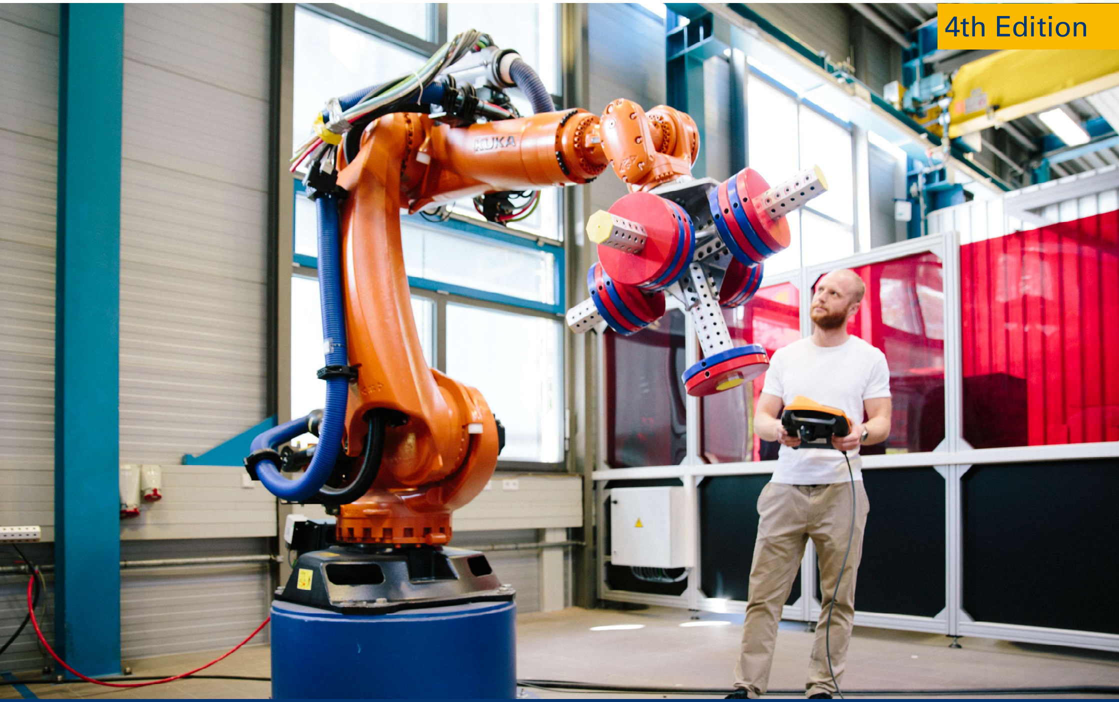

4th Edition

OSTFALIA I4.0 CATALOG

Demonstrators of Industry 4.0 Technology

Originally created as part of the project GrowIn 4.0 – Growing into Industry 4.0 · Accelerate Growth in Manufacturing SMEs, Further funded by the project Wissen.schafft.Kommunikation.

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The importance of digital technologies for the competitiveness of companies has already experienced an enormous boost across all industries. As part of the joint project „DiKom- Digital Competencies in Continuing Education“, needs surveys were conducted as part of seminars, workshops and interviews with experts. These show that although there is a high level of readiness for digital transformation in companies, it is also perceived as a difficult task at many levels of the company.

It is difficult to assess a company‘s own digital skills and potential. There is therefore a requirement for awareness-raising measures that make the benefits of digital technologies transparent and create understanding for the necessary changes.

A special focus of the requirement is to show a way to implement digital projects: Where do I stand digitally with my company? What is the potential? How do I exploit this potential?

The „Ostfalia I4.0 Catalog“ presents a selection of demonstrators and aims to encourage a conversation with your company. Ostfalia‘s labs, education and consulting services are open to companies interested in building digital competencies in a practical way within the company.

Contact us!

CONTENT

Networking Technologies

Resource Efficiency

Robotics

Reusable Sofware Building Blocks for IoT Applications

Knowledge and Technology Transfer

UNLOCK YOUR POTENTIAL - OUR KNOWLEDGE IS THE KEY

The Knowledge and Technology Transfer is your first port of call if you seek a link to the university. The service includes:

- Providing support for collaborative ventures in the context of grant-funded and contract research
- Consultation on funding possibilities for projects
- Information about research priorities and projects
- Arranging contacts to Ostfalia professors
- Providing advice on invention disclosures, patents and property rights
- Organizing events with a view to initiating collaborative ventures and exchanging ideas and knowledge

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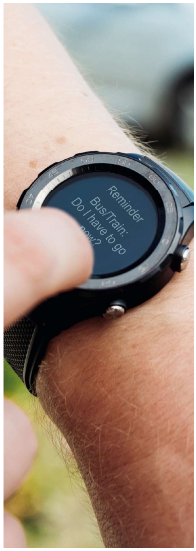
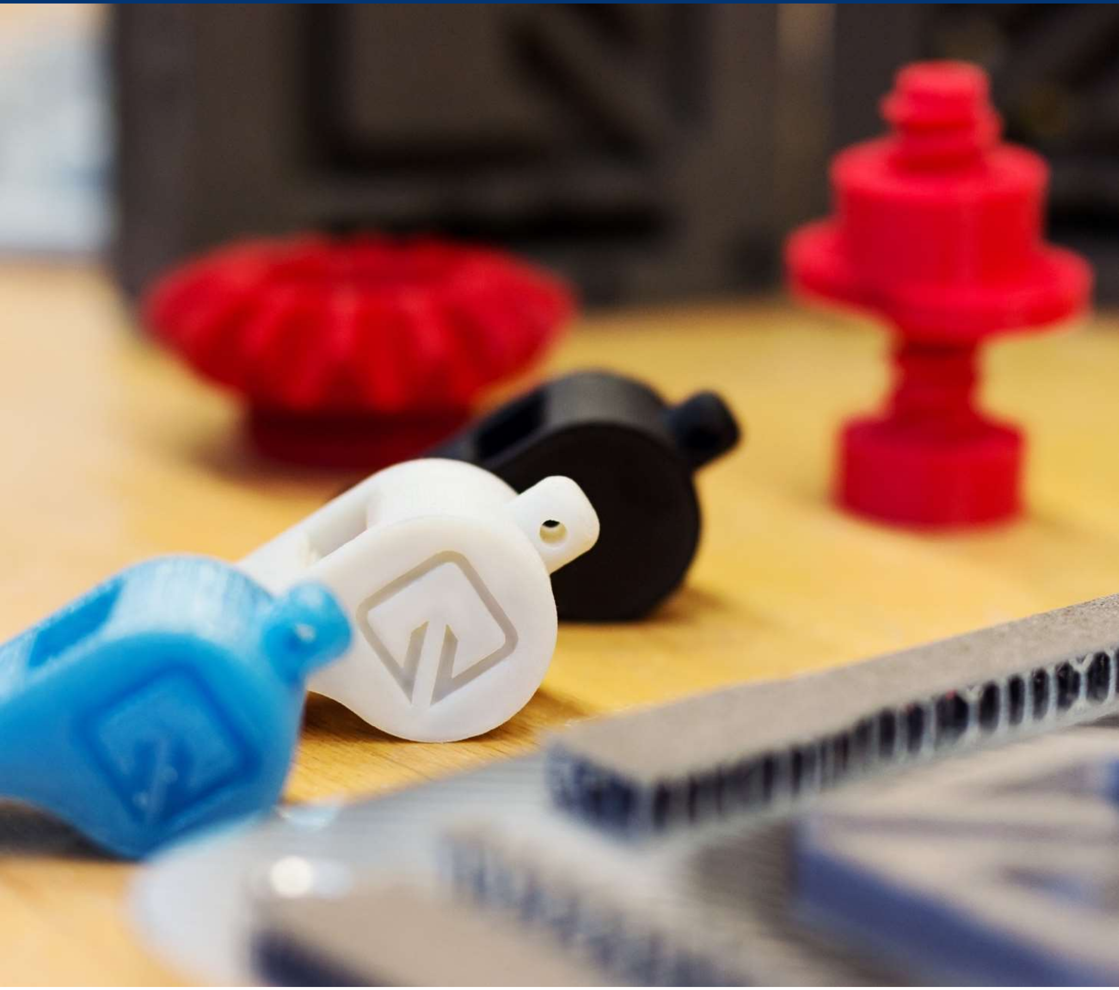


Research at Ostfalia is characterised by:

- Applied research activities
- Cross-discipline research approaches with focuses in seven research areas and six research centres
- Social relevance
- Open-ended, independent and responsible implementation
- Dependable partnership
- Strong regional anchoring
- increased alignment with the international research environment

Additive Manufacturing

Production of Components and Industrial Prototypes with 3D Printing



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I4.0 application(s):
Rapid Prototyping, Rapid Tooling, Rapid Manufacturing

I4.0 technology(-ies):
Additive manufacturing, simulation/compensation of thermal distortions, application-related material selection

Functional description:
Processing of a wide variety of materials such as AlSi10Mg, PA12, PA6 with carbon short fibers, PLA, ABS, PETG, PEEK and many more using the layer build-up principle.

