Logistics on the couch: cognitive ergonomics measures information load

Showcase transport: trucks as smart devices

Federal Minister opens test labs

Transfer projects make companies more digital

From augmented reality in the supermarket to key tracking during night deliveries
With the **SOCIAL NETWORKED INDUSTRY** we have developed the vision of a people-friendly working world in the era of Industry 4.0. In the Innovation Laboratory Hybrid Services in Logistics we are investigating how we can support people with new technologies in a targeted and meaningful way. Nature can also be helpful here - especially with regard to interaction between humans and artificial intelligence, something which is becoming more and more important in logistics. I would therefore like to add the aspect of biological transformation to support digital transformation in logistics and production – as a potential for sustainable value creation.

Digital technologies and bio-intelligence do not have to be in competition with each other here – on the contrary: examining the organizational principles found in nature should open up new opportunities for companies to successfully implement Industry 4.0. For several years now, Fraunhofer IML has been doing research in its research lab for »Cellular Materials Handling Technology« (ZFT) into how «swarm intelligence» – one of the important principles of self-organization in nature – can be used for intralogistics. But the new approach goes much further than that – to completely self-organizing systems in which technology replicates and optimizes itself.

Enjoy reading this exciting edition of logged-in which informs you about the latest research results for the social networked industry and their application.

Yours

Prof. Dr. Dr. h. c. Michael ten Hompel,
Managing Director of Fraunhofer IML
When people think of ergonomics today, most of them still think of things like back-friendly office chairs. In the context of optimising workplaces by improving work equipment and the working environment – whether it is at a desk or in a driver’s cab, in an office or on an assembly line – that is just one aspect of the work humans do: physical ergonomics. But, because of the increase in digitalisation, yet another subject is now in focus: cognitive ergonomics. Scientists are looking into how people’s »informational environment« can be designed in a better way, i.e. how humans can best cooperate or interact with technical systems. This is based on the awareness that employee-friendly human-technology-systems lead to better performance, more satisfaction and – even more important – better health for employees. Back in the 1980s, initial research was already being carried out into this area and it is now gaining importance again with its relevance for Industry 4.0 and technological progress. As logistical systems – and intralogistics systems in particular – are some of the pioneers when it comes to implementing Industry 4.0, logistics is proving to be a consistent driving force behind research into cognitive ergonomics.

The problems of »information work«

Connecting up the virtual and physical worlds facilitates new forms of cooperation between humans and systems and also integrates intelligent assistance systems in the work processes. Virtual reality, for example, is used for training and planning purposes, augmented reality supports maintenance projects. What at first glance sounds like having more fun at work, however, often leads to more complex work processes coupled with increasing information and communication requirements. Employees are having to face new or changing workloads to an even greater extent than when the automation of machines impacted on companies in the 1970s or when computers found their way into offices in the 1980s. The focus of cognitive ergonomics is on the psychological side of work whereas physical ergonomics continues to address the prevention of physical stress and strain.

Not everyone reacts in the same way to an information-intensive work environment. What is most important for this is a person’s technical background, their attitude towards technology and readiness to deal with new technologies. How do people value technological progress, which expectations do they connect with new technologies? Do they have the impression that new technology helps them or that it hinders them, that they are control it or that it controls them? These are exactly the factors that are the subject of investigations into cognitive ergonomics. The central research objective for cognitive ergonomics is to achieve stress-optimized design as the basis for Industry 4.0 systems for humans. People will continue to be an indispensable part of Social Networked Industry that furthers the development of Industry 4.0 based on the example of social networks. Furthermore, they will be subject to constant technological changes that will have a direct and indirect impact on the way we work and on the quality of work.

By means of cognitive ergonomics human performance can be optimised in a way that improves the efficiency of the human-technology system. In this way, logistics can only benefit from psychology and its perceptions, knowledge and methods based on human experience and behaviour – and without having to lie on the couch at all.

The more information people are faced with, the more responsibility they have to take on and the more the pressure increases.

