On May 1, 2030, International Labor Day, the evening news worldwide has only one top news item: China’s new prime minister is not a person, but an avatar. The pictures of the meeting of the Standing Committee of the Politburo of the Communist Party show, indeed, a lifelike figure on the right side of President Xi, who bears considerable resemblance to the first head of the government of the People’s Republic of Zhou Enlai, also bearing the name of his son Sun Yang, but in reality is a hologram.

China is celebrating the appointment as a great success on the way to fulfilling the Chinese dream and a vital stage victory just a few years before the centenary of the founding of the People’s Republic. President Xi says that the wisdom and courage of the founding generation will now be preserved forever. Xi says, “No power in the world can make better decisions if we are protected by our ancestors. They guide my hand and give us their wisdom. China, under the leadership of its party, has become invincible once and for all.”

Only insiders know that the top secret Tianhe-10 (Milky Way) supercomputer, which controls the Avatar’s utterances and movements, has been instrumental in preparing the Chinese leadership for decision-making for 2 years now. According to the findings of the American secret services, the rate of agreement between the recommendations of the supercomputer and the actual decisions of the Politburo was initially only 30 percent. In the meantime, however, it has reached 97 percent.

All attempts by the Western powers to gain access to the supercomputer have so far been in vain. Since the Trump administration, the open conflict between the United States and China had led to an increasingly aggressive rupture, turning an initial “decoupling” into a fundamentally hostile separation. As a result, for the past 5 years, all components and algorithms in Chinese products and applications have been domestically produced. All Chinese companies and government institutions were forbidden to use hardware or software from non-Chinese sources under threat of sanction. The standards have already diverged so far apart that there is no longer any compatibility.

So much for a possible vision from the year 2030: Of course nobody can know the future; at best plausible assumptions are possible. But as science fiction author William Gibson says, “The future is already there, it is just unequally distributed.”
To find and interpret these spores of the future is quite possible. This will lead to larger and broader developments, which will be obvious in 2030. By far, the most important development, therefore, which will have a massive impact on the coming decade, is the American-Chinese conflict, which will also affect the relationship between humans and machines in the future.

Even in the year 2030, people will still be superior to machines and use them as tools, not the other way around. Therefore, the tools will develop depending on the goals of the people. If they are aimed at enforcing the superiority of the respective system, the relationship between man and machine in both countries will show considerable differences and will no longer be compatible, but even contrary to each other.

Eric Schmidt, Former CEO of Google, is currently Chair of the National Security Commission on Artificial Intelligence and the Defense Innovation Board. In a programmatic opinion article in *The New York Times*, he warned: “Important trends are not in our favor” (Schmidt 2020). America’s lead in artificial intelligence, he wrote, is precarious. A recent study by the Tortoise Institute considering more than 100 metrics finds “that the United States is well ahead of China today but will fall behind in the next five to ten years” (Tortoise Media 2020). “China has almost twice as many supercomputers and about 15 times as many 5G base stations deployed as the United States. If current trends continue, China’s overall investments in research and development are expected to surpass those of the United States within ten years,” according to the 2018 Global R&D Forecast (R&D Magazine 2018). At around the same time, China’s economy is projected to become larger than America’s, according to a projection of the world in 2030 by the bank HSBC (Henry and Pomero 2018).

1 Artificial Intelligence (AI) as a Central Component for Future Human-Machine Interface Systems

Human-machine interface (HMI) encompasses the means by which humans and computers communicate with each other. It includes hardware and software that are used to translate user input into commands and to present results to the user (Tan 2020). The relationship between humans and machines is mainly influenced by the steady increase in the capabilities of artificial intelligence. AI gives systems the ability to analyze their environment and make decisions with a degree of autonomy to achieve goals. Although the limits of AI are uncertain and have shifted over time, automating or replicating intelligent behavior is one of the key aims of AI research and applications. That is how the test proposed by British researcher Alan Turing in 1950 came about. The goal was to determine whether a machine had the capacity to think, so that a person talking simultaneously to both a person and a computer would not be able to distinguish their answers.

AI is dependent on Big Data and powerful computers to analyze it, cloud computing to deliver distributed computing resources, and high-speed connections to link various sensors and sources of information. Its most important field, machine
learning, refers to the development of digital systems that improve their performance on a particular task over time, through experience. Machine learning describes the ability of software or a computer to learn from its environment or a very large batch of representative data and to adapt its behavior to changing circumstances accordingly or carry out tasks for which it was not explicitly programmed. The basic idea is to allow associative learning by linking simple information processing units and artificial neurons in such a way that the weighting of the connections and the corresponding performance of the network is adjusted automatically.

