This pyramid model depicts the relationship between different game mechanics and aspects that might support mind wandering. It provides the foundation to analyze the impact of individual factors in detail.

As our current test bed to explore these issues further, we developed a simple game (Figure 2, see link below), which we explain in the following.

The player is in control of a ball and is tasked with traversing the terrain made up of moving platforms, waiting for the right moment to go from one to the next. The game's design follows the proposed model and aims to induce mind wandering through all its aspects.

The visuals are deliberately kept simple to limit disruptive stimuli. The controls are limited to only the arrow keys and are very simple, becoming second nature quickly. The game loop of waiting for the next platform is repetitive and predictable, and the clear visual indication of how long it takes to be accessible leaves room for the mind to wander.

Occasionally, there are also power-ups that make the terrain easier and allow for mindwandering (Figure 3, see link below).

For a first study, two variants of the game were developed. One was designed with mind wandering as a goal as described above (undemanding condition). The other one was made faster and more difficult in order to keep players' attention on the game (demanding condition). In a remote study with 36 participants our results show that the design of the game that was intended to lead to mind wandering does indeed just that, measured through thought probes taken throughout the playing of the game (Figure 4, see link below). We believe that this supports the hypothesis that mind wandering can be induced by purpose into the design of a simple and short video game.

The further illustrations and sources [1–3] can be found in the original text at https://www.w-hs.de/forschungsbericht/ Forschungsbericht 2020, p. 22-23.

Publication //

OLAYA-FIGUEROA, J. F.; LAKHNATI, Y.; GERKEN, J. (2021). Facilitating Mind-Wandering Through Video Games. In: Lanzilotti, Ardito, Malizia (Hrsg.): Human-Computer Interaction – INTERACT 2021, Springer, Cham, 2021. https://dx.doi.org/10.1007/978-3-030-85613-7_9

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Social support in the career orientation process

The role of talent scouts from the point of view of educational climbers

Social capital and "significant others" are important not only for the career orientation process (Neuenschwander et al. 2012) but indeed also for the entire educational career path and in particular a move up the educational ladder (Gerhartz-Reiter 2017). Little is known, however, about how professional players who provide long-term and personal support in the career orientation process, are perceived by juveniles and young adults as a help.

Subject matter of research and methodological approach

Following on from this, the research project focuses its attention, from a subject-oriented perspective, on the career orientation process of school students preparing for the final school-leaving examination ("Abitur"). Proceeding from the social capital approach (Bourdieu 1983) and the social-cognitive career theory (Lent et al. 2002), one of the research interests concerns itself with social support (House 1981) during the career selection phase.

The core focus here is on "educational climbers" who participate in the NRW-Talentscouting programme, and the following research questions:

- What role and function does the talent scout perform, in the view of educational climbers, in their career orientation process?
- What action-guiding orientations of the interviewees in relation to their career orientation process can be reconstructed?

To gain some insight into how the participants in the talent scouting process experience their career orientation process and the support they have received, 15 problem-centred interviews with a narrative emphasis were conducted. The sample comprised students preparing for the "Abitur" at comprehensive schools and vocational colleges in the Ruhr district who came from families with no academic background and were accompanied for at least one year by a talent scout. The interviews were transcribed in full and anonymised, and are currently being interpreted using the documentary method of Bohnsack (2014). For the research project, the documentary method offers the possibility to reconstruct habitual orientations and action-guiding knowledge elements of the participants which are reflected in their specific practice in the career orientation process and, in a process of typification, to abstract from the individual case.

Interim results

A (comparative) analysis of the interviews shows first of all that similar topics are dealt with by the interviewees – such as learning for the final school-leaving examinations, planning the post-school educational path, and the support from the talent scout. There are, however, marked contrasts in how the students deal with the topics.

In each case, the talent scout allows him/herself to be perceived as an ally, despite the fact that all the cases differ significantly in terms of their framework conditions, action orientations and forms of support provided.

Talent scouting in North Rhine-Westphalia

Talent scouting started at the Westfälische Hochschule in 2011. Thanks to support from the Ministry of Culture and Science of the State of North Rhine-Westphalia, talent scouting has meanwhile spread to 17 traditional universities and universities of applied sciences, with now around 70 talent scouts.

The focus of the NRW-Talentscouting programme are juveniles and young adults who show above-average performance in their life context but have a family background that does not have financial means, experience in/with the education system and/or access to professional or academic networks.

The talent scout actively seeks out the relevant students in the senior grades of the around 400 participating vocational colleges, comprehensive schools and academic high schools and counsels them individually, even-handedly and on a long-term basis during the transition to vocational training or a (sandwich) study course and, if desired, right through to the job start. At the present time, some 20,000 talents are being accompanied by an NRW-Talent Scout.

In 2015, the NRW Science Ministry and the Westfälische Hochschule jointly founded the NRW-Zentrum für Talentförderung (NRW-Centre for Talent Development). As a central service and coordination point, it provides a place for talents, NRW-Talent Scouts and players from schools, universities and other educational establishments where they can exchange experience and obtain advice and further training in matters relating to talent development.

For further information on the programme, go to: www.nrw-talentzentrum.de

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Project information //

The research project described above is part of the doctoral graduation process of Magdalena Bienek and is being conducted within the scope of her employment as a research associate at the NRW-Zentrum für Talentförderung der Westfälischen Hochschule. She is undertaking her post-graduate study in the Faculty of Educational Sciences at the University of Duisburg-Essen under the supervision of Prof. Dr. Carolin Rotter.

Extracts from the interviews and their interim results as well as the sources used and quotations from the interviews are available in the original text at https://www.w-hs.de/forschungsbericht/ in the Forschungsbericht 2020 on pages 28 to 29.

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Parallel worlds – The candidates for the chancellorship and their messages on social networks and television news

Social networks are used by candidates running for political office to convey their messages direct and unfiltered to the public (cf. Bieber 2011, p. 73). During election campaigns, however, TV reporting still plays an important role (cf. Schulz and Zeh 2010, p. 313-314). So, for example, 69 percent of Germans still use television as their main source of information about an election campaign (cf. Paasch-Colberg 2016, p. 183). The purpose of this survey was to investigate the interactions between the social media and television in the reporting on the campaign for the election to the German federal parliament in 2017. The analysis adopts a comparative approach, examining the content publicised by the candidates for the office of chancellor through their own channels on Facebook and Twitter and the content disseminated about the candidates in the two principal TV news magazine programmes in Germany. It took the form of a quantitative content analysis based on the principles of Früh (2011).

No thematisation force

Martin Schulz uses the social networks equally for raising political issues and topics in all areas relating to the election and for the accompanying election campaign itself. In two-thirds of all his contributions on Twitter, Steffen Seibert addresses political issues, while the election itself plays virtually no part. Angela Merkel continues her "feel-good election campaign". The political opponent plays no part, though nor do political issues either. Dates are announced, and information is provided on forthcoming events. For Chancellor Merkel, in other words, the social networks are above all a vehicle for uncomplicated conflict avoidance.

One thing that is noticeable is that the efforts of Martin Schulz to raise political issues with the aid of the social networks, and, if possible, also include them in the media discourse, have no influence whatsoever on the TV reporting. Both in the "heute journal" news show (81.5%) and the "tagesthemen" (62.6%), the thematic focus is on the election campaign and the election. Political issues play only a marginal role in the reporting. For television, therefore, the maxim is people and performance, ahead of content.

In looking at the choice of issues, therefore, account must be taken of the focus of television on the performance of the candidates. In the social networks, Martin Schulz focussed strongly on his core issue of justice, which came up in particular in the topic area of work and social affairs (see Fig. 1).

In the TV news magazines, on the other hand, it is not possible to identify any main topic. Angela Merkel rarely has a clearly defined core issue, while Steffen Seibert's focus as government spokesman is on tax and foreign policy. This closer look at the thematic orientation of the individual channels also shows that Angela Merkel's election campaign gets along almost without content, while Martin Schulz tries unsuccessfully to set accents with his contentual core issue. In the TV news magazines, reporting on work and social issues takes place only on a much smaller scale. In other words, Schulz is not able to place his core issue in the news magazines through the vehicle of the social networks.

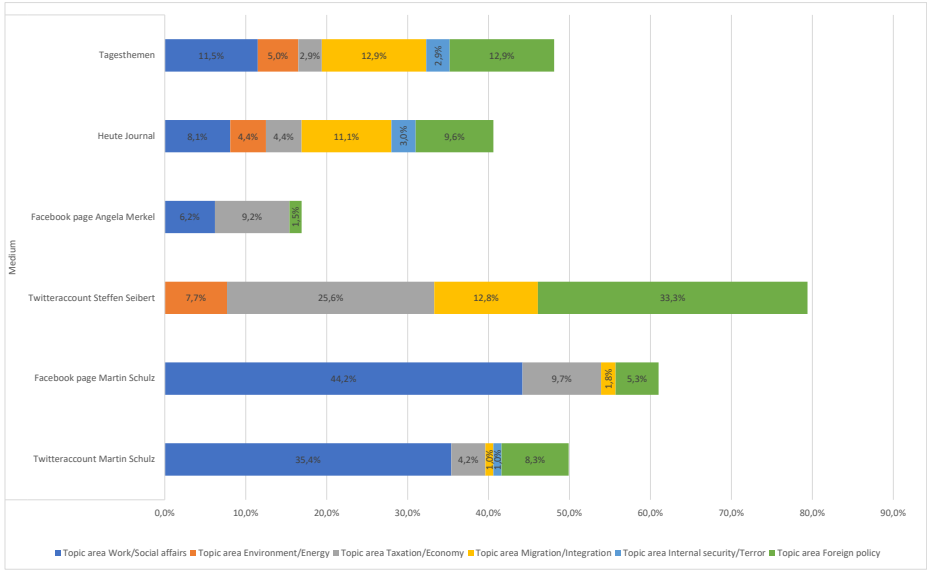

Fig. 1: Share of issues in the channels investigated (Absent: Other, No issue) / © Degen (2018)

Virtually no interactions

The results of the content analysis show clear differences between the TV reporting and the would-be chancellors' own presentations on the social networks during the 2017 federal election campaign. For the news magazine, it is possible to see some highly personalised reporting on the principal contenders. In the social networks, on the other hand, the candidates operate very differently. Almost no correlation can be found between the self-presentation in the social media and the journalistic presentation – whether in relation to the choice of topics, the assessment of individuals and situations, or the approach to political issues. Shared points of reference are altogether rare, and the mutual adoption of common content is almost never seen. The two media worlds exist for the most part parallel but separate from one another.

Current publications on this topic //

DEGEN, M., 2019. Parallele Welten – Die Kanzlerkandidaten und ihre Botschaften in sozialen Netzwerken und Fernsehnachrichten. In: KORTE, K.-R. und J. SCHOOFS, 2019. *Die Bundestagswahl 2017. Analysen der Wahl-, Parteien-, Kommunikations- und Regierungsforschung.* Wiesbaden: Springer VS.

Sources //

BIEBER, Christoph, 2011. Der Online-Wahlkampf im Superwahljahr 2009. In: *Das Internet im Wahlkampf. Analysen zur Bundestagswahl 2009*, Hrsg. SCHWEITZER, Eva Johanna und Steffen ALBRECHT, S. 69-95. Wiesbaden: Springer VS.

PAASCH-COLBERG, Sünje, 2016. *Die Bedeutung politischer Themen im Wahlkampf. Mediale Thematisierungswirkungen im Bundestagswahlkampf 2009.* Wiesbaden: Springer VS.

SCHULZ, Winfried und R. ZEH, 2010. Die Protagonisten in der Fernseharena. Merkel und Steinmeier in der Berichterstattung über den Wahlkampf 2009. In: *Die Massenmedien im Wahlkampf. Das Wahljahr 2009*, Hrsg. HOLTZ-BACHA, Christina, S. 313-338. Wiesbaden: Springer VS.

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Candidate experience and job market entry for Generation Y: What cultural institutions need to know

The shortage of professional and management personnel in the field of qualified administration (HR, marketing, controlling) is making itself felt in many sectors, and employers are finding that a wide gap exists between their own expectations and those of career beginners. In an effort to close this gap, a study has been conducted into "Candidate Experience" in a particularly attractive area of the labour market, i.e. the cultural sector, and also gives recommendations for action on the part of employers.

Different work expectations on the part of Generation Y

Many studies show that the values of Generation Y, i.e. those born between 1980 and 2000, differ in a number of areas from those of previous generations. So, for example, with regard to the workplace, they attach greater importance to personal and firm relationships, a pleasant and collegial work atmosphere, as well as regular and informal feedback. At the same time, Generation Y is internationally minded, is less respectful of hierarchies, and is more ready to change jobs. These changes in expectations present employers with a number of challenges.

Study into candidate experience in the cultural sector

The term ***Candidate Experience*** is a relatively new one in the context of HR discourse (Verhoeven, 2016: 8) and refers to the experiences of job candidates during the application process and the induction phase with the potential employer.

The study was conducted in the 2018 summer semester with a project group of students from the MA programme in "Communication Management" at the Westfälische Hochschule. The actual quantitative study involved 252 people, 158 of whom could be counted as career beginners (i.e. with no more than 5 years' work experience), from Generation Y. Some of the typical results are presented below.

Experience in the induction phase

A mere 56% of the career beginners were happy with the induction phase. Only two-thirds (62%) were initially introduced to the other employees, and only 58% were given some kind of guided tour to familiarise them with the premises. A mere one-third (31%) found a physical workplace equipped and ready for them on their first day. One career beginner in two (50%) criticised the fact that no target agreement was concluded with them, while over a quarter of the participants received no feedback on their initial work results. And not least, over 38% of the interviewees had no contact person or mentor named to them other than their employer.

High value attached to corporate culture and team spirit, low value to leadership responsibility

For all interviewees (97%), a good work climate plays an important role. This also includes certain expectations placed in the work superior, with almost 93% attaching importance to a cooperative leadership style. An autocratic boss, who decides matters arbitrarily and without discussion, is now viewed as out of place. Professional further development, on the other hand, is seen as very important by the career beginners, with 92% stating challenging work activities as an important job characteristic. Classical hierarchical career advancement, on the other hand, with the assumption of management responsibility, plays only a secondary role. Consequently, the majority of the interviewees showed only little interest in the subjects of personnel and budget responsibility.

Reasons for readiness to change jobs

More than half (54%) of the interviewees would be fundamentally willing to move to another job, with 32% who are currently looking for a new employer and another 22% who, while not actively searching, could well contemplate a change.

Of particular importance in this context are a range of reasons that relate to the concrete employer. Almost half the career beginners (46%) state dissatisfaction with the earning possibilities as their main reason, followed very closely by a lack of career prospects. Additionally, 25% criticise having too little independence and responsibility. Other important reasons lie in the leadership culture or in unclear agreements or the allocation of duties, while for more than one in three of the interviewees, problems working with their work superior/supervisor are the reasons for wanting to move.

In addition to the foregoing, other areas, such as the composition of the job description or preferences in the choice of employers, were also looked at in the survey.

Recommendations for action by employers

The present study confirms other results that indicate a change in attitudes towards employment. For many, the classical career with personnel and budget responsibility, is no longer an important job goal. Instead, a shift can be seen towards career patterns that allow compatibility with private interests and commitments. The value of work manifests itself in the opportunity for personal further development and in the meaningfulness of the work activity. The study strengthens the awareness of employers for this change in values, and gives recommendations for action during the induction phase of new employees, the elimination of pay inequalities, the support for financial independence and the possibilities of active support for job seeking on the basis of limited-term contracts.

The text illustrations together with information on current publications and sources can be found on page 10 of the original report of 2018: https://www.w-hs.de/forschungsbericht/

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UrbaneProduktion.Ruhr – Urban production as a local strategy

The research project entitled "UrbaneProduktion.Ruhr" (2016 – 2019) looks at the future sustainability and impact of manufacturing goods in urban locations, based on the experience of two urban quarters in the city of Bochum. The aim is to identify the potential of, and obstacles to, the establishment of urban production and, on the basis of the results, to develop a catalogue of measures for Bochum.

Approach

Through research and interviews with experts and on the basis of Germany-wide and international case studies, various forms of business enterprise, city support concepts and cluster structures for urban production are identified. Additionally, quantitative business surveys are used to identify the current situation and also the needs of production facilities. At local level, field trials are taking place in two city quarters of Bochum with the aim of testing the establishment of urban production in structurally weak locations. A deconsecrated church in Werne/Langendreer-Alter Bahnhof (www.lutherlab.de) and a shop premises in Wattenscheid (www.watcraft.de) are being used temporarily as open workshops for this purpose. Here, production workshops, events and network meetings are offered on the subject of "Urbane Production"; these are prepared and accompanied by a research concept (mapping of empty premises, on-site inspections, analysis of the actors, surveys of the participants, surveys of business enterprises, discussions).

Measures for strengthening urban production

It is planned for the catalogue of measures to be issued in late 2019 in the shape of a handbook. The following recommendations have so far been elaborated:

Meta-level (supraregional): As hitherto only little awareness exists on the part of politicians, city actors and the general public regarding the potential of urban production, publicity for the this topic can be generated using lectures, support programmes, campaigns or craft fairs, for example. Additionally, political decisions, e.g. in favour of production-friendly area categories, should be urged.

Macro-level (city): With a view to fostering urban production, an overall city strategy is recommended, together with a multisectoral commitment between the urban planning and business development agencies, business enterprises and the general public. In addition to a continuous process of identification and placement of vacant premises, an integrated zoning concept (for example in Vienna: the "Productive City" concept) can protect production businesses in urban locations from pressures on space and displacement.

Fig. 1: Forms of urban production

For purposes of the current research, urban production can be broken down into urban industry, urban manufacturing and repair, as well as urban agriculture. The manufactories, in their turn, can be broken down on the basis of their products and production methods into tech businesses, craft businesses and food businesses, although the boundaries between them are not always clearly defined.

(Presentation: IAT)

Meso-level (city quarter): City quarter agencies can support urban producers through space management, placements and city quarter funding resources. Local business associations (e.g. advertising pools, cooperatives etc.), business involvement in the local quarter and participation of the public (e.g. in the shape of neighbourhood festivals) can contribute to identification and the formation of networks (e.g. in Wuppertal: "Ölberg").

Micro-level (properties): Working in cooperation with the owners, interim usages make it possible to enhance the attractiveness of properties or render them more visible and also to try out new business concepts, which may potentially become permanent. Additionally, open workshops serve as incubation spaces, where the users can develop new products without financial pressure and also cooperate with other producers.

Summary

The conditions for the establishment of urban production vary from location to location. To strengthen the endogenous potential, therefore, account must always be taken of the local conditions. In city quarters which are structurally weak and business dynamic is otherwise lacking there, it may be initially necessary to support the self-help capabilities of the local residents and businesses. Through the association created in Werne/Langendreer-Alter Bahnhof, the project shows that activation of this kind is possible. Additionally, confidence-building cooperation between the groups of actors involved (city actors, the general public, businesses, local residents, property owners) is necessary, as all these groups represent different, and in some cases opposing, interests.

What impact the reintegrated urban production has or will have on the economy and development of the urban quarter concerned is hard to predict, as the surrounding conditions, which are uncontrollable, play a major role and the effects are hitherto difficult to measure. The same also applies to the field trials and the catalogue of measures, whose impact can only be evaluated in the long term and which should therefore continue to be kept under observation beyond the term of the actual project.

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Counselling in the NRW Talentscouting process between closeness and distance

A qualitative-reconstructive study of the counselling relationships of the NRW Talent Scouts

The investigation focuses on the NRW Talent Scouts, who work at 17 universities and universities of applied sciences in the whole of North Rhine-Westphalia and advise almost 20,000 young people at some 400 partner schools (NRW-Talentzentrum 2020). How the talent scouts should organise their work in practical terms has so far been left open. This research project therefore looks at the professional work of the talent scout using a structural theory approach. In this context, an attempt will be made to reconstruct the practical work of the talent scouts in terms of the organisation and structure of their counselling relationships with the young people.

Structure of the counselling relationship of the NRW Talent Scouts

A core task of the talent scouts is the conduct of counselling meetings with students, in connection with which a counselling relationship is built up. In the investigation, this is viewed from a structural theory point of view as a work alliance (cf. Oevermann 1996). As the tension between closeness and distance is a regular and ambivalent element in any counselling relationship, the focus in the research is placed on this dimension.

Various studies have already shown that in the configuration of counselling relationships, the habitus of the counsellor, which may be conditioned by organisation-specific or team-specific factors, can be of major relevance (cf. Kubisch 2008; Schmidt 2012). The leading questions in the research are, therefore: What action-guiding orientations of the talent scouts are capable of reconstruction in relation to the character and style of the relationship with the young people? How do the talent scouts structure the counselling relationship towards the young people in terms of the closeness/distance dimension?

Methodological approach

For dealing with the research questions, the adoption of a praxeological perspective appears appropriate. The reconstructive approach has the aim of providing access to the knowledge elements that guide the actions of the talent scouts in the management of the tension between closeness and distance in the counselling relationship. To this end, seven group discussions (cf. Bohnsack 2010; Loos and Schäffer 2001) were held with real groups of the talent scouting teams at the partner universities between July 2019 and September 2020. This means that almost 50 % of the talent scouts working at the various universities in North Rhine-Westphalia are included in the study sample. The group size was between three and five persons.

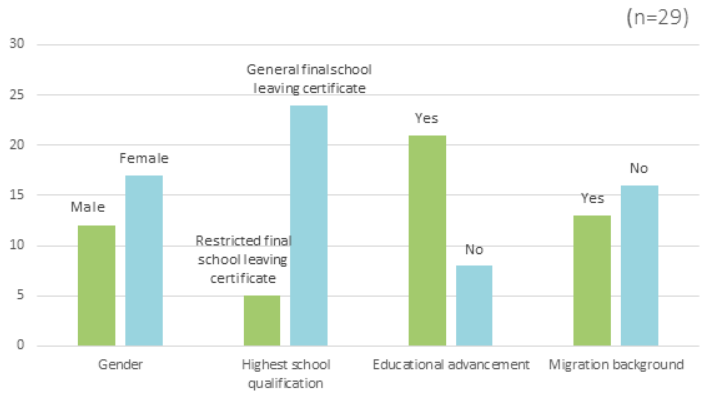

Fig. 1: Sociodemographic data of the talent scouts in the group discussions.

Figure 1 shows the sociodemographic data of the 29 talent scouts who took part in the group discussions. A look at the table makes clear that in terms of the characteristics shown, the talent scouts are a diverse group.

The group discussions were opened with the impulse: "Within the framework of your activity as talent scouts, one of the things you do is conduct counselling meetings with the young people. Please tell us about your most recent counselling meeting." It was recorded with a recording device and afterwards transcribed in full in accordance with the TIQ transcription guidelines (cf. Bohnsack 1993).

First impressions from the empirical material

It is planned to complete the evaluation of the group discussions in September 2021. Initial sighting of the material indicates that the talent scouts orientate their counselling to the individual (social) situation of the students. Thus, it appears that in particular factors such as education-related risks (Autorengruppe Bildungsberichterstattung 2012) play a part in the character and style of the counselling. Additionally, the counselling by the talent scouts appears to be orientated to the life experience of the students and the skills and abilities they have thereby acquired. A further topic in the group discussions is detailed discussion of the initial meetings with the students. In this context, it is emphasised that a special focus of the initial meetings is on getting to know each other. This would indicate a relationship orientation on the part of the talent scouts in the counselling meetings.

Outlook

In the course of the evaluation, these initial trends will be looked at in greater detail, leading finally to the reconstruction of team-specific types in management of the closeness/distance tension in the counselling relationships. The process of sociogenetic typing will thereby be undertaken by including the identified sociodemographic traits of the talent scouts as shown in Fig. 1. Ultimately, the research results may provide impulses for the professionalisation of talent scouting.

Ministerium für Kultur und Wissenschaft des Landes Nordrhein-Westfalen

Sources: See original text at https://www.w-hs.de/forschungsbericht/ in Forschungsbericht 2020 on pages 26 to 27.

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“LOUISE will deliver!” – Development of a business model involving local commerce and city logistics

“Business model” can currently count as one of the most frequently used terms in popular and scientific discussions. In many cases, it is simply a static description of how an enterprise works: On the basis of what resources and processes are what products or services offered for what markets and customer groups – and what revenue or profit does it earn? Of further interest, on a more dynamic view, are questions such as how a new business model can be developed – e.g. in a start-up – or how an existing model can be renewed, for example through innovative data-based services. The conceptual preparation of a business model – in many cases assisted with multicoloured tools, Post-its stickers and creative DIY efforts – must be supplemented by a multi-stage cycle of assessment, real-life testing and adjustment of the business model idea.

In a current research and realisation project known as LOUISE*, the IFI (Institute for Innovation Research and Management) is supporting the development of a business model in the field of local commerce and city logistics – in the “real-world laboratory” of the municipality of Bottrop. The ambitious project is being sponsored by the Bottrop business development agency, regional logistical and IT enterprises, together with the Fraunhofer Institute for Material Flows & Logistics and the IFI as research partners.

Strengthening the local economic business sector

Against the background of the current debate on municipal development and inner-city trading in the light of the digital transformation process, the focus of LOUISE is on building an online platform (www.louise-bottrop.de), the aim of which is, by offering goods and services of the local retail and business sector and through the integration of logistical services, to create possibilities for strengthening the local business operators (e.g. through a low-threshold entry into multi-channel trading).With a new digital infrastructure and also new physical logistical elements (parcel boxes and a city point, e.g. for extending opening hours), LOUISE is ultimately engaged in linking up private households, businesses and logistics in a real-world laboratory – a step on the way to implementing the vision of a regional Internet of Things and Services.

