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Artificial Intelligence in Industry 4.0

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ABSTRACT:

Many industry sectors have been pursuing the adoption of Industry 4.0 (I4.0) ideas and technologies, which promise to realize lean and just-in-time production through digitization and the use of smart machines. This shift is driven by technological advances, including Artificial Intelligence (AI) and machine learning, sensor networks and Internet of Things technologies, cloud computing, additive manufacturing, and the availability of large amounts of data that can be exploited by these technologies. However, the adoption of AI technologies for I4.0 varies considerably among industry sectors. This article complements broader reviews of I4.0 by examining the specific applications of AI. The recent White House report on Artificial Intelligence (AI) (Lee, 2016) highlights the significance of AI and the necessity of a clear roadmap and strategic investment in this area. As AI emerges from science fiction to become the frontier of world-changing technologies, there is an urgent need for systematic development and implementation of AI to see its real impact in the next generation of industrial systems, namely Industry 4.0. Within the 5C architecture previously proposed in Lee et al. (2015), the capacity to act specifically while addressing the ideal principle of artificial intelligence is solving the problem and achieving the objective. Finally, the paper identifies and discusses significant applications of AI for Industry 4.0.

Keywords: Artificial Intelligence, Applications, Challenges, Technology, Machine learning

1. Introduction

The recent shift towards customer-driven, highly customized manufacturing as part of the interconnected environment of the Industry 4.0 strategy is making it more and more important for manufacturers to strive for higher agility, productivity and sustainability. According to Tesler's theorem, artificial intelligence is anything that has not yet been finished. For instance, optical character recognition technology has becoming standard technology and are not included in items that are typically thought of as AI. Machines Modern capabilities are currently regarded as artificial intelligence (AI). They are capable of driving cars. autonomously, speech recognition, interactive game systems and simulation of military services sophisticated network routing, etc.

AI was regarded as a legitimate academic field in 1955. It gradually acquired support for upbeat Loss of financing, new methods for increasing success rates, then renewed In the year since, a finance plan was also adopted. The study on AI is classified into two categories in the historical domain. They frequently fail to build theoretical communication between them after subdividing them into subcategories. The subcategories emphasize the technological consideration, which includes deployment tools, objectives, and deep socially based philosophical main ideas.

Expert system research helped to resurrect AI-related research in the early 1980s [18–24]. It is a Using human knowledge and analytical abilities, an AI-based programme. Over time, by 1985, the AI The market had passed the $1 billion threshold. The fifth generation of computer systems was introduced at that time. The resumption of funds was motivated by a project under Japan. Consequently, the value of investing in AI The American and British governments eventually funded research. However, the decline of the Lisp Machine business in 1987 had an impact on AI research [1]. Consequently, the significance of AI was not well regarded by financing organizations.

Artificial neural network (ANN) development was impacted by the creation of Very large scale integration (VLSI) and metal oxide semiconductor (CMOS) technology are complementary. Late 1990s to early 2000s saw the start of AI research in the field of medical diagnosis. Data mining, logistics, and other pertinent fields [26–30]. The importance of the AI field has been contribution from researchers through the use of more powerful computing, cooperation statistics and mathematical models, problem-solving techniques for a particular issue, and Standards of science [2]. World champion chess player Garry Kasparov was defeated by a Deep Blue, a computer software, in 1997. Typically, AI examines the context and takes appropriate action to increase success. Problem solving task frequency. AI's utility and goal functions can be simple for a particular objective or complex within the execution. Industry 4.0 represents the fourth industrial revolution, a new era in manufacturing production. It is based on the use of digital technologies that make it possible to connect people, processes, and objects together, creating an integrated and intelligent system This new revolution, as it spreads and expands thanks to the use of new tools, will not only concern companies but will also involve end consumers, as they will have the opportunity to become an integral part of the production chain, influencing with their actions and feedback certain production lines.

