A Review of Fundamentals and Influential Factors of Artificial Intelligence

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Abstract— **Artificial intelligence (AI) is a trend that is currently leading to controversial discussions. On the one hand, it is a hyped technology with great potential to change the way people live and work. On the other hand, humans fear the possible consequences of misguided superintelligence based on the example of well-known movies. There are also numerous prominent scientists and technology pioneers who have very different opinions on this topic. In order to contribute to that discussion, this paper presents the drivers, advantages, disadvantages and challenges for the use of AI applications based on a literature search. In addition, historical developments, common definitions, types and functionalities of AI are described.**

Keywords: Artificial Intelligence, AI, Literature Review

I. INTRODUCTION

Artificial Intelligence (AI) is changing from a hype and marketing trend of Internet companies to an essential parameter for the competitive strength and profitability of many companies. After years in the academic niche, AI is experiencing a new, and so far unknown, phase of innovation and growth. Artificial Intelligence has left the research labs and is rapidly entering our everyday world in the form of talking devices and digital assistants. It is becoming increasingly difficult for us to distinguish bots from human beings in digital media, and more and more routine tasks are also being automated at the office. Autonomous driving and early detection of diseases are just a few more prominent examples of AI applications. This is made possible by increasing computing power, cloud applications and the growing availability of huge amounts of data.

Numerous surveys of experts indicate that every industry will be affected by AI applications in the foreseeable future [1]. It will take several years before companies will be able to leverage the AI technology for the creation of added value. But this also requires investments and efforts to adapt the technology for the company, to overcome hurdles and to develop application scenarios for its own business.

In the future, the performance spectrum of AI applications will expand significantly. This raises a number of political, social and ethical questions [2].

The objective of this paper is to identify possible drivers, benefits, barriers and challenges based on literature research in order to support companies in adapting the technology and implementing AI potentials. Drivers were also worked out to make the current hype of the topic comprehensible.

Based on the literature research mentioned above, this paper first describes the historical development of the topic. Followed by a selection of definitions, types and functionalities of the AI. The identified drivers, advantages, disadvantages and challenges are then presented. The paper concludes with an outlook on future research needs.

II. METHODOLOGY

A. Research Objectives

The aim of the presented research is to identify currently discussed benefits, barriers and challenges as well as drivers and trends in the field of Artificial Intelligence. The results were gathered by conducting a literature review on several databases and search engines. The main focus of the paper is to answer the following research questions (RQ):

RQ1: How can AI be defined and which variants of AI are available in the literature?

RQ2: What are benefits, barriers, drivers and challenges of AI?

B. Research Process

The literature review was carried out in five steps, which included (1) the definition of the basic research parameters by applying the taxonomy by Cooper [3], (2) the definition of the search terms and search term combinations for the database search, (3) the selection of the searched data bases, (4) the methodological application for findings analysis and (5) backward search for further information sources.

1) Definition of the research by applying the taxonomy of Cooper [3]

Cooper analysed literature reviews themselves and developed a taxonomy of literature reviews. This taxonomy contains six characteristics with several categories each. Table 1 shows Coopers characteristics (left column) which were applied for the design of the presented research. The definition of each characteristic for this research is described in the right column of table 1.

TABLE I. DEFINITION OF THE RESEARCH

Focus	The foci of the research are on research outcomes presented by scientists as well as on practices and lessons learned from AI applications.
Goal	The goal of the research is the identification of benefits, barriers and challenges for companies in the field of AI as well as the identification of drivers and further research needs.
Perspective	The perspective of the analysis is neutral.
Coverage	The coverage of the review is intended to be exhaustive with selective citation on the focused field of investigation.
Organization	The organization of the analysis is conceptually for the purpose of identifying same patterns in AI benefits, barriers, drivers and challenges.
Audience	The audience of the review are general scholars as well as practitioners.

2) Definition of search terms

Since the goal of the research was to identify benefits, application and adoption barriers, challenges, and drivers of Artificial Intelligence, the following search terms were chosen to identify relevant literature on the searched databases and search engines: Artificial Intelligence, AI, machine learning, history, benefits, enablers, barriers, challenges drivers, use case.

The reasons for the definition of the named search terms are, that benefits are factors, which favour and promote the adoption and application of AI. They encourage economic actors to offer, accept or support AI development. Barriers are issues that may occur before or during AI application and which hinder a successful implementation or usage of AI. Challenges are factors, which are not as discouraging as barriers but still make a successful AI application difficult and therefore must be mastered. Drivers are influential factors, which can also relate to benefits or barriers and have therefore influence on AI application. Trends focus on research directions and address further research needs.

3) Search for publications on the following search engine/database

The targeted publications were journals, conference papers, books, research reports and online contributions from the following databases/search engines: Science Direct, Springer Link, Google Scholar and EBSCOhost. Furthermore, the scope of the analysis was limited to the first one hundred findings from each source. The last criterion was that the publication had to be accessible with a regular license for the database. All search results were analysed by title and abstract. In addition, doublets and non-relevant findings were excluded from the analysis. The search was carried out in May/June 2018 and resulted in 102 relevant sources.

4) Analysis of the search outcomes by using the concept matrix of Webster and Watson [4]

All findings were inserted in an Excel file and the concept matrix methodology [4] was applied. The concept matrix provides a framework, for the concept-centric analysis of literature. Hereby, all relevant findings can be analysed by pre-defined concepts as well as by sub-concepts (units of analysis). Within the presented research, this methodology supported the structured analysis of the identified literature.

5) Further search based on the first analysis

If authors of the found articles cited other sources, which were not found by the initial database search, those sources were also considered by the analysis. This was done in order to provide the original source of important statements.

III. THEORETICAL BACKGROUND

The following chapter describes the state of the art in AI based on literature research. First, the historical background will be explained. Then the identified definitions from literature are compared. In the third step, the different types of AI are presented. Finally, an overview of the AI functionalities is given.