LOUISE services

The development of concrete services for registered traders and Bottrop residents as end-customers in the real-world laboratory is guided in all cases by the motto of “Make buying, selling and delivery in Bottrop easier!”. The use of the comparative form (“easier”) is deliberate: Only services that bring benefits for traders and end-customers as compared to the status quo – e.g. time-savings, reaching new customers – will find acceptance in the long term. The following LOUISE services are already available: a (same-day) delivery service with e-cargobikes and e-cars, a shopping service both for end-customers and selected institutions (e.g. old people’s homes). A food service for small and medium-sized enterprises is also in the LOUISE pipeline, as is a self-storage offering.

The observation that innovation processes are frequently accelerated through crises and dissatisfaction has also been reaffirmed through the experience with LOUISE. The coronavirus pandemic has had a positive impact on use of the LOUISE services in the real-world laboratory. The purchasing service “LOUISE hilft!”; designed specifical-ly with needy target groups in mind, has made a positive contribution. The volume of registrations and traffic on the online platform has grown significantly. How-ever, the fundamental challenge of online platforms in general – namely of achieving a critical mass of service providers and service users – continues to exist.

Whether the developed LOUISE services will ultimately bring in enough for a functioning business model is currently not foreseeable. A comparing glance at similar initiatives in other medium-sized towns shows that while the local commerce / city logistics sector is an interesting field for innovation, the hurdles to success are high. In mid-2021, LOUISE will move out of the financial support phase. It will only then become clear whether sufficient acceptance and participation have been built up in the real world in order for LOUISE to continue operating – whether as the complete service package or individual elements of it, and whether as a private business or in some other form (e.g. as a non-profit operating company or as an entity with local government participation).

Fig. 1: Loadster – the e-bike as a commercial vehicle The “Loadster” e-cargobike is available from the firm of Citkar: https://citkar.com/de/ (Image rights: LOUISE / NewsMedia)

* LOUISE – Logistical and Innovative Services for urban regions, taking the Emscher-Lippe region as an example, with funding support from the German Federal Ministry of Economics and Energy within the scope of the “Smart Service Welt II” programme (FKZ: 01MT18005C)

Website of “LOUISE bringt‘s!”
https://www.louise-bottrop.de/projekt.html

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Teachers on a treasure hunt?
Selection of pupils for scholarship programmes (taking the *RuhrTalente*[1] scholarship programme as an example)

In the Ruhr district, many schools are classified under the location type system as being of "Location Type 5": These are schools in which over 50% of the students have a migration background and in the catchment area of which, on average, one in five of the local residents is a recipient of unemployment benefit type II (QUA-LiS NRW 2017). While organisations devoted to fostering gifted students certainly strive to do so without reference to the students' origins, only small numbers of students at Type 5 schools are recommended by teachers for admission to scholarship programmes (see e.g. Studienstiftung des deutschen Volkes 2017). Of the students proposed through this route, only 15.4% come from families who are remote from the education system.

Which students count as worthy of support is often dependent on the system of orientation by which the individual teachers are guided in their actions. In school, for example, the notion of who counts as gifted is determined to a large extent by the grades they obtain – while the sociocultural context of the students, on the other hand, is often ignored (Stamm 2010). Education scientists plead for personality traits, broadened intelligence concepts and non-school abilities to be also included in the assessment of giftedness (Stamm 2016).

Definition of giftedness

The concept of giftedness is not defined uniformly in the research. It tends to be used very heterogeneously, as a rather broad, fuzzy term (Preckel et al. 2012). Thus, giftedness can be seen as a general performance requisite of all people, or alternatively as a special ability of just a few people, which may lie, for instance, in the intellectual, sporting or artistic sphere. Similarly, the various scholarship programmes apply different definitions of giftedness which may have different dimensions of manifestation (multidimensional versus one-dimensional, intrapersonal versus interpersonal, dynamic versus static, performance-orientated versus competence-orientated) (e.g. Ziegler 2002). Frequently used synonyms are gift, talent or ability. In particular, there is frequently no distinction made in scientific publications between the terms "talent" and "giftedness" (cf. Preckel et al. 2012).

Current research

For the present dissertation project, the decisions of those teachers who increasingly propose students from less privileged families for *RuhrTalente* are studied with regard to the following questions: For teachers, what is it that makes a student come into question for a scholarship? By what habitual system of orientation are the actions of these treasure-seekers guided? What notions of giftedness do they apply?

In order to reconstruct the scholarship proposal process and the associated experiences, interviews were conducted with teachers working at secondary schools of Location Type 5 in the Ruhr district who increasingly propose students for *RuhrTalente*. The sample includes both schools taking part in the NRW-Talentscouting programme, as well as some schools not participating in it. [2]

Methodological approach

The interviews are evaluated using the documentary method of Bohnsack (2014). This reconstructive methodology makes it possible for the researchers to acquire access to the conjunctive, i.e. implicit, action-guiding knowledge of the interviewees and hence to penetrate into a deeper level of meaning of the empirical material, in which the experiences described manifest themselves as documents of orientations. In order to identify habitual orientations of the interviewees, the interview guideline works with narrative-generating questions – implicit knowledge may be documented in narratives and descriptions – e.g. about the career biography ("Tell me how you came to be a teacher") and students ("Starting right from the beginning, tell me your story with a student you have recommended for a *RuhrTalente* scholarship!").

Initial findings

Initial findings may indicate that the teachers' orientations are shaped by their own social background, their own professional background, and the type of school at which they teach. In assessing students, teachers working at schools cooperating in the NRW Talentscouting programme appear to consciously pay attention to the students' socioeconomic context, looking in particular at students who possess great potential, but who have not yet been recognised as gifted. These are distinguished not only by an especially high (intellectual) gift, but frequently also by other forms of talent. These may include, for instance, assiduity, industry and (social) commitment.

[1] Scholarship programme, based since 2016 at the NRW-Centre for Talent Development (NRW-Zentrum für Talentförderung) in Gelsenkirchen, with a scholarship programme funded by the RAG Foundation as the anchor foundation to the tune of 3.5 million euros, tasked with individually promoting the top-performing from among the less privileged school students from the Ruhr district, thereby rating school grades and non-school activities in the light of the individual life context. With currently almost 500 scholarship recipients, *RuhrTalente* is the biggest school student scholarship programme in NRW. Teachers are supposed to nominate students for the programme though a letter of recommendation.

[2] Within the scope of the NRW-Talentscouting programme, talent scouts on the staff of universities conduct counselling meetings and accompany motivated and high-performing final-grade students at the over 370 schools cooperating in the programme on a long-term basis on their way into vocational training and study. Most of the students come from families with no academic background and/or are growing up in underprivileged circumstances. Teachers at the schools cooperating in the NRW-Talentscouting programme are called upon to become aware of school students who have the potential to become candidates for the talent scouting or other support programmes.

Ministerium für Kultur und Wissenschaft des Landes Nordrhein-Westfalen

Sources: See original text at https://www.w-hs.de/forschungsbericht/ in Forschungsbericht 2020 on pages 24 to 25.

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Major sports events in towns and cities – A mix of instrumentalising locational factor and enriching festival culture

The starting point for the research project into major sports events were (and are) the clearly evident problems on the part of the (co-)hosting towns and cities. Local authorities are deeply in debt and are withdrawing from the organisation of and support for major sports events. The competition between venues has become reduced to just a small number of towns/cities, and major sports events are being increasingly used for purposes that lie outside of sport. As a result, the support for such events among the population is no longer undivided. Moreover, substantiated criteria for the handling and structure of major sports events have to be developed, along with long-term strategies, which are the exception rather than the rule.

Fiscal and cultural legitimation for voluntary services of general interest

One matter requiring fundamental clarification is the amount to which expenditure spending for major sports events can be seen as reasonable and legitimate spending on a voluntary service of general interest. Even indebted local authorities are expressly permitted to spend (limited) means on voluntary services as they have a constitutionally guaranteed right to organise their own affairs. Thus, the municipal share for voluntary services ranges from 3% to 20% and for the financial support of major sports events from 0.01% to 0.05%.

On the characteristics of and misuse of major sports events by municipalities as "enterprises"

As well as the legal issues, a question was raised from a cultural viewpoint, namely with what justifications and with what characteristics festivals and celebrations of sport constitute a natural part of municipal life for everyone or are conceived as business-oriented events exclusively for target groups with the relevant purchasing-power. Today, the indebted towns/cities are increasingly focusing on local/regional events that are only funded with own resources and only exert an attraction on the nearby surrounding area. But even towns/cities that are in comfortable financial circumstances and are thinking of holding an event are (increasingly) weighing whether the image and publicity and the anticipated benefit that would be generated are in reasonable proportion to the effort and expense involved. The increasingly negative votes of the "affected" population to applications for the Olympic Games are clear signals, so that nowadays there is need for much more comprehensive and detailed conceptual justification and above all discursive legitimation.

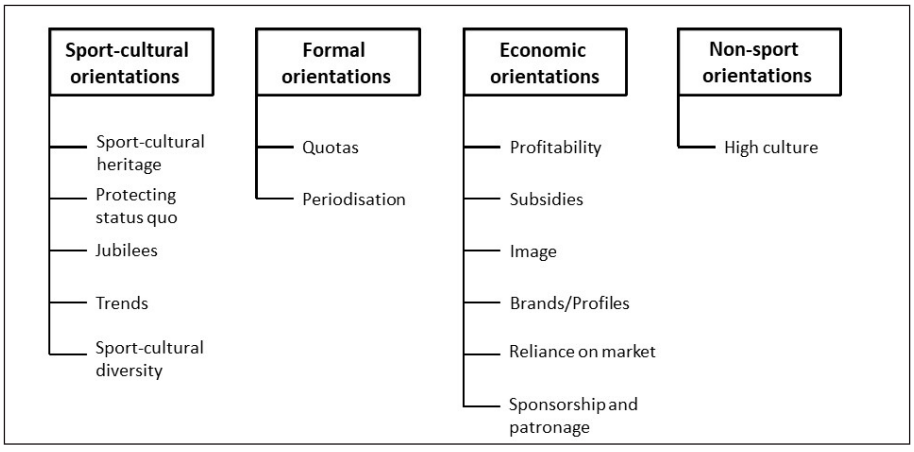

Fig. 1: Strategic orientations for major sport events

Economic effects and defects

As a further step, the individual elements of (interest-led) value-creation calculations. along with their "interpretative variances", which are used as instruments of sport-policy instruments for obtaining approval, were subjected to critical methodological scrutiny. As a real-life concrete example, the numerous failings and errors found in the expertise performed by the (eminent) consultancy commissioned with assessing the Grand Départ event of the Tour de France in Düsseldorf were exposed.
In a further section, the issue of the cut-throat competition in the commercial football sector, with its instability and wide internal economic spread, was raised. This development is accompanied at the same time by negative effects externally on "all other" sport, with increasing harm to the diversity of sport culture.

Recommendations for action, and further prospects

A prerequisite for the future prospects of major sports events was seen in the drafting of criteria (among other things relating to infrastructure, gentrification processes, fair distribution of risks between the promotors of events and those physically hosting them), as well as conceptual designs and sport-policy orientations. The various formal, economic and sport-cultural orientations are merely an extension to the utilisation of major sports events solely as vehicles geared solely to image-building and profit. The study gives the various actors at local political, city marketing, sport organisational and local population level an instrument for conducting a more transparent discussion in the decision-making process.

Project information //
The research project was carried out during a sabbatical semester in summer 2019 that was granted for this purpose. The results were published as a monograph by the Springer Verlag für Sozialwissenschaften, with financial support from the Federal Institute for Sport Science, in February 2020.

Term of project //
01.04.2019 – 31.08.2019

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Judith Terstriep, Maria Rabadjieva

Bottrop 2018+ – Participative governance for a sustainable and resilient economic structure

Building future-oriented economic structures is one of the core goals of economic development in Germany. Achieving this goal is hampered by the demographic change and the resulting labour shortage, tight local authority budgets, continuous change processes towards a diversified SME economy, and the growing relevance of sustainability. Traditional economic development structures by themselves are not able to meet these challenges. Rather, what is needed is a participative approach, which actively involves the actors from business, science, administration and politics in the economic development activities. "But how can participative economic development succeed?"

Bottrop 2018+

With "*Bottrop 2018+* – Towards a sustainable and resilient economic structure" ['Auf dem Weg zu einer nachhaltigen und resilienten Wirtschaftsstruktur'], the Department of Economic Development and Location Management of the City of Bottrop, working in cooperation with the Institute for Work and Technology (IAT) and Factor 10 – Institute for Sustainable Business, embarked on a trial of participative economic development. *Bottrop 2018+* pursued an ambitious work programme, combining quantitative and qualitative status quo analyses with strategic and structural development and tested solutions in experimentation spaces (real-world laboratories). The experience of the 3-year project implementation period shows that strong differences exist between the ideas of the various parties involved as to what participative processes should look like and who should perform what tasks in this process. The outcome is a guideline encompassing 10 steps towards participatory economic development to assist other local authorities and economic development agencies in the restructuring process.

10 steps to participative economic development

Participation in the economic development is not an end in itself, but it should be implemented strategically. Therefore, an in-depth analysis of the local status quo should be first carried out. Second, a distinction must be made between the structures and the topics for the new direction of economic development. The third key element is the identification of the relevant actors and a respectively structured stakeholder management. In fourth place comes the question of the communication channels to effectively reach out to the multiplicity of actors and, fifth, the appropriate language of the actors should be used to be heard. Sixth, it is crucial to get everyone 'on board' so as to create, seventh, a common 'us'. And finally, the role distribution (eighth), resource planning (ninth) and division of labour among all the participants (tenth) must be agreed upon (see Fig. 1).

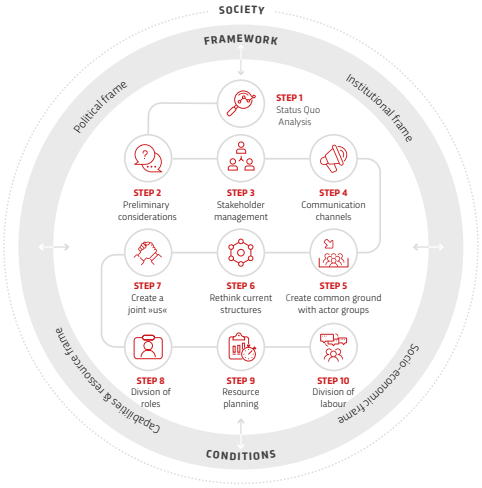

Fig. 1:
10 Steps to Participative Governance
Participative governance is usually stimulated from the top down by established structures for economic development. At the same time, however, maintaining participative governance requires bottom-up activities, in which economic actors not only call for a realignment of economic development practices, but also initiate a process of self-organisation and take responsibility for finding solutions to meet the challenges ahead.

Economic Alliance – an instrument for cooperation

The steps outlined above clearly show the need for an interplay between bottom-up and top-down activities (Gegenstromprinzip) to define, legitimise and operationalise the direction of change, account for the diversity of actors and contexts and create room for reflexion. In Bottrop, the approach of strategic alliances (Merten et al. 2015) was applied and the cross-sectoral network "Economic Alliance " ["Wirtschaftsallianz"] created to give all economic actors the opportunity to exchange views with one another on a regular basis, develop strategies, reflect on problems and present solutions. It is intended to continues these processes in the second phase of the project (01/2020-12/2021).

Conclusion

Participative governance is a long-term, time-intensive process that needs to be structured in a targeted manner. The local factors, modes of proceeding and instruments for the success of these processes were developed and summed up in the *Bottrop 2018+* project.

FONA
Forschung für Nachhaltige Entwicklung
BMBF

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

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www.wirtschaftsstrukturen.de

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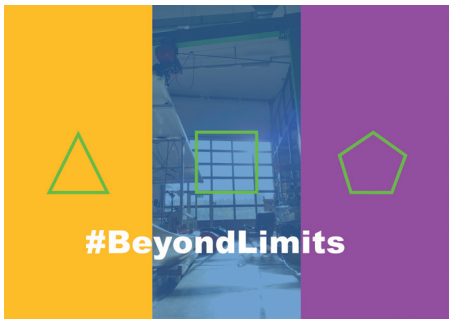
ANDERSMACHER – Your initiative. Our drive.

The "ANDERSMACHER" are an initiative committed to fostering the business start-up culture at the Westfälische Hochschule. Across organisational and professional boundaries, students, staff, professors and alumni are put in touch with one another, made aware of the idea of entrepreneurship, and skilled as businesspersons. This takes place with the help of a broad array of event formats, workshops and consultations. Here, the ideas and visions of the target group that were born in the course of study and research are developed further and formed into viable business models. For the first time, the "KickStart@WH" programme enables all phases of the business start-up process to be worked through at an accelerated pace – from idea to spin-off in just six months. Creative "doers" and novice entrepreneurs will find a home in one of our "StartUpLabs" or "Makerspaces". But also those still waiting for the big idea need not lose hope – thanks to the ANDERSMACHER and the regular workshops and seminars they offer for finding ideas. So, for example, in December 2020 the first ideas workshop took place, an ideal prelude to the ideas competition in the beginning of 2021.

No matter if the prospective founders need help concerning the budget, the equipment, an innovative idea or the business know-how, the skilled start-up coaches of the ANDERSMACHER are able to help in all phases of the process, arranging contact as needed also to an external network of start-ups, mentors and experts from the business sector. The future founders can look forward to advice across all three sites from start-up coaches, people who can also draw on their own start-up-experience in the fields of sustainable mobility, e-commerce, app development and social entrepreneurship. And also if capable start-up partners are still wanted, this, too, can be taken care of; after all, the wide range of events offers numerous opportunities for communication and interdisciplinary team building. Information on the initiative and the events is available at www.andersmacher.w-hs.

ANDERSMACHER
Deine Initiative. Unser Antrieb.



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The project ANDERSMACHER is funded by the Federal Ministry for Economic Affairs and Climate Action as part of the EXIST programme.

Bundesministerium für Bildung und Forschung

ruhrvalley Start-up-Campus

Key elements in the ANDERSMACHER initiative are two funding projects that were launched in the summer of 2020. The "BeyondLimits" project of the Westfälische Hochschule is being supported with funding from the German Federal Ministry of Education and Research for a period of four years. Its purpose is to encourage research and start-up talents and provide them with the skills and cooperations to turn their innovations into business.

The "ruhrvalley Start-up-Campus" is a collaborative project between the Westfälische Hochschule (Westphalian University of Applied Sciences) , the Fachhochschule Dortmund (Dortmund University of Applied Sciences) and the Hochschule Bochum (Bochum University of Applied Sciences) and will also be funded over a period of four years, but in this case by the Federal Ministry for Economic Affairs and Climate Action. Its purpose is to establish an attractive and proactive start-up culture at the universities involved and smooth the way for innovative spin-offs from the scientific sphere. With a varied mix of awareness-building and skilling measures, the target group is systematically introduced to the subject of business start-ups, equipped with the skills needed for entrepreneurship, connected with one another and with external partners from business companies and the start-up scene, and advised and assisted in the start-up process.

Project information //
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"Economic analysis of the law" as an interpretative, convergence-driving leitmotiv of the European Fundamental Freedoms

In addition to the promotion of peace and the values of the Union set out in Article 2 TEU, Article 3(1) TEU mentions the (economic) well-being of its peoples as a further aim of the Union. To this end, the Union shall establish an internal market (Article 3(3) TEU). The internal market not only comprises an area without internal frontiers in which the free movement of goods, persons, services and capital is ensured in accordance with the provisions of the Treaties (Article 26(2) TFEU), i.e. the TEU und the TFEU (Article 1(2) TFEU), but also includes a system which ensures that competition is not distorted – see Article 51 TEU in conjunction with Protocol No. 27 on the Internal Market and Competition.

Underlying this single market philosophy is the pursuit of an efficient allocation of economic resources, as traceable back to the thinking of *Adam Smith* and *David Ricardo*. Based on the principle of comparative cost advantage, welfare effects are expected to occur.

Article 26(1) TFEU states, as the instrument for achieving such level playing field, the adoption of measures by the Union with the aim of establishing or ensuring the functioning of the internal market, in accordance with the relevant provisions of the Treaties. To the extent that such secondary Union legislation does not exist, it is the function of the European Fundamental Freedoms in particular to remove any unjustified barriers to intra-Union commerce by means of negative integration (*minimum harmonization*). The respective provisions of Articles 28 et seq. TFEU ensure transnational market access, also and especially in the interests of macroeconomic efficiency.

Economic objective

This economic objective of realizing the internal market rightly calls for an economic approach within the framework of a teleological interpretation of the European Fundamental Freedoms as the primary law's instruments for establishing an internal market. Or more precisely: on the levels of "scope of protection" (*Schutzbereich*), "restriction" (*Eingriff*) and – to some extent – "limits to justification" (*Schranken-Schranken*), Articles 28 et seq. TFEU must be interpreted extensively in such a way that in particular the physical, technical, and fiscal barriers separating the individual markets of the Member States, as identified in the Commission's White Paper on Completing the Internal Market, are removed. This approach is given still more weight by the fact that in the context of EU law, teleological arguments generally carry heightened significance per se as well as through the topos of *effet utile*.

Legally constrained interdisciplinarity

However, insofar as non-economic aims are pursued on the levels of "(in-)applicability" (*Bereichsausnahmen*) and "codified justifications for restrictions" (*geschriebene Rechtfertigungsgründe*), de *lege lata* there is no room whatsoever for an economic approach towards the interpretation of Articles 28 TFEU et seq. In other words: A striving for economically efficient allocation of resources and, associated therewith, a corresponding interpretation of Articles 28 TFEU et seq. may find its normative basis in Article 3(3) TEU and Article 26(2) TFEU; but at the same time, these provisions – like the TEU, the CFR, and the general legal principles of EU law, each having the same legal value as Articles 28 TFEU et seq. (see Article 1(2) TFEU and Article 6(1) TEU) – limit the receptiveness of the law to the approaches offered by the different economic schools of thought.

Conclusion

Simultaneously, with regard to the European Fundamental Freedoms, the above answers the question as to whether or not economic aspects are exclusively reserved for the lawmaker (*de lege ferenda*) or are of descriptive-analytical value only. The view taken here may also "better explain" the CJEU's judgments in the given context and thus potentially increase their acceptance, e.g. the evolution of the European Fundamental Freedoms from their original dimension as mere anti-discrimination rules to the *Dassonville* formula. Moreover, the European Fundamental Freedoms' uniform objective of realizing the internal market reinforces their convergence and speaks in favour of their direct horizontal effect between individuals.

Current publication on the subject//
WIENBRACKE, M. Die „ökonomische Analyse des Rechts" als interpretatives, konvergenzforcierendes Leitmotiv der Europäischen Grundfreiheiten.
In: *ReWir* Nr. 45/2018.

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Non-tax levies in the tax state:
Is Bremen's policing fee for high-risk games in professional soccer constitutional?

In order to fulfil its tasks, the government requires financial means. Pursuant to the rulings of the German Constitutional Court, the *Bundesverfassungsgericht*, these means must, both at national (federal) and state level (including municipalities), be funded primarily from the source provided for in Articles 105 et seq. of the German Basic Law (Federal Constitution), the *Grundgesetz*, namely "taxes". [1]

Although this "principle of the tax-funded state", the *Steuerstaatsprinzip*, does not exclude the imposition of non-tax levies of different kinds per se – some of which are mentioned explicitly in the *Grundgesetz*, which does not set out a *numerus clausus* of permissible types of levies –, they each require special grounds of justification, i.e. beyond the mere generation of revenue in itself, both for raising the levy as such and for the rate at which it is levied, thus providing at the same time for a clear distinction from a tax. This is due to the limiting and protective functions of Articles 104a et seq. of the *Grundgesetz*, as well as in order to ensure equality between those liable to levies. [2]

§ 4(4) BremGebBeitrG

While the aforementioned standards are, for the most part, undisputed, the compatibility of particular non-tax levies with them is a matter of controversy. This was the case regarding the fee charged for the deployment of additional (!) police officers in commercial mass events with a high potential for violence such as high-risk games in professional soccer, where the constitutionality of § 4(4) BremGebBeitrG [Bremen Fees And Contributions Act] was at issue. The question arose in the context of a legal challenge brought against a fee notice issued by the City of *Bremen* on the basis of this provision, requiring the *Deutsche Fußball Liga GmbH* to pay a sum of 425,718.11 EUR in respect of a match between *SV Werder Bremen* and *Hamburger SV* in *Bremen's Weserstadion* venue.

Grounds for justification

The main issue in dispute in this matter, i.e. the justification for this policing fee, is the subject of an analysis published by *Mike Wienbracke* in *Deutsches Verwaltungsblatt* (2019, pages 344 et seq.). In it, he concludes that the special justification for raising a non-tax levy of the type "fee" as codified in § 4(4) BremGebBeitrG is, in any case, the individual benefit that the promoter of an event as defined in this provision receives from the government through its provision of the service "deployment of additional police officers" which is subject to a fee under this provision. It is this *maius* of compensating benefits, which justifies imposing the fee codified in § 4(4) BremGebBeitrG in the first place, that at the same time – quasi crosswise – justifies the rate of this fee, which is based on the *minus* of cost-covering, cf. § 4(4) sentences 2 and 4 BremGebBeitrG.