Every day, people and machines produce ten times more new data than that which exists in all of the world’s books. This will multiply by the factor of at least 100 by 2030. The ever-growing amount of digital material on the Internet, in the form of images, text, videos, and audio files, is used to identify patterns. The training of multilayered architectures on huge amounts of data, which will be much more important by 2030, is referred to as “deep learning.” Stuart Russell and Peter Norvig use the following classification for categorizing artificial intelligence: (1) systems that think like humans, (2) systems that behave like humans, (3) systems that think rationally, and (4) systems that act rationally (Russell and Norvig 2009). By 2030, we will see an increasing amount of HMI systems that act rationally. We may even see systems that deliberate along rational lines. However, it will be far too early for them to behave like a human or even to think like a person.

HMI systems acting rationally will still only work within the narrow context of a specific problem or application by 2030. They may show excellent results, but the benefits are significantly affected if the task is even marginally changed. While a person who can read Japanese characters can also understand Japanese, expand on their preferences for sushi or sashimi with recommendations for specific restaurants, and be aware that pink slippers are worn to go to the toilet, these tasks will require different HMI systems.

2 Goals for Future HMI Systems

The human qualities of creativity, the ability to improvise and cooperate, and resourcefulness open up new possibilities to engage and participate in value creation processes. Not only could new technologies create the need for different goods and services; they could also take over repetitive, physically demanding, and dangerous work. This would allow people to dedicate their time to other endeavors, such as pursuing their interests and doing things that are meaningful to them.

Anna Müller is a Doctoral Student at Robert Bosch GmbH in 2030. She remembers her school days, which were interrupted by the COVID-19 pandemic. The years that followed were marked by society’s handling of the virus and the recurring waves of disease. Her interest in sociology and philosophy dates from this period. She remembers the rapid digitalization in the field of education but also thinks back to her realization that her original professional goal of becoming a lawyer was losing its meaning. She wanted to better understand the causes and effects of the world around her. She is taking a course in philosophy at university. Only yesterday in the main seminar the vision of a communist
society by Karl Marx was discussed: “... in communist society, where nobody has one exclusive sphere of activity but each can become accomplished in any branch he wishes, society regulates the general production and thus makes it possible for me to do one thing today and another tomorrow, to hunt in the morning, fish in the afternoon, rear cattle in the evening, criticize after dinner, just as I have a mind, without ever becoming hunter, fisherman, herdsman or critic” (Marx 1845).

“That sounds pretty exhausting,” Anna Müller thinks. When did he actually relax, this Marx? What Anna liked, however, was the idea of not having to make a final decision, but to do what suited her. No one in her circle of friends wanted that. It was uncool and stuffy.

According to Daniel Newman and Olivier Blanchard (2019), the winners of the future will be those who identify how to harness the power of automation and artificial intelligence collaboratively. It is a continuation of the very long evolutionary development of humans creating tools to solve problems that they are not able to solve on their own. It is a question of task automation as opposed to job automation, recognizing that traditional roles can be broken down into elements to which either humans or machines are better suited.

A key element here is the ability to break larger tasks into their smallest parts, distribute those parts within a large network of workers according to their availability and skills, and then synthesize the results. Digital technologies in a networked world make it increasingly possible to collect accurate data regarding the output and productivity of both individuals and teams and to compare them. This data serves as the basis for the creation of algorithms for the efficient distribution of tasks. Still, at the same time, they make possible a new kind of Taylorism, associated with the potential for an increase in stress for individuals, and a further loss of privacy.

The goals for HMI systems are to improve learned models with an explanatory and corrective interface, increase the reliability of results, work with a high degree of transparency, and go beyond limited capabilities to develop skills that can be assigned to broader tasks. This would make it possible to communicate naturally with people and to extrapolate from past experiences in order to constantly solve new tasks and situations. Achieving this means recognizing the importance of processes and developing a broad understanding of the world by establishing contexts and connections, in the same way, people do.

Future HMI systems have to reduce their high energy consumption. The human brain uses the equivalent of a 20-watt light bulb, whereas a supercomputer uses as much electricity as a town of 20,000 inhabitants. A human brain also works without software, centralized controls, or an operating system. It is usually fault-tolerant and flexible and achieves learning goals much faster, more effectively, and more economically than a computer. Machines have to follow the human example, using energy from renewable sources.
3 Humans and Machines: An Increasingly Challenging Relationship

The ongoing wave of technological innovation could potentially spark new forms of economic activity and create new jobs, such as for employees capable of developing, building, maintaining, and repairing new robots and intelligent machines. Moreover, the demand for new infrastructure, transportation, and IT equipment will increase. Many developing countries have yet to build a reliable power, transportation, and IT infrastructure. Lower costs will increase competitiveness, while higher costs will stimulate investment. In turn, this will lead to increases in productivity as a result of innovation and economies of scale.

There are four drivers that are having an impact on the future of work: smart HMIs, coordination economies, immersive collaboration, and a new kind of “maker mindset” (Gorbis 2016).

- **Smart HMIs**
  Smart HMIs can communicate with each other, adjust to changing conditions in real time, learn from that experience, and operate autonomously without human intervention. They will take over tasks that people are not particularly good at, for instance, repetitive processes and dangerous or data-intensive tasks, or those tasks that are either too large or too small to be efficiently performed by human beings (Bengler et al. 2020).