In the summer of 1955 John McCarthy proposed a research project on Artificial Intelligence for the Dartmouth Summer Research Project. The proposal stated: *"We propose that a 2month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."* [5]. This proposal marked the starting point of AI research [6–9].

The initial impulse was given by Alan Turing in the year 1950 with his paper on "Computing Machinery and Intelligence" [10]. He dealt with the question "Can machines think?". In his published work however, he announced right at the beginning that this question could not be answered. He found the definitions of "think" and "machine" misleading, since the word "think" refers only to living beings and according to Turing computers would "think" in a different way. To avoid the direct question "Can machines think", he developed the so-called "Imitation Game" and thus investigated the question of whether a machine can simulate a person's thinking in such a way that a human test person would fall for it [10]. This test is one of the oldest test methods for AI, which widely known as "Turing Test". Turing only described a machine as intelligent when the answers of a computer cannot be distinguished from those of a human being. [11–14] Almost ten years after John McCarthy´s proposal, the computer program (ELIZA) for the study of natural language communication between human and machine was introduced by Joseph Weizenbaum [15].

Figure 1 shows an overview of AI relevant technological developments starting from the 1950s until the year 2017.

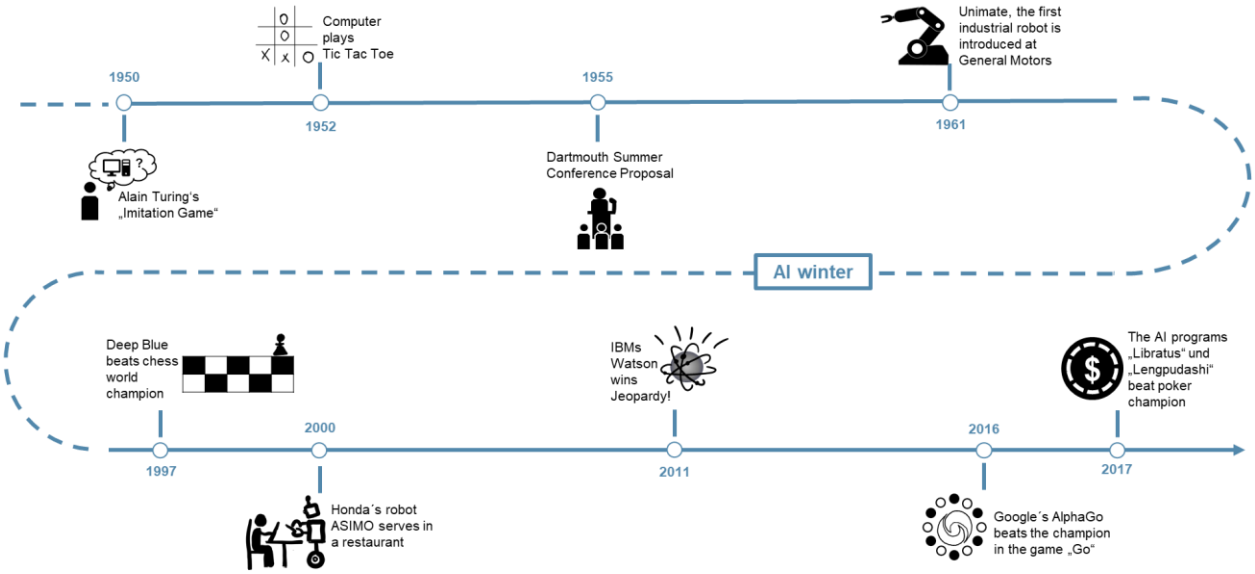

Figure 1: Selected illustration of AI developments over time

On a closer look at table 2, it is quite clear that AI experienced a peak in the 1950s and 1960s, during which many funds were raised to continue AI research. Especially after the conference with John McCarthy in 1956, many AI programs were developed and various research results published [16]. From the 1970s, the government cut funding for AI because not enough progress was visible. Thus the so-called AI winter began, in which disappointment and disillusionment spread [17, 18]. After the victory of the chess computer Deep Blue against the chess world champion Garri Kasparow, AI research had a new boost. This was probably also due to the new research possibilities offered by modern computers with higher computing power, the development of the Internet and thus the availability of large amounts of data. In addition, algorithms were improved, which also made the progress of AI possible. For example, Convolutional Neural Networks (CNN) were developed to recognize image patterns and were also used for speech and video recognition. In addition, Recurrent Neural Networks (RNNs) were developed for improved image recognition of computers and Graphical Process Units (GPUs) to reduce information processing time [11, 16, 19].

The following figure visualizes the degree of AI development over the years.

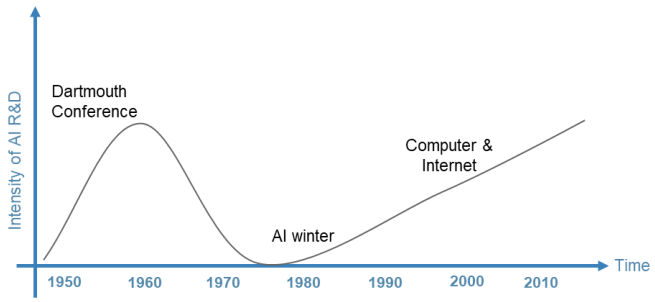

Figure 2: AI Development between 1950 and 2010 (Based on Smith et al. [20], own illustration)