Resonance in case law

Just as his earlier research into the question of constitutionality of the fee for advanced rulings (§ 89(3)-(5) AO) [3] has been cited by the courts (*inter alia* in decisions by the Federal Fiscal Court, the *Bundesfinanzhof* [4], [5]), the aforementioned article on § 4(4) BremGebBeitrG, too, has recently been mentioned in the judgement of the Federal Administrative Court, the *Bundesverwaltungsgericht*, of 29 March 2019. [6] In it, the supreme administrative court of the Federal Republic of Germany has essentially confirmed the opinion of the appellate court [7], which, in contrast to the court of first instance [8], had regarded the provision contained in § 4(4) BremGebBeitrG as constitutional.

Conclusion

Even though the *Bundesverfassungsgericht* has not yet had the opportunity to rule on the question of constitutionality of the fee codified in § 4(4) BremGebBeitrG, there are good grounds for answering this legal question in the affirmative. If, when and to what extent the other states of Germany will follow the (tentative) impetus of *Bremen*, is a decision that will have to be taken by politicians, however. The potential desire of the latter in future to make use of a fee which, as such, corresponds to the one codified in § 4(4) BremGebBeitrG not only for (partially or wholly) covering the costs of the particular administrative service which is subject to fee, but even more so for aiming at a budgetary surplus, is rightly prevented by the "general cost-covering principle", the *generelles Kostendeckungsprinzip*, which derives from Articles 104a et seq. of the *Grundgesetz* and limits the rate of fees levied with the purpose of setting off individual benefits [9] (contentious).

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[4] BFH, 30 March 2011 – I R 61/10, BStBl. II 2011, 536 at 537, 539 et seq.
[5] BFH, 30 March 2011 – I B 136/10, BFHE 232, 395 at 399 et seq., 403 et seq.
[6] BVerwG, 29 March 2019 – 9 C 4/18, NVwZ 2019, 1444 at 1447.
[7] OVG Bremen, 21 February 2018 – 2 LC 139/17, NVwZ 2018, 913 et seq.
[8] VG Bremen, 17 May 2017 – 2 K 1191/16, SpuRt 2017, 261 et seq.
[9] M. WIENBRACKE, DVBl. 2019, 344 at 351.

Current publications on the subject //

M. WIENBRACKE, *„Über Kreuz"- Rechtfertigung der Gebühr nach § 4 Abs. 4 BremGebBeitrG, DVBl.* 2019, 344 et seq.

M. WIENBRACKE, *§ 4 Abs. 4 BremGebBeitrG: Gebührencharakter und Gesetzgebungskompetenz*, NordÖR 2018, 518 et seq.

M. WIENBRACKE, *Zur Verfassungsmäßigkeit der Polizeikostenbeteiligungsregelung des § 4 Abs. 4 BremGebBeitrG betreffend kommerzielle Risikogroßereignisse*, VR 2019, 85 et seq.

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Florian J.Wirkert, Jeffrey Roth, Michael Brodmann

Hydrogen development proceeding under high pressure

Implementation on an industrial scale

As part of the energy transition process, the production of hydrogen from regenerative energy sources has taken on major importance. Without the universal generation and availability of so-called "green" hydrogen for the storage of energy and for use as a raw material in the chemical industry, the transition process cannot succeed. For storage and transport, the storage of hydrogen in gaseous form in pressure vessels has become the established method. In order to generate the required pressure already during the production of hydrogen through the process of electrolysis, an already patented system has been developed further at the Westphalian Energy Institute.

Modular cell design

With the polymer-electrolyte-membrane-electrolysis (PEMEL) method, the active components of the electrochemical cell are located between two metallic plates and are separated by a membrane that allows the conduction of protons. Along with the mass transfer within the cell, which depends above all on the electrode structure, the crucial factor for stable operation on a high performance level is even contact across the whole area of the cell. Based on the principle of hydraulic compression of individual cells, a near-industry-ready design has been developed that allows every individual cell in an electrolyser stack to be surrounded by a hydraulic fluid. Compared with conventional designs in which the cells are stacked on top of one another and then compressed with pressure plates, this approach offers several advantages. The evenness of the pressure distribution within the hydraulic medium ensures homogenous contact of all the active components, whereby the pressure level can be externally controlled. The cell compression can therefore be adjusted to the pressure level inside the cell – which corresponds to the hydrogen production pressure –, and this in turn allows the hydrogen to be produced directly at the pressures needed for storage. The hydraulic medium can also be used for controlled temperature management, i.e. for the realisation of high operating temperatures of over 80°C.

After validation of the method in the laboratory, a design was created in which, in each case, two plastic cell frames are combined with an integrated thin metal plate (pole plate) in such a way that a cavity is created between the two plates into which the active components can be inserted so as to be form-fitting. Through the flexibility of the pole plates, a homogenous pressure and heat transfer process can take place, while the transport of media to the individual cells takes place through integrated channel structures in the plastic frames. The design is such that any number of individual cells can be put together as a stack, whereby the cells can be manufactured accordingly in advance. This means that the capacity of an electrolyser can be easily and precisely adjusted to meet the individual requirements.

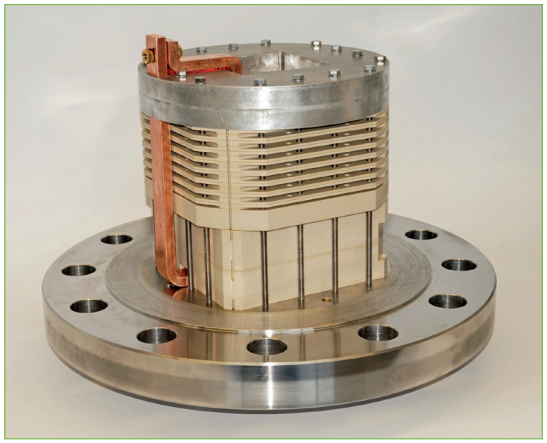

Fig. 1: Photograph of a high-pressure PEMEL stack operating on the principle of hydraulic single-cell compression.

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Demonstrator operation

The experimental implementation of the method as described was implemented for the first time in a patent validation project (Förderkennzeichen [Project Ref.:] EFRE-0400094). The knowledge gained from this was used in order to further advance the subject of high-pressure hydrogen production in cooperation with international partners. In the meantime, the campus of the Westfälische Hochschule in Gelsenkirchen is home to a high-pressure electrolysis test rig for investigating hydrogen production up to a pressure of 100 bar, with a capacity of 25 kW. The fundamental functionality of the system approach having thus been verified, a PEMEL stack (see Figure) is now being created as part of the EU's PRETZEL project (FCH2JU-Förderkennzeichen 779478), in which it is planned to utilise the full performance capacity of the test unit and so validate the practical capability of the concept for industrial purposes.

Moreover, as the system method functions independently of the nature of the integrated active components, the further development for use within another exciting research project is planned; this will allow alkaline electrolysis with the aid of an anion exchange membrane, or AEM. This technology is currently attracting much attention as it can function without the need for catalytic materials made of expensive precious metals, while at the same time retaining the known benefits (including dynamic high-pressure operation) of the PEMEL technology. Work is therefore already proceeding in parallel at the Westphalia Energy Institute on implementation of the concept for AEM electrolysis (Projekt NEWELY, FCH2JU-Förderkennzeichen 875118), whereby, within the scope of the *AEMruhr* project (Förderkennzeichen 13FH0I62IA), which is due to be launched in 2021, it is planned to create a test unit for investigation of this technology on an industrial scale.

Project Information //

http://pretzel-electrolyzer.eu/
https://newely.eu/
Concluding Report Project HiPresPEM:
https://www.tib.eu/en/suchen/id/TIBKAT:1684706831/

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Bio-based hot-melt pressure-sensitive adhesives – the natural base for labels

With around 140,000 tonnes per year, polylactic acid (PLA) is the only bio-based polymer that is currently produced from corn starch in industrial quantities at a competitive price. [1] This polymer therefore represents a promising alternative to oil-based polymers. In general, polylactic acids are semi-crystalline, with a melting point around 180°C. These materials are normally brittle and therefore not suitable for permanently adhesive glues. [2,3,4]

Development of the base polymer

To be able to use polymers for adhesives of this type, which are generally to be found on carrier materials such as textiles (sticking plasters), films (sticky tape) or paper, their tendency to crystallise must be reduced or even prevented altogether.

A project team comprising the Jowat, Henkel and Logotape companies, along with the UMSICHT Fraunhofer Institute and the Westfälische Hochschule, has now succeeded in this. The goal of creating the first hot-melt pressure-sensitive adhesive based on polylactic acid has been achieved. It is an adhesive that is applied to the carrier material direct from the melt. It thereby requires no solvent, is based to at least 70% on renewable resources and can also, compared to conventional adhesives, be processed at lower temperatures. Altogether, the efforts to develop a resource-saving, environmentally friendly adhesive have been successful. [5]

The base polymer was developed, optimised and registered for patent by the UMSICHT Fraunhofer Institute in Oberhausen, together with the Westfälische Hochschule. [6] The incorporation of components with long side-chains into the polymer chain has made it possible to prevent the tendency of the polymer to crystallise.

Development of the adhesive formulations

The formulations for the adhesives were then developed and optimised at the Westfälische Hochschule. This involved the incorporation of plasticisers, tackifiers and stabilisers. The optimisation process was shortened with the aid of statistical test planning, enabling over 100 polymers to be investigated and made up into several hundred formulations in the course of the project. One of the key tasks was to make the adhesive sufficiently stable to cope with both the production and utilisation conditions. To achieve this, it was necessary to improve its temperature resistance during the melt and also its humidity resistance. This was achieved through an optimised package of additives.

Both the raw material polymers and also the finished formulations were subjected to application testing by the industrial partners. It thereby became apparent that the adhesives are especially suited for the range of uses as labels, with further upgrade potential e.g. for use as adhesive strips.

Processing tests and results

Once these hurdles had been taken, the adhesive was required to pass a processing test. To this end, three selected base polymers were synthesised in 50 kg quantities by a contract producer. From this, the firm of Jowat produced adhesives in technical quantities. At Henkel, these were then applied to carrier film under industrial conditions and ultimately made up into finished adhesive tape.

Compared to oil-based hot-melt pressure-sensitive adhesives, the newly developed formulations are based almost entirely on natural raw materials, do not require the use of solvents, and consume less energy during processing. They show good initial adhesion, are highly elastic (Fig. 1), and are especially well suited for labels, as a comparison with commercial products from Jowat demonstrated.

Fig. 1: Elasticity
The adhesive – cast into a thick film – shows great elasticity and transparency, i.e. an indication for its absence of crystallisation tendencies.

Sources and patent //

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[4] WITZKE, D. R. *Introduction to properties, engineering and prospects of polylactide polymers*. Dissertation 1997, Michigan State University, Lansing, MI, pp. 123, 301–310.
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Energy Transition Planner
... the public energy transition tool

This freely available software tool is intended to help the interested citizen to form a picture of the energy transition process for him/herself and identify the anticipated potential of the energy transition on the basis of their own data.

Motive

In 2020, the German government resolved, by way of supplement to the discontinuation of nuclear energy already scheduled for the year 2022, to also terminate the use of coal in electricity generation by 2038. In the medium term, these energy fuels will be replaced by renewable energies.

Numerous studies on target scenarios for energy speak of the wide spread and largely diffuse nature of the data available. Fig. 1 indicates the status in 2019.
It shows the figures for primary energy and final energy consumption, electricity consumption and electricity generation from regenerative energy sources (green). Up to 2019, the measured values (actual status) are shown, and from 2019 projections up to the year 2050. The wide spread in the forecasts of energy demand for 2050 (light red and light blue rectangle) is conspicuous. On the other hand, forecasts indicate that supply exclusively from regenerative energy sources located in Germany will scarcely be possible within the legal framework as its currently stands (green rectangle). There will therefore be a gap in supply, the size of which is almost impossible to quantify with the data currently available on the anticipated energy consumption for 2050.

The data situation is also very mixed with regard to the storage capacities needed to be able to adjust the volatile renewable energies to an energy demand that fluctuates daily and seasonally around a mean value. So depending on whether the talk is of buffer storage facilities or pumped storage power plants or of long-term storage in the form of batteries or the use of hydrogen or methane storage technologies, the reports speak of a need for storage depths of up to 270 TWh.

Altogether, including the questions on the necessary expansion in the mains network, the necessary exports and imports of energy, the energy and power needs of a fully electrified traffic and transport sector and the fully electrified energy supply of buildings, the overall picture is hitherto unclear. It is virtually impossible to put a figure on the energy supply costs arising annually.

The tool

The "Energiewende-Planer" – the Energy Transition Planner – contributes towards reducing these planning deficits. It takes account of the intersectoral coupling between the generation categories of "renewables" (on/offshore wind, solar and biological sources, other) and "conventional energies" (e.g. natural gas), various types of storage (battery, pump, hydrogen, methane and thermal storage, other) with the energy consumers, i.e. electricity, heat (low and high temperature) and transport (electro, hydrogen, methane). Energy imports and exports are also included.

Operation

The Energiewende-Planer has an EXCEL® user interface, with a CAS calculation program running in the background. As default settings, the input mask already includes numerous elements of an energy supply system (e.g. wind energy, photovoltaics, battery, P2G systems, hydrogen storage, heat storage, G2P systems, electrical and calorific load, traffic and transport), which can be supplemented interactively with other elements. Technical, commercial and building-related data can be entered in popup windows, including, for example: Installed capacity/storage capacity, efficiency of power plant or storage facility, share of utilisable waste heat, annual level of utilisation, depreciation period, mean technical service life, output- and/or capacity-specific costs, space requirement, self-discharge of storage facilities, annual degradation, breakdown of traffic into gas- or electricity-powered vehicles, annual consumptions of electricity, transport and traffic, heat.

The computation results are outputted, among other things, in an automatically generated report in which, on over 100 pages, all data and results are presented in tabular and narrative form.

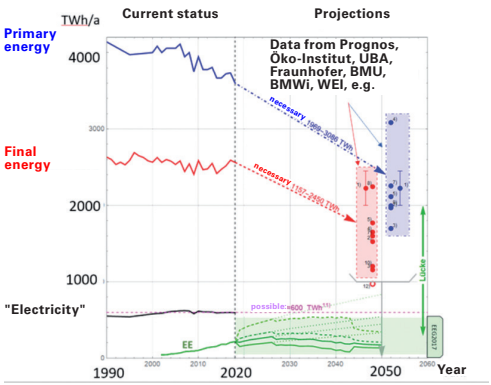

Fig. 1: Energy consumption, generation: Current status / Projections

Background information

The Energiewende-Planer draws on data from the years 2012 to 2018, which it then projects into the future. It is thereby assumed that the core characteristics of the energy input and energy consumption will change only insignificantly in future. The use of long-term views helps in taking account of the long-term effects of the energy supply. Thus, account is taken of the effects of years with strong or weak wind and solar energy input on the actual storage needs and on energy imports and exports.

Working on the "copperplate" principle, transient processes are ignored in the treatment of intersectorally connected energy consumers and energy generators.

Initial results, and future

Initial calculations indicate that implementation of the energy transition will call for an uncompromising move into the hydrogen economy. In their current form, the legal regulations restrict the potential yield of renewable energies in Germany and are forecast to make an energy import volume of over 50% necessary, predominantly in the form of hydrogen. In future, other scenarios will be calculated, also including energy exchange with neighbouring European countries. The tool is being continuously improved.

CAS – Computer Algebra System
P2G – Power to Gas
G2P – Gas to Power

For more information see original text at https://www.w-hs.de/forschungsbericht/ in Forschungsbericht 2020 on pages 40 to 41 or https://www.w-hs.de/wei/aktuelles/energiewende-planer/.

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The Human Factor in the choice of interaction modes

People interact multimodally with their surroundings [1]; these natural interaction patterns must therefore also be supported in the interaction with technology. Since the 1990s, research into forms of multimodal interaction has seen rapid development, with different combinations of modes, such as language, eye, hand and movements of the body, being subjected to investigation [2–4].

Part of the research has concentrated on comparing the efficacy and efficiency of different modes of interaction in digital environments. However, there is only little known about how a user behaves in an environment in which they can choose freely from a number of modes. In this research report, we look at the factors that influence the choice of input mode. In this context, a study was conducted that investigates the choice of modes in an interaction environment that does without the use of the hands.

Trial design and evaluation

The experiment was set up with the aim of better understanding the behaviour of users in the selection of mode in changing environmental conditions. For the utilisation scenario, we opted for system control in an industrial workplace environment in which the user has to operate a remotely controlled system, for example a robot system used in production. In workplace situations of this kind, the ambient conditions tend to change frequently as various distractions (visual, acoustic) or the level of complexity of the task may impact on performance of the task. The focus of the experiment was on exploring the motives underlying the choice of a mode without use of the hands (looks, head movements, language), if a user interface is controlled under six different conditions (noises, time pressure, interaction complexity, visual distraction, physical restrictions, none). Each restriction had the purpose of obstructing the utilisation of a certain mode.

The thinking behind the experiment was based on a model described by Jameson & Kristensson [5]. It works with three groups of variables that have an influence on the choice of mode: the characteristics of the situation, which are defined by the changes in the environment; the effects of the interaction which are determined by experience with the use of a mode in the performance of a task, and the characteristics of the user, which are conditioned by his/her individual skills and capabilities.

In the course of the experiment, the participants were given a training phase in which they could learn to use each of the modes individually. The task in this case consisted of choosing, moving and rotating an object. The purpose of the training phase was to familiarise the participants with the use of each of the modes and the interactions for performance of the task. The participants then moved on to the actual task, where they were free to choose either one mode or a combination of modes with which they were able to carry out the task effectively under the given conditions. The participants had been informed that they were free to modify or combine the modes in line with their own preferences at any time in the course of the experiment.

Results

After gathering the data from the experiment, the results were evaluated in relation to the Jameson & Kristensson model. It thereby emerged that the characteristics of a user have a greater influence on the choice of mode than the characteristics of the situation (the experimental conditions). The user characteristics that showed themselves in the results were, among others, personal preferences, skills and performance capability. The skills and performance capability in particular determine the level of mastery of a mode, which in turn affects the way in which a user chooses a mode. The "effects on interaction", such as experience (speed, success rate and errors), also play an important role. They determine how a mode is perceived and ultimately rated.

The most interesting new finding gained from this experiment relates to how people switch between modes. It was noted in about the same percentage of trials that, as the conditions changed, users either did not change mode at all, or they changed it several times. In this second group, the "mode changers", three behaviour patterns were observed: one group who tried to find the best combination of modes, i.e. a "combination strategy"; another group with one-time changers, who used a "one-mode strategy"; and then the "error-oriented changers", who switched to a different mode if they hit on problems with their previous freely chosen mode.

On the basis of these results, it is important to support the users in making the right choice when dealing with a multimodal interface. Without such support, there is a risk of users staying with a (sub-optimal) mode, instead of choosing a mode that works better in the conditions existing at any particular time.

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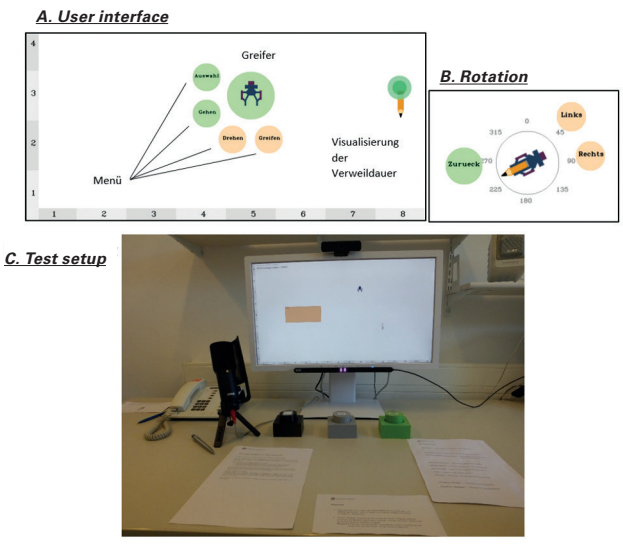

Fig. 1:
A. User interface: Menu surrounding the gripper and visualisation of the dwell time.
B. Rotation: Interaction possibilities during rotation of the gripper, with options for rotating.
C. Test setup: Three different-coloured switches for the respective modes are positioned on the bottom edge of the screen. The microphone is on one side of the screen. This is the form in which the experiment was presented to the participants.

The sources [1 to 5] and the project information can be found on page 22 of the 2018 Research Report: https://www.w-hs.de/forschungsbericht/

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Max Pascher, Jens Gerken

SwipeBuddy – A remote-controlled robot for the hands-free operation of tablets and e-book readers

Mobile devices such as smartphones, tablets or e-book readers are the key computer platform through which, in everyday life, we communicate with friends, watch films or read books. For people with severe physical handicaps, e.g. quadriplegics, who are unable to use their hands for operating such devices, the devices themselves are virtually unusable. In order to overcome this challenge, we present *SwipeBuddy*, a remote-controlled robot that allows no-hands operation by the user. The mobile device is mounted on the robot and can be remotely controlled by the user through head movements and gestures. Its principal tasks are a) to hold the digital device (e.g. Amazon Kindle), b) to provide an interaction mechanism with which the device turns the pages, and c) to be able to move flexibly so that other activities, such as eating, can take place at the same time. Touchscreen input is done with the aid of a controllable stylus. Additionally, the user can control the position and orientation of the mobile device.

The prototype

The prototype of *SwipeBuddy* is shown in the illustration. To ensure high manoeuvrability, e.g. to enable it to turn about its own axis, *SwipeBuddy* uses a crawler chassis. The holder for a mobile display device is located on a movable arm, which the user can adjust so as to allow a comfortable view of the device. The swipe mechanism consists of a stylus for capacitive contact displays and a motorised arm that provides the contact pressure for swiping and scrolling.

The interaction design

The interaction concept consists of the evaluation of head movements and gestures. For this purpose, we use a MARG (Magnetic, Angular Rate and Gravity) sensor which is mounted on a headband.

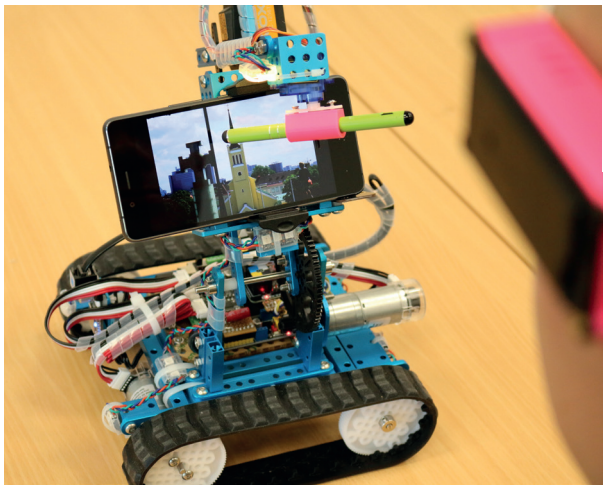
This sensor system comprises a MARG sensor, a microcontroller and a WIFI module for communication with the robot, and was developed by a work group headed by Prof. Dr. Gebhard (Department of Electrical Engineering and Applied Science). The orientation data are transferred to the actuators of the robot in order to perform the defined tasks. In this connection, we use the MARG sensor for identifying the head movements in the roll, pitch and yaw axes of the head, whereby the degree of freedom of movement can in each case be calibrated on the robot. With our interaction design, the user can switch between various modes for navigating the robot, adjusting the angle of inclination of the ramp and hence also of the electronic device, and performing a swiping action to left or right (scrolling forwards or backwards). Additionally, an idling mode is available for pausing all interactions or enabling the sensor headband to be put on or taken off. The user switches between modes by performing a head movement in the yaw axis. Depending on mode, movements in the roll and pitch axis are used for driving steering, swiping and tilting the ramp.

Altogether 25 RGB LEDs have been installed to give the user feedback on the currently selected mode. Additionally, when in drive mode, they indicate through different colours the location of front and back, and in this way enable intuitive control.

- **Driving**
  In this mode, S*wipeBuddy* follows a standard car metaphor. White headlamps and red tail lights are switched on and the crawler drive is illuminated in green. A slight movement in the roll axis, which is used for steering, changes the green lighting of the crawler drive into a blinking amber light to indi-cate a change in direction of travel on the respective side.
- **Tilting**
  The tilting platform is illuminat-ed.
- **Swiping**
  The swipe arm is illuminated (see Fig.).
- **Idling**
  Three LEDs on the back of *SwipeBuddy* blink in blue.

Discussion

With *SwipeBuddy*, we present for people with severe physical handicaps a robot assistance system that is not tied to any specific software or type of device. Its purpose is not to take the place of human assistants but to support them in certain specific tasks where users may not feel comfortable about having to constantly ask for help. The interaction design is based on head movements and gestures and allows individual adjustment to the specific freedom of movement of the user. While our scenario focuses on people with physical limitations in use of their hands, *SwipeBuddy* could also support individuals whose hands are meanwhile engaged in other activities, e.g. in an industrial context (Industry 4.0) where a user may perhaps require his/her hands in order to operate a machine interface while at the same time having to read a digital manual.



https://youtu.be/EZ5YSRRO_2o

Fig. 1:
The user controls the robot through head movements. During the swiping process, no other input commands of the user are carried out. After swiping, the swiper arm returns to its parking position and the system waits for new commands.

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Project information //

Further information on our research can be found at: https://hci.w-hs.de

This research work was conducted as part of the work on the cooperative project „MobILe – Physische Mensch-Roboter-Interaktion für ein selbstbestimmtes Leben“ (Förderkennzeichen: 16SV7866K)“, which is being financially supported by the BMBF for a period of 3 years.

