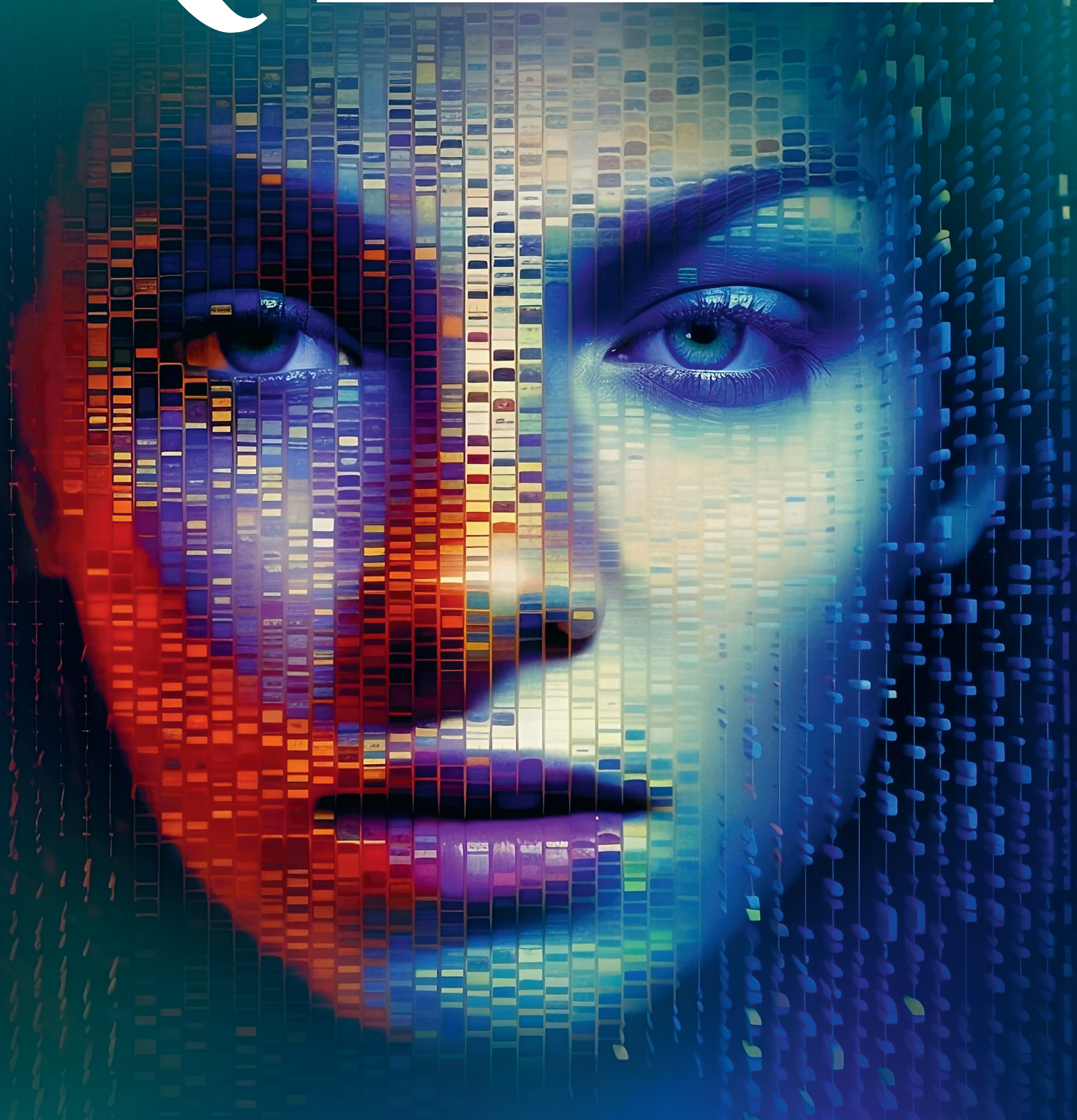
THE QUINTESSENCE | 2024

HUMAN MACHINE INTERFACES

FUTURE MARKETS MAGAZINE by EBV Elektronik



WITH SPEECH, GESTURES AND THOUGHTS? THE FUTURE OF MACHINE INTERACTION.

“The human machine interface market is forecast to grow rapidly with the integration of technology.”

Kanhaiya Kathoke
Research Analyst, ICT and Media at Allied Market Research

10.8

billion US dollars
Global market volume for Human Machine Interfaces in 2031

Source: Allied Market Research

FROM LIGHT SWITCHES TO GESTURE CONTROL

Technology has become an indispensable part of our day-to-day lives. Controlling it requires humans to interact with the device, machine or technical system in one way or another – which is where Human Machine Interfaces (HMIs) come in.

HMIs come in many different forms; you could even consider the humble light switch to be an interface between humans and machines (in this case a bulb). However, as new technologies come onto the market and our world becomes increasingly digitalised, HMIs have also become much more complex and challenging. The products released by Apple, for example, demonstrate very clearly how a product's appearance and a user-centric, intuitive operating concept can play a pivotal role in setting a brand apart and in providing a consistent user experience. As a result, the latest Human Machine Interfaces are made up of an entire system of hardware and software components. Motion sensors, various different peripheral devices, voice control and other solutions are all used to convey a person's instructions to the machine and send corresponding feedback. New ways in which humans can interact with technology are continually emerging, with a variety of HMI solutions now ranging from multi-touch screens and remote touch systems (where machines are controlled using a smartphone) all the way through to voice and gesture control.
These modern interfaces not only make it easier to use machines and devices error free, they also lower the operating costs (as fewer display panels and cables are needed) and allow for tailored designs to suit different users and applications. As a result, market analyses are forecasting stable growth in the Human Machine Interface segment. For example, Allied Market Research estimates that the global market for Human Machine Interfaces will grow from 4 billion US dollars in 2021 to some 10.8 billion US dollars by 2031.
Modern HMIs are based on MCUs, processors, sensors and, of course, software. They even use artificial intelligence, meaning they need high-performance microcontrollers and chips. Unfortunately, there are currently no available up-to-date figures on the potential market for semiconductor solutions in the HMI segment. However, if we look at various market analyses for micro-electronic components, it is plain to see that the HMI segment offers huge potential for the semiconductor industry. For instance, according to Reports Insights, the market for capacitive sensors is set to grow by an average of 5.3 percent annually until 2030, driven by trends such as the increasing demand for capacitive sensors for use as touchscreen input devices on smartphones, tablets and wearables. The growth forecast for contactless gesture recognition systems (which require a range of different semiconductor solutions) is even more impressive: according to Allied Market Research, this segment is set to grow by an average of 21.5 percent annually until 2031. The world of HMIs is diverse and complex, so this issue of "The Quintessence" aims to provide an overview of the different technologies and the latest trends. Our experienced experts would also be pleased to assist you if you have any questions regarding HMIs or the necessary semiconductor components.
I hope you enjoy reading "TQ of Human Machine Interfaces" and discovering more about this fascinating world.

William Caruso
President of EBV Elektronik

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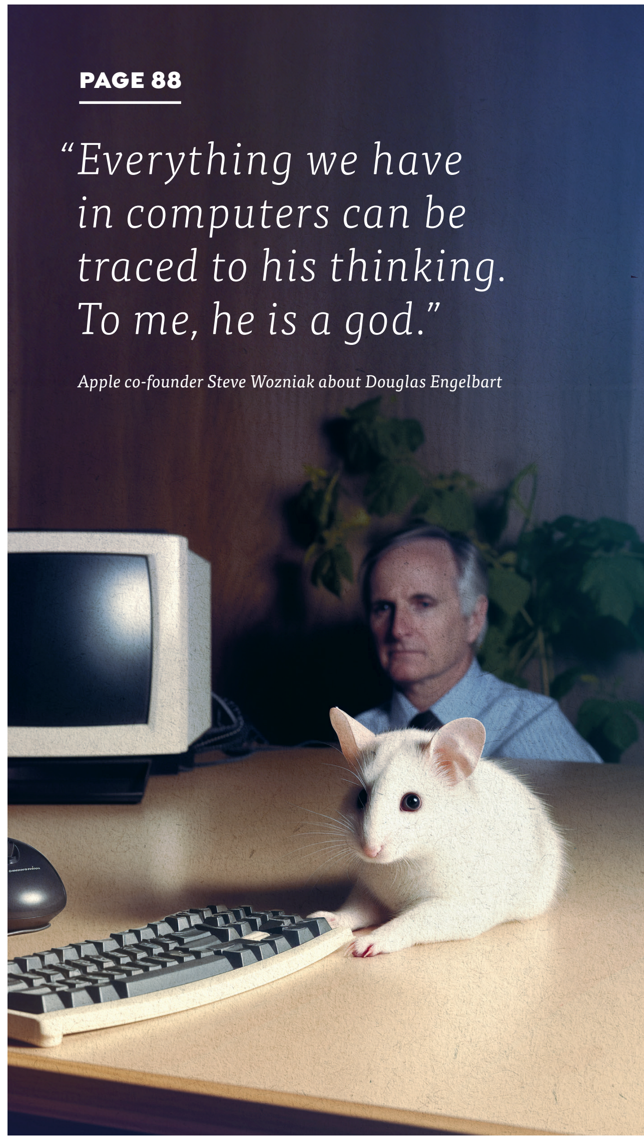
TECHNOLOGY

HMIs are helping to make human-machine interaction more and more natural.

APPLICATIONS

Across industries, operation is becoming increasingly multimodal and intuitive.



VISIONS

DIVERSITY OF HUMAN MACHINE INTERFACES

As the technologisation of our society increases, so does the importance of Human Machine Interfaces. The latest advancements now enable machines to be controlled intuitively with speech and gestures. In the future, technical systems may even be able to respond empathetically to humans.

Machines have been indispensable partners to us humans in everyday life since time immemorial. It is not only in large production halls or complex industrial manufacturing processes where human and machine-supported processes closely interlock. The number of electronic devices used in the private sphere is also continually increasing – from washing machines to smartphones. Interfaces are the key to enabling humans to interact with these machines or systems.

VARIETY OF SOLUTIONS

The design and functional principles of these Human Machine Interfaces can vary hugely – from a simple mechanical toggle switch to a touch display or a connected mobile device (such as a notebook or smartphone), to name a few.
The operation of machines has changed enormously over the centuries: the first human machines were operated predominantly via levers and cranks. This purely mechanical form of control was increasingly supplemented and eventually replaced by electrical buttons and switches when electrification started at the end of the 19th century. The next major change was brought about by automation and digitalisation: once computers started being used to control systems and machines, it became possible to visualise functions on screens and operate them via keyboards and input devices.

NEW POSSIBILITIES THROUGH DIGITALISATION

The invention of touchscreens has blurred the boundaries between the display and operation of functions: monitors can now recognise when a user touches a symbol or field and can subsequently translate this action into a digital command. Apple's products, such as the iPod or iPhone, are iconic examples of how intuitive touchscreens have simplified the operation of devices. They are now also prevalent in industrial systems, in smart home applications and in cars.
Digitalisation has enabled devices and the operation of these to be increasingly adapted to the human user and their personal capabilities. Not only can HMIs now be customised to the individual operator, they can also be modified again and again to reflect new machine functions. ►

HMIs use a broad spectrum of functional principles and technologies.

Augmented and virtual reality have also entered the world of Human Machine Interfaces: for example, maintenance and operating personnel can now use smart glasses that provide information from the machine directly "in front of the employees' eyes", meaning they no longer have to leaf through manuals to maintain the system.

SMART INTERACTION THANKS TO ARTIFICIAL INTELLIGENCE

The invention of Siri and Alexa a few years ago marked the emergence of another technology on the market – one that has significantly changed the way humans interact with machines: voice control. In many areas today, it is almost a matter of course that a user can give commands directly to devices with their voice – whether in the car or when playing their favourite songs. According to Statista, around 4.2 billion voice assistants were used worldwide in 2020. By 2024, this number is expected to double to up to 8.4 billion. The technological advancements in the underlying artificial intelligence are what have enabled the use of effective voice recognition today. Even in industrial production, it is possible to operate machines by voice despite the interfering background noise.

AI also provides the basis for another form of operation: gesture control, whereby humans can interact with a machine through gestures and movements. Contactless gesture recognition is a complex system that uses several technologies in addition to AI, such as sensor fusion and image recognition using camera systems. So far, the use of gesture control has been largely limited to computer games. But now we're seeing machines also being equipped with this innovative technology and it is already possible to control robots with gestures.

AI opens up new possibilities for Human Machine Interfaces with the aim of more efficient interaction.

The latest HMI development is systems that allow the operator to control devices solely by thought. Some companies in the medical industry are already testing implanted chips that capture brain impulses and translate them into digital commands, for example for writing emails.

FROM PURE OPERATION TO ASSISTANCE

In the future, Human Machine Interfaces will provide various different assistance functions for commissioning, operating, servicing and repairing machines, and also support the process of training users on new systems. Research is already being conducted on solutions that can psychologically interpret human behaviour and register their attention and control capabilities. These so-called empathetic HMIs make it possible for machines such as cars and robots to recognise the intentions of humans in order to work with them flexibly, proactively and safely. TQ

Researchers at the Fraunhofer Institute for Digital Media Technology IDMT in Oldenburg have developed a speech recognition solution for use in industrial manufacturing. The system works reliably even in noisy environments and can be adapted to the user's needs.

PREDICTIVE ROBOTS: OUR FUTURE ASSISTANTS

A conversation with Professor Elsa Andrea Kirchner from the German Research Centre for Artificial Intelligence (DFKI)

One of the biggest challenges in developing Human Machine Interfaces is natural interaction. Solutions such as gesture and voice control have already enabled significant progress to be made in this area. Recently, the focus has also shifted towards controlling machines with thoughts: Brain Machine Interfaces measure brain EEG signals and use these to derive control commands for computers, machines or robots. The DFKI is one of the pioneers in the use of EEG data for interaction with robotic systems. With its latest research project, EXPECT, the research centre is aiming to develop an adaptive, self-learning platform for human-robot collaboration. It should not only enable various forms of active interaction but also be capable of deriving human intention from gestures, speech, eye movements and brain activity: the machine should be able to anticipate what the human is going to do next. Professor Elsa Andrea Kirchner, project leader for the Robotics Innovation Center, provides insights into the project and the state of research on Brain Machine Interfaces.

CONTROLLING MACHINES WITH A BRAIN CHIP IS ALREADY BEING TESTED BY COMPANIES SUCH AS NEURALINK AND SYNCHRON. IS THIS INDEED THE FUTURE OF HUMAN MACHINE INTERFACES?

Elsa Andrea Kirchner: The problem with interacting with the brain through implanted chips is that you can only reach the part of the brain where the chip is located. You would need to implant many of these chips to obtain a good picture of what the brain is doing. For some purposes, this procedure is certainly useful, such as for stimulating the brain in Parkinson's disease.

WHAT IS THE ALTERNATIVE?

E. A. K.: Brain activity can also be measured externally, using electrodes attached to the head. However, when doing this, you are always measuring a sum of activities, so the resolution is lower than with an implanted electrode. Additionally, there is more noise because brain currents are measured through the skin, bones and hair. You therefore need powerful devices to record them, and you need good signal processing and machine learning to interpret the data correctly.

WHAT IS YOUR APPROACH IN THE EXPECT PROJECT?

E. A. K.: Quite often, when interacting with another person, we can tell what they want to do or expect from us. For example, a colleague hands me a tool because I am looking at it and he is standing right next to it. This is also something you want to achieve in interactions with machines. You don't always want to explicitly tell the machine every single step; you want the machine to understand it on its own. There are many ways to achieve this, and one of these ways is the direct use of brain activity.

DOES EVERY PERSON THINK THE SAME WAY? DOES AN EEG ALWAYS SHOW THE SAME THING, REGARDLESS OF WHO IS THINKING THE THOUGHT "ROBOT, OPEN THE GRIPPER"?

E. A. K.: Our brains are organised very similarly. So, we have the same areas in similar locations. But we also know that there are significant differences between people. This means that, once you have measured a person's brain activity with an EEG and analysed it using machine learning, you cannot simply transfer the trained model to another person. The performance might decrease by 20 or 30 percent. So, we have a number of challenges to overcome in training the models so that they can be used for several individuals, and this is one of the EXPECT project's objectives.

You can listen to the in-depth interview in the EBV Elektronik podcast "Passion for Technology"

YOUR PLATFORM FOR HUMAN-ROBOT COLLABORATION RELIES ON VARIOUS FORMS OF ACTIVE INTERACTION, NOT JUST THOUGHTS. WHY IS THAT?

E. A. K.: Imagine a stroke patient who, for example, is unable to move their right arm. Even in such a case, there is still some planning of movement happening in the brain. We can recognise that and move the arm using an exoskeleton. However, we encounter some problems with this approach. First, our interpretation is not 100 percent accurate. The second problem is that when a person thinks about a body movement, they may not necessarily want to execute it.

Most patients still have a tiny amount of muscle activity even after a stroke, which we can utilise. First, we interpret the EEG signal and recognise that the patient is thinking about a movement. At the same time, we monitor the patient's muscles and if we detect activity, we know that they truly want to perform the movement.

This combination of different signals is crucial because if an exoskeleton suddenly moves the arm without the person wanting it, they may feel like they've lost control and the exoskeleton has taken over their free will.

IN WHAT OTHER CASES DOES IT MAKE SENSE TO USE VARIOUS MEANS OF INTERACTION?

E. A. K.: Take speech recognition, for example. Often, the environment is too noisy for it. In our projects, we are working on combining EEG and speech to ensure accurate speech recognition. Simultaneously, speech recognition can help us better interpret the EEG. During the training phase, one might say, "Please fetch the hammer" while measuring the EEG. Later, you only have to think it and the robot will understand it based on brain activity.

THE MAIN GOAL OF YOUR PROJECT IS FOR THE MACHINE TO ANTICIPATE THE HUMAN'S INTENTION. IN WHICH APPLICATIONS DOES THIS MAKE SENSE?

E. A. K.: Sometimes you find yourself working with people who already know what they should do before you tell them anything. We find this to be a very positive experience. The same applies to when we work with a machine: there are situations where it would be better if the system knew my intention.

Imagine wearing an exoskeleton and trying to repair something overhead. The exoskeleton supports your arm and keeps it raised, which is initially helpful. But at some point you'll finish your work and want to lower your arm again. Although the sensors ►

recognise this, for a moment you still have to work against the exoskeleton. If we can recognise the planning of arm movements in the brain, the system can prepare for it and react faster. We have already tested this with individuals, and they could really feel the differences.

HOW DOES THAT WORK EXACTLY?

E. A. K.: We can look into the brain and examine the timeframe during which the brain is planning the movement before sending a signal to the muscles. This can take up to 1.5 seconds, sometimes even longer. We can look into this preparation phase and recognise that the person wants to move. And this can only be done through brain signals, not gestures, muscle activity, eye movements, or speech.

"It would be ideal if one couldn't see, feel or notice an interface."

WHERE ARE YOU CURRENTLY IN YOUR RESEARCH PROJECT?

E. A. K.: Within the EXPECT project, we are focusing on the possibilities of training on multimodal data and how to use it. For example, to switch between signals when the quality of one signal deteriorates. So, it's not about the general approach, but rather about how we can use different methods to adapt to changing signal qualities.
We can train with different signals than those we later use. For example, if a patient's muscle activity is not reliable initially, we can use EEG for training and later use muscle activity and eye tracking to improve and enhance performance.

YOU USE GESTURES, SPEECH, EYE MOVEMENTS, AND BRAIN ACTIVITY – IS THERE A TECHNOLOGY THAT WILL DOMINATE IN THE FUTURE?

E. A. K.: That's a difficult question to answer. It depends on how and what you want to communicate. But BCI is better suited for the future than other systems. However, I believe that the quality of interfaces will change in a way that makes them much more natural for us. Ideally, you wouldn't see, feel, or notice an interface. And I believe in multimodal interfaces because that's how we communicate as humans – with speech, facial expressions, and gestures.

WHAT DEVELOPMENTS IN SEMICONDUCTOR TECHNOLOGY ARE PARTICULARLY EXCITING FOR YOU?

E. A. K.: A group of researchers and engineers at the University of Duisburg Essen is working on terahertz technology. This technology is excellent for recognising the environment. You can see a wall, a window and a corner and even determine whether it's made of wood, stone or plastic. There are many ideas on how this technology can be used to measure biosignals without physical contact – for example, by measuring muscle movement through the reflection of terahertz waves. And from these movements we can infer what the hand and fingers are doing.
The use of graphene to realise epidermal electronics is also interesting. It allows us to measure electrical activity in the muscle with very high resolution. This is not only fascinating for interaction but also to understand muscle-related diseases.

IS THERE ANYTHING MISSING IN TODAY'S AVAILABLE SEMICONDUCTOR SOLUTIONS FOR YOUR PLATFORM?

E. A. K.: Imagine you want to perform a complex analysis of brain activity. This requires a large amount of data and powerful machine learning models. This might be quite challenging to achieve on-site, but research is already focused on implementing these large AI models into small embedded devices. This is also crucial for us because if you're walking around in nature with your exoskeleton and don't have internet access, relying on cloud-based AI processing can be problematic.
To integrate the AI model into the system, we need highly energy-efficient computing power. The model must also continue learning in operation. For example, imagine a patient whose signal becomes better over time. The model should recognise this, so the system relies more on muscle activity than EEG.

WHAT DO YOU CONSIDER IMPORTANT IN DESIGNING AN OPTIMAL HUMAN MACHINE INTERFACE?

E. A. K.: The most important thing is to be open-minded. That means not saying, "I'm a BCI researcher, so I want to work with brain activity." You should always think about what you want to achieve and how humans would interact.
Secondly, always keep in mind that we're talking about a diverse society. Facial expressions may vary among different nationalities, for example. So, when developing such a system, consider not only the technology but also the social context. For me, it's also crucial to talk to the people who will use the system in the future.

MACHINES THAT CAN READ HUMAN THOUGHTS – IS THIS THE FIRST STEP TOWARDS THE DYSTOPIA PORTRAYED IN HOLLYWOOD WHERE MACHINES GAIN POWER OVER HUMANS?

E. A. K.: At the moment, we are not yet at the point where we can truly read thoughts completely. And, to be honest, I don't believe the danger lies in the machine controlling the human. I think the risk is more likely to be another human having access to someone's thoughts.

"I believe that in the future, it will be very difficult to discern from the outside whether we are interacting with another human or a machine."

We had a project, for example, where we wanted to develop an EEG-based approach to detect high workload in individuals within a company, to prevent burnout, for instance.
In this case, you need to prevent someone with malicious intent from accessing the data in the Cloud. But even if this data is only used to optimise a person's production environment, such as slowing down a robot, it can still have consequences for the person. Because the employer might say, "I'd rather hire a younger person who can work faster."
So, understanding a person can also be used to worsen the situation or harm individuals. For example, we can discriminate against people because we discover that they cannot recognise certain things or have a very low attention span. This is already a very real possibility if someone has access to a person's EEG.