TABLE II. EVOLUTION OF AI

1950	Alan Turing carries out "Imitation Game", which later becomes known as "Turing Test"[10, 21].
1952	Alexander S. Douglass develops the first computer that is capable of playing Tic-Tac-Toe [22].
1956	The term "Artificial Intelligence" was first introduced at a conference at Dartmouth College by John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon. Today, this conference is considered the beginning of Artificial Intelligence [5].
1958	John McCarthy develops the programming language Lisp, which becomes the most popular programming language for AI research [23].
1959	Arthur Samuel invents the term "machine leaning" when he reports about programming a computer in such a way that through constant learning it is able to master the game "Checkers" better than the person who wrote the program [24].
1961	Unimate, the first industrial robot, is used for the very first time in assembly at General Motors [24].
	James Slagle develops the heuristic program SAINT (Symbolic Automatic Integrator), which is able to solve integral problems [24].
1965	Joseph Weizenbaum creates ELIZA, an interactive program that can conduct a dialogue in English on any topic [25].
	Edward Feigenbaum, Bruce G. Buchanan, Joshua Lederberg and Carl Djerassi started working on the expert system DENDRAL, which automates the decision making process and the problem solving behavior of organics [24].
1966	Shakey, is the first universal robot that can explain his own actions [24].
1968	Terry Winograd launches SHRDLU, a computer program for simple natural speech understanding [24].
1970	The first anthropomorphic robot, WABOT-1, which includes a limb control system, an image processing system and a conversation system [24].
1972	MYCIN, an initial expert system capable of identifying bacteria that cause serious infections and identify and recommend suitable antibiotics [24].
1980	Wabot-2 is being built at Waseda University in Japan. It is a human-like music robot capable of speaking to a person, reading a sheet of music and playing medium melodies on an electronic organ [24].
1995	Development of the chatbot A.L.I.C.E (Artificial Linguistic Internet Computer Entity), which was inspired by Joseph Weizenbaum's program ELIZA, but with the additional function of collecting sample data in natural language of hitherto unimaginable size, made possible by the introduction of the Internet [24].
1997	Sepp Hochreiter and Jürgen Schmidhuber promote Long Short-Term Memory (LSTM), a kind of repetitive neural network that is used today for handwriting and speech recognition [24].
	Deep Blue is the first chess playing computer program that beats the reigning chess world champion [26–28].
1998	Dave Hampton and Caleb Chung build Furby, the first household and pet robot [24, 29].
2000	Cynthia Breazeal (MIT) develops Kismet, a robot that can recognize and imitate emotions [24].
	Honda's ASIMO robot, an artificially intelligent human-like robot capable of running as fast as a human, brings trays to customers in a restaurant area [24, 30].
2006	Oren Etzioni, Michele Banko and Michael Cafarella dominate the term "machine reading". They define it as a basically unsupervised, independent understanding of texts [24].
2007	Fei Fei Li and colleagues at Princeton University are starting to build ImageNet, a large database of annotated images to support visual object recognition software research [24].
2009	Google begins, in secret, with the development of a driverless car [24, 29].
	Computer scientists at Northwestern University developed Stats Monkey, a program that writes reports on sports news without human intervention [24].
2011	Watson, a computer that answers questions in natural language, wins the game Jeopardy! against two former winners [28, 31].
2012	Jeff Dean and Andrewe Ng report on an experiment in which they showed a very large neural network 10 million unknown images randomly selected from YouTube videos [24].
2016	Google DeepMind's AlphaGo beats the champion Lee Sedol in the game "Go" [9, 18, 23].
2017	The AI programs "Libratus" and "Lengpudashi" created by Carnegie Mellon University beat the poker champion [28, 32].

A. Defintions of AI

The literature research has identified different definitions for the term “Artificial Intelligence” from the period 1955 to 2018. These are presented in table 3 and are analyzed in the following section.

By analyzing the researched sources and their definitions it appears that there is no coherent definition for AI. Each definition has individual focus areas, which often overlap with other definitions. Another issue, mentioned in the literature, is the missing common understanding of the terms “artificial” and “intelligence” [12, 16, 26, 33, 34]. Thereby the term artificial can be understood as the imitation of something that is not natural, which was modeled, manufactured or created according to a natural model by the use of technical means [12, 34–36]. Moreover, the word “artificial” can be derived from the word “art”, which implicates an artist or creator and cannot exist without him [12]. The term intelligence derives from the Latin “intelligentia” and "intellergere" and means insight, cognitive ability or understanding. It also describes the ability to act abstractly and reasonably and to derive appropriate action from it [12, 37]. Intelligence also stands for the characteristics of learning ability, abstraction ability, adaptability and logical thinking [38]. The characteristics of intelligence are mostly attributed to biological beings [7]. In the human context,

intelligence usually describes the ability to consciously adapt thinking to new demands, tasks and conditions of life [6].

TABLE III. DEFINITIONS FOR ARTIFICIAL INTELLIGENCE FROM 1955-2018

Source	Definitions of AI
[5]	The science and engineering of making intelligent machines, especially intelligent computer programs.
[39]	Artificial Intelligence is the study of how to make computers do things at which, at the moment, people are better.
[40]	AI is the ability of digital computers or computer-controlled robots to solve tasks that are normally associated with the higher intellectual processing capabilities of humans.
[6]	Artificial Intelligence (AI) is a scientific discipline that aims to operationalize human perception and board performance and to make artfully designed technical - especially information processing - systems available through artifacts.
[41]	To build artifacts - computer programs or robots - that can meet human targets in a rational and human-like and thus understandable way.
[42]	A system that has goals, which it tries to accomplish by acting in the world.
[11]	The modern definition of AI is the investigation and construction of intelligent agents that perceive and act in order to maximize their chances of success.
[43]	Artificial Intelligence (AI), […] is the intelligence of machines and the branch of computer science that aims to create it.
[44]	Simulation of intelligent human minds.
[45]	The scientific understanding of the mechanisms underlying thought and intelligent behavior and their embodiment in machines.
[46]	Artificial Intelligence is the science of making machines do things that would require intelligence if done by man.
[47]	AI is typically defined as the ability of a machine to perform cognitive functions we associate with human minds, such as perceiving, reasoning, learning, and problem solving.
[48]	The theory and development of computer systems able to perform tasks normally requiring human intelligence.
[49]	AI generally describes the ability of a machine to independently interpret, solve and learn from complex problems.

