helbling

Scientific Informatics

Digital solutions for a brighter future

Helbling Technik
Innovation, together we do it

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The world is constantly changing. New lifestyles, new desires, new insights, and new goals demand effective solutions tailored to market requirements and expectations. Long before innovation became a buzzword, Helbling valued its importance and began to specialize in working alongside clients as a dynamic, reliable partner, helping them to secure a competitive advantage in a changing landscape. Based on your requirements, we assist you in designing your technical product and developing it through the stages from ideation, conception to design verification, design transfer, and all the way to successful market launch.

Powerful teams and infrastructure

Helbling Technik operates innovation centers in Switzerland, Germany, the USA, and China and employs over 500 professionals including engineers, computer scientists, physicists, and human factors experts, with backgrounds from applied science and medicine to behavioral psychology. Since more than 60 years, cross-functional teams at Helbling have been relying on professional infrastructure and proven methodology to develop a wide range of innovative products for a range of sectors such as industrial, medical and consumer.

Together is better

Helbling Technik's mission statement is "Innovation, together we do it". This vision provides a uniform understanding of the innovation process, even though each of our 14 innovation centers features a different, complementary technological focus. The vision's core theme is that we innovate together and not in isolation. The collaborative process begins with a rich spectrum of novel ideas that address our clients' needs, which are then combined to create innovative, promising technology and product developments. Converting concepts into successful and profitable products requires an even more collaborative approach that involves Helbling and its established and trusted partner network and, of course, our clients. Our project and quality management as well as our execution expertise, enable us to coordinate all the participating parties effectively, paving the way to success for our clients.

We are specialized in scientific informatics

Data science

We extract insight from data and apply it to solving problems in a wide range of domains. Our approach is holistic and includes understanding the data source, be it a business process or physical sensor, and its destination, be it to informing people or triggering automated actions.

Intelligent sensor networks

Sensors are the source of data and information acquisition. We develop sophisticated sensors and connect them into elaborated networks that enable industry 4.0, IOT, digital health and other applications.

Computational modelling and simulation

We model and simulate complex systems to understand their behavior and limits. In addition to theory and experiment, computational modelling and simulation provides a third and often complementary approach for gaining new insights and developing technological innovation.

Connectivity and communication

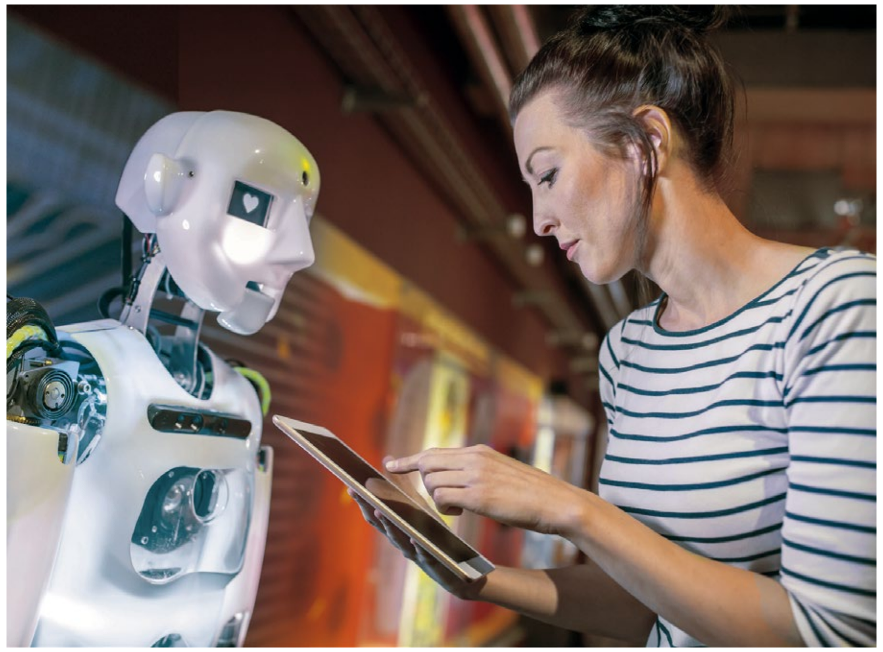
Today's products provide additional benefits through connectivity. We enable comprehensive user experience, efficient manufacturing processes and new business models by means of interconnectivity.

Computer vision

A wide range of fields profit from the automated ability to make sense of visual input. We develop algorithms which allow computers to extract relevant information from digital images or videos.

Scientific informatics

Scientific Informatics is the use of fundamental and scientific concepts and technologies for capturing, processing, storing, transmitting and displaying data/information.



Trends & technologies: The future has only just begun

Scientific informatics is about much more than software and encompasses areas such as data processing, artificial intelligence, data security, modelling and simulation – technologies with increasing importance for future use cases and products in a digitalized world.

It is only around 80 years since the invention of the first computer, and roughly 55 since the birth of the internet. Inventions such as smart phones have already changed most aspects of our lives and the transformation process is continuously accelerating and expanding in hitherto untouched areas. Informatics is having a big impact on every aspect of our lives. Its applications are all around us, even if we don't notice them. In all aspects of our civilization, we make use of the powerful functionalities of electronic data processing, be it in medicine, industry, agriculture, consumer, or infrastructure. The possibilities seem inexhaustible. If applied appropriately and responsibly, scientific informatics will help to improve our lives – and at Helbling Technik, we're already hard at work making this into a reality.

Research meets engineering

At the core of scientific informatics is the application of basic concepts and technologies to capture, process, save, transmit and visualize data or information. This vast field comprises both basic research topics as well as engineering disciplines.

While it has long been an implicit part of our technological development efforts, Helbling has increased its focus on establishing exhaustive and wide-ranging knowledge in scientific informatics.

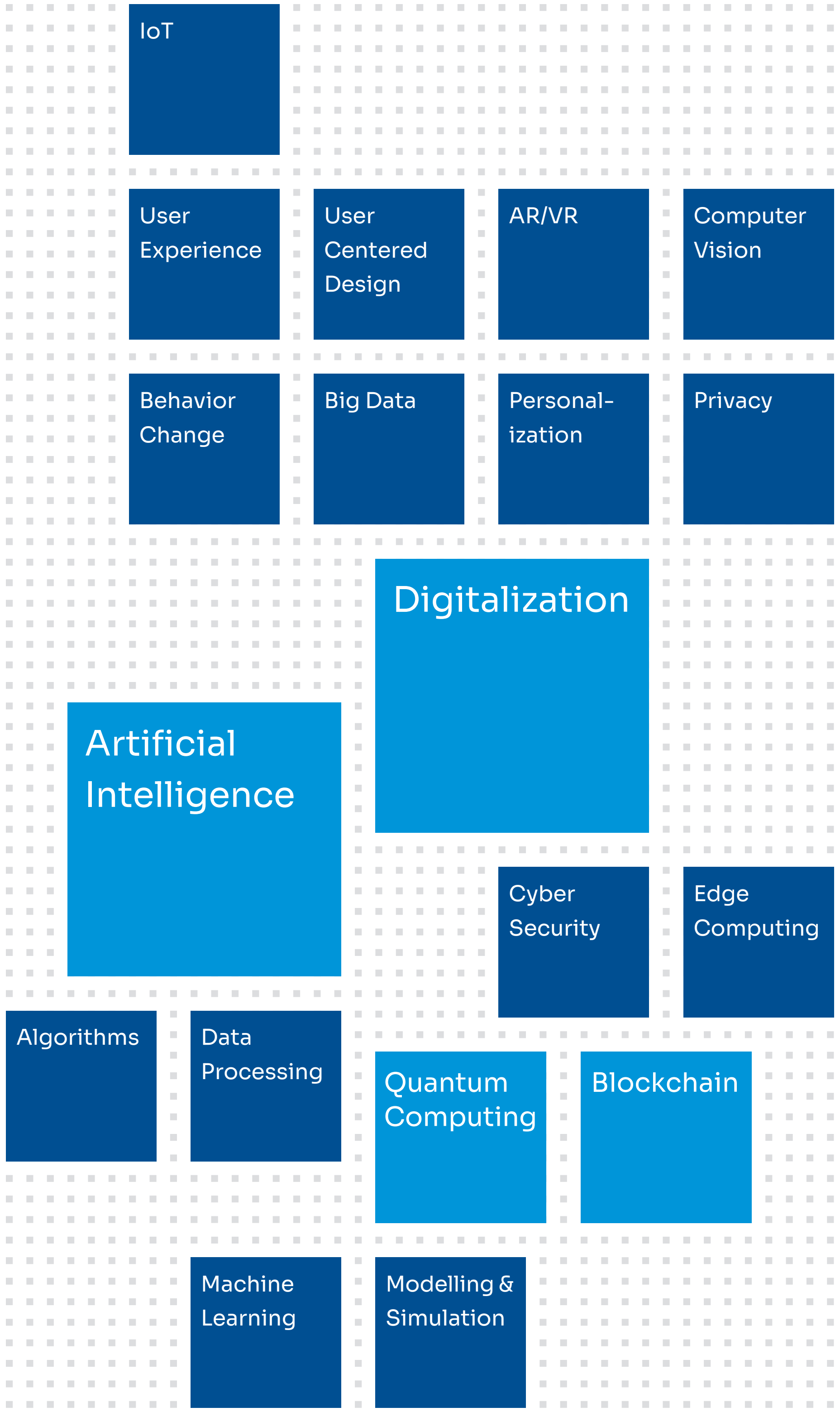
We have persistently pursued the relevant technologies and methods, such as advanced data processing, cyber security, and edge computing, and internalized them across our entire service portfolio. Hence, Helbling is well prepared to play an active role in today's key trends such as digitalization, artificial intelligence, quantum computing, and distributed ledger technology.