FINALLY, A LOOK INTO THE FUTURE – YOU CAN NOW BE A VISIONARY: HOW WILL WE INTERACT WITH MACHINES IN 25 YEARS?

E. A. K.: I expect that interacting with machines will be very similar to interacting with other people by then. We will interact with systems and speak to them very naturally. These systems will understand what we want. Multimodal interaction will be taken for granted. I believe that in the future, it will be very difficult to discern from the outside whether we are interacting with another human or a machine. TQ

FACTS AND FIGURES FROM THE WORLD OF HMIS

Control concepts are as varied as the devices and machines with which humans interact. With new technologies, Human Machine Interfaces can be operated more intuitively – with solutions that most users are already familiar with from their smartphones.

Robots are increasingly interacting with humans

39,000

cobots
were installed in 2021 – that's around 50 percent more than in 2020.

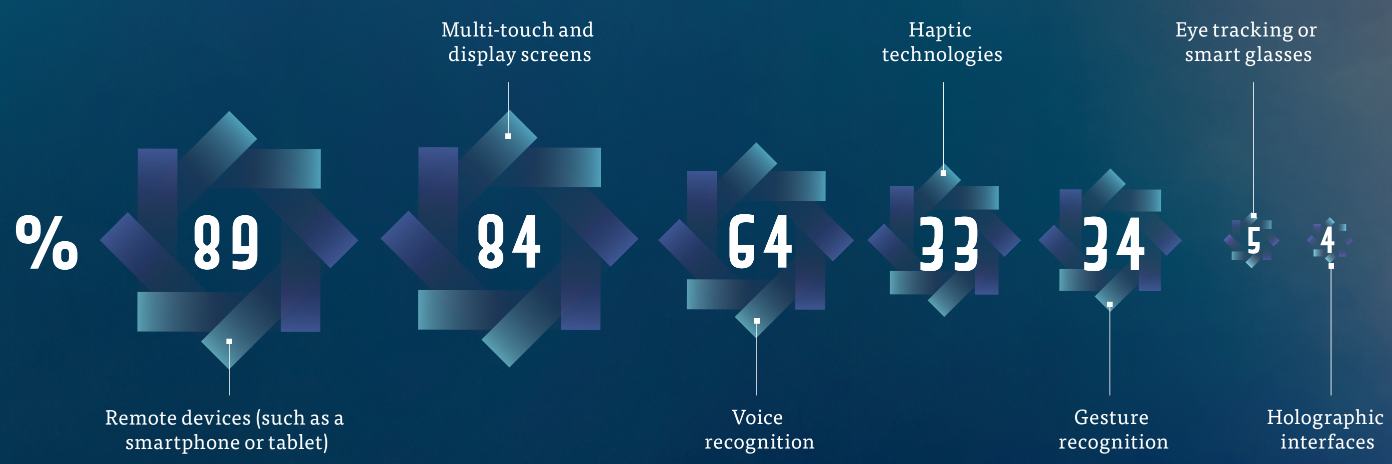
Source: World Robotics 2022

› 326,000

cobots
are to be delivered in 2031.

Source: Yano Research Institute

Mobile devices leading the way in controlling smart homes
These types of Human Machine Interfaces are used by users for their smart home solutions.



Source: Jabil's 2023 Smart Home Technology Trends Survey

The billion-dollar market of touchscreens
The global market for touchscreens is expected to more than double by 2030.

Source: Spherical Insights & Consulting

Did you know...

that the first computers with a graphical user interface were called Lisa (1983) and Macintosh (1984)?

that the first computer mouse was demonstrated by the inventor Douglas C. Engelbart on December 9, 1968?

that Maurice Goldberg and William J. Newton patented the light switch for the secure turning on and off of electric light in 1917?

TECHNOLOGY

Human Machine Interfaces allow us to monitor and control machines, processes and systems. The primary objective of HMI design is to achieve an intuitive and user-friendly interaction. A variety of technologies are available for this purpose, which can be categorised into different types by their interaction mechanisms, display technologies and applications. Each type of HMI technology has its own advantages and disadvantages, so each one is generally suited to specific use cases and industries.

AT THE PUSH OF A BUTTON

Hardly any machine or device can function without traditional controls such as buttons, switches or keyboards. They still form the basis of most Human Machine Interfaces.

The Human Machine Interface is as old as the first machine developed by humans – thus, the history of control elements dates back to antiquity. It all began with purely mechanical levers and handwheels. With the advent of electrification, it became possible for the first time to operate controls remotely from the function or machine. This led to significant advances in operator safety and allowed users to control all functions or multiple machines from a central control station.
Various designs have been – and continue to be – used: with buttons, push-buttons, rocker switches, and toggle switches or levers, operators can trigger two mutually exclusive options – for example, on/off. Rotary knobs and switches, sliders and slide switches can be used to activate a variety of options or control a function with varying values, such as dimming a light.

ADVANTAGES OF ELECTROMECHANICAL CONTROLS

Although technologies such as touchscreens or smartphones are increasingly used as Human Machine Interfaces, traditional electromechanical controls still have their place. For instance, they are still essential for critical functions (emergency stop), but even non-critical input operations are sometimes represented by mechanical interaction elements. Encoders, for example, enable the precise input and confirmation of values through rotary push controls, and a tactile grid provides the user with the necessary haptic feedback. The increase in industrial production, higher safety requirements and the growing use in home automation and automotive solutions is ensuring solid growth in the push-button market: market analysts from Dataintelo have predicted an annual increase of eight percent from 2022 to 2030 for industrial applications alone.

FLEXIBILITY THROUGH BUS SYSTEMS

Traditionally, individual controls were discretely connected to the corresponding actuator with one-to-one wiring. But as machines became more and more complex, the installation process became very time-consuming. For complex control systems, thick bundles of cables often needed to be connected to the plant. Today, it is possible to use control elements that communicate with actuators via a bus system, which means that all the switches and buttons are connected via just one line. This saves space and weight and significantly reduces the effort required for maintenance and diagnostics. In the industrial sector, for instance, IO-Link is often used, while in the automotive field, the CAN bus is more common. As well as significantly reducing the amount of wiring, these smart control elements also have the advantage that they can be reprogrammed. If a machine is extended, for example, a switch can be reassigned to a new function. The switching elements can also be individually configured – such as the sensitivity of capacitive buttons or the force-travel curve. Integrated microcontrollers also enable smart functions, such as the timely prognosis of maintenance needs through self-diagnosis.
In the past, especially in the field of working machines, it was often said that operators could "feel" the machine better through traditional hydraulic controls. However, today's electronic systems also provide mechanical feedback to the machine operator with the help of "force-feedback" solutions.

HMIS FOR GAMERS

When computers started to be integrated into machines and systems, keyboards began to triumph as a Human Machine Interface. Various technologies have become established, but mechanical keyboards are currently trending and are making particular headway among computer gamers: they use small switches under each key to send the corresponding signals. As a result, these keyboards are more expensive than membrane keyboards but offer improved performance in terms of response time and tactility, which are essential for professionals and gamers. Another advantage is their longer lifespan; they last more than 50 million keystrokes, while membrane-based keyboards can only endure about 10 million strokes. In addition, mechanical gaming keyboards allow the user to precisely adjust the operation of the keys to their needs.

Market for mechanical keyboards

1,463

million US dollars
in 2021

↓

20.2

percent
average annual growth rate (2021 – 2028)

Source: Coherent Market Insights

Push-buttons still in demand in industry

8

percent
average annual growth rate (2022 – 2030)

Source: Dataintelo

KEYBOARDS FOR THE INDUSTRY

Keyboards are also used in the industrial sector. Here, robust construction, ease of operation and reliable function are of primary importance. The input unit must be protected against vibration and shocks, or even designed to be explosion-resistant. It should be protected against water, dust, dirt, oils and chemicals, and be able to withstand temperature fluctuations. In addition to appropriately encapsulated "classic" keyboards, membrane keyboards and silicone rubber keypads are also used.
Input keyboards are often used today as a supplement to touch systems, depending on the application. Tried-and-tested input components, such as membrane keyboards, silicone rubber keypads and push-buttons remain the preferred choice – including in terms of costs – in devices that have a limited number of functions, require good visibility and are in constant use. This is because the financial expenditure for programming a graphical user interface between human and machine is a significant factor. The rule is: not everything that is technically possible is also economically viable. TQ

Find out about all-in-one HMI solutions that we offer together with our partners.

tq@ebv.com

GET IN TOUCH!

From smartphones to machine tools, operating devices by touch has become commonplace today. The type of technology that is used is determined by the application.

Touch-sensitive displays as Human Machine Interfaces have long become a firm part of our everyday lives. Anyone using a smartphone is utilising touch technology. In shopping centres, touchscreens help people find information about products or stores. Many functions in cars are controlled via touch displays. In factories, touchscreens allow employees to easily access information and intuitively operate even the most complex systems. According to a report published by Spherical Insights & Consulting, the global touchscreen display market is expected to grow from 65.60 billion US dollars in 2021 to 163.10 billion US dollars by 2030. The proliferation of touchscreen displays can in part be attributed to the superior intuitiveness of graphical user interfaces compared to traditional input devices such as a mouse or keyboard. The possible input options are predefined for the user by the system and can be varied depending on the task or user. This simplifies operation, thus saving time and reducing input errors. All sorts of technologies are used to detect touch, but they can be broadly classified into five fundamental systems.

OPERATION BY PRESSURE

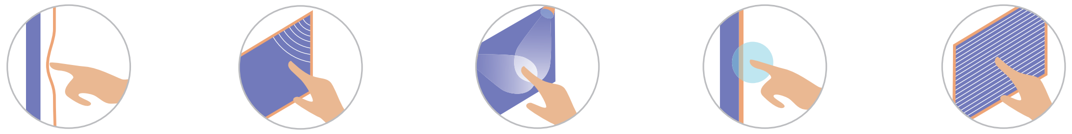
Resistive touchscreens react to pressure. They are constructed from two transparent conductive layers separated by an overlay. As soon as a user touches the screen, the two layers deform and come into contact, causing electricity to flow. A controller detects the electrical voltage difference and can determine the position of the input from this. ►

8

percent
predicted annual growth
of the touchscreen market
from 2022 to 2030

Source: Spherical Insights & Consulting

Comparison of touchscreen technology



	Resistive	SAW (Surface Acoustic Wave)	Optical imaging	Projected capacitive	Infrared
Light transmission	fair	excellent / yes	excellent / yes	excellent / yes	excellent / yes
Accuracy	okay	okay	varies	excellent / yes	varies
Typical display size	< 20"	< 20"	19 – 100"	< 32"	20 – 150"
Multi-touch	not typically, but some demonstrated	not typically, but some demonstrated	yes	yes	yes
Input method	finger or stylus	finger or soft tip pen	finger or anything	finger or conductive pen	finger or thick stylus
Challenge	needs forceful touch but no sharp objects	rain, dust contamination	dust contamination, strong light source > 500 lux or > 840 nm wavelength	can't use with thick gloves	sunlight, contamination, wide bezel
Application	for basic touch with 1-point gesture	for basic touch with 1-point gesture	medium to large size, indoor touch	for best user experience	large size, e-whiteboard

excellent / yes — fair — varies — okay

Source: ViewSonic, own research

Our experts can support you in integrating a touch solution into your product design.

tq@ebv.com

Resistive displays can be operated with a finger, stylus or gloves. They are also resistant to foreign bodies and moisture. However, the light transmission is lower than with other technologies due to the layers of film, and the mechanical deformation reduces their lifespan.

RESPONSE TO CAPACITANCE CHANGE

A significantly longer lifespan and higher brilliance are offered by projected capacitive touch technology (PCAP). Micro-fine wires are incorporated into the glass surface of the screen and voltage is applied in order to create a capacitive field. When a conductive object – for example, a finger – is placed on the surface, this field changes. The touch controller can thus detect and evaluate the touch. PCAP technology offers precise touch detection and fast response times. However, it cannot be operated with a glove, and PCAP displays are typically only produced up to 32 inches.

DETECTION BY INFRARED

Much larger touchscreens – up to 150 inches – are enabled by infrared touch technology. Infrared LEDs are arranged along the frame of the display, and each LED has a corresponding photodetector on the opposite side. This creates a grid of invisible infrared light beams. The input can be determined by interrupting individual light beams, for example with a finger. This means that infrared touch panels can also be operated with gloves, offer good light transmission and are relatively long-lasting. However, glare can negatively affect the user experience.

OPTICAL IMAGING

Also suitable for large screens is optical touchscreen technology. Optical sensors register a touch as soon as the line of sight is blocked by any object. Light transmission and image sharpness are generally good with this solution, as no additional layers are applied to the display itself. Optical touchscreens are considered one of the simplest and most cost-effective touch solutions, although the resolution of touch detection depends on the number and type of optical sensors installed.

"HEARING" TOUCH

SAW technology (Surface Acoustic Wave) also belongs to the touch solutions. Piezoelectric transmitters on the surface generate an invisible grid of ultrasonic waves, which are collected by receivers. Touching partially interrupts these waves, enabling accurate determination of the finger's position. SAW technology offers high contrast and colour accuracy, a robust design, and enables IP certification.

ANTICIPATING TOUCH

Recent advancements have made it possible to anticipate which part of the screen the user intends to touch and to execute the control step without actual physical contact. Jaguar Land Rover and the University of Cambridge have developed a corresponding solution called "predictive touch". It uses artificial intelligence and sensors to recognise the user's intended input target early on, which significantly accelerates the interaction.

TOUCH-SENSITIVE SURFACES

Touch detection is not only possible on displays. Capacitive touch operation or operation via strain gauges can also be used under thin sheets. These types of solutions are particularly suitable for premium products, such as those found in the domestic appliance sector, and for hygiene-sensitive areas – for example in a medical technology environment. TQ

SECURER TOUCHSCREENS CAN BOOST YOUR POS SECURITY

Familiar and easy to use, touchscreen displays are the public facing part of every modern-day payment system and point of sale (POS) terminal. Yet, they also have security vulnerabilities. Secure hardware and software systems that comply with the Payment Card Industry Data Security Standard (PCI DSS) are essential to building robust, protected payment products. This article looks at POS payment systems, security vulnerabilities of touchscreens and the criteria to pass PCI certification for any touchscreen.

TOUCHSCREENS IN POS DISPLAYS

Consumers are accustomed to paying for goods and services with credit cards on POS terminals, which feature small low-cost displays, physical buttons that match virtual buttons on the screen, and mechanical keypads to enter card numbers and PIN codes.

Today, larger colour touchscreens are replacing the mechanical buttons and monochrome displays of the past. As well as being more attractive, touchscreen displays also remove the need for moving parts, thus improving reliability.

Another trend in larger touchscreen displays is the rise of electronic cash registers (ECRs). As it is not a secure payment device, ECRs are usually combined with a POS terminal to process payments.

POS SECURITY AND PCI COMPLIANCE

The security of user data, such as the Primary Account Number (PAN), credit card numbers and PIN, is of paramount importance. Magnetic stripe (swipe) card transactions have inherent security issues, so more secure methods include Dip (chip-and-PIN) and Tap (near-field communication: NFC).

However, touchscreens also have vulnerabilities. The transfer of touch data and PINs is vulnerable to tapping or man-in-the-middle attacks via touch sensor overlays and underlays, and even to attacks on the communication bus between the touch IC and the secure host MPU.

The touch controller firmware can be hacked to extract card details. The configuration of the touch controller can be modified to expose vulnerabilities, even on systems certified as secure. Other security issues include extreme environmental noise, active NFC interference, extreme emissions and the need for resistance to moisture.

PCI COMPLIANCE TO THE RESCUE

The major payment card brands have created the Payment Card Industry Security Standards Council (PCI SSC), which developed the PCI DSS to protect card holders' data. Payment service providers and acceptance points have a responsibility for creating PCI-compliant products. PCI compliance requirements may change, which can affect the design of hardware, software and systems.

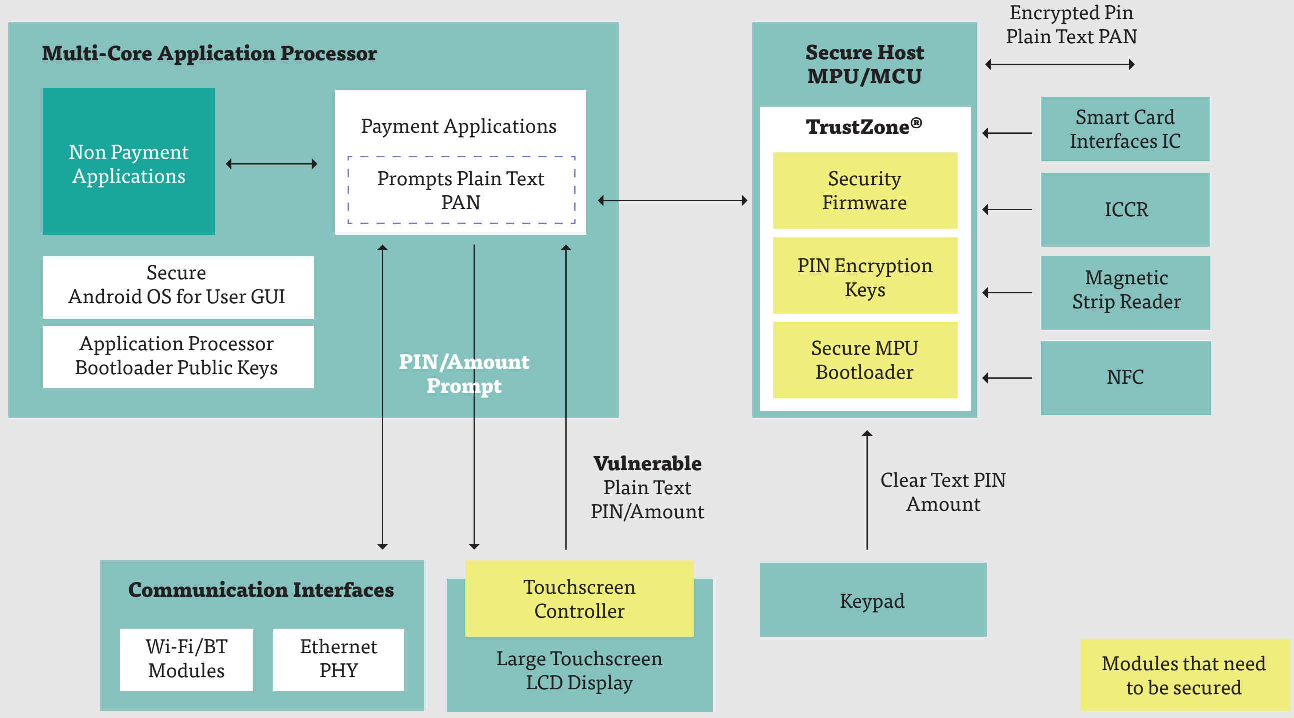
Most POS terminal vendors are now industry compliant with PCI Data Security Standards. If a payment system uses a separate payment module that is pre-certified to the PCI DSS for secure card transactions using a card reader with mechanical keypad, the touchscreen does not transmit any secure information via the communication lines. PCI PIN Transaction Security (PTS) certification of the touchscreen is only needed when the touchscreen is used for entering of credit card and/or PIN code data. This requires shielding the touchscreen's communication interface or encrypting the touch message data.

GENERAL PCI CERTIFICATION REQUIREMENTS

Under PCI-PTS, PIN transaction requirements are:

» The system must shut down in the event of physical or software tampering
» Confidential user data may only be transferred when necessary (always encrypted) and stored only for as long as needed
» Conduct software updates or boot up only if software integrity can be verified
» Only authenticated users can update software
» Store key in a protected area and create mechanisms to protect key loading
» Device should self-test and report anomalies

Two-Processor Architecture for POS Systems



The following features could be built into touch controller products at system level:

» 24-hourly reboot schedule
» 15-minute timeout on manual key entry
» Advanced Encryption Standard (AES) PIN encryption with ISO format 4
» Strict use of encryption keys for the intended purpose, with a separation between customer and manufacturer key hierarchies
» PAN encryption
» TR-34 Remote Key Loading (RKL) protocol

A PCI lab validates the touchscreen display to check that it meets the security requirements of the PIN Transaction Security standard. This validation includes the following tests:

» Assessing the vulnerability of the PIN entry to hacking
» Assessing access to sensitive data through tampering and examining the response mechanism
» Validation of the methods and documentation of the key management in production.

GETTING TO THE POINT, QUICKLY

Solutions such as Microchip's maXTouch® controller portfolio can fulfil such complex system requirements. Its integrated analog front end and proprietary firmware can be configured for secure encrypted communication for any end user application.

A dedicated support team, such as Microchip Technology's touch controller experts, can guide customers through their system level design and support them in the software/driver integration process, product testing and debugging.

CONTROL VIA GESTURE

Gesture control is a Human Machine Interface technology that detects and interprets human body movements for interaction with devices without direct physical contact. Thanks to its natural form of communication, this technology is spreading into an increasing number of fields.

Thumbs up, waving, the open hand as a stop sign – gestures are a natural form of communication for humans. Thanks to significant advancements in sensor technology and artificial intelligence in recent years, it is now possible to control machines and devices through gestures.

The breakthrough came with the introduction of Nintendo's Wii console in 2007 and Microsoft's Kinect motion control in 2010. Both solutions were developed for the gaming market and entertainment electronics still dominate the gesture control market today. According to market analysts from Grand View Research, the segment had a revenue share of 59.4 percent in 2022.

However, other industries are also discovering the benefits of gesture control for operating devices and machinery: for example, both the automotive industry and healthcare sector have placed great emphasis on adopting gesture recognition. This technology makes it easy and intuitive for users to interact with computers and other devices. The COVID-19 pandemic has further focused attention on gesture control, as it enables contactless and thus hygienic operation.

CONTROL VIA WEARABLES

Various different technologies are used to detect user movements. One option is special wearables, such as bracelets or rings, equipped with motion sensors that capture the rotation rate or acceleration of the wrist. An intelligent algorithm recognises which gesture has been performed and issues the corresponding command.

CAMERA-BASED SOLUTIONS

Another approach is camera-based systems. In principle, 2D cameras can capture and interpret movements. However, the algorithms used have difficulty distinguishing movements in front of the screen correctly – the precise capture of distance as the third dimension is missing. For this reason, 3D cameras or image sensors are increasingly being used for gesture control. They have become more affordable in recent years and can be integrated into almost any device due to their small size. These systems complement 2D image data with depth information, mostly obtained through Time-of-Flight technology, which measures the travel time of a light pulse reflected by an object to determine the distance to the camera. Today's image sensors can detect not only general hand movements but even the movements of each individual finger.

Gesture recognition market in 2031

88.3

billion US dollars

In 2021, the market had a volume of 13.9 billion US dollars. Accordingly, the expected average annual market growth is 20.6 percent.

Source: Allied Market Research

DETECTION VIA THERMAL IMAGING

However, camera-based systems require adequate lighting to reliably recognise gestures. This problem does not affect infrared sensors: they detect the infrared radiation emitted by the human body (passive sensors) or emit infrared radiation themselves as active sensors and capture the reflection. The corresponding algorithms then analyse the patterns and movements of this radiation. The sensors can also generate a depth image. Thus, various different gestures can be recognised depending on predefined movement patterns and algorithms. Nevertheless, systems based on infrared sensors tend to be more suitable for simple gestures. Since they are relatively cost-effective, they are used in many industrial, consumer and automotive applications.