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Next Level Sports – Mixed-reality sport and movement offerings

Beside the creation of immersive game worlds, the use of Virtual[1] and Mixed Reality[2] allows the conception of completely new sporting challenges, and hence also the gamification of sports activity. Movement capture and fitness tracking also offer the possibility to promote the correct performance of movements or training plans and allow them to be more precisely observed and analysed than hitherto. This will therefore make the technologies not only of interest to everyday athletes, but also and in particular for use in the medical and rehabilitation sector.

Research topic and question

This is where the "Next Level Sports" come in. On the basis of various application scenarios, this investigates whether and to what extent the use of virtual and mixed reality in the fields of sport and health can generate added value. The focus is thereby on applications in the areas of prevention, high-performance sport, and adult and juvenile rehabilitation.

At the present time, the project team is working on a VR box application aimed at "prevention" and "performance-oriented sport" with the focus on correct training behaviour, adequate movement and correct movement performance. In this context, alongside warm-up and stretching concepts based on sports science knowledge, the two following aspects play a major role.

The first of these aspects is motivation, or the pleasure associated with movement. The other is the correct movement of the user during training, broken down by quantity, nature and focus on certain muscle groups. Both aspects should be steered through an adaptive, intelligent opponent, as shown in Figs. 1 and 2. Tests are conducted to establish how the opponent's behaviour positively influences and motivates that of the player. Behaviours can thereby lie, for example, in the aggressiveness of the opponent, in the distance apart and the general movement in the room, but also in what kind of punches, feints and blocks he uses. This could also be used to steer what groups of muscles the player uses, for example by the opponent focusing primarily on one side of the player or blocking certain attacks better than others. By tracking the previous movements of the player, it is possible, through adjustment of the opponent's behaviour, to optionally favour a balanced whole-body training approach or to proceed on the basis of a pre-recorded training plan. Another focus of study is whether certain individuals respond differently to the opponent, and whether these can be typified.

Fig. 1: Reticent opponent, seeks for distance and stimulates attack by opening his cover. (Own depiction)

Fig. 1: Aggressive opponent, keeps close and carries out fast attacks. (Own depiction)

At the same, through the box application, the use of physical training equipment can also be studied in virtual reality. The aim is to find out whether visual or haptic perception has a greater influence on immersion in VR. In this context, investigations are conducted into the degree of acceptance of a physical placeholder object which in virtual space takes on the role of various objects. Relevant characteristics may thereby include mass, size and form, along with surface properties.
With regard to mass, the study investigates whether the perceived weight is influenced by the visual display, for example because it appears to consist of different materials, e.g. cotton wool or steel, or because it reacts with different degrees of inertia to movements of the players. A further point of investigation is the degree to which the nature of the physical object can differ from that of the virtual object until immersion is negatively impacted. The aim is thereby to establish what properties a placeholder must have in order to depict a large number of virtual objects.

Methodological approach | Test design and evaluation

The mode of proceeding in the project is characterised by close proximity to the end-user and short, iterative development cycles. For each application scenario, around three-monthly phases of development and evaluation alternate with each other. The evaluation phases are all based on application tests with subsequent interview rounds and a sports-scientific examination during the tests.
The strands of the four application scenarios overlap, so that while application tests and evaluations are being conducted for one scenario, the development for a different application can be carried forward. In this way, instead of one big study, a large number of small run-throughs can take place, allowing the hypotheses to be constantly adjusted.

[1] VR: Virtual reality.
[2] MR: Mixed reality, term for the visual mixing of the virtual and physical world.

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen

Project information //
https://www.ifi-ge.de/projekte/aktuelle-projekte/next-level-sports/
https://github.com/nls-whs/

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Levelling out demand fluctuations with the aid of the Heijunka method

Fluctuations in demand typically occur in the logistics chains of the automotive industry. The demand fluctuations can even build up more and more, the nearer you get to the beginning of a logistics chain. This phenomenon is also known as the "bullwhip effect".

Negative effects of demand fluctuations include material bottlenecks, fluctuating levels of production capacity utilisation, as well as high stoppage, stock holding and set-up costs. Smoother production can lessen these problems. Smoothing or levelling out means that for an extensive stretch of time during each production period, the same quantity is produced consistently, with physical material stocks being held on a low level and the fluctuations on the demand side still able to be served punctually. The idea of production smoothing stems from the Japanese automobile industry and is known by the term "HEIJUNKA".

Smoothing out the production volumes

One of the challenges to smoothing/levelling production is defining the required production quantity per period and product, which should remain as constant as possible. To this end, an MS-Excel/VBA-aided tool by the name of "HEIJUNKA-OPTI" has been developed, which also incorporates a generalised reduced-gradient process (GRG process) from the field of operations research.

Under this method, optimisation is carried out for each product, such that the availability of product for the customers is assured, but paired with physical stocks that are kept as low as possible. A real-life example of optimisation of this kind, based on anonymised business data of an automotive supplier, is shown in Fig. 1.

The blue line in Fig. 1 shows the weekly customer demand. It can be clearly seen that this demand fluctuates strongly from week to week. This is where HEIJUNKA-OPTI comes in, calculating the same or almost the same production quantities for a period of several weeks (orange line), subject to the conditions of 100% supply capability (green line being always greater than zero stocks) but stocks being kept as low as possible.

The following insights and recommendations are based on a HEIJUNKA-OPTI application, using anonymised company data of an automotive supplier.

Classification of Heijunka-capable products

Suitable for optimisation (Heijunkacapable) are products for which there is a regular and sizeable demand. Other products are, for economic reasons, aggregated for several periods and produced in one batch. These are, for example, products that only occur sporadically or have production times for the weekly demand that are in the region of the set-up time. Batch aggregation can be done using classical economic batch size methods.

Optimisation with multiple Heijunka production quantities

In the case of some products, optimisation involving only one optimum Heijunka production quantity has the effect of building up stocks after a number of periods. The reason for this are sporadic and unusually high levels of demand occurring at the beginning of the optimisation period, to cover which high Heijunka production quantities are then calculated. Subsequently, in later periods, when the demand has slowed again, these high production quantities lead to a build-up of stocks. In order to counter this effect, it is advisable to perform the computation using multiple Heijunka production quantities. In practical terms, this means that the Heijunka production quantity is successively reduced during the course of the demand periods, as shown in the example in Fig. 1.

Recognisable smoothing effect on production capacity

For 14 production weeks (calendar week 16/2016 to 29/2016), optimum production quantities were calculated for one production unit and for 18 (Heijunkacapable) products out of 86 products, and from this the number of production shifts needed per week.

Over the period, the number of production shifts required fluctuates between around 4 and 14 if the quantity of demand per week is produced (broken blue line in Fig. 2). This means that the weekly production quantity per product and week corresponds to the demand quantity per week.

If, however, production is done for optimum Heijunka production quantities, a fluctuation of only between around 9 and 11 shifts can be seen (orange line in Fig. 2).

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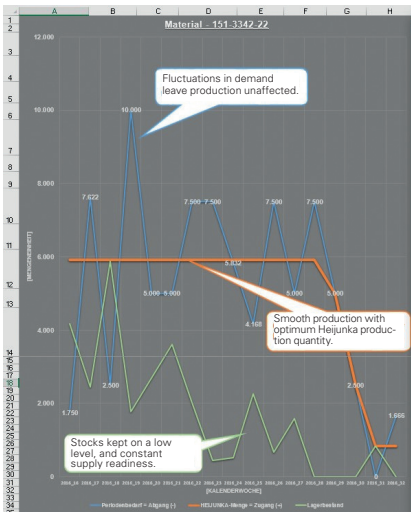

Fig. 1: Optimisation result with anonymised company data of an automotive supplier. (© H. Passinger)

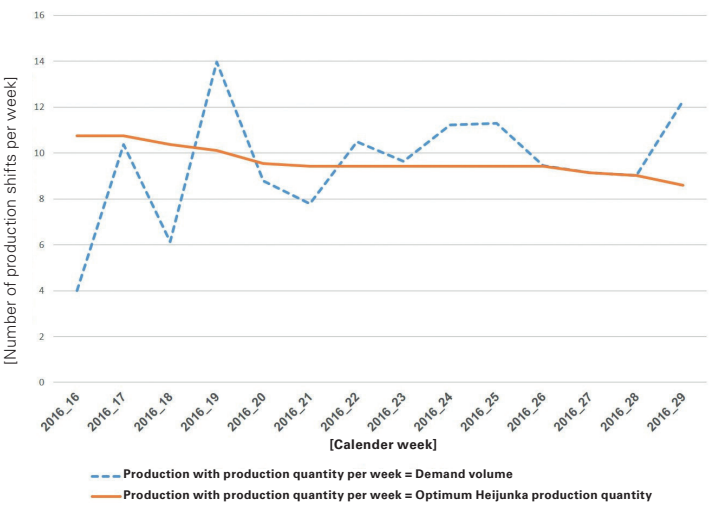

Fig. 2: Smoothing effect for production capacity (© H. Passinger)

„GeoSmartChange“ Introduction, accompaniment and optimisation of the “Digital Twin” for the model Emscher-Lippe region

Proceeding from the already market-ready solution of using mobile imaging to generate a high-resolution, dimensionally accurate and georeferenced “Digital Twin” with 360° panorama vision, the research commissioned by the Westfälische Hochschule is to develop an adaptation of this technology as a pilot study within the administration of cities and towns in the Emscher-Lippe region, which has been chosen as the pilot region. The Westfälische Hochschule will approach the subject with three different useful objectives in mind.

Practice-oriented change management

Ideally, the introduction of the “Digital Twin” in the municipal administrations of the Emscher-Lippe region will generate added value at local government level for both staff and citizens, by making itself felt in particular in the handling of planning and approval proceedings, where everything can be done from the desk.

But in this change process, what role do the people working in the administration have to play? To proceed from the classical definition of change management, which defines people as the central interface in the implementation of innovations, at the heart of the research focuses in particular on investigating the organisational and staffing barriers to implementation of the project, and the potential of the organisation and staff for its success.

To this end, the staff in the administration of the 12 local authorities in the Emscher-Lippe region are being invited to take part in several surveys in the course of a longitudinal study. It is intended that the knowledge gained as a result of this study will be transferred to other regions, especially in the form of recommendations for communication concepts, workshops and training programmes.

Informational research and development

Through their “Digital Twin”, the local authorities acquire a huge volume of valuable data. It enables a large number of objects to be recognised, which can be of great value in building up new or adjusting existing local authority inventory systems. The decisive question is: To what extent can information be extracted from the data using automated processes?

As part of the delivery package, the service provider supplies not only the image and laser data, but also other metadata, in particular positional information for specific objects (traffic signs, street lamps and traffic lights, and their masts).

This information is obtained for the individual objects from the image data using a complex, partially automated post-processing system. In the automation processes, use is made of machine learning algorithms.

Generally speaking, these algorithms must be trained for each object with an extremely large volume of training data. The production of such training data involves much effort and expense as the desired objects have to be manually marked and categorised.

But can the training process be simplified?

There are some promising approaches for significantly reducing the effort and expense involved in generation of the training data, namely by leaving the learning algorithm to decide for itself in the course of the learning process what training data is most effective. One such process, known as “Active Learning” (see Fig. 1), also promises to improve the quality of the learning method.

The project intends to use new research results in this area and develop them further, possibly with the inclusion of additional synthetic training data and the additionally available laser data.

Further research topics will also be pursued in consultation with the local authorities, including the automated classification of the state of the roads on the basis of an existing quality rating of the roads of individual towns/cities.

Legal security

In the project, it is essential to comply with data privacy regulations and to avoid all infringements of rights of personality through people being filmed during the mobile imaging process.

Consequently, the image material is automatically scanned for faces and vehicle registration numbers, which are then anonymised through pixelation. Additionally, to this end, the project was announced in advance through the press and the dates of filming published on the website of the service provider involved.

As the service provider has given a contractual commitment to comply with the data protection code for geodata services of the Verein Selbstregulierung Informationswirtschaft e.V., the self-regulation body of the German information industry, any affected property owners can additionally require that depictions of their own person or their house fronts can be rendered completely unrecognisable.

The creation of a “Digital Twin” will make the work within the public administrations significantly easier as the work flow no longer has to be interrupted through physical outside site visits.

Fig. 1: Goal: Automated recognition of objects through Active Learning

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DIGITALES NORDRHEIN-WESTFALEN MODELLREGION GELSENKIRCHEN

For further project information, go to: www.ifi-ge.de/projekte/aktuelle-projekte/geosmartchange/

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Christian Jestel, Hartmut Surmann

AI-Arena
A real-life scientific research and qualification concept for interdisciplinary AI research

AI research has developed a fascination that extends right into the heart of society. Data are the new raw material that drives this development. However, the demand for personnel who combine both the specialist knowledge of their own domain with expertise in AI vastly exceeds the initial and further training capacities that are currently available in Germany in this area. Moreover, research in the application of machine learning in the field of robotics requires transfer of the simulated computer agents into real, open worlds and to real-life robots, with all the attendant difficulties and problems. Simulations frequently lack the required precision, and also the high speed needed for learning processes. AI research is also lacking in interdisciplinarity and access to large numbers of industrial robots (swarm robotics), as well as researchers in industry and its very expensive research infrastructure with industry-near hardware.

Current status
The research goal of the AI-Arena project is therefore the collaborative further development of AI-autonomous (swarm) robotics with the aid of machine learning on autonomous robots in logistics. The implementation of this project is accompanied by the initial and further training of qualified personnel working within the teaching and research operations staff of universities and research institutes. With the vocational training it offers in the area of technical computer science, the Westfälische Hochschule can already point to some successes in this area. Along with teaching concepts and training course content, numerous qualified robotics and AI personnel have already completed vocational training. Additionally, in a high-performing parallel simulation environment that has been newly developed by us as a prototype for swarm robots, a so-called actor-critic network (GA3C) has undergone training using a "deep reinforcement learning" approach and subsequently tested successfully in the real world. As well as simulation, this involved the development of a new swarm of robots on which the AI agents decide and set the direction and speed of the robots themselves, directly on the basis of their sensor values. Through a newly developed compiler, the neuronal network of the agent was translated into special code that can be efficiently executed in real time on the computers embedded on the robots, with their limited computing resources.

Fig. 1: The AI Arena with a swarm of drones, transport robots and motion capture system. People can also interact with the robots in the arena.

Emergence
The newly trained artificial intelligence based on the swarm robot simulation shows quite remarkable behaviour. While each robot acts for itself and attempts to reach the goal set for it, there are repeated instances of cooperative behaviour. When two groups of robots encounter one another at a bottleneck, the agents have autonomously learned to apply the "zipper", or alternate merging, method. If two groups of robots encounter one another at an intersection, in most cases they automatically form a kind of roundabout. These and other behaviours were neither programmed nor stipulated and are solely an outcome of the learning process of the agents, in which each one strives to score as many points as possible by reaching the goal.

Partners in the research project
The partners in the research project are the Fraunhofer Institute for Material Flows and Logistics (IML) in Dortmund and Dortmund University.

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Project Information //
Förderkennzeichen 01IS19060C (logo bmbf)
Project website: https://www.aiarena.de
Videos on the project can be found at: https://www.youtube.com/user/RoblabFhGe

Current Publications on the Subject //
JESTEL, Christian, Hartmut SURMANN, Jonas STENZEL, Oliver URBANN and Marius BREHLER. *Obtaining Robust Control and Navigation Policies for Multi-Robot Navigation via Deep Reinforcement Learning, International Conference on Automation, Robotics and Applications*. ICARA 2021.

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A-DRZ: Competence Centre
Creation of the German Rescue Robotics Centre

In spite of good training, good tactical concepts and good protection equipment, thousands of search and rescue personnel throughout the world are injured or killed every year. With the advances in technical development, it is foreseeable that tasks will be increasingly performed by mobile robot systems as a means of making the handling of missions safer. The creation of the A-DRZ Competence Centre aims to foster the deployment of robot systems in dealing with non-military terrestrial hazards in environments that are hostile to humans. Two key goals of the collaborative project are the provision of efficient robot systems that are in line with the latest status of research, and their safe and effective deployment.

Within the scope of the project, the Westfälische Hochschule is contributing to both these goals through the provision of basic and further training on the hand and, on the other, analysis of the data for reconnaissance purposes, especially the evaluation of data from aerial robots. For this purpose, a "living lab" is being created, i.e. a laboratory with adjoining testing ground, where solutions for ancillary rescue robots can be researched and tested under realistic conditions. The project, which is initially scheduled to run for four years, is being financed by the BMBF, the Federal Ministry of Education and Research, under the funding announcement "Civilian safety – Innovation laboratories / Competence centres for robotic systems in environments that are hostile to humans" and is being conducted by an interdisciplinary collaboration of high-calibre partners, including users, industry, universities and research establishments.

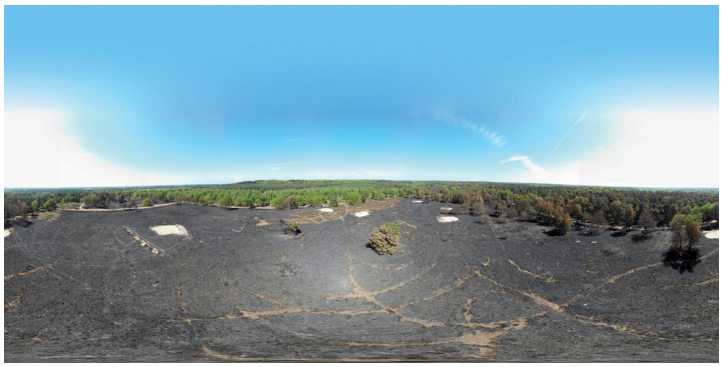

Fig. 1: 360° image from the UAV during the vegetation fire in Viersen in April 2020, showing the large burnt areas (black) which make 3D mapping difficult.

Fig. 2: One of the two workplaces for the robot operator in the Rob-LW (mobile transporter of the fire brigade).

Current status

The deployment of robots in rescue missions is always accompanied by digitalisation of the missions, and therefore with a need for highly trained rescue robotics experts. Consequently, the project to date has included the development of corresponding theoretical and practical training modules in the field of robotics/informatics and their prototype testing. In the field of data analysis for reconnaissance applications, several UAV pilots have undergone training and have programmed and flown aerial robots (< 2kg) in various exercises. This involves the capture of various types of image data with subsequent spatial and time analysis, e.g. with the aid of AI methods. In the situation picture system, this results in a georeferenced, textured 3D-pointcloud and 360° overview image with annotation of important features and/or events. The situation picture system is installed in a mobile transporter operated by the fire service (RobLW). The key goals for the future will be on speeding up the software and the deployments and improving them further.

UAV – Unmanned aerial vehicle

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Project information //

Project website: https://rettungsrobotik.de

Videos on the project are available at: https://www.youtube.com/user/RoblabFhGe

Financed by the Federal Ministry of Education and Research (Förderkennzeichen [Project Ref.:] 13N14860).

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Jeroen Schäfer, Marion Gebhard

MobILe – Multimodal sensor systems for controlling a complex robot system

People who, whether through illness or as the result of an accident, are paralysed from the neck downwards are dependent on support in all day living, e.g. eating or drinking. Support is provided by personal assistants. However, a major goal for Tetraplegics people is to gain as much autonomy as possible by means of their residual mobility. The R&D work presented here proposes innovative methods of robot control by eye and head motion. The use case is a robotic assistance scenario with drinking, where the tetraplegic user is controlling the overall situation by eye and head motion. The tireless and precise robot is performing the main motion tasks of filling the glass with water and delivering it. Human and robot are working together in close collaboration.

Sensor Modalities

Various sensor modalities are evident for robust robot control by eye and head motion. The most promising methods for the dedicated use case scenario are presented here. Electrooculography is used to control the robot by eye motion. Electrodes are placed in the vicinity of the eyes to record electrical dipoles generated by eyeball motion. The electrode output voltage is proportional to the angle of eye rotation. Video-based eye trackers represent another sensor modality. The position of the pupil is detected with the aid of a camera giving information about the gaze angle. For head motion estimation a sensor system with three axis accelerometer, three axis gyroscope and three axis magnetometer, a so called nine axis Inertial Measurement Unit (IMU), which is very small is used and sensor data are fused by dedicated algorithms. Based on the data fusion this sensor system represents a self-contained reference system which is independent e.g. from complex installation of markers in the environment. Another method for head motion detection uses cameras in the infrared range to compute the head orientation with reference to landmarks in the face, e.g. lips or eyes, which are recognised and tracked by computer vision.

Validation of Sensor Technologies

Tests are performed for validation of the most robust sensor technology for the use case of robot assistance with drinking. Robust means independent from environmental parameters, e.g. sunlight, room light, magnetic fields or type of glasses worn by the user and as well from sensor parameters, e.g. signal to noise ratio. All sensor technologies are commercially available systems and tested by persons, which are not motion impaired. The Electrooculography modality is tested with glasses from JINS MEME, which has hidden invisible electrodes. However, eye motion is not detectable within the specified resolution. Much more elaborate tests are performed with relatively large electrodes and a high-resolution bio-signal amplifier from G-Tec, showing good results in the eye motion resolution. However, with some 10.000 € the amplifier is too expensive and large relative to the specifications.

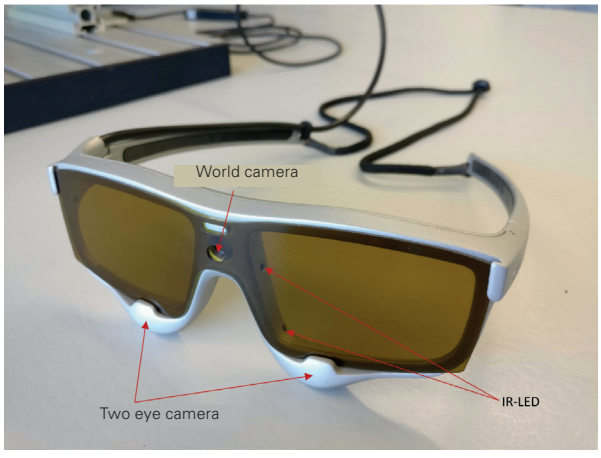

Fig. 1: Eye-tracking glasses ETG 2W from SMI with six infrared LEDs for each eye. The two eye cameras are housed in the segment on the lower edge of the glasses. The world camera is mounted on the front bridge of the glasses.

For eye-tracking, the ETG 2W glasses from SMI and the stationary tracker 4C from Tobii are used. Tests have shown the eye-tracking glasses to be valuable and highly robust against external factors, such as magnetic fields and light. Thanks to the high sampling frequency, even rapid eye movements such as saccades are recorded. In addition control of the robot by gestures is enabled by the eye trackers.

The head motion control is tested with an IMU sensor from Hillcrest, the FSRM9 and an infrared camera system. Precisely defined rotations and translations of the head are performed by the test users. The tests show very good resolution in head orientation for both sensor technologies. However, the infrared based method suffers from a small range of motion and serious problems of reliable data provided when the user is wearing glasses.

Conclusion

The use of IMU sensors in combination with eye-tracking and Electrooculography shows best results for robot control with eye and head motion. This is validated in the use case scenario providing support with drinking, The next step is the research and development in sensor fusion algorithms, design, manufacturing and testing of a demonstrator.

Project Information //

The five partner project MobILe is funded by the German Federal Ministry BMBF for four years, 7/2017- 12/2020.
Further information is available on the project at: https://www.interaktive-technologien.de/projekte/mobile

Current Publication on the Subject //

J. SCHÄEFER et. al., 2019 ACM PETRA conference, Feasibility Analysis of Sensor Modalities to Control a Robot with Eye and Head Movements for Assistive Tasks, https://doi.org/10.1145/3316782.3322774.

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MobILe – Head- and eye-based control of an assistance robot

The BMBF project MobILe is subject to the development of a continuously operated as well as event-oriented discrete robot control system in three-dimensional space by means of head and eye motion for all day living activities. For people paralysed from the neck downwards assistive robotics enables to experience gain in autonomy.

Sensor Technologies

Three different sensor technologies are being investigated for research and development in algorithm and fusion of sensor data. Inertial Measurement Units are used for the detection of head orientation. A low cost consumer grade Inertial Measurement Unit is used which delivers data being proportional to the angles related to the three spatial axes of head motion. Beside gyroscopes and acceleration sensors the self-contained unit comes with magnetic field sensors and is referred to as Magnetic Angular Rate Gravity (MARG) sensor by the sensor community. The preferred sensor technology for eye motion is eye tracking (Eyetracker). The position of the pupil is captured with the aid of an eye-safe infrared emitter and an infrared camera and mapped with the images of a world camera. This enables to compute the point of gaze. The implementation of Electromyography (EMG) is being studied as well. Here, the potential that occurs during contraction of the lateral eye muscles (blinking) is measured relative to a reference electrode via electrodes on the temples of the user.

The three sensor technologies are mounted on a commercially available lightweight glasses frame (Fig. 1). The demonstrator is being used to validate the robustness for robot control. The challenge is to fuse the data from MARG, Eyetracker and EMG and to map the three degrees of freedom (DoF) of head motion to six plus one DoF of the robot arm including the gripper. The robot DoFs are arranged in different groups, e.g. translational, rotational and open/close gripper fingers. Actuation control is enabled in continuous control mode, whereas switching between the DoFs is activated through discrete, event based control areas on the graphic user interface of a display mounted for example on the wheelchair of the user.