According to the identified sources and the definitions contained therein, certain key topics can be identified. These include the assignment to a scientific research area, imitation of human-like intelligence and the solution of complex problems, as well as learning from preceding experiences. Furthermore, the applications generally involve computer programs or machines (especially robots).

For this reason, a novel definition was formulated for this paper, which covers the identified focuses and is intended to provide a general understanding of AI:

Artificial Intelligence is a research field with the aim of creating artifacts, such as computer programs or machines. The objective of most applications is to solve problems by applying algorithms. Applications can address the imitation or extension of human intelligence. Another possible focus of AI applications can be the learning from complex problem solutions and the extension of the functionalities of existing applications.

The following subchapters will describe several types of AI and their functionalities.

B. *Types of AI*

In principle, Artificial Intelligence can be divided into two general sub-areas: the "weak" and the "strong" AI. When using weak AI, it is sufficient if only a few characteristics connected with the idea of human intelligence are used to solve concrete application examples and to support people in their specific tasks. In contrast, a strong AI is expected to act truly intelligently. Attempts are made to create intelligence that is equal to or even better than human intelligence. However, the basis for this are skills such as logical thinking, making independent decisions in the event of uncertainty and independent learning. Turning these characteristics into reality is still one of the greatest challenges today [14, 34, 50]. The highest form of Artificial Intelligence is Artificial Super Intelligence (ASI). Super Intelligence is currently only a hypothesis, and no one can be sure whether there will be superintelligence or when the first superintelligence application will appear [16, 51].

The following figure shows three consecutive types of Artificial Intelligence.

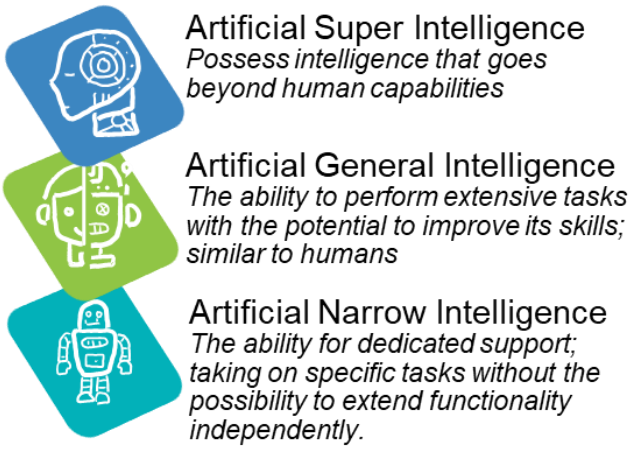

Figure 3: Types of Artificial Intelligence

1) *Artificial Narrow Intelligence (ANI)*

Today we are already surrounded by numerous intelligent machine systems. This includes object-oriented programming languages and graphical user interfaces. Every smartphone offers numerous intelligent applications. For example, personalized public transportation timetables can be created in seconds, a task that took a lot of time and effort just a few decades ago. Digital assistants, such as Apple's Siri, Amazon's Alexa, Google's Assistant and Microsoft's Cortana, can understand, process and interpret spoken human language. Questions can be answered, online purchases made and entire

texts translated. Further possible applications in which human tasks can be performed are manifold and will grow in the near future. All examples mentioned so far are Artificial Narrow Intelligence (ANI), also known as weak AI [51–53].

Artificial Narrow Intelligence focuses on one or more specialized areas [38, 47, 54, 55]. Thereby weak does not necessarily mean that this type of AI lacks skills. It only emphasizes the characteristics of specialization [16]. This kind of Artificial Intelligence is characterized by the fact that it can solve certain tasks in a specific area very quickly and/or precisely [51].

This special form of AI is thus limited to a single field of activity or rather to a particular problem to be solved and should support human thinking in particular. If an AI system is trained in a specific field, it may be able to solve selected tasks as well as or better than a human being. The training is usually done by machine learning. [9]

2) Artificial General Intelligence

Artificial General Intelligence (AGI) is also known as Human-Level AI or strong AI. Kurzweil [56] defined strong AI as machine intelligence with the entire spectrum of human intelligence. Such systems are intellectually equal to humans and are therefore not limited to individual fields of activity. Typically, these machines are equipped with human-like cognitive abilities and are therefore able to plan, solve problems, think abstractly or learn independently. [16, 28, 51]

Thus, a strong AI describes IT systems that are able to "think" and act in a human-like interconnected manner in many different areas at the same time [47, 57]. It is generally accepted that an AGI is not yet feasible and is currently the subject of controversial discussion [38, 52].

Both AI approaches, ANI and AGI, have a right to exist in AI research. It is advantageous to have specialized AI systems that solve certain tasks, as well as systems that have the ability to tackle new problems they have never faced before. The distinction between the two systems should emphasize the need for different evaluation procedures for ANI and AGI. Specialized AI applications should receive a task-oriented evaluation. On the other hand, multi-purpose AI applications require a performance-oriented evaluation [14, 38, 50].

3) Artificial Super Intelligence

The ultimate form of Artificial Intelligence is Artificial Super Intelligence (ASI). Nick Bostrom defines such a Super Intelligence as one that is superior to even the brightest mind in all aspects [58]. Especially the scientific creativity, general wisdom and social skills are decisive for this. Super Intelligence is currently only a hypothesis, and it is not certain whether there will be superintelligence or when the first application of superintelligence will appear [16, 51, 55].

As soon as such a Super Intelligence system begins to continuously improve itself, the state of singularity is reached, where machine intelligence as a whole exceeds human cognitive performance [32, 59].