Tomorrow's use cases

Elements of scientific informatics can be found in different areas and represent the hallmarks for various systems. In the following section, we illustrate how the toolbox of scientific informatics can be used to address diverse challenges of tomorrow's use cases. Understanding the advantages as well as the limitations of a technology is key to successful product development.

Scientific informatics toolbox

#augmented intelligence
#augmented/mixed reality
#autonomous navigation
#behavior change
#computer vision
#digital twin
#edge computing
#federated learning
#hyperspectral imaging
#image processing
#infrastructure monitoring
#numerical simulation
#patient motivation
#pattern recognition
#personalization
#predictive maintenance
#predictive quality
#privacy
#psychological modelling
#real time
#real world data
#reinforcement learning
#sensor networks
#small dataset
#smart factory
#supervised learning
#unsupervised learning



With great power comes great responsibility

Security and accountability are fundamental to every scientific informatics process: cybersecurity and responsible AI are the fundamental challenges that run as a common thread through all our projects.

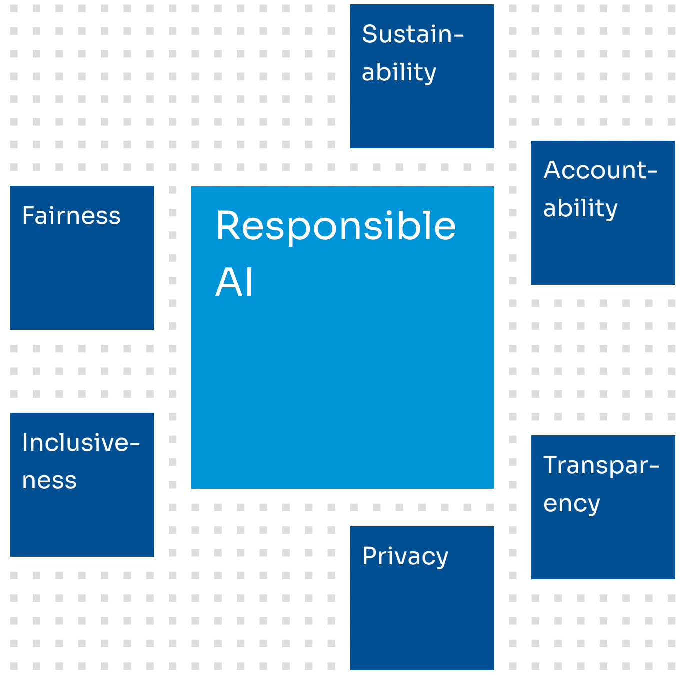
Cyber security – by design

The number of connected devices connected worldwide continues to grow rapidly and will reach 38.6 billion by 2025, according to Statistica. Every second, 127 devices are connected to the internet.

The trend towards personalized products increases the demand for cyber security as it requires the collection of sensitive personal data and makes security threat mitigation more important than ever.

Cyber security cannot be addressed as an afterthought. It must be handled “by design” and be part of solution architecture and ongoing security practice. Helbling leverages its expertise to address these challenges by following a general principle well known by security engineers: Zero trust. Always verify, never trust, and assume breach.

This principle can also be adopted for machine learning (ML). Data poisoning is one of the biggest security threats in ML today. That is, if data integrity is not verified, an attack may reduce the quality of data models and may even cause physical harm or risks to products and services. On the other hand, in privacy-sensitive applications, e.g., medical diagnostics, so called model inversion attacks attempt to recover private data that were used to train a ML model. Preventing attacks requires awareness of them and careful checks not to expose sensitive data in any way – in other words, security by design.



Governmental regulations for motivating responsibility-aware development are still in an early stage. An important European baseline is the General Data Protection Regulation (GDPR) which states a human’s right for explanation of algorithmic decisions which concern them.

Responsible AI

Artificial intelligence (AI) is creating new opportunities and will achieve a transformative impact on our lives and businesses. Responsible AI is about ensuring consistency with societal laws and norms. The root cause for irresponsible AI is a bias in the data used to create AI algorithms. The underlying prejudice can ultimately result in discrimination and other social consequences.

Many real-life examples of AI bias have been reported in the past years. For example, an AI algorithm trained on data from approx. 50,000 patients favored white patients over black patients when predicting which patients would likely need extra medical care. The algorithm has been used on more than 200 million people in U.S. hospitals.

Another danger lies in self-fulfilling prophecies, i.e., ML models whose predictions impact what they aim to predict – and which are likewise typically biased. For example, U.S. courts use a model to estimate the probability that a convict will become criminal again. The higher the probability, the harsher the punishment – but the longer the sentence, the more likely the recidivism.

Helbling is committed to ensuring responsibility through our code of conduct, which demands “responsibility toward society and our complex environment”. Building responsible algorithms means conducting analysis and taking measures to protect people or the environment. First, we question and carefully verify if training data is representative and allows for generalization. Second, we apply methods for increasing an algorithm’s interpretability and explainability. Third, we evaluate whether unwanted side effects or a self-fulfilling prophecy are at hand.

Tools & methods

Interdisciplinarity

To provide our clients' projects with the best support, Helbling relies on disciplined system engineering and the ability to combine different competences for designing, integrating, and managing complex systems over their life cycles. Extensive and wide-ranging understanding of the interacting engineering disciplines around scientific informatics is vital for successful design and development initiatives.

Sound methods & iterative approaches

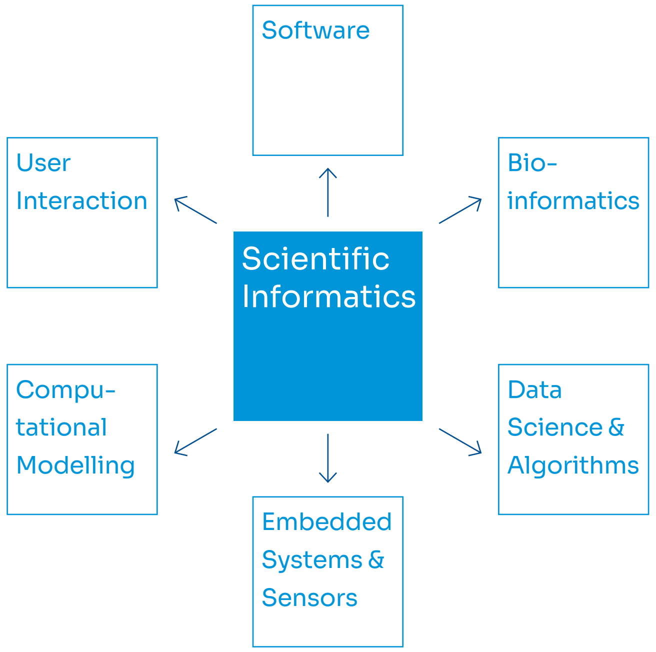
We are convinced that quality is achieved and maintained through appropriate methodology and scientific proceeding. Throughout the development process, we focus on