- **Coordination Economies**
  The appearance of new coordination economies on the order of Uber and Airbnb is occurring concomitantly with automation and the proliferation of smart HMIs. Digital online platforms bring together customers and those offering goods and services so that they can negotiate with each other directly. This way of organizing human labor goes hand in hand with the decline of the formal and traditional management hierarchies of the previous century.

- **Immersive Collaboration**
  Physical and digital-virtual environments, media, and interactions are more thoroughly interwoven than ever before. Cyberspace is turning into a constantly present experiential cocoon, which is closely integrated into the real world. Factors that facilitate work processes and the exchange of ideas include the proliferation of mobile devices and devices equipped with sensors, advances in virtual and augmented reality, and the increase in a wide variety of digital platforms supporting cooperative work.

- **A New “Maker Mindset”: The Democratization of Production and Development**
  In connection with biotechnology and nanotechnology, new digital production technologies—in particular 3D printers—make it possible to adapt a product’s material properties to its function more precisely. This world of open production has the potential to call conventional methods of production and development into question.
4 Future Drivers of HMI Development

Currently, the Internet is the biggest driver of AI-based HMI systems. Websites and Internet-based applications are the biggest sources of user-specific data. Every click and every transaction on an e-commerce website feeds into a paradigm, which acts as a learning tool. Huge and influential platforms, such as Google, Facebook, Amazon, Baidu, Alibaba, and Tencent, are the biggest beneficiaries of these data sets, which will form the base for HMI systems of the future. These will continue to build on data collections, which are constantly expanded to optimize business processes and ease decision-making. Due to the bifurcation into American- and Chinese-led data worlds, the results will differ ever more due to the diverging databases. The sectors where these enhanced HMI systems are applied will be seen strongest in the United States mainly in the financial sector, the insurance industry, and logistics, while China will develop them mainly in central planning, in the transportation sector, in education systems, and in policing. Adrian Lobe describes how by using Big Data and AI a digitally managed economy could appear. Using centralized data processing systems based on the availability of a large amount of data on consumer behavior, the former “competitive disadvantage” could be compensated in comparison to capitalism (Lobe 2019).

Security concerns underpin China’s current and future efforts to keep valuable data exclusively under the control of Chinese technology companies. That will be even more so in 2030. To this end, China has already pushed national standards in AI-related fields such as cloud computing, industrial software, and Big Data that differ from international standards. A report by the Mercator Institute showed that Chinese standards for smart manufacturing, cloud computing, industrial software, and Big Data clearly diverge from international standards (Zenglein and Holzmann 2019).

China’s aim is to define the contours of the global HMI industry by setting standards at an early stage. It was reported in January 2018 that guidelines were being developed for the “China Standard 2035” strategy, which includes sectors relevant to AI. According to reports and “to preempt competitors in emerging technologies ranging from cloud to virtual reality, the Standardization Administration of China (SAC) and the National Academy of Engineering are quietly working on “China Standards 2035” (中国标准2035), a nation-wide effort to develop industrial standards and eventually internationalize them” (http://www.cnstandards.net/wp-content/uploads/2019/03/China-Standard-2035.pdf und https://www.mericsonline.org/en/blog/chinese-tech-standards-put-screws-european-companies).

The 2017 cybersecurity law forbids foreign companies from storing data about Chinese customers outside of China. HMI systems in autonomous vehicles cannot process the data they collect, as unchecked information about the areas travelled could fall into foreign hands. This hinders cross-border data pooling and will have prevented the development of common data-sharing standards by 2030.

Perception-based HMI, which will grow strongly in both camps, enables the even larger digitization of the physical world using sensors and intelligent devices. By collecting data that was previously unavailable or unusable, new applications will be
created. HMI in 2030 relies on a huge number of networked sensors and a new combination of data—in the form of multimedia content—with new user interfaces guided by voice, gesture, or electric impulse. The ability to read some of the major impulses of a human brain will see some advances.

HMI technologies in 2030 will allow for a high level of customization, which allows individualized value propositions and user experience. Most importantly, HMI will release people from repetitive tasks so they can pursue more creative work. Self-driving cars, self-directed robots, and interconnected systems in a smart city will make significant advances. The widespread technical deployment of the 5G mobile networks, which are indispensable for the uninterrupted functioning and communication of automated systems, will be the backbone for a tactile Internet. Some pilot projects applying 6G networks are mainly confined to defense-related projects.

5 HMI with Chinese Characteristics

Over the past two decades, China has been the fastest-growing economy, and it has challenged American hegemony in many areas, including HMI. One should neither underestimate China’s innovation capacity nor the pace of development in the country. About 12.5 million production jobs vanished in China alone in the period from 2013 to 2017 as robot use accelerated (Frey 2020).