Veronika Kretschmer

Logistics on the couch? Cognitive ergonomics shaping human-technology interaction

The employee-friendly design of Industry 4.0 systems is becoming more and more important for the success of digitisation (not only) in logistics. Currently, making improvements to the effectiveness and efficiency of human-technology systems is particularly in focus for so-called cognitive ergonomics. Its theoretical foundations are based on knowledge originating in psychology and ergonomics.

About the author

Dr. phil. Dipl.-Psych. Veronika Kretschmer is a scientific employee at Fraunhofer Institute for Material Flow and Logistics IML. She carries out her research into cognitive ergonomics in the context of both the National Centre of Excellence for Logistics and IT and the Innovation Lab.

You can find the complete article on the internet:
Augmented Reality (AR) can help to shape how humans and technology coexist in the Social Networked Industry of the future so that humans get specific support and are relieved of certain aspects of their work. This is demonstrated by the first study carried out by the Innovation Laboratory Hybrid Services in Logistics. According to these studies, AR-based solutions with additional virtual information could supplement or even replace classic methods of picking and packing. Basically, all studies show that digital solutions are a good alternative to the well-known picking and packing methods. Overall, they are more user-friendly and less burdensome for people. The use of new technologies also promises both time and cost savings for companies, for example, by avoiding picking or packing errors or by packing pallets and packages in a more space-saving way.

Data glasses score with zero error rate

In a recent lab study into palletizing carried out by the Innovation Laboratory, employees evaluated data glasses as being better than classic paper lists when it came to usability and put them on a par with tablet PCs. There were no fundamental differences between the three methods regarding the overall workload on those taking part. However, the study participants felt they were under less stress when using the data glasses compared to when they used paper lists. The participants also favoured AR-based data glasses in their preference ranking.

This is also of benefit to companies: the study participants’ performance was actually very high throughout all the processes. Yet, remarkably, only the data glasses achieved a zero-error rate.

LED instead of virtual information?

The data glasses also go down well with people doing order picking: in an evaluation study conducted by Fraunhofer IML in a major brand manufacturer’s training centre, scientists compared three different picking methods. In addition to paper lists, the company primarily used pick-by-voice. The study was intended to reveal whether pick-by-vision with data glasses is a good supplement or an additional alternative to the methods being used so far. In contrast to the investigations in the innovation laboratory, this study involved employees who worked in the warehouse. According to the study, the data glasses performed very well in terms of presenting information and design quality, and well when it came to user-friendliness. In the ranking, however, they only came second or third.

What will be the next steps for the company?

The study shows that data glasses are a good substitute for paper lists and are at least as good as tablet PCs. It also shows that data glasses can help to lower the workload for employees. However, the employees also feel less stressed when using data glasses. This is also of benefit to companies: the study participants’ performance was actually very high throughout all the processes. Yet, remarkably, only the data glasses achieved a zero-error rate.

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From the laboratory to the »Working Worlds of the Future«

The Innovation Laboratory Hybrid Services in Logistics has been involved in the Year of Science 2018 with various different activities. The researchers place great emphasis on bringing the »Working Worlds of the Future« in logistics and production that have been developed in the »laboratory« to the people and entering into a dialogue with them.

One key element of the communication instigated by the Innovation Laboratory is to make its research alive and accessible – in particular for target groups who usually have little contact with science. Guided tours of the research centre and the application centre in the Innovationlab at the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund are always a great way to get people excited about technology and ultimately to promote its acceptance. It is particularly pleasing that the official opening of the test labs (see page 9) took place in the Year of Science 2018. Some very different groups of people have taken up the offer to visit the lab including citizens from the region, works coun- cils and vocational school teachers. A lot of people are still concerned that new technologies will steal jobs away from people. It is often a real click moment for visitors to find out that the technology at the Innovation Laboratory is being developed in a way that is intended to serve people and make their work easier and not just to replace people. The Innovation Laboratory also wants to achieve something similar with its participation in »MS Science«. The swimming Science Centre, a project initiated by the Federal Ministry of Education and Research, is on tour until the end of October and has an exhibit from the Innovation Laboratory on board. Such platforms are especially attractive for young people. Young talents are an important target group for the Innovation Laboratory – especially because some logistics companies are already lacking suitable personnel. Although logistics has developed into a high-tech industry in recent years, people still see it differently. With the use of new technologies like those developed in the Innovation Laboratory, careers in logistics and production are becoming even more attractive and exciting, especially for young people growing up with smartphones and tablets. This also needs to be communicated clearly for specific target groups.