1. clear problem understanding and structuring with a goal and an expectation oriented mindset
2. unbiased solution finding by combining extensive knowledge with creative minds
3. rigorous and reproducible implementation
4. holistic and integral evaluation

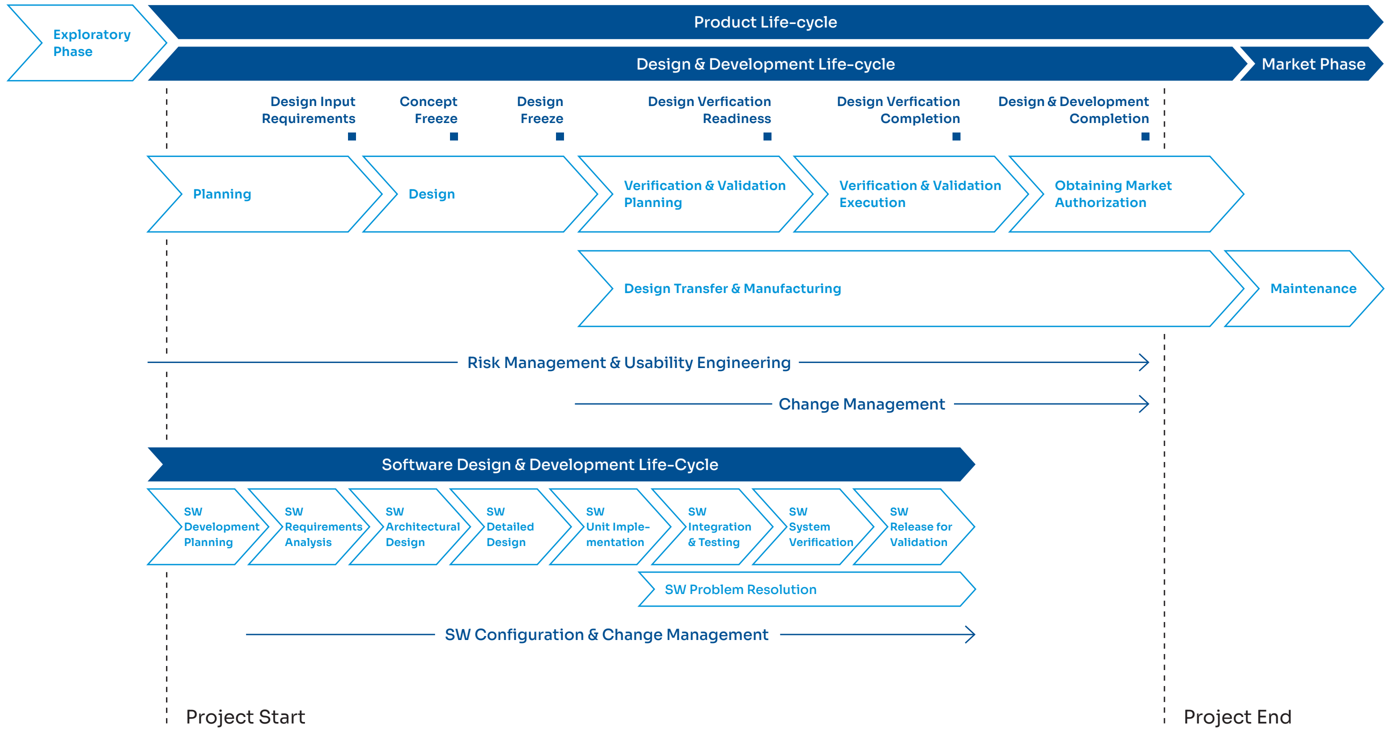
Development infrastructure

Helbling relies on professional design tools and qualified in-house lab infrastructure:

- dedicated data processing hardware for resource-intensive tasks
- state-of-the-art software development toolchains and scientific computation tools
- fully equipped hardware test labs



Proven processes for your project



Quality management systems

Certified quality management system

Helbling Technik is certified according to EN ISO 9001, EN ISO 13485 and EN ISO 14001. Our quality management system guides our project management and development efforts in all our engineering faculties.

Medtech development needed?

Helbling operates an EN ISO 13485 and FDA 21CFR 820 compliant quality management system, including IEC 62304 and IEC 62366 compliant medical device software development and usability engineering services. The development processes can either be operated "as is" for full compliance with EN ISO 13485 standards, providing a compre-hensive set of documentation for full design control or else adapted to specific customer needs.

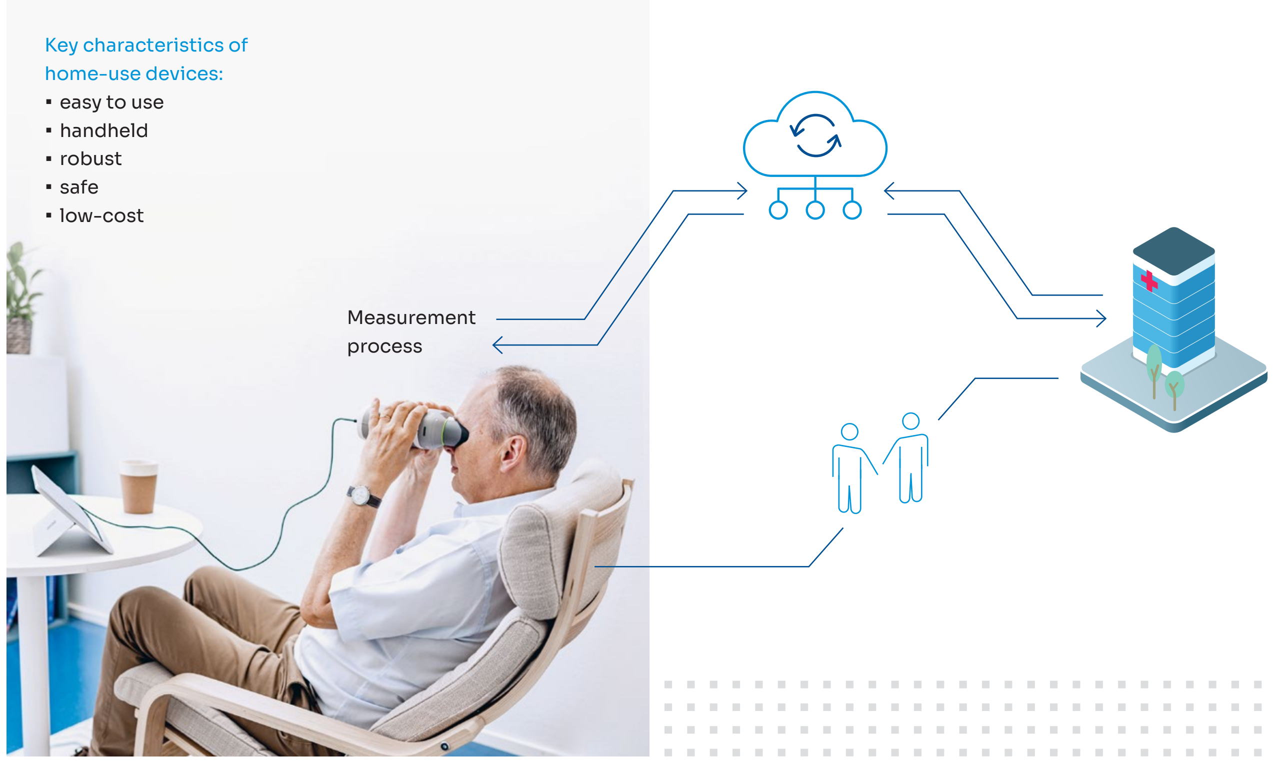
Enabling healthcare at home through home-use devices

Efforts at bringing healthcare closer to the patient can be seen as a fundamental shift throughout the health care industry. It is enabled by point-of-care devices, connectivity, and intelligent algorithms. Close monitoring of the health status of patients also accelerates the transition of healthcare reimbursement from "treatment-based" to "outcome-based".

Millions of people worldwide suffer from wet age-related macular degeneration (wet-AMD), which is a chronic eye disorder that causes blurred vision or a blind spot in the visual field. State-of-the-art treatment is based on repeated injections into the eyeball. Precisely scheduling these injections is thus critical. If a patient is called in too late, undertreatment and unnecessary vision loss are the consequences. If patients are called in too early, unnecessary visits happen and costs occur accordingly.