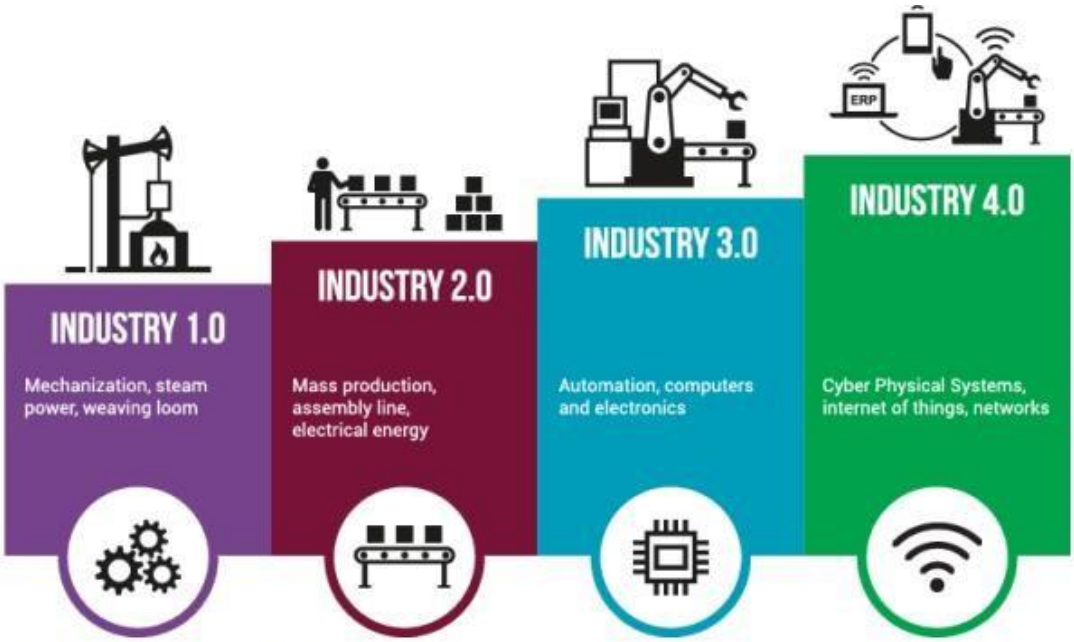


Figure 1: The Four Industrial Revolutions (source: elsist.biz)

Goals for the AI may be stated directly or impliedly. If reinforcement is intended, If a person is learning, they can set it implicitly by giving out points for good behavior or punishing other characteristics. Similarly, It is possible to create an evolutionary system with objectives and mechanisms that will duplicate AI. system for a model based on an animal's task of looking for food. On the other hand, AI systems lack objectives or follow logic and training sets, such as nearest neighbor [3]. During the study community, the creation of standards for such nongoal systems where the purpose is to achieve the categorization of issues, is becoming more popular [3].

Algorithms are used to implement AI. An AI system's algorithm is a collection of instructions that a machine follows. follows. The development of simple algorithms for issue solving is done first, then complicated algorithms. An Tic-tac-toe player example of a straightforward method is covered elsewhere in [7]. The The algorithm's many steps are as follows:

1) Capture the last square if an agent has a "treat," or two squares in a row. As opposed to that,
(2) Play the move if an action has "forks" that can simultaneously create two treats. As opposed to that,
(3) Head to the main square if it's free. As opposed to that,
(4) If the adversary is in a corner, take the opposing corner. As opposed to that,
(5) Hold a vacant corner if one is available. In other situations, head to the empty square. The algorithms built on artificial intelligence are able to process and absorb data. They are capable of resolving issues. either by developing an algorithm on their own or by learning new things. a few deployment techniques Bayesian networks and nearest neighbour can theoretically learn to approximation through decision tree. the mathematical operations that would best clarify the approach to issue solving. They can get the necessary knowledge gained through data mapping and all conceivable hypotheses. Due to the combinatorial explosion, practically Since there are so many different ways to solve an issue, it is

impossible to evaluate them all. Time increases rapidly. The goal of the AI study is to identify practical solutions from a wide variety of alternatives while avoiding those that would not be useful in solving the challenge.

Find the shortest route from a location in Denver to a destination while looking at a map. A good example is New York's location in the East. The traveller can skip seeking for any subterfuge here. Route through San Francisco or significantly to the west. Therefore, the AI may use the A* algorithm as a way search for the traveler's best and shortest route.

