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DESIGN OF AUTOMATION SYSTEMS IN INDUSTRIAL PRODUCTION UNDER ARTIFICIAL INTELLIGENCE TECHNOLOGY

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INTRODUCTION

Industrial production is developing towards efficient, automated, and intelligent manufacturing, and automation technology continues to improve and broaden its capabilities. With the advent of artificial intelligence technology, automation systems are also evolving continuously. At present, automation systems can be developed in industrialized countries by adopting many existing mature technologies, and their ability to assist traditional industries in enhancing competitiveness is also increasing. AI also has broad prospects. It can help automation systems not only by recognizing and adapting to unknown environmental changes but also by achieving the entire intelligent control of production based on customer needs. Therefore, the introduction of the theory and application of advanced AI and its related fields into automation systems is currently widely researched and shows a broad application prospect and development space. This extension will help people design more efficient and flexible automation systems and improve the level of intelligent production and efficient flexible manufacturing.

The challenges facing industrial production in the area of automation systems becoming more complicated include the design and development of: (1) automation systems with new structures and reduced complexities, (2) decision-making algorithms that can adapt to real-time data changes in a secure and efficient manner, and (3) human-like flexible decision-making strategies that can be used for executing production control under various conditions. The motivations driving research and development of automation systems in industrial production under artificial intelligence and decision-making technologies can be summarized as follows: (a) Automation machinery can help to avoid repetitive, lengthy, and complex operations done manually, which will reduce human costs and increase productivity. (b) The control machine offers dual sine wave. A large variety of traditional manufacturing processes are expected to be transformed by using automation technology in the coming years, owing to their high labor intensity and severe environment. (c) Customization. In manufacturing, the adoption of various automation technologies has led to notable output gains. The introduction of robots increases productivity, and manufacturing wages and overall economic activity are positively impacted. Consequently, various industries are willing to invest in semi- and fully automated technology for their production processes.

Background and Significance of Automation Systems in Industrial Production

1.1. Background and Significance

Industrial production is a systematic project that has developed from simple production tools to a cyber-physical system influenced by artificial intelligence technology. Automation is a milestone in the development of industry that evolves from the significance of individual effort to the input of energy and technology. The concept of automation was raised around 1940.

Later, continuous studies and developments of automatic devices occurred. Experiencing rapid growth, maximization has made a significant transformation in automation within the industry globally. Automation not only possesses the character of operational continuity but also simplifies control that is installed by punched tape and electronic logic operators. Industrial automation has extended applications among different industries, such as the mechanical industry, chemical industry, mining industry, metallurgy, and transportation industry. Industrial automation has been widely adopted and popularized due to its benefits in several aspects over manual operation, such as productivity, production quality, flexibility of production, efficient use of energy and material resources, simplification of production management, and reduction of labor intensity.

The rate at which enterprises have invested in automation technology is considerable. A significant percentage of buyers believe they should invest in technologies that reduce costs, with a large percentage envisioning the purchase of automation equipment. The strongest demand for automation so far this year was reported by two-dimensional and three-dimensional automated internal structure design companies. Key trends that both individual consumers and technology leaders should focus on include the deepening automation effect and personalized automation usage scenarios, data lakes administration, and some querying operations with the reduction of data transmission frequency. Furthermore, some issues of automation are intractable to solve or at least difficult to address regarding investment. The speed at which businesses invest in automation has obviously decreased from 2019 to 2020 due to the uncertain development of the world economy. At the same time, there are still multiple challenges in front of everyday automated operations. First, the automation of routine transactions and operations could probably result in extra threats of data loss, malware, and IT system malfunctions. Second, many customer transactions and non-routine activities still require manual processing. Whether AI technology could be applied to practical processing for this part to keep improving effective productivity management is a question worth considering. The design and development of AI in manufacturing and treatment industries have become a topic of warm concern, and the potential effect of AI in enhancing an automation system should be pondered.