Some structural advantages speak in favor of China having a leading role in some areas of AI-driven HMI. The main reasons are the huge amounts of data collected, a large talent pool, aggressive entrepreneurship, and the government’s strong, pragmatic approach to new technologies. China’s advantage in data finds its source not only in the size of its domestic market but also because Chinese citizens are more willing than others to share their data. By 2030, when compared to the United States, China will have compensated its disadvantages, mainly poorer research performance, a lack of scientific experience, and a weak presence in global platforms.

In July 2017, the Chinese State Council approved the “Next Generation Artificial Intelligence Development Plan,” which stipulates that the country shall be the leading power worldwide in AI technology by 2030. The State Council’s AI plan calls for the introduction of AI in a particular range of areas, such as industrial production, jurisdiction, public safety, and military uses. The education of young talent in AI is to begin at the elementary school level and to be intensified at institutions of higher learning. The history of Chinese government support for AI-related development of HMI systems manifests a consistent focus on robotics and innovation at home. Intelligent manufacturing technology and the industrial Internet will continue to be priorities.

Specific areas will have achieved breakthroughs by 2030. These include connected vehicles, service robots, facial recognition, and AI-supported medical diagnostic tools. Linking governmental specifications with the business goals of the private companies spearheading the development of AI-driven HMI is a key factor in the implementation of China’s strategic goals. Moreover, in the development of HMI
up to 2030, the country will have focused on cooperation with the military. In neither
Russia nor the United States is this symbiosis between defense capability and the
economy so pronounced. Especially when it comes to AI-driven HMI technologies
by 2030, it will be impossible to discern a clear separation between military and
civilian uses (Kania 2017).

6 Digital Leninism: AI-Driven HMI as a Means
of Consolidating Power

In the area of public security, China’s ruling class views AI-enabled HMI as a means
of consolidating and reinforcing its power. AI and Big Data are being utilized
systematically in the service of social control and economic coordination. Social
stability and social control are to be perfected through the widespread use of facial
recognition software. The value of AI for proactive policing will be established by
2030; technologies will help Chinese authorities to discern patterns in large
quantities of communications data. In particular, the system of “social credits” will
collect and evaluate data updated in real time on all Chinese citizens, all companies
doing business in China and their employees, and all foreigners in the country. That
data will reflect transactions, mobility patterns, communications among friends and
the makeup of social circles, interactions with business partners, and violations of
laws and contracts.

The data stream records how payments are made, people’s location,
communications data, and mobility and health profiles. The system would constantly
monitor and evaluate the activities of every Chinese citizen and determine his or her
level of reliability. Moreover, the social credit rating will have serious consequences;
for example, it would have an impact on one’s chance of receiving a mortgage or
getting a job or on the educational opportunities available to one’s children.

Sofia Wu looks out the window of her Beijing apartment. In the distance, she sees the
mountains. The view is fantastic. There hasn’t been smog for years, but she suffers from
allergies arising from her childhood days when the air was still so dirty. It’s annoying that
her illness becomes a topic of conversation every time she is interviewed with the computers
in the personnel departments of large companies. Sometimes she feels that she is only invited
to interviews because her uncle is deputy mayor.

She had finally found a job with the largest advertising company in the country. Her job
is to validate, among her large circle of friends and at parties, the micro-trends that update the
daily advertising messages. The household robots, in particular, which have become a status
symbol over the past 3 years, should only recommend those brands that are among the
company’s most important customers. Because they do this reliably, they can be offered at a
price that is below their production cost. Nevertheless, they quickly pay for themselves.
Sofia has also ordered one from the latest line at the factory outlet. He looks like the Brazilian
student who was her first great love. His hologram was the inspiration for the custom-made
product. Only that the robot, unlike its human counterpart, is never hurtful but always knows
exactly what she wants.
By 2030, a new type of technology-driven social and government order will have emerged in China. It is an open question as to whether the new technologies will reinforce the power of the ruling class over the long run or whether at some point they will bring about a change in the country’s power structures. Political changes in an authoritarian environment would be driven not so much by an opposition made up of human beings, but rather by the limited capacity of those in the leadership, their families, and power structures to understand and control the new technologies. Therefore, my guess is that they will enlist the power of those technologies and provide them with legitimacy by adopting a “human” face to it, as described in the initial “report from the future.”

7 Ethics and HMI

When it comes to the fundamental differences between a person and a machine, the ability to take action and make decisions is a key concept. Human beings can set goals and choose the means with which to reach those goals. Machines, on the other hand, are products made by human beings. Their actions are viewed as purely mechanical processes. Machines are technological helpmates that cannot pursue goals on their own. Even in 2030, HMI systems will not possess consciousness or free will, and consequently, they will have no sense of guilt or morality. They neither reflect on nor justify decisions nor do they themselves make changes to those decisions. They thus still cannot be held responsible for their actions, are not be liable for damages under civil law, and cannot be found culpable under criminal law.

By 2030, there will be quite a few legal cases in order to hold manufacturers or users responsible for the actions of machines. Identity, self-determination, and the ability to take responsibility for one’s actions, meanwhile, are not written in stone, but rather exist in a state of constant change. The more that machines lose their solely instrumental character, and increasingly take on the role of a self-directed actor, or form a hybrid unit of action in concert with human beings, the more the borders between human beings and machines will be blurred.