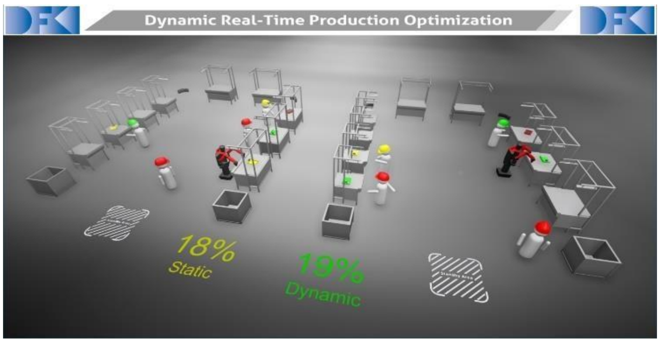
Need of artificial intelligence for industry 4.0

Industry 4.0 needs to prepare for networked factories that are highly embedded in the supply chain, design team, production line and quality control into a smart engine that provides practical insights with the help of AI. To exploit Industry 4.0's many opportunities, manufacturers need to develop a system that considers the whole production process as it needs cooperation across the whole supply chain cycle. Today, the main fields of AI, ML and IoT adoption are asset control, supply chain management and resource management. Combining these new tools, asset tracking precision, the visibility of the supply chain and stock utilization can be improved. Predictive maintenance can be improved using ML strategies like algorithms, processes powered by machine intelligence and quality optimization (**Shi *et al.*, 1995**; **Kunst *et al.*, 2019**; **Javaid and Haleem, 2020**). Effective time monitoring of operating loads at the factory floor contributing to production planning efficiency can be quickly undertaken using AI. By combining ML with overall equipment effectiveness, producers can increase production, preventive maintenance and asset workloads.

Industry 4.0 readiness

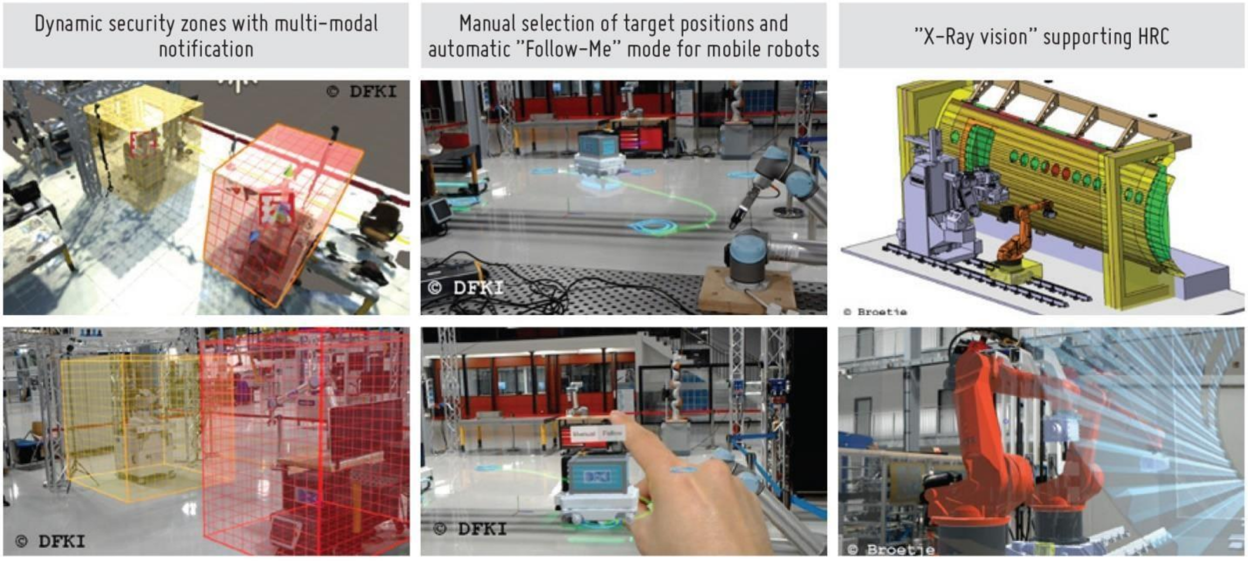
It is crucial for companies to have a deep insight in their degree of digitalization and Industry 4.0 readiness in order to take appropriate decisions for their development. For this task of Industry 4.0 maturity assessment of production, several indices have been created. Increasing levels of maturity may be computerization, connectivity, visibility, transparency, predictability, and adaptability. A maturity index developed by the German FIR institute, together with DFKI and other partners, follows an assess and assist approach that enables companies to set up specific, benefit-oriented I4.0 roadmaps. This approach takes into account the four different structuring forces of companies: information systems, resources, organizational structure, and culture for an enterprise-wide assessment.