Possible problem-solving/process optimization:
Application is only possible through digitization. Prime examples of the complete digitization of the process chain. Creation of tools and components in small batches (from quantity 1), creation of (functional) prototypes.
Resource-saving development through quickly available prototypes (if necessary from the target material) and in-house manufactured tools (e.g. custom grippers for robots, holders, etc.). Product development in general is reduced by short development cycles and thus production costs are significantly lowered (especially compared to external manufacturing).

Available 3D printing methods:
- Selective laser melting (metal)
- Selective laser sintering (plastic)
- Stereolithography (synthetic resin)
- Fused Layer Manufacturing (plastic also with fiber reinforcement)

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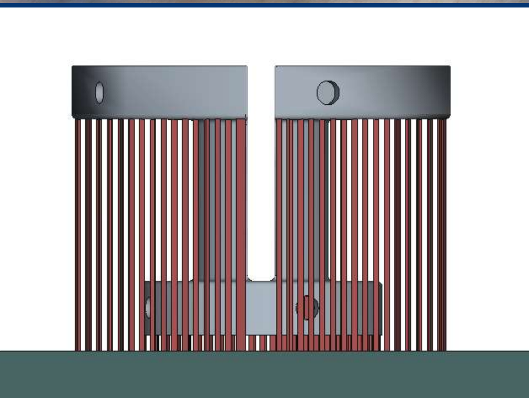
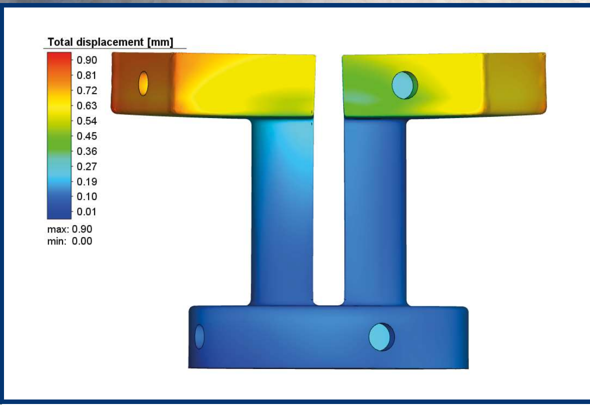
Additive Manufacturing

Virtual Dimensioning of Additively Manufactured Components





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I4.0 application(s):
Rapid Prototyping, Rapid Tooling, Rapid Manufacturing

I4.0 technology(-ies):
Topology optimization, simulation/compensation of distortions, installation space utilization

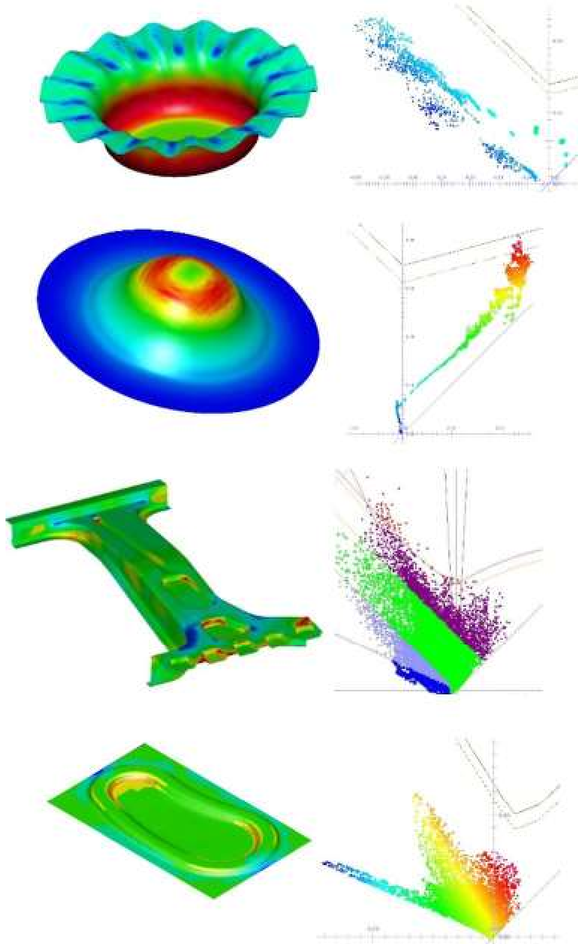
Functional description:
The topology of metal and plastic components is optimized with the „Siemens NX“ software as a function of the acting force flow, and the mechanical simulation of a wide variety of metallic materials such as AlSi10Mg is carried out with „Simufact Additive“; additional material parameters are required for thermomechanical simulation. Finally, „Materialise Magics“ is used to adapt support structures for minimum material use and to optimize the alignment and positioning of components in the installation space in such a way that maximum utilization of the production equipment and efficient material use prevail.

Possible problem-solving/process optimization:
The process chain is completely digitized. The measurement (optical, tactile) of manufactured components helps to gain information and validate the preceding process steps. In this way, it will be possible to proceed according to a best practice in the future. Production resources are conserved, less material is wasted due to defective components and superfluous support structure. Output is significantly increased.

Technical structure:
Siemens NX (to create the model), Materialise Magics (to calculate the component including support structure / „component anchors“) and Simufact Additive (to simulate the warpage and corresponding recalculation for compensation) are used. A 3D scanner / coordinate measuring machine measures the sintered test objects to the hundredth of a millimeter (mechanical approach).

Process Simulation

Finite-Element-Simulation of Forming Processes



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I4.0 application(s):
Manufacturability analyses, risk assessment, component and process optimization