MARG, Eyetracker and EMG technologies are investigated in a study involving one person who is paralysed from the neck downwards and ten persons with unrestricted motion capability. For validation purposes, various parameters are recorded. These include objective data, e.g. activation time and error rate. Fitts's law test is deployed for investigating the continuous steering of a cursor on the display screen. A NASA-TLX questionnaire is used for subjective data, e.g. workload of the user related to the performance of the control tasks.

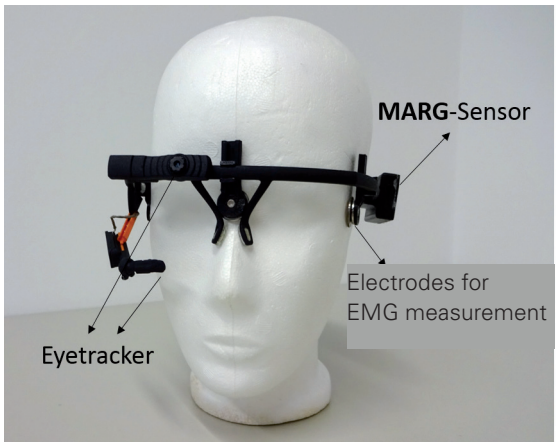

Fig. 1: Demonstrator

Results and conclusion

Evaluation of the study for continuous control of the robot in three-dimensional space results in the MARG sensor to be the best sensor technology in terms of sensitivity, robustness and size. The activation time recorded shows no significant difference related to MARG versus Eyetracker. However, the error rate for the Eyetracker is significantly higher.

For discrete, event-based control the performance of MARG versus Eyetracker is almost the same related to the activation time of the switch areas on a display. However, the NASA-TLX questionnaire indicates a higher level of mental strain, effort and frustration for robot control with Eyetracker technology. Again MARG sensors are more advantageous. Blinking recorded using EMG is a further technology for discrete control of the robot. However, for deploying the EMG technology a high-quality amplifier is needed. In conclusion, as reason of most comfort, usability and implementation the MARG sensor is the winner for continuous robot control as well as for switching. Data from Eyetracker and EMG will be fused to improve the MARG sensor control in future.

Project information //

The five partner project MobILe is funded by the German Federal Ministry BMBF in 7/2017- 12/2020,
Final report: doi: 10.21934/baua:bericht20200917
Final video: https://www.w-hs.de/elektrotechnik-naturwissenschaften/gebhard/videos/

Current Publication on the Subject //

S. STALLJANN et. al., Sensors 2020, Performance Analysis of a Head and Eye Motion-Based Control Interface for Assistive Robots, doi.org/10.3390/s20247162

Further publications can be found in the original article in the Forschungsbericht 2020 on page 56.
https://www.w-hs.de/forschungsbericht/

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Bundesministerium für Bildung und Forschung

Lukas Wöhle, Marion Gebhard

MIA – Robust sensor systems for human-robot interaction

Project information //
The project MIA "Human-Robot Interaction for motion impaired people at work" was funded by the German Federal Ministry BMBF call "IngenieurNachwuchs" for four and a half years; 7/2017 - 3/2022.

Human-robot collaboration is becoming increasingly important especially in the context of industrial workplaces. A prerequisite for the human is to have robust, safe and secure input capabilities to collaborate with a robot. For this purpose a variety of approaches to control these systems has been developed. A highly intuitive approach is head-motion based control, which enables precise mapping of 3D control commands onto a system via deliberate head movements.

MARG sensor and Eye Tracking fusion for head orientation robot control
This work presents a system to ensure the necessary robustness and adaptivity for the control of a robotic system by means of head motion. For that purpose, a lightweight, infrastructureless sensor system was developed that is worn on the head to fully control a robotic system.
The system is modular in design and data fusion scheme to grant as much adaptivity as possible. The core of the sensor system consists of Magnetic, Angular Rate, and Gravity (MARG) sensors, which are used to determine the orientation of an object in 3D space. The orientation computation is based on the numerical integration of angular rate measurements from a three-axis gyroscope. Unfortunately Micro-Electromechanical Systems (MEMS) gyroscopes are subject to noise terms that degrade the orientation estimation. To counteract this, MARG sensors are equipped with global reference measurement sensors: an accelerometer and magnetometer. The accelerometer is used to correct orientation in the plane perpendicular to gravity, while the magnetometer is used as an electronic compass to correct the remaining axis. This arrangement enables a globally referenced orientation computation. However, magnetometers are subject to interference, which have the potential to completely invalidate its use as a reference measurement. To increase robustness against such disturbances, a data fusion process has been developed which compensates short-term disturbances and allows for simple incorporation of additional references for error correction without further effort.
On this basis, a novel approach was developed that uses the physiological coupling of humans eyes and head rotation to support the MARG sensors orientation determination during long-term magnetic field perturbations. The physiological interdependence between head and eye movements during the visual fixation of static objects leads to an eye rotation as an indicator (toggle) for static or dynamic head movements (Fig. 1, [3]). During a static phase no change in orientation takes place relative to the orientation. This information is used within a data fusion process to reduce the rotation velocity drift. Experimental data demonstrates that this method provides an error reduction of up to 50 percent [1].

Current publications on the subject//
[1] 2022, L. WÖHLE, "Multimodal Sensor Data Fusion Methods for Infrastructureless Head-Worn Interfaces," PhD-thesis doi.org/10.26092/elib/1401.
[2] 2021. L. WÖHLE and M. GEBHARD, "Towards robust robot control in cartesian space using an infrastructureless head- and eye-gaze interface," MDPI Sensors, doi.org/10.3390/s21051798.
[3] 2020 L. WÖHLE and M. GEBHARD, "SteadEye-head–improving MARG-sensor based head orientation measurements through eye tracking data," MDPI Sensors, doi.org/10.3390/s20102759.
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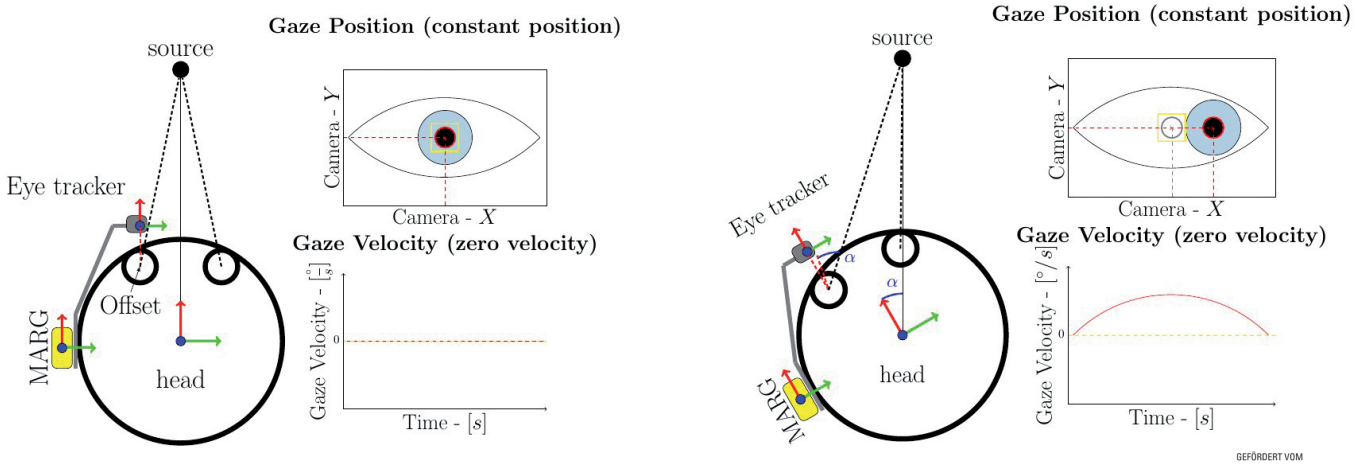

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Fig. 1: Schematic depiction of the physiological interdependency between head and eye rotation during fixation of a static object. In static phases (without head rotation), no significant eye rotation can be measured on fixation of a static object. If rotation of the head occurs, eye rotation can be measured by the eye tracker, thereby identifying a dynamic phase.

„ProLAND2“ – Production logistics system using autonomously navigating transport drones

In addition to classic internal logistics systems, the "ProLAND2" project is developing a system for the transport of time-critical goods, that specifically focuses on the use of the third dimension for the provision of materials in production using autonomous transport drones. By using the direct air line and a comparatively high speed compared to other route-flexible means of transport, an increased agility and reduced replenishment time of material provision is aimed at.

In cooperation with the TH-Köln and the SME business enterprise Tünkers-Nickel, a logistics solution is being developed which, in addition to the transporting drone, includes a guidance system with flight control and a loading and unloading station.

Research goal

The aim of the research at the Westfälische Hochschule is to provide a reference-free navigation solution that enables self-localization of a drone system independently of external infrastructure.

The localization of the drone system describes the process of inferring the current position in space (with respect to the starting point) from measured values of installed sensor systems. If the position in a developed environment is known, a safe flying off of the space coordinates is made possible.

To enable precise localisation, a fusion of SLAM (Simultaneous Localisation and Mapping) and IN (Inertial Navigation) techniques is increasingly used. INs use IMUs (Inertial Measurement Units), i.e. a combination of angular rate and acceleration sensor values, along with a magnetometer so as to generate a short-term stable localization solution. IMUs supply their measurement data, which are largely independent of the environment, at high frequency. Through processing and filtering of the measurement data, a statement can be made concerning the actual orientation. By integrating acceleration and angular rate, the change in position is also determined. Due to the manufacturing process, acceleration and angular rate sensors have a non-zero arbitrary offset at the signal output. On integration, this offset adds up and results in drifting of the angle or position signal. To counteract these processes, methods are used that support inertial localization and provide a more accurate localisation frame. In the case of drones being operated outdoors, GPS, which is able to localise precisely within the metre range, is used for this purpose. However, the project ProLand proposes indoor localisation where GPS is denied.

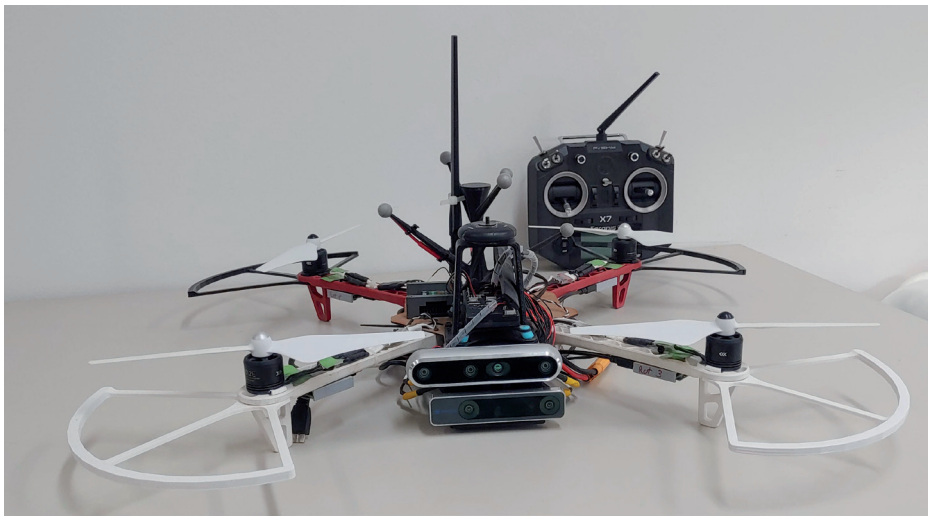

Fig. 1: General configuration of the demonstrator system: the companion computer for onboard localisation and interfacing with the additionally integrated sensors. Flight con-troller for direct motor control, positioning und location regulation through the use of internal sensors.

As an alternative, SLAM methods are used. Independently of the sensor system, SLAM consists of three main processes: feature extraction, comparison with a reference system (keyframes/map) and loop closure (closing and correction of the map). Features are extracted in two measurements and placed in reference to previously known measurements.

For this purpose, visual SLAM methods use a camera system that evaluates the surroundings. Images, and the features extracted from them, are stored as keyframes. These serve as a reference of the actual video image. Through comparison and evaluation of the change in the position of features, a statement can be made about the position change of the sensor system. There are various implementations of this concept, which differ in terms of localisation precision, localisation speed, and stability.

The performance of the systems used is tested under real-life conditions in an industrial environment and against local reference measurements. To ensure the most stable behaviour possible, different systems are proposed.

The ORB-SLAM2 system is viewed as a promising approach. The most promising candidate for the application in question is Depth-SLAM (RGBD-SLAM), which in addition to the image information, also includes depth information on the surroundings for mapping and localisation. Additionally, with the aid of this method, pure localisation in a known map can also be used, which significantly reduces the computation effort required of the system.

A demonstrator drone system was developed and tested, which serves as a flexible basis using industrial standard components. The quadcopter developed uses the control electronics and software of the PX4 opensource project and an onboard single-board computer, which has been optimised in particular for the rapid processing of matrices. In order to lower the dynamic problems existing with SLAM techniques, additional support processes are undergoing investigation. Possible approaches are the integration of Magneto-SLAM techniques and hardware temperature compensation of the IMU sensors.

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EUROPÄISCHE UNION Investition in unsere Zukunft Europäischer Fonds für regionale Entwicklung

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„MobILe“ – Physical human-robot interaction with body contact

MobILe, a collaborative project of the BMBF is subject to the exploration and implementation of innovative robot control concepts. The aim is to research and realise basic skills involving direct physical contact between a robot and a human being.

The target group consists of persons with tetraplegic disabilities, who are paralysed from the neck downwards. In MobILe the scenario of assisted drinking is investigated. Because of their restricted motoric abilities, the people in the target group are unable to use traditional input devices such as joysticks. The MobILe project therefore seeks to make use of the residual mobility for controlling the robot, i.e. in the form of head and eye motion. However, a robotic system should perform as many tasks autonomously as possible. The process of assistive drinking is broken down into the following steps:

1) The robot fills a drinking cup with water, e.g. by means of autonomous robotic skills, and raises the cup in its gripper.
2) The robot recognises and localises the user and moves the drinking cup towards the user's mouth until the rim of the cup touches the user's lips.
3) The robot tilts the cup enabling the user to drink.

When the robot is moving, the user needs to have an abort command to stop the robot for safety reasons. The goal of this 16-month MobILe sub-project is to develop and validate the autonomous positioning of the drinking cup and to establish physical contact between the cup rim and the users mouth.

Cup deployment – Step 1

The autonomous recognition of the user and the navigation of the cup to the mouth have been implemented using a hybrid visual system. It consists of a regular camera and a TOF ("time of flight") distance sensor. Using computer vision, the sensor data is fused to obtain the position of the users face and mouth. The fusion of the camera and distance sensor data contributes significantly to robustness and reliability of the system. The robot control for navigating the cup to the users mouth has been designed on the basis of the safety concept with the assumption for the robot to carry out the intentions of the user. The user is therefore included into the closed control circuit of the system and, in the event that an abort command is given by the user, the robot stops immediately. The user's intention is deduced from the direction of gaze. If the user looks at the robot, he/she wishes to interact with the robot. If the user looks away, this is interpreted as an abort command. In a test, positioning and navigation of the cup to the mouth was investigated with nine test persons, whereby a success rate of 99.54% was achieved.

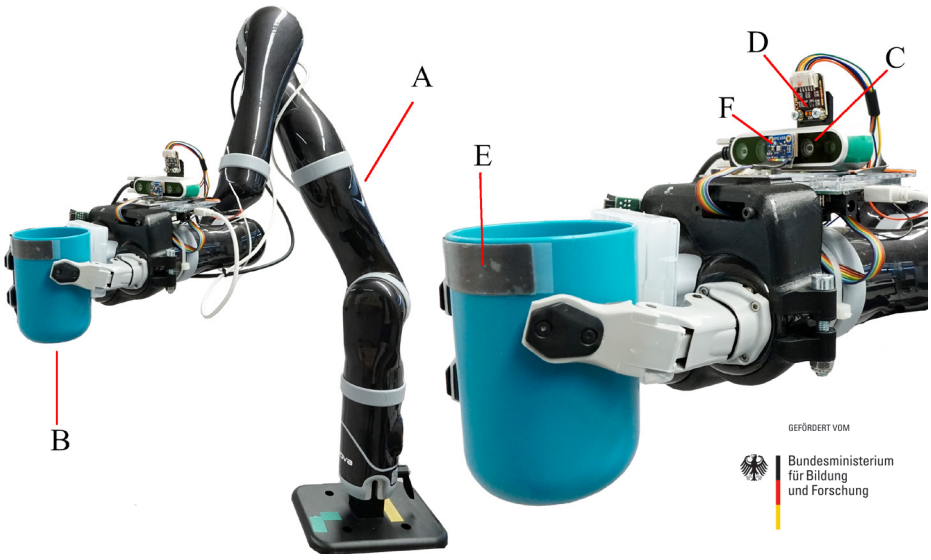

Fig. 1 from paper [2]: The robotic system.
(A) Kinova Jaco Robot Arm, (B) Drinking Cup (C), Intel RealSense D435 Camera, (D) VL53L1X Distance Sensor, (E) Tacterion Plyon Force and Capacitive Sensor, (F) Environmental Sensor BME680.

Physical contact and drinking – Steps 2 and 3

Contact force measurement plays a major role in the field of assistance robotics. It is used as a safety function and/ or as an input method. In most systems, resistive sensors are used for contact force measurement. However, these types of sensors need a relatively high minimum force of 0.2N. Therefore, a sensor is used that performs both resistive and capacitive measurement. Capacitive measurement not only enables the detection of contacts with significantly smaller forces, but also enables detection of the proximity of the user up to a few millimeter. In 500 tests carried out with different persons, the test persons were detected, on average, at a distance of 7 millimeter from the user mouth to the resistive and capacitive sensor.

When the cup is successfully delivered at the users mouth, the actual drinking procedure is started. The user controls the tilt by varying the contact force. If the user exerts a force on the sensor with the lower lip, the cup is tilted and the user is able to drink. The drinking procedure is aborted if the user remains inactive over an extended period of time, exceeds a maximum contact force or releases the lips from the sensor. In the event of abortion of the procedure, the cup is returned to the upright position an afterwards back to the start.

Additionally, a new input modality for tetraplegic people was investigated, based on the detection of human breath and exhalation with the BME680 environmental sensor. In this work sensor data fusion of temperature, humidity, pressure, and concentration of the volatile organic compounds data enables reliable detection of slight exhalation for the immediate stop of the robot.

Project information //

The proposal MobILe - Physical human-robot interaction with body contact is funded by the German Federal Ministry, BMBF for 16 months as a sub-project of the MobILe framework 7/2017- 6/2021.

Publications //

[1] SCHÖLLMANN et al, IEEE MeMeA conference 2021, Sensors for Assistive Robotic Drinking with Physical Contact, doi.10.1109/MeMeA52024.2021.9478687
[2] TRY et al., Sensors 2021, Visual Sensor Fusion Based Autonomous Robotic System for Assistive Drinking, doi.org/10.3390/s21165419

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Development of a universal storm spring with structural and flow mechanical simulations

Storms regularly give rise to enormous costs in Germany. At wind speeds of over 75 km/h, branches can be broken off trees and slates or tiles blown off roofs. More powerful storms can cause trees to be uprooted and whole roofs to be lifted off buildings. In order to minimise the damage caused by falling or flying roof tiles, regulations stipulate that the tiles must be secured against the suction force of the wind.

To fix the tiles to the rafters, so-called storm clips are used, which are generally made of wire. Given the wide variety of differently formed roof tiles, however, there is also a wide range of clips, with each one in most cases only suited for one specific type of tile.

Storm springs

In a cooperative research project with the company Lütfrink Technische Federn GmbH, funded by the AiF 1 and conducted as part of the ZIM2 project, a storm spring is now being developed on the basis of a leg spring. The patent application process is already running. It is intended that the innovative new storm spring should be capable of securing the majority of different tiles. This should reduce the amount of work and organisational effort involved in roofing considerably.

Unlike the clips generally used hitherto, with their relatively stiff fastening, the elastic spring ensures a constant contact pressure, which means that when starting to be lifted, the tiles are pressed down with greater force; this should increase the security under wind load.

Test rig

Built for a previous project, a mechanical test rig was already available at the "Mechatronik Institut Bocholt (MIB)". This enables the storm springs to be tested for compliance with the standard. The measurements have shown that the storm springs are able to secure the tiles against the wind suction force and meet the specifications of the standard.

Simulations

In the current project, the development of the storm spring is now being continued with the use of simulation software at the MIB. To this end, a finite element model is being established that describes the structural mechanical behaviour of the spring in contact with the tile. For this purpose, the pre-tensioning of the spring and the frictional contact between the spring surface and tile surface must be taken into account. This gives rise to a sharply non-linear and complex problem. The associated poor convergence behaviour and high computational input required constitute a challenge in this context.

Additionally, the mechanical flow behaviour under storm conditions is simulated using computational fluid dynamics (CFD) (see Fig. 1). To this end, a model is being built up that enables the influence of different roof tiles, roof designs and wind directions to be studied. To validate the airstream simulations, it is planned to conduct trials with a scale model of a roof in the wind tunnel at Hamburg Technical University.

A development tool will then be programmed on the basis of the computations which allows an approximation of the influence of the various relevant parameters on the behaviour. This will assist in defining the optimum design of the storm spring.

Outlook

To be able to model the behaviour of the storm springs under wind load even more realistically, computations with fluid-structure couplings are necessary. To do this, the creation of a model is in planning that is able to simulate the interactions between the airflow, roof tile and storm spring.

[1]AiF – Arbeitsgemeinschaft industrieller Forschungsvereinigungen

[2]ZIM – Zentrales Innovationsprogramm Mittelstand

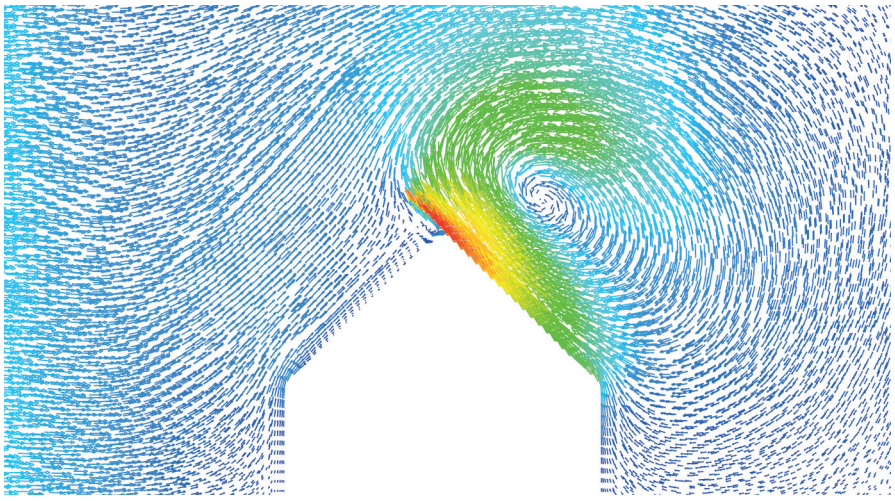

Fig. 1: Flow conditions on a gable roof, calculated with the aid of CFD (computational fluid dynamics) A vortex on the lee side of the roof, which exerts wind suction (under-pressure) on the roof tiles (not shown), can be clearly seen.

Forschungsnetzwerk Mittelstand

ZIM Zentrales Innovationsprogramm Mittelstand

Bundesministerium für Wirtschaft und Technologie

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Endurance limits of roller bearings with rotating outer ring

The endurance or service life of roller bearings depends on the probability of how many changes of load the material volume, with its pitting and its subjection to stresses, is able to tolerate. This is a statistical value that is based primarily on figures obtained experimentally.

The basis for the calculation of service life dates back to work of Lundberg and Palmgren from the 1940s and '50s. The authors developed the formulae for service life computation on the assumption that, as a rule, it is the inner ring of the roller bearing that rotates. This assumption does not, however, apply in the case of roller bearings used as the planetary bearing in planetary gear systems. In the case of planetary bearings, it is the outer ring of the roller bearing located in the planet gear wheel that rotates, while the inner ring is mounted stationary on a pin.

The goal of the research project is to more closely study the instance of a "rotating outer ring". This involves both theoretical considerations and practical experiments.

Basis

The work of Lundberg and Palmgren was normed in 1962 as an international recommendation in DIN ISO 281. This standard describes the endurance and service life calculation of roller bearings under varying operating conditions, such as load, speed of rotation, lubrication, or ambient conditions. What it does not include, however, is the way in which the running surfaces of the outer and inner ring are stressed, i.e. whether the load bears, as a point load, on the inner or the outer ring. DIN 26281 goes a step further and provides equations for calculation of the load ratings and service lives for a rotating inner or outer ring. ISO TR 1281-1 provides a derivation for the formulae. It states, however, that the difference in the dynamic equivalent load amounts to only 2% and is negligible.

In the light of field experience, this assessment must be viewed critically, given that, especially in the case of "rotating outer rings", there is no knowledge of any tests having been performed with systematic analysis of the mechanisms of action.

Improved manufacturing methods and higher steel qualities in recent years have meant an increase in actual life spans compared to the calculated service lives. The improvements are taken into account empirically. First, the dynamic load ratings were gradually increased, and later, "service life coefficients" were introduced, designed to take account mathematically of the survival probability, the material purity and the operating conditions.

Research in the field of roller bearing is still far from over. The bearings continue to be the subject of experimentation, and new computation models are being developed.

