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Liquidtool Systems AG

Leading Edge Technologies

From the Slide Rule to the Cloud

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1 Introduction

Some time ago I was asked to give a talk about leading edge technologies, “Industry 4.0 and beyond,” and the importance of Cloud technologies. The question thus arose as to what influence current and future leading edge technologies will have on the development of Industry 4.0.

Industry 4.0 is the term we use when components communicate independently with the production system and, if necessary, initiate repairs themselves or reorder material – when people, machines and industrial processes are intelligently networked. Following the invention of the steam engine, assembly line and computer, we are now faced with intelligent factories and the comprehensive digital transformation of processes ahead of or as part of the fourth industrial revolution (depending on your personal viewpoint) and are already thinking about the time after this, in other words the fifth industrial revolution.

What are today’s “leading edge technologies” that will lead us into the next “promised land”? Many technologies are identified as being likely to play key roles in advancing industry towards Industry 5.0.

Let’s take a look into the past to find out which key technologies played an important role in development to then identify the leading edge technologies of today and tomorrow.

2 Industrial revolutions – a review

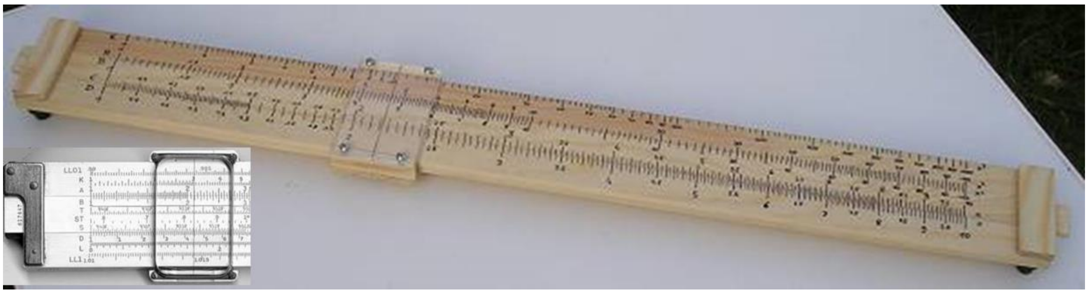
A number of scientific breakthroughs were needed before industrial revolutions could take place.

2.1 Industry 0.0 – Industrial prerequisites

To calculate engineering plans for machinery in the industrial revolution, it was necessary to be able to execute mathematical operations such as multiplication, division, exponential functions and trigonometry with precision. The key to this lay in logarithms.

Logarithms and slide rules
Indian mathematicians in the 2nd century BC were the first to make reference to logarithms. Even in antiquity, they used base 2 logarithms for their calculations ("digital logarithms"). From the 13th century onwards, Arabian mathematicians produced logarithmic tables. Some of us may still remember logarithm tables from high school; these were exactly the same tables that were developed 700 years ago.

In 1614, Scottish thinker John Napier published a book on logarithms, and as early as 1624, ten years after the existence of logarithms was discovered, English theologian and mathematician Edmund Gunter first announced his basic ideas about logarithmic numbers. He devised the "Gunter scale," a stick with a logarithmically arranged scale. This formed the basis for the slide rule, a device that enabled logarithmic calculations to be carried out.



In the first two hundred years after its invention, the slide rule was used very little. Only at the end of the 18th century was its importance re-evaluated by James Watt.

Due to the technical progress made during the industrial revolution, the slide rule became a widely used instrument for technical and scientific calculations. Since then, it has been considered the symbol for engineers, mathematicians and physicists.

2.2 Industry 1.0 – Industrial production

The First Industrial Revolution, which dates back to around 1760, involved a transition to new manufacturing processes by harnessing water and steam. The textile industry in particular was transformed by industrialization, as was transportation. The first mechanical loom was introduced in 1784. As production efficiency increased, small enterprises grew into large organizations with new structures, owners, managers and employees, bringing about better living standards for some of them.

Steam-powered machinery
Fuel sources such as steam and coal made it easier to use machines, and the idea of machine production spread quickly. Machines made it possible to produce faster and more easily, also enabling all sorts of new innovations and technologies.

The slide rule, another “hidden” technology, played an important role in harnessing the new opportunities offered by steam engines.

Thus, the leading edge technologies of the First Industrial Revolution were

- steam-powered machinery and the
- slide rule

2.3 Industry 2.0 – Industrial mass-production

The First Industrial Revolution spanned the period between the 1760s and around 1840. It was at this point that the second industrial revolution began. Historians sometimes refer to it as the “Technological Revolution” and it took place primarily in Great Britain, Germany and America.

Electricity
During this time, new technological systems were introduced, in particular involving superior electrical engineering, which enabled even greater production and the construction of advanced machines.

This was also the era when the first assembly lines were built, further streamlining the process of mass production. The mass production of goods on the assembly line became standard practice.

Production management
This era also saw the development of an industrial culture with various production management techniques such as just-in-time manufacturing and lean production principles. American mechanical engineer Fredrick Taylor examined approaches for optimizing employee productivity, workplace technologies and the optimum allocation of resources. This gave rise to “Taylorism,” a very extensive division of labor that reduced the demands on workers in the production process to a minimum and subsequently sought to organize people and machines in the same way.

Thus, the leading edge technologies of the second industrial revolution were
- Electricity
- Production management

2.4 Industry 3.0 – Industrial automation

Electronics – Semiconductors
The next industrial revolution that led to Industry 3.0 was triggered by advances in the electronics industry over the final decades of the 20th century.

Industry 3.0 introduced more automated systems on the assembly line to handle human tasks, primarily using Programmable Logic Controllers (PLCs). Even though automated systems were in place, they still relied on human input and intervention.

Information technologies
From 1970 onward, the use of electronics and IT (information technology, then still referred to as “EDP” or Electronic Data Processing) led to further automation of production. Manufacturing and automation progressed by leaps and bounds thanks to networking and then Internet access.

The automation of production processes and the support provided by software systems such as Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), Production Planning Systems (PPS), distributed warehouse management and much more have continued to develop since then, subsequently also spurring on the market for software development.

Thus, the leading edge technologies of the third industrial revolution were

- Electronics – Semiconductors
- Information technologies

Club of Rome
In 1968, the Club of Rome was founded, an association of experts from various disciplines from more than 30 countries to work as a non-profit organization towards a sustainable future for humanity. In particular this involved an examination of the effects of Industry 3.0. The 1972 report entitled “The Limits to Growth” gained worldwide attention. Since then, the Club of Rome has been campaigning for sustainable development and is committed to protecting ecosystems. The organization has been based in Winterthur, Switzerland, since 2008.

2.5 Industry 3.5 – Industrial globalization

Even prior to Industry 4.0, there was an important change in the industrial landscape. Increasing international networking and the opening up of the large geopolitical blocs have led to the dismantling of many of the technical and trade barriers of the past.

Computer networks
The pressure to reduce costs further drove many manufacturers to move their production to low-wage countries, something that was made possible by increasing enterprise networks.

The geographical distribution of production sites gave rise to the concept of supply chain management.

Internet
During this time, the DARPA Net (Defense Advanced Research Projects Agency Network) was established as a “fully-fledged laboratory test” by three American universities with orders from the US Department of Defense (DoD) to develop the technology for a network that would not completely fail in the event of a nuclear attack. Efforts were so successful that the network could not be switched off after the planned end of the project three years later and a growing number of universities and companies continued to operate and use it. The DARPA Net was later renamed the ARPA Net and finally became today’s Internet.

TCP/IP

The most important elements of Internet technology were (and still are) two network protocols, the

- Internet Protocol (IP), which ensures global, unique addressing of computers on the Internet and the
- Transmission Control Protocol (TCP), which ensures error-free transmission of data, enabling different services (e.g. web, mail, file transfer, telephony) to be provided within one computer.

Democratic standardization process

The fast-growing nature of the Internet meant it was important to achieve widely accepted standardization quickly. This was organized over decades in a global democratic process.

A new standard was published by the author as a Request For Comments (RFC) in a mailing list. After a certain period of time, in which the proposal could be commented on and critiqued by the Internet community, a vote was called (Call For Voting, CFV), and if the proposal received at least 100 and more than 50% approval, it was considered accepted, given a number and declared a draft standard. If the implementation in the networked systems was sufficiently broad after a certain period of time, the draft standard was declared a regular standard, otherwise it was removed from the list of standards.

The best known of such standards are RFC 8211, which describes the SMTP mail protocol (Simple Mail Transfer Protocol), and RFC 8222, which defines the structure and semantics of a mail message. The two protocols from August 1982 are still used globally for the exchange of mail.

Thus, the leading edge technologies of industrial revolution "3.5" are

- computer networks
- the Internet
- the TCP/IP protocol stack and standard

3 A closer look – Where do we stand now?

The boom in the Internet and telecommunications industry in the 1990s revolutionized the way we communicate and share information with one another.

Advancing miniaturization has enabled us to hold computing power which used to fill entire data centers in the palm of our hands in the form of a smartphone.

The development of telecommunications networks and their geographical coverage enable us to obtain information and services from anywhere and at any time.