By providing a home-use medical device to patients with the respective diagnosis, the scheduling of injections can be optimized. The patients use the device to monitor retinal thickness and the size of fluids pockets, which are reliable indicators for disease progression. The measurement data is automatically processed and transmitted to the cloud where it can be accessed by authorized healthcare professionals. An alert is triggered if the disease progresses, which allows for the scheduling of patient visits when needed. Moreover, non-responders to medication can be identified early.

Home-use devices need to overcome two major challenges compared to similar instruments used in a clinical practice. First, the ease-of-use is critical as patients use the device on their own. The solution is to reduce manual operation steps through automation. Second, the device needs to be low-cost in order to be commercially viable. Sophisticated signal processing and powerful computational resources compensate for imperfections in low-cost components. By overcoming the challenges, a convincing product could be created.



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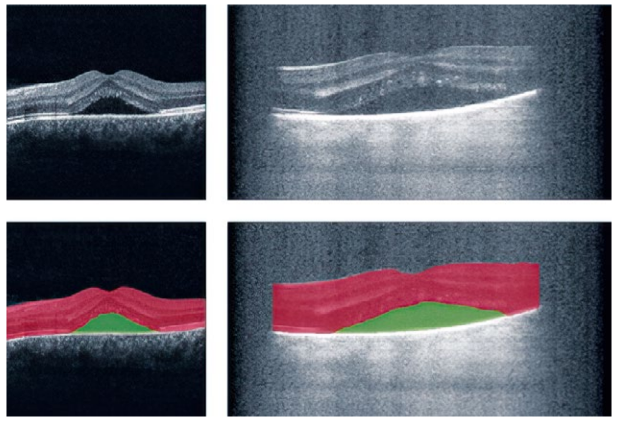
Machine learning with small datasets

To extract as much information as possible from the low-resolution retinal image, a deep neural network is deployed. Gathering medical data for training the network is time-consuming and expensive as it involves clinical studies and highly skilled medical personnel. Several techniques facilitate usage of small datasets:

- Selecting an appropriate network architecture
- Data augmentation and transfer learning
- Retracing of model decisions to detect irrelevant data properties



Data privacy

Personal health data is sensitive and needs protection. A comprehensive data strategy ensures privacy "by design"; it implements the following principles:

Encrypted personal health data – at rest and in transit.

Data minimization through data retention policies and procedures.

Isolation of data: one doctor never gains access to another doctor's patients' data.

Data de-identification: data is anonymized for training machine learning models. For retrieving patient specific measurement results, pseudonymization techniques can only relink to the patient with additional secret information.

Use case 2

Monitoring of plant growth through precision farming

Traditional farming can be inefficient and ineffective as it often relies on decisions involving low granularity. Modern technology is, however, ready to take farming to the next level. Main drivers for this development are autonomous navigation, remote sensing with drones and satellites, and the digitalization of workflows.

Traditional farming relies on decision-making based on few data points from various sources, e.g., manual inspection of the soil at a few locations, weather forecast in the newspaper, and generic pesticide concentrations recommended by the chemical suppliers. Monitoring of plant growth and plant protection is performed on a large scale, typically per field, but the states and needs can vary even among neighboring plants. This mismatch in scale is inefficient and ineffective. Modern technology provides remedies and improvements for all these aspects.

Today's sensing possibilities are manifold, incl. remote sensing by satellite and drones combined with local sensors mounted on farm machinery on the field. Drones are able to provide high-resolution hyperspectral images revealing soil moisture, nutrient deficiencies, disease infection, and pest infestation. Local sensors include vision systems for weed detection and movement sensors on farm machinery to accurately track its trajectory. Thus arises a fundamental change in farming: it becomes possible to precisely monitor and maintain on a per plant basis or to even select ripe fruits for harvesting on a per fruit basis. This change reduces the impact on the environment while saving costs on pesticides. Time planning is optimized through knowing the specific ideal timeframes for plant protection measures and harvesting.

#hyperspectral imaging
#autonomous navigation
#sensor networks

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Autonomous navigation

Autonomous navigation relies on sensing and interpreting of environmental information for orientating and steering. It builds a dynamic map and keeps it updated for dealing with unknowns and changing conditions. However, navigations rely not only on the dynamic map, as, sometimes immediate reactions to deviations from the current map may be required. The wide range of applications requires a coordinated range of sensors for monitoring the environment, such as laser-based sensors (LIDAR), two or three-dimensional camera systems as well as ultrasonic sensors or capacitive sensors. Algorithms tailored to each device and purpose evaluate and fuse sensor data for localization as well as dynamic planning of the path to the intended target.

Hyperspectral imaging

While conventional images contain information about the visible spectrum, hyperspectral images can cover a larger part of the electromagnetic spectrum at a higher resolution. They are acquired by either scanning the wavelength or the location, or through snapshot mode. Hyperspectral images are not flat, but 3-dimensional data cubes. Dimensionality reduction methods help manage the resulting large datasets and handle highly correlated spectral bands. Transformations such as principal component analysis or maximum noise fraction remove redundant information. The processing step of spectral unmixing allows interpretation of hyperspectral images and derivation of characteristics such as soil moisture, fertility, and other chemical or physical properties.

Use case 3

#reinforcement learning
#predictive quality
#smart factory
#augmented intelligence

Coating quality control for high-tech films to ensure a continuously increasing performance

Modern manufacturing must meet high quality demands. Technologies such as connected sensors for continuous monitoring of a production process, augmented intelligence for operator support, and machine learning for automated line control enable meeting these demands while reducing waste, time, and costs.

On a production line, high-tech films are coated under vacuum with several thin layers of varying materials. Quality demands are high; a deviation of one nanometer in layer thickness can ruin the product. Since uncoiling and re-coiling must also be done inside the vacuum, all coating steps are performed in the same vacuum, and the coating quality can only be measured at the end-of-line test. Hundreds of parameters impact the coating quality, ranging from line configuration over physical states inside the coating cells to film properties like the humidity level of the coil.

Configuring the line for a product requires several test runs – costing time and resources, – and small irregularities can slowly build up over time, leading to a loss in quality. Furthermore, there are no hard rules on how to configure the line or how to correct for irregularities; instead, operators adjust parameters based on their individual experience. Even if the manufacturer's expertise as a whole is superb, leveraging the internal know-how is time-consuming and highly dependent on the individual experience of the operator at hand.

Gathering all relevant information – measurements from the coating cells and the end-of-line tests, the configuration of the line, actions of the operators, visualizations of automatically processed data – enables monitoring of coating line performance in real-time. The data collected by this connected factory then provides the basis for training an artificial intelligence (AI) for predictive quality. It evolves over time, first supporting the operators (augmented intelligence) while at the same time learning from the operator's example (apprenticeship learning). Finally, the AI takes on full control of the coating line, increasing performance and reducing time and costs.

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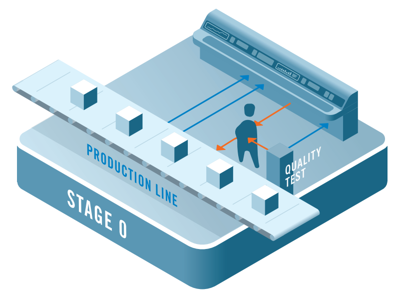
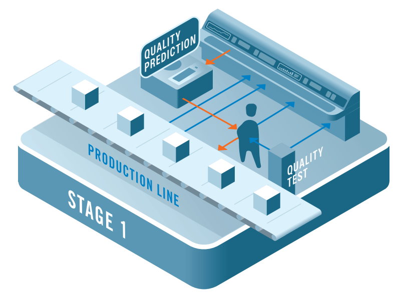
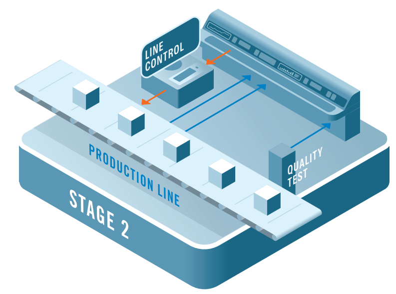


Connected factory
Processed real-time data from the line keeps operators and management up to date. Connected actors along the line enable remote control of the production process.



Augmented intelligence
During production, a stream of online process data is fed to the algorithm for quality predictions. A GUI displays the latest quality measurements and predicted quality of the processed products. It also recommends correction measures and allows the simulating of the effect of configuration changes. The capabilities of operators are enhanced through AI and permit them to react faster to quality issues, even before they can be measured.