As nowadays all the influences are subsumed in the dynamic load factor Cr, the influence of the internal load spectrum and the stressed volume can no longer be individually identified.

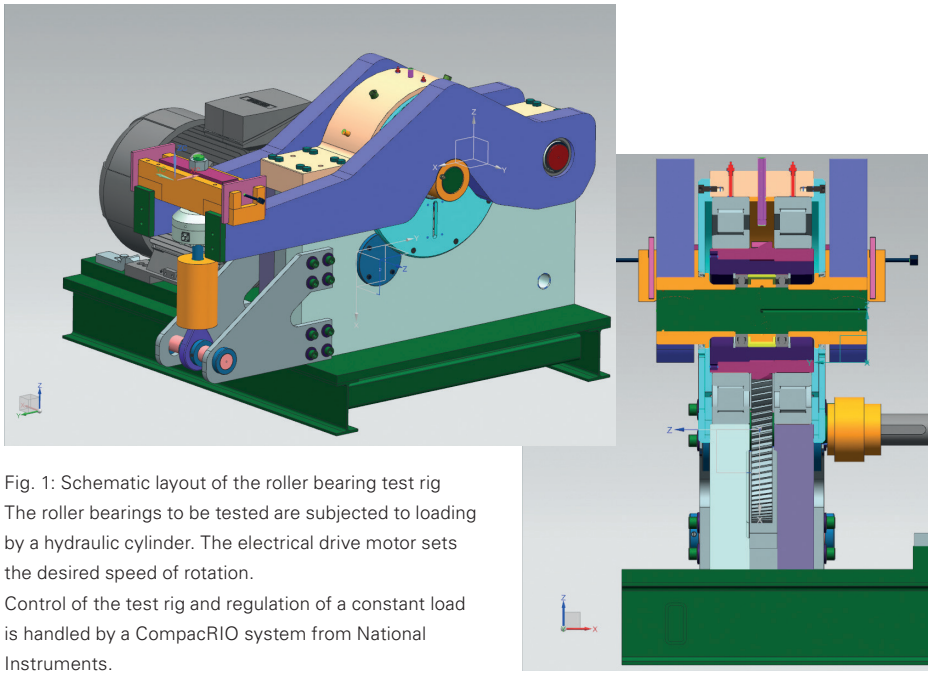

Fig. 1: Schematic layout of the roller bearing test rig
The roller bearings to be tested are subjected to loading by a hydraulic cylinder. The electrical drive motor sets the desired speed of rotation.
Control of the test rig and regulation of a constant load is handled by a CompacRIO system from National Instruments.

Current project status

The project has brought about transparency through derivation of the precise calculation equations. The load ratings, survival probabilities and/or service life spans for the contact between rolling element/inner ring, rolling element/outer ring and overall bearing can now be calculated separately. Calculation of service life span computation is therefore done independently of load factor Cr. The formulae also allow separate computation of service life for the case of "rotating inner ring" and "rotating outer ring" respectively.

For calculation of the roller bearing service life, a computation tool has been developed which, depending on bearing type, profile of the rolling elements, bearing play and tilt, determines the tensions and deflections for all rolling elements, covering the full range of Hertzian factors.

Two FEM[1] models are used for verification of the local loads in the bearing contact type "rolling element/inner ring" and "rolling element/outer ring". The overarching macromodel is used for calculating the load distribution via the rolling element in a cylindrical roller bearing. Based on the loads, the second model calculates the local load in the roller contact.

To enable the roller bearings with rotating outer ring to be tested for their service life, a roller bearing test rig was devised and constructed (see Fig. 1). The main focus of interest is to define the exponents c, h and e experimentally, based on the formula of Lundberg and Palmgren

$$\log \frac{1}{S} \sim \frac{\tau_0{}^{c}\, N^{e}\, a\, l}{z_0{}^{h-1}}$$

through service life testing in the case of "rotating outer rings".

In this equation, S is the survival probability, τ_0 a load value, N the number of load changes, and a, l and z_0 geometrical values.

FEM[1] - Finite Element Method

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Development of a guide "Introduction of Predictive Maintenance in Small and Medium-Sized Enterprises"

"Predictive maintenance" (abbreviated "PdM") is, by definition, a maintenance technique that is based on the evaluation of process and machine data and that can be found in particular in the linguistic context of Industry 4.0. The purpose of the technique is to service and maintain machinery and equipment proactively and in this way minimise machine downtimes.

Predictive maintenance promises many benefits for manufacturing businesses. Predictive maintenance prevents expensive machine failures and helps business enterprises to plan better. Through continuous analysis of the captured data, it is possible to improve the performance of the machine and, in the long run, achieve higher productivity. However, the introduction of PdM is not meaningful in all cases.

Innovationsforum PdM@KMU

To assist businesses in the Münsterland region on the way to moving to predictive maintenance, the "Innovationsforum PdM@KMU" has been created. The Innovationsforum PdM@KMU is a programme that is being funded by the BMBF, the Federal Ministry of Education and Research, and has the goal of assisting small and medium-sized enterprises in Germany in the implementation of PdM activities.

For the project, the Mechatronik Institut Bocholt, working in collaboration with the Wirtschaftsförderungsgesellschaft für den Kreis Borken (Business Promotion Company for the District of Borken, abbreviated "WFG Borken"), has developed a guide for the introduction of PdM at small and medium-sized enterprises. Designed for use as a practical too, the guide provides small and medium-sized enterprises in particular with concrete approaches for the implementation of predictive maintenance, offering potential solutions for their particular situation and arousing the interest of the companies. The process of drafting and testing the guide for practicability has been carried out with the involvement of two pilot companies, Ferro Umformtechnik GmbH & Co. KG in Stadtlohn, and Bischof + Klein SE & Co. KG in Lengerich. The experience gained has gone into the further development of the guide and been incorporated into the finished tool.

The guide provides a model on how to proceed, reducing the large volume of information that is already available to a series of manageable steps. In this way, it offers an aid to orientation for SMEs in finding their own understanding of PdM and understanding the benefits it can offer for their own enterprise. Finally, the level of readiness of a business enterprise for the introduction of PdM is determined through use of a traffic light system.

Identification of the level of readiness is based on the "Werkzeugkasten Industrie 4.0" (Toolbox Industry 4.0) from the "Leitfaden Industrie 4.0" (Industry 4.0 Guide) of the VDMA, which has been adapted for the application of PDM. In the Toolbox, the various levels of application of PdM are explained and broken down into individual, manageable development stages. Classification in the relevant development stage is done through questionnaires conducted with the personnel of the company. The outcome of the questionnaire, entitled "Reifegradbestimmung" (Quantification of Readiness), indicates on what levels of application there is still potential for optimisation. The decision-making phase then provides an overview of the analysis and thus gives support in deciding whether the introduction of PdM is worthwhile, and if so, what equipment items should be given priority.

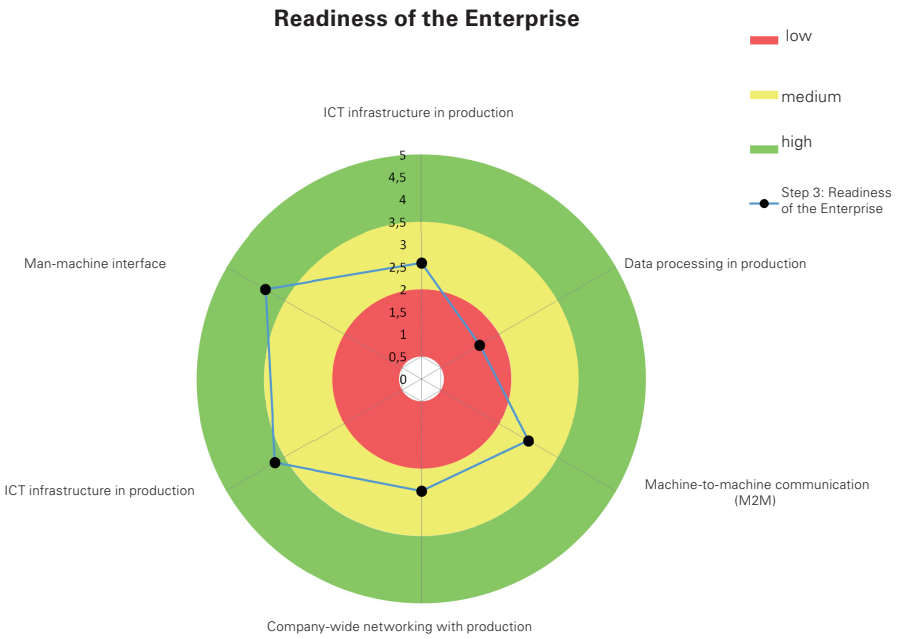

Fig. 1: Diagram "Readiness of the Enterprise"
Identification of the level of readiness is based on the "Werkzeugkasten Industrie 4.0" from the "Leitfaden Industrie 4.0" of the VDMA, adjusted for the application of PdM.

Current project status

Professor Franz-Josef Peitzmann of the Westfälische Hochschule presented the PdM Guide on 10 and 11 September 2020 in the course of a virtual conference organised by the WFG Borken and entitled "Innovationsforum@KMU" and answered questions from the online audience. Subsequently, the digital PdM Guide was released for download (www.wfg-borken.de/pdm-leitfaden) and is available for all interested parties.

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„Ovoraptor“ – Development of an egg-searching, finding and collection machine

In conventional henhouses, up to 6,000 hens per group may be kept. Species-appropriate keeping and animal welfare requirements in general are playing an ever more important role both among the public and on the farms themselves.

In henhouses, the hens do not always lay their eggs in the nesting facilities provided. 2% of all eggs are simply laid “somewhere” on the floor. Among other places, the eggs may be laid under the raised nesting boxes, in a space that is only 35 cm high. For hygienic reasons, these eggs must be sought for and removed – at the present time still manually by an employee. This task is stressful and potentially harmful to the health of the person performing it as it has to be done directly above a floor that releases fine dust.

In “Ovoraptor”, a cooperative research project being carried out in collaboration with the poultry farm of Kottsieper GmbH & Co. KG and with funding from the Ministry of Environment, Agriculture, Nature and Consumer Protection of the State of North Rhine-Westphalia, a mobile robot that automatically searches for and collects these eggs has been undergoing development since 1 September 2020.

Function description

The specification is for the robot to be able to navigate autonomously through the henhouse, gathering up to 50 eggs on its way. It is planned that it will detect the “lost” eggs with the aid of optical scanning systems and pinpoint their locations. Subsequently, the eggs will be picked up carefully by a grab arm, which is still to be developed, and placed in the load area of the robot. To prevent the robot from travelling around randomly in the henhouse and enable it to find its base station, an indoor localisation system is required to enable it to navigate autonomously. After returning to the base station, it will recharge its batteries automatically. At the present time, smaller robots are also in planning that can only carry 1 – 4 eggs, but to make up for this, the will need to travel more often.

As additional functions, further sensors may be installed on the robots in future, e.g. an app that provides the henhouse owner with information. This could include, for instance, data on the ambient conditions in the barn, or information about unknown objects (e.g. dead hens).

Fig. 1: Near the bottom of the picture, a lost egg can be seen, surrounded by numerous hens. Eggs can also be seen under the raised nesting boxes. Only ¼ of the building can be accessed by people walking upright.

Fig. 2: Testing of the robot substructure and recording of the camera images with the aid of a manual app control.

Challenges / Risks

The development of a mobile robot of this kind involves a number of challenges that will have to be resolved within the course of the project.

- The scanning system and its image processing software must be capable of dealing with the dusty and dirty conditions.
- If at all possible, the eggs should not be damaged during the grabbing process.
- The overall height of no more than 35 cm is also a challenge.
- The substructure of the robot must be able to cope with the ground conditions.
- The robot must be capable of navigating intelligently through a localisation system.
- Emptying of the collection box should be done automatically.
- Automatic recharging of the power supply must be reliably ensured.
- The electronic and mechanical components chosen should be such that they are subsequently available at favourable cost on the free market for series production.

Conclusion

The project will contribute to optimising the keeping conditions for the animals in a henhouse environment. This applies both economically and in animal welfare terms. The results and knowledge acquired can be expanded as needed. The know-how acquired can also be applied to other stabling systems.

Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen

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Finding the way like an ant – A biomimetic navigation system - from analysis to application

The bionic development process enables us to transfer mechanisms, working principles from nature to technical designs, and develop innovative solutions in doing so. At the Westfälisches Institut für Bionik [Westphalian Institute of Biomimetics], this principle is being put to practical application in tackling the concrete problem of the navigation of walking robots. In cooperation with the University of Duisburg-Essen (Prof. Dr.-Ing. Dieter Schramm, Chair of Mechatronics), research is being conducted in the context of a doctoral thesis into the contribution the desert ant can make in enabling walking robots to find their way home more quickly in future.

The goal of the research is to develop a robust odometer that makes position determination possible in the absence of external cues like GPS or local beacons. This is based on knowledge acquired into the egocentric navigation used by the desert ant *Cataglyphis fortis*, which reliably finds the way home to its nest in even the most difficult circumstances.

Biological inspiration: the desert ant

When searching for food, the desert ant *Cataglyphis fortis* may cover distances that exceed its body length several thousand times over. Nevertheless, even in the burning midday sun and without the presence of any prominent landmarks in the barren landscape by which to navigate, it reliably finds its way back to the nest.

Through highly sophisticated behavioural studies, it is known that the creatures are able to derive compass information from the position of the sun and so determine the direction they are taking. They also register every one of their steps and so know their current position at any time, calculated as a vector based on direction and distance from the nest entrance. Once they have found food, they only need to follow this vector to find their way home.

Technical application: walking robots

A major challenge for autonomous robots is navigation. This is especially true of walking robots, as these are predominantly deployed in rough or inaccessible terrain, where no external infrastructure is available for position finding. This may be the case, for example, in cave exploration, underwater operation or space missions, where no GPS signal can be received and additional infrastructure would be either impossible or too expensive to install.

Transferring the method used by the desert ant to a robot brings benefits in several ways. The ant odometry is not only not dependent on external information, but is also robust against disturbances from outside; it is also quick and dynamic due to the low computational effort required, thus allowing constant live update of the current position.

The development in two dimensions is already highly promising. For real-life application, however, one important step is still lacking. While it is known that the ants take the gradient of the terrain into account, the question of how this mechanism actually works is not fully understood and is now the subject matter of the present research. Answering this question will enable the creation of walking robots with a robust, redundant system of position finding that needs no additional sensors.

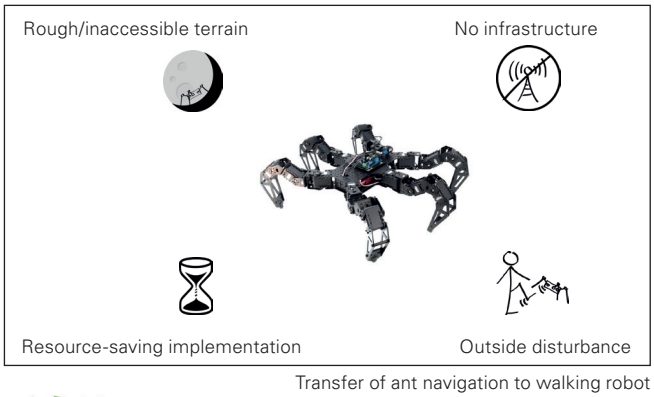

Fig. 1: Technical problem: Walking robot

Transfer of ant navigation to walking robot

Research

The movement of the legs (kinematics) and their shape (morphology) are the subject of investigation at the Westfälische Hochschule.

Using the imaging processes of computer tomography and photogrammetry, the shape of the ant's leg can be determined and used for refining the simulation and the robot technology.

High-resolution images produced by a scanning electron microscope allow the force sensors to be localised. These are mostly located close to the joints, enabling the original hypothesis of the force measurement to be refined. It now needs to be tested whether measurement of the torque in the joints or the corresponding servo motors is sufficient to determine the gradient. The movement sequence is tracked in high-speed video images of the creatures, digitalised, and subsequently transferred to the simulation and the robot.

Testing in application

The abstracted biological principle of how the ant navigation works is being tested in a simulation and on a robot platform. The first step in development was to build a one-legged robot platform. The connecting pieces were printed on a 3D printer at the Westfälische Hochschule. They are connected via three servo motors, which allow movement on a specially constructed rail. A moving belt with tilt adjustment enables measurements to be conducted at different gradients. This enables the influence of factors such as load, leg geometry and motion sequence to be investigated.

The measurements are mirrored for validation in a simulation. This also makes it possible to investigate other configurations, such as a near-natural hexapod arrangement which allows conclusions to be drawn about the ant.

The investigations are complemented by measurements made on a commercially available hexapod platform, enabling field trials of the navigation system as implemented to be conducted.

Current publication //

SCHLÖGL, B., T. SEIDL, T. WÖHRL, T. BRUCKMANN und D. SCHRAMM, 2018. Odometrie bei Laufrobotern nach Vorbild der Entfernungs- und Steigungsmessung von Wüstenameisen Cataglyphis spec. In: *IFToMM, D-A-CH Konferenz*. doi:https://doi.org/10.17185/duepublico/45300

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Karina van den Broek, Achim Zielesny

Mesoscopic simulation of large (bio)molecular systems

The underlying physical laws necessary for ... the whole of chemistry are thus completely known – These were the words with which, in 1929, Nobel prize winner Paul Dirac characterised the new quantum theory, which will also keep the 21st century (not just with digitalisation and Industry 4.0) on its toes. But even for small chemical molecules, the underlying physical laws of motion are far too complicated, with the result that for practical computations, only simplified (in some cases drastically simplified) approximations are used. Mesoscopic approximation methods are used to study the movement of large molecular systems with millions of atoms. They describe the dynamics of the nanoworld, which underlie not only material properties but also medically important biomolecular processes.

Development of a computer-aided application

An integrated rich-client software for (bio)molecular mesoscopic simulation has been developed in recent years as part of a joint project between CAM-D Technologies (Essen, under CEO Dr. Hubert Kuhn), Inorganic Chemistry and the Centre for Nano-Integration at the University of Duisburg-Essen (Prof. Dr. Matthias Epple), and the Westphalian University of Applied Sciences (Westfälische Hochschule). It encompasses several hundred thousand lines of program code and is published as open source on GitHub and in the scientific literature. For scientists working in industry or academia, it provides a graphical user interface (see illustration) that supports all aspects of a simulation study. Thus, the definition of simulation box start geometries is supported by molecule, protein and compartment editors, *state-of-the-art* algorithms for integration of the equations of motion are provided, modern multi-core processors are addressed by parallelized calculations and simulation movies as well as animated diagrams can be easily generated.

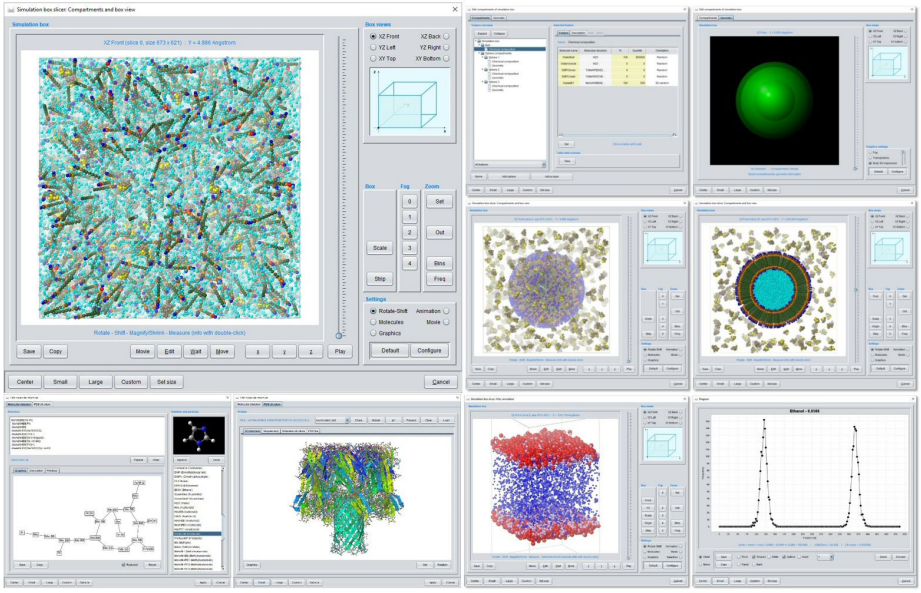

Fig. 1:
Screenshot of the graphical user interface of the new open-source application for mesoscopic (bio)molecular simulation

Components and part-aspects of the extensive development project have already been published in international scientific journals [1-4]. And not least, numerous especially gifted and committed students have successfully produced their bachelor, master or doctoral degree dissertations within the scope of the project – a fact that illustrates the extent to which sophisticated and challenging research and development projects are ideal in supporting scientific teaching and training.

Current Publications on the subject //

[1] VAN DEN BROEK, K., M. DANIEL, M. EPPLE, H. KUHN, J. SCHAUB and A. ZIELESNY, 2018. SPICES: a particle-based molecular structure line notation and support library for mesoscopic simulation. In: *Journal of Cheminformatics*. 10:35. Verfügbar unter: https://doi.org/10.1186/s13321-018-0294-7

[2] VAN DEN BROEK, K., H. KUHN and A. ZIELESNY, 2018. Jdpd: an open Java simulation kernel for molecular fragment dissipative particle dynamics. In: *Journal of Cheminformatics*. 10:25. Verfügbar unter: https://doi.org/10.1186/s13321-018-0278-7

[3] TRUSZKOWSKI, A., K. VAN DEN BROEK, H. KUHN, A. ZIELESNY and M. EPPLE, 2015. Mesoscopic Simulation of Phospholipid Membranes, Peptides, and Proteins with Molecular Fragment Dynamics. In: *Journal of Chemical Information and Modeling*. 55(5), 983-997.

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Project information //

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DECIMER – Artificial intelligence for optical chemical structure recognition

The past few years have seen remarkable progress in the development of "artificial intelligence" systems based on machine learning: For the complex game of GO, the AlphaGo-Zero learning system is able, in only a few hours of training, to develop a level of attainment that far exceeds human capabilities and is able to beat the world's best GO players, while the DeepL learning system is characterised by a hitherto unmatched quality in language translation, e.g. from German to English.

Recognising the structure of chemical compounds

These advances form the basis for an ambitious deep-learning project at Friedrich-Schiller University in Jena and at the Westphalian University of Applied Sciences (Westfälische Hochschule): The DECIMER-(Deep Learning for Chemical Image Recognition) learning system is designed to recognise the structure of chemical compounds that are available as in image in the form of a pixel graphic, i.e. to translate these images into chemical information (atoms, chemical bonds etc.). To do this, the chemical information is depicted as a string of characters – so-called SMILES – which are machine-readable but are also comprehensible to human experts. As the language of the chemical formulas encoded in the images is highly sophisticated, the task of translating "from pixel graphic to SMILES" is also very demanding. To achieve this, the DECIMER learning system is equipped with the latest *state-of-the-art* neuronal network components, such as the Inception-V3 model for the primary image processing and an only recently developed Show-Attend-Tell auto-encoder network for the subsequent image recognition/translation (Fig. 1). The DECIMER system, using large data quantities, is only expected to attain its full performance capability with Cloud-implementation, as the required big data computing capacity cannot be achieved with scientific workstations alone [1].

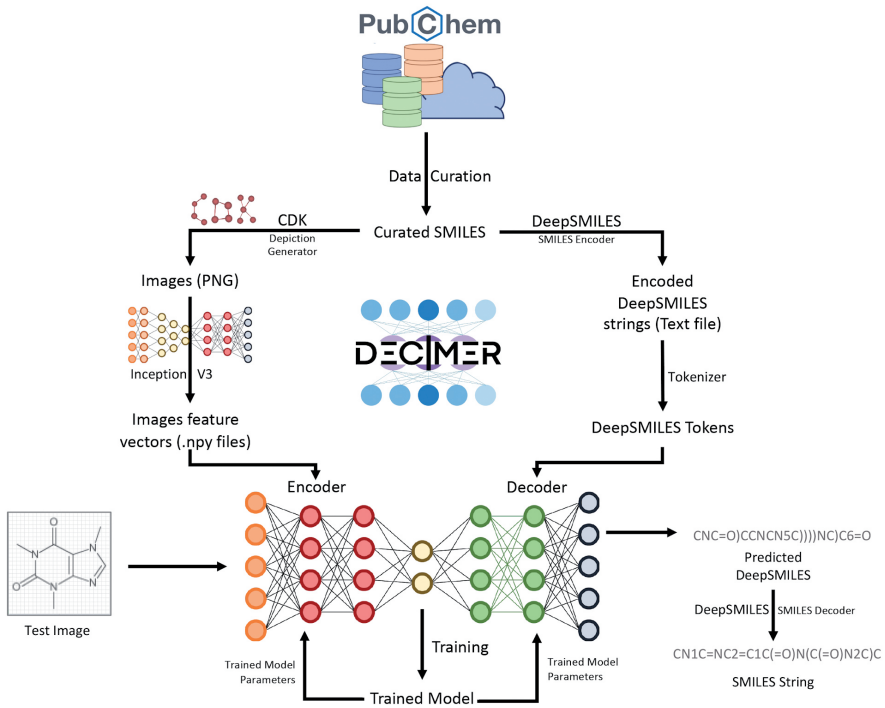

Fig. 1: Architecture of the DECIMER learning system

Outlook

In practical terms, the project partners aim to use their system in future for recognition of the chemical structures of natural products, which in many scientific literature sources are only available as images [2]. Natural products and their chemical derivatives play an important role in the development of active pharmaceutical substances – most of today's drugs being based on them. Moreover, this provides excellent support for the academic education at both universities as it gives highly gifted and committed students the opportunity to produce their BA and MA dissertations in one of the most modern fields of scientific work [3].