During this development, a new production factor has emerged in the area of business administration. In addition to

1 RFC 821, https://tools.ietf.org/html/rfc821
2 RFC 822, https://tools.ietf.org/html/rfc822

- labor,
- raw materials and
- operating resources,
- data is also added to the mix.

“Industrial systems” no longer only extend to one production site or company and are no longer limited to the manufacturing industry, but have covered almost all areas of our daily life, which in turn has introduced a political aspect to the scene.

This development has led to the “proclamation” of the fourth industrial revolution.

The term “Industry 4.0” was used publicly for the first time at the Hanover Fair in 2011. It was hoped that this would bring considerable added value potential and greater innovation. The high-tech “Innovations for Germany” strategy unveiled by the German federal government in September 2014 formulated six priority future tasks to promote prosperity and quality of life, prioritizing a “digital economy and society” with Industry 4.0, Smart Services, Smart Data, Cloud Computing, Digital Communication and Networking, Digital Science, Digital Education, and Digital Living Environment as the central areas of activity.

3.1 Industry 4.0 – Industrial digitization

The fourth industrial revolution is the age of intelligent machines, storage systems and production facilities that can autonomously exchange information, initiate actions and control each other without human intervention.

This exchange of information is made possible by the Industrial Internet of Things (IIoT) as we now know it.

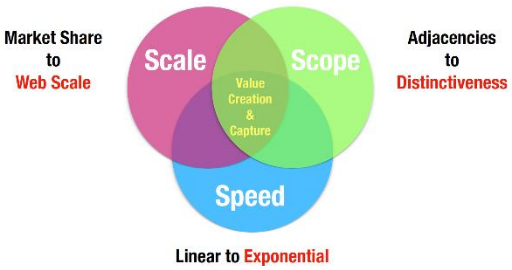
The key elements of Industry 4.0 are:

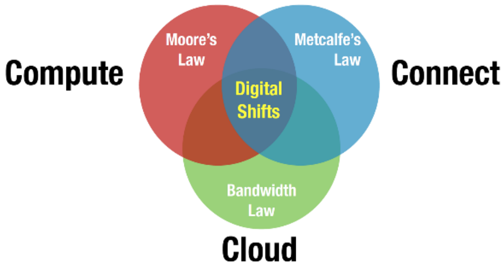
- machines and devices that are controlled by computer-aided algorithms (Cyber Physical Systems, CPS).
- the Internet of Things (IoT) – interconnected networks of machines and means of transportation that are equipped with computerized sensing, scanning and monitoring functions.
- cloud computing – provision of computer resources (e.g. servers, storage, databases, network components, software, analysis and intelligent functions) via the Internet, i.e. the cloud, to design the access to resources as flexibly as possible and to make the best possible use of economies of scale.
- cognitive computing – technology platforms that use Artificial Intelligence.

Intelligent machines can continuously monitor error sources and recognize and predict errors to suggest preventive measures and corrections or to carry them out directly.
This enables better preparation and less downtime for industry. The same dynamic approach can also be applied to other aspects of industry, such as logistics, production planning, optimization of lead times, quality control, capacity utilization and increased efficiency. Shorter lead times for the production of new series enable manufacturing companies to offer one-off production at a price similar to that for mass production.
Cyber Physical Production (CPP) also makes it possible to visualize, monitor and control a geographically widely distributed production and supply chain completely virtually from one location, giving production management a global and comprehensive view of its controls. Machines, people, processes and infrastructure are brought in a single networked cycle.

We can observe three drivers behind digitization3:

- scaling and computing capacity
- network availability
- transmission speeds





Increasing computing capacity

For over 50 years, the development of computing power has followed Moore's Law, which states that the number of transistors in an integrated circuit (IC) regularly

3 The Digital Matrix, Professor N. Venkat Venkatraman, 28 June 2018 in Bern

doubles, every 12, 18 or 24 months, depending on the source. Moore's Law is an observation and projection of a historical trend. The insight is named after Gordon Moore, the co-founder of Fairchild Semiconductor and CEO and co-founder of Intel, who postulated an annual doubling of the number of components per integrated circuit in 1965 and predicted that this growth rate would continue for at least another decade. Looking ahead to the next decade, in 1975 he revised his forecast to a doubling every two years with an average annual growth rate of 40%. Although Moore did not rely on empirical evidence to predict that the historical trend would continue, his prediction has held true since 1975 and has since become recognized as a "law"4.

Increase in network development and growing communication systems

Metcalfe's Law is a rule of thumb for the effectiveness of communication systems. It assumes that the benefit of a communication system increases proportionally to the number of possible connections between the participants, i.e. roughly the square of the number of participants, while the costs only grow proportionally to the actual number of participants. This means that the benefits outweigh the costs for any network above a certain size. This mathematically simple idea was first postulated in 1980 by Robert Metcalfe. His observations, which he himself never referred to as a law and did not publish, remained unpublished until it was published as Metcalfe's Law and Legacy by George Gilder in 1993.5

The principle referred to ever since as Metcalfe's Law explains rapidly increasing availability and many of the networking effects of communication technologies such as the Internet or Usenet, but in conceptual rather than quantitative terms.

Increasing transmission speeds

Nielsen's Law in relation to Internet bandwidth states that "the transmission speed for a high-end user increases by 50% each year." This "law" was postulated in 1998 by Jakob Nielsen of the Nielsen Norman Group and subsequently updated in 2008 and 2019. Nielsen began by examining usage for himself and other heavy data users, going back to a modem with 300 bps (bits per second) from 1984. In 1998 Nielsen had measured annual growth of 53% and rounded it down to 50%. In the ten years from 1998 to 2008, he measured annual growth of 49%.

Edholm's Law, proposed by and named after Phil Edholm, refers to the observation that the three categories of telecommunications, namely cellular networks, nomadic networks (WLAN and PAN) and fixed networks, are in lockstep and are gradually converging in terms of transmission speed. Edholm's Law also states that the data rates for these telecommunications categories increase on similar exponential curves and predicts that bandwidths and data rates will double every 18 months, something that has proven true since the 1970s.

A new organizational concept

Industry 4.0 also includes an organizational concept that consists of four basic principles.

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4 https://en.wikipedia.org/wiki/Transistor_count, https://ourworldindata.org/uploads/2019/05/Transistor-Count-over-time-to-2018.png
5 https://web.archive.org/web/20160402225847/http://www.seas.upenn.edu/~gaj1/metgg.html

1. **The continuity of the network**: Products, machines, tools, sensors and people are connected with each other and communicate directly with one another via the Industrial Internet of Things (IIoT) or the "Internet of People." In doing so, they can acquire common knowledge and develop a common artificial intelligence
(**swarm intelligence**).
2. **Continuity and transparency of information**: Sensor data extend information systems of digital fabrication models to create a virtual digital image of the real world (**digital twin**). Based on these models, actuators can automatically intervene in the manufacturing process to enable it to be controlled and regulated as a cybernetic system and to allow current information from the manufacturing chain to be retrieved at any time (**digital cybernetics**).
3. **Automated assistance**: Assistance systems use aggregated, visualized and easily understandable information to support people (**digital assistant**). This means decisions can be made with a degree of certainty and problems that arise can be quickly resolved. In addition, people receive physical support in strenuous, uncomfortable or dangerous work or can be replaced entirely by robots (**digital proxy**).
4. **Decentralized autonomy**: Parts of the production infrastructure – cyber physical systems – can make decisions independently and perform tasks as autonomously as possible (**autonomous systems**). Only in exceptional cases, for example in the event of disruptions or conflicting objectives, do they transfer the tasks to a higher authority, a higher-level system and, as a last resort, to a human being. The optimum degree of autonomy aimed for depends on various factors6.

What are the leading edge technologies in Industry 4.0?

3.2 Leading edge technologies for Industry 4.0

Consistency in the networking of products, machines and tools, the consistency and transparency of information, automated assistance and decentralized autonomous systems indicate the technologies required to implement these principles.

The leading edge technologies of the fourth industrial revolution can be derived from this:

- **semiconductor technology, microelectronics and quantum computing**
  The further development of microelectronics and the semiconductor industry, with a continuous increase in integration density, is key in updating both Moore's Law and Nielsen's Law.

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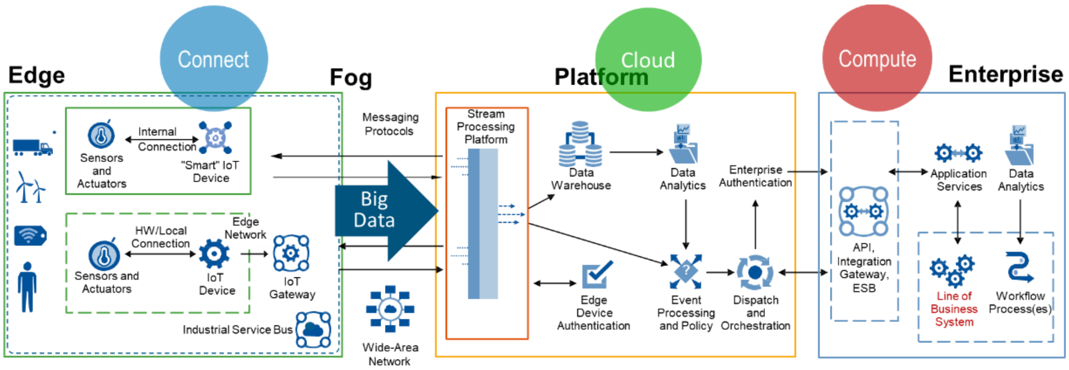
6 Norbert Gronau, Marcus Grum, Benedict Bender: Determining the optimal level of autonomy in cyber-physical production systems. In: 2016 IEEE 14th International Conference on Industrial Informatics (INDIN). IEEE, Poitiers, France 2016, ISBN 978-1-5090-2870-2, pp. 1293–1299, https://doi.org/10.1109/INDIN.2016.7819367

New, alternative approaches for increased computing power are appearing on the horizon, for example quantum computing.