Putting ideas into practice

In her speech, the Minister described the Innovation Laboratory as »the largest European research campus for logistics« and was impressed by the courage, creativity and performance of the scientists as they put ideas into practice.

New impetus for the area

Such a strong network and transfer of knowledge into the market can give new impetus to the entire region. »Modern logistics plays a key role for Germany as an exporting nation and a country lacking in raw materials, and offers the Ruhr Region prospects for the future as an attractive and competitive location,« the new Innovation Laboratory will strengthen the whole region.

Lively transfer

The Innovation Laboratory brings companies and well-established research institutions like Fraunhofer Institute for Material Flow and Logistics or the TU Dortmund University together more quickly. The Minister said: »This lively transfer will also support a creative and innovative start-up scene.«
Contours of the key principles of digital work

Adaptive, integrated and participative: this is how human-oriented logistics work must develop in the context of progressive digitization. A total of six key criteria can serve as a basis for well-designed digital work.

**01** What is the key aspect of adaptivity all about? Industry 4.0 (logistics) systems should be designed to meet the specific demands made upon them, i.e. digital systems should be ergonomically adapted to explicit working conditions and stresses. Furthermore, both information and assistance systems must be intelligently adaptable to suit the range of qualification levels of different employees.

**02** Complementarity focuses on the flexible, situation-specific distribution of functions between humans and machines as well as ensuring the system is sufficiently transparent and controllable by the employees. Intelligent machines already carry out orders autonomously in real situations in companies. This changes the way humans and technology interact. Intelligently networked lifting and material handling equipment, that can only be started by humans when all safety questions have been dealt with satisfactorily, are good examples of systems that can be operated intuitively and learnt quickly.

**03** The integrity criterion refers to the completeness of activities in two respects: an activity profile should always include implementation tasks as well as organizational, planning and monitoring tasks. A mix of both more and less demanding tasks is required to ensure that overall stress levels remain acceptable. In addition, an integrated approach to activities is the key condition for achieving a high degree of regulation while providing room for manoeuvre and the chance to achieve self-organized work.

**04** The dynamics of activities, so-called polyvalence, are all about the possibilities of work organization which can enable and foster learning processes. This is also where (tried and tested) methods of systematic job rotation are applied in companies, such as when switching between conveyor work, order picking or driving forklifts.

**05** The introduction of decentralized systems is intended to make organizational use of the design potential of new, highly decentralized digital technologies. Thanks to self-organized, i.e. autonomous, production and logistics systems, new opportunities are opening up to create the technical and organizational conditions for new forms of flexibly integrated and innovative work. Decentralized systems are also an important organizational condition for companies to open up more to the outside world, for a stronger service and customer orientation as well as for changing business models.

**06** By involving employees, their experience and process knowledge can be utilized in system and work process design. At the same time, broad participation and co-determination structures increase the acceptance and involvement of employees and their representative bodies.

More about the topic

Peter Illerstamm and Martin Eisele: more specifically look into the scientific discourse about this topic in the research report «Hybrid services and change of work. Challenges and prospects in logistics», sociological working paper no. 50/2017, TU Dortmund University (in German).
When the glove talks to the glasses

When the inventory management system at a supermarket reports negative stocks, an employee must immediately recount the goods on the shelf: daily stock control in food retailing is almost an obligatory exercise. This is normally carried out by an MDR device with the corresponding software. These mobile data recording devices are small all-rounders, they can easily be connected to the respective inventory management system and are therefore popular in retail. The main disadvantage is their lack of user-friendliness. The small display makes reading them quite difficult and the many tiny keys, also arranged in a very small space, lead to input errors. In addition, the devices can only be operated with both hands. As part of one of the Innovation Laboratory’s transfer projects, project manager Patrik Elfert and his team developed a new smart system for inventory control for the Hamburg-based company Lunar, the IT service provider for the EDEKA Group, using a combination of data goggles and scanner glove. »Our solution has the potential to replace such MDR devices in retail one day – as it means employees will be able to do their work faster and more ergonomically«, says Patrik Elfert, pleased with the successful »proof of concept«.