The assessment examines relevant core processes of a company and consists of three phases. Evaluation and recommendation are based on the surveys conducted at the enterprise. The results of the survey are transferred and combined to the maturity level radar for the four structuring forces. The analysis of this combined radar identifies the functions and structuring forces where capabilities have to be expanded. It allows for a clear vision of what has to be targeted next by deriving action items for a transformation roadmap to Industry 4.0.



Intelligent software systems

Given a sufficient degree of digitalization as described before, intelligent software systems based on knowledge processing can be employed with AI entering the scene. Being a part of Computer Science, with its aspects of Computational Science and Engineering, AI has also strong links to Cognitive Sciences and, therefore, integrates insights from Linguistics, Biosciences, Psychology, and Philosophy. AI is meant here as Avantgarde Informatics and, in this sense, describes realizing intelligent behavior and the underlying cognitive abilities on computer systems. Knowledge processing covers retrieval, extraction and inference of knowledge as well as its presentation and distribution. Core aspects are the representation and the management of knowledge, deployed by discovery, learning and teaching of (inferred) knowledge. At present, in cognitive systems, we often use hybrid architectures: knowledge bases combined with Machine Learning.



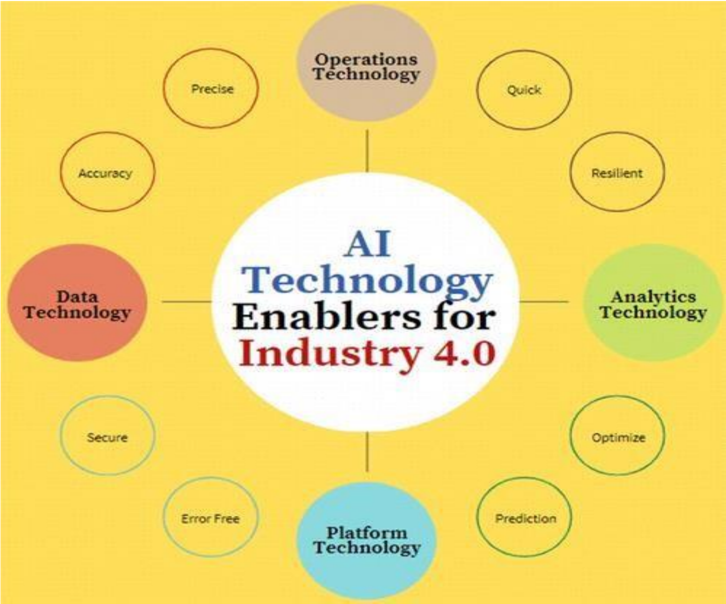
Today's rapidly developing IT environments like Web and Cloud technologies, in-memory computing, and GPU parallel cluster as well as mobile internet, 5G, and Big Data boost AI solutions. Combining AI with Smart Data creates (new) smart products and services. Being collaborative, autonomous, proactive, interoperable, adaptive, self-healing, self-explanatory, self-learning, self-optimizing, and fault-tolerant are the key features of AI systems.

Industry 4.0 based on AI

The key aspects of Industry 4.0 based on AI for the Internet of Things (IoT) must cope with the needs of the manufacturing industry to increase efficiency, handle batch size 1, and apply to the multi-adaptivity required. According to and adapted from Siemens, these needs can be clustered into four core aspects: Modularity, Connectivity, Autonomy, and Digital Twin. Smart Factories are defined by several factors that refer to these core aspects: Dynamic networks of local controllers and anytime planning in real-time are needed for a flexible production configured in response to rapidly changing processes. Self-organization lead to an optimization of production, e.g. through Cyber-Physical Production Systems. Digital Twins of the entire process and its constituent elements are essential to monitor components and results, even simulated in advance, to plan in detail the start-up of a new asset, product or line.