I4.0 technology(-ies):
Virtual manufacturing, FE simulation, digital twin

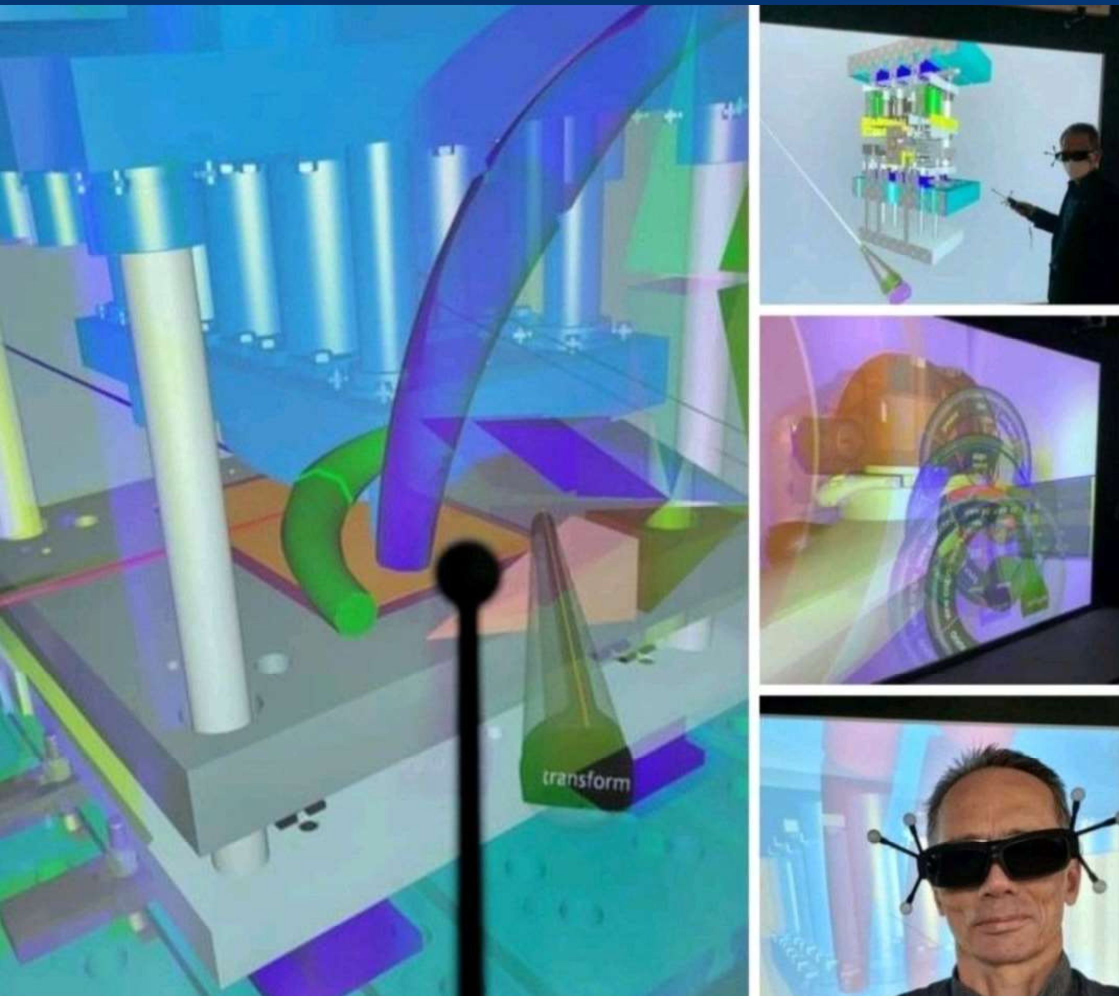
Functional description:
1-Step Simulation: CAD import of the part, model setup and inverse one-step simulation without tools. Rough calculation of the expected deformation changes and comparison with the forming limit change. Evaluation of the risk of tearing with subsequent optimization of geometry and material. Accurate prediction of the required sheet metal blank geometry.
Incremental FE simulation: design of deep drawing tools based on the part, import of tools, model setup (blank definition, material selection, process selection, etc.). Stepwise forward simulation, more accurate calculation of the shape changes that occur and comparison with the limit shape change. Evaluation of tear and wrinkle risk with subsequent optimization of part geometry, material selection, and deep drawing process. Springback analysis and subsequent iterative springback compensation in the mold.

Possible problem-solving/process optimization:
Based on the simulation results, critical radii in the part can be increased, for example. In the process, holding forces can be varied due to the blank-holder pressure or the drawing bead geometries in order to get into the so-called good part window with the shape changes. Shape changes and sheet thickness curves are transferred to subsequent simulations (joining simulation, crash simulation) by means of mapping in order to improve the prediction accuracy there.

Technical structure:
- 1-Step: Forming Suite
- Incremental FE: Pam-Stamp
- Use of virtual hardware at the data center (VMware/Horizon)
- CAD models from CREO or NX

Process Simulation

Visualization of process and product data at the 3D powerwall



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I4.0 application(s):
Collision investigations, installation and removal investigations, functional investigations

I4.0 technology(-ies):
Virtual development, kinematics simulation

Functional description:
CAD import and model setup incl. linking of components with each other in IC.IDO. 3-dimensional visualization on the projection surface (4 m x 2.5 m) in WQHD resolution. Analysis with up to ten people on site (using shutter glasses). Operation by means of flystick.

Possible problem-solving/process optimization:
Detection of functional defects using moving 3D models. Dynamic viewing of arbitrary section planes and accurate evaluation via integrated measurement functionality. Adaptation of component geometries for collision avoidance. Cross-location networking and joint collaborative work (also with HMD users) is possible.

Technical structure:
- Display (4 m x 2.5 m)
- Laser beamer (WQHD / 3D)
- Graphics Workstation (High Performance)
- IC.IDO (immersive software)
- Tracking cameras, tracking PC and DTrack (associated software)
- 10 shutter glasses
- Flystick, space mouse

Assistance Systems

Digital assistance systems in (warehouse) logistics

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I4.0 application(s):
Intelligent picking, Intelligent process support in the warehouse

I4.0 technology(-ies):
Pick-by-Scan, Pick-by-Light, Pick-by-Vision, Augmented/Digital Reality

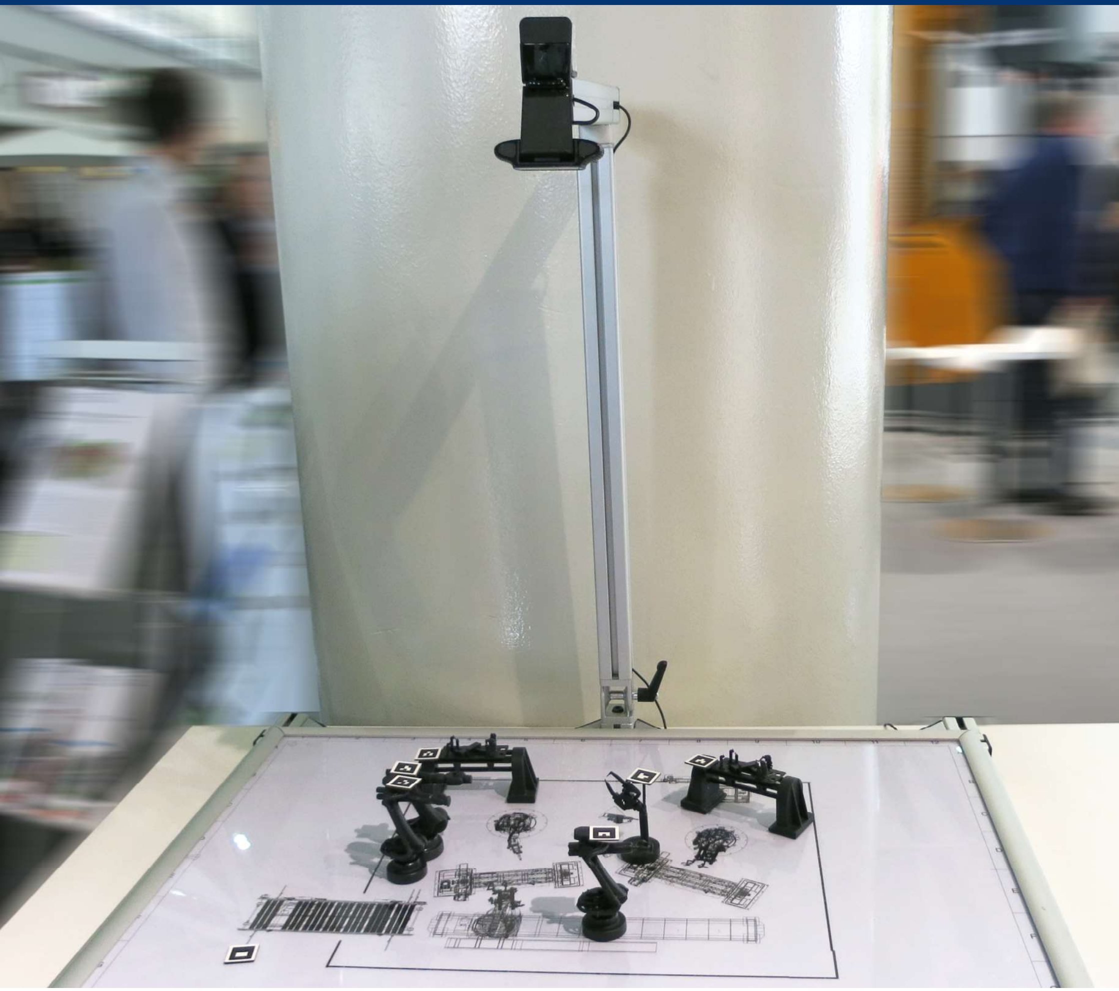
Functional description:
Companies that already maintain an inventory management system with real-time inventory lists of the warehouse can make use of the picking technologies Pick-by-Scan (hand scanner use for storage, retrieval and transfer), Pick-by-Light (sequential assembly of picking orders) and Pick-by-Vision (use of data glasses). While Pick-by-Scan requires searching the shelves using information such as shelf and compartment numbers, Pick-by-Light uses the illumination of compartment indicators and Pick-by-Vision uses data glasses to guide the specialist to the required storage location.