Are you still talking or are you touching already?

To implement their vision of smart inventory control in retail outlets, the researchers worked with the company to select the most suitable hardware available on the market. These turned out to be Google Glasses, which have recently celebrated a big comeback, and a high-tech glove with a removable scanner.

The data goggles guide the employee through the inspection process by displaying the information they need. As a result, even an unskilled employee can take care of stock control without needing any special instruction. The glove allows the employee to activate the scanner with a finger-tip. During the process, the employee always has at least one hand free to continue sorting the goods on the shelf.

Basically, people can decide whether they prefer to work with voice commands (e.g. »start scan process!«) or with a touchpad on the glasses. An interface program developed by the research team enables the glasses and the glove to communicate with each other and – more importantly – with the retailer’s inventory management system. In addition to shortfall checks, the solution is of course also suitable for individual or random checks. Both methods are recorded in the program and can be selected by the employee. »The result of the transfer project reflects the idea of our format«, says Andreas Nettsträtter, responsible for network management and knowledge transfer in the Innovation Laboratory. »In a limited period of time, the company was able to try out augmented reality very simply – one of the much-vaunted new and innovative technologies of our time – to see if it was suitable for practical use.« In fact, Lunar also wants to test the solution on the market now in order to gain initial practical experience. They are particularly interested in seeing how people accept the new solution. Patrik Elfert and his team have already thought about further expansion stages; for example, the solution can also be used for annual inventory taking – and not only in supermarkets or in food retail.

Transfer projects make companies more digital

»Making Innovative Leaps in Tandem« is the idea behind the transfer projects at the Innovation Laboratory in which science and business lay the foundations for the implementation of new technologies together – here are two examples.

You can find more information about transfer projects at:

transfer projects at: 03 innovations
Trust is good, transparency is better

Night Star Express, which has its headquarters in Ulm, offers its customers a real competitive advantage by delivering spare parts overnight: workshops and traders can then have cambelts, pumps, etc., at their disposal early in the morning and complete important orders right at the start of their working day without having to wait for normal deliveries.

The Night Star Express drivers deliver the goods to specifically defined locations which can be anything from a warehouse to the boot of a car. This is possible because the customers provide them with any keys that are needed. Depending on the location, the drivers either carry keys for all their customers in their delivery zone or only for the 20 to 25 customers on that particular tour. However, unlike the deliveries themselves, the keys they were using could not be tracked. That is why Maximilian Schellert and his team decided to take on the digitisation of their key management as part of another transfer project by the Innovation Laboratory, the results of which could also be of significance for fresh food logistics of the future, for example.

The researchers developed a system for key management which is both secure and transparent, consisting of smart hardware and software architecture with a link to route planning. The keys have been equipped with RFID patches so they can be tracked and traced. A specially developed app shows exactly which driver is carrying which key. The aim is for all locations to use the same software so that only those keys needed for a tour are on the road. «Our concept is attractive for all parcel service providers who offer delivery when the recipient is not actually present – this is especially useful for food deliveries to private customers, something which is very much on the increase,» says Maximilian Schellert, head of the transfer project. «The link to route planning is also exciting: it gives the company a completely integrated concept.»

SUSTAINABLY GOOD: THE PICK-UP STATION OF THE FUTURE

The Innovation Laboratory’s talent workshop gives students the opportunity to implement some very diverse projects. The result of the first project of this kind is a supplier-neutral pick-up station with a real lifestyle look.