According to a survey conducted by Müller & Bostrom [60], most experts believe that such a Super Intelligence could only be developed about 30 years after the development of the strong AI. In order to meet the requirement of the designation as ASI it is sufficient if the system is only slightly superior to humans. Müller & Bostrom [60], however, assume a Super Intelligence that is many times superior to all of humanity and whose structure can no longer be understood and comprehended by people. Tim Urban [61] provides a detailed description of this classification. This development is based on an insight that Kurzweil [56] describes, which states that technological developments are increasing exponentially and thus the frequency at which new technologies emerge is increasing. This assumption also corresponds to Moores Law, which had already predicted the development of the performance of integrated circuts (ICs) in the 1960s [62]. Based on research on technological development, Barrat [63] assumed that a strong AI could possibly be developed as early as 2030. If this assumption is correct, a first Super Intelligence application could be introduced around the year 2060 at the earliest.

C. Functionalities of AI

The term Artificial Intelligence includes a wide range of techniques of varying complexity. AI is characterized by its systems and their performance, as well as outcomes and results. The way those findings are generated has usually no high importance since the internal processes of an AI system are not always traceable and can therefore represent a black box [64].

The following sections describe the functionalities of artificial intelligence. These include Machine Learning, Deep Learning and Cognitive Computing. The three areas presented differ strongly in the clarity of the application purpose and the degree of autonomy. The clearer the purpose of such a functionality is, the less autonomy it allows. This also applies the other way round. Likewise, the degree of innovation of the functionalities rises with the increasing degree of autonomy of the application. Following this argumentation, a strong AI would have the highest degree of innovation and autonomy, but there would be less clarity of purpose [49, 64].

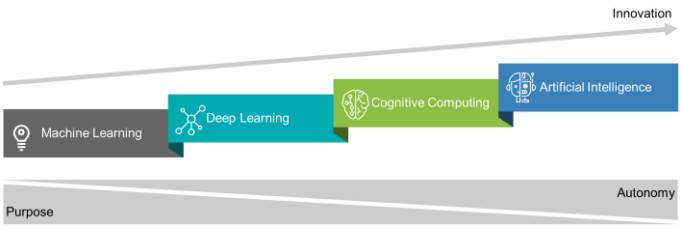

Figure 4: AI functionalities and their categorization (based on [58])

1) Machine Learning

Machine Learning (ML) is an important technical approach of AI. ML forms the basis for the development of new solutions for a wide range of applications [59, 65].

Machine Learning is of importance because it facilitates the meaningful processing of large amounts of data, since traditional rule-based systems are already reaching their limits [66].

ML is therefore a partial aspect of AI, which generates new knowledge from existing experience. Based on data or examples, an artificial system is trained to recognize patterns or repetitive characteristics. These are then used for an analysis of new, previously unknown data in order to draw the right conclusions for solving specific tasks [14, 32, 66].

With Machine Leaning, a system learns from existing data and examples. Neural networks are a special form of these approaches [67]. This AI technology uses simulated artificial neural networks in computers to understand the functioning of the human brain or to solve concrete application problems in statistics, economics and technology [14, 68, 69].

The success of a neural network often depends on so-called training data sets. Here, for example, the contents of images are previously described by machines or people and assigned to the image. If a sufficient number of these training data sets are fed into a neural network, the machine learns independently whether an image is a dog or a cat [49, 70].

Neural networks are based on a very simplified reproduction of the structure and function of the human brain. Essential mathematical elements are neurons that act as nodes and pass on information depending on the input data and subsequent activation. Synapses represent a weighted connection between the neurons. The neurons are additionally arranged in different layers (input layer, hidden layer, output layer) and compress the input data to ever higher knowledge until a result is finally available in the output layer [67].

A major advantage of Machine Learning is that results can be achieved with a low data volume and low computing power without having to produce a special code.

Furthermore, three techniques of Machine Learning can be distinguished. Those are Supervised Learning, Unsupervised Learning and Re-enforcement Learning [49, 71].

Applications for ML include spam detection, content personalization, document classification, customer migration prediction, automated solution recommendation for customer service, transaction fraud detection, diagnostic systems, traffic jam prediction, medical diagnostics, chatbot applications and personal assistants like Siri, Alexa, Cortana and Google now [9, 64].

2) Deep Learning

Deep Learning, also known as Deep Network Learning, is a specialized form of Machine Learning that uses statistical data analysis rather than an algorithm for input evaluation. The goal of DL is for a computer to learn an ability that people already own [14]. Deep Learning is based on neural networks, which allow machines to understand more complex structures and complicated solutions through new applications than it is possible with ML [52].

Simulated neurons, which are supposed to resemble the human brain, are modeled and arranged in many layers one behind the other or one above the other [67]. Each level of the network performs a single task, such as edge detection. This extraction of characteristics takes place separately within the individual layers [53]. The output of the individual layers then serves as input for the next layer. In combination with many high-quality training data, the network then learns to perform certain tasks. Existing applications brought initial success, especially in the medical field, as the machines were able to diagnose cancer cells in images quick and efficient. Similar to Turing's [10] description, these methods of Artificial Intelligence do not give people an insight into the layers of the network. The decision is made solely by the trained machines. Deep learning-based systems therefore already have a significantly higher degree of autonomy and offer a variety of application possibilities. The principles of DL operations are currently difficult to understand from the outside, since the next generation of neural networks learns independently after initiation and decision-making [14, 59, 64, 71].

These intelligent systems are used in particular for more complex problems, which are also associated with a large amount of data. These data records can contain both structured and unstructured data. They support decision-making, interpret patterns, control processes or move autonomously in unknown use cases. Other known areas of application are the recognition of objects in images and videos, as well as speech recognition [49].

3) Cognitive Computing

In recent years, the AI has increasingly turned back to the original orientation of the pioneers of the field, which is the reproduction of cognitive functions in the human brain. Algorithmic implementation using neural networks is already well advanced. Now the focus is moving more towards the architecture of cognitive structures [32].