Possible problem-solving/process optimization:
Pick-by-Scan simplifies inventory control and speeds up stocktaking processes. Pick-by-Light and Pick-by-Vision also help workers find their way around the warehouse. Search times are reduced to a minimum, throughput times in order picking are reduced (potential savings, process reliability thanks to error-free processes).
The Pick-by-Light system also supports assembly processes by providing the skilled worker with required objects in the correct sequence via the light display. Due to radio-controlled displays, this technology can be used flexibly for changing processes.

Technical structure:
Merchandise management system, handheld scanner/gateway with display/data glasses, in-house WLAN, local control computer/server or cloud-based system (Internet connection required).

Augmented / Virtual Reality

Digital Planning table



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www.youtube.com/watch?v=dfG3GiL-YXY

I4.0 application(s):
Visual Layouting: Modeling Production Environments

I4.0 technology(-ies):
Marker recognition with ARToolkit, 3D printing (miniatures), simulation

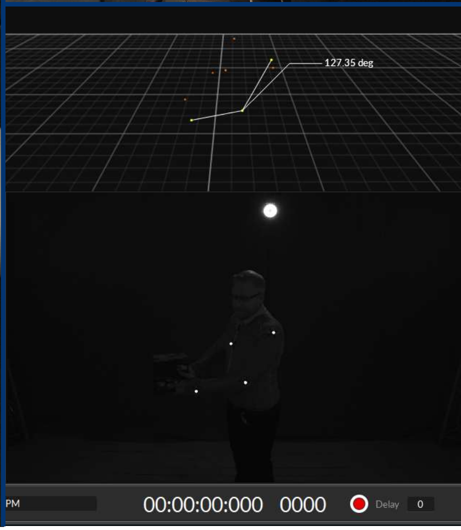
Functional description:
In the 3D printer, a miniature of a production machine or other manufacturing-level equipment is created. A marker with a simple pattern is placed on it, which is used to link the miniature to its virtual counterpart - this requires the marker to be positioned in front of the camera in a learning process. If the miniature is then moved on the planning table, the position and rotation of the marker are recorded - the virtual model is positioned according to this data.

Possible problem-solving/process optimization:
A collaborative element is introduced into the planning process, the personnel who will later operate the equipment can be involved in planning the production level.
No software knowledge is required, the layout is done intuitively, whereby an increased spatial imagination is helpful (if necessary on the future area, since the setup is mobile).
Since the layout is agreed upon jointly and thus no more iteration steps than necessary have to be gone through with a planning office, costs can potentially be saved.

Technical structure:
Table and camera arm made from item profiles, FullHD USB camera (an upgrade to 4K resolution is planned), computer and software: Siemens Process Designer.

Augmented / Virtual Reality

Motion Tracking with machine learning



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I4.0 application(s):
Factory 4.0, Virtual Reality, Ergonomics Computer Models

I4.0 technology(-ies):
Optical Tracking, VR Analytics, Neural Networks

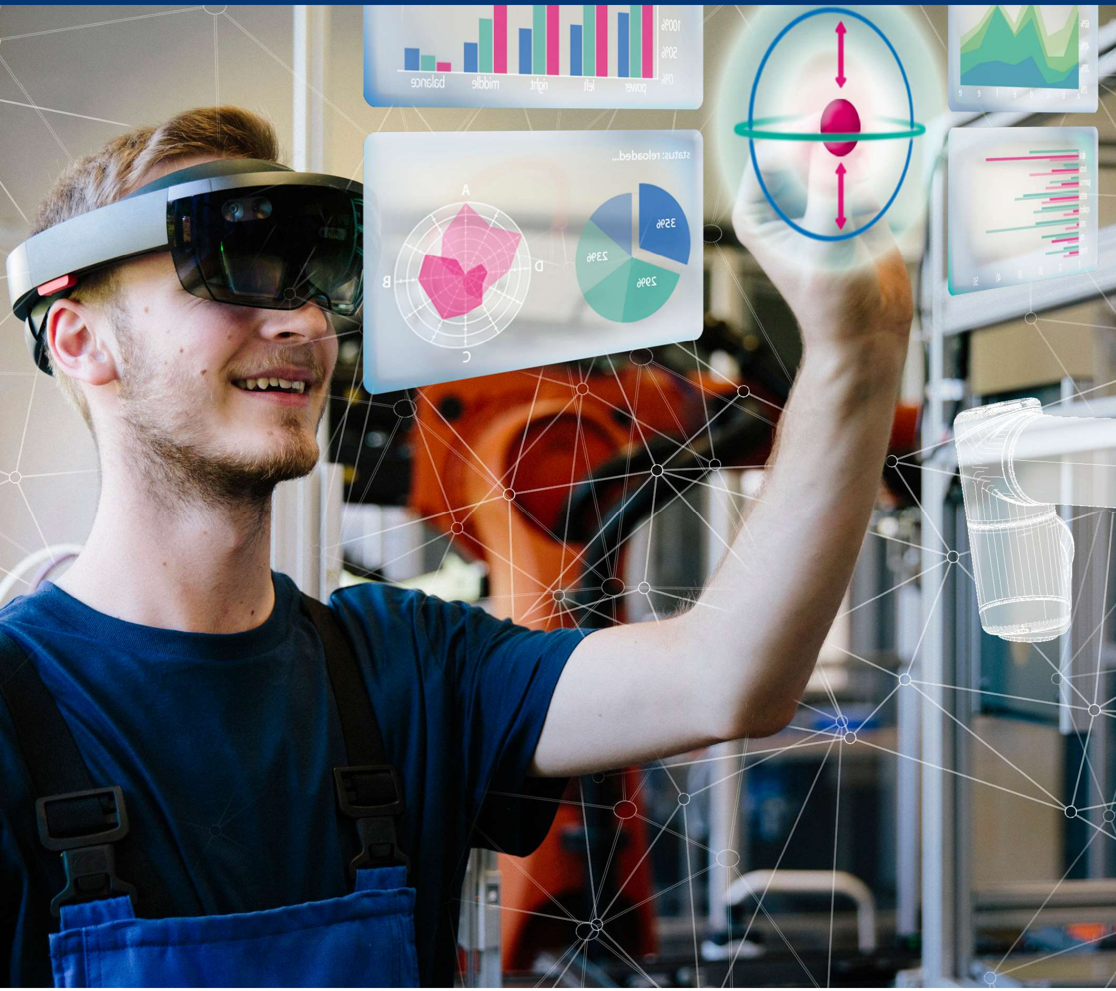
Functional description:
Eight cameras with infrared emitters capture perons movements. A system of „markers“ (infrared reflectors) attached to body joints maps all possible degrees of freedom. The recorded scenes are transferred to a 3D model, which can be viewed on the computer from all sides. With the help of machine learning with artificial neural networks, scenes can be interpreted in various application areas: „(How) do people interact with cobots or each other, for example?“ (process optimization in production), „Has a person fallen, for example?“ (nursing/medical technology) or „Are motion sequences ergonomically correct?“ (working world/sport)

Possible problem-solving/process optimization:
The transfer of real situations to a digital 3D model is thus possible in a memory-efficient way, data to be processed can be reduced to a few vectors per motion sequence. The gigabytes (up to 360 images/sec à 8 cameras with „x“ captured vectors) are significantly lower compared to video data with the same recording duration. Subsequent computing operations also run more resource-efficiently.

Technical structure:
Eight OptiTrack Prime 17W cameras, connected to a server via Gigabit Ethernet, a suitable network switch is required (purely local application). The resulting data is collected and interpreted using OptiTrack Motive software.

Augmented / Virtual Reality

Visualization of process and product data with augmented reality



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I4.0 application(s):
Maintenance, diagnosis etc.