Apprenticeship learning
While supporting the operators, the algorithm continuously learns both from process data and from the example of experienced operators. Since there is no ground truth for correct configuration changes, the AI is trained to imitate the operator actions. At the same time, the operator's decisions are enhanced by the increasingly improved recommendations. In an iterative process, each version of the AI learns not just from the operator, but from the augmented intelligence of the operator and the previous AI version. Once the operators start to consistently follow the suggestions, it is given autonomous control of the coating line.

Improving quality of life for patients through early recognition of neurological disorders

#real world data
#privacy
#federated learning
#unsupervised learning
#pattern recognition

Multiple sclerosis (MS) is a chronic neurological disease affecting millions of people, currently without a known cure. It causes acute attacks during which patients have to drastically adapt their everyday activities. Patients would thus greatly profit from accurate predictions. While this was hitherto impossible, large-scale, real-world data from modern sensors and predictions, and sophisticated data science are poised for changing the game.

Modern sensor technology allows acquiring patient data in a real world setting on an unprecedented scale. The integration of commercially available components renders the latest generation of patient monitoring sensors less costly and feasible for mass use.

Wearables improve patients' quality of life by providing real-time feedback and treatment recommendations, omitting the burden of visits to a clinic. They are also broadly accepted data acquisition devices, for example, in the form of a digitally enhanced bracelet. Wearables come equipped with various sensors e.g., typically for tracking the motion of a patient (gyroscopes, accelerometers, GPS), acquiring physiological data (heart rate, oxygen saturation, skin temperature), gathering data from the patient's environment (sound, humidity, temperature), and many more.

Sensors on thousands of patients gather huge amounts of real world data. In combination with data from clinical research and with dedicated processing algorithms such as pattern recognition, the identification of diseases and the prediction of the disease progression become possible. The advent of scientific informatics will thus provide invaluable intelligence for entering into a new era of personalized, multi-disciplinary approaches for disease management.

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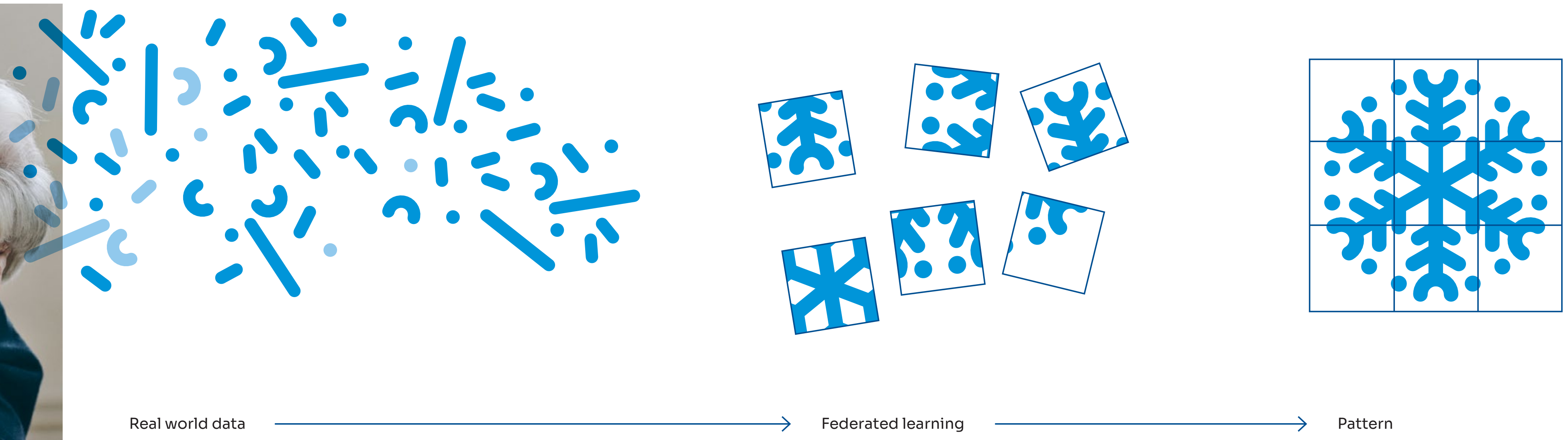
Real world data
State-of-the art data analysis methods combining clinical and real-world data (RWD) can help to better understand the disease. These methods yield high granularity for each patient since they rely on individual prediction models. Still, meaningful output can only be generated if the data can be exploited. Manual labeling of the accessible data sets would be extremely cumbersome. Luckily, unsupervised machine learning does not require data to be labeled. It can process electronic health data from an activity tracker for detecting patterns and anomalies on its own. The processing of combined RWD with historical health data sets ultimately leads to the identification of disease progression patterns.

Federated learning
In federated learning, devices (the nodes) acquire the data locally. The raw data does not leave the node and is used to locally train a model. The approach is particularly suited for unsupervised learning. Only specific parameters are shared in order to further train and optimize the models on other nodes. Federated learning reduces the amount of data transmitted and thus helps to achieve security by design.



#digital twin
#numerical simulation
#predictive maintenance
#infrastructure monitoring

Monitoring infrastructure through digital twins

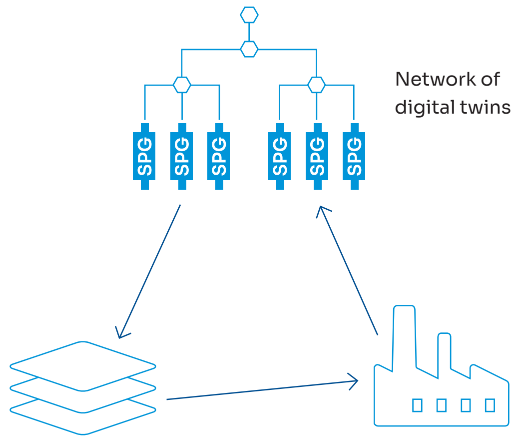
Cleaning Waste to Energy (WtE) boilers in incineration plants represents a tough challenge due to tenacious slagging. Shock pulse generators efficiently conquer this difficulty; basically, they induce shock pulses by explosions, therein blasting away slag. Sophisticated numerical modelling enables investigation of aspects such as shock propagation or structural loading. So-called 'digital twins' provide thorough understanding of the working principle and allow testing and optimizing of the system in a safe and efficient way through a virtual environment.