Cognitive computing refers to systems that take on tasks or decisions that are currently mainly carried out by humans. This is the case, for example, with insurance claim management, on the service hotline or in hospital diagnostics. Cognitive systems are primarily characterized by their ability to adopt certain "human" characteristics and to deal with ambiguity and blurriness. The degree of autonomy can be high with these systems. The term Artificial Intelligence is used when machines have complete cognitive abilities. Thereby it is no longer possible to distinguish man and machine from each other from the outside. In an advanced stage of development, these systems of Artificial Intelligence have achieved a very high degree of independence. They make their own decisions, define their own strategies and determine the way in which they learn and

communicate. Such systems are currently the focus of many researchers, while companies and their use cases refer to simpler functionalities of artificial intelligence [64].

IV. Influential Factors

The field of AI is influenced by numerous factors. In recent years, technological progress has encouraged development. Current and potential applications have advantages as well as disadvantages for stakeholders, which have an impact on the general acceptance of the technology. Especially negative influences cause challenges, which have to be solved in order to be able to utilize the full potential. In this context, it is necessary to consider all stakeholders concerned in order to achieve broad acceptance of the technology.

A. Drivers

Drivers are relevant developments or technologies that promote future changes of a technological, social or other nature. For the subject area AI, the following drivers are mentioned in the literature: Big Data, Internet of Things (IoT), Cloud Computing and Cloud Storage, Higher Processor Speed, and Algorithms.

1) Big Data

One of the most frequently mentioned drivers for the strong increase in interest in AI is the large amount of data that is available everywhere nowadays [49]. This data is routinely generated, collected and stored by digital systems. The amount of data generated worldwide doubles every two years [52]. Large amounts of data are essential for AI, as big training data sets are currently the basis for many AI applications. They are also needed to continuously improve the system. With the AI it is now possible to process large amounts of data that previously required extremely expensive hardware and software. The input data are an essential element for the quality of the output results [52, 66, 72–74].

2) Internet of Things (IoT)

In recent years, communication networks have gained speed so that large amounts of data can be quickly distributed between servers and devices. Broadband as well as 4G and 5G communication networks and communication technologies for nearby areas serve as the technological basis. The IoT also allows more data to be generated by the large number of communication-enabled devices. For the AI, this means that most of the intensive real-time data processing can be performed on servers in data centers. Furthermore, AI systems can be connected via networks if required to share experience and benefit from the new data [52, 55].

3) Cloud Computing

Cloud computing is a network of remote servers hosted on the Internet. Thus, data can be stored, managed and processed in the cloud without using a local server for these tasks. Increasing availability and consistency of fast connections to the Internet also mean that large amounts of data can be quickly transferred to cloud servers and stored by cloud service providers. Cloud computing is therefore a key factor for AI technology. The increased use of cloud computing has reduced cost of storing data in the cloud, which in turn reduces the cost barriers for companies using this technology [52, 75].

4) Processor Performance

The data volumes described above are a relevant driver for the AI. The increasing collection of data requires an extension of the ability to perform calculations. This increase in computing power is made possible, for example, by Graphical Processing Units (GPUs) used in Machine Learning [26]. Faster processors mean that more complex problems requiring more data and more computing operations can be solved. Processing and managing all this data takes time, and even relatively simple training sessions can take from a few hours to several days. Any improvement in processor performance therefore helps in the use of AI applications [52, 75, 76].

5) Algorithms

In general, algorithms are guidelines for solving problems that consist of defined individual steps and are implemented in a computer program [77]. AI algorithms have improved significantly in recent years. Faster calculations and improved data quality allow algorithms to be trained to work with better accuracy and inference. Experiments based on the Minimal Viable Product (MVP) [78] model are also made easier by improved algorithms and higher available computing power [75, 79].

B. Benefits

Benefits are factors, which favor and promote the adoption and application of a technology. The following list shows identified benefits of AI.

- Increase in productivity
- Increase in efficiency in the production area
- Forecasts are improved, processes optimized and the user experience improved
- Processing of large data sets
- Introduction of new business models
- Expand human abilities and possibilities of learning and exploring
- Solving complex problems
- Competitive edge
- Higher profit margins
- Replacement of human labor
- Better decision making

1) Increase in productivity

In the production area, an increase in productivity of up to 40 percent can be reached through the use of cognitive machines [80]. Along the entire production chain (from design, logistics and production to reengineering), an intelligent human-machine interface should collect data volumes through interaction with the user and the system's environment and is able to make data-driven predictions in real time and adapt processes and behaviors with foresight. AI thus encourages the improvement of the value chain [76]. This is only made possible by the improved connectivity of the systems and products on the Internet of Things and enhanced by advances in machine learning [71, 81].

2) Increase in efficiency in the production area

The basis for the factory of the future is a modern infrastructure combined with a wide variety of AI technologies. These enable the introduction of new types of cognitive machines into the factories, which are supposed to generate an increase in productivity [80]. These intelligent information and assistance systems are intended to ensure more user-friendly and efficient work in the production area. These include intelligent user interfaces that adapt to the user, or intelligent data glasses with augmented reality applications that provide visual support for various production steps. [76, 81]

3) Forecasts are improved, processes optimized and the user experience improved

AI helps to improve forecasting and procurement, to optimize and automate processes, and to develop targeted marketing and pricing. These measures lead to the improvement of the holistic customer satisfaction [47].

4) Processing of large data sets

Companies nowadays possess a high quantity of structured and unstructured data, which is constantly multiplying [49]. The quality of Artificial Intelligence applications depends on the input data used for training. The more data available as a basis, the more extensive are the possibilities to link new information and connections and to process them by means of AI [66, 72].

5) Introduction of new business models

Artificial Intelligence influences the way the economy operates, for example by influencing the way decisions are made. By adding new sources of value creation, existing business models are questioned and disturbed, but completely new ones can be also created [52, 76, 82]. This new markets or services leads to cost reduction and sales increase [73].

6) Expand human abilities and possibilities of learning and exploring

Artificial Intelligence expands human abilities and possibilities of teaching, learning and research. Advances in sensors and networking as well as in computing and storage performance increase the number of available data. This also enhances the number of possible intervention points. This expands the application possibilities of machines, devices and software. Only through these developments the actual potential of AI technology can be unlocked [76, 83–85].