I4.0 technology(-ies):
Augmented Reality (AR), Cyber-Physical Systems

Functional description:
The AR glasses use server data to superimpose information on processes and/or products into the user's field of vision, for example energy requirements of the production machines, material flow or a CAD model of the product that has just been created.

Possible problem-solving/process optimization:
Maintenance and repair processes could be drastically accelerated if the information currently required is displayed directly in the overlay instead of having to search for it in documents, databases or manuals.

Technical structure:
Microsoft HoloLens, server and network infrastructure

Augmented / Virtual Reality

Virtual Prototyping/ Digital Twin

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I4.0 application(s):
Visualisierung, Simulation, Virtual Prototyping

I4.0 technology(-ies):
3D Modelling und Animation, 3D Druck, Motion Capture

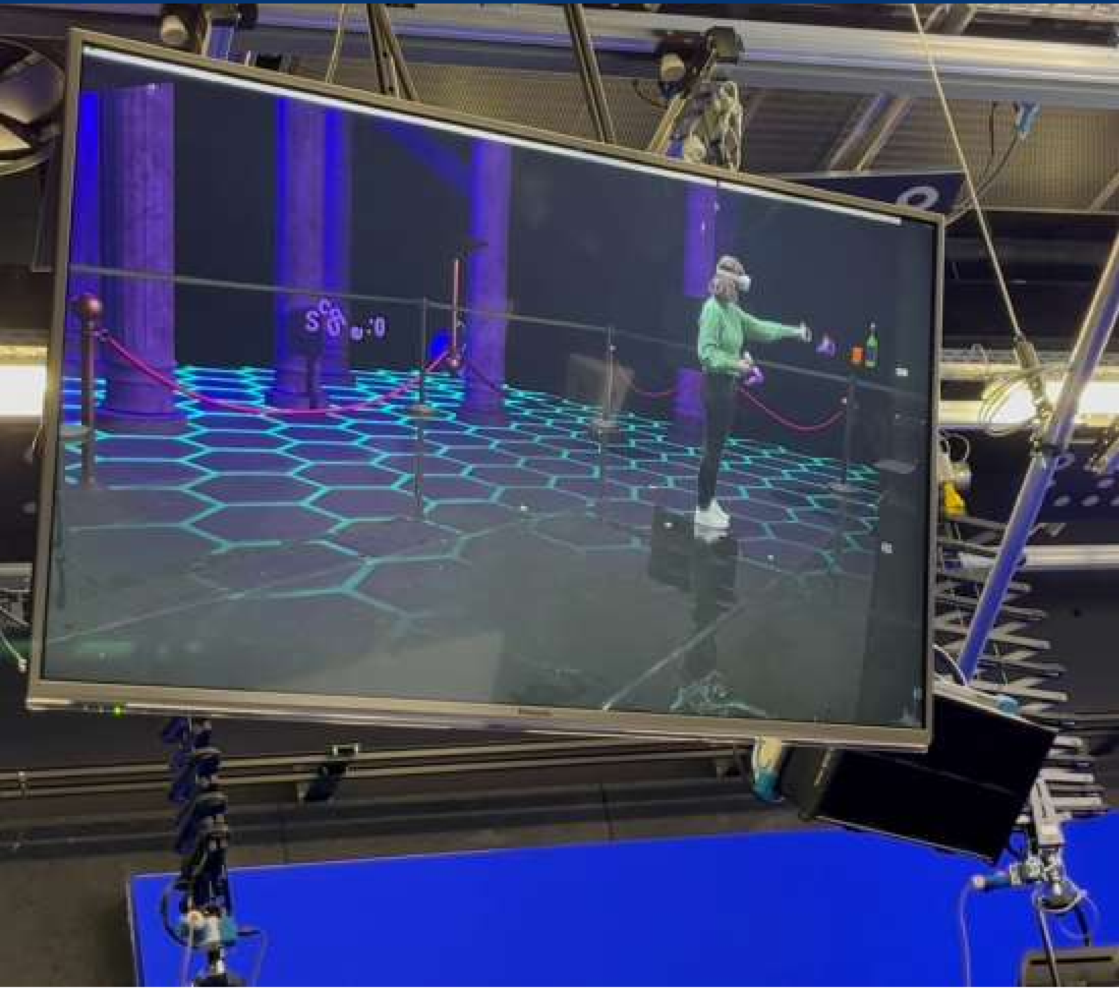
Functional description:
Digitale Twins sind die virtuellen Nachbildungen bzw. Visualisierungen von Objekten, Umgebungen oder auch Menschen. Sie helfen bei der Kommunikation, Entwicklung und Optimierung der realen Systeme.

Possible problem-solving/process optimization:
Digitale Twins können zum Virtual Prototyping und zur Produktentwicklung eingesetzt werden: z.B. im Automobilbau, bei Produktionsanlagen oder Räumen können Design, Arbeitsprozesse und Usability untersucht und verbessert werden.
Digitale Twins können mittels 3D Druck als (Miniatur-)Protoytpen bereitgestellt werden. Virtuelle Menschen können z.B. für die Bekleidungsindustrie für Digitale Fashion oder für die Virtuelle Kleidungsanprobe verwendet werden, um Rücksendungen zu minimieren. Modelle können als Videos gerendert, oder in Echtzeit an PC oder in AR/VR interaktiv bereitgestellt werden.

Technical structure:
High End PCs mit Animations- und Visualisierungssoftware.
Rokoko Motion Capture System für Körper- und Finger-Tracking (kameralos und mobil). 3D Scanning. ggf. AR/VR Headsets

Augmented / Virtual Reality

Virtual reality/ Metaverse



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I4.0 application(s):
Training, education and simulation

I4.0 technology(-ies):
Virtual and augmented reality

Functional description:
In VR or AR, complex processes are visualized in 3D and can be trained interactively. VR glasses such as the Quest 2 offer wireless application possibilities. AR, e.g. with the HoloLens 2, allows virtual objects to be embedded in the real environment.

Possible problem-solving/process optimization:
Virtual Reality is particularly suitable for immersive environments, e.g. for the simulation of dangerous or rare learning situations, the visualization of planning projects for rooms or buildings, or medical rehabilitation (-> possibly with the integration of gamification).
VR in connection with the use of avatars is suitable for virtual meetings -> metaverse in VR.
Augmented Reality is suitable for visualization of objects or products, both for virtual prototyping, as well as for the purpose of training or marketing. By means of AR, virtual objects, instructions for use and training steps can also be integrated into the real environment.

Technical structure:
Meta Quest 2 Standalone, HTC Vive Pro or Microsoft HoloLens with PC setup.
AR can also be used via tablets or smartphones.
Unreal Engine/Unity for real-time environments.

Machine Learning

Self-learning neural controllers through machine learning

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I4.0 application(s):
Neural controllers, controller design

I4.0 technology(-ies):
Artificial Intelligence, Machine Learning, Reinforcement Learning

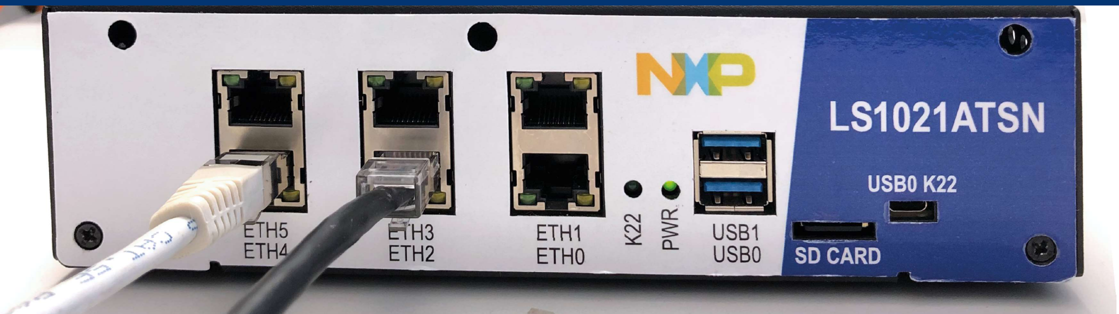
Functional description:
Using neural networks with machine learning and reinforcement learning, a neural controller is developed that independently learns the control of a non-linear technical system - for example in the form of an inverse pendulum. Open-source libraries such as TensorFlow and Keras are used on the Nvidia Jetson edge computer employed.