Current publications //

[1] RAJAN, Kohulan, Achim ZIELESNY, Christoph STEINBECK, 2020. DECIMER - Towards Deep Learning for Chemical Image Recognition. In: *Journal of Cheminformatics*. 12:65

[2] RAJAN, Kohulan, Henning Otto BRINKHAUS, Achim ZIELESNY, Christoph STEINBECK, 2020. A review of optical chemical structure recognition tools. In: *Journal of Cheminformatics*. 12:60.

[3] RAJAN, Kohulan, Jan-Mathis HEIN, Christoph STEINBECK, Achim ZIELESNY, 2020. Molecule Set Comparator (MSC) – A CDK-based open rich-client tool for molecule set similarity evaluations. In: *Journal of Cheminformatics*. 13:5.

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The research project „Find it – Use it“

For use in Germany's raw material supply and for recycling purposes in general, flows of separated and sorted waste are essential. This is largely dependent on a functioning interface between the collection system and the citizens. Separation is frequently not done with sufficient care, resulting in problems with the further handling and treatment of the waste. An EFRE.NRW research project entitled “Find it – Use it” aims at sustainably improving the separation quality and the collection quantities of the public collection systems and thus creating an important basis for the recycling of secondary raw materials.

The Zentrum für Recyclingtechnik (Recycling Technology Centre) of the Westfälische Hochschule is conducting the research project in close and strategic cooperation with Bottroper Entsorgung und Stadtreinigung AöR [Town of Bottrop Waste Management and Cleaning Department] from 2016 to 2019 in the municipality of Bottrop. The project is in receipt of funding from the European Regional Development Fund (EFRE.NRW) to the tune of approx. 550,000 euros. With the aid of citizen surveys and waste analyses, the aim is to further develop the collection systems and also the digital possibilities for integration of the residents in the recycling process.

Pilot phase

In the course of a three-month pilot phase lasting from April to June 2018 and involving 600 households with some 952 residents located in three trial areas represent three types of residential settlement structure, namely “Urban”, “Suburban” and “Rural”, a sack-in-container waste collection system (see Fig. 3) was tested in real-life operation, with waste collection tailored to demand. During the pilot trial, the normal municipal waste collection schedule was suspended in the test areas and replaced by a dynamic collection system.

This involved the bin collection service being ordered by the residents as and when required, via WhatsApp, app (see Fig. 4), email and telephone. In other words, an existing communication structure was used, which also served as a return-flow route for the dissemination of news and information to the customers. The orders submitted by WhatsApp, email and app were automatically evaluated by a developed software system and, along with telephone messages on an answering machine, compiled into a collection list. The collection list was transmitted to the waste collection company, which then generated a route for emptying the bins on the basis of the list.

Evaluation of the pilot test (extract)

Evaluation of the project, in particular the pilot test and the survey of the residents that was conducted on completion, is still ongoing.

The initial results of the comparison between the static and dynamic bin collections indicate the potential for major savings for the waste collection firm.

Analysis of the domestic waste during the pilot phase in June 2018 shows an increase in the level of bin filling and a reduction in the volume of binning errors. Additionally, with the aid of a food leftovers sack made of biologically degradable material, additional food remains with a high level of product separation were generated.

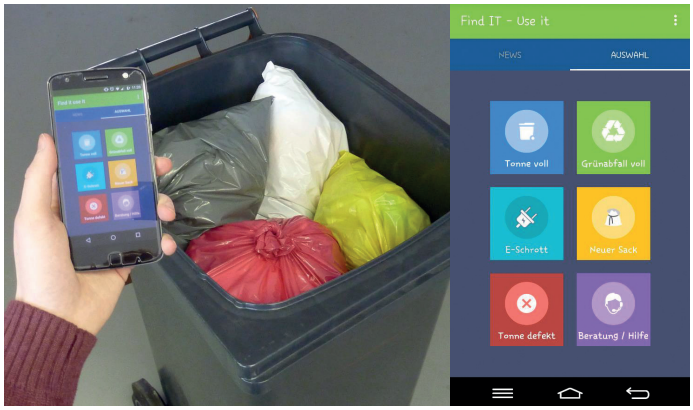

Fig. 1: The innovative collection system required that all the different categories of waste (residual waste, lightweight packaging, paper/cardboard, food waste, small electric goods and textiles) should be collected separately in different-coloured sacks in a single bin. Using digital channels, the residents could place an order for the bin to be emptied when needed. If requested in sufficiently good time via the app “Find IT – Use it”, the waste could already be collected on the next working day.

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Even before the pilot trials, activities specifically aimed at digitalisation were already rated as innovative and practicable. Consequently, with circular infinity GmbH as a spin-off company created by the Westfälische Hochschule, the know-how can be developed further and marketed beyond the term of the project.

Current publications in specialist journals //

ALTHOFF, T, S. SADOWSKI und R. HOLZHAUER. Integration von Umfeldfaktoren bei der Festlegung von Versuchsgebieten in der Siedlungsabfallwirtschaft. In: *Müll und Abfall: Fachzeitschrift für Abfall- und Ressourcenwirtschaft* 49 (2017) 10, S. 489-540.

ALTHOFF, T., R. HOLZHAUER, U. WOLTERS und C. SUSSMANN. Identifikation von Potenzialen der stofflichen Verwertung am Beispiel der Stadt Bottrop. In: *Müll und Abfall: Fachzeitschrift für Abfall- und Ressourcenwirtschaft* 50 (2018) 02, S. 53-100.

ALTHOFF, T., S. SADOWSKI, R. HOLZHAUER und K. KORTMANN. Perspektiven der vertiefenden Bürgerintegration in Abfallwirtschaftsprozesse. In: *Müll und Abfall. Fachzeitschrift für Abfall- und Ressourcenwirtschaft* 50 (2018) 03, S. 101-156.

Current publications in the “Tagungsband” //

ALTHOFF, T. und R. HOLZHAUER. Bürgerintegration in den Sammel- und Verwertungsprozess. In: BOCKREIS, A., M. FAULSTICH, S. FLAMME, M. KRANERT, M. MOCKER, M. NELLES, P. QUICKER, G. RETTENBERGER und V. S. ROTTER, Hrsg. *8. Wissenschaftskongress Abfall- und Ressourcenwirtschaft*. Am 15. und 16. März 2017 an der Universität für Bodenkultur (BOKU) Wien: Tagungsband. Innsbruck 2018.

ALTHOFF, T. und R. HOLZHAUER. Digitale Bürgerintegration in die Sammel- und Verwertungsprozesse der Abfallwirtschaft. In: POMBERGER, R., J. ADAM, A. ALDRIAN, A. CURTIS, K. FRIEDRICH, L. KRANZINGER, B. KÜPPERS, K. E. LORBER, S. MÖLLNITZ, S. NEUHOLD, T. NIGL, K. PFANDL, B. RUTRECHT, R. SARC, T. SATTLER, T. SCHWARZ, P. SEDLAZECK, S. VICZEK, D. VOLLPRECHT, T. WEISSENBACH und M. WELLACHER, Hrsg. *Recy & DepoTech 2018. Vorträge-Konferenzband.* Leoben 2018.

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Project HeizKreis Recovery and re-use of rare earth magnets – Closure of cycle in the case of heating pumps

Rare earths – raw materials of special value

Rare earths (REs) are among the most sought-after raw materials in the world and are predominantly mined in China. This therefore means a dependency on China, which reached its peak in 2011 with a ban on exports and a dramatic increase in prices, and clearly demonstrated China's dominance [1]. The production and treatment are associated with adverse working conditions and environmentally harmful processes. Aside from the risk to the groundwater, there is a constant danger of the emission of radioactivity, as many rare earths contain radioactive substances.

Today's technologies re dependent on the use of REs, e.g. in wind farms, smartphones or heating pumps [2]. 19% of REs go into the production of magnets. These are installed in the rotors of high-efficiency pumps in the form of neodymium-iron-boron magnets (known as NdFeB magnets) and give the rotors their name [3]. At the present time, there are, however, no industrial process routes for recovery of the RE magnets. They land together with the steel scrap in the steel recycling process and are then lost forever [4].

The "HeizKreis" project

The "HeizKreis" (Heating Cycle) project is a project funded by the Deutsche Bundesstiftung Umwelt [German Federal Environmental Foundation] for the design and testing of a circular value creation chain between producers, wholesalers, the craft trades and recycling firms. The project aims at creating an industry-wide solution that allows resources to be saved by closing the cycle from recovery to re-use of the NdFeB magnets and other pump components.

For the project to be successful, it is essential for each link in the sales chain to have a presence on the project team. Therefore, alongside the Westfälische Hochschule as scientific adviser and project coordinator and WILO SE as a pump manufacturer, the project members also include TSR Recycling GmbH as a recycling enterprise, Kurt Pietsch GmbH & Co. KG as a wholesaler, and Th. H. Heidemann GmbH & Co. KG und Vollmer GmbH & Co. KG as two firms operating in the SHK [sanitary installation, heating & air-conditioning] sector. Agentur Winter, a marketing firm that specialises in communication and motivation strategies and operates particularly in the SHK sector, is also a member.

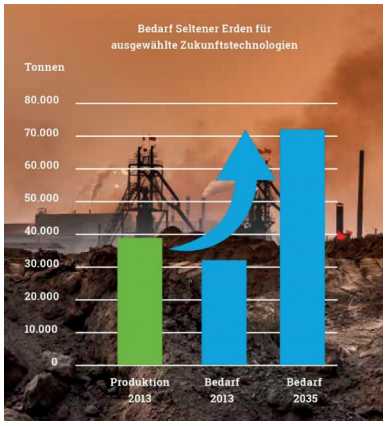

Fig. 1: Demand for rare earths for use in advanced technologies

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Pilot phase

Since September 2018, the recovery channels are being tested in a large-scale pilot phase. Altogether 179 firms have agreed to take part in the pilot phase, after being fully informed of the project and the project idea by the sales teams of Wilo, TSR and Pietsch. The participants include both small and large firms operating in the SHK sector, along with industrial companies and metal wholesalers. Up to the beginning of March this year, the pilot participants are collecting used pumps and returning them via the offered recycling channels (see Fig. 3). This will be followed by a statistical evaluation of the pilot phase with a view to elaborating a Germany-wide industry model.

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Public events/Presentation of the project //

- Graduierteninstitut NRW, Fachgruppe Ressourcen, Thema „Wasser", Gelsenkirchen, 06.12.2017
- ERFA Kreis, Hamburg, 14.04.2018
- Nachhaltig.digital, Bonn, 15.05.2018
- Landtag NRW, Forschung 21, Düsseldorf, 05.06.2018
- Interview mit SHK-TV, 08.08.2018. Ausgabe SHK-TV Nachrichten vom 15.08.2018
- Interview mit SHK TV, 31.08.2018. Ausgabe SHK-TV Reportage vom 04.09.2018
- Fraunhofer IML, Zukunftskongress Logistik 2018, Dortmund, 11.09.2018 – 12.09.2018
- Graduierteninstitut NRW, Fachgruppe Ressourcen, Thema „Kunststoffe und Nachhaltigkeit", Leverkusen, 06.11.2018

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Zehra Ese, Waldemar Zylka

A contribution to the planning of radiation therapy for patients with passive and active Implants

The number of patients with implantable medicinal products who receive radiation therapy due to illness involving a malignant tumour is growing constantly [1,2]. The interactions between ionising radiation and active implantable medical devices (AIMD) have hitherto been only inadequately researched. Malfunctioning of AIMDs during and after treatment with ionising radiation can be observed. Malfunctions can have a massive negative effect on the safety of the patients. It has not yet been possible to define radiation dose and radiation energy limits for AIMDs. Many institutions follow the guidelines of Work Group No. 34 of the American Association of Physicists (AAPM), which were published in 1994. This 25-year-old report only takes account of cardiac pacemakers using outdated technology. Moreover, radiation therapy units and techniques have changed over the years. The following basic recommendations have already been pronounced by the AAPM report: (i) Avoid the position of the pacemaker in the direct beam, and (ii) limit the total dose for cardiac pacemakers to 2 Gy. Case reports show, however, that malfunctions can occur even below this threshold [2]. However, it remains difficult to measure the dose received by an AIMD during radiation. This is because, for one thing, in-vivo measurement during radiation exposure is not possible, and for another because AIMDs are mostly located outside the radiation field and so are exposed to the scatter radiation. Despite this, clinics tend to work to their own experience or to follow the outdated AAPM report.

Dosimetry problems

It is known in modern radiation therapy planning software (TPS) that the precision of dose calculation decreases with increasing distance from the field edge. The peripheral doses depend on the radiation energy, the size of the field and the distance from the field edge, and are generally estimated on the basis of earlier publications. The dose calculation and beam modelling of the TPS are based on tissue-specific x-ray absorption values, which are obtained from computer tomography (CT) and measured in Hounsfield units (HU).

Most CT scanners use a limited, so-called "Conventional" HU scale (CHU). This allows depiction of the different body tissues but has limitations when it comes to displaying materials with higher atomic density. Thus implant materials, in particular the metals, can cause saturation at the CHU maximum. Additionally, high-density materials generate CT image artefacts that can overlay the anatomical structures and even the geometry of the object itself. In order to achieve more precise dose calculation for the radiation therapy planning, the HU values of implant materials should be established as precisely as possible in the CT. For active implants, it is necessary to determine at what radiation energy level and dose the likelihood of malfunction is increased.

The Extended Hounsfield Unit Scale (EHU)

In computer tomography, the Hounsfield Unit scale is used to describe the absorption of x-ray radiation in tissue and present it as a greyscale image. The HU value of a certain material with x-ray absorption level μ is based on water and is calculated as follows:

$$HU(\mu) = \left[\frac{\mu}{\mu_{H_2O}} - 1\right] 1000\ \mathrm{HU}$$

This definition initially contains no upper and/or lower limit for the HU scale. In clinical practice, a range from [- 1 024 HU; + 3 071 HU] with 12-bit data acquisition (4 096 values with a resolution of 1 HU) has become established. However, materials with higher atomic mass cause even stronger absorption, all the way to total absorption. An extended HU scale has been analysed with the aim of achieving a possible improvement in the depiction of metals [3, 4]. The EHU scale of Siemens CTs, which are used in this study, ranges from [+ 10 240 HU; + 30 710 HU] and also uses 12 bits. To achieve this 12-bit HU range, a resolution of 10 HU has been implemented on these devices.

Table1: Materials used in this study, with their physical density values and relative electron densities
The HU values, quantified on the CHU and EHU scales, and their difference (in %) are shown.

Material x	$\rho(x)$ $[\frac{g}{cm^3}]$	$\rho_e(x)$ $(\rho_e(H_2O) = 3.343\ \frac{1}{cm^3})$	CHU [HU]	EHU [HU]	ΔHU [%]
Aluminium (Al)	2.70	2.34	2132 ±83	2039 ±313	4.36
Titan (Ti)	4.50	3.73	3070 ±0.65	6100 ±503	98.70
Chrom (Cr)	7.14	5.94	3070 ±0.77	7260 ±737	136.48
Kupfer (Cu)	8.92	7.33	3071 ±0.32	8584 ±814	179.52

Calibration of the EHU scale

The metal samples shown in Table 1 (diameter ø = 20 mm, thickness D = 5 mm, purity P ≥ 99.5 %) were used in this study. CT scans of the samples were conducted using a standard CT protocol. The images were reconstructed using the CHU scale and EHU scale respectively (see Table 1). For HU quantification of the metals, a rectangular region of interest (ROI) with dimensions 11 px x 3 px on the central layer of the sample was chosen. Quantification of the HU values was done with Varian Eclipse™ software and a MATLAB algorithm developed in-house. To analyse the influence of the tube voltage on extended HU values, the tube energy was varied in 20 kV steps from 80 kV to 140 kV. A CT calibration curve was computed by adjusting a linear regression through the HU profiles determined at various kV energies.

Conclusion

The EHU series reproduces HU values of highly dense materials better and is therefore suited for the computation of dosages in radiation therapy. However, the quantified HU value depends strongly on the chosen size and position of the ROI. The HU values also show a dependence on voltage: the higher the tube voltage, the lower the HU value for the specific material. The calculated HU values could be used with limitations for the metal in order to extend the CT calibration curves used in TPS and enable more precise dose calculation for patients with metallic implants. Further investigations with in-vitro measurements and Monte Carlo analyses are currently being carried out with the aim of enabling precise in-vivo dose monitoring of implants.

The publications and illustrations to the text can be found on page 42 of the 2018 Research Report https://www.w-hs.de/forschungsbericht/.

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Development of radio frequency coils for 7 tesla magnetic resonance imaging

Magnetic resonance imaging (MRI) is the most effective diagnostic imaging technique available in terms of spatial resolution and soft tissue contrast, and uses energy in the radio frequency (RF) range. This allows the application of this technology for diagnostic purposes and for monitoring the development of illnesses and the effects of treatment. Continuous technical improvements and the development of MRI scanners call for the use of powerful magnetic fields. At the present time, 1.5 tesla and 3 tesla high field magnets are in operation in the clinical environment. Ultra-high field magnets, such as 7 teslas, are at the present time still restricted to research applications.

The emission and reception of the RF signal is performed through radio frequency coils. When the magnetic field increases, the RF frequency also increases proportionately. During an MRI procedure, the patient's body absorbs most of the HF energy transmitted for the imaging. This absorption results in warming of the tissue [1] and constitutes a potential hazard, right up to tissue damage or even burns. Research is working on understanding and predicting how, when and where the warming generated in the body through RF irradiation can occur [2,3].

Design and simulation of MRI coils

Forecasting the distribution of the electromagnetic fields is based on the correct modelling and computation of MRI systems, including the radio frequency coils and the models of the sample used, e.g. models of the human body, using numerical computations and simulations with advanced software tools. We have analysed a multichannel coil of a 7 tesla MRI [2]. The 29 cm x 10 cm transmission dipole coil was described in [3, 4] and is depicted in Fig. 1.

Magnetic field distribution

The magnetic field distribution was simulated for the scenario of a charged coil in combination with a virtual sample (phantom). The phantom is a cylindrical agarose-gel-based sample with a height of 13.3 cm and a diameter of 7 cm.

Experimental investigations were conducted to validate the simulations. The experiments were performed on the 7 T MRI scanner at the Universidade São Paulo (USP São Paulo, Brazil). The magnetic field distribution was determined with the Siemens pulse sequence SA2RAGE (TR = 2400 ms and TE = 0.9 ms) [5,6].

Comparisons between the calculated and experimentally transmitted magnetic fields were carried out for two lines in the central coronal plane along the x and y axis, with the phantom centre as the common point. Comparison shows the magnetic field distribution to be similar in extent in each case, but to be slightly different in amplitude.

Safety analyses

The dosimetric term used for description of the absorption of RF radiation is the SAR value (Specific Absorption Rate). Clinical MRI scanners work within the legal guidelines for the maximum permitted SAR volume so as to avoid harmful effects on health. Moreover, the SAR distribution in the body is not homogenous, and with high fields, SAR hot-spots can occur that may possibly also cause a rise in temperature at some points in the tissue.

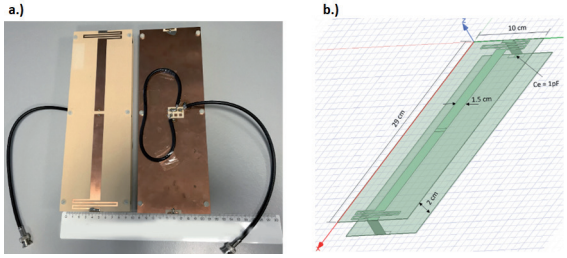

Fig. 1: a.) The dipole coil element (top and bottom view). b.) The simulated dipole coil element that was computed in the software.

Phantom safety was evaluated through calculation of the local SAR values. The SAR computations were performed on the basis of the size of the electrical field and post-processing of the simulation results.

Conclusion

Radio frequency coils and their RF field distribution can be modelled and computed. Through numerical simulation, it is possible to find the optimum design for a coil. This can save a lot of time and cost in the production process. To obtain the optimum design for a coil, it is essential to analyse the homogeneity of the coil and the SAR distribution in a phantom or body model. The numerical and experimental investigations in our research contributions show a dipole coil to be suited as an element in a multichannel coil for 7 T MRI. The results indicate that with the proposed dipole coil, satisfactory imaging studies can be performed. With use of the coil, the safety of a body is assured with a high degree of probability. The SAR distribution shows that no hot spots occurred and that the SAR values are within the legal limit. A high degree of concordance between simulation and measurement was found. However, an improvement in the validation process is planned, especially in terms of the use of more realistic phantoms.

The publications and sources for the text, along with further illustrations, can be found on page 64 of the Forschungsbericht 2020 at https://www.w-hs.de/forschungsbericht/.

Project Information //

Maíra Martins Garcia, M.Sc. is in receipt of a scholarship from the Brazilian government organisation "Coordination for the Improvement of Higher Education Personnel (CAPES)" under the "Full PhD Programme Abroad (Programa de Doutorado Pleno no Exterior) – Process n. 88881.173609/2018-01".

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Britta König, Waldemar Zylka

Is iterative reconstruction with low-dose computer tomography suitable for the screening and detection of lung tumours?

For the year 2020, the German Centre for Cancer Register Data (Zentrum für Krebsregisterdaten) forecast the incidence of lung cancer in Germany at 36,460 males and 25,920 females [1]. The Federal Agency for Radiation Safety (Das Bundesamt für Strahlenschutz) undertakes continuous scientific assessment of screening examinations using low-dose computer tomography (LDCT) [2]. The risks and benefits of LDCT screening are weighed against one another. For the risk group of heavy smokers, the Institute for Quality and Economics in Health (Institut für Qualität und Wirtschaft im Gesundheitswesen) found LDCT screening to be predominantly beneficial [3]. The Belgian-Dutch NELSON Study identified a reduction in lung cancer mortality with LDCT in high-risk patients over a period of 10 years of 26% for men and of up to 61% for women [4].

Quo vadis?

Model-based iterative reconstruction algorithms (MIR) and LDCT offer a strategy for dose reduction. Compared to conventional filtered back projections (FBP), MIR algorithms can reduce the patient dose by up to 60% without any loss of image quality [6]. With MIR, however, radiologists report a change in the image impression which can affect the reliability of lung tumour detection [5]. Earlier findings also [5-7] indicate a need for validation of the MIR strengths in terms of their fitness for lung tumour detection on the basis of subjective evaluation by radiologists, and their intra- and inter-protocol comparison.

Material and methods

ADMIRE (Advanced Modelled Iterative Reconstruction Algorithm, Siemens Healthineers GmbH, Erlangen) is a specific algorithm that implements a reduction in artefacts and noise in an extended CT scanner model implemented in forward projection. Using the Poisson noise of the x-ray quanta, a noise-optimising iteration updates the reconstruction in the image space, whereby the MIR strength of the noise correction can be selected on the CT console, with the recommended strength being S3.

For simulation of an adult thorax, a QRM thorax phantom (QRM GmbH, Möhrendorf, Germany) with extensions rings, into which artificial lung nodules were inserted, was used [7]. Thorax diameters could be simulated by adding further soft tissue and fat rings.

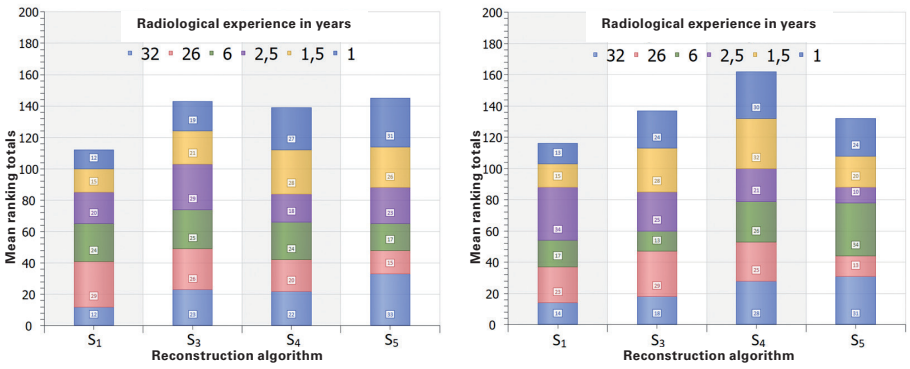

Fig.1: Overview of the overall and individual assessments of the radiologists from the ranking test with test image sample 1 (left) and test image sample 2 (right). The subjectively rated fitness of the CT images in relation to lung nodule detection is represented through the mean ranking totals of all ranking tests for each test person. The results are depicted via the reconstruction algorithms S1, S3, S4 and S5. The radiological experience in years uses the following colour coding: 1 year (Dark blue), 1.5 years (Yellow), 2.5 years (Purple), 6 years (Green), 26 years (Red) and 32 years (Light blue)

Volume scans were acquired with a Somatom Force-CT (Siemens Healthineers GmbH, Erlangen), with different dose protocols being selected. The MIR was performed at IR strength levels S1, S3, S4 and S5 and with cores BI57 (standard for lungs), Br32 (soft) and Br69 (hard). Radiologists with varying levels of professional experience classified the CT images in a statistical 4-field ranking test in terms of their fitness for lung nodule detection. A Friedman test to identify chance rankings and an intra- and inter-protocol comparison with an enhanced kappa coefficient was performed.