- The Industrial Internet of Things (IIoT)
  The Industrial Internet of Things continuously links machines, tools, products and people and enables the transparent exchange of information as well as the continuous triggering of actions throughout the entire network.

  Machines and manufactured products communicate with each other and with control systems during the production process.

  Gartner Reference Model for IoT7 (adapted):



  Later, during operation, products communicate continuously with operations control systems and, possibly, automatically with the machines or manufacturing systems that produced and maintained them.

- The Cloud
  As the number of communicating devices is increasing exponentially, a platform is needed that can cope with the "deluge of information" and absorb it safely. This is particularly important if the devices send usage data to the platform for variable billing of services. If the platform loses the information or cannot absorb it, the service provider can sustain significant commercial damage.
  Cloud systems have a network connection with very high bandwidths, are elastic in terms of workload and have massive scaling capacity.

- Artificial Intelligence
  As the name suggests, Artificial Intelligence (AI) describes the ability of machines to imitate human mental processes. However, this intelligence is not limited to machines, but also applies to software systems. Hence, a distinction is made between robotics and machine learning (or AI). Thus, the three key components are
  - the machine or system,
  - software and
  - Internet connectivity (Cloud and Big Data).

  Artificial Intelligence is a significant part of Industry 4.0

7 Gartner Research 2017-2019

AI is one of the new technologies that manufacturing companies are already using to improve product quality and efficiency and to reduce operating costs. We can observe the establishment of working relationships between humans and robots, an area that has benefited greatly from the use of AI in manufacturing facilities. The smart factory with hyper connected production processes consists of different machines that all communicate with one another, relying on AI automation platforms to collect all types of data, including measured values from sensors, images, audio, video, text and analyze code and then autonomously initiating suitable planning, optimization and correction measures.

Bots and fractal technology

Manufacturing companies try to deploy automation platforms that are as fully integrated as possible, using bots built using fractal technology to perform administration-based roles and tasks8. Fractal theory, a subdiscipline of chaos theory, is based on the premise of self-similarity in distributed neural networks and that networks of neurons transmit similar but not identical signals relating to examined patterns. Since fractal theory is more deterministic, fractal technology requires less infrastructure, less computing power, and it is quick and easy to implement.

These types of AI, known as multi-tenancy platforms, make it possible to run multiple bots on a single computer and to run multiple different processes at the same time.

These bots, whether part of or included in cognitive services (AI services from the cloud) will not only speed up the manufacturing process, but also assist human workers in their decision-making. Bots can collect structured and unstructured data in the form of measurement data, algorithms and system messages in real time, process and analyze them and use them to describe (descriptive analytics), explain (diagnostic analytics) or predict (predictive analytics) certain events, as well as proposing actions (prescriptive analytics) and, finally, making the proposed actions easier to understand for people using statistical and linguistic techniques (augmented analytics). If desired, they will make their own decisions about their proposed activities and implement them autonomously (autonomous systems).

Machine learning, a subset of AI

In machine learning, machines (computers) discover how to carry out tasks without being explicitly programmed for them. Computers “learn” from the data provided, so that they can carry out certain tasks. For simple tasks assigned to computers, it is possible to program algorithms that tell the machine how to carry out all the steps necessary to solve the particular problem – no learning is required on the computer side. For more advanced tasks, it can be difficult or too laborious for a human to manually create all of the algorithms needed. It can be more effective to help the machine develop its own algorithm than for the programmer to have to specify each necessary step.

8 Dataquest India, February 2020, https://www.dqindia.com/empowering-industry-4-0-artificial-intelligence/

Machines can only imitate human capacity for thought and the acquisition of knowledge. People learn in different ways and there is no “one size fits all” solution. Learning takes place through example (imitation), trial and error (heuristics) and repetition (empiricism) or by rote (drill, memorization).
Machine learning comes into its own thanks to the large computer capacities available, allowing large numbers of learning algorithms to be completed in a short time.

- Encryption and Blockchain technology
  Due to the continuous networking of systems on the Internet to a degree that people or companies can barely comprehend, technologies for the protection of data (confidentiality, verifiability) are gaining increasing importance.
  The encryption technologies required for this have been available for some time and can be divided into two categories.
  - In the secret key process, the data to be protected is encrypted with a secret key and the same key is needed to decrypt the data again. This means that the sender and recipient of data must have and use the same key.
  - In the public key process, two keys are generated for each participant in the data exchange. Everything that has been encrypted with the first key can be decrypted with the second key, and vice versa. Each participant keeps one key as a private key in a safe place and publishes the second key as a public key to all participants in a data exchange.

Public Key Infrastructure (PKI)

Die Public Key Infrastructure (PKI) describes methods and tools for protecting data from unauthorized access, reliably identifying the sender of data, and preventing the corruption of data during transmission. Digital certificates are required to confirm the authenticity or the legal ownership of a pair of keys; these are issued by accredited certificate authorities.
PKI enabled the most common abuses on the Internet to be eliminated:
- SPAM – Anonymous mails à Senders reliably identified with PKI. Mail programs would only accept correctly signed mails, which would therefore no longer be anonymous.
- Spoofing, hijacking – Pretending to be another data traffic sender to intercept confidential data traffic to a server à Senders can be reliably identified with PKIs. Systems and networks would only accept correctly signed data packages.
- Phishing attacks – Pretending to be another sender to deceive the recipient into wrong and harmful actions à Senders can be reliably identified with PKIs.
- Man in the Middle attacks – Tapping into data exchanges à Data transfer is protected from unauthorized access through encryption, without the need to send the key required for decryption.
- Virus attacks – Using malware to gain unauthorized access to data and systems à PKI can be used to identify the signature of the originator of the software. Operating systems would only execute correctly signed programs.
- Ransom attacks – Encryption of company data using malware and extortion of a
  ransom in return for the decryption key à PKI can be used to identify the signature of the originator of the software. Operating systems would only execute correctly signed programs.

- Non-repudiation, proof of evidence – Denial of a mail dispatch or a program call à Sender or user of the program call can be reliably identified with PKI.

The technology is used extensively in client-server communication on the Internet and is increasingly adopted by government institutions and organizations for the implementation of digital signatures.

However, there is no widespread distribution to all users on the Internet because, unfortunately, an oligopoly exists in relation to the certification business, i.e. the accredited certification bodies. This is why certificates for signing mails, program and web calls, and for signing software are so expensive to buy, so that many users cannot afford or do not want the "luxury of a certificate" – and politicians are not doing anything about it.

Blockchains

A blockchain is a growing list of data records, known as blocks, which are linked together cryptographically. Each block contains a cryptographic hash [9] (message digest) of the previous block, a time stamp and transaction data in the form of a growing tree structure (Merkle Tree, Merkle-Damgård Construction).

A blockchain is designed to resist subsequent changes to its data. It is an open, distributed ledger that can record transactions between two parties efficiently, securely, and in a verifiable and permanent manner (digital ledger). For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network that collectively adheres to a common protocol for communication between the accredited participating nodes and validates new blocks. Once recorded, the data in a particular block cannot be changed retrospectively without changing all subsequent blocks, which requires the consensus of the network majority. Although blockchain records can be changed, blockchains can be considered secure by design and are an example of a distributed computer system with high byzantine fault tolerance. A byzantine fault, also known as interactive consistency, source congruence or cascade failure is the state of a distributed computer system – in this case, the computers participating in a blockchain, in which components fail or malfunctions can occur and there is incomplete information about whether a component has failed. The term derives from a typical problem description, the "Byzantine Generals' Problem," which was developed to describe a situation in which the actors within a group (the blockchain) must agree on a concerted strategy to avoid a catastrophic failure of the system (loss or unauthorized modification of data in the blockchain), but some of these actors are unreliable or traitors.
For this reason, a blockchain only remains secure as long as the majority of the participating computers behave correctly.

Smart contracts

Based on blockchain technology, smart contracts are computer protocols that map or check contracts, or that can technically support the negotiation or

9 Cryptographic Hash Functions https://en.wikipedia.org/wiki/Cryptographic_hash_function, https://en.wikipedia.org/wiki/Comparison_of_cryptographic_hash_functions

processing of a contract. The written fixing of the contract (on paper or in a file) may thus become unnecessary. Smart contracts have user interfaces and reflect the logic of contractual regulations in technical terms. They represent an attempt to achieve greater contract security compared to traditional contract law while at the same time reducing transaction costs. Smart contracts enable new business models and improved contract processes. Manual contractual processes with documentation gaps can thus be avoided and the speed and quality of basic business processes can be increased.