Complex AI systems cope with these manifold requirements by the idea of 'AI on Demand': AI components ('building blocks') for sensing, understanding, and acting work together in complex systems. Here are some examples of AI technologies for Industry 4.0 characteristics:

- Machine Learning for Predictive Maintenance
- Ontology Merging for Plug & Produce
- GPU-based Anytime AI Planning Algorithms for Real-time Line Balancing
- Deep Learning, and Active Sensor Fusion for Online Quality Control
- Semantic Product Memories and further Semantic AI Technologies for the Digital Twin
- Plan Recognition, and User Modelling, AR/MR/DR for Worker Assistance
- Deep Learning for Process Anomaly Detection
- Multiagent Planning, BDI (belief–desire–intention) Architectures for Hybrid Teams In this context, the DFKI research department 'Cognitive Assistants' present a system for planning and optimizing



Ba Sys 4.0

The joint German reference research project, BaSys 4.0 aims at building a software infrastructure for Industry 4.0, which also supports production-relevant change processes. Main building blocks are the so-called Asset administration shell (Digital Twin), Structured (semantic) domain models, and a Service-oriented production concept. BaSys 4.0 provides an open source reference implementation. Its service-oriented production approach covers three layers: The orchestrated production process specifies the required resource capabilities, the asset administration shell of device provides uniform service interface for access to capabilities, while Powerline Communication (PLC) functions realize the pure skills (not the production logic). All services participate in the same distributed service platform via communication APIs and a uniform service structure.

Challenges

The foundation of artificial intelligence is an algorithm, a science, and technology that most people are familiar with. not aware of it. There are very few people working on building

AIbased technologies. Both an algorithm and a use. This is because implementing AI calls for new technological metrics. System based on. Researchers' ability to develop their data science and analytics skills should be improved use of the AI domain.
The need for the implementation of AI-based systems in industries has led to the business units' hiring of qualified analytics and data scientists for their various business needs and advancement. Business units practice their expertise to make greater use of AI-based systems. Given that an AI-based system needs pricey primarily for processing computing powers on hardware, such as graphics processing units (GPU), General business divisions cannot use their current funding to implement FPGS and the machine learning paradigm resources. Despite the increasing adaptability of using AI in business units, it is not integrated as quickly as was anticipated. websites that are planned to join a chain of businesses. Additionally, the companies that already the AI-based system, although it is still not fully utilizing its functional properties under models for machine learning. After decades of debate about the benefits and drawbacks of implementing AI-based systems for Investors are very skeptical about investing in company units because of the black box problem and humanity.
The use of AI-based technologies can be controlled by machines and algorithms, which improves the decision-making and Handling Black Box tools requires a progressive improvement in problem-solving skills. The automated system is to blame evaluation challenges while identifying errors and malfunctions during functional operation. Moreover, because because there aren't enough people to study and comprehend how these tools work, the industry Units have little to no control over such deployment, which can lead to complex market strategy.

The AI also has a set of limitations that prevent it from addressing all complex business logics. However, the AI field might offer well-known employment descriptions for sectors across the globe. That was done The AI community includes scientists and engineers with a variety of specialties and objectives. goals and preferences. However, the study of human intelligence is given the most attention in order to solve creating and implementing techniques for machines that can replicate the meticulous human process. The practical AI's machine learning and decision-making technique is built on analyzing categorized datasets that are private and frequently delicate in character.
When this happens, it might be challenging for people to understand. people. As a result, delicate problems like identity theft and data breach could occur. The majority of government Organizations and businesses that are vying for control and financial gain take advantage of AI-based systems that are globally interconnected. Algorithms are used to process data in AIbased systems. The precision Simply on the basis of how the system is trained, measures of decision-making AI systems are evaluated. utilizing objective and reliable data Consequences that are unfair and unethical might create problems for crucial making decisions. When solving problems, AI-based systems that were biased during training can introduce bias.
The effectiveness of employed AI systems and technologies directly affects their capabilities and power.

2. Conclusion

Industry 4.0 is one of the many fields in which the influence of Artificial Intelligence technology can be felt. In order to continue to improve and make industrial processes more efficient, the advancement of technology in general and AI in particular can be a great ally. AI technologies are a key success factor for Industry 4.0. Semantic technologies guarantee interoperability in multi-vendor factories and are the basis for a disruptive SOA production logic. GPU-based automated production planning in real-time is a breakthrough for flexible automation. User Modeling, Plan Recognition as well as Intelligent Multimodal Interfaces are the basis for a new generation of worker assistance systems. Hybrid teams of cobots, softbots and people are a challenge for basic research in multi-agent coordination, e.g. with an acceptable solution of the transfer of control problem. Industry 4.0 brings many AI subfields together in one of the most important fields of industrialized countries like Germany. But the base line is that there is no Industry 4.0 without digitalization.

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