Results

Radiologists found subjectively that medium and high IR strengths are fit for the detection of lung nodules. The mean values of the ranking totals are shown in Fig. 1. In the first image sample, there were 11 out of 18 chance rankings, but only one in the second. The inter-protocol reliability of the radiologists produced a level of concurrence for the first sample which was "bad", and for the second sample of "weak".

Conclusion

Medium to high strength levels of the MIR algorithm ADMIRE are better suited for lung tumour detection, with a clear preference for S4. The uncorrelated concurrence of the findings of the radiologists was presumably due to the professional assessment practice of the radiologists, which raises dichotomous or multi-stage categorical questions. The correlation between radiological experience and subjective perception of the MIR-reconstructed CT images is, while detectable, not statistically significant.

The publications and sources for the text can be found on page 66 of the Forschungsbericht 2020 at https://www.w-hs.de/forschungsbericht/.

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Micro-macro characterization and modeling of fatigue properties of hybrid welded joint of AlSi10Mg parts produced by selective laser melting and casting

Innovative lightweight design requires coordination of optimized component design, adapted manufacturing processes and appropriate material selection. Selective laser melting (SLM), as a metal additive manufacturing process, provides the advantage of virtually tool-free manufacturing almost without any limitations regarding structural complexity. However, a major restriction for the widespread application of SLM as an industrial manufacturing procedure is the limited size of the products. Therefore, there is a clear need to study the weldability of additively manufactured components to themselves or to conventionally manufactured components in assemblies. Particularly, friction stir welding (FSW), as a solid-state welding process, has been well employed in order to avoid common weld solidification related problems. However, there is still lack of a quantitative description of the influence of inhomogeneous microstructure associated with porosity on the variability of fatigue response of friction stir welded joint of additive manufactured parts, which makes it difficult to specify the safety factor for cyclic loading conditions being important for many industrial applications. Additionally, the development and optimization of SLM welded joints largely depends on simulation nowadays, where the microstructural heterogeneity of local areas of the welded parts joint must be taken into account.

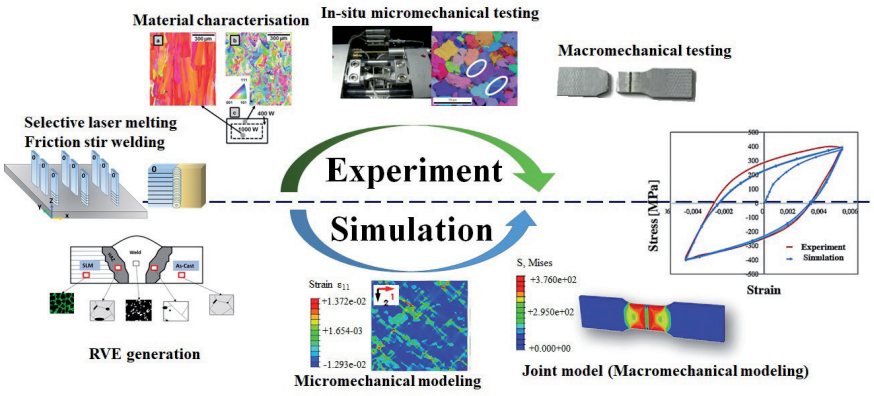

Fig. 1: Schematic presentation of the procedure in the project

Objectives

The main goal of the proposed research project is to develop a microstructure- and defect-sensitive computational scheme to predict the fatigue behavior of friction stir welded joint partners produced by SLM and casting process, taking into account the microstructural features of all regions in the welded joint, i.e. microstructure, chemical composition, phase fraction and imperfections (i.e. porosity and inclusions). Lightweight aluminum alloy AlSi10Mg samples processed by SLM and casting processes will be considered. Solid-state friction stir welding will be used to produce the sound welds of hybrid components.

Outlook

The comprehensive mechanical and microstructural characterizations will be performed on the SLM and as-casted AlSi10Mg components as well as their friction stir welded joints. The material characterization provides the necessary input for the development of microstructure- and defect-sensitive fatigue simulation of the hybrid welded joint.

The microstructure- and defect-sensitive fatigue simulation will be performed based on the real microstructure of local areas of welded joint. Additionally, the effect of porosity and defect distribution, respectively, on the mechanical properties, especially fatigue behavior, of SLM parts and hybrid welded joint will be investigated and validated with the experiments.

DFG Deutsche Forschungsgemeinschaft

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Tobias Urban, Norbert Pohlmann

Modern methods for the detection of website manipulation by malware

Through the constant growth in provision of Cloud-based services, Web browsers are offering ever greater access to information, enabling a wide range of social interaction capabilities, and offering the possibility to store private data on remote servers. However, this broad range of browser functionalities also brings new security risks for the users. Examples of such hazards are the theft of user data (e.g. credit card information), the generation of utilisation profiles of users, or attempts to infect users' terminal devices with malware, with the aim of taking them over and controlling them remotely for the hacker's own purposes. A further danger, which has increased dramatically in the last few years, is the unauthorised manipulation of websites by attackers ("Web injects"). Such manipulations range, for example, from the manipulation of online banking websites to – more recently – the insertion of advertising on all and any website. Malware is also used to gather extensive private information on the victims in order to generate precise profiles of them. Such profiles are used, for example, for the infiltration of personalised advertising.

Manipulation of websites

The manipulation of websites, in particular infiltration with advertising, has increased sharply in recent months. Among the 20 most frequently discovered malicious objects discovered by the IT security firm of Kaspersky Lab, there was an explosive increase in adware products. Consequently, the dissemination of adware1 grew from only 4.91% in the first quarter of 2014 to 34.07% in the third quarter of 2015.

The greatest danger from the manipulation of websites by malware is that it takes place on the user's terminal device (e.g. laptop, smartphone or tablet) and the user is not able to recognise whether all the content really does stem from a trustworthy webserver or has possibly been tampered with by software on the user's device. Even a TLS-secured connection ("HTTPS") does not protect the user from this form of manipulation. What the end-user sees, therefore, is the manipulated website, even though he/she is using an adequately secured end-to-end connection with the server. This is possible because the content was only inserted or altered by the malware after being decoded on the user's terminal device.

Attack vectors

Man-in-the-browser is the term used for an attack vector that constitutes a special case of a man-in-the-middle attack. In the case of this particular vector, the attacker takes over control of the victim's Web browser, as well as of display of the website and also of the data being exchanged between the client and server.

Malware using this form of attack additionally means a not insignificant risk to the privacy of the end-users. Adware is, for example, the more successful the greater the number of users who click on the infiltrated advertising. Conventional adware therefore strives to understand the individual victim as well as possible. To this end, private data on the user (e.g. search terms for websites, websites visited by the user, or the user's origins) is gathered and used for advertising purposes. It can be assumed that such information is sold on, illegally, by the operators of the adware, which in turn means a severe violation of the user's privacy.

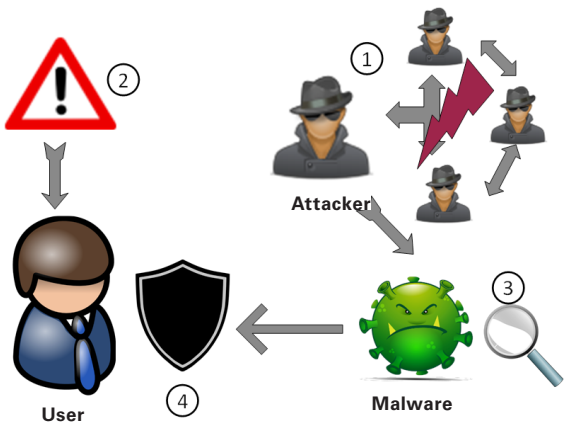

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Fig.1: The intended goals of the methods developed and the research conducted within the scope of the project.
① symbolises disruption to the attacker's economic model.
② indicates a rise in the users' awareness.
Analyse of the malware is indicated by ③.
The protection of the users becomes apparent in ④.

Goal of the research project

Within this research work, the aim is to create a holistic approach for protecting the users from such manipulation. This includes analysing the business model of the developers and operators of the malware, in particular adware, uncovering the networks used for distributing the advertising, and putting measures in place for recognising and putting a stop to website manipulation. The current technical approaches for protecting against unauthorised changes to websites are either not adequate or not practicable. Additionally, despite the urgency of this problem, it has not yet been dealt with adequately within the scientific and research sphere. Nonetheless, a good understanding of the internal structures of the "advertising networks" that have been built up by the adware operators is essential – if only to be able to combat them.

The research project intentionally works on different but supplementary approaches:

- It involves the research of concepts that are designed to enable **user-side protection** against the unlawful manipulation of websites, such as the anonymised analysis of websites that have just been viewed with a distributed reputation system.
- It aims to identify approaches for **disruption of the adware economic model**. The goal of a sustained approach of this kind would be to raise the input required by the attacker to such an extent that their financial benefit would be significantly reduced.
- **Informing the public** is essential. The user is at the heart of all security considerations. It is of key importance to inform the public of the dangers of website manipulation (e.g. in the context of online banking).

Through a combination of these approaches, the harm caused to the public through malware (e.g. adware) can be sharply reduced.

Adware – The word "adware" is made up from the words "advertising" and "malware".

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The influence of the General Data Protection Regulation on online advertising

Today, browsers process ever more personal and sensitive data. Of the web applications used, many in their turn use online advertising as a primary source of revenue. Modern online advertising commonly utilises individual user-profiles in order to expose the users to targeted advertising. To generate these profiles, advertisers seek to track the online activities of the users so as to find out about their tastes and habits. This kind of tracking is seen by many as an invasion of the users' privacy, since it often takes place with neither their knowledge nor their consent. The result is a large power imbalance between the service providers (responsible parties) and the users (affected persons), which has increased significantly in the last few years. In order to resolve these problems and protect the privacy of European internet users, the General Data Protection Regulation (GDPR) has introduced significant changes as to when and in what way personal data may be processed. After a transition phase of two years, the GDPR came into force on 25 May 2018. All firms that offer services to European citizens must comply with the provisions of the GDPR.

The research studies focus on the impact of the GDPR, thereby following a technical and application-oriented approach. They analyse the challenges faced by firms striving to develop services that are in conformity with the GDPR. Additionally, they evaluate changes which the new law is having on the economic system of online advertising. They also examine how users can avail themselves of the right to portability of their data and whether they perceive the data they receive in consequence as useful.

Technical influence

As part of the technical analysis, two large-scale measurement studies were carried out. The first study is concerned with the dependencies of third parties in modern web applications and examines whether these are involved deterministically. The results show that the involvement of a third party may lead to the successive involvement of many further parties. The measurements also show that it is not always possible to decide deterministically what third parties should be involved and that 93% of all websites analysed involve a third party at least once who may be in conflict with valid law. A further important result of the study is that the results of work done earlier, which only analysed the start page of a website, may only be seen as the lower limit as sub-pages are more likely to use techniques that intrude into the privacy of the users. The measurements have shown, for example, that around 36% more cookies are found when websites are analysed more deeply. In the second measurement study, the exchange of information between advertisers ("cookie syncing") is analysed in detail. The measurements show that after the GDPR came into force, the exchange of information between the firms fell by around 40% (see Fig. 1). However, the sharing of data then increased again somewhat over time. The measurements have not shown any decrease in the tracking of users or in the general structure of how firms connect to one another. The changes in the economic system have resulted in a more central infrastructure, and this could itself impact negatively on the privacy of the users.

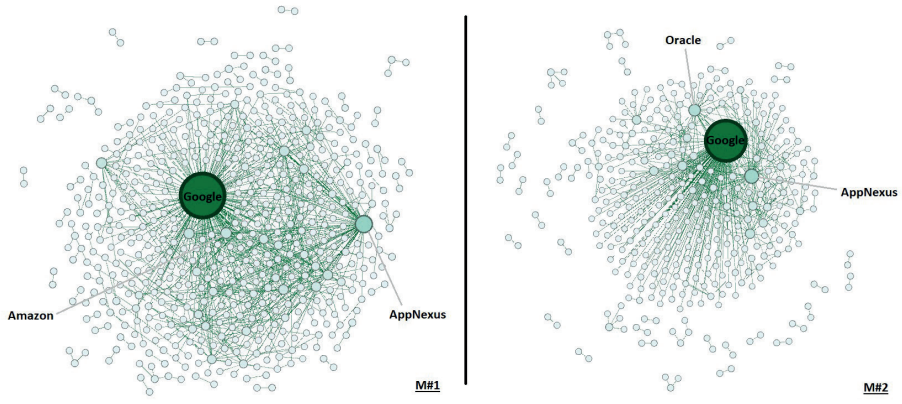

Fig. 1: Changes in the relations between the advertising firms prior to entry into force of the EU GDPR (left – M#1) and thereafter (right – M#2). The nodes represent the advertising firms and the edges the connections between them. The bigger and greener an edge or a node, the more important it is for the network. It can be seen that after introduction of the EU GDPR, the network has in itself been shrinking (there are fewer nodes and edges).

Human aspects

The user-oriented study is made up of two complementary studies. The first study examines the extent to which users make use of their right of data portability under the GDPR. To this end, the right was exercised in relation to various firms operating in the field of online advertising, and the process was analysed in terms of the outcome, the input required, and the time taken. The data obtained from this process were then used in the second study, the aim of which was to evaluate three common variants of the data received by means of an online survey with 490 participants. The resulting view was complemented by the opinions of experts obtained in the form of online questionnaires (n = 24) and interviews (n = 8), the aim being to understand design decisions and challenges in the development of tools for improving transparency. Within the studies, sharp differences were observed in how firms respond to queries from users. Only 21 of the 38 firms contacted (55%) provided information within the period stipulated by the GDPR and only 13 (34%) granted access to the data collected. The shared data contain a range of information, from technical raw data all the way to the deduced interests of the users. The results also show that users do not yet know how they can use this data; they also question the completeness of the data. Moreover, the new requirements are causing major problems for an industry that is dependent on the collection and sharing of data.

The publications belonging to the text along with further illustrations can be found on page 66 of the Forschungsbericht 2020 at https://www.w-hs.de/forschungsbericht/.

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„AdeLeBK.nrw“ Adaptive e-learning offerings in the vocational technical sub-disciplines for the training of teachers at vocational colleges

In M.A. study programmes for teachers at vocational colleges, there is often a lack of tailor-made subject content available at universities that can be integrated into the teacher training content. This applies, among others, to the engineering science subjects. The conception of individual classroom teaching is not always feasible due to the small number of students involved.

As an approach to tackling this problem, the *AdeLeBK.nrw* project was created in May 2019 as part of the state-wide “Digitaloffensive/Digitale Hochschule” (Digital Offensive/ Digital University) by the Ministry of Culture and Science of the State of North Rhine-Westphalia.

The goal of the joint project, involving the Westfälische Hochschule, the Bergische Universität Wuppertal and the Universität Paderborn, is to design e-learning modules for the vocational fields of mechanical engineering technology (manufacturing technology, supply technology and automotive technology) and electrical engineering (automation technology and information technology). On conclusion of the project in 2023, the modules will be available as flexible concept units to all universities in NRW.

Project participation of the WH and approach

The core task for the Westfälische Hochschule is to develop suitable e-learning offerings for the field of “supply technology”. To identify the subject matter that should go into the new modules, the first step was to view the existing teaching material and match it against the theoretical and practical requirements for the skilled trade of system mechanic for sanitary, heating and air-conditioning technology (“Anlagenmechaniker/-in Sanitär-, Heizungs- und Klimatechnik”). Additionally, the professional work tasks of the trainees/ apprentices were analysed so as to incorporate the required basic knowledge along with more advanced specialist knowledge into the module design.

To design an M.A. programme with sustainable content, analysis was conducted to identify trends that are already being implemented at firms or that will play a role in future. To this end, relevant studies and materials of the education sector that are concerned with trends in the respective training vocations were sought out. This is necessary as innovations that have already become established in industry and the craft trades tend to find their way into the framework curricula for vocational training only with some delay. The approach adopted by us has the aim of ensuring that the students are also supplied with knowledge that is not yet or is only partially anchored in the framework curricula.
Trends were identified, among other things, in the fields of additive manufacturing processes, digital interconnectivity, and IT-aided system modification, etc.

After identification of the requirements and the necessary knowledge, the material is clustered into individual (self-contained) modules and the M.A. content subjected to a sequencing process.
The results are an overview and description of relevant content packages and a collection of appurtenant work tasks.

Interim results

Analysis of the scientific content revealed that the sub-discipline of supply technology is offered at universities in Aachen and Wuppertal. Closer scrutiny of the scientific material offered at these universities showed that it provided only little convergence with the content needed for the framework curriculum. The result is shown in Fig. 1 (see original text, link below). The outcome of further analysis was that the M.A. programme content for both the aforementioned sites should be developed anew.

Among the current trend areas that were identified are the following:

- Additive manufacturing processes (3D printing)
- IT-aided system modification (3D planning)
- System integration (digital interconnectivity, IoT)

Structuring of the content

For the planning and implementation of the digital learning environments, the “Decision Oriented Instructional Design” (DO ID) model should be used (Fig. 2; see original text, link below).
The DO-ID model provides an instruction model for digital learning environments that covers all aspects of conception and implementation, from the initial planning steps to practical realisation at the place of learning. The learning formats employed include web-based training, classical and interactive videos for demonstration of the learning topics or problems, and text documents with the possibility of linking up to further information and discussion forums. With the aid of 360° videos and photos, information can be provided in the room easily and effectively. Augmented Reality applications offer virtual content as an extension to reality. Virtual Reality applications allow the user to become immersed in a computer-generated world. With “Serious Games” or simulations, a teaching format is available that enables subject content to be put across in a motivating and practical manner. Generation of the content will begin in the near future, with parallel planning of the competence-oriented testing concepts, and the theoretical thinking and models will be implemented.

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The illustrations can be found on page 70 of the Forschungsbericht 2020 at https://www.w-hs.de/forschungsbericht/.

Project information //
The projects is receiving financial support from the Ministry of Culture and Science of the State of North Rhine-Westphalia.
Project guideline: FH ZEIT für FORSCHUNG (Förderkennzeichen (Project ref.:): 005-1703-0021 - “MEwM”).

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Social Learning and Just-in-Time Teaching
in computer science studies

Online learning platforms that allow students to process teaching content in interaction with one another and discuss it among themselves independently of fixed lesson times are an important supplement to synchronous learning, and have indeed been so since well before the Coronavirus pandemic. Therefore, within the scope of a project funded by the Ministry of Science and Culture of the State of North Rhine-Westphalia and a Fellowship for Innovation in Digital University Teaching given by the Stifterferband organisation, a study has been undertaken into how a social learning platform can be used in teaching in such a way that, in addition to activating the students, a focus on the key topics can also be achieved in synchronous teaching programmes ("lectures"), enabling both motivation and learning outcomes to be improved as a result.

Background
In order to make the contact time with the students as effective as possible, the participants in various introductory computer science modules are provided, in the previous week, with preparatory information on the next lecture, in which then those topics will be dealt with intensively with which the students had comprehension difficulties during the preparation. In practice, however, it became evident that only a small number of students really had concerned themselves with the preparatory information and that a majority of them therefore came to the lecture unprepared, with the result that much of the precious contact time had to be used for general introductory treatment of the topic, rather than for going in depth into the clarification of questions of understanding.

Goals
As a means of motivating the collaborative processing of teaching content, while avoiding the drawbacks of other collaborative learning approaches such as WhatsApp-groups (where less socially integrated students can easily be shut out from the social interaction, and comprehension difficulties can be left "hanging" within the group), the introduction of an online platform should result in the teaching material provided being able to be read and commented on by the participants and questions discussed within the group ("social learning"), and all independently of time and place. The interactions taking place between them should then also serve as a basis for the subsequent treatment of the subject matter, in particular the "problem topics", in the lecture ("just-in-time teaching").

Implementation
Thanks to a long-standing personal contact with Professor Eric Mazur of Harvard University in Boston, USA, and following a guest residency there, the *Perusall online platform* was introduced for the first time in the German-speaking world in the summer semester of 2019 in various modules at the Westfälische Hochschule (WH). The cooperation with the group around Eric Mazur involves not only exchange of experience, but also the provision of support in learning the integrated assessment mechanism for the writing of comments in German, along with corresponding adaptation of the user interface.

Perusall is meanwhile integrated with Moodle, the learning management system used at the WH, so students no longer need to register separately. Through the platform, they are given so-called "reading orders", which may relate to specifically uploaded documents, textbooks of the participating publishing houses, or also videos (including YouTube) and podcasts. *Perusall* also offers the possibility to highlight specific sections online and provide them with annotations or questions. Other participants, including lecturers, can also see who is currently working with the text, and can add a response to every annotation/question and give feedback on usefulness ("thumbs-up"). *Perusall* provides lecturers with an automatically generated "Confusion Report", indicating the sections or topics that have evidently triggered the most intense discussions. The report can be seen as an indication for comprehension difficulties, enabling these topics to be handled with priority in the lecture; those that do not elicit any annotations from the students, on the other hand, do not require any major attention from the teacher.

Assessment
Surveys among the students have shown that their preference is to work in groups, and independently of time and space. Through the use of *Perusall*, this wish is being met. It should be noted, however, that they first have to become accustomed to this way of conducting a teaching course, particularly for as long as in other modules the traditional "lecture" is still the normal method for the communication of teaching content.

Conclusion and outlook
The introduction of *Perusall* marks the start of a comprehensive and continuously developing change in the teaching and learning process towards a strengthening of "social learning" and the possibility this now makes possible to focus on the evident comprehension difficulties of the students. It is planned to continue this form of "blended learning", also in combination with other approaches such as "flipped classroom", transfer it to other teaching courses and optimise it further.

Learning habits
A remarkable fact is that around three-quarters of the participants prefer to learn collaboratively and interact with others while learning, compared to less than a quarter who prefer to work by themselves. Asked about their preferred place of learning, the response was unequivocal: The majority of students prefer to learn at home.

STIFTERVERBAND

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The link to the publication, along with illustrations to the text, can be found on pages 72 and 73 of the original text of the Forschungsbericht 2020 at: https://www.w-hs.de/forschungsbericht/

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Em³guide – The easy multimedia museum guide

Almost everyone visiting a museum has a smartphone with them. Why, then, should museums provide special devices whose only capability is to replay audio texts? Apps installed on a smartphone are able to take the place of conventional audio guides additionally displaying images and texts or even animations and videos. A multimedia museum guide of this kind can adopt the roll of an exhibition catalogue, too.

Imparting information in a museum

Traditionally, information relating to objects on display in museums is provided by printed labels near to the exhibit. The length and form of textual presentation depends on restrictions of space, didactic considerations and an overall design concept. Recently, there is a trend to reduce the number of objects on display and the length of textual explanations as well. On the other hand, detailed information about individual exhibits is provided by additional leaflets or exhibition catalogues.

In many museums visitors may also borrow audio guides, special audio players equipped with a keyboard the number of an exhibit may be entered by in order to get additional information. Thus textual explanations may be shortened to just a numeric label. Disadvantages of such systems are high costs for purchase of the devices, for cleaning and maintenance, and for the sound recordings, too.

Use of touchscreens and mobile devices

Since the 1980s, many museums have installed POI systems* mostly in the form of touchscreen terminals. Due to cost reasons, the number of terminals is rather low. Thus, there is further explanation about a small number of exhibits only.

With the growing use of mobile devices, applications (apps) have been developed for tablets and smartphones spreading information about exhibits and museums. Their advantage is that a large number of visitors are able to access information at the same time using their own devices. On the other hand, using them is often not as simple as using classical audio guides. Design and programming of individual apps is rather expensive. An app containing all information about the exhibition may render a visit to the actual museum unnecessary. Therefore, many museums provide apps that only work within the museum itself. But then visitors are not able to take any information home.

Fig. 1: In the museum, the app connects to the museum's network automatically showing the available exhibitions. When an exhibition has been downloaded and selected, a virtual number pad can be used to access information about an item. For each exhibition item, there may be an audio, a written text, and several images with corresponding texts. Performing a long press on any text a user may have it read out.

The em³guide concept

The easy multimedia museum guide (em³guide) avoids these disadvantages of apps. It can be downloaded as a cost-free app for smartphones and tablets using Android and iOS, but it is only a replay program without data about the exhibition. These data, on the other hand, are only available on site in the museum. Here, visitors can download the desired exhibition(s). The museum may offer various exhibitions (permanent exhibition or special exhibitions, e.g.), even in different languages or in different versions for children and adults.

Data stay on the device until deleted by the user. Thus, they may be viewed and listened to at leisure even after the visit. Operation is very easy and based on classical audio guides. Exhibits carry numbers which can be entered by keyboard making images, texts and sounds of the respective item appear. If desired, the device may read out all texts like an audio guide. Default sound output is telephone instead of loudspeaker in order to avoid auditory disturbance.

Technical requirements

In the museum, a WIFI system must be installed. It is advisable to hold a small number of simple smartphones or tablets in store that can be lent to visitors who do not have their own smartphone or tablet with them.

Loading data takes place at a specific location, namely where the WIFI router is installed. This may be in the vicinity of the cash desk in a museum, e.g. Afterwards, the application is functional everywhere, so the exhibits may be located either inside or outside the building. Consequently, the application is suitable for city guides, too.

Data are researched and processed by the museum staff. Guidelines on formatting texts, images and audios enable the museum staff to produce new exhibitions. To facilitate formatting, an appropriate editor is under development.

*POI system – Point of Information

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