7) Solving complex problems

Machines today still have difficulties understanding and interpreting real-world situations. However, with the help of artificial intelligence, machines are already able to solve combinatorial problems better than humans [86]. So machines can imitate human cognitive abilities to understand our feelings and thoughts and strengthen human-machine interaction [87–89].

8) Competitive advantage

Artificial Intelligence creates a competitive advantage for companies at an early stage of use. This advantage is growing steadily and is difficult to compensate later on. Successful applications include many elements of a digital and analytical transformation: identifying the business field, setting up the right data ecosystem, using adequate AI tools, and implementing appropriate workflow processes. This change also depends on the willingness to adapt one's own corporate culture and to break new ground. Key factors here are leadership skills and technical understanding, as well as seamless data access [47, 82].

9) Higher profit margins

AI techniques will play an important role in the future, especially in the areas of marketing and sales. "Next product to buy" recommendations addressed to individual customers - as already successfully implemented by companies such as Amazon and Netflix - can lead to a significant increase in sales. Individual pricing and promotion is also applied across a wide range of industries [90]. Higher profit margins can be achieved by combining advanced digital capabilities with pro-active strategies [47].

10) Replacement of human labour

In the past, technological progress has been a medium to eliminate dirty and dangerous jobs and improve human quality of life. New technological developments have led to the takeover of monotonous and repetitive tasks. This results in a re-allocation of the time available for more demanding activities, but also more freedom for creative or leisure activities [73, 88, 89].

Nowadays robots are already capable of performing many tasks quickly, reliably and in the highest quality - and all this without breaks and finishing work. Up to now, however, the acquisition and configuration of such robots has only been worthwhile in mass production or in highly repetitive processes. AI will enable robots to perform a wide range of activities in the future, even in such environments, which require continuous adaptation. This would make them more versatile and, due to an increasing range of products, more affordable to buy [76].

11) Better decision making

Artificial Intelligence provides a better basis for decision making, taking into account a higher amount of information, looking into the future, and performing rigorous analysis. Likewise, there are no potential heuristics and distortions by humans that could have a negative impact on decision making [73, 91].

C. Barriers

Barriers are issues that may occur before or during AI application and which hinder a successful implementation or usage of AI. The following list shows currently discussed barriers of AI.

- Liability: who is responsible if something goes wrong?
- Part of the human labor force can be replaced by AI
- Users no longer have control over the use of their data
- Lack of system verifiability due to lack of transparency (security)
- Increased default risk of the new systems
- High investment costs
- Increased risk of arming AI (both physical and cyber)
- Data manipulation
- Misuse of AI systems
- Difficulty of AI to recognize emotions
- Very large amount of training data required
- Data protection
- AI systems have difficulty transferring their experience in changing circumstances

1) *Liability - who is responsible if something goes wrong?*

One of the advantages of AI is that the system works with a certain autonomy and can make decisions independently up to a certain degree. This also raises the question of who is liable if an activity carried out by the AI is performed incorrectly or does damage. This question is particularly of relevance in the field of autonomous vehicles, which contain components from a large number of suppliers. In the event of damage, the question arises which party is to blame. Is it the driver, the manufacturer or, for example, the supplier of AI relevant components or the software [73, 90]? Similarly, this example can also be applied to many different industries. The question of liability is therefore a very important one.

2) *Part of the human labor force can be replaced by AI*

On the one hand, there is the view that if robots start to replace people in all fields, it leads to unemployment. Thus many people would remain without employment and the empty time could end in their destructive use [38, 92]. On the other hand, sources highlight the view that the forecasted change will be less disruptive and slower. This would give the labor market more time to adapt to the changes, which in the long run would lead to new fields of activity [76]. Available applications indicate, that repetitive and rule based tasks like e.g. administrative tasks can be replaced by AI [83]. Therefore, the literature recommends to prepare employees for a lifelong retraining, during which they should be able to adapt to changing working conditions [47, 93]. Furthermore, Heinen et al. [76] argue, that some pessimistic studies have questionable data quality and methodology.

3) *Lack of user data control and transparency*

AI is very good at personalizing product recommendations based on aggressive customer data and understanding customers' individual preferences [90]. However, customers have reservations about services that deliberately invade their privacy, even if this improves the customer experience [94]. In addition, AI is a black box for many outsiders, whose internal processes are difficult even for experts to understand and decisions that used to be based on human reflection are made in seconds using algorithms [26, 73, 95, 96]. Thus, there is the fear that those who control the algorithms now also have comprehensive influence on people and many areas of society [47, 83].

4) *Increased default risk of the new systems*

In complex AI systems, which consist of many applications and where algorithms have to work together at high speeds, there is a risk that these systems may unexpectedly break down due to internal errors or external influences [31, 92].

5) *High investment costs*

Large internet companies and other tech firms have invested billions of USD in R&D of AI solutions in recent years. However, survey-based results show that many companies using AI are not sure whether the business case is working and whether there will be a near-term Return on Invest (ROI) for it [47, 97]. Especially the development of higher levels of AI will be difficult to implement and will therefore be costly [98].

6) *Misuse of AI Systems*

Fears about the use of the AI as a weapon have been identified in various sources. This applies to both the physical and the cyber world. Furthermore, there are fears that existing social and economic inequalities may be exacerbated by inequalities in access to AI systems. Uneven access to AI benefits can also result in economic benefits that are not equally beneficial to all people [31, 60, 81].

7) *Data manipulation*

Aspects of AI such as Machine Learning are based on data that are made available to the AI system for training purposes. During the training phase the algorithms try to find systematic structures and rules. Thus, AI systems are vulnerable during the training phase. If an attacker succeeds in manipulating the training data, the output of the training phase is modified and the system does not function as planned [26].