Foundations of Automation Systems

Automation is the creation and application of technology to monitor and control the production and delivery of products and services. These concentrated applications within numerous industries can be grouped into three classifications: automation systems, information systems, and manufacturing execution systems. Automation systems are also called automation production systems, and they can be directly associated with operations in assembly lines, logistics, chemical reaction controls, and machining. Because automation systems exist for a wide array of industrial applications, trade-offs are made in timing, productivity, and control effort. Questions need to be explored about what to automate, when to automate, to what degree the automation is accomplished, to what extent atmosphere modification is needed, and how to ensure employees maintain competency if automation of a system occurs. Machinery, censorship, and human control are the components of a system of automation. A machine part of the system is usually denoted as a control mechanism that modifies an output, such as force, speed, or position. Censored feedback with human intervention mediates the relationship between the machinery and the mechanism. The human-instrument system's three basic levels accommodate the degree of automation. Many automation system coatings can be influences commonly organized toward architecture in a hierarchy of control. Service levels applying to automated automation systems are upper

management control, planning and lower limiting, and direct control that is closest to hardware. Automation designates the approach to trade-offs in controls utilized in the assembly of the automation system. Automation does not automate a method according to those determined to be unmanageable or impossible as determined by the manufacturer. An important aspect of successful modification specifications for an automation system is its trade-offs. Automation levels often need to be altered due to technical barriers and customer requirements for industrial products. The system created should conform to the proposed levels by considering the trade-offs. Another question posed by automation of nonprofit organizations is: does someone or some organization need to be in control in order to alter the best process criteria? An automation blueprint designed according to the multi-sided cost of the two essential benefits can respond to these conflicting requirements. Predictively, control inhabiting benefits are different than deterministic intra-working noise between the methods. The operation of a machinery component is typically based on the control method. The control methods manage a control loop integrally associated with automation levels. The direct assessment and evaluation methods from the control and automation areas are expounded as well. Additionally, linear predictive control considerations are presented in view of the aforementioned trade-off and entropy politics. A brief description of applications in association with automation systems with advanced control methods is also discussed.

Basic Concepts and Definitions

Automation is used as a general name for systems and procedures that accomplish or simplify tasks without direct human intervention. It is intentionally used as a high-level, general term to favor an interdisciplinary frame of reference. Automation can be defined as technology that broadly replaces in a restricted field the human previously executing a specific physical or chemical operation. In a more general view, automation is the use of any type of domesticated artificial intelligence without substantial human intervention. More formally, it can also be defined as a process or the resulting system capable of complete or substantially complete operation without human intervention.

Any specific automation system is based upon a number of substructures. At the heart of any automation system, one will find sensors. The task of a sensor consists of converting some form of energy or another mode of representation into electrical, magnetic, or other signals, in order to prescribe a control intervention performing the next higher ordered hub. This increasingly primitive command structure, frequently referred to as a controller, computes the optimal control solution specified by a control algorithm. This algorithm consists of a controlled system, a model serving as an objective function, and a set of constraints enabling the selection of the control signals, and the control is executed by an actuator. This actuator performs the inverse task of the sensor inasmuch as it changes electrical signals to physical energy.

Any automation systems are interconnected with various degrees of intensity. A wide variety of feedback loops integrate the various subsystems into a network with various levels of cohesion. The more unanimously guided towards a common purpose the units of any given automation system are, the closer one gets to the absolute automation that is so vocally contested by current business, socio-cultural, and academic debates. The technologies enabling the creation of these increasingly integrative automation systems are able to fashion the basic bricks and mortar out of which world-systems can be buttressed and start losing gradual semblance of a coherent planetary society. The terminology used for automation has frequently evolved of late. This clearly brings confusion into our currently emerging multi-disciplinary field. Economic, technical, and social sciences each

utilize the terms. Even inside these communities, meanings significantly differ. Only very remotely does some form of ontological equality emerge between any two of these meanings when exchanged among the various forms of discourse. Especially when crossing discursive boundaries, definitions found in marginal literature tend to spark lively debate.