Possible problem-solving/process optimization:
The AI-based approach to controller design with machine learning enables the design of controllers without the effort usually associated with the design process for human experts.
Compared to using conventional controllers, the design is faster and expertise in control engineering is not mandatory. Also, the edge computer used is less expensive and more versatile than conventional systems for real-time control.

Technical structure:
The neural controller is run on an edge computer such as Nvidia Jetson and controls an inverse pendulum in this application example.

Networking Technologies

Dynamic machine-to-machine real-time communication with time-sensitive networking



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I4.0 application(s):
Real-time communication, machine-to-machine (M2M) communication

I4.0 technology(-ies):
Time-Sensitive Networking (TSN), OPC/UA (Pub/Sub) or MQTT as M2M protocols

Functional description:
Time-Sensitive Networking enables reliable real-time communication with constant, low latency in Ethernet-based networks.
Using various standards for time synchronization and traffic scheduling, network traffic is divided into classes. Each class is assigned previously configured time slots in which data transmission is guaranteed to occur. Central coordination instances dynamically control the configuration.

Possible problem-solving/process optimization:
Real-time traffic relationships between industrial plants can be dynamically set up and dismantled and additionally adapted to changing requirements. Thus, the communication of a production line can be reconfigured to manufacture another product in a short time.

Technical structure:
TSN bridge (e.g. InnoRoute TrustNode, NXP LS1021ATSN or TTTech DE-Switch Akro 6/0 TSN), central coordinating instance, end devices

Networking Technologies

Internet of Things wireless networks using the example of test and laboratory setups

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I4.0 application(s):
Internet of Things (IoT): Predictive Maintenance

I4.0 technology(-ies):
LoRa, LoRa Radio, LoRaWAN, Bluetooth 5.0, SigFox, WiFi

Functional description:
Transmitter and receiver (concentrator) modules enable efficient data exchange in the 433 MHz / 868 MHz / 2.4 GHz ranges, with license (SigFox) or license-free, narrow-band or ultra-narrow-band at low transmission rates.

Possible problem-solving/process optimization:
Transmission of sensor data over short and medium distances without costly retrofitting, energy-saving operation of sensor technology (in some cases even battery operation for years).

Technical structure:
several projects: Feather modules in the 433MHz range, WiFi modules, LoRaWAN modules (transmitter and concentrator), partly in test, partly in the lab.

Networking Technologies

Spectrum sandbox for IIoT wireless networks

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I4.0 application(s):
Among the best-known application examples are 5G private networks. These are networks based on 5G technologies that meet specific connectivity requirements within a limited area. 5G private networks are suitable for a number of different IIoT applications in the industrial sector.

I4.0 technology(-ies):
Spectrum Management, Cloud, Software Defined Radio (SDR), Network Function Virtualization (NFV), Machine Learning (ML)

Functional description:
The increasing use of network function virtualization, software-defined radios, and the ability to collect and process large data sets are enabling innovative solutions for radio spectrum sharing. Based on field trials, technical solutions to improve radio spectrum sharing will be investigated.

Possible problem-solving/process optimization:
Many IoT applications would benefit from automatic, local access to spectrum. Those where the need for spectrum access is variable over time or where variations in quality of service (QoS) can be tolerated are best suited for testing dynamic spectrum management approaches.
In general, automating the spectrum licensing process can shorten processing times, reduce human involvement, and make room for M2M interfaces through which a radio system can automatically obtain the license it needs to operate.

Technical structure:
Software-centric radios (SDR), smart sensors, cloud-native spectrum management system

Networking Technologies

M2M communication with the Hermes standard

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I4.0 application(s):
Machine-to-machine (M2M) communication

I4.0 technology(-ies):
Hermes standard as M2M protocol, Ethernet

Functional description:
IPC-HERMES-9852 is an open source standard based on the well-known TCP/IP protocol. Via Ethernet, machines of a production line exchange small amounts of data in XML format. The machines are either connected directly (peer-to-peer) or via an existing network infrastructure. Each production machine establishes a connection to downstream machines and acts as a server for them. It also acts as a client for upstream machines.
In a simulated production line, Hermes controllers are inserted as software nodes, allowing conformance tests to be performed and error conditions to be simulated in order to test the hardware controller without the need for further machinery.

Possible problem-solving/process optimization:
Cost savings through the use of standard components instead of proprietary hardware/software solutions („vendor lock-in“). The Hermes standard enables manufacturer-independent communication between machines - in this case PCB production - low complexity and high transparency simplify implementation. The upgrade of existing systems enables cost-effective retrofitting. Tip: A low-cost single-board computer can be used as a communication device on/in production machines (old or new).

Technical structure:
Simulation computers on which Hermes controllers are emulated. A GUI is available for the visualization of the processes.

Networking Technologies

Monitoring of Tree Populations in Municipal and Forestry Applications with 5G and mMTC

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More information:
www.ostfalia.de/forschung/forschungsfelder/digitalisierung/smart_country

I4.0 application(s):
Environment Monitoring, Smart Forestry, Smart Farming

I4.0 technology(-ies):
IoT, 5G massive Machine Type Communication (mMTC), LPWAN infrastructure (here: LoRaWAN), NB-IoT

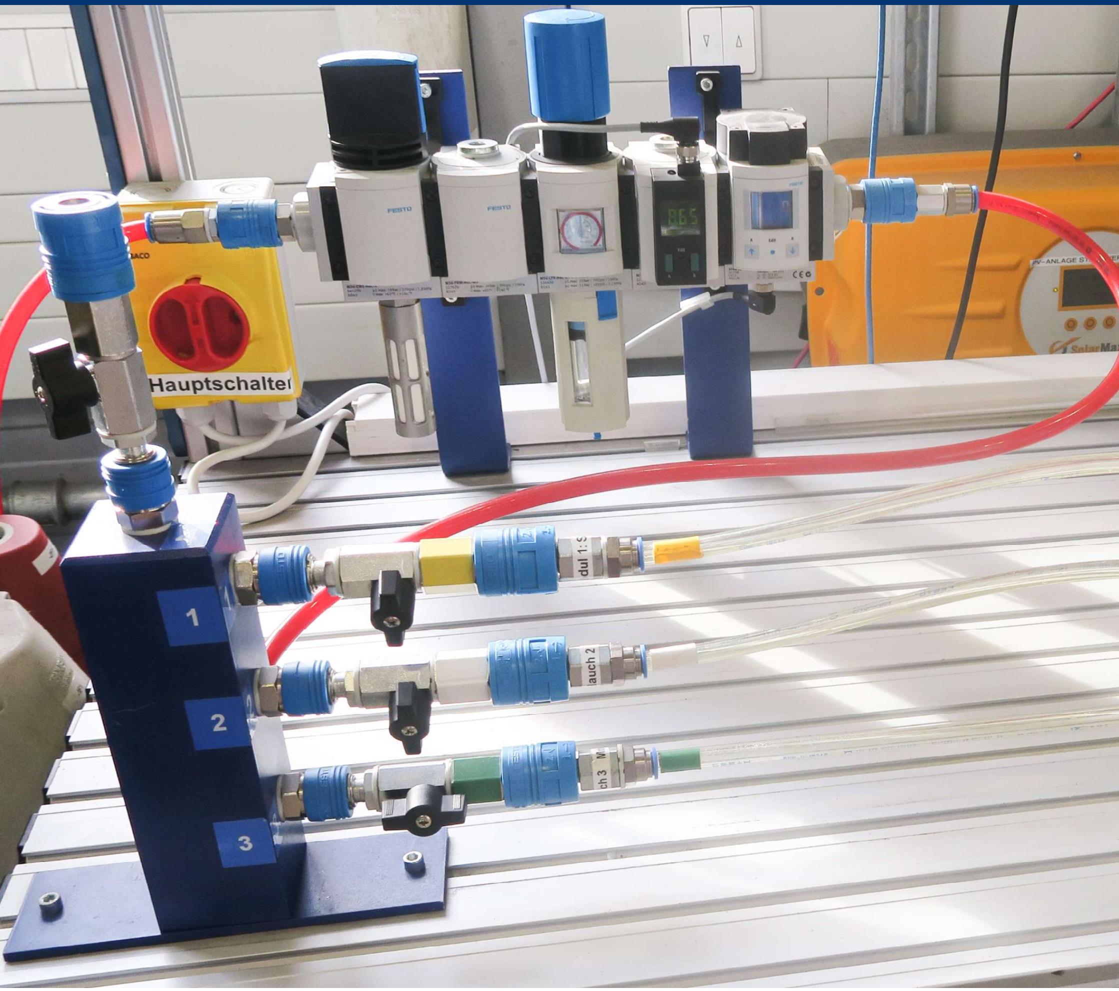
Functional description:
Environmental sensors equipped with an LPWAN transmitter unit are mounted on trees whose direct environment they monitor - e.g. for air and soil moisture, air and soil temperature, CO2 levels and photosynthesis values. Storage/processing of this data after transmission through an IoT wireless network in cloud environment.