Today, according to digital association BITKOM, every fifth German citizen orders things online several times a week. People who cannot be there to receive their parcels at home are dependent on automated pick-up/drop off stations or shops working for the parcel service providers and, since there are several courier services on the market, often have to go to several places to pick up their purchases. Patrick Zimmerman, a masters student in logistics at TU Dortmund University, and his fellow students, had been annoyed about this for a long time: two years ago, at a festival for young ZEIT ONLINE visionaries, they presented their idea of a supplier-neutral pick-up station which could be set up in cafés or similar public places. The talent workshop gave them the opportunity to build a prototype. The station is designed as a shelf equipped with individually removable boxes of different sizes. The boxes are secured by a special locking mechanism. A conventional metal bolt and a motor are connected to a coupling piece which the students developed specially for this purpose. This comes from a 3D printer. The recipient of a parcel registers online and receives a message with a barcode on their mobile phone as soon as the parcel arrives. This is held up to a scanner on the shelf and the storage box is unlocked. In addition to the technology and processes, the young researchers also worked on the design: the entire pick-up station is made of MDF board. The team worked on the prototype for about half a year. It is fully functional and ready for use. The students are currently looking for a location for their first shelf. There have already been several enquirers from potential investors, too.

About the author

Sils Brunn is a freelance editor and regularly reports on new technical developments in the Innovation Laboratory Hybrid Services in Logistics.

Smart Device with plenty of horsepower

Digital technologies can open up considerable potential for optimising urban logistics. Current research for the Innovation Laboratory’s Transport use case shows that truck drivers’ job descriptions will change considerably in future.

Permanent transport and information chains, more transparency in the supply chain and links between short- and long-distance transportation as well as networks between different modes of transport are not only the components for intelligent urban logistics, they also form the information technology basis for dynamic delivery scheduling. This in turn creates the conditions for vehicles to drive autonomously to logistics centres and navigate their way through city centres – which will make a considerable contribution to greater efficiency and environmental sustainability for the transport of goods. As soon as transport volumes and shipment details can be presented transparently for logistics service providers, automated vehicles will also be able to run along these optimised routes. Humans – and in particular the truck driver – will still be irreplaceable for these processes because customer contact and many other processes can only be managed by them. Their flexibility and experience are also required for loading and unloading and for tricky driving situations. But they must be integrated into the digital processes and interact with new technical devices. The most important smart device for the truck driver will be the truck itself: vehicles can already be equipped with smart technologies for accomplishing the actual driving tasks (such as at intersections, construction sites, navigation, etc.) or specific processes (for example approaching loading bays, loading and unloading, complex positioning). Interfaces for data communication create a connection between the vehicle and the factory premises (e.g. for registration or route and loading bay allocation). Like smart watches, smart trucks have long ceased to be some sort of nightmare for drivers. On the contrary: the new technologies actually increase the attractiveness of the job – and can also counteract the lack of drivers. In a study by the Innovation Laboratory with 76 truck drivers, the respondents showed great interest in automated driving and smart devices. Those who had already had some personal experience with the new technologies were particularly open to future developments and more confident with respect to the benefits of the technologies. With this in mind, it is important to integrate the use of smart devices in driver training programmes.

About the author

Maximilian Schellert, M.Sc., scientific employee in the Department of Transport Logistics at Fraunhofer IML, is in charge of the Transport use case at the Innovation Laboratory.
The monitoring system is connected to a planning system that helps to re-plan the processes and technologies. On the basis of any functional and performance requirements that have changed in the intralogistics system, it develops various technology variants and dimensioning – providing an important basis for the planner to make decisions on how to adapt the system.

Such predictions are transferred to a monitoring system that analyses and observes the key figures in the intralogistics system. As soon as a key figure is forecast to exceed or fall below certain pre-set parameters, an adjustment to the system is triggered.

The key instance here is the digital twin – a digital image of the logistics system. This is where data about all the different statuses of the system are gathered and stored. They then form the basis for planning, analysis, and optimisation in all other modules of the digital design. It is then possible to use the status of the digital twin in simulations to predict future system statuses.

Having a virtual image of a re-planned system enables any weak points of a solution variant created in the planning system to be evaluated before it is implemented physically – this is called participative realisation. Employees can practice new processes and how to handle the new techniques before they are actually implemented and, if necessary, can even get involved in designing the solution.