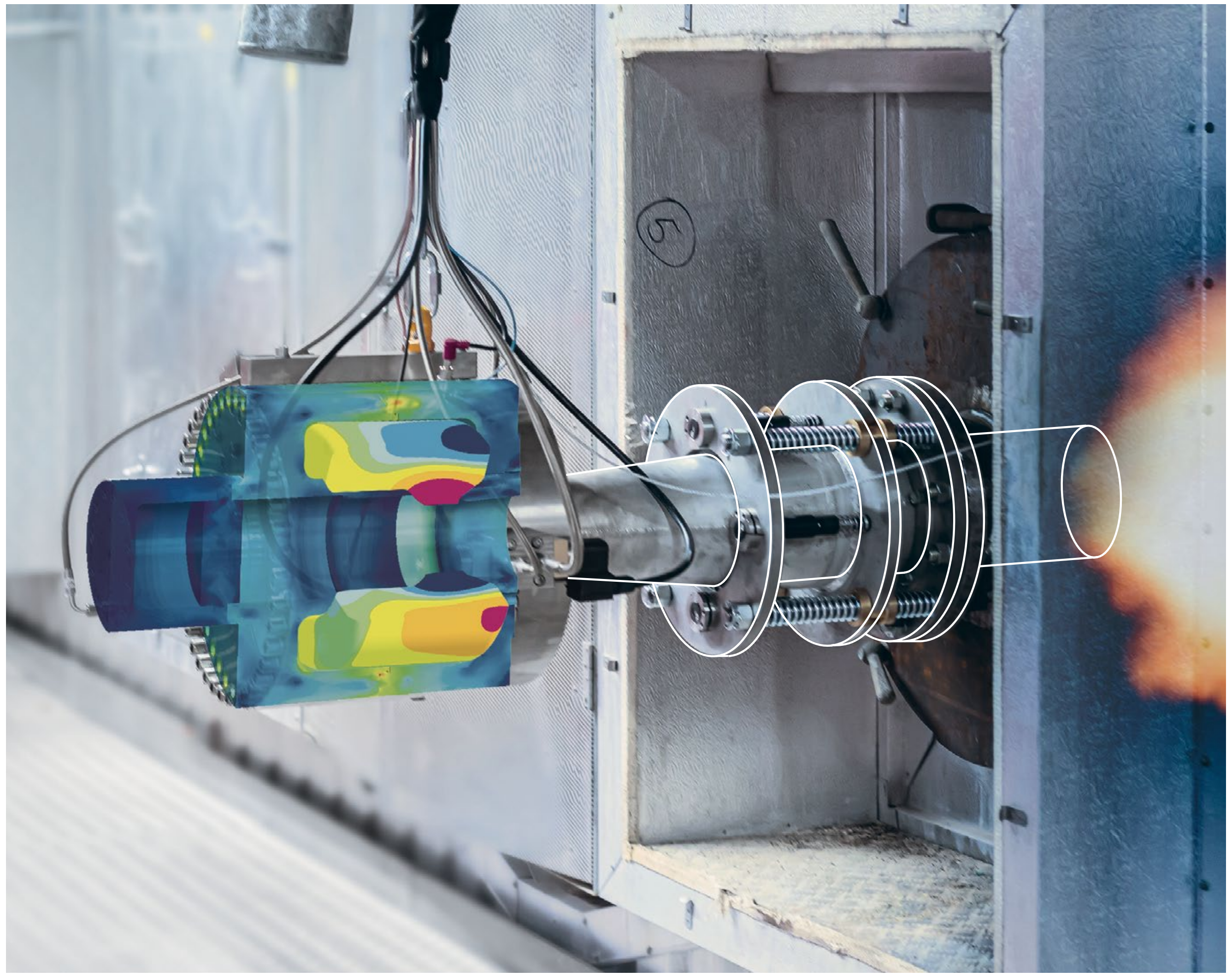
Shock pulse generators (SPG) initiate swift combustion of a gas mixture outside the WtE-boiler, causing a spherical shock wave in the boiler through a supersonic nozzle. Propagating through the WtE-boiler, the shock wave removes slag and other deposits. This provides longer operating periods, higher system availability, and lower maintenance costs. A critical tool for targeted product development and for ensuring the safe and efficient operation of these SPGs are digital twins.

First, while already deployed in WtE-plants, the functionality of a SPG is not fully understood due to the intricate coupling of various disciplines of physics involved. In the form of numerical models of individual aspects or components, a digital twin provides a deeper understanding of complex phenomena, e.g., explosions, and how to exploit them.

Second, as the SPG must govern an explosion, each system requires accurate control and thorough testing before commencing operations. Virtual commissioning facilitates this process. That is, a digital twin of the real machine can be understood as a network of "small digital twins", representing all relevant components of the SPG such as gas lines, valves, actuators, sensors, etc. To accurately simulate the behavior of components and system, both the individual digital twins and the network are validated with operational data. This approach allows thorough testing of the control software and optimization of the components in a virtual environment. A digital twin is used to train operating personnel and demonstrate the operation of SPGs.

Digital twins offer manifold benefits: They enable real-time monitoring and control of a machine or system. They allow testing of a wide range of operating states, especially those that are difficult or even dangerous to assess in real life. They increase product quality, guarantee the reliability of updates, and shorten time-to-market.





Simulation-based engineering

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Machine learning models
Digital twins that use complex physical models can be computationally intensive, which is a limiting factor, particularly for real-time applications. By combining them with machine learning, digital twins can be replaced by computationally efficient algorithms. More data increases precision and reliability of the results. With digital twins, the breadth of data can be extended, for example, into areas where no measurement exists because it would be too dangerous or expensive.

Networks of digital twins
Digital twins are virtual representations of real products, machines, processes, or entire plants, accompanying them through the entire value chain as digital shadows, continuously updated by operational, measurement, or other data. Single "physical" digital twins enable the efficient dimensioning and optimization of products such as the SPG. In combination with other digital twins, a composite simulator of a system results. The collected information of one or several systems not only helps to optimize operation, but it also supports designers and engineers to develop next generations of products.

Simulation-based engineering
Simulation applications contribute to optimizing and shortening product development and enable the investigation of the behavior of complex components, products, or processes under diverse physical circumstances. The analyses are based on characteristic models, whose validity and evidence are further increased by verification with measurement data. Through improvement of explanatory power and validity of such models, a digital twin arises.

Digitize labs
for an improved work flow

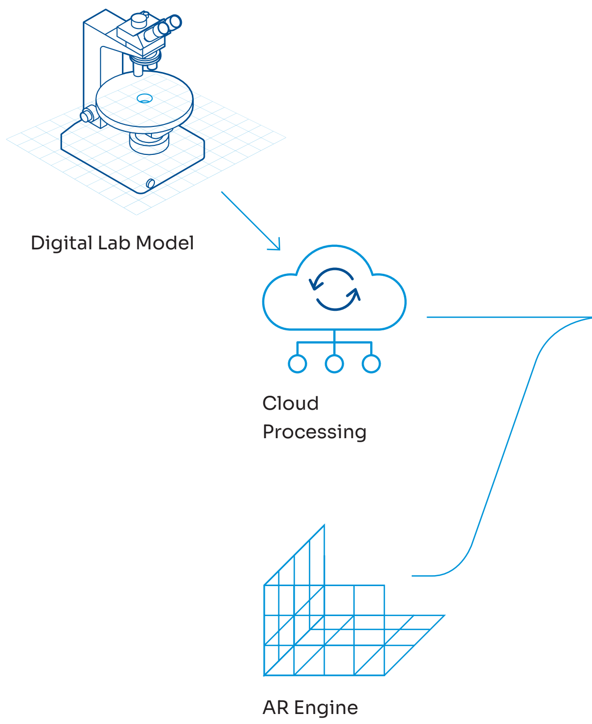
Modern monitoring and user interface technologies set new standards for lab safety and work efficiency. Edge devices provide real-time information displayed in augmented reality (AR) goggles for guiding workflows and for ensuring the safety of lab operations round-the-clock.

Laboratory workflows pose many challenges as they are often tedious, repetitive, and need to be documented in detail. Processes can consist of several hundred steps, and slight errors can lead to substantial loss of time, money, and precious samples. The handling of hazardous materials can pose environmental and health risks on a global scale.

Picture a lab that automatically generates reports detailing every single step. Think of a safety system that informs staff if hazardous materials are handled improperly, or when the room concentration of a harmful gas crosses a critical threshold. It will all result in increased efficiency, process reliability, and work safety.

Before useful information can be displayed in augmented reality googles, a computer-vision based system identifies the position and orientation objects such as pipettes, trays, flasks, and hazardous substances. Moreover, interactions between objects and with lab staff are tracked and semantically analyzed. As augmented information needs to be provided in real-time, laboratory equipment may act as an edge device for capturing and processing data in a decentralized and local manner. Instead of solely relying on bulky image data, various sensor elements such as accelerometers are integrated directly into laboratory devices. Equipped with increased computational power "at the edge", data transmission and lag can be reduced, which are critical factors for real-time applications.

Modeling virtual objects and overlaying them with perceived reality opens up new possibilities such as training of new employees. This so-called mixed reality enables time-efficient training sessions while involving a minimum of productive resources. Guided by instructions in the augmented reality goggles, trainees become acquainted with complex processes on the job and on their own.



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Real-time object tracking
At the heart of a real-time object tracking system lies a pose estimation algorithm working on specific patterns of forms located on the objects. Additional algorithms such as statistical modeling track the path of a moving object with high accuracy. Furthermore, devices equipped with embedded hardware such as microcontrollers, storage and battery, can process data locally and as a result, allow for controlling, filtering, storing and transmitting of only the relevant information to and from the other devices. The locally-run embedded software is optimized to reduce the amount of data transmitted. With low computing power, real-time information with low latency is obtained. The required components can be off-the-shelf and at low cost.

Augmented reality
Complex toolchains and frameworks are required for processing data from a sensor network and for combining the information with a digital model of the lab. In particular, an AR engine provides the ability for creating the two- or three-dimensional output which is visualized to the user at runtime.

Connecting home appliances

Additional benefits such as predictive maintenance can be generated by connecting home appliances, whilst improving the user experience and helping gain market insights. Even the energy consumption of the overall system can be reduced and the robustness of the application increased accordingly.