D. Challenges

Challenges are based on the known barriers of a topic area and must be at least partially overcome for the successful adaptation of a technology. This work identified several challenges, including fear of change, algorithm comprehensibility, technology, cost-benefit ratio, legal framework and security. These challenges are described below.

Artificial Intelligence is a universally usable technology that will fundamentally change all aspects of life. The idea is compared with the invention of electricity or the steam engine [99]. Already today AI has become an important part of everyday life and can be found in various applications, private as well as public. Technologies based on machine learning, such as text and speech recognition or translation, have become an integral part of our everyday lives. Algorithmic calculations provide product suggestions for those who surf the Internet, or customized messages for those who browse their social media account [90]. The number of possible AI applications is not yet exhausted [19].

One of the main barriers to the implementation of AI applications is the general fear of what changes can result from this technology. This fear occurs especially when the AI fundamentally reforms the way people work. Up to now there have already been many changes in the way of working, which could increase drastically due to the AI developments. Automation of factories, offices, administration, traffic, household and many other areas has for many years ensured that more and more heavy, dirty and unhealthy work is taken over by computers, machines and robots [19, 23, 52]. Speculative reports by academics and institutions repeatedly report job losses [38, 92]. Some authors go one step further and also address existential threat scenarios as a consequence of Artificial Super Intelligence [58]. Artificial Intelligence does not necessarily lead to job losses. Instead, expectations and types of jobs will be transformed in the future. The fear that these predictions will come true, however, leads to a natural resistance from those who might be affected [100, 101].

A possible advantage of AI systems is their autonomous operation, which is the key attraction of this technology [90]. Nevertheless, AI systems often work as so-called black boxes [71, 96]. A large part of the computing work done by an AI system is unknown to the developer or user. This means that there is no traceable path to determine how a decision was made. This poses challenges in the areas of liability and negligence in the case of complications [55].

Especially with larger and more complex models it is difficult to understand why a certain decision was made. This makes clear why the acceptance of some AI instruments in certain areas of application in which much explanation is needed is not provided. This is especially true where predictions or decisions directly influence human beings. For example, an AI system cannot always explain why a particular applicant was accepted or rejected for a job or why a particular medication was recommended. For this reason, AI users need to be confident that the content of the black box makes decisions in their own interest. Since this trust is not often given by society, this is an obstacle to the implementation of AI applications [52, 55, 95, 102].

Despite major advances in data management and cloud infrastructures, AI systems are primarily monolithic systems that require a critical amount of data to train and learn skills [103, 104]. Companies face challenges in the development of such systems. One of the main reasons why tech-companies such as Google, Microsoft, Amazon or IBM are successful with this topic is their access to a large amount of data with which they can work and experiment. Companies that want to deal with AI and enter this market usually do not have the necessary data available in the required quantity, structure and form [52]. This hurdle is also referred to in the literature as the so-called data wall, which denies companies an easy entry into this field [104].

After successfully overcoming the data wall, companies face further challenges in the development of AI systems. This includes the necessary personnel expertise, prioritization of competing AI applications and their financing, as well as the technological challenges [97, 105].

For the training of AI systems, the training data are essentially responsible for the learning success. Hence, a massive amount of data is necessary. The more extensive and detailed the information in the training data is, the better it can be used for training the AI. This is one of the reasons why companies have been keen to pursue the subject of big data in recent years. The desire of companies to possess comprehensive, coherent and as valid as possible data sets of their customers can easily come into conflict with the provisions of the European General Data Protection Regulation [106], which has been in force since May 2018. For this purpose, Article 5 is relevant, which deals with the principles for processing personal data. An example for this is the principle of data minimization (Article 5.1c), which aims primarily at the collection and processing of personal data. This means that data for AI applications can be used either only without personal reference or with explicit permission. Furthermore, Article 5.1b regulates the appropriation of data. In most cases, this means that the data collected would not correspond to the original purpose if it were used for training purposes and hence to obtain new information [66, 104]. Such regulations intent to protect personal data, but from an AI point of view, it seems to get harder to get relevant data without destroying its usefulness [47].

Further challenges for companies are competing investment priorities and the high investment costs in relation to the benefits gained. This raises the question of a cost-benefit ratio. High initial costs arise for the development and implementation of AI applications. It can be assumed that the advantages of AI technology will predominate in the future, but these cannot yet be reliably estimated. Based on the current state of AI research, it is not yet clear when the technology can be used to create added value [90, 97, 105].

V. Summary and Outlook

The presented paper contains a literature review on the AI topic. First of all, the historical development was examined in more detail. This began with the origins of the AI and continued through the AI winter until today, when the topic is experiencing an upswing due to technological progress and the urge for innovation. Furthermore, definitions were analyzed on the basis of existing approaches and an attempt was made to generate a

comprehensive definition. Afterwards, types and functions of AI applications were identified and presented. The aim of this article was to provide a fundamental understanding of the categorization of the technology into maturity levels. In addition, the functionality and potential future developments were examined in more detail. Based on the literature review, drivers for the adaptation of the AI technology were presented. The advantages and disadvantages were compared subsequently. Finally, challenges were described which need to be overcome for the successful development, implementation or application of AI.

This paper concentrates on the basics of AI and the currently known influencing factors. However, in the course of the literature investigation presented here, a variety of use cases were also identified. As already described above, there is no common definition for AI. This makes it difficult to classify the examples. Use case descriptions within the identified sources are not consistent. The literature usually names use cases according to industries or areas of application in the companies, but they rarely describe the maturity of the application. As a result, it is not always clear whether the example presented is a blueprint, prototype or actually implemented. The question of the actual economic benefit of the use cases also usually remains unanswered. As a result, the identified use cases cannot be compared with each other and require further analysis and synthesis. This investigation should be part of future work. The potential of AI applications is not yet exhausted and offers many opportunities for innovative applications in the future.

ACKNOWLEDGMENTS

This research was partially supported by Clarissa Gosemann, Fabian Kaltenbach and Fabienne Stuber who are students at Pforzheim University.

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