In times of volatile markets, hybrid services are required to ensure the flexibility and agility of the supply chain and to expand competitive process and cost structures. The socio-technical networks at the interface between humans and technology have to be able to adapt dynamically and individually and to provide highly flexible hybrid services. This means constant change has become the normal state of affairs and rigid, heavyweight planning is now obsolete. The concept of digital design answers the question of how agile design and implementation processes must look for future logistics systems in order to be able to exploit the potential flexibility of hybrid services.

Virtual Training for Warehouse Processes
Digital design can be seen in practice in the Hybrid Services in Logistics Innovation laboratory in the Virtual Training Showcase. This presents the simulation of a performance and a capacity bottleneck in a small parts warehouse.

About the researchers
Anike Murrenhoff, Christoph Pott, Moritz Wernecke and Philipp-Akira Bürer are responsible for the work package «Digital Design».

Digital design complies with the requirement for continuous short-cycle adaptations to intralogistics systems.

Christoph Pott

The concept of digital design

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SMEs benefit from research

The Arnsberg-based company META-Regalbau provided the Innovation Laboratory with an ultra-modern shelving system that is used in a realistic warehouse setting in the laboratory’s application centre to showcase various picking and replenishment processes. «Working together is exciting for us because, as a future-oriented company, we are very interested in research and the knowledge that can be gained from it», explained Michael Steinrücke, Department of Business Development at META. Other companies are following suit. «We want to make logistics 4.0 possible, so welcome it when medium-sized companies get involved in research and benefit from the results», said Benedikt Mätzig from the Innovation Laboratory who prepared the cooperation.

In the middle of May, works councils from NRW took part in a workshop organized by the Innovation Laboratory and the Cooperation Centre Science - Working Environment at TU Dortmund University where they discussed the opportunities and challenges presented by digitizing work and the new synergies between humans and technology that result from it. The works councils were particularly impressed by the contribution that the new technologies can make to relieving the strain on employees – with “better work as a motto. However, some people voiced a warning, pointing out the possible loss of jobs.

In the opening event of the new series “Fraunhofer Technology Experience Series” by the Fraunhofer Office in Brussels in mid-June showcased the Innovation Laboratory and the Social Networked Industry. Representatives of the Innovation Laboratory informed the more than 50 participants – employees of the EU Commission, companies and other Brussels liaison offices – about what the cooperation between people and technology will look like in the working world of the future.

Dialogue with Brussels
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Hannover Messe
At the end of April, the Dortmund Innovation Laboratory and the Stuttgart Future Work Lab showcased an intelligent assembly and packaging workplace at the Hannover Messe to demonstrate what work in production and logistics could be like in the future. Industry 4.0 functions and technologies could be experienced live at the booth of the Federal Ministry of Education and Research (BMBF). «We were one of two places that exemplified the changes happening in the world of work», said Arkadias Schier, Project Manager of the Innovation Laboratory.

Hello, Colleague Robot:
The training magazine “Treffen”, by the Ruhr Nachrichten in Dortmund, also took part in a visit to the Innovation Laboratory. After all, digitization is changing education – both in theory and in practice. «This development is taking place rapidly: tablets and smartphones – technology that young people use privately and already master today – have also become indispensible in logistics and production», said Andreas Nettsträter from the Innovation Laboratory. This makes many jobs more attractive – especially for young people.
About us
The Innovationlab Hybrid Services in Logistics is an interdisciplinary research project in which technological innovations are developed for a Social Networked Industry. The focus is on human-technology interaction. Our so-called showcases – which are organised in the five fields of trading, production logistics, transport, maintenance and virtual training – guarantee that innovations are transformed into hybrid services.

The Federal Ministry of Education and Research (BMBF) is sponsoring the project with a total of 10 million Euros over a period of three years. On the one hand, the Innovationlab is intended to strengthen Dortmund’s pioneering role in services and logistics, and, on the other, to accelerate the acceptance and implementation of technical solutions in the context of Industry 4.0. Academic and industrial partner networks and social partners and multipliers from the Ruhr metropolis and beyond are integrated in the work of the Innovationlab.

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