The prospect of a loss of human autonomy and control threatens to impinge on the basic human need for security and self-determination. That could systematically lead to a situation in which no one can be held responsible for the decisions of an HMI system that can no longer be understood, nor controlled. The actions of cognitive tools are no longer programmed linearly by human beings. Deep learning and “generative adversarial network approaches” make it possible for machines to teach themselves new strategies and seek new cues. Due to the machine’s learning and self-development processes, which occur in the context of changing conditions, the manufacturer can’t predict the concrete actions of an autonomous system in their entirety. While users utilize the HMI system, they cannot control its actions, because they can only imagine the machine’s potential for action. In many cases, it is thus no longer possible to make sense of the actions taken by machines, nor for those actions to be analyzed by human beings.
The year 2030 may mark a transition toward a world, where machines will be tied increasingly to their actions. Maybe artificial “culprits” may even be pursued and tried by other oversight mechanisms, driven by pattern recognition. One possible HMI system architecture that includes ethical principles could be a two-tier surveillance architecture: it would keep HMI operations separate from a surveillance agent responsible for the ethical or legal assessment of practical measures.

In 2030, HMI systems may have some features that will enable them to even act in a morally superior way than people could in comparable situations, as they cannot be influenced by irrational impulses or emotional stress, cannot be seduced, and do not have any specific biases. Moreover, in 10 years’ time, they can make decisions in real time, without moments of shock or external influences.

By 2030, the question as to whether there are boundaries that should not be crossed as technology progresses will be discussed with different perspectives, because it was already necessary to go so far as to bar automation in certain areas of life. This may include the area of palliative care, where humans decide on ethical grounds, if and when to terminate life-supporting mechanisms. Machines may even be excluded in applying genetic preconditions in deciding on who may progress to leadership positions in business or administration. The debate will rage on in 2030 and beyond, as to which fundamental principles shall be inviolable, although human dignity shall be seen differently from what the present dictates.

Up until the point at which robots develop self-awareness or this awareness is created, these principles, which cannot be translated into machine code, must be observed by those who build robots, as well as those who manufacture and operate them. This debate will be in full gear by 2030. Algorithms and system architectures must observe evolving laws, social norms, and ethical principles. What is more, ethical problems are interpreted differently, depending on culture, religion, and value systems. Values also change over time.

The more HMI systems develop, the more their architectures will contain subsystems capable of assessing ethical problems on several levels. These will include the ability to compare patterns quickly, define lines of argumentation, and justify actions. Subsystems will also enable trust-building social interaction with human users, as well as social processes that will enable the HMI system to understand cultural norms in various contexts and apply them accordingly. Making the HMI system’s findings and actions understandable and transparent to people will be a special challenge in itself.

### 8 Systematics of Human-Machine Interaction

Goals for the future of HMI will evolve along the lines of the “ten challenges” of Klein:

1. “To be a team player, an intelligent agent must fulfill the requirements of a Basic
2. To be an effective team player, intelligent agents must be able to adequately model the other participants’ intentions and actions vis-à-vis the joint activity’s state and evolution.

3. Human-agent team members must be mutually predictable.

4. Agents must be directable.

5. Agents must be able to make pertinent aspects of their status and intentions obvious to their teammates.

6. Agents must be able to observe and interpret pertinent signals of status and intentions.

7. Agents must be able to engage in goal negotiation.

8. Support technologies for planning and autonomy must enable a collaborative approach.

9. Agents must be able to participate in managing attention.

10. All team members must help control the costs of coordinated activity.” (Klein et al. 2004)

Joint human-agent activity should be based on a voluntary agreement to cooperate, mutual predictability of all actors, and the consistent goal of maintaining common ground. Key requirements to be fulfilled by future HMI systems will certainly include the following principles: adaptability, modularity and interchangeability, flexibility and extensibility, distributed industrial cloud, service-oriented design, programmable networks, compliance to standards, security/safety/privacy, and usability/ease of use.

According to Carsten and Martens, identified elements of HMI design in automated vehicles would entail the following aspirations:

- “Provide the required understanding of the capabilities and status of the automated vehicle (minimize mode errors)
- Engender correct calibration of trust
- Stimulate appropriate level of attention and intervention
- Minimize automation surprises
- Provide comfort to the human user, i.e. reduce uncertainty and stress
- Be usable.” (Carsten and Martens 2019)

Common industrial standards “classify automated systems according to their functional scope via different levels of automation. As the functional scope of the automation system increases, the role of the traditional driver changes from an active operator, to passive monitoring (during partially automated driving), to the passive passenger (during conditionally, highly, and fully automated driving) within a specific operational design domain” (SAE International 2018). As the functionality of the automated system becomes more and more advanced, the human-machine interaction becomes more complex. Adapting to rapid changes in the influencing factors is essential. Relevant HMI interrelations are the concurrence for space,
content transitions, practicability, consistency, and chronological coordination (Bengler et al. 2020).