RADAR – ROBUST AND PRECISE

Unaffected by lighting conditions, resistant to contaminants, and with high resolution, radar is increasingly conquering the field of gesture control. Even the smallest movements can be detected by a radar device, with the latest systems offering a resolution of just one millimetre. Radar sensors measure the speed, direction of movement, distance and angular position in real time to detect changes in the position of objects. This makes it possible to track and depict movements of persons or specific motion patterns. And for those who associate radar with the large rotating antennas on ships – the radar sensors needed for gesture recognition fit on a microchip.

AI AND EDGE COMPUTING

No matter which technology is used for gesture control, one challenge remains: everyone performs gestures in a different manner. This means that the systems must be able to recognise numerous interpretations of a gesture. Artificial intelligence and machine learning processes are highly useful in this regard: through complex signal evaluations, gestures can be clearly identified and classified. To process sensor data in real time and achieve the fast response times necessary for device operation, machine learning algorithms are increasingly being executed locally on the chip, close to the sensor itself – typically referred to as the edge. TQ

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VOICE CONTROL: A MEGATREND

The quality of voice recognition systems is steadily increasing thanks to developments in AI and semiconductor and microphone technology. Voice assistants are gaining in importance and popularity beyond the smart home environment and are increasingly being used for more sophisticated applications, such as voice-based device control in cars and industry.

200

million devices
is the predicted market size for smart speakers in 2023.

Source: Statista

Find out about our solutions for voice control at the Edge.

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Alexa, turn on the living room light!" is just one of the many commands that smart speakers can execute today. Smart speakers and their voice recognition systems are already the central control point for many smart home functions in many households. Statista reports that Amazon's Alexa alone can be used to control over 60,000 different smart home devices.

USE OF VOICE ASSISTANTS IS INCREASING

Human Machine Interfaces that function via voice are no longer just a vision from science fiction series like Star Trek or Knight Rider. In the latter, the hero of the series regularly had humorous conversations with his car K.I.T.T. In fact, cars have made the biggest leap in the use of voice-controlled HMIs: for example, according to the industry association Bitkom, almost half of users in Germany already give voice commands to their cars – be it to set the navigation system on course, to start a playlist, or to have messages read out. "Automobile manufacturers have massively expanded voice control in vehicles in recent years," says Dr Sebastian Klöß, an expert for consumer technology at Bitkom. "Voice control not only increases comfort at the wheel but also makes driving safer. Voice assistants will establish themselves as the dominant way to operate the vehicle's functions on the move."

BETTER THAN A HUMAN

Research into voice recognition systems has been ongoing since the 1950s. The first systems could identify just a single voice and barely a dozen words. It was not until the 2000s that technology advanced enough to make virtual assistants like Google Home or Amazon Alexa possible. Since then, HMIs with voice control have significantly improved – today's systems recognise words better than a human, achieving a "Word Error Rate" of three to four percent. Humans, on the other hand, typically do not understand around five percent of words.

INCREASING ACCURACY THANKS TO AI

The high accuracy of voice recognition has been greatly improved through the use of artificial intelligence. Machine learning algorithms, such as deep learning, are used to recognise complex speech patterns, understand natural language and differentiate between different languages.

FAST REACTION THANKS TO EDGE-PROCESSING

Besides accuracy, the speed at which speech is converted into computer-readable commands is crucial – especially when time-critical functions need to be controlled. However, as the amount of data to be processed in voice recognition is enormous, the necessary algorithms for most virtual assistants run in the Cloud, or rather in a data centre. This, however, is associated with relatively high latency – the time between issuing the command and its execution. But thanks to immense advances in semiconductor technology, special AI and digital signal processors are now available that can process speech directly on-site. The reaction times are correspondingly low, as the data no longer need to be uploaded to the Cloud. Dedicated audio-edge processors further increase the efficiency in voice-controlled devices: they act as an energy-efficient wake-up switch that only turns on the power-hungry application processor when a specific keyword is mentioned. It can also take over the task of noise suppression, thereby alleviating the main processor of this responsibility.

INCREASINGLY POWERFUL MICROPHONES

In addition to digital signal processors, microphone technology is crucial for the accuracy of voice recognition. Microphone arrays, for example, enable the voice recognition system to focus on the user and filter out background noise. This beamforming technology is already used in smart speakers like the Home Pod and Echo. Increasingly, MEMS microphones – miniaturised micro-electromechanical systems that are mounted directly on electronic boards – are being used. They are characterised by a high signal-to-noise ratio, low power consumption and high sensitivity. Miniaturisation enables several microphones to be combined in a small space, which is a prerequisite for beamforming, noise suppression and wind noise filtering.

HANDS-FREE IN PRODUCTION

With advancements in hardware and voice recognition algorithms, voice control is now becoming a viable option for application areas that were deemed impossible just a few years ago, such as industrial production, which is characterised by high levels of ambient noise. The Fraunhofer IDMT in Oldenburg has developed a solution in which ambient noise is almost completely filtered out through a combination of directional microphones and effective noise-cancelling. "For the first time ever, we can use voice command technology to control production machines in a robust and intuitive manner," says Marvin Norda, project manager for Voice Controlled Production at Fraunhofer IDMT. "For manufacturing companies, this means improved efficiency and lower costs." In the future, machine operators will have both hands free. They can position a workpiece in the work area and simultaneously give a robot instructions, such as "lower arm" or "grip workpiece". TQ

FROM HEARTBEAT TO EMOTION

Systems that capture users' vital parameters represent a form of Human Machine Interface that is relevant not only in medicine. They can be used to monitor a person's health and ensure that they are fit enough to operate machinery such as a car properly.

Tired? Angry? Inattentive? Or even sick? A person's state of mind or wellbeing can have a significant impact on their ability to use and operate machinery and on safety. This is why HMIs are being equipped with technology for monitoring a user's vital parameters in an increasing number of domains. These interfaces are not necessarily used to receive and execute control commands from the user. They are mainly utilised to monitor the user's condition and trigger an action when certain changes in their vital parameters are registered.

The healthcare sector is the natural home of such HMIs: from the tiny pulse meter clamped on a finger to the highly advanced, sophisticated technology of artificial intelligence – everywhere, HMI technology is an essential part of the assessment, monitoring and treatment of patients. Typically, sensors from various devices are stuck to the patient's skin to measure brain waves, impedance, motion, blood oxygen and temperature data. A local processor system can create individual warning messages for the patient based on the data obtained and automatically alert a caregiver if it detects unusual changes in the patient's condition.

RECOGNISING CARDIAC ACTIVITY

Thanks to the success of smartphones and smartwatches, many of these parameters can now also be measured in high quality wherever the wearer is. This includes cardiac activity, where two methods have prevailed. The simplest is the single-channel ECG: here, two electrodes are integrated into a smartwatch, for example. The electrode on the back of the device is in contact with the wearer's arm, and the second electrode on the top of the watch is activated by touching it with a finger on the other hand. In the automotive sector, so-called multi-touch ECGs are used. Here, the ECG sensor technology is integrated into various positions such as the steering wheel, gear lever or armrests. The system automatically detects which electrodes are in contact with the user. Thus, ECG measurements can take place unnoticed in the background, while the human has a high degree of freedom of movement.

ANALYSING VITAL PARAMETERS THROUGH LIGHT

Photoplethysmography (PPG), which measures a person's heart rate optically using infrared light, has an entirely different operating principle. It detects how much light emitted by the system is reflected by the skin. This amount depends on how much blood flows through the superficial capillaries. Since the blood volume in the capillaries increases with each heartbeat, more light is absorbed and less reflected in that moment. The system converts the reflected amount of light into a pulse wave. The heart rate can then be determined through this pulse wave analysis. If RGB cameras are used to capture the light, the respiratory rate and oxygen saturation can also be determined contactlessly by analysing the red, green and blue components in the PPG signals. Recent studies have shown that the pulse wave signal can also be measured with a camera placed a few centimetres to metres away from the skin.

RADAR-BASED SENSORS

Radar-based sensors can even capture heart and breathing values through clothing and over a distance of several metres. Electromagnetic waves with a frequency of, for example, 60 gigahertz are used, which are reflected by the body. Based on the reflected rays, the sensor detects the vibration of the skin caused by the pulse wave. Such systems are already used to monitor the driver's condition in trucks, trains or aeroplanes.

CAMERAS READ EMOTIONS

Camera systems also offer several possibilities for monitoring vital parameters. In addition to photoplethysmography, they can also recognise a person's state of consciousness. Special CMOS cameras – usually with a resolution of one to two megapixels – take 30 or 60 frames per second in the infrared spectrum, depending on the model. A downstream system evaluates them and analyses, for example, the driver's direction of gaze or the frequency of eyelid closure. From this, conclusions can be drawn about a distraction or increasing fatigue of the person, and if necessary, an alarm can be triggered. State-of-the-art solutions are able to recognise – in part thanks to AI – the smallest changes in behaviour, sleepiness, negative emotions and the possible influence of alcohol or drugs. Ultimately, such a system can form a complete picture of a person's physical and emotional state. TQ

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USING THE POWER OF THOUGHTS

Brain Computer Interfaces make it possible to control machines and devices solely with the mind. The number of practical applications being found for this technology outside of the laboratory is steadily increasing.

The human brain contains approximately

86

billion neurons,
which communicate with each other via electrical impulses.

Source: Helmholtz Association of German Research Centres

The market for Brain Machine Interfaces is growing

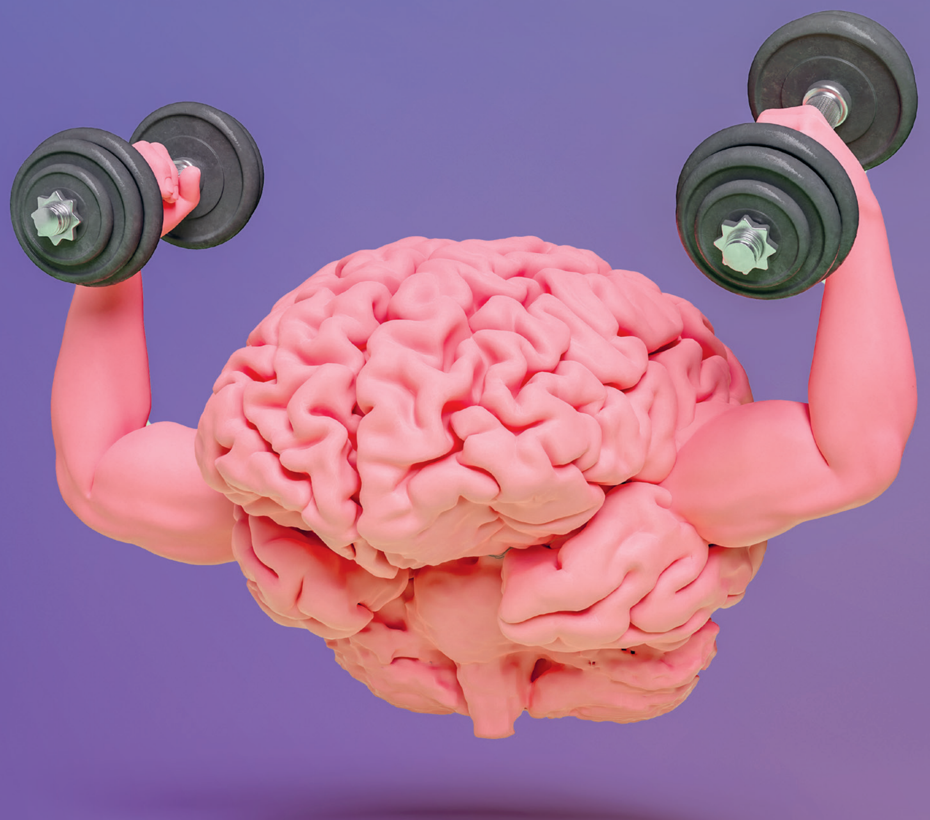
1.81

billion US dollars
in 2023

2.95

billion US dollars
in 2028

Source: Mordor Intelligence



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The human brain contains about 86 billion neurons. They communicate via electrical impulses, which among other things initiate muscle movements. Wouldn't it be elegant to be able to bypass the detour taken by traditional Human Machine Interfaces from the brain through the muscles to flipping a switch and instead directly control a device with the brain's electrical impulses? Thanks to Brain Computer Interfaces or Brain Machine Interfaces (BMI), this is now possible.

DEVICES ARE BECOMING SMALLER AND MORE AFFORDABLE

In 1925, the German psychiatrist Hans Berger recorded the first human electroencephalogram (EEG). Since then, technology in the field of Brain Computer Interfaces and data processing has continually improved. For at least ten years, the trend in EEG hardware has been to make these devices smaller, wireless, portable and more affordable. Basic brain wave measurements can already be taken through relatively simple headsets, enabling more and more practical applications outside the laboratory. Ultimately, BCIs could be used not only for controlling neuroprosthetics but also for all computer-assisted devices like smartphones and tablets, or a smart home. An increasing number of non-medical use cases is also becoming more and more conceivable, ranging from the PC gaming industry to the simultaneous control of drone swarms. The U.S. Defense Advanced Research Projects Agency (DARPA) is even working on an advanced communication system based on BCIs: the idea is for soldiers and military personnel to be able to issue commands telepathically using the "Silent Talk" solution.

MEDICAL APPLICATIONS STILL DOMINATE

The medical sector is still the main market for BCIs. "Active and passive BCIs are already being used to improve movement control in Parkinson's patients via deep brain stimulation, detect epileptic seizures and diagnose brain diseases. Digital and technological progress offers unprecedented new possibilities and has sparked broad scientific and economic interest," explains Professor Florian Mormann from the German Society for Clinical Neurophysiology and Functional Imaging (DGKN). BCIs can also translate brain activity into control signals for external devices such as prostheses, robots and exoskeletons. Bidirectional BCIs, moreover, allow for the brain to be electrically stimulated, for example to simulate a sense of touch when controlling a prosthesis.

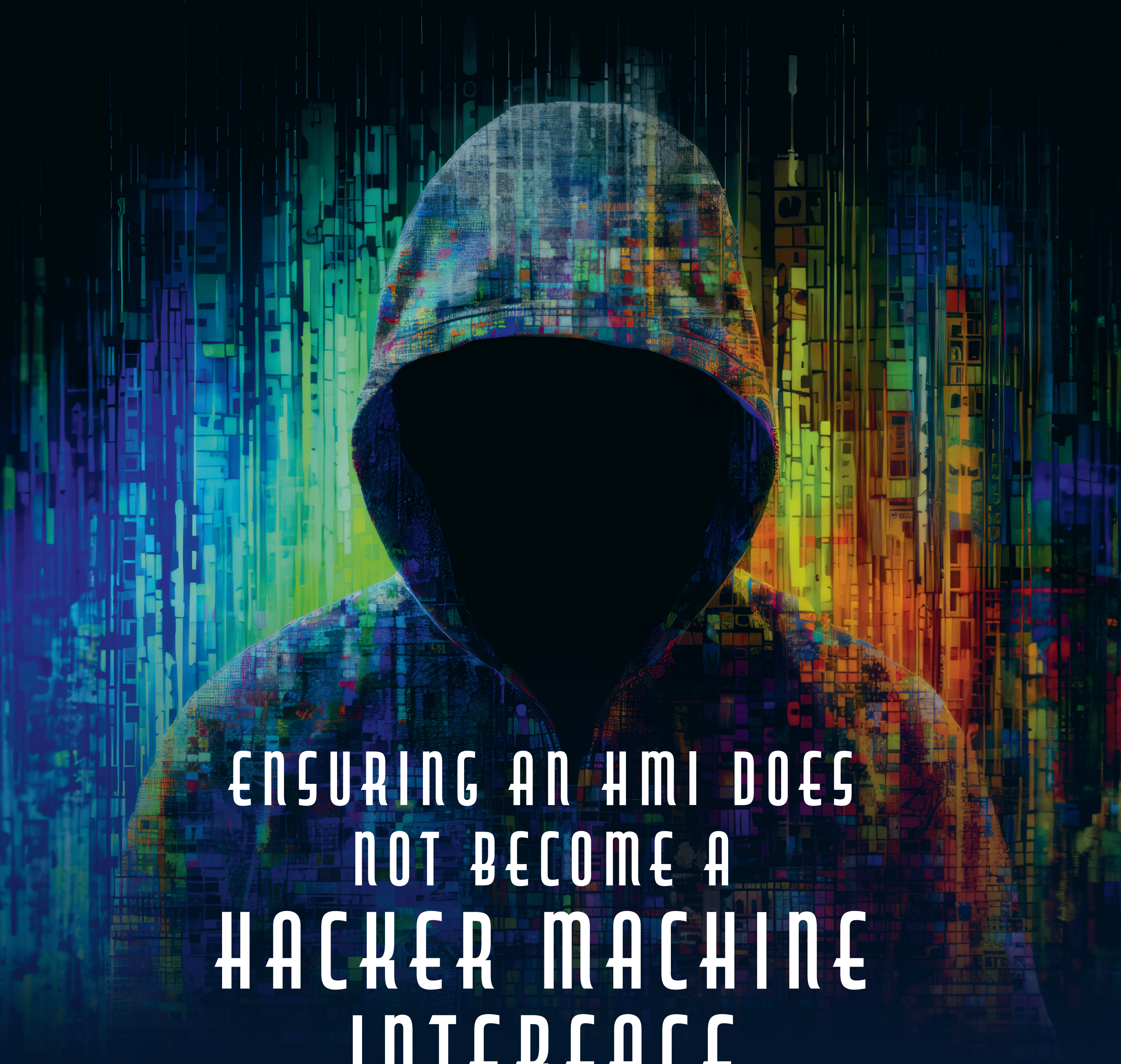
"Medical technology has made huge progress during the last few years," says Professor Alessandro Del Vecchio, head of the Neuromuscular Physiology and Neural Interfacing Laboratory (N-squared Lab) at the Friedrich-Alexander University Erlangen-Nuremberg (FAU). "However, much research and development still needs to be done in terms of fine motor skills, for example to enable movement of individual fingers of paralysed hands." Together with the Institute for Factory Automation and Production Systems at the FAU, the N-squared Lab aims to develop a neuro-orthosis that restores hand function so that patients can perform more than 90 percent of everyday tasks independently. "Our aim is to move the fingers and the thumb of the hand independently of one another and with a high level of strength," says Del Vecchio.

INCREASING ACCURACY

BCIs can generally be divided into invasive systems that are implanted into the brain. Semi-invasive and non-invasive systems. Non-invasive BCIs currently have the largest market share because they spare the patient from having to undergo a laborious and risky surgical brain procedure. "We have already developed a non-invasive BCI system that allows people with high spinal cord injuries to grip everyday objects by voluntarily changing their brain waves," says Professor Surjo R. Soekadar, Einstein Professor for Clinical Neurotechnology at the Charité – Berlin University Medicine. "Despite considerable progress, it has not yet been possible to control complex hand movements with such a non-invasive system." Yet this is precisely what Professor Soekadar's team is striving to achieve: they are currently testing the use of ultra-precise sensors, so-called quantum sensors, which can measure brain activity with much higher accuracy on the surface of the head than EEG or other non-invasive methods. The basis of the high-tech sensors is gaseous atoms that act as magnetic field probes and respond to electrical brain signals.

CHIP IN THE BRAIN

Implanted BCIs can capture brain impulses even more precisely. Companies such as Synchron and Neuralink are already testing such implants on humans. Elon Musk, who co-founded Neuralink in 2016, has promised that the technology "will enable someone with paralysis to use a smartphone with their mind faster than someone using their thumbs". Ultimately, however, the implanted chip is intended to make the human brain more powerful – even to the extent of merging the brain with artificial intelligence. According to Professor Mormann, this is still pure science fiction based on current knowledge: "Neuro-enhancement means targeted and specific influencing of brain activity. The prerequisite for this is a detailed and mechanistic understanding of this activity. Our knowledge so far is still too incomplete and patchy." TQ



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ENSURING AN HMI DOES NOT BECOME A HACKER MACHINE INTERFACE

From a cybersecurity perspective, the Human Machine Interface is considered the most vulnerable element in a technical system. To operate a machine, the HMI has access to all essential system data. If the system is hacked, it can have devastating consequences: operating personnel can lose control over a process, valuable data can be stolen and systems can be damaged or destroyed. In the worst case, lives can even be put at risk.

To prevent unauthorised access to the Human Machine Interface, the recommendation is to have several layers of protection. It all depends on the type of risk that would be caused by a device or machine being operated by an unauthorised person. For permanent operating points, the first step is to ensure that access to the room where the HMI is located can be monitored and controlled. This starts with a lockable door to which only authorised persons have a key and extends all the way to complex access control systems.

SECURING NETWORKS

Given that many HMIs are networked today, protecting the associated network infrastructure is also crucial. This includes the wiring that connects the HMI to the network as well as measures like IP addressing, routers, switches, WLAN access points, etc. Segmenting the network using firewalls provide an additional security measure. For web-based applications, communication between the browser and the server should be secured, for example with HTTPS: the browser loads a server-side certificate and checks it for trustworthiness and validity. Based on the certificate, the data transmitted between the web server and the browser is encrypted. This way, process data and user input exchanged between the HMI browser and the HMI web server can neither be manipulated nor spied upon. Another useful security measure is to install systems that monitor network activity and can detect and ward off intruders.

PROTECTING THE HOST AND OPERATING SYSTEM

The operating system of the HMI itself and its hardware, such as interfaces or drives, also need protection against unauthorised access. To minimise the attack surface, unnecessary ports and system services should be disabled and unused applications removed. The operating system's security patches and antivirus services should be kept up to date.

AUTHENTICATING THE OPERATOR

Ensuring that the operator of an HMI is indeed who they claim to be is a fundamental prerequisite for ensuring security. A study conducted by Trend Micro in 2018 demonstrated the significance of secure authentication: according to the study, almost half of the successful cyber attacks on HMI systems could be attributed to insecure passwords and inadequate access rights management.
The use of passwords, as we are accustomed to from smartphones and PCs, is widespread and used for various devices. However, the protection is only as strong as the complexity of the password. Unfortunately, the use of overly simplistic passwords often comes down to work efficiency: which operator, who operates several stations within a facility, wants to or is able to enter a 16-digit password on a touchscreen keyboard every time?

IDENTIFICATION BY BADGE

A solution here is badges with integrated RFID chips: as the operator approaches an HMI, the radio chip sends the identification data wirelessly to the operating terminal. This solution is particularly suitable in areas where wearing protective clothing, gloves and mouthguards is required for hygiene reasons. ►

Multi-factor authentication

By combining two or more authorisation credentials for identity verification, HMIs are more effectively secured.