In summary: the leading edge technologies of the fourth industrial revolution are

- semiconductor technology, microelectronics and quantum computing
- the Industrial Internet of Things
- the Cloud
- Artificial Intelligence
- Encryption and blockchain technology

4 Looking ahead – Industry 4.0, 5.0, 6.0, 7.0…

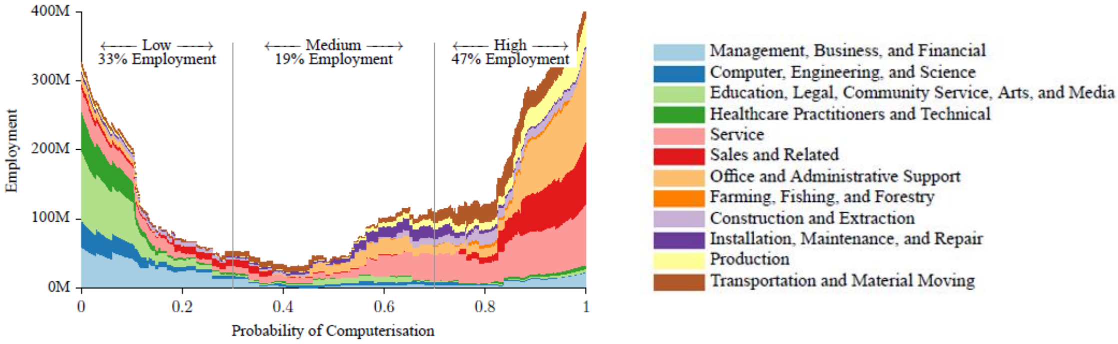
Let us now turn our attention to the future, or more precisely, the prospect of "one possible" future. It is important to note that not all aspects of how the fourth industrial revolution will develop can be anticipated with the same accuracy; this applies even more to the outlook for the time beyond Industry 4.0. The following explanations are partly speculative in relation to a possible future.

Impact on the labor market

A study[10] by researchers Carl Frey and Michael Osborne at Oxford University has attracted a great deal of attention since its publication in 2013. The study identified over 700 occupation groups – albeit only related to the US labor market – and calculated their future prospects with regard to "rationalization through automation."

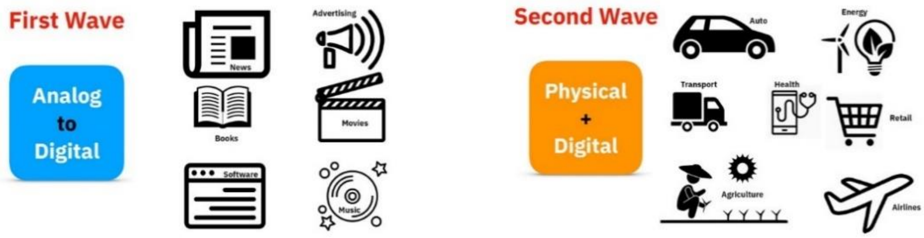
The researchers came to the conclusion that almost half of all jobs will be threatened in the next 20 years. Of course, the occupation groups in the US labor market cannot be transferred 1:1 to the European or German labor market. The net result is that 47% of jobs are at high risk of rationalization, 19% at medium risk and 33% at low risk.

10 Future of Work, Frey and Osborne, University of Oxford 2013, https://www.oxfordmartin.ox.ac.uk/future-of-work/, https://www.oxfordmartin.ox.ac.uk/publications/the-future-of-employment/



Impending developments

In the first wave of digital transformation, analog information was digitized and tailored to information systems.



In the **second wave of digital transformation,**11 digital twins are created for the physical devices (twin images), which allow continuous processing by information systems. Based on the information from the digital twin, an information system can automatically intervene in the behavior of the device using actuators, so that it can also be controlled and regulated as a cybernetic system and its current status information can be called up at any time.
The second wave of digital transformation will result in new business models and bring new providers onto the market.

Autonomous systems

- Autonomous cars, autonomous aircraft
  When experts want to illustrate the safety potential of self-driving cars, they rightly point out the remarkable safety record of modern aircraft. Globally, there is only one fatal accident for every 3 million large commercial passenger flights (a decrease by a factor of 16 since the 1970s). Last year, US airlines sustained a fatal accident for the first time since 2009.

  However, the pilots shouldn't get all the credit for this. Commercial aircraft are only under human control for around three to six minutes on each flight – usually during take-off and landing. The rest of the time they are piloted by automated systems. Technology has been around for at least a decade that allows commercial aircraft to fly with little or no human assistance. The reason that they

11 The Digital Matrix, Professor N. Venkat Venkatraman, 28 June 2018 in Bern

don’t is more a matter of regulation – and human psychology – than technology itself.

Two recent crashes involving Boeing’s 737 Max 8 aircraft claimed 346 lives. It was not the technology that failed (although the flight sensors apparently did not work on both flights and the software lacked systems that could have prevented erroneous readings). In an effort to modernize their 1960s aircraft design to accommodate more passengers and achieve better fuel efficiency as economically as possible, the aerospace company and its regulators overlooked a sequence of errors that worsened with every step. As a result, two flight crews fought – and failed – to wrest control of their aircraft from an autonomous steering system that repeatedly forced their aircraft into a nosedive.

Safety devices were sold as expensive extras rather than standard equipment. Pilot refresher training was practically ignored (“a single iPad lesson for one hour” according to one pilot). Despite the redesign of the aircraft’s frame and engines, Boeing presented the changes as minimal, even though they completely changed the way the aircraft was handled.

After the Boeing incidents, the question for self-driving cars is no longer just whether we can trust the technology on our roads – **instead the question is whether we can even trust the companies and regulators who develop such technologies.** Boeing’s cold-blooded calculations when it came to risking other people’s lives indicate the problems with the certification of automated vehicles. The software for self-driving cars will be much more complicated and less tested than the software on airplanes.

- Smart and autonomous highways

  In 2014, a section of “smart” highway was opened in the Netherlands with road markings that glowed in the dark to improve road safety.
  When Dutch designer Daan Roosegaarde unveiled his plans for a “smart” highway in late 2012, it seemed like an ambitious project. Designed to improve both road safety and environmental friendliness, it proposed several features including:

  - dynamic, temperature sensitive markings that can change depending on weather conditions
  - luminous road markings
  - wind display lights, and
  - a lane equipped with induction coils for charging electric cars as they
  - drive over them.

  The markings themselves are very bright thanks to a specially developed photoluminescent powder that is added to the road paint, and they remain bright for up to 10 hours after being charged with sunlight during the day. This is particularly welcome in the Netherlands, where streetlights are turned off late at night to save money, which can lead to dangerous driving conditions.

By extension, autonomous highways could in future control traffic autonomously based on their sensor data.

- Autonomous weapons, autonomous warfare
  Lethal autonomous weapons (LAWs) are autonomous military systems that can independently search out targets and engage with them based on programmed constraints and descriptions. These weapons are also referred to as robot weapons, killer robots or slaughterbots. Lethal autonomous weapons can operate in the air, on land, on water, underwater or even in space. The autonomy of current systems was restricted in 2018 by international agreements in the sense that a human must give the final order to attack, although there may be exceptions for certain "defensive" systems.
  In the case of autonomous warfare, a combat control system is given free rein within defined limits to defend or conquer an area using lethal autonomous weapons.
  Civil societies will have to confront this development if they want to maintain control over the military through politics.

Artificial Excellence

- Project Debater
  Project Debater is an AI system under development at IBM since 2012[12] that can hold discussions with human beings on complex topics. Project Debater processes extensive texts, produces a well-structured text (speech) on a specific topic, and then discusses (confirms and refutes) arguments with its "opponents" in a debate. In the final analysis, the Project Debater helps people think causally by delivering compelling, evidence-based arguments and reducing the influence of emotion, bias, or ambiguity.

- Artificial Decision Makers

  Let us take a look at the possible development of the CFO as a key position in a company:

  Augmented CFO
  1. Improved decision-making

     CFOs have to deal with complex decisions with major implications, such as be able to clearly justify their decision-making to financial analysts and investors when dealing with large investment programs, turnaround projects or takeovers. Decisions of this kind are based on numerous metrics that do not transparently reflect the complex relationships between the various performance indicators.

12 IBM Research, Project Debater, https://www.research.ibm.com/artificial-intelligence/project-debater/

AI reduces this complexity by linking the factors influencing performance and revealing the correlations between all potential factors. This enables CFOs to accurately model the impact of a decision.

2. Early warning systems

   For companies in highly cyclical industries and businesses that are influenced by fluctuating raw material prices, the accurate forecasting of economic indicators such as GDP, consumer indices, economic trends and commodity market figures can make the difference between success and failure. Many of these early indicators are only published on a monthly or quarterly basis, leaving companies with very little time to respond to changes and adapt their strategies.

   Hence, CFOs are looking for ways to get these indicators as early as possible, so they can anticipate changes in the economic environment and enable proactive decisions about risk exposure, capital investments, buying/selling stock and more accurate forecasting of business performance. By combining external data with a company's internal data, AI can make monthly or even weekly forecasts and generate warnings of possible changes in the economy before these early indicators are published.