In the case of factories of the future, the aim at automation lies on multiple levels, according to a White Paper published by the Industrial Communication for Factories Initiative (Industrial Communication for Factories 2019). Main goals include increased flexibility of the production process and zero factory downtime. A clear trend is heading toward fully automated and on-demand reconfigurable factories by linking different domains together to form a large heterogeneous system.

5G as the first communication standard designed to enable connectivity for people as well as for the Internet of Things will be essential in realizing the goals mentioned above. German car manufacturers, chemical companies, and other industrial firms are taking steps toward creating their own private 5G networks. BMW AG, Robert Bosch GmbH, Volkswagen AG, BASF SE, and Deutsche Lufthansa AG are among the companies that applied to set up local 5G networks in November 2019 (Stupp 2020). The technology provider Robert Bosch GmbH is going to apply its license to operate its own industrial 5G network and extend it by 2030 to all of its industrial sites. The new standard has impressive characteristics: it is up to 20 times faster than 4G, transfers data virtually instantaneously with a latency of 1 millisecond, and is very reliable. Experts from the business consultancy IHS Markit estimate “that there will be up to 125 billion connected devices worldwide by 2030” (IHS Markit 2017).

The prospect of a human digital twin (HDT) is to develop a digital representative of a human user, taking into account the user’s goals and preferences, what the user knows, and what the user does while interacting with services, assistants, and the Internet of Things (IoT) environment. A digital twin can provide a holistic view of most capabilities an asset has. A digital twin is the representation of the thing itself and the contact point to access and work with different capabilities and features of that thing. According to experts from Bosch, the major benefit of digital twins in the IoT is “that you do not have to worry about connecting to the asset to extract and transmit any data. Instead, you can simply deploy applications in a secure sandbox in the cloud, which works with the digital twins as if they are sitting side-by-side these physically distributed IoT assets” (Glocker 2020). Security risks and development costs are reduced, which means IoT applications can be developed faster.

The HDT harnesses the increasingly available user data from smart environments and interactive services and thanks to adaptive learning technology can evolve over time. The HDT shall be entitled to self-reliantly execute tasks on behalf of the user, thus exceeding the scope of traditional user modeling. Challenges encompass assuring the user’s privacy while interacting with services and the environment, the coevolution of the HDT with the user in an open environment, and aspects of trust and transparency. By 2030, personalized, user data-based applications will become more and more ubiquitous with the proliferation of connected devices and the IoT.
9 SWOT Analysis for Future HMI Systems

The strengths of future HMI systems could be seen as follows:

- They solve complex problems rationally.
- They analyze surroundings perfectly and detect hazards in time.
- They increasingly take decisions autonomously that are needed to meet targets.
- Customization creates value added for users and reduces repetition and stress.
- They will offset human weaknesses and enhance strengths.

The weaknesses of future HMI systems are obvious:

- They will continue to function only in the limited context of a specific problem or application.
- They still consume a great deal of energy and require high computing capacity.
- The necessary access to large data sets could lead to loss of privacy for humans involved.
- The ability for HMI systems will still be limited to consistently function and communicate instantaneously.
- As algorithms will remain anonymous for some time, they and their developers are thus not liable for potential damages.

Opportunities for future HMI systems are based on their intelligent behavior which will be automated or replicated and will thus increase:

- User preferences will be predicted and material wealth will increase.
- Rational decisions will become a more common part of daily life.
- Resources will be used more efficiently, and losses and disease will be prevented or limited.
- The human brain will be freed of clutter, and human intelligence, creativity, and innovation will flourish as a result.

Risks of future HMI systems are closely tied to the development of general AI:

- By 2030, the goal that it can be applied at different cognitive levels will still be a distant vision.
- Future HMI systems are prone to decisions that lack transparency, incorporate ethical traps, incorrect patterns, and offer the potential for misuse.
- Authoritarian and totalitarian systems could use future HMI systems to secure their power.
- The worst risk of all is that future HMI systems could inflict damage on people.

In 2016, based on research from Carl Benedikt Frey, the US Council of Economic Advisers estimated “that 83 per cent of workers in occupations that paid less than 20 USD an hour were at high risk of being replaced, while the corresponding figure
for workers in occupations that paid more than 40 USD an hour was only four per cent.” In a 2020 report, Frey further states “that 113 of 483 occupations, accounting for 52 per cent of the US workforce, could be performed remotely” (Frey 2020). If something can be done remotely, it means that it is being transmitted digitally, thus being prone to algorithms and potentially being substituted by automated systems.

Ben Voegele, who graduated from university 5 years ago, never worked in an office. His architectural practice exists only in virtual space. He has only seen his employees on screen. They are in the Ukraine, Pakistan, Argentina, and Nigeria. Nevertheless, he succeeds in realizing projects not only better but also faster and cheaper. The new HMI system, which converts voice commands directly into sketches and drafts, serves this purpose. Linked to this is a 3D printer that quickly develops models on a faithful scale, giving customers a feeling for the final product. Embedding in virtual reality, which shows customers their object under changing conditions and can also react flexibly to changing user requirements, has also proven its worth.