Source: Identeco

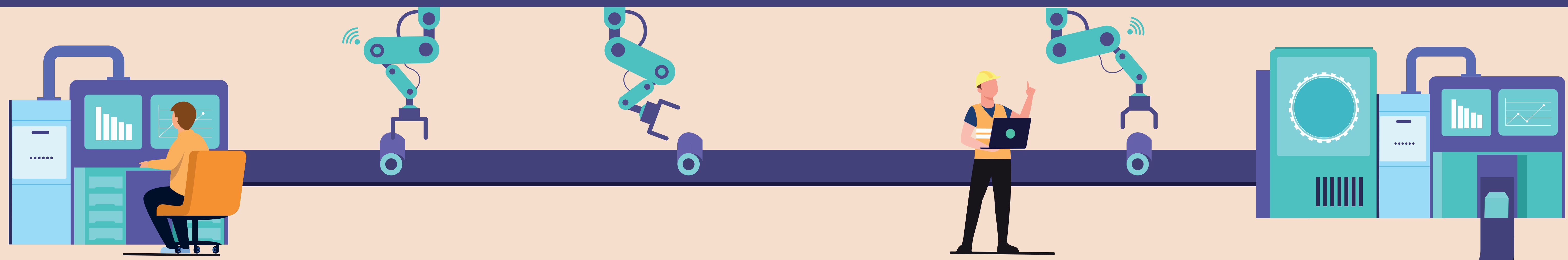
BIOMETRIC METHODS

Biometric methods for checking access authorisation, such as fingerprint scanners integrated into the HMI, represent an even more sophisticated approach. This ensures that the respective person is actually physically present and a hacker cannot enter a command virtually.

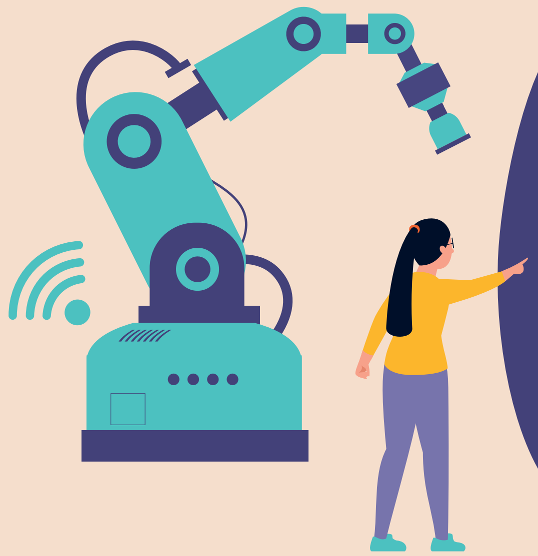
If an HMI already works with voice control, these systems can also be used to identify the operator. Authentication via voice uses the respective voice's individual characteristics: every single person has a unique voice with a multitude of measurable features. This voice profile is harder to fake than a fingerprint.

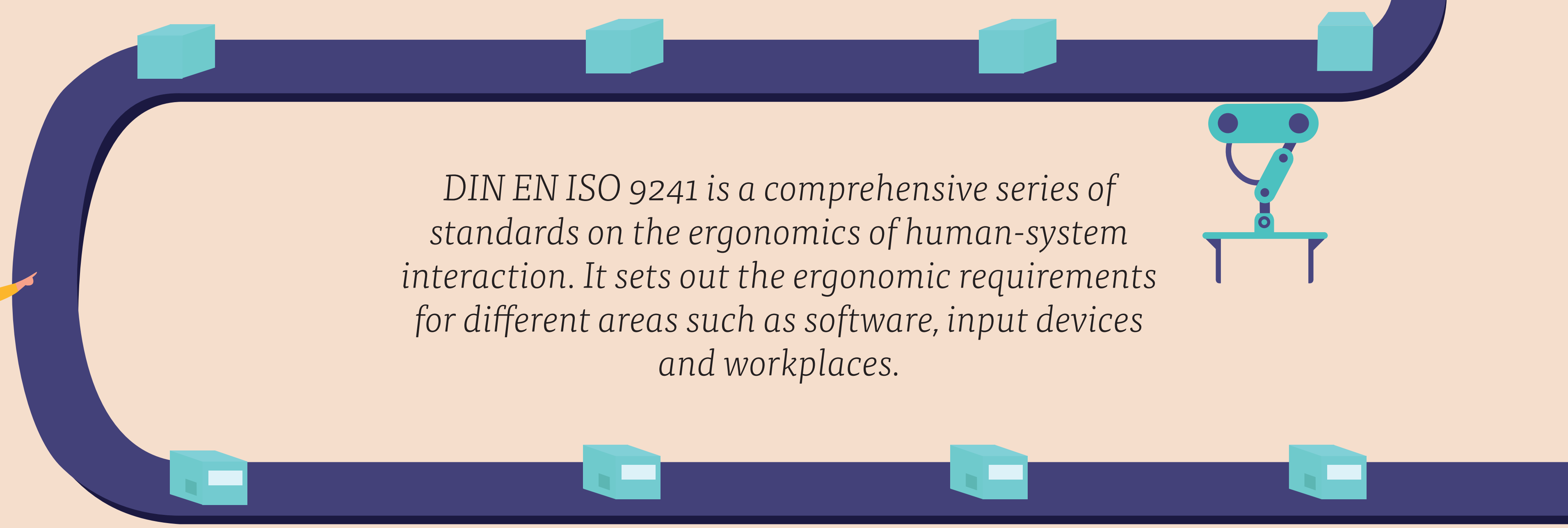
If an HMI uses camera systems for gesture control, it makes sense to also implement authentication via facial recognition. The biometric data of the face (for example, distance between the eyes, width of the forehead) captured by the camera is compared with a stored dataset. Modern "Face Authentication" systems are not fooled by three-dimensional masks either: the authentication process includes a genuineness check, which involves capturing the three-dimensional depth or recognising genuine skin based on a reflected infrared light beam, for instance.

Very often, several factors are used in the authentication process, for example a fingerprint and a password. This type of multi-factor system is much more secure than using just a conventional password. While it is never possible to achieve 100-percent security in the realm of cybersecurity, combining several factors can significantly reduce the risk of unauthorised access to an HMI.



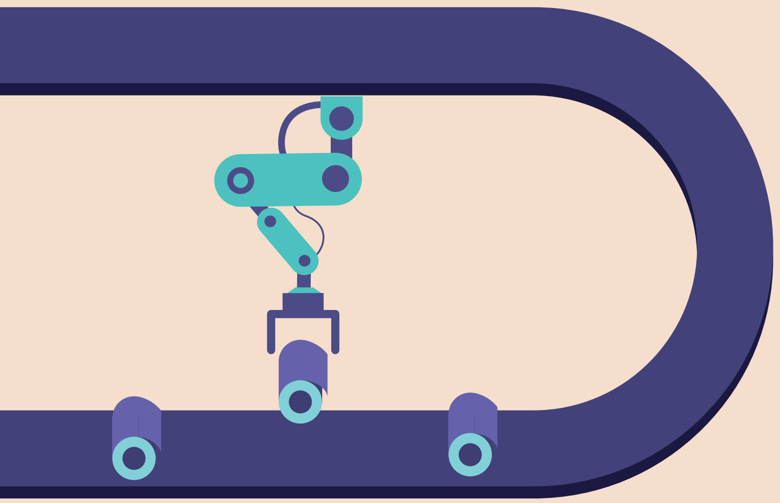
PUTTING SAFETY FIRST





DIN EN ISO 9241 is a comprehensive series of standards on the ergonomics of human-system interaction. It sets out the ergonomic requirements for different areas such as software, input devices and workplaces.

As collaboration between humans and machines becomes closer, the level of required safety must increase. It is therefore imperative that functional safety occupies a pivotal position in the design of a Human Machine Interface.



Wherever a human interacts with a machine, there is theoretically a risk of injury or material damage if a technical component fails. Machines and devices must therefore be "functionally safe".

SAFE EVEN IN THE EVENT OF FAILURE

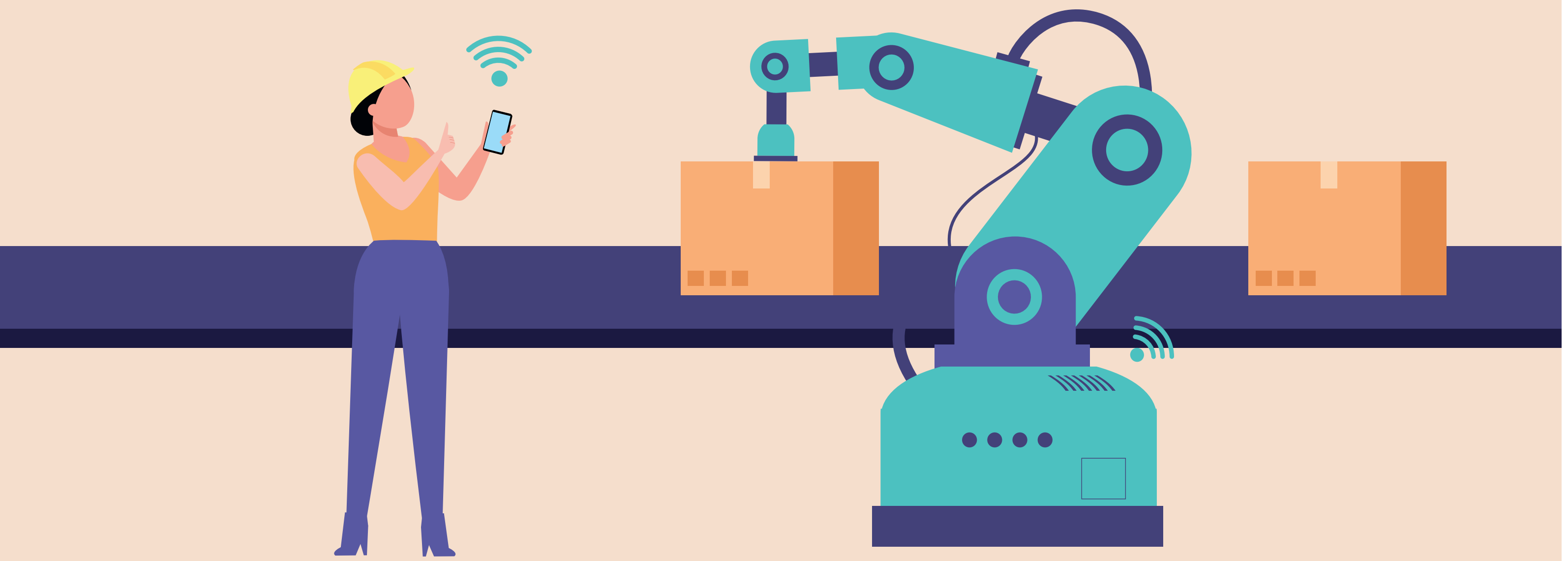
Functional safety describes the ability of a technical system to assume a safer state in the event of errors or hardware failures that pose an unacceptable risk to the safety of people or the system itself. This also applies to Human Machine Interfaces. The most common cause of work accidents is operational errors, for example because the operator did not understand or ignored the information provided by the machine, or simply provided the wrong input. The design of an HMI also plays an important role: a poorly designed Human Machine Interface can cause the operator to perform inappropriate actions, such as using shortcuts or bypassing safety devices.

HUMAN IN THE CENTRE

Therefore, humans should always be at the heart of the design process for a Human Machine Interface. This human-centered design process is described in DIN EN ISO 9241-210 – it is a good guide for anyone managing an HMI project. The design of the operating sequences, interaction and communication mechanisms, and the structuring of functions and information to be displayed have a significant impact on productivity, the prevention of operational errors and the reduction of training and servicing requirements.

EVEN SWITCHES MUST BE FUNCTIONALLY SAFE

Even seemingly simple control elements like capacitive switches must be safe. In a car, for example, capacitive HMI systems are being increasingly integrated into the vehicle's critical functions, where reliable functioning – or safe operation – is required. The start/stop button, for instance, usually requires a ►



Safety Integrity Level up to ASIL B (Automotive Safety Integrity Level risk classification scheme defined by ISO 26262 – functional safety for road vehicles).

BETTER TO ASK

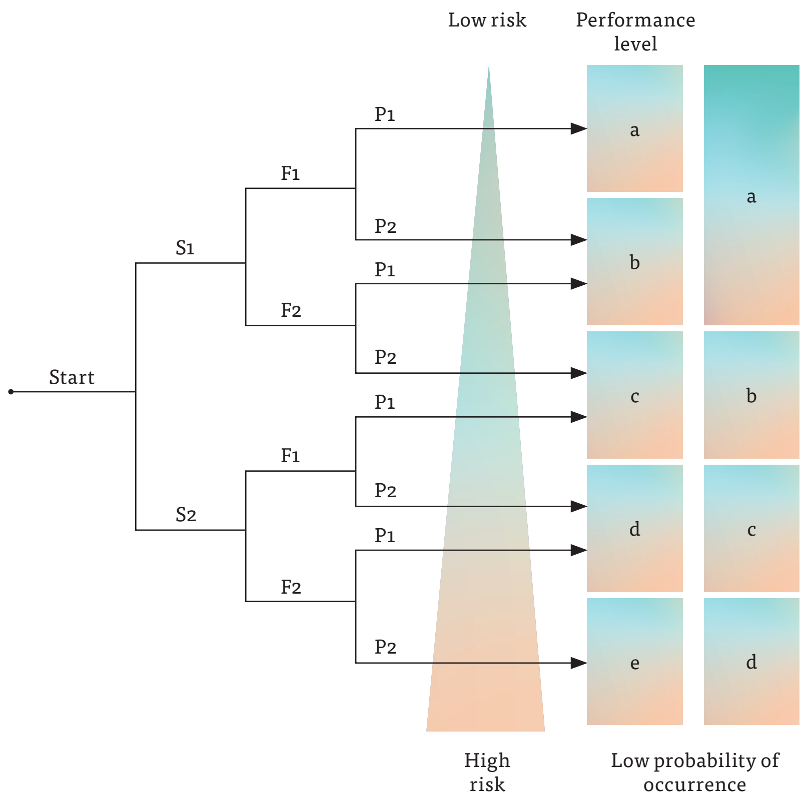
Given that incorrect data input, even when done unintentionally by the operator, can never be completely ruled out in safety-relevant applications, appropriate precautions such as two-button operation, key switches, or safety queries in the software must be taken. This also applies to modern HMIs such as voice control: where the consequences of incorrect data input can lead to damage or injury, there must be a safety mechanism in place. This could be a verbal question, such as "Are you really sure?", or achieved through another means, such as a manually operated switch.

PERSON RECOGNITION ENSURES SAFETY

When humans and machines work closely together, systems for automatic person recognition form an important component of safe operation. With the help of various sensors, they monitor hazard areas and determine whether people are present in them. Depending on the monitoring task, there are different detection methods. For monitoring the entire work area, different camera systems such as 3D or multi-cameras are suitable. On the other hand, a 2D laser scanner is suitable for monitoring individual sub-areas. In addition to areal use, sensors can also be attached directly to the machine or the person. Machine-centered sensors such as pressure sensors respond to touch and brake the machine in the event of a collision. Person-related sensors such as radio transmitters are carried by employees during work to determine their position.

HUMANS AND ROBOTS WORK SAFELY TOGETHER

Especially in view of the increasing interaction between humans and robots, sensor systems and measuring methods for automatic and safe person recognition are of particular importance. Collaborative robots, known as cobots, can cooperate with humans without a protective fence, where human safety must always be ensured. This is enabled, among other things, by power and force limiting: it ensures that biomechanical limits (force, pressure) are not exceeded in the event of contact between persons and robots. Another possible operating mode for cobots is speed and distance monitoring. This requires technologies for the early detection of dangerous situations (e.g. collisions) between humans and robots. Monitoring can be done, for example, via camera systems. Projectors can also project the relevant safety area onto the floor for the operator. A violation of this area by an interruption of the projection beams is detected by the surrounding cameras. With this solution, safety areas can be dynamically adapted to the work situation and robot configuration.



Performance level according to EN ISO 13849

In mechanical engineering, safety is often classified according to EN ISO 13849 into so-called "performance levels." The performance level is divided into five stages ("a" to "e") and sets out requirements for the reliability of safety functions. Which performance level individual safety functions must meet depends on the assessment of the hazards in a risk assessment.

LOCALISATION FOR REMOTE CONTROL

Remote controls are indispensable not only in robotics but also in many other applications. However, they can pose significant risks with medical and other devices – for example if functions are triggered unintentionally. Therefore, it is essential that critical functions can only be controlled if the remote control is within a certain area. This requires precise and interference-resistant distance measurement – for example, using Ultra-Wideband technology (UWB). It enables device locations to be pinpointed to within half a metre using the Time of Flight (ToF) method.

SAFETY FROM THE START

There is a multitude of solutions to make interaction between humans and machines safe. Which path is the right one always depends on the application. In any case, safety should already be considered in the design process of an HMI, and it is essential to always consider various different safety systems. TQ

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THE MANY WAYS OF NETWORKING

Various different communication standards are used for transmitting human data input to the machine – or more precisely, to the machine control system. The right one depends on factors such as the industry, the data to be transmitted and the transmission path.

For a long time, the individual control elements of a Human Machine Interface were connected discretely, meaning each had its own cable: in complex control systems, this quickly led to cable bundles that had to be connected to the machine. This installation effort can be significantly reduced by bus systems – only one connector and one cable are required.

EACH INDUSTRY HAS ITS OWN BUS SYSTEMS

Currently, a significant number of bus systems can be found on the market. There are a number of reasons for this: every industry and application has different requirements when it comes to data transmission, different technical solutions are available, and several manufacturers have brought their own bus system to the market. In industrial applications, systems like Profibus, Modbus, CC-Link and DeviceNet have been established. Other industries use different solutions: for example, KNX, LON (Local Operating Network) or BACnet in building technology.

In the automotive sector, the CAN bus (Control Area Network) has the largest revenue share at 37.8 percent, according to Precedence Research. Other bus systems that are in use today include Local Interconnect Network (LIN), Media-Oriented Systems Transport (MOST), FlexRay and Ethernet. Each bus system focuses on specific requirements: LIN, for example, enables the cost-effective integration of sensors and actuators in vehicle networks, while FlexRay can be used in safety-relevant distributed controls.

ETHERNET GAINS MARKET SHARE

Ethernet is also gaining importance across industries. This bus was developed in the first half of the 1970s and is currently the transmission standard in the IT world. For industrial applications, Ethernet has been adapted to be fast enough for the high demands of industrial automation. These "Industrial Ethernet" protocols include Profinet, EtherCAT and Ethernet IP. The factors driving growth in the area of Industrial Ethernet systems include higher performance, larger data volumes, better real-time properties, the integration of safety protocols and the continuity into office networks – and thus also easier connection to the Internet of Things and to the Cloud. Ethernet has been further developed to be able to control safety-relevant tasks: with TNS (Time Sensitive Networking), a set of standards has been defined that supplements Ethernet with functions for the real-time transmission of data.

MANUFACTURER-INDEPENDENT COMMUNICATION

When integrating an HMI into complex machines, there is the problem that devices from different manufacturers must be connected. A potential solution here is the data exchange standard OPC Unified Architecture (OPC-UA). It was developed in close cooperation between manufacturers, users, research institutes and consortia. OPC-UA bridges the gap between the IP-based IT world and the production world.

REMOTE CONTROL OF MACHINES VIA RADIO

Operating machines, systems and devices via radio remote control has many advantages. A radio remote control enables the free choice of location during a process or action. Typical frequency bands for radio remote control are 433 MHz and 868 MHz. The 433 MHz frequency band offers greater range, but this band is more susceptible to interference than the 868 MHz band due to high utilisation. The use of the 2.4 GHz frequency band is also very widespread. It can be freely used around the world and is the only frequency band that can be used in all countries without additional permission. The uncomplicated access process makes the 2.4 GHz band very popular and particularly interesting for non-professional use. Model building, drones and WLAN routers often operate on this frequency.

Stable radio connections are a prerequisite for operating a machine via remote control. Various radio systems therefore use LBT/AFA technologies ("Listen Before Talk" / "Adaptive Frequency Agility"). First, a channel is checked to determine whether it is free, and if it is, a connection is established on this channel. If not, the next channel is checked and used if possible. In this way, emergency stop functions can also be realised via radio.

Ethernet is gaining importance as a communication standard across industries.

FROM THE CONSUMER SEGMENT TO PROFESSIONAL USE

Cutting-edge products in terms of ergonomic user interfaces were smartphones and tablets. Many people now use them on a daily basis; a fact that many companies are leveraging to enable professional applications to be increasingly controlled via mobile devices. Depending on the application, the connection is established via a WLAN modem or Bluetooth.

The USB interface is another well-known development from the consumer sector. Today, it is also used in professional applications to connect an HMI to a control device, or to connect auxiliary devices, such as a mouse, keyboard, signal lights or fingerprint scanner, to the operating terminal. TQ

NATURAL INTERACTION THANKS TO AI

Artificial Intelligence has influenced the interaction between humans and machines like no other technology before. However, with increasing capabilities, regulations are also required to make their decisions transparent, understandable and safe.

Ask our experts from the "High-End Processing" technology segment about AI processors.

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James Cameron's 1984 film "Terminator" is a classic that still shapes many people's perception of Artificial Intelligence to this day. In the film, a computer system developed by the military was to start a devastating war against humanity in 1997 to protect itself from being shut down. Now in the 2020s, the horror scenarios predicted in "Terminator" and similar films have not come to pass. Nevertheless, AI has now become a part of professional and private everyday life, enabling a new era of human-machine collaboration: chatbots respond flawlessly to questions, smart home devices are controlled by voice and cobots work hand in hand with humans. AI systems are the basis for many innovative Human Machine Interfaces like voice and gesture controls.

ATTEMPT AT A DEFINITION

But what exactly is meant by Artificial Intelligence? There is, in fact, no universally accepted definition in science or practice. The draft of the European "AI Act" defines artificial intelligence as "software that is developed with one or more (...) techniques (...) for a given set of human-defined objectives and generates outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with." At its core, AI uses algorithms and complex mathematical models to analyse data and identify patterns. Like humans, AI is supposed to learn from experience, make judgments and solve problems independently – to be able to perform tasks increasingly better.

SEVERAL SUBAREAS

The term "artificial intelligence" covers several subareas, including Machine Learning and Deep Learning. In Machine Learning , the system independently discovers connections based on example data. Thus, AI systems can learn from data and solve problems on their own without being explicitly programmed in the form of rules. Machine Learning is particularly suitable for recognising and generating so-called "patterns" from existing datasets – for example, the system can thus recognise which gesture a hand performs. Deep Learning goes a step further by automating further aspects of the learning and training process. Deep Learning algorithms can decipher unstructured datasets such as texts or images, so much less human intervention is required.

AI BECOMES CREATIVE

Thanks to ChatGPT, the latest technological developments in AI are currently a hot topic – the so-called generative AI and foundation models. They are capable of independently generating content such as software code, texts, images and music. This sets generative AI apart from "classic" discriminative AI, which is designed to differentiate and classify input but does not create new content. Compared to previous AI models, generative systems are particularly powerful as they are trained based on a very large amount of data. With this breadth and amount of information, foundation models can, for example, translate between languages and systematically work through tasks. In terms of HMIs, they offer advantages in voice control, among other things: the conversation with the machine is more natural, and responses can be given based on the context. Additionally, generative AI can process complex commands better. Instead of simple actions, users can give more detailed instructions: the AI can interpret these, ask follow-up questions if necessary and generate appropriate actions.