In the past 10 years, an increasing number of potentially cloud-connected devices have been marketed, in particular, in the field of home and office appliances. The purpose of the connectivity includes improvement of the user experience on the one hand, and market insights, on the other. Complete cloud-based ecosystems have been created to provide the foundation for notifications, remote operations, app interactions and data acquisition. However, remote processing of the vast amount of data collected in the cloud reveals technological challenges and limitations, such as increased power consumption for wireless communication, bad connection stability, latency, high costs for data transfer or privacy concerns with the end customer.

By integrating data analysis and smart behavior and machine learning algorithms “at the edge” into the controller of the appliance, new possibilities open up and avoid the above limitations. Instead of transmitting huge amounts of raw data to the cloud, the data is pre-processed locally with sophisticated algorithms. By analyzing and compressing the data before transmission, it is also possible to meet privacy requirements of the user by eliminating data portions that contain critical personal information such as high-resolution pictures, timeseries of sensor values or others. In many cases, transmission of the complete data is not required, and the edge device contains sufficient input for generating low latency predictions that may be used for functions such as adaptive control, object recognition, predictive maintenance, or personalized behavior. In such cases, the communication to the cloud becomes optional, the energy consumption of the overall system is reduced, and even the robustness of the application is increased accordingly. Compiled, compressed and anonymized data sets may be transferred to the cloud in order to further train algorithm models for deployment with remote SW updates. This optional loop opens up the door for even more robust, adaptive and sophisticated applications on the edge.

Tech Insight

Edge computing

Localized functionalities for data collection and processing such as wavelet scattering on time series or machine-learning-based optical control can be implemented even on low performance devices such as 32-bit micro-controllers with simple real time operating systems. The connection to the outside world can be achieved through selected communication technologies such as LoRa, NFC, NB-IoT, UWB, Bluetooth, WiFi, Zigbee and many more. For each design decision, it is important to understand strengths and limitations of the technology, impact on user experience, and cost. The system design process must include both the cloud and the edge design to achieve the best product results.

Predictive maintenance

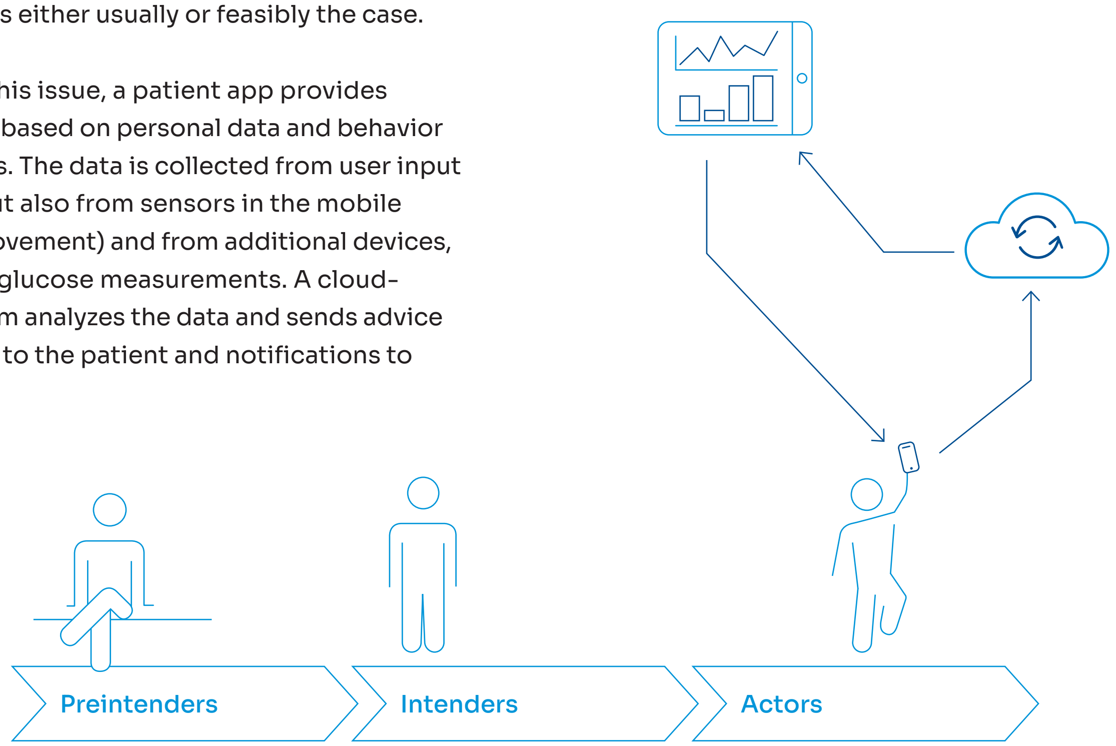
Sensor data is required for building reliable prediction models for looming component failures and for preventing damage of further system components through the halting of the application. Low-cost sensors such as acoustic sensors may be used to detect pump or tube failure and avoid leaks inside the device. Service intervals are not executed along a fixed schedule anymore, but on-demand when the time and money spent by the service technician actually brings about a benefit. Furthermore, the aggregation of compiled data from multiple devices in the cloud allows for the detection of anomalies over a complete machine park and hence may be additionally used to trigger pre-emptive service trips.

Supporting motivation for a healthier lifestyle to improve blood sugar

Diabetes is a large and growing health issue. A suitable lifestyle helps prevent diabetes and its consequences but is notoriously hard to sustain. Together with human support, automated systems based on psychological research and personal data help to keep it up.

In 2021, more than half a billion adults lived with diabetes, and 6.7 million people died directly as a result. This number is expected to increase. While it is well known that a lifestyle with sufficient exercise and balanced diet helps prevent diabetes and its dire consequences, it is also well known that lasting changes to one's own behavior are hard to achieve. Support is thus required, from family, from people in similar circumstances, and not the least from health care providers. Such care could employ models based on psychological research whose personalized application has proven to be effective towards lasting behavioral changes. Unfortunately, these models require timely interventions as well as patient-provider interactions in much shorter intervals than is either usually or feasibly the case.

To overcome this issue, a patient app provides reinforcement based on personal data and behavior change models. The data is collected from user input (e.g. meals), but also from sensors in the mobile phone, (e.g. movement) and from additional devices, such as blood glucose measurements. A cloud-based algorithm analyzes the data and sends advice and reminders to the patient and notifications to health care providers. Crucially, the analysis and identification of actions are performed in an evolving framework based on behavior change models from scientific research. Moreover, the app does not stand alone but is part of a comprehensive ecosystem. A social network enables interaction with other patients for mutual support. Health care providers obtain information about their patients and can offer remote checkups or additional support. In this ecosystem, scientific informatics and human compassion work together to fight diabetes.



Tech Insight

Behavior change models / HAPA

There are several scientific models which aim to explain why people change their behavior; the AI consults them for support in promoting change towards a healthier lifestyle. For example, the Health Action Process Approach (HAPA) model depicts behavioral change as a sequence of two processes – the motivation phase and the volition phase in which actions are planned and performed. Individuals go through **three stages, from preintenders to intenders to, finally, actors**. Each stage profits most from a different kind of support. Understanding what stage a patient is going through enables precisely the right kind of help they currently need the most to be provided.

Framework and model evolution

The data collected is used to personalize support for each patient and to continuously improve the usage of behavior change models. Insights gained from analysis of anonymized real-world data provide feedback about the models' performance and about potential improvement measures. The wide range of data – from glucose values to exercise and diet to the observed effects of past tips – allows the framework to grow both in scope and reliability. This general framework evolution benefits each patient as the support provided is based on an increasingly refined understanding. At the same time, the historical data of each patient enables identification of their personal motivational drivers over time, which in turn helps in tailoring the framework to the patient. Hence, the framework not only improves on itself, it is also more and more precisely fitted to a patient.

Next steps into future

The realm of scientific informatics evolves fast. Not only are the technologies previously described continually used for new applications, but there are also emerging technologies in varying stages of readiness that will bring powerful new abilities in the near and not-so-far future.

Analog computing

Analog devices fell out of favor due to digital computing, which is more versatile and generally applicable. Now, the rise of AI brings new demands on performance and energy-efficiency which analog computing meets with vigor.