Artificial Intelligence in Industrial Production

In recent years, the research in artificial intelligence (AI) in industrial production has also emerged. AI and optimization techniques are generally combined in automation systems. Machine learning is applied not only in the industry but also in an increasing number of scientific and other domains dealing with large datasets. In the field of production and logistics, machine learning is used in the context of predictive and prescriptive analytics. In predictive analytics, models to evaluate different scenarios are built based on historical and real-time data. In prescriptive analytics, possible decision options are further considered and evaluated. The possible decision options are formally and comprehensibly structured in a graph model. In prediction analysis, real-time data from the production processes can be directly integrated as feedback to the algorithm. In conjunction with eligible training data, trends can then be directly recognized and predicted. The utilization of machine learning or predictive analytics generally allows for more informed decisions since complex interrelations in the production system are included.

Some unique properties and the prerequisites of AI systems offer several distinctive advantages for application in smart and more autonomous systems, especially in industrial production. Modern AI techniques often make decisions by first learning behavior based on training data. As a consequence, the decisions are made according to the process and data characteristics that have been learned and are often data-driven. This can considerably improve or generically enhance overall system performance. In production systems, progressively complex relationships within large datasets are often difficult or impossible to describe and understand in a straightforward manner, especially under severe uncertainties. The gradual integration of AI, starting from advanced monitoring techniques up to autonomous decision and control algorithms, offers completely new perspectives. The progression and practical implementation of AI seem to be slowed by obstacles such as data security or legal issues. A qualitative assessment of the prospects of AI application in production forms the focus of innovation that AI may bring to production and manufacturing. Some of the challenges in implementation are partially stated by referring to limitations. Current developments regarding the convergence of AI, especially deep learning and reinforcement learning, with existing automation frameworks enable smarter cyber-physical systems with closer utilization of peripheral measurement and detection. Research communities are working on steering the upscaling of AI platforms to production control, obscured by hype limits and resultant exaggerated expectations. AI in production advances integrative forecasting and planning features; its routine performance, on the contrary, entails sophisticated data handling. The deployment of AI in series manufacturing is embodied in AI-supported data analysis and simulation. The build of AI systems for control applications involves an approach to analyzing rather than learning from data, except for the objective to detect and classify aberrations and faults nested in complex data compounded by process technology. AI- and IIoT-based production systems are under scientific challenge of human-oriented and cyber-secure smart technical actions in the work environment. Advanced innovative automation, AI, and software engineering showcase the application of AI inside smart production. In-depth business model studies include the application of AI in the area of industrial production. AI in production emphasizes

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optimization despite facing hurdles and limitations while attempting to enhance existing and future cyber-physical systems.

Overview of Artificial Intelligence Technologies

Shares of industry production through intelligence platforms primarily include intelligent perception modules and intelligent decision-making modules. Based on actual industrial production process requirements, this part describes the technical combination to serve the design of the system more clearly. It will be documented in the following three subsections: intelligent perception and learning, planning and decision-making, and intelligent motion execution. According to various works, the hot research topics and progress about the information feature are further provided.

Artificial intelligence technologies have been extensively applied in industrial production. The primary AI technologies for production equipment include natural language processing, expert systems, robotics, and other technologies. Robotics can be further divided into hard robots, soft robots, and swarm robots. With the continuous development of AI technology, new production equipment and methods gradually apply AI technologies, including autonomous guided vehicles, 3D printing, exoskeletons, and brain–computer interfaces. The research on them based on AI is becoming increasingly active in the related professional fields. Intelligent perception and learning of AI technologies are mainly used in fault detection and diagnosis and intelligent maintenance. In addition, they can also be used in quality control, instruction recognition, and intelligent safety monitoring. AI algorithms, such as neural networks, support vector machines, and Kalman filtering, were utilized in the research. Many methods integrated the neural network and its variants with other algorithms. Expert systems, planning, and decision-making of AI technologies are mainly used for production scheduling and resource dispatching. Many novel algorithms were also developed to improve planning and decision-making in the real world. Robotics is also a part of AI technologies widely applied in the production process. They are utilized to grasp, spray, weld, transfer, and more. The research for robotics mainly focuses on the development of flexible soft robots, component and system design, and control. It is also divided into parallel modules according to the purpose; among them, the human–machine cooperation module in intelligent assembly has received extensive attention.