Boom in Edge AI processors

14.54
billion US dollars
in 2022

54.38
billion US dollars
in 2029

To realise AI functions in Human Machine Interfaces, so-called Edge AI processors are important as they can evaluate the data directly on-site and thus ensure a quick response to commands. According to Maximize Market Research, the market will grow by an average of 20.1 percent annually in the coming years.

LEGISLATIVE REGULATION

Despite all the advancements, artificial intelligence is still far less sophisticated than portrayed in Hollywood blockbusters. Nevertheless, regulations are needed so that AI can make the right decisions. An AI system is only as good as the database with which it was trained. There have already been several practical examples of AI systems having a certain "bias" because the database was not diverse enough. If, for example, a language model were trained only with a North German dialect, the later system would have problems understanding someone from southern Germany. To make AI safe and trustworthy, the European Union has introduced legislation to regulate its development and use: the AI Act. This regulation, which is expected to come into force in 2026, is intended to ensure that AI systems used in the EU are safe, transparent, understandable, non-discriminatory and environmentally friendly. AI systems should be monitored by humans and not by automation to prevent harmful results. Thus, the "Terminator" should remain pure science fiction in the future. TQ

ROBUST HMIS FOR HARSH ENVIRONMENTS

The freezing cold, dust, moisture – Human Machine Interfaces often have to withstand extremely harsh environmental conditions. Protection against vandalism and hygiene requirements also play an important role in some areas of application.

Whether in the rough daily routine of construction machinery, in food production or as a public terminal in the city – Human Machine Interfaces are often exposed to extreme environmental conditions. By using qualified materials and appropriately designed constructions, and choosing suitable operating technologies, HMIs can work reliably even in the most adverse conditions.

REPLACING MECHANICAL SWITCHES

Traditional mechanical buttons, which are operated by actual touch, are robust components, but germs or impurities can easily settle on mechanical and moving parts. Moreover, they cannot be installed flush in plants – an additional gateway for dust and the like. A resistant and hygienic alternative is provided by capacitive buttons. ►

Foreign bodies – first digit		Liquids – second digit	
0	No protection	0	No protection
1	Protection against objects with a diameter > 50 mm, like a hand	1	Protection against vertically falling dripping water
2	Protection against objects > 12 mm, like a finger	2	Protection against dripping water when the housing is tilted up to 15°
3	Protection against objects > 2.5 mm, like a cable	3	Protection against sprayed water at up to 60° deviation from the normal position
4	Protection against objects > 1.0 mm, like a nail or wire	4	Protection against splashing water from all directions
5	Dust-protected – resistant to occasional dust ingress	5	Protection against jet water from all directions
6	Dust-tight – no dust ingress	6	Water-resistant against strong jet water
		7	Protection against immersion (up to 1 m) for a limited time
		8	Protection against continuous immersion (over 1 m)
		9	Protection against high-pressure jet water from close range

IP67

Well protected?

The degree of protection provided by a housing for electrical equipment against dust and other foreign objects, accidental contact and water is described by the IP code. IP stands for "Ingress Protection". The code was defined by the International Electrotechnical Commission (IEC) in the standard IEC 60529. The first digit of the IP classification indicates the degree of protection of the housing of an electrical device against solid foreign bodies (with level 6 being the highest protection level). The second digit of the IP rating stands for the housing's resistance to liquids. The protection types for liquids go up to digit 9.

Learn more about our
media-resistant HMI solutions
and those of our partners.

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They can be integrated flush into any system and have no mechanical elements where dirt particles or germs can settle. Thus, sealed, smooth and easy-to-clean user interfaces are possible, preventing the ingress of moisture or dust.

SEALED KEYBOARDS

Elastomer keyboards offer a high-quality, tactile feel with an underlying switch layer. They are characterised by high weather resistance in harsh environments, and moisture and chemical resistance. Elastomer keyboards are used when three-dimensional buttons are needed in environments with high moisture, such as in maritime or defence applications.

In the food, laboratory and medical sectors, the membrane keyboard plays an important role due to its closed surface, resistance to chemicals and its imperviousness to liquids and dust. The classic membrane keyboard consists of about eight layers, of which only the top layer, the "front foil," is visible in the later application. The actual switching element, the snap disc, is placed between the different layers and is thus well protected against dust and moisture. Integrated acrylic inlays also prevent deformation of the snap disc.

EASY-TO-CLEAN TOUCH PANELS

In harsh application areas, touch panels should be equipped with scratch-resistant and shock-insensitive surfaces and components. They must withstand high stresses from jet water, steam and dirt, and be sealed against harmful gases. The entire surface of the input system must be resistant to oil, solvents and aggressive chemicals. Touch panels should meet the IP67 protection class and have a continuous, closed front structure without dirt edges. This facilitates cleaning, which is of great importance in the food industry, for instance. The robustness against mechanical stresses can be ensured by choosing hardened glasses. In conjunction with a laminated composite glass pane on the back, for example, vandal-proof touch panels for public applications can be realised. Capacitive PCAP touch technology meets both industrial and medical requirements. It is resistant to water and saltwater, electromagnetic radiation and chemicals. Moreover, it can also be operated with gloves and can be equipped with antimicrobial surfaces.

ANTIMICROBIAL COATINGS

With antimicrobial coatings, HMIs are also equipped for particularly high hygiene requirements. Generally, a distinction is made between active and passive materials. Passive coatings prevent microbial colonisation through the surface structure alone. The so-called Lotus effect inhibits the adhesion of microorganisms to the material surface. In contrast, active antimicrobial materials contain biocidal components that attack microorganisms at the cell wall, in metabolism or in the genome. To meet high hygiene standards, it is recommended to provide switch handles and user interface for touch applications with coatings with Log reduction values of 5.25 (disinfection) to 6.05 (sterilisation).

THE INSIDE MATTERS TOO

Vibrations, extreme temperatures and chemicals affect not only the surface of a Human Machine Interface. HMI assemblies generally consist of a multitude of layers or components. Adhesives and sealants ensure that thermal and electrical contacts remain consistently connected, possible damage from overheating is prevented and HMIs are protected from short circuits, contamination ingress or mechanical failure due to vibrations. For example, display layer bonds must have adequate peel adhesion, shear strength and impact resistance under harsh environmental conditions. Furthermore, vibration and shock absorbers and seals are indispensable components of HMI design. Thin and lightweight foams absorb vibrations and shocks very effectively and are flexible enough to fit into predefined housing dimensions and consider temperature change swelling and contractions.

All these materials must not lose their function in harsh conditions, for example by contracting, drying out or outgassing at extreme temperatures. Accordingly, careful attention should be paid to the materials for adhesives, seals and co. when designing an HMI for harsh environmental conditions. TQ

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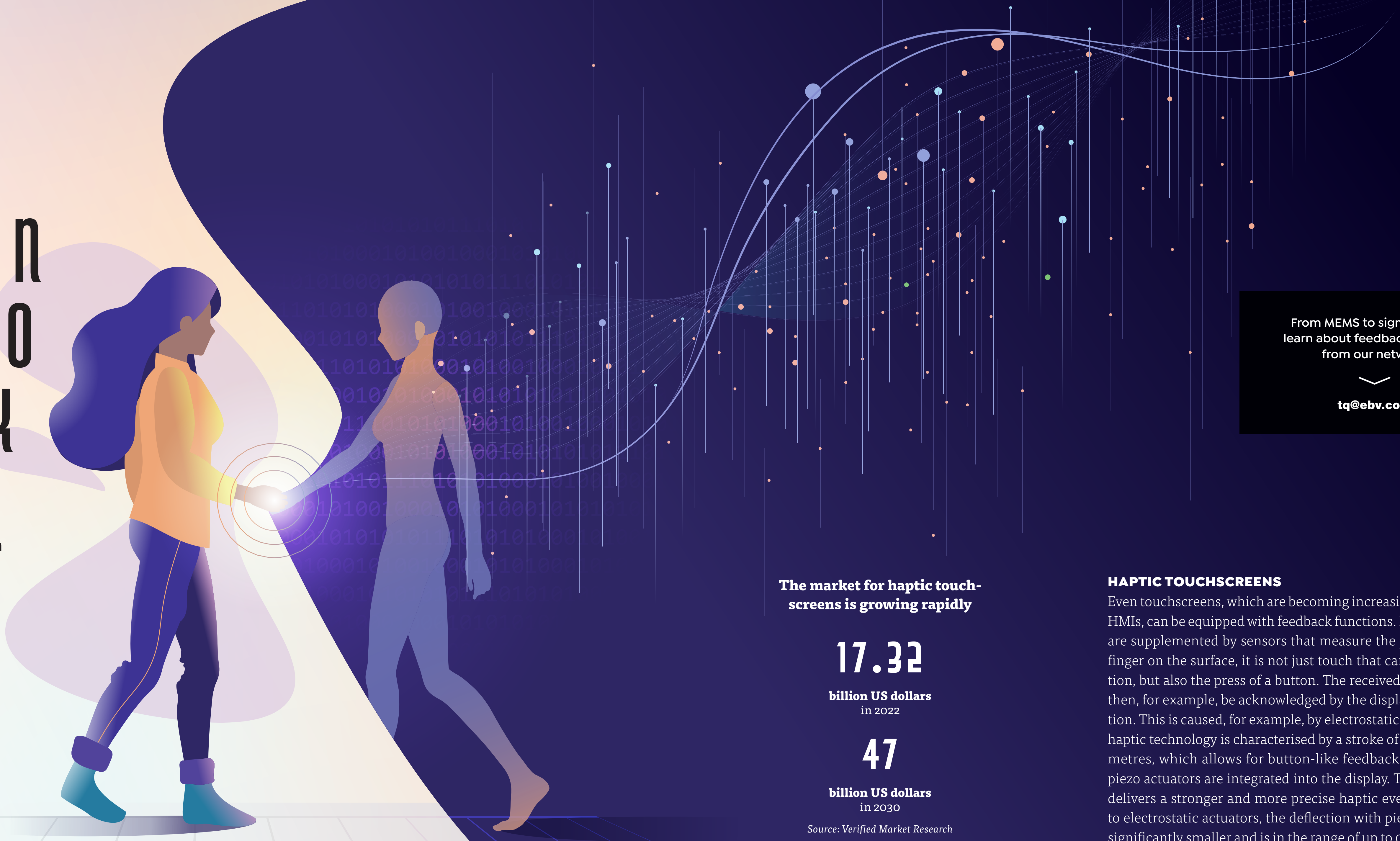
BETTER OPERATION THANKS TO FEEDBACK

With feedback technologies, Human Machine Interfaces can provide feedback to humans. The applications range from a simple confirmation of the received command to the transmission of diverse information.



The interaction between humans and machines is usually not one-sided, but rather a kind of communication: the operator issues a command and receives feedback on whether the command has been received. For example, with toggle switches, it is the changed position, and with push-buttons, it is often a certain resistance that must be overcome, sometimes coupled with a control light. Important for operators of many machines is also direct feedback on the force or the angle of rotation triggered by the operating part. For example, an excavator operator can feel the strength of the force with which a shovel penetrates the ground through the resistance of the operating lever of a hydraulic system. The same applies to machine tools: through mechanical operating parts, force and vibrations are transmitted directly to the hand and body of the operator.

OPERATE WITH FEELING

With the introduction of electronic controls and operating elements, however, this haptic feedback has been lost. But thanks to microelectronics, the feeling can be replicated in modern Human Machine Interfaces. In general, sensors detect the force that the human applies to the operating part. If necessary, additional sensors also measure the force or angle at the executing part – that is, the tool, the shovel of an excavator or the wheel of a car. Micro-actuators at the operating part can then, for example, cause a noticeable counter-movement based on these measured values. The technologies used for this are summarised under the term "force feedback".

GAMING LEADS THE WAY

Such systems have been well-known in the gaming sector for a long time, for example with driving simulators: a steering wheel with force feedback technology generates vibrations and simulates gravity. High-end systems dial into the physics and the audio engine of a game to enable an ultra-realistic experience. The player feels in real time the roar of the engine of their virtual race car, the tyre traction, the nature of the terrain of the track and the feedback of the steering wheel. So it feels as if you are sitting behind the wheel of a real car.

From MEMS to signal lights – learn about feedback solutions from our network.

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The market for haptic touch-screens is growing rapidly

17.32

billion US dollars
in 2022

47

billion US dollars
in 2030

Source: Verified Market Research

FEEDBACK FROM THE CAR

Force feedback solutions are found not only in virtual vehicles but increasingly also in real ones: especially in the context of highly automated driving, the classic steering wheel with mechanical steering column is being replaced by mechatronic actuators – this is called steer-by-wire. Thanks to force feedback, however, the mechatronic steering wheel conveys exactly the same feeling as a classic mechanical one. Additional functions can also be realised – for example a vibration of the steering wheel when the car detects that the driver is getting tired.

Accelerator and brake pedals are also equipped with force feedback. Such active accelerator pedals with integrated actuators and freely programmable haptic signals can, for example, help the driver to drive as fuel-efficiently as possible: depending on the selected driving program, a variable pressure point in the pedal travel can be generated, which signals the optimal accelerator pedal position to the driver.

HAPTIC TOUCHSCREENS

Even touchscreens, which are becoming increasingly popular as HMIs, can be equipped with feedback functions. If touchscreens are supplemented by sensors that measure the pressure of the finger on the surface, it is not just touch that can trigger an action, but also the press of a button. The received command can then, for example, be acknowledged by the display with a vibration. This is caused, for example, by electrostatic actuators. This haptic technology is characterised by a stroke of up to 0.8 millimetres, which allows for button-like feedback. Alternatively, piezo actuators are integrated into the display. This technology delivers a stronger and more precise haptic event. In contrast to electrostatic actuators, the deflection with piezo actuators is significantly smaller and is in the range of up to 0.3 millimetres.

ADDRESSING THE SENSE OF TOUCH WITHOUT CONTACT

However, operating elements are increasingly being controlled completely without contact, for example through glances, hand gestures or voice control. Until now, users have received control-related feedback in the form of displays or acoustic signals. The Institute of Construction Technology and Technical Design at the University of Stuttgart is currently working on enabling haptic feedback here as well. This involves the use of ultrasound waves: they are projected onto the palm of the hand, for example as circles, triangles or moving points, and produce a tingling sensation. Once you have learned the language of these signals, this feeling helps to move the hand in the right direction and at the right speed.

Feedback technologies are an important part of Human Machine Interfaces. They improve the user experience and open up new possibilities for the optimisation of safe and efficient workflows. TQ

APPLICATIONS

Human Machine Interfaces have become an indispensable part of modern machinery and equipment – whether in industrial processes, in medical technology, in cars or in smart homes. Modern HMI technologies have led to significant advances in efficiency, user-friendliness and overall system performance. The combination of AI and HMI technologies further enhances these benefits by enabling more intuitive, context-related and personalised interactions between humans and machines.

USER EXPERIENCE TAKES CENTRE STAGE IN MACHINE OPERATION

Operators of machine tools need to be able to concentrate on their work. This is why there has been a greater focus on developing HMIs for use in industry that are intuitive and have a multimodal operating principle. Traditional control elements are being replaced by virtual switches on touchscreens, which will be supplemented by gesture and voice recognition in the future.

Today, operating complex CNC machine tools requires several years of training and solid technical knowledge. However, the industry is increasingly suffering from a lack of suitably qualified skilled workers. Manufacturers are therefore counteracting this with intuitively operable machines. The latest machine tools are able to simplify operability through integrated feedback systems and the display of visual action prompts, so that even inexperienced operators can understand the handling of the machine in a short time.

INTUITIVE USER INTERFACES

An example of this is the C.O.R.E. operating concept of the machine tool manufacturer United Grinding, which was awarded for its user and customer experience by the jury of the UX Design Awards in 2022. The core of the Human Machine Interface is a multi-touch display that largely dispenses with buttons. Self-explanatory icons simplify navigation through the machine menu and process steps. Each operator can configure their user interface individually. The user identifies themselves with an RFID chip with a stored role profile, and "their" interface is automatically called up. "It was important to us that the new operation appeals to all generations of users," explains Christoph Plüss, CTO of United Grinding Group. "We therefore gravitated towards the operating concepts that are widely used in consumer electronics today and with which practically everyone is familiar from everyday life."

REMOTE CONTROL VIA SMARTPHONE

This increasingly includes wireless HMI solutions that can be connected via Wi-Fi and Bluetooth. They offer maximum freedom of movement and flexibility. There is also increasing consideration of dispensing with industrial hardware for machine operation and instead using standard devices from the consumer sector. It is already common practice today for machine data to be retrievable via an app on a smartphone or wearable. However, real operation of the machine is currently only realistic for non-time-critical process control, as consumer devices do not have the necessary security architecture to ensure functional safety. Given that smartphones and tablets are particularly captivating due to their ease of use, this technology could well determine automation in the near future.

VOICE-CONTROLLED USER INTERFACES

Voice-controlled user interfaces are increasingly being integrated into industrial HMI concepts, mainly in order to complement traditional graphical user interfaces. With the increasing accuracy and performance of natural language processing (NLP) technology, machines can understand complex voice commands and respond accordingly. The company Voice Inter Connect, for example, offers voice control for industrial applications as a ready-made kit. Real-time capability, AI-based semantic analyses and algorithms for beamforming and noise cancelling ensure high operating comfort and audio quality. The system can also process

acoustic feedback in the form of input prompts or text-to-speech for voice output. Thanks to local voice processing, the voice control does not need an internet connection and thus meets high standards of security and data protection.

OK BY GESTURE

A natural extension to Human Machine Interfaces for machine tools could also be gesture control. However: "The operation of machines via interfaces is very visually oriented," says Professor Katrin Wolf, head of the Human-Computer Interaction research group at the Berlin University of Technology. Hand movements are still rarely used for interaction.Professor Wolf says one reason for this is: "It is uncomfortable for people to learn gestures and then perform them correctly without visual feedback or support if they make errors." In the WINK research project, Professor Wolf's team is therefore investigating how feedback can be given via tactile stimuli. For this purpose, the scientists are constructing special bracelets for the forearm that can transmit tangible signals to the skin. To do so, the researchers have joined forces with tool manufacturer Trumpf, who is providing the use of a laser cutter to make the work process more efficient. On one side the operators push the steel plates into the industrial machine, and the cut parts emerge on the other side, where the employees check their quality. If they find faulty cuts, they have to go to the other side of the machine and record the findings via a keyboard. The idea: with a simple hand movement, such as a hook symbolising "OK", the employees could give feedback to the machine without having to go back and forth. Trumpf uses a bracelet from Kinemic for gesture recognition. It recognises two-dimensional gestures based on movement but only returns sound and vibration via a built-in motor. However, Professor Wolf's team wants to realise more complex vibration patterns and integrate more motors for this purpose. Although a prototype already exists, Professor Wolf is certain that: "The use of haptics for the control of digital devices will remain a research field for many years." TQ

HMI: THE WINDOW TO THE SOUL OF TECH GETS BRIGHTER

Human Machine Interfaces are increasingly appearing in new and unexpected places, but this comes with a range of challenges. How can companies create rich animations and "smart" User Interfaces (UIs) on the latest embedded systems while keeping costs down?

Human Machine Interfaces exemplify the well-known idiom "putting information at our fingertips". By replacing the push-button with displays and graphical representations, they have transformed how people interact with technology. In the 1990s, HMIs ran on PCs and CRTs (Cathode Ray Tubes), and engineers had greater flexibility thanks to Ethernet, GPUs and Windows. However, ever since HMIs branched out from the world of personal computers to run on embedded systems and LCDs, they have become truly ubiquitous. Many analysts point to the smartphone as the canary in the coal mine that demonstrated that low-power arm architectures could run graphical interfaces. Additionally, software and sensor innovations have enabled energy-saving paradigms on battery-powered systems. However, this new reality has also given rise to some unique challenges.

WHAT ARE HMIS AND WHY ARE THEY CHALLENGING?

In the simplest terms, an HMI is a User Interface (UI) representing a system's control and monitoring features. It is often interactive thanks to a touchscreen or buttons, and it is highly popular because it enhances productivity by making complex systems easier to use and data more easily digestible. However, because HMIs can now run on microcontrollers, users want to use them everywhere. Consequently, engineers must create portable interfaces suited for different screen sizes and hardware specifications. This means dealing with widely different constraints while keeping costs down. Moreover, HMIs keep growing in complexity as developers add features like over-the-air updates and machine learning capabilities that need a UI. Put simply, HMIs now have to perform more tasks and run on more platforms while keeping costs down.

A SOLUTION AT THE CROSSROAD OF HARDWARE AND SOFTWARE

To solve this challenge, ST has released devices like the STM32MP13, the STM32MP2 and the STM32U599, among others. The first two microprocessors feature a Cortex-A7 and Cortex-A35, respectively, which means that they can run embedded Linux and all its graphical frameworks. They are also some of the most cost-effective devices of their kind; the STM32MP13 costing less than four dollars. Both support numerous communication interfaces, like Gigabit Ethernet. The STM32MP2 even offers compatibility for time-sensitive networking, meaning engineers can integrate HMIs into systems with stringent constraints without blowing their bill of materials. Similarly, the STM32U599 MCU opens the door to HMIs that weren't previously possible on microcontrollers at this price point thanks to its NeoChrom GPU. This ST technology provides new hardware acceleration to enable a higher frame rate and smoother animations. Consequently, UI makers are now showcasing interfaces on our devices to demonstrate how engineers can run more feature-rich HMIs on a wide gamut of processing devices while keeping costs down.

HMIs have also become more efficient and convenient thanks to new sensors. For instance, the new STHS34PF80 thermal metal-oxide semiconductor (TMOS) from ST uses an infrared sensor with a wavelength between 5 µm and 20 µm. It provides presence detection at a fraction of the power consumption and the cost of what a regular sensor using a more complex VCSEL would require. This vastly increases the overall efficiency, making HMIs a reality on more systems. Similarly, while ST works with numerous makers of graphical frameworks, the company also provides TouchGFX, a free framework that takes advantage of all the hardware features baked into STM32 devices. Hence, taking advantage of hardware IPs is as easy as pushing a button in TouchGFX Designer, thus considerably optimising workflows.

WHAT'S NEXT?

The popularisation of machine learning at the edge is leading users to ask for smarter HMIs with modular interfaces and contextual applications. That's why the STM32MP2 comes with a neural network accelerator. ST understands that design teams need to jump on the bandwagon early if they are to stay ahead of the curve. Additionally, as more users expect an HMI on products that previously had none, engineers must find ways to bring them to more systems. Understanding how to navigate constraints is thus essential, which is why ST often provides webinars, blog posts, documentation and tech demos. The key to tomorrow's innovations in HMIs doesn't solely lie in a product portfolio but in a different mindset around how we, as an industry, create HMIs and how they will improve our relationship with technology over the next decade.