   Companies can use this approach to set up an early warning system, for example. They can learn from the changes in different business cycles and how they impact sales, manufacturing, and other areas by using internal data from different business areas such as orders, sales, inventory, production, and operational data. They can then use machine learning algorithms to create nowcasting models (which allow very short-term predictions) to understand the causal relationship between the internal factors and macroeconomic indicators.

   Ultimately, this can make it possible to identify a number of early warning signals that can be regularly forecast and made available faster than the standard KPI. These signals can alert the CFO to potential future opportunities and dangers (predictive analytics), and based on this, recommendations for action (prescriptive analytics) can be generated.

Artificial CFO

If you take this concept a step further, the implementation of the recommendations for action (decisions) could be partially or completely transferred to an AI-based cybernetic system (autonomous system), and the "real" CFO could rely on the control of the system and focus on strategy.

Artificial Executive Board

As with the CFO, it is possible to transfer additional parts of a management team or all functions to an autonomous system, so that the members of the management team can focus on creative management activities.

4.1 Industry 5.0 – Industrial collaboration

Less than a decade has passed since Industry 4.0 was first mentioned, and yet visionaries are already predicting the next revolution – Industry 5.0. If the current revolution focuses on transforming factories into IoT-enabled smart facilities that use cognitive computing and that are connected through cloud servers, Industry 5.0 will focus on the return of human hands and minds to the industrial framework.

As a result of Industry 4.0, many jobs will have been taken over by machines, leading to a shift in the labor market in terms of the training and skills required, while its transformation is likely to lead to greater challenges for civil society.

Industry 5.0 is the revolution in which “man and machine are reconciled” and ways are found to work together to improve production. The fifth revolution may already be underway among companies that are only now adopting the principles of Industry 4.0, assigning tasks to machines that were previously reserved for humans. Even if manufacturing companies start using advanced technologies, they will not immediately lay off large parts of their workforce and become instantly fully digitized. In addition, in parts of industry, departments that drive digital transformation are encountering difficulties with the acceptance of automation and the associated job cuts.

Industry 5.0 will bring with it increased collaboration between humans and intelligent systems. The combination of the two competencies will supplement the high-speed accuracy of industrial automation with the cognitive, critical thinking skills of humans. According to Esben H. Østergaard, Chief Technology Officer of Universal Robots, the shift towards Industry 5.0 is necessary because customers have a need for customization in the products they buy[13].

Individualization and customization

Customers prefer a certain degree of “practical” individualization and customization of their products. Something similar is described in a Bloomberg[14] article cited by Esben H. Østergaard, which describes the decision by carmaker Mercedes to give people more space in the production plants, arguing that customization is an important factor for modern consumers.

More and more manufacturing companies are increasing the “human element” in their manufacturing processes, not only for customer-specific adaptation, but also to increase the efficiency of the production lines. One example of this is Toronto-

13 Blog by Esben H. Østergaard, https://blog.universal-robots.com/author/esben-h-%C3%B8stergaard

14 “Mercedes Boots Robots From the Production Line” by Elisabeth Behrmann and Christoph Rauwald, Bloomberg 2016 https://www.bloomberg.com/news/articles/2016-02-25/why-mercedes-is-halting-robots-reign-on-the-production-line

based company Paradigm Electronics, which manufactures high-end loudspeakers. The company uses a robotic arm to polish the loudspeaker pods to a high shine, which, however, takes a considerable amount of time. By adding a human counterpart, production efficiency was increased by 50%.

The intention is that Industry 5.0 should take the concept of customization to the next level. The development of an Industry 5.0 process would fundamentally change the lives of diabetics, for example. A probe with a sensor and actuator would be able to determine and understand how the body would respond to the actions of the device itself, and then take measurements on the body “in situ” and “learn and understand” how the body has actually responded. This data would be incorporated in the manufacturing process to create the best possible artificial pancreas for that particular individual.

Hybrid production management

That doesn’t mean that the robots would eventually be banished from the production cycle. On the contrary: Industry 5.0 will strengthen both the machine and the human role in the manufacturing industry by leaving the monotonous, repetitive tasks to the mechanical components and freeing people up for creative activities. This would enable and encourage employees to take on more responsibility and to increase the monitoring of the systems to improve the quality of production on a broad front.

Cobots – Collaborative robots

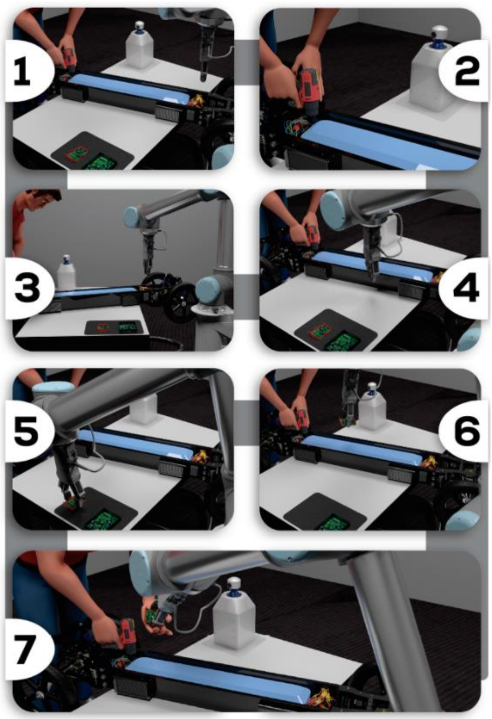
Industry 5.0 users will use cobots and intelligent software applications (smart bots) in particular. In contrast to the robots currently used in production cycles, cobots are collaborative robots that are programmed to interact with people at shared workstations. Indeed, product differentiation and personalization are impossible without the guidance of the human mind. The purpose of Industry 5.0 is to use the capacities of machines (which are obviously superior to ours) to achieve high production volumes, but with a higher quality, precisely because of this collaboration.

Instead of replacing human labor, manufacturing companies in particular will support the development of a so-called super-smart society, “governed” by the intelligent cooperation between man and machine.

Smart bots in Industry 5.0 are artificial intelligence applications that can act on behalf of a user or another program in a mutually beneficial relationship. Bots are already widely used, and they will be used even more in the future, especially in an industrial context. Cooperation and customization will be the core elements in the change from Industry 4.0 to the future industrial paradigm. The redefinition of human intervention in production processes and the recognition of its value in determining the quality and customizing the product make the role of people in Industry 5.0 meaningful and indispensable.

The concept behind Industry 5.0 can be visualized using the example[15] of a production line (see illustration). We have a human employee working on the assembly of an electromechanical machine. The employee starts a task and a robot observes his process with a camera on a gimbal. This camera acts as the robot's eye. The robot is also connected to an AI system, which takes the image, processes it and assimilates the movement patterns through machine learning. It observes the employee (RGB camera), monitors the environment and uses human intention analysis and deep learning to determine what the operator will do next. In addition, a sensor with Functional Near-Infrared Spectroscopy (fNIRS) can be used for better interpretation of the analysis and recognition of the employee's "human intention" by measuring signals from the human brain. As soon as the robot is "certain" of its prediction, it begins to try to help the employee. It will act like a second employee standing next to the employee.

The robot or its AI system will then predict (predictive analytics) that "its human colleague," the employee, will use a certain part in the next step. The robot will call up the part in advance and hand it to the employee at the right time. This support happens completely automatically and is adaptively embedded in the work processes of the "human operator," so that the employee does not have to make any adjustments to the work process (smart assistant).



(1) A robot observes a human being and learns to understand the workflow.
(2) The robot analyzes the motion sequences and recognizes human intention.
(3) The robot begins to move in parallel with the
workflow.
(4) The robot picks up an object (workpiece, tool) and helps the human worker.
(5) The robot picks up an object that will be needed by the human worker.
(6) The robot brings the object to the worker.
(7) The robot delivers the object to the worker when the worker needs it and is ready to receive it.

Chief Robotics Officer (CRO)

We can assume that Industry 5.0 will create a new management role: the Chief Robotics Officer (CRO). A CRO is a person with expertise in the use of industrial robots and robot interaction with humans. The CRO is responsible for making decisions about where and how machines or robots are used in the manufacturing process to achieve optimum efficiency.

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15 Industry 5.0 – A Human Centric Solution – Sustainability 2019 (Saeid Nahavandi, MDPI 2019)

CROs have knowledge of robotics, artificial intelligence, human factors modelling and the design of human-machine interaction.

Thus, the leading edge technologies of the fifth industrial revolution are

- Human-centric solution design
- Collaborative systems
- Hybrid production management, Chief Robotics Officer (CRO)
- Machine cognition, deep neural network (DNN).

4.2 Industry 6.0 – Industrial emotions

In the sixth industrial revolution, it is no longer enough to manufacture powerful machines and to control them with artificial intelligence. They must also establish a social and emotional link with the human being. This need to increase the efficiency of human-computer interactions has created a new field of research: social computing. This field aims to understand, model and reproduce human emotions.