Integration of Automation Systems and Artificial Intelligence

To expand the capabilities of the existing systems of automation and to develop a range of new opportunities, a possible direction lies in integrating modern automation and artificial intelligence (AI) systems. It is considered that such integration of automation systems and AI can bring in new potential, making the two systems work cooperatively, such as one plus one is greater than two. There are many strategies to embed the AI component in modern systems, for example, to develop a completely new AI approach based on up-to-date advanced automation systems, or to endow some AI capabilities to the operator of the automation systems, etc. From the viewpoint of industrial production, the AI system can be integrated into the existing automation framework of the factory, for instance, to analyze data from some existing automation frameworks to discover valuable insights.

Meanwhile, simulated approaches can be utilized to mimic the workflow and operations of existing automation frameworks, and then employ AI techniques to conduct the decision-making process. There are two major types to embed the AI system in existing automation systems: a cyber-physical system approach where an AI system is integrated as part of the automation control system, and a human-aware decision-making approach where structured decision-making AI tools are employed to support human workers from outside the existing automation control system.

The effective implementation of AI capability requires thorough consideration of the infrastructural components. At the software level, it needs true AI technologies to enable various functions of the software, such as natural language processing and machine learning based data analysis and decision-making processes. With respect to the hardware infrastructure, the AI-enabled production line demands sensors and actuators, as well as advanced computing facilities with AI-dedicated hardware processing units. In practice, the adoption of AI-enabled automation would require the integration of various extant technologies, including IoT systems and big data management systems.

As in any technology shift, the integration of AI and automation systems also faces two challenges. There are people who are worried about robots taking their jobs and the new system replacing their previous skill sets. People are afraid that some of their functions have been changed by the new system. The second challenge is how to train the workforce to employ the new system efficiently, especially during the migration from traditional automation systems to the new AI/automation integrated system. Another technology adoption challenge is to lead the "people aspect" of innovation. The effective application of AI could improve operational efficiency and that up to 38 percent of production throughput could be realized in facilities around the world. Expected improvements would vary based on the present characteristics of the systems and the improvement domains in production operations. In a case study concerning the Working Point Automation Factory, the returns spanned critical areas such as workforce productivity, manufacturing performance, and asset utilization. It could accelerate production efficiency significantly, offer real-time monitoring and alerts of the production process, predict anomalies and failures, and support human operators' decisions on control in a collaborative manner. The benefit is that the new AI-based automation system could make the factory run more smoothly.

Benefits and Challenges

Efficiency should not be the end goal in industrial production system design, traditionally speaking. Systems should be implemented and operated manually or semi-automatically as long as it is efficient to do so. Nevertheless, there are clear improvements and added value that can be brought by the use of artificial intelligence in the system's automated layers today. The advantages of deep integration of systems in automation design are that AI can deal with fuzzy, uncertain matters, create advanced self-regulatory behaviors, and generate full and optimized system state solutions, which lead to balancing efficiency and cost elements other than yet-anticipated possibilities. There is economic and social pressure on improving the competitiveness of businesses, which can only be achieved with the rapid and inventive capability to master sophisticated but still economically feasible technologies. This is crucial if you want to have a more advanced life and business environment than you have hitherto. These advantages can be achieved only if they are accompanied by an economically justifiable investment in achieving system automation.

The fact is that implementation, maintenance, certification, and adaptation in real time, integrating all these layers and exploiting the potential benefit, is not an easy, straightforward task. Besides the vision of performance as good as possible, an automation solution must find the proper trade-off between raw technology, processing time, and the environment where production takes place—human operators need a certain specific "sense of familiarity." A high-level automation solution developed with nothing else in mind is very probably far from being practical. There are two kinds of obstacles hindering the deep integration of modern AI into industrial production environments that make up a connected system. While advantages can be identified at different layers, major

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challenges are present at the requirements layer and at the AI methods and tools layer.