Possible problem-solving/process optimization:
The transmission of sensor data from the tree population facilitates the work of forest owners, cities and municipalities. Continuous monitoring of the environment is possible, and the vital signs of the trees can be called up at any time via the cloud (time savings). Timber harvesters can use daily updated data to differentiate between timber qualities (securing and, if necessary, improving yields, targeted and sparing use of resources). Algorithmic analyses of the sensor data enable the implementation of location-based online early warning systems in order to react promptly and specifically to disturbance variables.

Technical structure:
Battery powered temperature, humidity, CO2 and photosynthesis sensors with Low Power WAN (LPWAN) radio module, public LPWAN infrastructure, cloud data storage and service for data processing/analysis and visualization.

Resource Efficiency

Digitization Measures for Resource Efficiency



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I4.0 application(s):
Energy and measurement data acquisition and evaluation (local and cloud-based), smart maintenance, visualization

I4.0 technology(-ies):
Digital Twin, AR / VR, Intelligent Sensor Technology

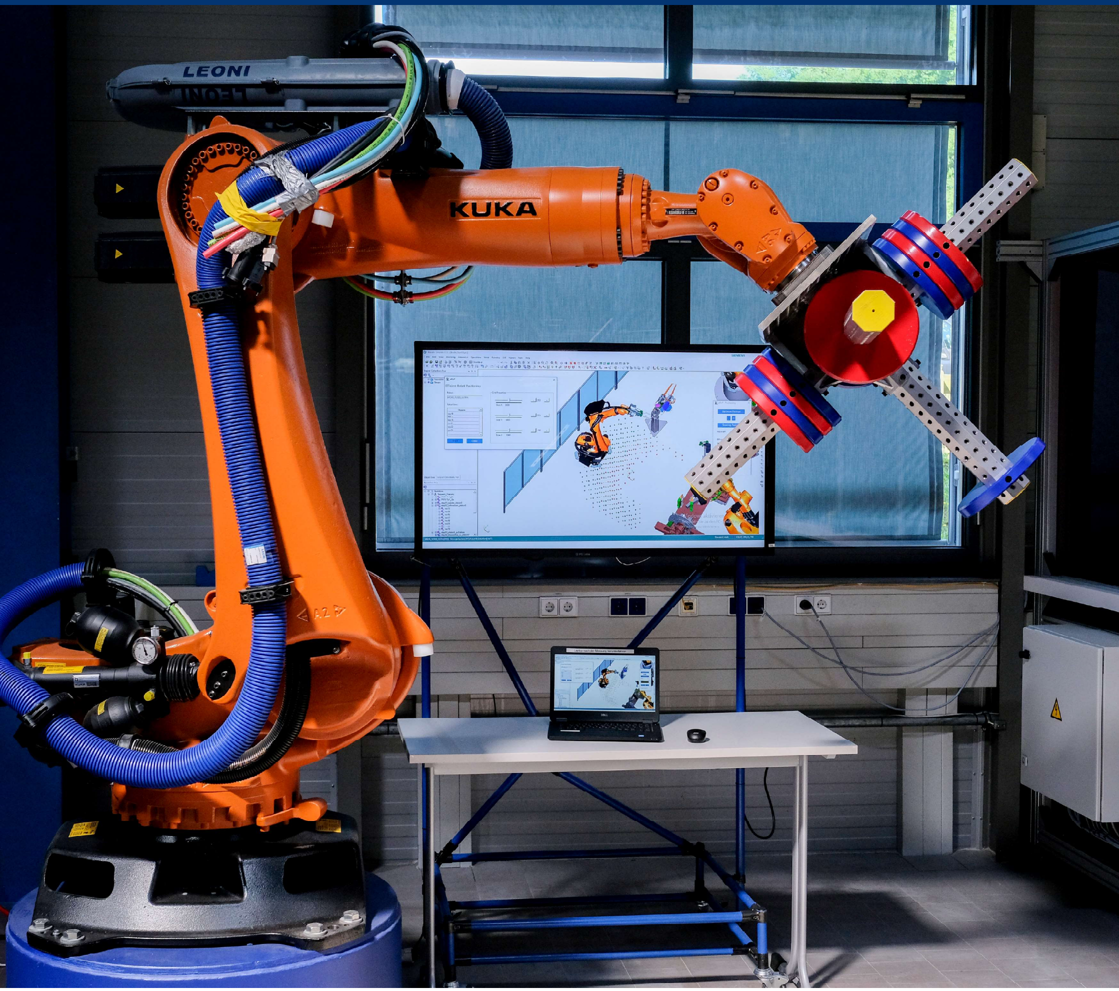
Functional description:
Measures for digitalization, such as the introduction of energy management systems, the use of sensors (here on more than 25 devices with over 300 measured variables, such as pressure sensors for detecting leaks, see figure), strategies for networking and database connection or the use of AI applications have a major impact on resource consumption in companies. The right approach to introducing such digitization measures is crucial for the achievable savings, and we offer training.

Possible problem-solving/process optimization:
Both the collection and the evaluation, maintenance and visualization of data are improved. Data can be processed in real time and thus reduce scrap and rework in manufacturing companies, for example. In development, for example, virtual products and plants are generated („digital twin"), optimizations are carried out and the worker is supported in production by visualization, which saves material, energy and thus also costs.

Technical structure:
Intelligent sensors, Energy data acquisition (incl. measuring case), AR/VR facilities like Microsoft HoloLens and Realwear HMT-1, Visualization, software like NX, MCD, PLCSIM-Advanced, Cloud connectivity, "Compressed air stand" (see figure) and "electrical stand"

Robotics

Energy Efficient Robot Operation



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More information:
www.ostfalia.de/en/forschung/research-areas/digitization/rg_robotics

I4.0 application(s):
Reduction and management of energy needs

I4.0 technology(-ies):
Robotics, sensors, computer-aided measuring technology

Functional description:
The energy needs of a robot can be determined via measuring kit and PC, potential energy saving measures can be found in the broschure (see "URL"), for example optimizations in positioning, tracking points, beginning of movement, home position, velocity, acceleration, brake application time

Possible problem-solving/process optimization:
Implementing the recommended measures for energy efficient robot operation directly leads to energy saving and thus cost reduction. Furthermore, data about the energy requirements of the used equipment can be acquired, which may not have been collected before (implementation of energy monitoring).

Technical structure:
Used for this case study: KUKA KR210, KR120, KR60 (210, 120 and 60 kg load capacity). Suitable for recommended measures: all industrial robots with said load capacity. Programming environment: online (Pad)/offline (PC).

- where appropriate: loop in the measuring kit
- where appropriate: using simulations software, Siemens Process Simulate as tool for implementing/visualizing the optimization measures (e.g. KUKA source code can be loaded into ‚Siemens Process Simulate').

Robotics

Camera-based Object Recognition with Adaptive Gripping

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I4.0 application(s):
Object recognition, pick-and-place, human-robot-collaboration, adaptive gripping

I4.0 technology(-ies):
Lightweight robotics, image processing, gripping systems, cobots

Functional description:
The camera system and the adaptive gripper are located on a ‚UR 10' by Universal Robots. The position of objects to be gripped is scanned and determined using the camera. In addition, already known objects are identified. The robot can grab objects and store them in a defined location based on this generated data. The adaptive gripping system allows the raising of objects of various geometries.