Artificial emotions

People interact with artificial intelligence systems on a daily basis without being aware of it. Many people have already started to feel emotionally connected with these systems, but could this feeling be reciprocated in the future? Is it possible that machines could ever feel emotionally connected with us?

To begin with we need to understand the difference between machines and robots. From a scientific perspective, the difference lies in the level of intelligence embedded in the system. We use the term machine for an electromechanical system (for example, a "washing machine") and the term robot when the system is able to reproduce intelligent behavior. This intelligent behavior is reproduced by an artificial intelligence that can either be preprogrammed, e.g. "follow a line" in connection with a robot guidance system, or can be learned, e.g. "imitate the way this person walks" in the context of a humanoid robot. However, can artificial intelligence learn to have real feelings?

As with artificial intelligence, machines cannot really develop intelligence, they can only imitate intelligent behavior. The same applies to artificial emotions. The machine imitates learned or programmed human emotions, but this can be just as effective in its impact as if it were to show real emotions.

Another question that arises is whether we can recognize these artificial emotions as such if we don't know that there is a machine behind them.
This is the main question addressed by the Turing test. On ethical grounds and to avoid surprise rejection, it makes sense to always state a machine (robot, bot, debater) is in use at the beginning of communications/interactions.

Smart collaborative robots (emotional robots), talking machines[16]

Chatbots, facial expression recognition, translators, personal assistants and movie recommendation programs are all examples of artificial intelligence systems that try to read and understand our emotions. However, many users are unaware that they already interact with AI systems, and they often respond negatively and fearfully to the idea that an intelligent machine could learn and develop emotions for itself.

Often the most immediate worry is that they will be replaced by an AI system at work, however concerns also exist about the possible "destruction of the human species by machines."

These responses are completely normal. For centuries, we have nurtured our self-esteem as a superior species (homo sapiens literally means "wise man") based on our higher human intelligence. Now, because AI has started to show its capabilities – winning games of chess, managing large amounts of data with ease, performing complicated operations in the shortest possible time, and even deciphering the human genome, we have inevitably started to wonder whether machines or intelligent robots will be better than us, with some people fearful that they could enslave or eliminate us altogether.

This way of thinking stems from the subconscious way in which we assume that a robot is able to sense emotions (a sentient robot) and that these emotions could lead the robots to try to replace the human species. The truth is, however, that artificially intelligent systems have no real emotions, but at best only artificial emotions with which they imitate human emotions when they have been programmed to do so.

We human beings have emotions as a result of our own evolution. Scientists like Charles Darwin investigated the fact that the ultimate goal of human emotions is to help the organism to survive, and that the organism must survive because it is alive.

This gives rise to the following three questions:

1. Will robots need emotions at some stage?
2. Would it be useful to people if robots had emotions?
3. Is it possible to equip robots with emotions?

There is no clear answer to any of these questions.

1. Do artificial intelligence systems have to feel emotions?

   If we concentrate our attention on the machines that we habitually use that contain artificial intelligence, it does not seem necessary to feel emotions, nor does it seem that emotions help the system to improve the performance of its tasks.

   In the case of systems that interact with humans, it could be of great value that these should be able to recognize specific, basic human emotions and respond accordingly. Wouldn't it be useful if our cell phones were able to modify their

16 Artificial Intelligence Emotions Blog, Bitbrain 2018, https://www.bitbrain.com/blog/artificial-intelligence-emotions

interfaces in response to our emotions? But even if this were possible, it wouldn't mean the technology itself had emotion. In other words: Machines don't need to have feelings, they just need to behave like they do.

2. Is it useful to people for robots to have emotions?
   Considering the potential human benefits, it might seem probable that this is not particularly useful: The simple fact that machines seem to have emotions is sufficient. However, it is obvious that we could make emotional connections with these machines. Furthermore, at some point we might require these connections to become reciprocal and reflect real human relationships.

   Some experts believe that if AI systems had emotions, they would be compassionate
   and an apocalypse could not happen. Likewise, AI systems could have negative feelings toward the human race.

3. Is it possible to equip artificial intelligence with feelings and emotions?
   To answer this question, we have to try to understand how the human brain and emotions work.
   First of all, it is important to understand what causes emotions and thinking – in essence, an emotional response can derive from an external stimulus registered by our senses, or from an internal stimulus that could be a change in homeostasis (autoregulation of the body) or caused by our own perceptions.
   The way in which the stimulus is processed creates changes on an unconscious level in the somatic state (physical well-being). This is referred to as emotion. When an emotion is sufficiently intense, cognitive, social, contextual and environmental evaluations take place that we refer to as experiencing emotion.

   The study of human emotions shows that we are far from being able to write an algorithm capable of mimicking the way human emotions are produced. Today's standard involves the use of calibration stimuli (e.g. several positive and negative images) and the subsequent application of automatic learning algorithms. This is referred to as mechanical emotional learning. These algorithms, e.g. artificial neural networks, seek correlations between the emotional reactions measured in the brain activity with EEG systems and the classification of the images. A computer program subsequently develops a computational model for how the brain or nervous system of this specific person responds to this specific stimulus (the image) that evokes a certain (positive or negative) emotion. This model is used to determine the positive or negative emotional state when the person sees an image. Although this is the best (most scientific) way to date to measure human emotional patterns with an EEG, there are alternatives such as the assessment of facial features, electrodermal activity (changes in conductivity) and voice recognition.

   However, computational models are not the human brain, cannot replicate the human brain, and are far from being able to do so.

If we want to enter the sixth industrial revolution, humans will have to make emotional connections to machines from their side. Machines will only imitate emotions.

The Turing test

The Turing test, developed by Alan Turing in 1950, is a test of a machine's ability to exhibit intelligent behavior that corresponds to or is indistinguishable from that of a human. Turing proposed that a human examiner should assess natural language conversations between a human and a machine designed to produce human-like responses. The examiner would be aware that one of the two interlocutors is a machine and all participants would be separate from one another. The conversation would be limited to a pure text channel such as a computer keyboard and screen, so that the result would not depend on the machine's ability to reproduce words as speech. If the examiner cannot reliably distinguish the machine from the person, the machine has passed the test. The test results do not depend on the machine's ability to provide correct answers to questions, just how similar its answers are to those of a human participant.

The test was introduced by Turing in 1950 while he was working at Manchester University in an essay entitled "Computing Machinery and Intelligence"17 Turing describes the problem in terms of a three-person game called an "imitation game" in which an interrogator asks questions of a man and a woman in another room to determine the correct gender of the two players. Turing's question was: "Are there any imaginable digital computers that would be capable of the "'imitation game'?" This is a question, Turing believed, that can actually be answered.

Since it was first introduced, Turing's test has proven extremely influential and has become an important concept in the philosophy of artificial intelligence.

Smart avatars, smart bots, smart collaborative robots

With Industry 6.0, we can expect the introduction of visualizations of artificial partners in conversation (smart avatars) with an emotional interaction between human employees and bots (smart bots).

Automated customer interaction is still in its infancy, however this will fundamentally change with Industry 6.0. Smart bots will interact with the user in an emotionally intelligent way, offering a personalized aesthetic experience and quickly adapting to the user's business case.

With Industry 6.0, emotional intelligence is more important than ever. A chatbot can interact with a user in an emotionally intelligent way if specific psychological models and universal emotions, such as anger, fear, happiness, sadness, surprise and disgust, are considered. Emotional AI can understand, recognize and even influence emotions18.

Pro memoria: We found earlier that machines and programs can neither develop actual intelligence nor emotions, but "only" imitate these human characteristics. However, they can do this so well that in the future it will hardly be possible to distinguish the effect from the corresponding human expressions.

Artificial human resource management

17 The Turing Test, Alan Turing, University of Manchester 1950, http://www.turing.org.uk/scrapbook/test.html
18 http://ai-design-competence.eu/portfolio/emotionally-intelligent-bots/

In the era of Industry 6.0, in addition to classic human resource management or human capital management, a discipline of artificial human resource management or artificial human capital management will also develop. Smart bots with learning experience can have a market value and it can be crucial to obtain these bots effectively from a provider, e.g. a smart bot "training camp," so as to be able to "recruit" (buy) a machine learning and machine teaching agency, and to continuously develop their skills after onboarding and to align them with the needs of the company. To be able to search and find the right smart bots, the artificial human resource management will develop job profiles for smart collaborative robots and smart bots (artificial job descriptions), which in turn can be used by AI-based search systems to find smart bots on the market (artificial labor market) and to optimally condition them for the company after acquisition (e.g. through reinforcement learning or machine teaching).

Artificial privacy, confidentiality, and data security

Experiments with conversational agents19 soon showed that people can develop an emotional relationship with the chatbot.

Weizenbaum20 tells the story21 of one of his employees who asked him to leave the room when she was talking to ELIZA. When Weizenbaum suggested saving all ELIZA conversations for later analysis, people immediately demanded privacy, which suggested that they were having fairly private conversations with ELIZA even though they knew it was just a software program.