Talking about requirements, high initial investment and complex system integration lead to difficulty in developing the concept and investment risk that arise at concept time. Extreme difficulties in identifying KPIs are present, methodological practices are not defined yet, system scalability, certified long-life systems, and advanced software maintenance are some of the common problem sets at this level. Methods and tools should be set as flexible, standardized to guarantee the original system aspect, and fully predictable as much as possible. Integrated standards and test protocols should be developed, and also the continuous creation of new point solutions and their maintenance and system-level certification is an AI deployment consumption task. Concerning a few phobias of investing in the deep integration of AI into automation systems, the most important for the anticipated audience is the network maintenance, real data reliability, cloud privacy and security, social acceptance of the real driverless systems, and job loss concerns. Now, all these problems are not difficulties at the general consumer level.

Design Principles for Automation Systems under Artificial Intelligence Technology

This chapter discusses design principles that must be observed in the future when creating new automation systems. Emphasis is placed on the creation of systems driven by artificial intelligence as a specific aspect. One of the fundamental values of automation design is the need to design systems with a focus on the user. The designed systems must be intuitive for the user and fit his psychophysiological and cognitive predispositions. In production, automated systems must be equipped with scalability. A characteristic feature of industrial production is change. The needs, requirements, and production rates are constantly changing, which requires a systematic approach to the design of automation systems that take into account changing requirements. That is why the concept of the cascade structure of production was introduced in the context of designing a production enterprise.

The designed systems must be equipped with the ability to adapt to the current product lifecycle. We define such systems as lifecycle scalable. In the field of automation, the idea of the possibility of operation under changing conditions has been present for years, which results from the modular approach to automation. The second aspect that should be present in the design philosophy is flexibility. Production flexibility depends on factors such as scale, speed, and product structure. This change and constant learning are the responsibility of experts in the field of informatics to whom the task will be assigned to build heuristic models. An important element of the design of future systems is high reliability and safety for man and the environment. The whole idea of automation has evolved from the very beginning of robot design in the direction of ensuring the safety of this technology. Control systems are equipped with artificial intelligence primarily to increase the reliability and safety of technology. This aspect is particularly important in the field of systems being the automation of critical infrastructure objects.

Human-Machine Collaboration

5.1. Human-Machine Collaboration. The most critical aspect of a human-automation system is collaboration. Collaboration is essential because it improves the overall performance and productivity of industrial production. The most important goal of the collaboration between a human operator and an AI system is to do a better job than anyone alone. The human does what the AI does not do well, and the AI does what the human does not do well. So, by working together, the combined team, human and AI, does what neither alone does well. From this point of view, the AI aiming to substitute the human and the human aiming to replicate an AI's behavior are inconsistent with the collaborative environment between them.

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The human operator should be aware of the strengths and limitations of both human and AI.

Humans are not only beneficial but also essential for the performance of certain tasks. They can provide intuition, common sense, and creativity, which are difficult to program with precision, while people need others to defer to them and to run second opinions. A principle that in systems operated by humans, operators are identified to possess superiority, can better guide the division of operator functions and machine functions. Yet, this might eventually reflect greater assumptions about responsibility and formal work practices. A number of different approaches to the human factor in the design and operation of automation systems have proved effective. An important task in the design of human-in-the-loop systems is to design the interface at which the human interacts with the automation. The communication protocols and the training and education provided for the human operator may require particular attention in this context and may have a degree of independence from other system parameters. There would be an opportunity to consider the psychological limits of the human operator in interacting with the automation. The human needs to be trained, and their interaction with the system indicates that they can have an impact on the interface, and this may need special consideration. People want their work to satisfy them and to give them a sense of achievement and competence in some way. An excessive reliance on automation might lead to dissatisfaction with a single job and low identification with work. A disastrous consequence where a person is driven by a machine may lead to a fight or flight response. Several successful case studies show the integration of human and AI cooperation. Successful case studies of human-machine collaboration show different contexts that work for the practical use of human-machine collaboration. Satisfying work experiences, even in the automated environment, contribute to the decision. In this view, human beings are not adversaries but complementary in terms of developing opportunities for automation systems even further. These perspectives seek to design a system that optimally leverages the strengths of both human beings and machines.