Possible problem-solving/process optimization:
The recorded camera images can be evaluated in many ways (object identification, quality assurance, avoidance of errors, ...). In addition, the overall concept is able to relieve employees of monotonous sorting operations and to be integrated as a semi-automated process into existing manual workplaces. Depending on the object viewed, ergonomic improvements can also be achieved.

Technical structure:
Lightweight robot UR 10 from Universal Robots,
Gripper from RightHand Robotics,
2D camera from Robotiq

Robotics

RID: Robot Input Device – Input Assistance for Positioning Simulations of Industrial Robots

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I4.0 application(s):
Robot programming, possibly: Control/Teaching of industrial robots

I4.0 technology(-ies):
Simulation: digital twin

Functional description:
A miniaturized model of an industrial robot can transmit its positioning via a USB interface to a simulation environment, in which a virtual model reflects the positioning. The necessary data ist provided by rotary angle sensors in the axes. In principle, any number of degrees of freedom is possible (in the model shown: 6 degrees of freedom). In the simulation environment, motion processes can then be displayed.

Possible problem-solving/process optimization:
The Robot Input Device (RID) can be used as part of further training measures on robot function or for simplified input during simulations (ergo as input assistance). Planning of positioning with haptic elements facilitates visual thinking and encourages energy-efficient programming (resulting in operation of the industrial robot with the lowest possible energy consumption).

Technical structure:
Miniature of an industrial robot, with rotary encoders on its axes: Pewatron 7S series (resolution: 400 pulses/revolution, meaning < 1°). Transmission takes place via a serial transceiver, which in turn polls the values of the rotary encoders.

PC software: "Tecnomatix Process Simulate"

Robotics

Self Learning Transport System (SeLeTraSys)

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I4.0 application(s):
Automated production logistics, machine-to-machine (M2M) communication

I4.0 technology(-ies):
Artificial intelligence, environment recognition, networked sensors, feature map

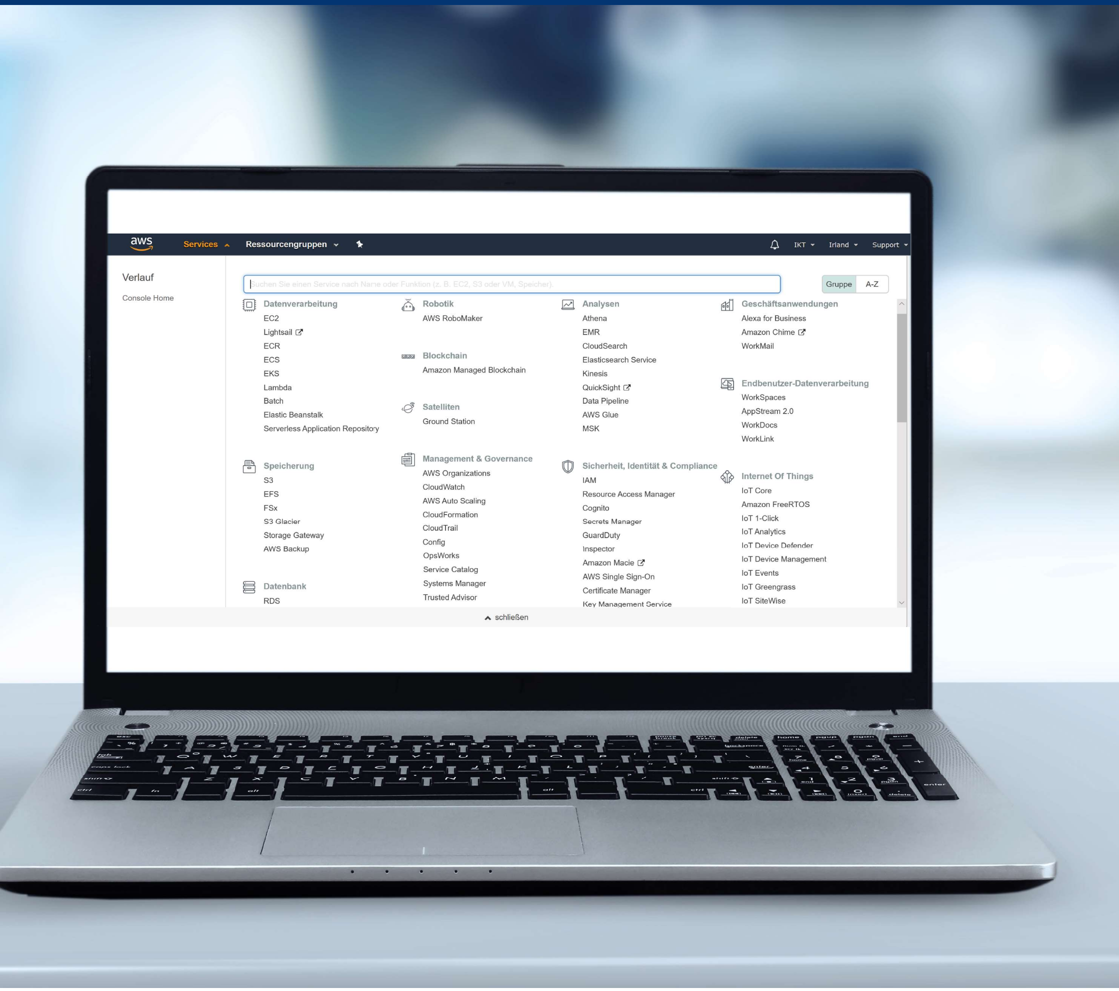
Functional description:
A central computer (control center) receives environment perception data such as obstacle detection/object classification, the location (camera/lidar data) as well as odometry and tactical information such as loading status of the transport vehicles. The computer generates a digital map (feature map) of the warehouse/production environment and returns it to the transport vehicles, which autonomously calculate the route to their destination. Points of interest (PoI) such as loading bays, fixed loading points (logistics nodes, parcel transfer points) can be entered into the feature map.

Possible problem-solving/process optimization:
The present transport system operates independently of existing infrastructure and can mark and avoid obstacles in real time. Except for loading cycles and maintenance appointments, no operational interruptions are required. With the self-learning transport system, personnel can be supported or can devote themselves to more complex tasks in parallel. Logistics processes in production and warehousing are accelerated. In addition, the physical strain on employees can be reduced.

Technical structure:
Central computer: conventional or virtual machine (VM) with UNIX-based operating system; control computer transport vehicle: industrial PC „Advantech MIC-7700"; environment/vehicle sensors: lidar, industrial grayscale camera, infrared sensors (optional)/steering angle and speed sensors. Wireless communication via WLAN.

Reusable Software Building Blocks for IoT Applications

Services in the Cloud



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I4.0 application(s):
Internet of Things (IoT) applications in industry, pharmaceutical, medicine, agriculture

I4.0 technology(-ies):
AWS (Amazon Web Services); MQTT, hybrid automation

Functional description:
Data from IoT sensors is transmitted to IoT clouds via Machine-to-Machine (M2M) protocols and can there be processed with a multitude of different software modules. Besides classic data storage and analysis, many innovative software functions are available as services, IoT-related functions in particular.

Possible problem-solving/process optimization:
Low cost compared to conventional automation solutions, standardized and vendor-independent solutions, short implementation time for innovative solutions, for applications like e.g.: predictive maintenance, preventive maintenance, smart monitoring, hybrid automation, basis for the use of Artificial Intelligence (A.I.) for automation purposes, dynamic, event-based visualization, open interfaces, e.g. for connection to ERP, high availability device management

Technical structure:
In this showcase data from various IoT sensors (e.g. temperature, movement, air pressure, humidity ...) is transferred to an IoT cloud via IoT radio technologies. For this purpose gateways are used to translate the sensor data from IoT radio protocol to classic IP-based communication. Afterwards the sensor data is sent to the IoT clouds via cellular router, where they lastly get processed by IoT applications from reusable software modules.

Digital Version (PDF):
www.ostfalia.de/en/forschung/research-areas/digitization

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