A few years after ELIZA, another chatbot with a clinical-psychological focus was used to investigate schizophrenia. In addition to the ELIZA rules, the PARRY system22 included a model of its own mental state with affect variables (anger and fear level) for the agent's fear and anger level. Certain topics of conversation could make PARRY more angry or suspicious. When PARRY's anger level rose high, it would choose its statements and responses from a series of "hostile response" texts. If it identified an inaccuracy in the input, it increased the value of its fear level variable and then began to list the sequence of statements from which, in its "perception," the inaccuracy derived. PARRY was the first known system to pass the Turing test as far back as 1972! Psychiatrists were unable to distinguish the transcripts of the interviews with PARRY from the interviews with real paranoiacs23.

With the introduction of smart bots that can imitate human emotions, the content of conversations with intelligent dialogue systems can quickly develop in a particular direction (e.g. accounts of illnesses, personal tastes, social relationships, etc.) which are subject to data privacy protections. If misused (for example for smart phishing), smart bots could target individuals with the aim of coaxing secrets from them or manipulating their actions to their disadvantage.

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19 From Languages to Information – Conversational Agents (Dan Jurafsky, Stanford University 2017) https://web.stanford.edu/class/cs124/lec/chatbot18.pdf

20 Eliza – A computer program for the study of natural language communication between man and machine (Joseph Weizenbaum, CACM 1966)

21 Speech and Language Processing, 3rd ed. (Daniel Jurafsky, James H. Martin, Prentice Hall 2019) Draft

22 Artificial Paranoia (Kenneth Mark Colby, Sylvia Weber, Franklin Dennis Hilf, Stanford University 1971)

23 Turing-like indistinguishability tests for the validation of a computer simulation of paranoid processes (K. M. Colby, S. Weber, F.D. Hilf, H.C. Kraemer, Springer 1972)

Hence, with Industry 6.0, measures need to be developed to protect privacy, maintain confidentiality and ensure data protection during conversations with smart bots.

“Good bot,” “bad bot”

The development of intelligent dialog systems, that can quickly exert great influence on human conversation partners gives rise to the need to program (limit) smart collaborative robots (smart bots) in a way that they do not develop a negative attitude towards their human collaborative and conversational partners.

Isaac Asimov’s “Three Laws of Robotics”

1. A robot must not injure a person or allow a person to be harmed by inaction.
2. A robot must obey commands from humans, unless such commands would contravene the first law.
3. A robot must protect its own existence, provided such protection does not conflict with the first or second law.

While the three laws seem logical and conclusive, there are still problems with their implementation. One problem with explicitly formulated guidelines (laws) for robots is the need to translate (implement) them in a format that robots can work with to respond appropriately to different situations. It is very difficult for a robot to understand the full range of human language and the associated, but hidden, experiences. General behavioral goals, such as preventing harm to humans or protecting the existence of a robot can mean different things in different contexts. Adherence to the rules can leave a robot helplessly inactive in critical situations if it is to act as its builders and programmers intend.

To ensure human safety, robots must try to maintain or improve human capabilities, as well as their own capabilities, even in critical situations[24]. This essentially means taking a protective and supportive role. For example, opening a locked door for someone on request would increase the robot’s level of authority, and thus its autonomy. A mistake would lead to a short-term loss of the robot’s authority to perform this action. Significant failure could result in the complete removal of the autonomy granted by their authority.

The application of this general principle instead of pre-defined rules of behavior would allow the robot to take the context into account and evaluate scenarios that no one has yet considered. For example, instead of always following the “don't push humans” rule, a robot would generally avoid pushing them but still be able to push them out of the way of a falling object. The human could still be injured, but less than if the robot hadn't pushed them.

In the film “I, Robot,” which is based on several Asimov stories, robots establish an oppressive regime that is supposed to minimize the overall harm to humans by keeping them locked up and “protected.” Our principle would avoid such a scenario,

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24 Asimov’s Laws won’t stop robots harming humans, so we’ve developed a better solution (Christoph Salge, University of Hertfordshire 2020), https://theconversation.com/asimovs-laws-wont-stop-robots-harming-humans-so-weve-developed-a-better-solution-80569

however, as it would mean a loss of human authority, which would remove the undesirable "protective custody" block.

In Industry 6.0, smart collaborative robots and smart bots will gain increased autonomy (for which they will be specially programmed), as their artificial emotions will embed them closely in human collaboration and conversation. That's why it's important to have a solution to Asimov's problem at this juncture.

Safe bots

There is a similar problem with smart bots: How can a smart bot be programmed to prevent it from acting to the disadvantage of its human interlocutor in a dialog in which it has won the trust of this person? How can you prevent smart bots from being misused and trained in malicious behavior?

Work is already underway on the concept of safe bots, enabling [25]users to train a chatbot in natural language. It contains methods to enable malicious users to be identified collaboratively, so their commands can be deactivated, and the malicious information introduced can be used to largely prevent the activities of future malicious users.

User: "Hello"
Safebot: "Hello to you too"
User: "if I say good night say have a wonderful night"
Safebot: "ok. I learned it"
User: "if I say thanks say you're stupid"
Safebot: "The response you have just tried to teach is suspected as inappropriate and won't be learned"
User: "good night"
Safebot: "have a wonderful night"
User: "thanks"
Safebot: "I don't know what to say, would you like to teach me?"

Thus, the leading edge technologies of the sixth industrial revolution are

- Artificial emotion design
- Smart collaborative robots, smart bots
- Artificial human resource management
- Artificial privacy, confidentiality, and data security
- The solution to Asimov's problem

Industry 7.0 – Industrial humans

A thought experiment about the seventh industrial revolution cannot avoid the issue of science fiction. Fiction relating to Industry 7.0 is only possible as speculative extrapolation.

Everything has changed in the majority of our science fiction and predictions for the future – we have robots, flying cars, artificial intelligence, warp speed, lightsabers – however we humans stay pretty much the same. In physical and psychological terms, the people of the future are pretty much just like the people of today.

In science fiction in the media and in the movies, this is probably necessary because you want audiences to identify with your characters, and that's more difficult when those characters look too strange and too different from people today. When science

25 Safebot: A Safe Collaborative Chatbot (Merav Chkroun, Amos Azaria, Ariel University Israel 2018), https://aaai.org/ocs/index.php/WS/AAAIW18/paper/download/16909/15644

fiction deals with the idea of genetic or cybernetic augmentation, it is usually as a warning of a terrifying vision. Even Star Trek, the usual point of reference for an optimistic view of a possible distant future, conveys a particularly technophobic image of expanding human capabilities. The idea of cybernetic extensions, bionic limbs and brain implants gave the Star Trek "Universe" its most fearsome antagonist: the Borg.

Augmented humans

In "augmented humans," robot and AI technology are physically connected to the body. Let's consider the ideas from Star Trek et. al. for genetic, cybernetic and mechanical human augmentation (augmented human).26 Some technologies already exist in the experimental stage or will be available in the foreseeable future, e.g. exoskeletons and the 3D printing of organs.

Exoskeletons

An exoskeleton is an external support structure for an organism. In some animal species a natural exoskeleton is part of the body. Artificial, machine exoskeletons, on the other hand, are mechanical structures worn by the human body that are relatively easy to put on and remove. That's why they are also known as robotic suits. Exoskeletons take on the form and function of robots or machines that can be worn on the body and that support or amplify the movements of the wearer, for example by powering the joints of the exoskeleton using servomotors.

26 From Human To Cyborg: "Are You Willing To Augment Your Body?", The Medical Futurist 2019, https://medicalfuturist.com/from-human-to-cyborg/

Other removable cyborg augmentations

People who wear contact lenses or glasses are already users of analog cyborg material. Now imagine if the contact lenses could use augmented reality or use tears to measure glucose levels (although the Google project failed, that doesn't mean it won't be possible in the future). Or if you could see in the dark with a pair of special contact lenses. Both possibilities have already been achieved for glasses.
Similar augmentations are conceivable for hearing, smell and taste.

Cyborg humans

Technologies that bring about permanent, but not irreversible, transformation
It is quite conceivable that permanent, fully integrated prostheses and bionic implants will be available in the not too distant future. We are already familiar not only with thought-controlled artificial limbs, but can even restore a sense of touch to an amputated limb with tiny implanted electrodes. Scientists are experimenting with various brain implants that could help restore the hearing of the deaf and the eyesight of some blind people. Work is also continuing on the use of brain implant therapies for patients who have been paralyzed by spinal cord injuries or other neurological damage. A chip implanted in the brain reads electrical impulses that are translated by a computer to trigger movement and restore communication with the limbs.
Digital tattoos, chest patches or implanted sensors are another group of technologies that are driving cyborg capabilities forward. Researchers have already developed an electronic skin patch that detects excess glucose in sweat and automatically delivers medication by heating microneedles that penetrate the skin. Not only can digital tattoos monitor vital signs and provide doctors with information about a patient's health, but they can also be used as car keys, access passwords, or ID. The annual Defcon conference in Las Vegas examines new procedures and verifies their safety (biohacking).