Future Trends and Innovations

The design of automation systems for future industrial production, or the further development of those already in existence, will be characterized by a number of main emerging trends or innovations, some of which are expected to occur in the next years. The most important of these trends are: • Increasing use of artificial intelligence to develop more autonomous and adaptable production systems, able to capitalize on different solutions, analyze incoming data, and reconfigure their operations, or make other adaptations, to work more cheaply, efficiently, and effectively for different task execution scenarios; • Increased growth of the IoT and the continuous technological development that is allowing the bridging and utilization of digital data across real-time control of automation technologies, such as PLCs, so that real-time automation systems work on the igniter of consumption of energy, parts, etc.; • Increased focus on the use of artificial intelligence in production for environmentally friendly development, from optimal management of energy consumption to more flexible usage of resources that require best-of-breed production of components; • The automation landscape will increasingly rely on robots that are more intelligent and require less human interaction. This will be brought about by the increased use of existing technologies, as well as the addition of new sensors, particularly in the areas of touch and vision. Robotics will increasingly be applied in healthcare and related industry sectors. • The automation landscape will change significantly. This will mean a shift from the traditional approach involving the automation of process tasks by machines to approaches of handling exceptions and processes by machines. It is expected that this focus on developing more adaptable, less reactive, and more creative

approaches to automation will affect the skills that are required by the workforce, and hence there is a need for lifelong education and training for upskilling of the workforce, in order to fit in with increasingly intelligent and adaptable automation solutions. In a comparative survey of current developments in automation in four countries, it was noted that although the technology is to some extent still in its infancy, significant development has already taken place in a number of technologies. According to the same survey, there is, among those companies who are now at the forefront of mobile robotics and industrial automation developments, a vision of autonomous, intelligent automation systems that are heterogeneous and flexible and that can recognize products. These autonomous systems would then automatically change and optimize their performance. The Intelligent autonomous application area characterization was divided into the automated logistics, transport, and manufacturing applications division. In the smart manufacturing division, the survey reported that the technology was driven forward by the long-term vision of zero-cost manufacturing where no humans are employed on the manufacturing side.

Emerging Technologies in the Field

Emerging technologies are playing an integral part in shaping the direction of automation systems and artificial intelligence. Advanced robotics have the ability to operate alongside human labor and perform challenging manipulation tasks. Cognitive computing is focused on using patterns present in big data to create value for the user. Big data and analytics are used to store and process large quantities of data to provide insights and improve decision-making processes. These technologies are largely applied in multiple industrial settings, including automotive, energy, materials science, healthcare, and supply chain management sectors. Automation in multiple processes throughout these industries is improving productivity, product quality, safety, and flexibility to operational demands. Applying a data-driven approach to improve robotics and cognitive computing can result in higher operational efficiency and reliability. Machine learning and deep learning act as attractive technologies to produce predictions or detect hidden correlations in the underlying data. In the context of automation, machine learning and deep learning are automatic starting points for decision-making processes that offer high potential for early predictive maintenance or other diagnostic methods.

Here we considered generalized and special intelligence. While researching the field of generalized intelligence using artificial cognitive platforms, there is a dedication to the major components and systems of cognitive agents, but it does not have foreseeable future applications that can be dedicated to production. On the other hand, automation and artificial intelligence, where AI is implemented in an integrated system structure, have applications of dedicated cognitive automation. AI is the capability of a non-organic information processing agent with perceived intelligence to match or outperform human intelligence for a specific combination of domains and tasks. These systems are therefore dedicated to a few inputs of sensors and a few controllable actuators, utilizing mostly expert systems and data-driven applications. Moreover, AI combines soft computing and various techniques that are being developed within the area of general intelligence, such as deep learning and reinforcement learning, to empower decision-making processes. These models are not designated for the spirit of general intelligence since they have very little practical application in the real world when integrated.