GENTLE COLLABORATION

Work with us to find suitable sensor and drive solutions for integration into your cobots.

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Collaborative robots work in close proximity to humans – even as a team. The interaction between humans and machines is thus very close and direct. The robot has a multitude of sensors that allow it to perceive the human and adjust its movements accordingly.

In recent years, a new generation of robots has been pushing its way into the market, enabling the automation of processes while remaining cost-effective and allowing uncomplicated collaboration with humans: the cobots. Professor Robert Grebner, president of the University of Applied Sciences Würzburg-Schweinfurt, says, "Cobots are an important next step towards automating complex motion sequences. Wherever physically demanding and monotonous tasks occur, cobots will ease the work for humans by being integrated into work processes."

32

percent increase each year
The global market for cobots is set to grow from 1.23 billion US dollars in 2022 to 11.04 billion US dollars in 2030.

Source: Grand View Research

What is a cobot?

A cobot, or collaborative robot, is a robot that possesses a range of safety features and characteristics that allow it to work not only in proximity to humans but often also in collaboration with them.

To ensure human safety, almost all cobot components are equipped with sensors to detect humans, making all cobots an extensive Human Machine Interface. Unlike with classical robotics applications, this avoids the need for protective fences or similar barriers.

PERCEPTION OF THE ENVIRONMENT

Sensitive force monitoring continuously checks the torque and speed of various drives. If the robot encounters an obstacle – which can also be a human – the movement is either stopped immediately or continued very carefully and gently. Additional sensors enable the perception of the environment. Robots can thus adapt their way of working early on when a human approaches. For example, the Swedish lighting manufacturer Fagerhult Belysning currently has three Motoman cobots in operation. The robots, each with a load capacity of ten kilograms, take over complex assembly steps among other tasks. The unique thing about the cobots is that they can switch between the classic full-speed industrial robot mode and a safe collaborative mode. Safety scanners detect if an employee approaches the defined safety area and then slow down to a safe pace.

THE CLOSER, THE SLOWER

The "sBot Speed" safety system from Sick also enables adaptive perception of the environment: laser scanners and a safety control system guide the robot so that it slows down the closer a person moves into the robot's working area – until it comes to a complete stop. The ability to automatically adjust the robot's operating conditions to the position of people in the environment protects against accident hazards while simultaneously improving productivity, as downtime is reduced and workflows are optimised.

SMART SAFETY ZONES

A research team from the Fraunhofer IWU is pursuing a slightly different approach. They have divided the robot's perception areas into smart zones. With faster movements, such a zone "grows" to exclude the risk of collision with humans. Lidar sensor technology (Light Detection and Ranging), which recognises and categorises objects using pulsed laser light, as well as cameras, are used for environmental perception. The combination of response times (Lidar: 50 milliseconds, camera: 10 milliseconds) and surveillance areas (Lidar: larger areas; camera: near field) now allows the robot to move faster. Although the speed must still be reduced when humans approach, it is considerably less than before: about 25 percent faster robot movements mean a significant gain in efficiency.

EFFICIENT WIRING OF SENSORS

The numerous systems that ensure human safety require many cable connections for sensors and actuators in traditional robot architectures. The wiring effort can be significantly reduced by using FSoE technology, or Fieldbus Safety over EtherCAT. Fraunhofer IWU, NexCobot and Synapticon have jointly developed a corresponding safety architecture. It is decentralised and enables safe human-robot collaboration even when work situations change dynamically – with significantly reduced wiring effort. "An intelligent safety system monitors the relevant areas and adjusts the robot control situationally to any conceivable interaction between humans and robots," emphasises Dr Mohamad Bdiwi, team leader of Collaborative Robot Systems at Fraunhofer IWU. Another advantage: given that the safety of the motion sequences is monitored directly at the drive axis, there is significantly less reaction time.

HAND-GUIDED TEACHING

Cobots differ from classical industrial robots not only in collaboration but also in their interaction with humans during programming. Even a person who is not a robot expert should be able to quickly and easily "teach" the cobot a new task. On the one hand, this is done using graphical programming systems or apps for tablets or smartphones, which do not require specific training. Above all, however, the cobot learns the execution of certain tasks by the human literally taking it by the hand: the employee manually guides the robot arm through the required motion profile. Additional control buttons "on the wrist" are used to save the respective positions – so not every position has to be confirmed on the robot's hand control panel. Thanks to so-called hand-guided teaching, the cobot is ready for use very quickly. So this really is a case of humans and machines working together hand in hand. TQ

FULL CONTROL IN OFF-ROAD MACHINERY

Mobile work machines have undergone various technical advancements in recent years to increase efficiency and safety at work.

In agricultural and construction machinery, the human factor is becoming even more central to human-machine communication. This means that the industry must increasingly rethink conventional operating concepts: "The construction site of the future is a more connected place, and so-called gamification will play an important role. Demographic changes and consumer preferences are pushing our industry into areas that were previously unknown or underutilised in the machine sector," explains Vijayshekhar Nerva, head of Innovation and Acceleration at Doosan Bobcat EMEA.

LOADER CONTROLLED BY SMARTPHONE

A clear example of this is the remote control via smartphone developed by Bobcat. This allows the operator to remotely control their compact loader within seconds without worrying about additional devices. Using a smartphone, the machine can be sent into a dusty or potentially unsafe environment to complete its tasks while the operator stays at a safe distance. The remote control communicates with the customer's iOS device via a Wi-Fi signal and operates within a range of up to 100 metres.

OPERATION VIA TOUCH

The controls in the driver's cabin are also evolving. As land and construction machinery become more complex, touchscreens are increasingly being used in the off-road sector. They allow a variety of information to be called up and displayed in a targeted manner. With special die-cast housings and robust adhesive technologies, touchscreens can also withstand the inevitable shocks and vibrations in this area. The integrated PCAP touch provides optimal conditions for comfortable control of machine functions. PCAP stands for "Projected Capacitive Touch". This technology turns a window or glass surface into a touch-sensitive interface, allowing users to interact as they are accustomed to from a tablet or smartphone with a touchscreen.

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COMMUNICATION VIA VIBRATION

Since the machine operator's visual and auditory senses are already heavily demanded in daily work, the company elobau has developed a vibration module for joysticks. With certain vibration patterns, high-quality tactile feedback can be generated, making human-machine communication more efficient. The module's vibration motor is controlled by an electronics module via the CAN bus. Manufacturers can define different parameters such as intensity, duration or number of vibrations via the CAN protocol. These parameters create individual, application-adapted and above all intuitive vibration effects. Thus, the information content to be transported can be significantly increased compared to simple punctual knocking signals.

ADAPTIVE CONCEPT

With the multitude of functions that need to be operated in today's work machines, the control console can quickly become cluttered. The joint project aISA (adaptive interface systems in tractors) has presented itself as a promising solution. An adaptive armrest has been developed that only provides the functions of the attachment that is in actual use. Through the Isobus, the intelligent operating armrest can adaptively adjust to any attachment as soon as it is coupled. It provides the user with an optimal and ergonomic interface in terms of position, availability, visualisation and operating mode. This includes, for example, a joystick that can assume four different positions depending on the required function (for example, it is retracted when its function is not needed). Other controls are provided via a rotary control unit. Each position adjusts depending on the attached work equipment and presents only the functions that are currently necessary.

AUTOMATED LOAD MANAGEMENT

When working with construction and agricultural machinery, there are typically phases of both very high and relatively low stress. "Various studies have shown that people's well-being is highest when there is a medium level of stress," says Professor Marcus Geimer from the Karlsruhe Institute of Technology (KIT). Overloading leads to the driver not being able to concentrate enough on the important aspects, overlooking things and becoming more prone to making errors. On the other hand, underutilisation – for example through complete automation – is also a problem. The boredom that arises leads to fatigue and loss of concentration.

As part of the "Driver's Cab 4.0" research project, KIT is therefore developing an "adaptable Human Machine Interface" for agricultural machinery. It is capable of recognising drivers' current stress levels via eye tracking. Research is also being conducted on a fitness bracelet that uses light signals to determine the pulse and thus measure the level of stress. If the system detects an overload, all unimportant information is faded out. In situations of underutilisation, additional tasks should be offered to the driver. "Meaningful additional tasks for phases of low stress come from accounting, personnel or material management, and the private task field," says Patrick Lehr from the Institute of Mobile Work Machines at the Institute of Vehicle System Technology at KIT. In the future, the recommended tasks will be projected into the driver's field of vision via an augmented reality-based interface, to avoid overloading the cabin with controls. TQ

WHERE HUMAN AND MACHINE MERGE

Prostheses and exoskeletons are nothing more than machines. However, as they interact very closely with humans, their interfaces have to fulfil a particular set of requirements.

The interaction can hardly be any closer: "We are literally working at the interface between humans and machines," says Professor Claudio Castellini, professor of medical robotics at Friedrich-Alexander University Erlangen-Nuremberg (FAU). He and his team are researching how to further improve prostheses and make them more reliable. "Over the last few decades, significant advancements have been made in upper limb prosthesis technology." Lifting a glass, clenching a fist, typing a phone number with an index finger – state-of-the-art robotic hands can already do remarkable things with the help of biomedical technology. Surface electromyography is used as a Human Machine Interface: skin electrodes detect the finest muscle movements on the remaining arm stump. These biosignals are converted and transmitted as electrical impulses to the prosthesis. Targeted Muscle Reinnervation (TMR) is a proven treatment method. In a surgical procedure, the nerves in the stump that previously controlled the arm and hand are reassigned a new function. They are extracted from the surrounding tissue and precisely connected to muscles in intact body regions. This allows the patient to control their future arm prosthesis via "thought signals". When the user imagines moving their phantom arm, the nerves pass signals to the new target muscles, causing them to tense. This generates electrical signals in the millivolt range, which are measured by electrodes in the prosthesis shaft. A mini-computer analyses the signals and converts them into the intended movement. To move several joints simultaneously, TMR arm prostheses are equipped with up to six electrodes. This allows the user to control up to six movements through independent muscle signals. "The wearer controls the hand prosthesis independently with their arm stump," explains Professor Castellini. "Through methods of pattern recognition and interactive machine learning, the human can also teach the prosthesis their individual needs when performing a gesture or movement."

RECOGNISING MOVEMENT PATTERNS

Ottobock has brought to market the first prosthesis control in Europe with pattern recognition. It uses eight electrodes to measure muscle movement patterns in the forearm stump and assigns them to specific hand movements. So, when the patient reaches for a bottle of water, the prosthesis control recognises the associated movement pattern and commands the prosthesis to execute the respective grip or rotation. This is automatic. The patient can

independently control the prosthesis with an app and visualise the measured movement patterns, allowing them to learn how to subconsciously call up these patterns more deliberately.

ANTICIPATING INTENTIONS

However, even these advanced robotic prostheses are not yet perfect in terms of comfort, function and control. The EU Horizon project "IntelliMan" is therefore looking into how the prostheses can interact more effectively and purposefully with their environment. The focus here is on so-called "intent detection". Professor Castellini and his team are further developing the capture and analysis of human biosignals and designing innovative machine learning algorithms to identify individual movement patterns in a person. "We use the possibilities of intent detection for the control of assistive and rehabilitative robotics," explains the scientist. "This includes wearable robots such as prostheses and exoskeletons, as well as robotic arms and simulations in virtual reality."

DIRECT INTERFACE WITH THE BRAIN

Modern technology can help not only people who have lost limbs, but also those who cannot move their hands or legs as a result of a spinal cord injury, stroke or other illness, for instance. Brain Computer Interfaces create a direct connection between the human brain and technical systems, allowing the control of a device solely through brain activity.

Blackrock Neurotech is one of the leading manufacturers of implanted electrodes. Its arrays have so far recorded data from the brain across 600 channels. Now, the American manufacturer has introduced a BCI that operates with more than 10,000 channels – which enables an exponential increase in capabilities. "If our current BCI can help people move and feel again with only six hundred channels, imagine what we can achieve with ten thousand or more channels," says Florian Solzbacher, co-founder and president of Blackrock Neurotech. He plans to develop a vision prosthesis using the new BCI by 2028. "This is a taste of what will be possible in the future with BCI." TQ

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CARS THAT TAKE CARE OF THEIR PASSENGERS

Driver fatigue and distraction are common causes of accidents, which is why modern Human Machine Interfaces in the automotive sector include systems that monitor the condition of the occupants. These systems are an integral part of the testing protocols of Euro NCAP, the new European General Safety Regulation for vehicles and various other regulations around the world.

By 2030, the EU aims to halve the number of traffic deaths and injuries. This ambitious endeavour encompasses everything from the mandate of state-of-the-art vehicle technologies to the modernisation of infrastructure. However, one factor plays a particularly significant role: the human. More than 90 percent of all accidents are caused by human error. In addition to violations such as speeding and driving under the influence of alcohol, it is important whether the driver is tired or distracted. According to the European Commission, 10 to 20 percent of accidents and near-accidents occur as a result of fatigue.

MANDATORY WARNING SYSTEMS

To address this problem, the European Commission published a regulation in August 2021 that, effective in July 2022, mandates the use of Driver Drowsiness and Attention Warning (DDAW) systems. They assess the driver's vigilance by analysing other vehicle systems such as steering and lane keeping and warn the driver if necessary.

KEEPING AN EYE ON THE EYES

However, relying solely on data from other vehicle systems is not necessarily sufficient to assess a driver's condition. Therefore, from mid-2024 in the EU, new vehicles must be equipped with an Advanced Driver Distraction Warning (ADDW) system. The first generation of ADDW solutions primarily relied on the driver's eye movements: a camera with a CMOS image sensor monitors the driver using invisible infrared light. "The infrared light generates a reflection on the cornea of the eye, which is captured by the camera," explains Martin Wittmann, marketing director for the sensor division at OSRAM Opto Semiconductors. "By tracking the direction of gaze, we can see whether the driver is looking at the road. The size of the pupil also indicates how awake the driver is. Finally, we can also recognise when the driver becomes tired by the movements of the eyelids." When this is the case, the system warns the driver and redirects their attention to the road.

SUPPLEMENTARY HEALTH MONITORING

Fatigue or lack of attention are highly complex states, so the latest generation of solutions capture additional parameters besides eye movement. The company Smart Eye has integrated the capture of vital signs into its driver monitoring software. ►

Driver monitoring still faces resistance

The majority of drivers are still skeptical about electronic monitoring of the driver, known as driver monitoring, for driver condition detection. At least that's what a study by the insurance company Allianz shows. It reports that only 39 percent of those surveyed agree to camera or infrared scanning of the eyes, face, or head, where the technology anonymously only detects distraction. "We still have work to do in persuading drivers to accept driver monitoring," says Christoph Lauterwasser, head of the Allianz Center for Technology. "It should not be about patronising, but about support. The latest vehicle and traffic technologies enable us to warn drivers when they are distracted. Just this feedback can contribute to a positive change in behaviour. We should use this to make road traffic safer for all of us."

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Using AI methods, the new function analyses several physiological signals to accurately determine the driver's heart and respiratory rate. Smart Eye, in particular, uses remote photoplethysmography (rPPG), a contactless, camera-based method that measures fluctuations in light reflection from the skin to estimate heart rate. Another method is micro-movement analysis, which allows the software to detect subtle changes in movements associated with breathing or pulse that are not visible to the human eye. "By integrating heart and respiration rate detection into the driver monitoring system software, we provide an even deeper layer of insight into the driver's state of health," says Henrik Lind, Chief Research Officer at Smart Eye. This can be lifesaving if, for example, a driver suffers a heart attack or seizure.

COMBINING RADAR, CAMERA AND AI

A more accurate capture of the driver's condition is enabled by multi-sensor systems, such as those being developed jointly by emotion3D, Chuhang Tech and SAT. The "human analysis" software from emotion3D derives information about the driver from camera images, while Chuhang Tech's radar solutions analyse the driver's vital parameters. These two measurement methods are combined with SAT's algorithms for predicting sleep onset. Wogong Zhang, CTO and co-founder of Chuhang Tech says: "We believe that our combined solution, which combines radar technology with advanced imaging algorithms, will revolutionise fatigue detection."

SAFETY FOR AUTOMATED DRIVING

Driver monitoring systems are becoming increasingly important in view of the increasing automation of driving. As a vehicle becomes more autonomous, better safety systems are needed – for example to monitor whether a driver is ready to take over control of the car in a difficult situation. "Particularly well-functioning systems, especially in areas such as adaptive cruise control and lane keeping, tempt many road users to turn to tasks other than driving," said Jann Fehlauer, Managing Director of DEKRA Automobil, at the presentation of the DEKRA Road Safety Report 2023. Several serious accidents have already been the result of such a misjudgment.

1.3

million people
die each year in traffic accidents around the world, according to estimates by the World Health Organization (WHO).

Accidents in Germany in 2021 where distraction played a role, 8,233 people were injured and 117 died, which is just under five percent of all fatalities (2,562).

Source: Federal Statistical Office of Germany

By integrating the detection of heart and respiratory rates, driver monitoring systems gain insight into the driver's condition and health.

SMARTER CONTROL OF THE HOME

Smart home applications make up a large part of the market for Human Machine Interfaces. The ultimate benchmark remains the kind of interaction offered by today's smartphones.

How will future customers interact with smart home products?

49	43	52	3	2
percent Voice recognition	**percent** Multi-touch & display screens	**percent** Remote devices	**percent** Gesture recognition	**percent** Haptic technologies

Source: Jabil, "2023 Smart Home Technology Trends Survey Report"

Ask our experts from the market segment "Light, Home & Building" about HMI solutions for the smart home.

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Lights controlled by an app, a smart thermostat that automatically turns off the heating when a window is open, a vacuum cleaner robot that starts with a voice command: smart home devices have long been established, and the market is a booming billion-dollar business. Analysts from Brainy Insights estimate that the global smart home market will grow from 90 billion US dollars in 2022 to 657.41 billion US dollars in 2032. This market is a key driver for Human Machine Interfaces – as HMIs are the crucial component in the intelligent home to seamlessly integrate smart home devices into the daily lives of residents.

HMIS AS A SUCCESS FACTOR

The further development of HMIs and the functionalities associated with them are closely linked to the growing demand for smart home devices. In a survey conducted by the global contract manufacturer Jabil together with SIS International Research among 200 decision-makers for smart home solutions and devices, 39 percent stated that intuitive Human Machine Interfaces are the most important factor for the success of their smart home solution.

MULTI-TOUCH AND SCREENS

In the Jabil survey, 84 percent of respondents stated they currently use multi-touch and display screens in their smart home solution – the second most common response. Moreover, 43 percent expect their customers to continue using displays to interact with smart home solutions in the future. One study participant highlighted a particular advantage: "An intuitive touchscreen display, simple controls that facilitate use, and a thoughtful design ensure that [the device] is easy to clean and maintain."

VOICE COMMAND OPERATION

Voice assistants like Google Home and Amazon Alexa have revolutionised the operation of intelligent devices at home. "The smart home has become the main area of application for the voice control of devices," said Bitkom President Achim Berg already in 2022.

Systems like Alexa or Siri work over the Cloud – which repeatedly raises concerns about data protection. The data leaves the smart home and could be used by third parties. Indeed, more than three-quarters (76 percent) of manufacturers in the Jabil survey stated that they use HMI interactions, such as voice commands, to collect data on their smart home solutions. Systems that process speech locally offer more data protection security: for instance, Peaknx building control has offline voice control from ProKNX, which operates independently without internet access in the configured operation. The spoken commands are only processed locally and do not leave the building. No recording takes place either. Thus, following the motto "What's said at home, stays at home," the privacy of residents is always preserved.

HOLOGRAPHY IS NOT SCIENCE FICTION

The COVID-19 pandemic triggered a massive demand for touchless HMIs that enable interactivity like a touchscreen without the risk of contamination. One of the most effective ways to achieve this is holographic projections. Corresponding HMIs create a holographic image of a control element by directing the content of a display through a special holographic plate. In addition to a deflection of angle, a convergent bundling of rays occurs there, creating a virtual image floating freely in space. An infrared touch sensor is mounted below the virtual image. Its beam path is interrupted when the image is "touched". The interruption is evaluated as a touch event. While manufacturers of public touchpoints are already using holographic HMIs for "germ-free" contactless operation, applications for the smart home are still in the development stage – for example for coffee machines or intelligent fitness equipment. Nevertheless, already four percent of the participants in the Jabil survey are using holograms in their HMI solutions.

GESTURE CONTROL IN LOW DEMAND

As with holographic HMIs, COVID-19 has significantly increased the demand for solutions with gesture recognition. Just over a third of the participants in the Jabil survey currently use this technology for their HMIs. However, only three percent of them expect their customers to continue using gesture recognition to interact with their products in the future. However, facial recognition and eye-tracking solutions could gain market share in smart home HMIs. Such solutions could, among other things, improve the accessibility of smart home devices for people with mobility or speech disabilities – one could simply look at a control panel to change the temperature of a room or the volume of the television instead of using a remote control or giving a command.

MODERN REMOTE CONTROL

However, the most important HMI in the smart home is still the smartphone: according to Bitkom, 85 percent of people in Germany control their smart home applications and devices via a smartphone app, 20 percent via remote control. In the future, wearables will also be used to control smart home devices, which is also what the manufacturers surveyed in the Jabil study expect. Devices such as smartwatches or fitness trackers could, for example, send a signal to the smart home network as soon as the resident enters their home, in order to automatically activate the lights, heating or television. TQ

BETTER INFORMED IN THE SMART CITY

Digital information pillars are becoming an increasingly essential way to connect citizens with municipal administrations. Since they are typically installed outdoors, it is essential that they are protected against weather and vandalism.

Connected infrastructure made up of electronic and digital technologies aims to positively change life in the city. Energy savings, more efficient traffic flow, increased public safety and a healthier environment are just a few of the many benefits that a smart city can offer.

DIGITAL SIGNAGE AS AN INTERFACE

The most important interface between citizens and the smart city is undoubtedly the smartphone, which people use to connect to the infrastructure and retrieve information through apps, as well as to provide information. However, digital signage is also an important resource for administration, public transport and citizens.

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For example, digital information pillars from ST-Digital in Lucerne offer interactive city maps, a diverse range of information and additional advertising content. Smart city maps help passersby and tourists orient themselves in city centres thanks to their integrated touchscreen. Directions, weather forecasts or a comprehensive selection of information about destinations in the vicinity are further examples of the offering. The company Inputech even offers digital display and input systems that can optionally be expanded with visual sensors. Thus, characteristics such as age, height and gender of the passerby are recognised, and the information displayed is tailored to specific groups.

ROBUST SIGNAGE SOLUTION

The municipal administration of Bussigny in the Swiss canton of Vaud uses an outdoor digital signage solution that allows it to improve communication with citizens at various locations. The outdoor solution had to withstand the elements, as it is exposed to extreme weather conditions all year round. Furthermore, the system was to be installed in a public setting and therefore needed to be particularly shock-resistant to protect against potential vandalism. A display solution with IK10 rating was sought. Eventually, special Outdoor Digital Menu Boards from Peerless-AV were used.