The advantage lies not only in the respective networks on-site, which each of them contributes to, but also in the decomposition of the projects into individual subtasks. Each of them starts where the other one has left off. That is why there are no delays or breaks in implementation. Although they are so far apart, a great feeling of togetherness has developed. Ben invests the costs saved on rent and operating expenses in bonus payments for his employees.

10 Implications for Leadership, Self-Management, and Organization

Leadership principles will be much affected by the development of future HMI. Technological development can lead to significant increases in productivity, but it will depend on how these gains are distributed between economic and social groups. This point is especially important, as current technological innovation is taking place at a time when general income inequality has reached an all-time high. Combined with advances in the realm of artificial intelligence and robotics, this inequality could take our society in the direction of twenty-first-century economic feudalism, in which the owners of capital have more power over the economy and society than ever before. Much will depend on who will own robots and artificial intelligence in the future and who will benefit from the activities of artificial intelligence. Responsible leadership is aware, visionary, imaginative, responsible, and prepared to take action and rise up to these challenges. All five dimensions need to be considered at the individual, organizational, and societal level (Bettignies 2020).

Recommendations for implementing the different elements of responsible leadership consist of seven concrete steps:

1. Take stock of personal strengths, weaknesses, life goals, priorities, development
potentials, and limits, and assess how all of this fits within the competitive environment. Self-management will not be able to function sustainably without an inner balance.

2. Identify current and future opportunities and risks associated with employer or business unit, taking a number of factors into account (including environment, competitiveness, level of automation, resilience in the face of globalization, cost structures, future profitability, and potential for innovation).

3. Develop an awareness for one’s own role within existing structures, assume responsibility, and contribute to change.

4. Strengthen personal abilities by continuously acquiring knowledge.

5. Improve creative ability in the quest for new and innovative ideas. Stimulate learning by observing colleagues and partners. Human attitudes and willingness to be flexible will play a larger role than ever in determining where, when, and how they work. Dynamic and agile team structures will become the norm.

6. Perfect interpersonal communication skills within global teams that cross-cultural, religious, racial, and language barriers. That entails the ability to organize, coordinate, participate in, and navigate the flexible networks of the future.

7. Improve technical skills and the ability to cooperate with automated systems. Employees will increasingly be defined by their ability to transform themselves and adapt to automated means of production.

Organizational principles will revolve around the focus of developing abilities such as creativity, analytical thinking, and abstraction, as well as the capacity to recognize disruptive trends and to organize the living environment accordingly. To remain relevant, employees will have to commit to lifelong learning, and the characteristics of symbiotic learning will gain importance: highly personalized learning, constant feedback loops, the integration of learning and playing, flexibility, and adaptation. According to Barro and Davenport, “thoughtful adoption of intelligent technologies will be essential to survival for many companies. But simply implementing the newest technologies and automation tools will not be enough. Success will depend on whether organizations use them to innovate their operations and their products and services—and whether they acquire and develop the human capital to do so” (Barro and Davenport 2019).

Organizations must want and implement cultural change to stay innovative. Long-term work relationships and corporate structures are increasingly being called into question. It will be more important to attract and retain the right talents. Idealistic motives will play an increasing role. The best talents will be able to choose who they want to work for—money or power will not be the sole deciding factors. The purpose of the work will become a central motive because the best talents will pay very close attention to what specific difference they can achieve in an organization. The evolving HMI environment will enable them to maximize their talent. The interaction with the new HMI technologies will have a great leverage effect on the individual.

In the future, it will also be a question of which environment is best suited for personal development. Bertolt Brecht describes it in a few words in his stories from
Mr. K.: “A man who had not seen Mr. K. for a long time greeted him with the words: ‘You haven’t changed a bit.’ ‘Oh!’ said Mr. K. and turned pale” (Brecht 1965).

In 2030, Fritz Krause has 2 years left until his retirement. So much has changed since he started working for Bosch 30 years ago. In fact, he is the only one of his colleagues who has remained with the company for so long. Most older people have accepted the generous severance packages offered after the pandemic subsided. Among the younger ones, there are only a few left who work permanently for Bosch. Almost all are employed on a project basis and work for several companies at the same time.

If I’m honest, Fritz thought, I haven’t actually contributed anything productive over the past few years. I’ve always just been a facilitator of contacts and asked questions that my colleagues never thought of. It was also more luck than brains that I pointed out during the market launch of the new Bosch Volkswagen in India that the automated systems should react particularly carefully in regard to cattle that are in front of the car. Quite mundane, but somehow it was completely overlooked in the development.