Ethical and Social Implications

While implementing automation systems and utilizing AI capabilities during the development process within Industry 4.0, issues related to data privacy and the sharing, traceability, and usage of data arise. The accountability of AI-based systems to perform automatic decision-

making is also a challenging issue. The opacity of internal AI mechanisms can create an information asymmetry between employees and management. Social implications are also important to consider, such as the study of workforce evolution and its implications in terms of new skills to be realized by the workforce. The change in the workers' tasks performed in industrial environments, reducing the operatives' responsibility and performing their duties by robots, may motivate the operators. These ethical considerations are essential for driving technological advancements in production and for defining economically viable technological infrastructures. Traditionally, the development of ethical guidelines has faced technological advancements boosted only by technological improvement, not ethical issues. Few guidelines have been developed regarding the implementation and development of AI systems. The guidelines are centered on fundamental rights, human and social empowerment, and adherence to human-centric values in terms of steering the development towards producing AI for good, and not AI for itself, e.g., without ethical constraints. The document also defines the following seven key requirements for trustworthy AI: human agency and oversight; technical robustness and safety; privacy and data governance; transparency; diversity, non-discrimination and fairness; societal and environmental well-being; and accountability.

Impact on Employment

There has been much attention on the widespread adoption and deployment of advanced technologies in the workplace, including automation systems, and their potential impact on jobs. The deep-rooted fear is that it could displace many or all jobs in a particular sector; however, technology can provide new opportunities for employment. There is potential for new jobs to be created through AI and other advanced technologies. Hence, it will not merely be a complement to employment, as have been other technologies. Indeed, as machines undertake tasks routinely performed by workers, an intelligent machine can do any work. It reduces the demand for workers who perform these tasks, at least in some circumstances.

If policymakers and society prepare for the jobs that will have to be created for the people who will be displaced, then there will be no problem. While advanced technologies can reduce the demand for workers in their current occupations, they also change the relative prices and profits, which could increase the demand for workers. A number of studies have highlighted that, because of the ability of advanced technology to automate while making new tasks possible, it could increase the demand for education and skills. In other words, the automation possibilities of future work will probably tend to move workers into more complex, non-routine jobs. In this light, special attention is required in terms of the current and future capability, especially educational and training requirements, of the nation's workforce. In response to the potentially unprecedented challenge to regional labor markets, U.S. labor market policy should focus on providing for a more flexible, adaptable workforce, building stronger relationships between high schools, colleges and universities, and the business and labor federations that train their workers.

Conclusion and Recommendations

In this article, design principles of automation systems for industrial production within the context of artificial intelligence technology have been presented. Artificial intelligence technology is expected to drive a fundamental transformation for industrial production in terms of efficiency and innovation. It is important to acknowledge that human–machine collaboration is crucial in approaches that have been elaborated for a successful and sustainable design of such systems. By building upon these principles, design objectives and requirements for automation systems within the context of artificial intelligence are presented and investigated with an analysis of current

approaches to cognitive production management.

The successful adoption of artificial intelligence and automation systems for industrial production not only faces scientific challenges but also depends on the readiness and the will of the industry to adopt such technologies. For the industry, we envisage several implications and insights for future developments: Firstly, the production of knowledge workers at the intersection of ICT development and production is needed. Secondly, companies are encouraged to invest in good practices of ethics and responsibility, as innovation and minute decisions by the employees may have more and different impacts than ever. They are encouraged to use transparent, accountable, and sustainable approaches for the design and evaluation of systems and provide literacy for the workforce. For the scientific community, future work can focus on the integrability of auxiliary technologies, collective use of artificial intelligence, the understanding of value and values for the potential further increase of the adaptability principle into an integration principle. Recommendations for the scientific community also extend to continuous research on the understanding of emerging AI technologies in contributions to foster an ongoing discussion on the development of the field and show its potential to stakeholders. In light of this, we believe that artificial intelligence will play a crucial role in the automation of production and organization design of further factories. Of course, it will bring new challenges and possible disadvantages to society as well. But in a responsible and well-considered manner, it may also open up the era of a more collaborative relationship between humans and intelligent entities and create a better world.

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