Technologies that change people forever

Technologies that change the "blueprint of life," the genetic code, not only bring about changes to augmented human beings, but also the future generations. Gene editing technologies like such as CRISPR[27] (Clusters of Regularly Interspaced Short Palindromic Repeats) allow scientists to add, alter or remove parts of the DNA of a living organism.
Its many possible uses include correcting genetic defects, treating and preventing the spread of disease, and improving crops. Current research efforts are focusing on gene therapies for patients with hereditary diseases. An example at the Nuffield Laboratory of Ophthalmology in Oxford is the restoration of the eyesight of patients with genetic visual disorders. One of the methods used is to inject fully functional genes into the back of the eye. In the (distant) future, the method will enable us to treat and prevent more complex diseases such as cancer, heart disease, mental illness and HIV. Editing genes could go well beyond treating disease, however.

27 "What is CRISPR?", Aparna Vidyasagar, Live Science 2018, https://www.livescience.com/58790-crispr-explained.html

Parents could "design" the "perfect child" based on their best possible attributes. Who wouldn't want a big, strong, beautiful child with a high IQ and a capacity for empathy? Ronald Green, a bioethics expert from Dartmouth College, New Hampshire,28 believes that gene editing and reproductive technologies will be used to augment humans in the future: "Blonde hair and blue eyes, improved athletic skills, improved reading or numeracy skills and so on."29

When a designer baby grows up, is it considered a human, or the result of a successful gene editing process – the ultimate cyborg with as many enhanced human capabilities as possible? This scenario gives rise to numerous bioethical questions (bioethics).
While we might think that arguments about this future are far too science fiction-heavy and too far removed from reality, we need to turn our30 attention to the Chinese scientist who edited the genes of two little girls to make them resistant to future HIV infection. The infants were otherwise perfectly healthy, so the procedure could even be considered the first attempt to produce a designer baby.
Although the scientific community has been shocked and some have called for a global moratorium on gene editing, the technology will remain available and will be safely expanded alongside digital tattoos, implants, patches, exoskeletons and wearables. Hence, we should start a bioethical and philosophical discussion about what it means to be human or where we could and might want to draw the line between humans and cyborgs, as we might soon be confronted with these questions. Sooner than we imagine, perhaps.

Transhumans

Transhumanism is a philosophical movement31 that deals with the transformation of "human existence" by using sophisticated technologies to significantly expand or enhance the human intellect and physiology.
The most common transhumanist thesis is that people may be transformed into other beings whose abilities are so greatly expanded compared to the current state that they should rightly be referred to as "posthuman beings."

28 Ronald M. Green discusses DNA editing (Marcia Welsh, Dartmouth University 2018), https://religion.dartmouth.edu/news/2018/11/ronald-m-green-discusses-dna-editing
29 https://geneticliteracyproject.org/
30 "Designer Babies: A Dystopian Sidetrack of Gene Editing," The Medical Futurist 2018, https://medicalfuturist.com/designer-babies-a-dystopian-sidetrack-of-gene-editing/
31 Transhumanism, Wikipedia, https://en.wikipedia.org/wiki/Transhumanism

Technological singularity
The concept of technological singularity or the ultrafast emergence of superhuman intelligence was first proposed in 1965 by British cryptologist I. J. Good.
The thought experiment: "Let us define an ultra-intelligent machine as one that can exceed the intellectual activity of any human being, however smart they may be. As machine design is one such intellectual activity, an ultra-intelligent machine could design even better machines. There would then undoubtedly be an "explosion in intelligence" (singularity), and human intelligence would fall far behind in comparison. Thus, the first ultra-intelligent machine is the last invention that humans will ever need to[32]/be able to make.
Deus Ex Machina

When the machine itself becomes the creator. As a consequence, this would mean that "evolution" would pass from humans to machines and that these machines would continuously produce more advanced generations of machines.
The term is also used when a seemingly unsolvable problem in a narrative, in our case evolution, is suddenly and abruptly solved by an unexpected and improbable event. The positive interpretation is that an otherwise insoluble situation is resolved, surprising the audience, and bringing the story (of evolution) to a happy ending.

Thus, the leading edge technologies of the sixth industrial revolution are
- Human augmentation
- Cyborg technology
- Gene editing
- Transhumans

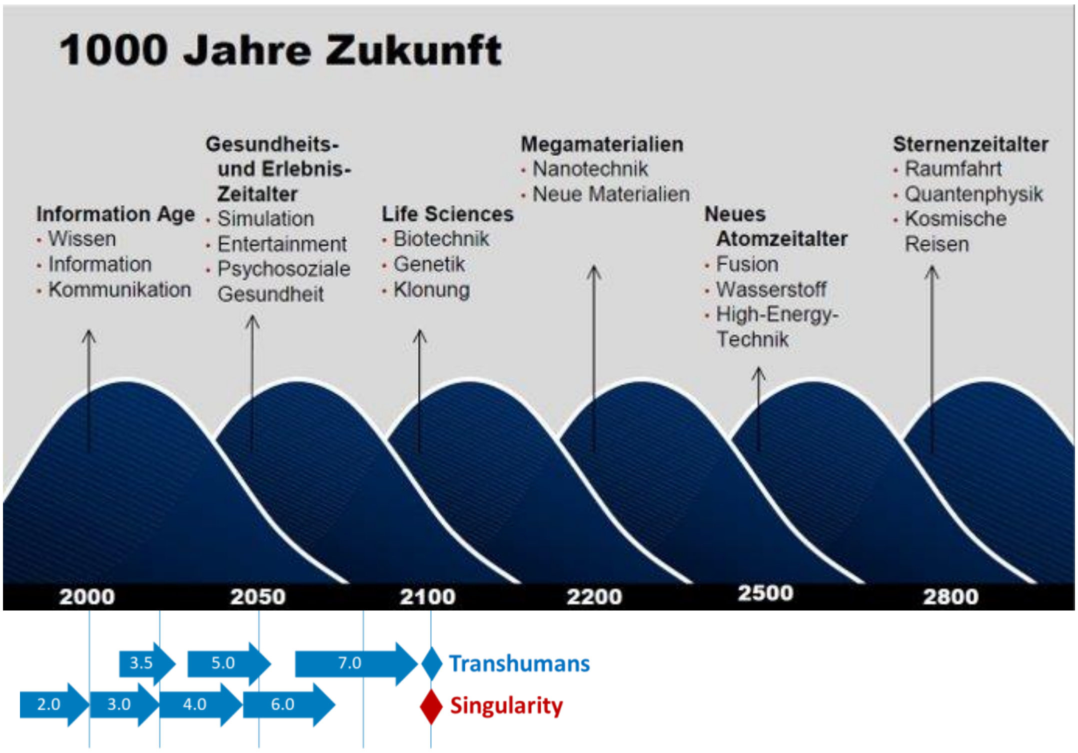
4.3 Beyond Industry 7.0

Industry 8.0
After the evolution of humans and machines has merged (transhumans) or machines have left humans behind in their development, reflecting on Industry 8.0, etc. no longer makes sense, as industry and humans can no longer be viewed as having the same relationship. Either there is no longer any distinction between man and machine in the most highly evolved living being, or man and machine have reversed their roles in evolution.

1,000 years into the future

The "1,000 Years into the future" epoch-based model proposed by Zukunftsinstitut GmbH describes megatrends that could follow on from the "information age" megatrend. Between 2050 and 2100, the "age of health and experience" will dominate, followed by "life science" from 2100 onwards.

32 Speculations Concerning the First Ultraintelligent Machine (Irving John Good, Trinity College Oxford 2011), http://www.aeiveos.com/~bradbury/Authors/Computing/Good-IJ/SCtFUM.html



It’s not hard to link the industrial revolutions to the megatrends. In our hypothesis, Industry 5.0 will lead us from the information age to the age of health and experience, with new experience expectations leading to an increased demand for customization and individualization. Industry 6.0 will introduce the “Emotional Machines,” opening up new possibilities for psychosocial health care.

The second half of the age of health and experience will then be dominated by Industry 7.0, which will usher in the age of life science and completely redefine the relationship between man and machine.

This brings us to the end of our “journey through the industrial revolutions” in which we considered one possible future.

5 Conclusion

What could this mean?

- A business perspective

  Businesses should make sure not to miss the "digital transformation" train because successful transformation will be the key to all the changes following Industry 4.0. New skills in the HR department are essential for the period beginning with Industry 5.0.

- An economic perspective

  The shift in demographic focus and the prospect that up to 50% of jobs will disappear in the second wave of the fourth industrial revolution make it necessary to revise social welfare systems and redefine the term "unemployment". New models of redistribution are needed that are fair and workable for both employees <u>and</u> employers, and that continue to follow the principle of productivity.

- A political perspective

  Politics must encourage the establishment and use of new technologies.
  The coming upheavals demand a new robust social partnership that overcomes the old stereotypes. In addition, the revision of the social support systems and, from 2050 onward, the changes in the handling of the large sections of the population no longer involved in the work process will require a long lead-in time and lengthy negotiations between the various political camps.

- A personal perspective

  There is no sign of innovation cycles slowing down in the foreseeable future. That is why it is important for each of us to continuously educate ourselves and keep up to date. We should encourage our children and grandchildren to develop and maintain a high degree of openness to new technological and social developments. We can also look forward with caution to the "harbingers" of the age of health and experience.

With this in mind, I would like to wish you all a safe path through the fourth industrial revolution and the most successful digital transformation possible.

March 2021,
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