If production processes in a knowledge-based society shift to micro-contributions, then the algorithmic coordination of tasks, nonmonetary incentives, and reputation metrics of many companies will be obliged to fundamentally reassess their operations. This includes reward mechanisms as well as workplace design and location. Rather than being places of work that employees are expected to travel to every day, offices will become temporary locations for human interaction. New jobs could be carried out in a purely virtual environment, just as one or several identities can already be created in these environments. Organizations will increasingly be obliged to network work and source its results in connected systems, just as the terms crowdsourcing or cloudsourcing suggest. Corporate functions will focus their efforts on the best possible integration of these delegated work steps to create added value. This new type of organization, which will be driven by a social structure, will be characterized more strongly by permeable and flexible structures and less by conventional corporate bureaucracies.

11 Outlook and Recommendations

Recommendations for the development of HMI systems within the next decade include a consistent push for digitization and connectivity.

By 2030, qualities such as mechanical precision, reliability, and sound logistics will not be worth much unless they are enhanced by digital HMI expertise. Digitization calls for the ability to master the world of data, and it will be the key to value-added services. Perception-based HMI will enable the digitization of the physical world with sensors and intelligent devices. By gathering new data that was not previously available or useable, new applications will be created. A growing number of connected sensors and a new combination of data will make this possible. Companies who are able to dwell on their systems knowledge, hardware expertise, and a leading position in sensor technology will prosper. Making the conclusions and actions of HMI systems understandable, convincing, justifiable, ethically sound, and transparent will be decisive and remains a central challenge. Finally, companies
should prepare to seek separate partnerships with Chinese and American companies and institutions on HMI-related projects, as the coming years will see a deepening of the antagonism between the United States and China.

Connectivity will be virtually comprehensive by 2030. Accordingly, the future priorities of a connected world will concentrate on security, trust, and the integrity of data. These topics are linked to one another in a very logical way. As we become more connected, we are radically increasing the potential for attacks. The scope for connected end-points is going to increase 10- to 100-fold just in the next few years. It will no longer be just a device that you use; it will also talk to other devices, either on your behalf or on behalf of the infrastructure. We will have an increase in density, vulnerability, dependency, and data. That data is going to have many elements, some of which will not be cause for concern. It might be benign to most individuals, even to the system itself. However, there could also be very critical information that is going to create risk. It could control infrastructure or personally identify individuals. The biggest concern by 2030 is the “big brother” phenomenon that could follow: potentially, an entity (government or commercial) would be able to monitor everything humans do online. Whether we are talking about China, the United States, or Germany, we would be looking at different kinds of tracking and predictive mechanisms potentially involving government or commercial entities.

This brings us to the question of trust, or more specifically, who do we trust with our data? Who should own that data? How long should they store it? What should be disclosed and how? To what extent should it be contained within the device itself, within the system, or within the cloud? How much should it be shared with others, with third parties? We are moving from a period of human intervention security responses to machine intervention security responses. Traditionally, humans were involved in protecting the network, patches were downloaded, and computer systems were monitored by a human. These things are going to be fully automated and instantaneous by 2030. As we move from human to assisted, to autonomous security, we are going to experience growing pains. We are moving from concerns about the information collected online versus in our everyday lives in the physical world. Ultimately, we need a way of interacting with this Internet of Things and explaining to it what we want it to expose about humans. We need some means of knowing and resolving when bad things are happening because of these interconnected devices.

By 2030, we are going to see an explosion of devices in the radio space, just like we are going to see an explosion of the Internet of Things and of IoT space. One of the critically important tasks is to think about the mechanisms required for heterogeneous networks, different carriers, and different types of systems to interoperate. We have to think about what sharing and etiquette might look like in a future world of dense, heterogeneous HMI systems.

We build and operate very complex systems on which we make ourselves increasingly dependent, without having fully understood them. We are often caught off guard by cascading breakdowns. This tendency to link systems, to automate them, and to integrate information technology can lead to new risks, such as the collapse of networked infrastructure. The power system plays a prominent role in
this area. Greater interconnectedness means greater complexity. The risk of a collapse is real, not just at the national level but across Europe. For that to happen, however, several events must take place, not just one. The combination of factors is often triggered automatically, in a cascade pattern rather than independently, and in the end, the system collapses. Therefore, resilient systems should not collapse but instead rebound, absorb the disturbance, adapt to it, and achieve a balanced state that either corresponds to the starting position or is even better. One of the most important questions will remain: whether people and machines are going to work together or against each other. Will they complement each other by using their respective strengths and compensating for their weaknesses? As Davenport asks, “what new feats might people achieve if they had better-thinking machines to assist them? Instead of seeing work as a zero-sum game with machines taking an ever-greater share, we might see growing possibilities for employment” (Davenport and Kirby 2015). According to him, one should see the threat of automation as a complementary aspect of technological innovation and as an opportunity for augmentation. The ability to make sense of combined human-machine outputs will be key for success in the next era of HMI partnerships (Institute for the Future 2017). Much will depend on whether overall productivity will increase. The opportunities and risks of the future will be fundamentally influenced by who owns the means of production and how profits are distributed or invested. The results will be clear for all to see.

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