The manufacturer's smart city kiosks feature a fully sealed, IP66-certified design that prevents foreign bodies such as water, dust, moisture and insects from entering the display. Particularly important for city installation is high-temperature resistance: the displays operate at temperatures ranging from -35 °C to 60 °C. They can be expanded with an optional IR touch overlay that can recognise up to ten touch points. Housings made of stainless steel, aluminum and corresponding paint offer high resistance to corrosion and vandalism. In addition, the display features shock-resistant, hardened cover glass with an IK10 rating.

PROTECTING SURFACES

Sensitive resistive and capacitive touchscreens, as well as front foil keyboards, are the most important Human Machine Interfaces in public areas. The surfaces of these input devices must be protected against various environmental conditions, such as heat or UV or EMV radiation. They should also be resistant to yellowing. Besides a scratch-resistant display surface and shatter protection, they must also be protected against vandalism. This can be achieved by laminating the surfaces with special films. The films and lamination processes used depend on the desired technology (resistive or capacitive), surface (glass or plastic), area of application and the respective environmental conditions. Touchscreens can also be protected by hardened protective glass, which can be up to 10 millimetres thick. An alternative option is to use safety glass designed to break into small, rounded pieces when destroyed.

The possibilities of intelligent digital signs are still being explored. What is certain, however, is that they enable cities to provide contextual and personalised information for their communities, thus offering benefits for everyone. TQ

The IK Standard EN 62262

EN 62262 specifies the resistance or the degree of shock resistance of an electrical device against external mechanical stresses, especially impacts. There are 12 strength classes, starting from the lowest category IK00 up to the highest classification IK11.

IMMERSIVE GAMING

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Immersion is the key term in the gaming sector. Gamers want to dive into the game, to experience the virtual world as realistically as possible. The industry is continually bringing new solutions onto the market – from game controllers to Brain Computer Interfaces.

Anyone who has ever been engrossed in a game knows what "immersive" means. It comes from the Latin "immersio," meaning to dive in. In the context of computer games, the word describes the extent to which a player perceives themselves to become part of the game world. Besides the pure visuals, such as a first-person perspective, the interaction with the virtual world is decisive.

FAMILIARITY WITH DIGITAL TECHNOLOGY

The industry uses all the possibilities offered by modern Human Machine Interfaces, making it an exciting testing ground for new technologies. "Gaming is more than just entertainment. Through interactive gaming experiences, users are playfully familiarised with modern technology. As they dive into virtual worlds, they intuitively learn to handle digital interfaces, menus and control options," says Dr Sebastian Klöß, head of Consumer Technology at Bitkom. Young people's familiarity with complex Human Machine Interfaces is even utilised by the military, which uses HMIs resembling gaming controllers rather than military equipment – many systems can be used by young soldiers without intensive training.

HAPTIC FEEDBACK IN CONTROLLERS

To achieve the goal of an immersive gaming experience, manufacturers are constantly coming up with new ideas. This starts with the "simple" controller such as the PlayStation 5 from Sony: it makes the game action palpable through haptically fine-tunable vibrations. Adaptive triggers allow the adjustment of the analog shoulder buttons. In this way, certain activities in the game, such as shooting, accelerating and jumping, become more nuanced. Moreover, Sony has recently patented a new controller design that integrates an elastic area that can change its shape and temperature and respond to various physical inputs such as pressing or rubbing. This would offer new possibilities for immersion, such as the controller being able to enhance intense game moments with heat.

MEASURED PRESSURE

Keyboards with force sensor technology are already a reality, although they may not be as visionary as some other technologies. They are used, for example, in special gaming laptops. Typically, the W, A, S and D keys are supplemented by a force function, making the keyboard much more intuitive and sensory for players to operate. "Imagine driving down your local highway and your accelerator is restricted to just 2 options, 'off' or 'full speed'. Reality-based physics calls for acceleration dependent on how hard you press on the accelerator pedal, or how hard you turn the steering wheel. This is the difference Peratech intelligent tactile sensing makes," explains Jim Thomas, CCO of Peratech. The company equips, for example, the Lenovo Legion 7i and 7 gaming laptops with corresponding force keys.

CAPTURING HEAD MOVEMENTS

Lenovo's top model can also capture the player's head movements. The integrated software solution from Tobii Ho- ►

> *"This is just the beginning for neurotechnology. We are at the cusp of being able to ethically create a seamless relationship between people and their technology."*
>
> *Dr Ramses Alcaide, CEO Neurable*

rizon uses the laptop's built-in camera for this purpose. Players can thus control the field of view in the game with their head movements. When a player turns their head to the right, the camera follows his gaze to the right. This is particularly helpful in games where it is important to be aware of the surroundings, such as in first-person shooters or racing games.

DIVING INTO VIRTUAL REALITY

Players can truly dive into a game through virtual reality and augmented reality technologies. Special VR glasses let the player sink into the artificially created, virtual world. These headsets can be mounts into which a smartphone is inserted, such as with Samsung Gear, or so-called "Head Mounted Displays", which integrate the entire technology, such as Microsoft's Hololens. In both approaches, the player is at the centre, and their virtual view follows their own movement. With its immersive and interactive nature, virtual reality has revolutionised the way games are experienced. But VR becomes truly "immersive" with input devices specially designed to make the virtual world seem more real.

INTERACTING WITH OBJECTS

Like the Oculus Touch: these handheld devices are designed to mimic hand movements in the virtual world. Equipped with sensors, buttons and triggers, the system allows the player to interact with objects and move precisely and effortlessly through virtual environments. The VR controller HTC Vive Wand also features haptic feedback – allowing the player to feel the virtual objects they interact with.

PLAYING WITH BODY MOVEMENTS

The gaming experience becomes completely realistic when the movements of the entire body can be used to guide the character through the virtual world: jumping, running, kneeling – all captured by full-body tracking systems like Omni One from Virtuix. It is an omnidirectional treadmill that allows players to walk or run in any direction through video games and other virtual environments. It is currently shipped with a Pico Neo 3 Pro headset with 6DoF technology (6 Degrees of Freedom) and additional hand controllers for hand and gesture tracking.

EMPATHISE WITH THE AVATAR

For players who still want more, in future they will be able to experience their characters' suffering from the game. For instance, the game provider Ubisoft plans to offer a shirt with haptic feedback for its game Assassin's Creed Mirage. With the Haptic Gaming System from OWO, the player is supposed to experience sensations on the body that correspond with the actions in the game. "By leveraging OWO's groundbreaking technologies and expertise, we are able to immerse players in the world, sounds and sensations of Assassin's Creed Mirage in an innovative and enhanced way," Fabian Salomon, lead producer at Ubisoft Bordeaux. The sensations that the shirt can convey range from wind or free fall to knife stabs, thus also exploring the limits of immersion.

SEAMLESS INTERACTION

But the future of VR controllers goes even beyond that. Companies like Neurable are working on Brain Computer Interfaces that allow players to control virtual environments with their thoughts. The company, a spin-off from the University of Michigan, is developing neurotechnological reference designs, APIs and capabilities that function outside of laboratory conditions and can be integrated into everyday technologies. Neurable licenses its technology for headphones, earbuds and AR devices. Dr Ramses Alcaide, CEO of Neurable, is sure that: "This is just the beginning for neurotechnology. We are at the cusp of being able to ethically create a seamless relationship between people and their technology." TQ

PRODUCT PRESENTATION

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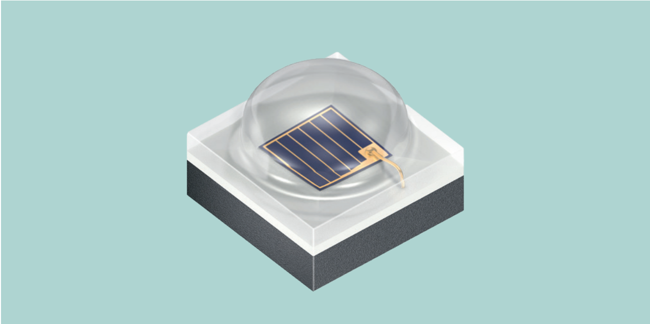


MIRA050 CMOS IMAGE SENSOR

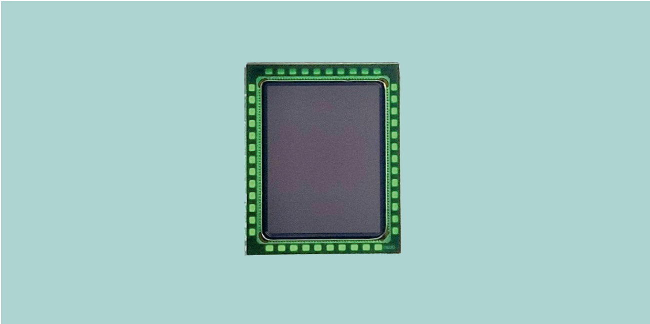
Mira050 is a 0.5 MP Near IR enhanced global shutter image sensor designed for 2D and 3D consumer and industrial machine vision applications.

The MIPI CSI-2 interface enables easy interfacing with a plethora of processors and FPGAs. On-chip registers can be accessed via the standard I^2C interface for easy configuration.

Mira050 is well suited for 2D and 3D applications, which include Active Stereo Vision, Structured Light Vision and AR/VR. High sensitivity in NIR enables increased measurement range and enables overall system power consumption optimisation.

KEY FEATURES

» High pixel area to die area ratio
» High frame rate
» On-chip power management
» High sensitivity and QE in visible and NIR spectrum
» On-chip noise reduction
» On-chip defective pixel correction



ams OSRAM

MICRON MEMORY & STORAGE FOR NEXT GENERATION HMI

The advent of IIoT and AI have evolved HMI systems to support real-time interaction between users, the plant systems, and big data. Memory and storage will play a critical role in enabling these solutions.

DRAM & LPDRAM OFFERS THE PERFORMANCE AND SCALABILITY FOR INCREASED COMPUTE & AI

HMIs have advanced from a simple grid-patterned touchscreen with fixed menu tiles, and limited on-board compute. Next generation HMIs allow more sophisticated interactions – intelligent capacitive touch, biometric fingerprint, facial recognition, even hand gestures. In addition, it must support a programmable dashboard that can offer high-resolution charts and real-time data changes. These capabilities require higher performance memory. Micron's industry leading DDR4 and DDR5 supporting a broad range of CPUs, as well as LPDDR4, with data rates of up to 4266 Mbps, and LPDDR5x up to 9600 Mbps for low power embedded solutions, are the ideal mix of memory solutions for higher compute HMIs.

LDDR5 KEY FEATURES

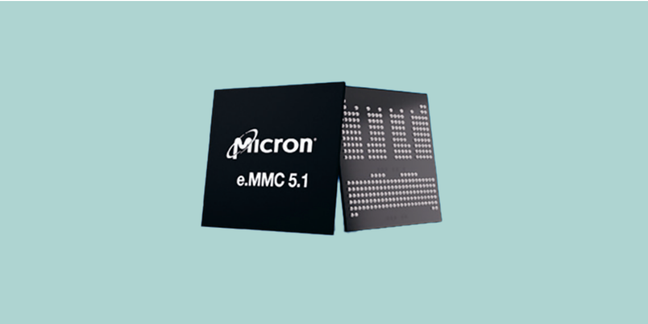
- » Densities: 16 GB to 128 GB – Provides higher density in a similar footprint
- » Configs: x16, x32, x64 – Enables the use of fewer components to support wide bus
- » Lower Core and IO power helps reduce power consumption
- » Data rates: 6400 MB/s (LPDDR5) / 8533 MB/s (LPDDR5x) – up to 2 times faster to LPDDR4X

E.MMC STORAGE OFFERS ROBUST SOLUTION FOR CODE AND DATA

e.MMC in HMIs enable immediate bring up of dashboards and images and offers a secure enclave for code and IP. From higher resolution images to increasing code, e.MMCs are managed NAND devices that support increasingly complex error correction code (ECC) implementation and data management technologies. Micron's e.MMC leverages the latest 3D TLC NAND technology with v5.1 MMC standards ranging from 32 GB to 256 GB.

E.MMC KEY FEATURES

- » Dual voltage support 1.7 ~ 1.95 V, 2.7 V ~ 3.6 V across all product variants
- » Blackbox ultra-endurance for automotive
- » 3xIR TLC reflow: Enhanced post-reflow refresh time to one fourth
- » User data protection with ECC and Bad Block management

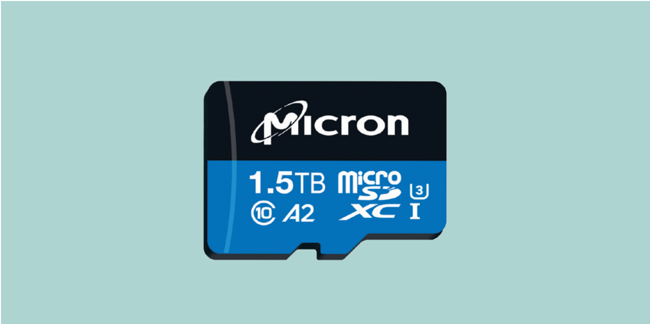


HMI DATA STORAGE REQUIRES INDUSTRY-PROVEN MICRO-SD & SOLID STATE DRIVES

SSD and micro-SD storage devices store vast amounts of real-time and historical data that is generated by multiple systems – not just from machines, but also from multimodal sources such as video capture, mobile devices and tablets. Micron's i400 micro-SD offers 64 GB to 1.5 TB capacity range, and is specifically designed to support 24/7 enhanced video recording performance with no frame loss. In addition, Micron's industrial-grade 2100 series SSDs in m.2 form factor and PCI Gen3 x4 interface, 256-bit AES encryption and TCG Opal 2.0 compliant, are the perfect solution for embedded storage up to 1 TB capacity.

MICRO-SD KEY FEATURES

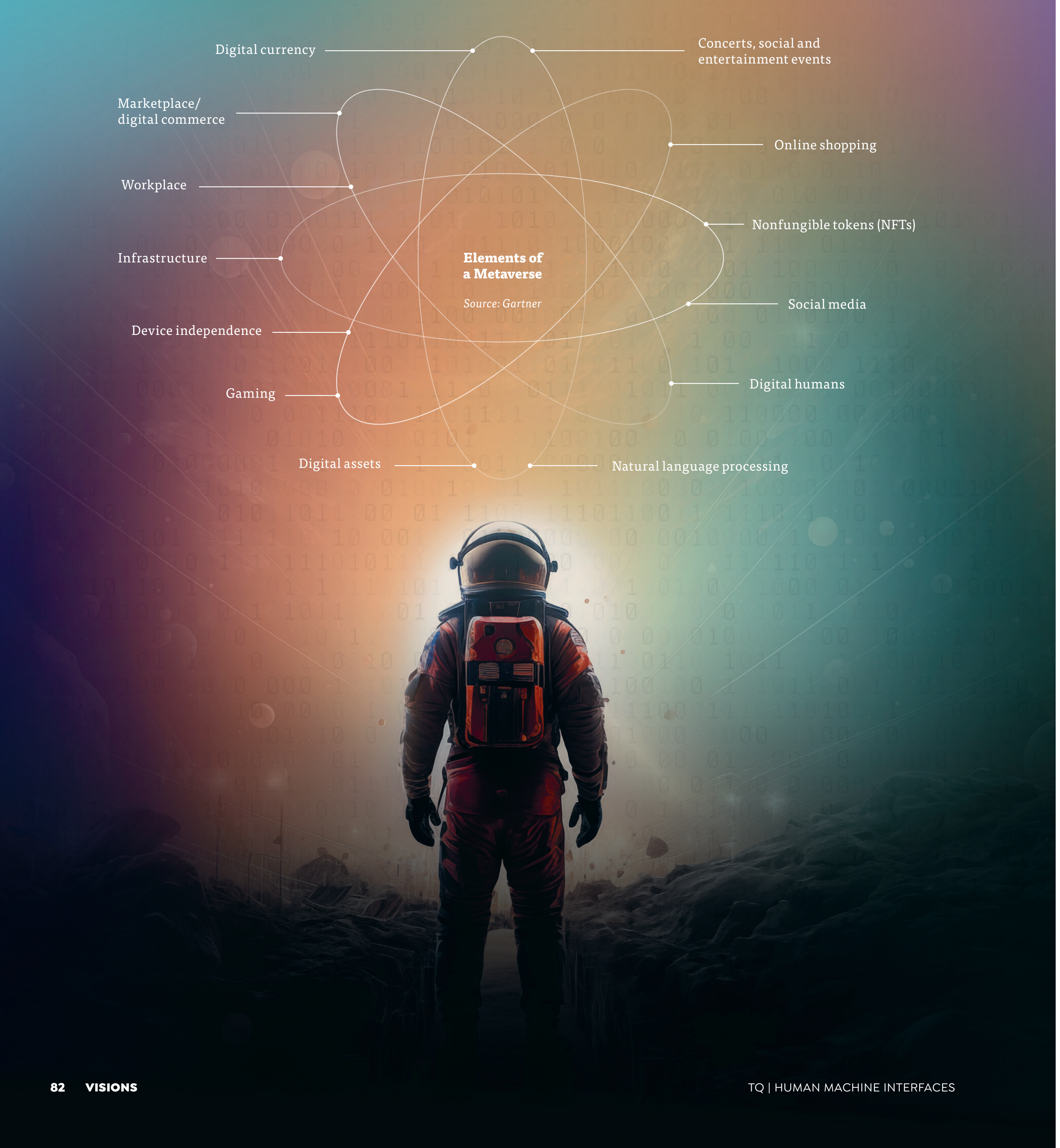
- » High capacity: 64 GB to 1.5 TB
- » Outstanding recording performance
- » Industrial quality
- » Smart management



VISIONS

Technological innovations are designed to enhance human capabilities. Douglas Engelbart envisioned the notion of "Augmented Human Intellect" as early as the 1960s, and his first step towards realising this was the development of graphical user interfaces and the invention of the computer mouse. Today, this concept is reincarnated in augmented reality, where Human Machine Interfaces enable humans to immerse themselves in the Metaverse.

A COMPLETELY NEW UNIVERSE



Rarely has a term such as the Metaverse garnered such rapid and widespread media attention. Fundamentally, it's about the experience of a virtual world that individuals can shape according to their own ideas. Pioneering Human Machine Interfaces will be a core technology in this endeavour.

It's posited to be nothing less than the future of the Internet – the Metaverse. At its heart, it's about a new, complex virtual world where one lives as a digital twin or avatar and may, in the future, also work and carry out daily activities. There are numerous connections with the real world: for example, virtual goods can be purchased with real money within the Metaverse. Behind avatars are real people, and behind virtual machines are real industrial complexes in the sense of a digital twin. "The Metaverse is one of the most thrilling visions of our time," says Dr Bernhard Rohleder, CEO of the German industry association Bitkom.

The Metaverse is built upon technologies that are already well-established, such as augmented and virtual reality, blockchain, or artificial intelligence. The representation of virtual three-dimensional spaces, objects or individuals and the ability to interact with them are increasingly being employed not only in entertainment, marketing and eCommerce but also being tested and applied in industry, education and services. What has long been familiar to computer gamers is now being discovered as potential across various industries.

REALISTIC INTERACTION

A core element of the Metaverse is the potential for realistic interaction in real time between different users or between users and machines. The immense advancements in hardware – both at the infrastructure level and in Human Machine Interfaces – have been prerequisites for the growing acceptance of this new virtual world. The major software companies are now entering the market with their hardware solutions: Meta purchased the VR headset developer Oculus in 2014 and now sells its own headsets under the name Quest 2. Apple has filed several patents over the last decade and aims to bring its VR headset to market in early 2024. Current systems also use controllers that enable targeted "touches" with virtual objects through finger, hand and arm movements. On the infrastructure side, faster fibre optic networks and the introduction of 5G are reducing the effects of latency times and increasing available bandwidth.

COLLABORATION IN VIRTUAL SPACE

Today, "serious" applications in industrial environments are possible. For example, Igus, a manufacturer of energy chains and plastic glide and linear bearings, has created its own virtual world where users from around the world can interact and collaborate on projects without the need for physical presence. Automation solutions can be planned, controlled and tested in virtual space using extended reality technologies like virtual reality and augmented reality. "In the future, we will see how collaborative work between humans in the Metaverse and, for instance, the control of robots from virtual worlds will change the way we work together," says Marco Thull, Senior Marketing Activist at Igus.

FEELING THE VIRTUAL WORLD

In the future, the virtual world may even become literally "tangible." Jürgen Steimle, a computer science professor at Saarland University, aims to achieve this through ultra-thin electronic films that can be applied to the body like transfer tattoos. Most applications of augmented reality have one thing in common: they only or primarily address the sense of sight. "The sense of touch is usually left out, although it's a crucial factor in how we perceive our world," explains Jürgen Steimle, who leads the research group on Human-Computer Interaction at Saarland University.

Steimle's team has developed an ultra-thin, only 35 micrometres thick electronic film in the project "Tacttoo", which can be applied to the skin and stimulate the sense of touch solely through electrical stimuli, without any moving parts. Because the film is so thin, objects can still be perceived and felt as before. Not only can haptic experiences for purely digital objects be created – as already possible with other solutions – but real objects can also be extended with other sensory impressions. For example, the technology could be used in product design: with the help of augmented reality and a physical prototype, the haptics of different materials could be tried out.

STANDARDS FOR AN OPEN METAVERSE

For the Metaverse to find broad application, a range of technologies for collaborative spatial data processing must be integrated, from interactive 3D graphics to physical simulations to the online economy. The Metaverse's potential will only be unlocked if it is built on a foundation of open standards. To this end, the Metaverse Standards Forum was established in 2023, a non-profit consortium that doesn't want to develop its own standards but brings together various Metaverse stakeholders to create consensus on interoperability requirements. "Interoperability is the key to the metaverse scaling to its full potential beyond siloed games, experiences and worlds, and the unprecedented level of participation in the Forum demonstrates strong industry interest in the broad cooperation necessary to bring that vision to life," says Neil Trevett, president of the Khronos Group and initial president of the Metaverse Standards Forum.

THE KEY TO EVERYTHING IS AI

Karl Lehnhoff, Director Segment Industrial, Scientific & Medical at EBV Elektronik, on trends in the field of Human Machine Interfaces.

Our daily life is now permeated by technology. With the complexity of technologies that surround us every day, there's a growing need for Human Machine Interfaces that provide a positive user experience. The possibilities for interaction are becoming increasingly diverse: the range of HMI solutions extends from push-buttons to multi-touch screens to voice and gesture control. This breadth is something that particularly fascinates Karl Lehnhoff.

A LIGHT SWITCH, A COMPUTER MOUSE, A NEURO-IMPLANT FOR CONTROLLING A PROSTHESIS – WHICH OF THESE DO YOU CONSIDER A HUMAN MACHINE INTERFACE?

Karl Lehnhoff: That's easy to answer – all of them. Switches are a basic HMI. But other things like a computer mouse are clearly Human Machine Interfaces. Of course, there are high-tech devices like Brain Machine Interfaces, representing the most advanced variant of an HMI.

"The most important aspects of an HMI are reliability and accuracy."

WHAT TECHNOLOGIES FOR HUMAN-MACHINE INTERACTION ARE CURRENTLY IN HIGH DEMAND?