Modern analog computers represent numbers by the strength of a current. The physical composition follows the structure of the intended calculation, which literally constitutes the implementation of an algorithm in hardware. While extremely powerful, analog circuits are single purpose tools. In mixed analog/digital circuits, each part brings its strengths to bear.

There are different forms of analog circuits. In-memory computation utilizes the fact that conventional memory cells have not only states 0 and 1, but a continuous range. Connecting cells of specific states makes current flow through the cells just as numbers “flow” through an algorithm. This approach represents a predefined model as a circuit, which can be applied in an extremely efficient manner.

Other approaches even enable the training of new models in hardware. By imitating the brain and nervous system in silicon, neuromorphic chips process signals as humans do. Memristors are components whose states change with the voltages they are fed, representing algorithms which change with the numbers they processed – the ‘learning’ in ‘machine learning’.

Analog computing fits the very large as well as the very small scales. With former, there are central cloud-based AIs which process huge amounts of data and are very power-hungry.

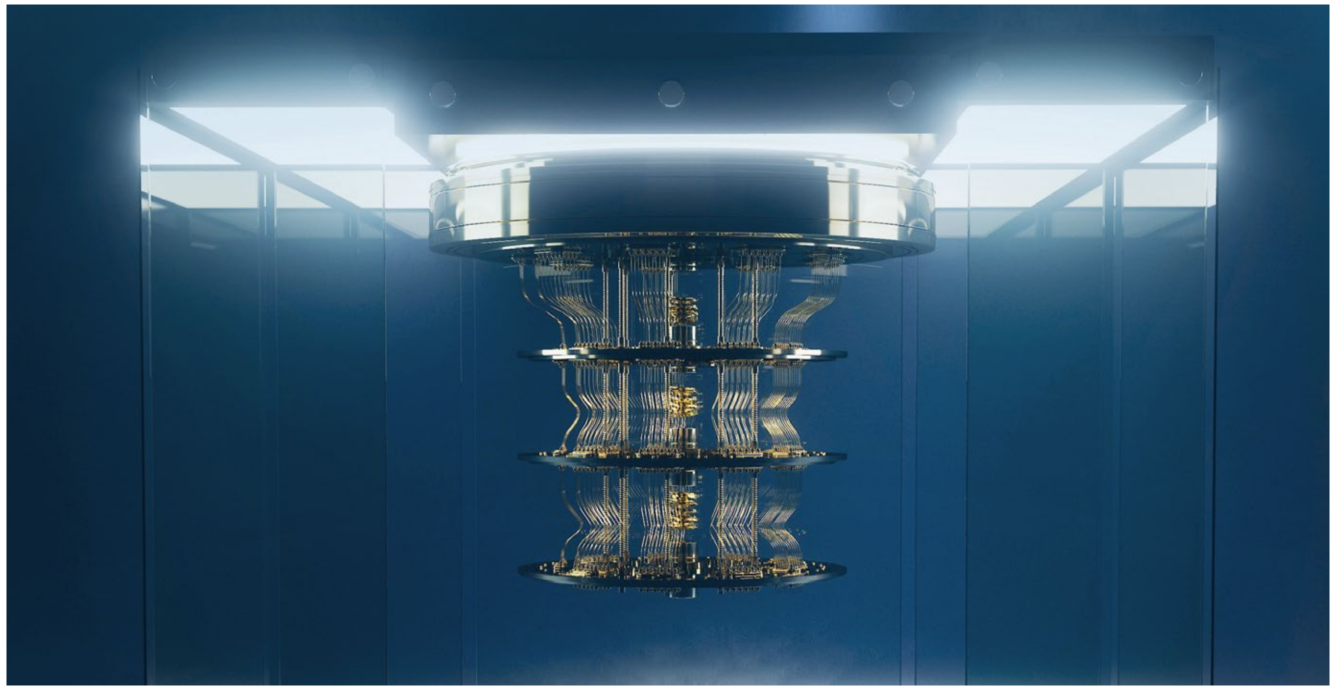
Analog computing helps to meet demands for lower energy consumption while processing increasingly bigger data. At the very small scale, mixed analog/digital circuits bring yet unknown computing power to devices with a tight power budget. Small IoT devices with sensors can process data on their own and only transmit the results, saving battery life. Wearable medical devices and even implants can use AI to monitor a patient, adapt to their characteristics and detect dangerous anomalies.

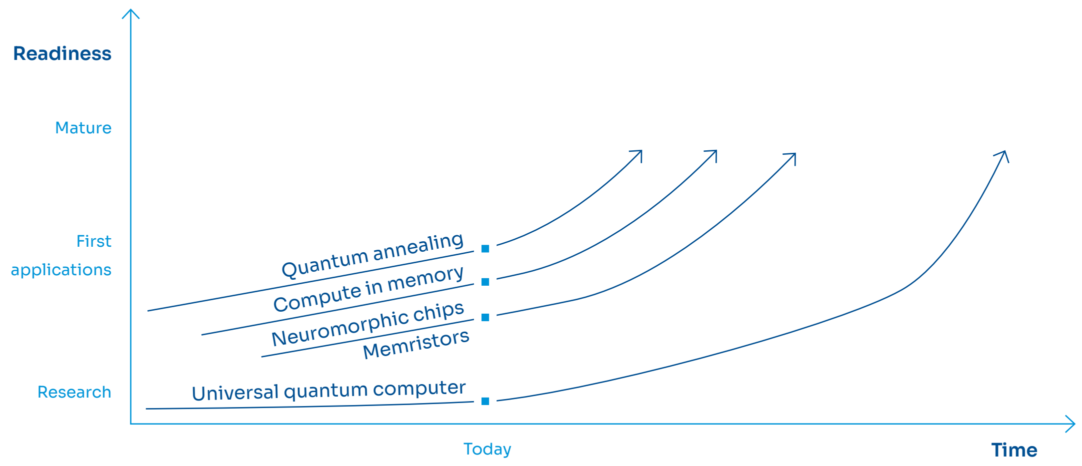
Quantum computing

The idea of a computer operating on principles from quantum physics dates to the 1980s. In recent years, quantum computing received massive interest in research and made significant progress. The technology is still in an early stage and not yet ready to deliver its full potential, but has the potential to solve problems that are much too complex for classical computers.

While classical computing works on bits of a known value of 0 or 1, quantum computing works on “qubits” which are based on quantum effects. When read, the qubits also are either 0 or 1, but before reading, they can be in a complex ‘mixed’ state related to the probability of reading 0 or 1. Quantum computing operates on unread qubits which can carry more information than conventional bits, enabling much more efficient calculations for some tasks.

Building a functional quantum computer is extremely difficult. One of the main challenges is to prevent the qubits from interacting with the environment, e.g., by cooling them to almost absolute zero. Universal quantum computers with a wide range of applications are for that reason not yet available. There are





examples of very dedicated applications, e.g., in pharmacology, such as the computation-intensive comparison of molecules. In 2017, Biogen and others showed that quantum computing already provided more information than classical methods, even as it did not yet sufficiently scale. Then there’s quantum annealing – an optimization method utilizing quantum behavior –, which is already being used to solve problems such as finding the most efficient allocation of resources for concurrent tasks.

For all its opportunities, quantum computing is a huge threat to cyber security. Many common encryption methods rely on hard mathematical problems which Shor’s algorithm for quantum computers can solve in a short time. Most of today’s security measures will stop being reliable. Some encryption algorithms are more secure against quantum attacks. Researchers are working hard to make them useable and also to find new strong security methods based on quantum effects.

Conclusion

The realm of scientific informatics is clearly a vast field of powerful technologies and great innovations, some of them already well established in industry, others being close to a turning point. Helbling recognizes the potential in this field. We are not only working to improve our existing competences but also regularly invest in the creation of new services around emerging technologies. We are dedicated to innovation, and together with our clients, we are passionate about transferring today’s ideas into tomorrow’s solutions.

Helbling Group

Established in 1963, the Helbling Group has international operations and positions itself as an interdisciplinary nexus of engineering and consulting expertise. With independent ownership, the Group is run by 36 managing partners and employs more than 620 staff at locations in Switzerland, Germany, Poland, the USA and China. The Group's main focus is on providing selected services in the fields of innovation and product development, management consulting, mergers and acquisitions, business turnarounds and financial performance management, IT, real estate, and construction planning.

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Helbling Technik is a division of the Helbling Group and currently employs over 500 professionals.

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