K. L.: Let's start with the classic: the switches. We use them everywhere. And we will continue to use them in the future. On the other hand, we are using more and more touchscreens, ranging from smartphones to those found in cars. In the future, we will integrate more haptic feedback. What's also becoming more established is voice recognition. We're already using it with smartphones or with Alexa and Siri in smart homes. It will be used in the future in other applications as well, for example in industrial production. Gesture control is also becoming increasingly popular.

But the HMI area also includes solutions for biometric authentication, such as facial recognition on phones or other applications, fingerprint scanners and iris scanners.

What I also find exciting are augmented and virtual reality. At this year's Hannover Messe, for example, I observed a solution where a robot for the logistics sector is controlled via smart glasses.

TOUCHSCREENS ARE CURRENTLY USED ALMOST EVERYWHERE – WHERE IS THE DEVELOPMENT HEADING?

K. L.: Today, touchscreens are everywhere, and they are continually being improved and refined. We are already seeing 3D touchscreens and the possibility of integrating haptic feedback. In the future, touchscreens will also be combined with other HMI technologies such as gesture control.

HOW CAN HAPTIC FEEDBACK BE INTEGRATED INTO A TOUCHSCREEN?

K. L.: Typically, a motor or piezoelectric actuator is used today, which provides a tangible response. There are also displays that have tactile feedback layers. They "create" buttons under the display so that you can feel when you press them. Feedback is not only relevant for touchscreens but also for other applications where buttons behind glass provide feedback. Here too, a motor is often used to provide a mechanical response. This is even possible when the operator wears gloves – although in this case, the feedback force must be greater, perhaps in a range of 1 or 2G, otherwise, you don't feel it through the glove.

WHEN WE TALK ABOUT HMIS TODAY, WE CAN HARDLY AVOID AI. BESIDES ITS USE IN VOICE AND GESTURE RECOGNITION – WHAT ROLE DOES AI PLAY IN HMIS?

K. L.: We may not always recognise it, but we are already using a lot of AI today – for example with smartphones and for voice or facial recognition. It is often used in image processing. In the future, for example with voice recognition, it will be about improving language comprehension and recognising more words. AI is also needed for Brain Computer Interfaces, virtual and augmented reality, or for predictive analysis. Machine learning will also play an increasingly important role, as it can enable the device to continue learning on its own, and perhaps even teach itself a new word. ►

You can listen to the in-depth interview in the EBV Elektronik podcast “Passion for Technology”

WHAT REMAINS THE KEY TO AN IDEAL USER EXPERIENCE?

K. L.: One of the most important points is recognition accuracy. I experience this every day with my car – it understands some words, not others. So we need to have high accuracy and reliability. AI can help here. But there are a lot of other criteria for a good HMI: data protection, feedback, dealing with errors. But the most important points for me are reliability and accuracy.

WITH THE RANGE OF TECHNOLOGIES – HOW CAN EBV ELEKTRONIK HELP REALISE AN HMI?

K. L.: We are one of the leading specialists for semiconductors. So we can help with the selection of suitable technology. We can also advise customers on software. For this, we have our segment structure with the different market and technology segments. This is also reflected in the field, with our Field Application Engineers for technologies and systems. And we can also provide support in production, supply chain management and all the other things needed to bring a product to market.

DO YOU ALSO WORK WITH YOUR SISTER COMPANIES FROM THE AVNET GROUP? HOW DOES THE CUSTOMER BENEFIT FROM THIS?

K. L.: We do. For example, our sister company Avnet Abacus supplies connection technology, passive components and electromechanics. So we can cover the complete bill of materials. Avnet Embedded offers complete solutions for customer applications. They look after the development process, including production, and can work in a wide range of applications. And then we have our software specialist Witekio, which covers the entire development from the lower software levels to embedded applications and connectivity. EBV Elektronik is ultimately a full-service partner. This means the customer has only one point of contact through which they receive all the information and the entire service.

WHAT DO THE CURRENT DEVELOPMENTS IN THE HMI SECTOR MEAN FROM THE SEMICONDUCTOR INDUSTRY’S PERSPECTIVE?

K. L.: We clearly recognise the trend away from microcontrollers to microprocessors. This has a lot to do with the increasing functionalities of the touchscreen. This trend is now also transferring to other applications. The display itself is becoming more complex. This can no longer be met with microcontrollers. So in the future, it will depend on more powerful microprocessors. Of course, you also need more computing power to cater for the increasing use of artificial intelligence. Future 3D touchscreens will also require more powerful processors than in the past.

WHICH DEVELOPMENTS IN THE HMI SECTOR DO YOU FIND PARTICULARLY EXCITING AT THE MOMENT – AND WHY?

K. L.: Voice and gesture recognition – because they enable natural interaction like with a human. They are helpful in many situations, both when driving and in industry. But the key to all this will be artificial intelligence.

DO YOU THINK WE WILL BE ABLE TO CONTROL MACHINES WITH OUR THOUGHTS ALONE IN THE FUTURE?

K. L.: That’s hard to say. But from a medical point of view, it’s a very interesting area. I hope this technology will be able to help people with physical limitations live better.

AND DO YOU UNDERSTAND THE FEARS OF MANY PEOPLE WHEN THEY THINK OF A CHIP IN THEIR BRAIN?

K. L.: On the one hand, I understand the fears, but I think it’s also a question of personal situation. Someone with a restriction and whose daily life could benefit from such a chip is likely to see the advantages. People who have no need for it are more likely to perceive it as a risk.

FINALLY: WHAT FASCINATES YOU PARTICULARLY ABOUT THE TOPIC OF HMIS?

K. L.: For me, the fascinating thing is that the field is so broad. Starting with the on/off switch through touchscreens and voice recognition to the Brain Computer Interface. And after the HMIs we have today, something new will come along. I don’t know what it will look like, but people are investing time in research and development and trying to go new ways. I like that. TQ

NEW IDEAS

Start-ups around the world are working on innovative solutions for increasingly natural interactions with machines and computers. Here we present six exciting companies as examples of this inventive spirit.

RECOGNISING COGNITIVE STATE

The deep-tech brain monitoring developed by CorrActions utilises existing motion sensors, for example in the steering wheel, to detect the cognitive state of drivers and passengers. It analyses micro-movements that indicate a range of cognitive symptoms, such as whether a driver is drunk or overly tired. The existing hardware in the vehicle does not need to be changed.
www.corractions.com

LIGHTWEIGHT AR GLASSES

Kura’s AR headset offers 95 percent lens transparency and a 150-degree field of view in a compact form factor that is almost the same as a normal pair of glasses. Thanks to the high transparency, natural eye contact is possible, and the user can perform other tasks while using the headset. No light escapes forward, so others cannot see the display.
www.kura.tech

TRANSPARENT DISPLAY

The transparency of the 55-inch OLED panel developed by United Screens is about 40 percent. This allows an object in the background to be seen through for staging purposes. An infrared touch frame captures up to ten simultaneous touch points and the interface invites intuitive interaction with the content shown. The display can be used as an eye-catcher at an event or for digital signage.
www.united-screens.tv

BANDWIDTH FOR THE BRAIN

Paradromics is bringing to market a high-data-rate Brain Computer Interface. The first application of the interface is a BCI-capable communication aid for people with severe motor disabilities. Cortical modules record signals from more than 1,600 individual neurons; a cranial hub powers the cortical modules and completes signal processing.
www.paradromics.com

FEELING THE VIRTUAL WORLD

HaptX has developed Human Machine Interfaces in the form of gloves that simulate touch sensations using hundreds of microfluidic actuators. This allows for natural interaction and true touch haptics in virtual reality and robotics. In a multiplayer collaboration, multiple users can work in the same virtual environment and touch the same objects.
www.haptx.com

VOICE-BASED HMI

Linguwerk has developed voice recognition specifically for intuitive human-machine communication. The solution incorporates a variety of input and output modalities into the HMI behaviour of the machine, device or assistant, in addition to voice recognition and speech output. With an individually configurable wake word, the voice interface can be activated touch-free and reliably.
www.linguwerk.de

THE INVENTOR OF THE MOUSE

Douglas Engelbart's numerous technological innovations were crucial to the development of personal computing. His work helped make computers operable for everyone.

It was December 1968. An as yet unknown scientist from the Stanford Research Institute stood before a silent crowd in San Francisco and began what would go down in history as "the mother of all demos." In his 90-minute demonstration, he presented practically everything that would later define modern computer technology: video conferencing, hyperlinks, networked collaboration, digital text processing and something called a "mouse".

THE WORLD OF TOMORROW

The scientist who demonstrated the potential of collaboration with computers to the astonished audience was Douglas Engelbart. Not a computer specialist, but an engineer and passionate inventor. "Back then, most people thought that computers were only for computation – big brains to crunch numbers. The concept of interactive computing was alien," he recalled years later. "It was hard for people to grok what we did at my lab, the Augmentation Research Center at SRI in Menlo Park. So I wanted to demonstrate the flexibility a computer could offer: the world of tomorrow."

> *"Everything we have in computers can be traced to his thinking. To me, he is a god."*
>
> *Apple co-founder Steve Wozniak about Douglas Engelbart*

VISIONARY ENGINEER

Engelbart (1925 – 2013) graduated from high school in 1942 and then studied electrical engineering at Oregon State University. During World War II, he served as a radar technician. In 1948, he earned his bachelor's degree and worked for the NACA Ames Laboratory (a precursor to NASA). He then applied to the graduate program in electrical engineering at the University of California, Berkeley, and earned his Ph.D. in 1955. A year later, he left the university to work for the Stanford Research Institute (SRI).

At SRI, Engelbart acquired a dozen patents within two years and worked on magnetic computer components, fundamental phenomena of digital devices and the scalability potential of miniaturisation. In 1962, he published his visionary work "Augmenting Human Intellect: A Conceptual Framework", in which he outlined his ideas for using computers to enhance human intelligence. Douglas Engelbart once articulated his motivation for his developments as follows: "The complexity of the problems facing mankind is growing faster than our ability to solve them."

ENHANCING HUMAN CAPABILITIES

Engelbart wanted to use technological innovations to expand human capabilities. His goal was not for people to have less to do because of technology, but for them to achieve more with it. He saw the computer as a suitable medium to support and enable human intellect, thereby allowing the resolution of highly complex problems more swiftly. An example of this extension of human intellect is the "X-Y Position Indicator for a Display System", which allowed direct manipulation of elements on the screen. "I first started making notes for the mouse in 1961. At the time, the popular device for pointing on the screen was a light pen, which had come out of the radar program during the war. It was the standard way to navigate, but I didn't think it was quite right." Who came up with the term "mouse" for the novel operating device, Douglas Engelbart later could not remember. "It just looked somewhat like a mouse: a wooden box with a cable at one end. On top, a red button to click, and below, two wheels that transmitted movement impulses."

PART OF A MUCH LARGER PROJECT

"The mouse was just a tiny part of a much larger project that aimed to improve human intellect," Engelbart said. Because this rudimentary-looking device greatly facilitated the operation of a graphical user interface – also a development by Douglas Engelbart and his team. A graphical user interface (GUI) uses visual elements such as windows, buttons and menus through which the user can interact with the software. Initially, computers consisted only of text blocks and required extensive knowledge of programming and computer interfaces to operate them.

FOUNDATION FOR APPLE'S SUCCESS

However, Engelbart was perhaps too far ahead of his time; the presentation at the Fall Joint Computer Conference and the significance of his inventions were quickly forgotten. Engelbart failed to convince SRI, investors or other potential sponsors of his vision. It wasn't until 1980 that he signed a licensing agreement with the two Apple founders Steve Jobs and Steve Wozniak for the patent of the mouse – receiving 40,000 US dollars for it. Four years later, Apple introduced the "Macintosh" based on Engelbart's ideas: with a mouse and graphical user interface. Today, Engelbart's vision of a computer for everyone has long since become a reality. When he died in 2013, Apple co-founder Wozniak honoured him with the words: "Everything we have in computers can be traced to his thinking. To me, he is a god. He gets recognised for the mouse, but he really did an awful lot of incredible stuff for computer interfaces and networking." TQ

‹‹ GLOSSARY ››

6 DEGREES OF FREEDOM (6DOF)
refers to the number of fundamental ways in which a solid object can move through a 3D space. In total, there are six degrees of freedom. 6DoF refers to the translational movement along these axes, generally understood as forward or backward motion, upward or downward motion, or left or right motion.

ADVANCED DRIVER DISTRACTION WARNING (ADDW)
A system capable of detecting the degree of a driver's visual attention towards the traffic and warning the driver if they become distracted.

ACTUATOR
A component that converts electronic signals into mechanical movement or other physical quantities, such as pressure or temperature.

AUGMENTED REALITY (AR)
Augmented reality is a combination of perceived and computer-generated reality. The user receives additional information in addition to the real perceptions.

AVATAR
An avatar is a computer-generated 3D character that represents a human user in the online world.

BEAMFORMING
The process of focusing a radio signal using intelligent multi-antenna technology in a specific direction, thereby achieving better signal strength and quality.

BLOCKCHAIN
A virtual ledger in a network of computers. Each change is recorded and distributed and stored on multiple computers. As a result, it no longer requires a central entity, such as a bank or authority.

BRAIN COMPUTER INTERFACES (BCI), ALSO KNOWN AS BRAIN MACHINE INTERFACES (BMI)
A direct interface between the brain and a machine or computer that records the brain's electrical activity using electrodes, analyses it and transforms it into control signals.

CONTROLLER AREA NETWORK (CAN)
A serial bus system, originally developed to reduce the wiring effort in vehicles.

CMOS (COMPLEMENTARY METAL OXIDE SEMICONDUCTOR)
One of the most important integrated circuit families on which a large part of digital logic circuits is based.

COMPUTERISED NUMERICAL CONTROL (CNC)
A manufacturing process that automates the control, movement and precision of machine tools using pre-programmed computer software.

DEEP LEARNING
A subfield of machine learning that uses deep neural networks. While machine learning works with linear algorithms, the algorithms of deep learning are hierarchical, with increasing complexity.

DIGITAL TWIN
A digital representation of a real entity or system. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object, process, organisation, person or other abstraction.

DRIVER DROWSINESS AND ATTENTION WARNING (DDAW)
A driver assistance system (ADAS) that monitors the driver's eye and head movements for signs of fatigue or distraction.

EDGE COMPUTING
A form of data processing that occurs directly or near a specific data source.

ELECTROCARDIOGRAM (ECG)
A measurement of the electrical currents that regulate the heartbeat, displayed as a curve.

FORCE FEEDBACK
The application of physical force in response to user inputs.

GRAPHICAL USER INTERFACE (GUI)
A user interface that graphically displays information, typically with movable windows, buttons and icons.

IK CODE
Classifies the protection against mechanical impact, the degree of impact resistance.

‹‹ GLOSSARY ››

IMMERSIVE
A term describing a type of experience or technology that completely immerses the user in a virtual world.

IO-LINK
A globally standardised IO technology (IEC 61131-9) to communicate with sensors and also actuators.

IP RATING
The level of protection provided by an enclosure for electrical devices against dust and other foreign bodies, accidental touch and water is described by the IP code. IP stands for "Ingress Protection". The code was defined by the International Electrotechnical Commission (IEC) in the standard IEC 60529.

LIDAR (LIGHT DETECTION AND RANGING)
A method related to radar for optical distance and speed measurement. It involves sending out laser beams. Sensors detect the light that is scattered back. The distance is determined from the travel time of the light.

MACHINE LEARNING
Methods by which computer systems can independently acquire and expand knowledge to solve a given problem better than before. The system extracts the most important patterns and features from large datasets and can use these to make predictions.

NLP (NATURAL LANGUAGE PROCESSING)
Technology that deals with the processing of natural language. With appropriate algorithms, computers can understand human language and its semantic meaning and execute corresponding instructions.

RADAR (RADIO DETECTION AND RANGING)
Detection and location procedure based on electromagnetic waves in the radio frequency range.

RFID (RADIOFREQUENCY-IDENTIFICATION)
RFID is a technology for contactless data transmission based on radio waves. The heart of the technology is an RFID transponder. This tiny computer chip with an antenna is placed on various objects and contains a number code. The number code is read with a reader.

RGB-KAMERA
A digital camera that composes images from the three primary colors red, green and blue.

SENSOR FUSION
The intelligent merging and processing of all (environmental) sensor data required for autonomous processes. The result obtained from sensor fusion is better than if the measurements of individual sensors were interpreted.

TIME-OF-FLIGHT (TOF)
A measurement method that captures the time taken to travel a distance to determine the distance, speed or properties of the medium.

USER EXPERIENCE (UX)
Describes all the perceptions and emotions of a user in relation to a product or application.

VIRTUAL REALITY (VR)
The depiction and perception of a computer-generated and interactive virtual environment in real time.

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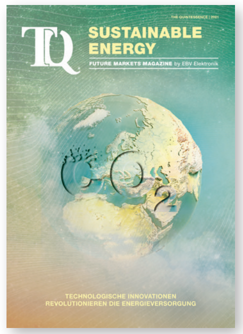
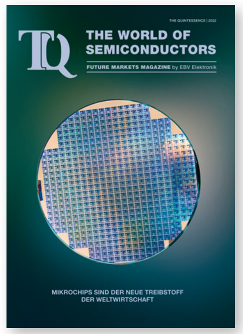
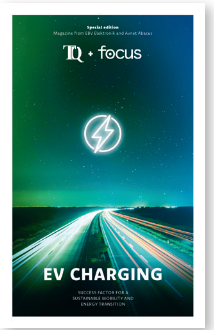
PASSION FOR TECHNOLOGY
People with a passion for technology are needed more than ever. They provide answers to the challenges of the future, from medicine to climate protection. Like Dr Simon Haddadin: the CEO of Franka Emika talks about how his "sentient" robots are making both a technological and a social impact.



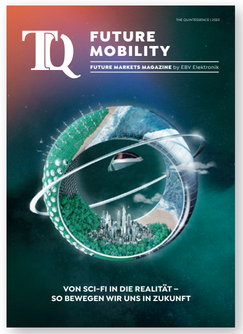
SUSTAINABLE ENERGY
It is imperative that we transform our economy to become climate-neutral. But the energy sector is already on its way there. From generation to consumption, clean technologies are paving the way to sustainable energy. Costs are falling, markets are growing and never before have the benefits of the energy transition been so clear.



THE WORLD OF SEMICONDUCTORS
The issue looks in detail at the structures of the semiconductor sector and how the supply of chips can be made more resilient. The issue also provides background information on semiconductor production and on current trends. One thing is certain – Moore's Law is far from over.



SPECIAL ISSUE ON EV CHARGING
The technology for charging electric vehicles is certainly complex. Car manufacturers, the charging infrastructure and the energy sector all need to work together in order to create efficient charging infrastructure. From a technological point of view, there are two trends that are steering developments: smart, communication-enabled charging points and charging that uses ever-increasing currents.



FUTURE MOBILITY
The world of mobility is in a state of upheaval. Electrification, autonomy and the sharing economy are changing vehicles as well as user behaviour and entire business models. Kersten Heineke, co-leader of the McKinsey Centre for Future Mobility, is certain that this will improve people's lives.

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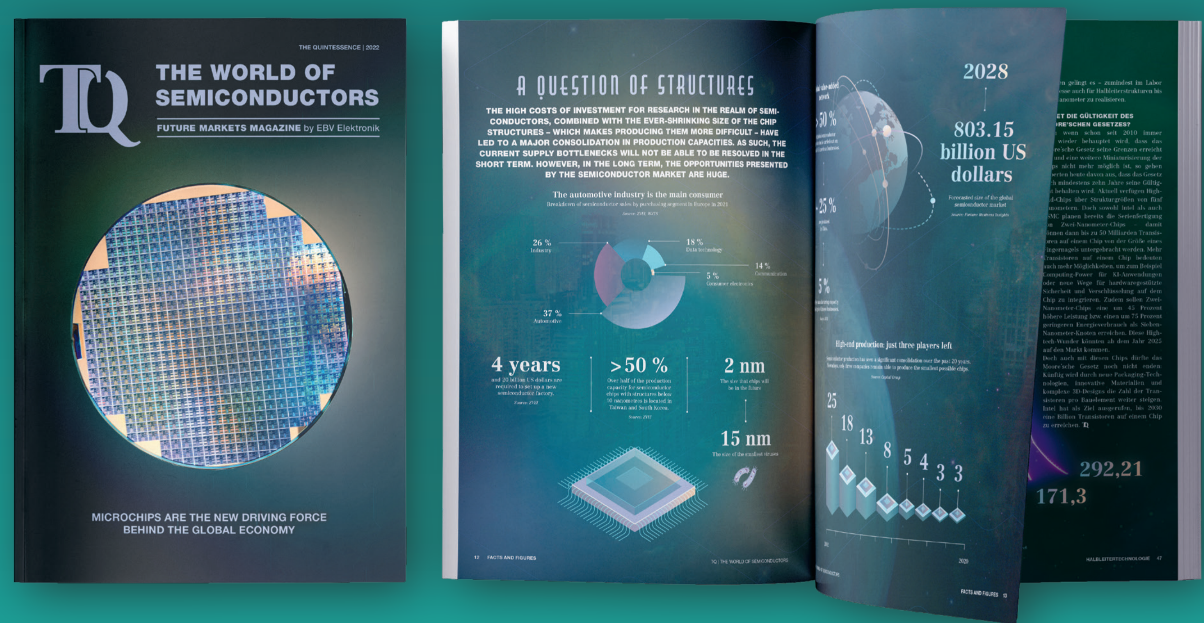

INFO POINT

TRADE FAIRS, CONFERENCES AND CONGRESSES:

Vehicle Displays & Interfaces Symposium, Detroit, USA
www.vehicledisplay.org

World Usability Congress, Graz, Austria
www.worldusabilitycongress.com

PUSH UX, Munich, Germany
www.push-conference.com

Augmented Humans, Glasgow, United Kingdom
www.augmented-humans.org

International Conference on Human-Machine Interaction (ICHMI), Xi'an, China
www.ichmi.org

ASSOCIATIONS AND INITIATIVES:

User Experience Professionals Association (UXPA), supports people who research, design and evaluate the user experience of products and services.
www.uxpa.org

German UPA e.V., Professional association of German Usability and User Experience Professionals
www.germanupa.de

ACM Special Interest Group on Computer-Human Interaction (SIGCHI), the world's largest association of professionals in human-computer interaction
www.sigchi.org

BLOGS, MAGAZINES AND JOURNALS

The ACM Interactions magazine focuses on Human-Computer Interaction, Interaction Design (IX) and User Experience (UX).
interactions.acm.org

Advances in Human-Computer Interaction is an interdisciplinary journal that publishes theoretical and applied papers on interactive systems.
www.hindawi.com/journals/ahci/

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is Senior Marketing Communications Specialist at EBV Elektronik. Her knowledge of communications played a crucial role in the implementation of this magazine.

"I believe that in the future, it will be very difficult to discern from the outside whether we are interacting with another human or a machine."

Professor Elsa Andrea Kirchner,
German Research Centre for Artificial Intelligence (DFKI)