DHBW
Duale Hochschule
Baden-Württemberg
Ravensburg
Campus Friedrichshafen

SCHRIFTENREIHE DER FAKULTÄT FÜR TECHNIK DER DUALEN HOCHSCHULE BADEN-WÜRTTEMBERG RAVENSBURG

2020/03

Artificial Intelligence in Engineering and Society – Current Trends and Applications

Prof. Dr.-Ing. Jens Christian Timmermann, Dr.-Ing. Atheer L. Salih Al-Tameemi

DHBW
Duale Hochschule
Baden-Württemberg
Ravensburg
Campus Friedrichshafen

SCHRIFTENREIHE DER FAKULTÄT FÜR TECHNIK DER DUALEN HOCHSCHULE BADEN-WÜRTTEMBERG RAVENSBURG

2020/03

Artificial Intelligence in Engineering and Society – Current Trends and Applications

Prof. Dr.-Ing. Jens Christian Timmermann, Dr.-Ing. Atheer L. Salih Al-Tameemi

IMPRESSUM

Schriftenreihe der Fakultät für Technik
der Dualen Hochschule Baden-Württemberg Ravensburg

Herausgeber

Prof. Dr. Heinz-Leo Dudek
Prorektor und Dekan der Fakultät für Technik

Duale Hochschule Baden-Württemberg Ravensburg
Baden-Wuerttemberg Cooperative State University
Marienplatz 2
88212 Ravensburg
Deutschland

http://www.ravensburg.dhbw.de

2020/03, November 2020

ISBN 978-3-945557-09-9
ISSN 2199-238X
DOI 10.12903/ DHBW_RV_FN_03_2020_TIMMERMANN_AL-TAMEEMI

Druck und Verarbeitung

Gestaltung
Nicole Stuepp
DHBW Ravensburg
Marienplatz 2, 88212 Ravensburg

Druck
Online-Druck GmbH & Co. KG
Brühlstraße 6
86381 Krumbach

Artificial Intelligence in Engineering and Society – Current Trends and Applications

Prof. Dr.-Ing. Jens Christian Timmermann[1,*]
Dr.-Ing. Atheer L. Salih Al-Tameemi[2]

* e-mail: timmermann@dhbw-ravensburg.de

Keywords:

Artificial Intelligence (AI), speech recognition, image processing, robotics, autonomous systems, smart devices, communication networks.

ABSTRACT

Artificial Intelligence (AI) is a modern field of research that pushes recent technological developments in different fields of industry. AI fundamentals have origins in mathematics, information technology and engineering. The scope of this article is to provide an understanding of basic AI ideas, the evolution of that field and important theoretical modelling approaches. Furthermore, the paper gives an overview of AI based applications in science, society and engineering. Hereby, a special focus is laid on some recent developments in mobile communications and networks. In a final step, the contribution discusses future trends in AI. In this context, the authors also present an own idea, namely a hybrid device based on speech and image recognition.

[1] Manager of B.Eng. study program "Communications with focus on traffic systems" within Electrical Engineering, Baden-Wuerttemberg Cooperative State University, Faculty of Engineering, Germany, 88045, Friedrichshafen, Fallenbrunnen 2

[2] Academic staff member Electrical Engineering, Baden-Wuerttemberg Cooperative State University, Faculty of Engineering, Germany, 88045, Friedrichshafen, Fallenbrunnen 2

1 INTRODUCTION

Cambridge dictionary defines Artificial Intelligence (AI) as the ”study of how to produce machines that have some of the qualities that the human mind has, such as the ability to understand language, recognize pictures, solve problems, and learn.” (Cambridge dictionary website, 2020).

AI is a technology leading to advantages in many fields, e.g. by optimizing processes and/or the processing time. First applications were e.g. found in computer science, where AI helped to improve software and enabled progress in engineering applications. For example, systems could react automatically in a clever way when e.g. environmental conditions changed. AI has been a new scope of research in computer science, especially in the last two decades.

EVOLUTION OF ARTIFICIAL INTELLIGENCE

Simply, AI is a technology aiming at transferring the human actions and behavior to machines, imitating rational actions, and thinking. Usually, this process depends usually on previous input data related to the intended actions. For this purpose, professionals and experts in particular fields define some goals, and the AI may learn and establish a set of rules in order to take the right decision. AI has to solve a dedicated problem, and to find an adequate solution.

There were some first trials to apply AI during the 1940s and 1950s. During the second world war, there were also first applications of AI in the field of coding/decoding by Alan Turing and he published his article (Computational Machinery and Intelligence) that attracted attention and admiration (Muggleton, 2014). In the 1950s, John von Neumann supported the idea of computer design based on the human brain model (Parkes and Wellman, 2015; Nilsson, 2014). The first conference on AI was the Dartmouth Conference which took place in the summer of 1956. This conference has established AI as a new discipline at that time. McCarthy chose the term ‘artificial intelligence’ to the funding application of the ‘Rockefeller Foundation’ for this conference. Initially, McCarthy et al. submitted a proposal of such an AI conference gathering establishment from August 1955 (McCarthy et al. 2006).

One of the earliest text books about AI was written by Elaine Rich (Rich, 1983). This book provides a very good clear primary introduction to the problems and techniques in AI. It covers important descriptions for some basic techniques in AI problems solving. In 1993, Ross Quillian was the scientist who instructed a program for a complicated AI net involving computer simulation of human memory, and language processing. He represented a semantic network in a graph that consists of nodes and arrows for link connection between this net (Crevier, 1993).

A well-known AI example was IBM's Deep Blue chess computer that played and beat chess master Garry Kasparov in 1997. Later applications involved applications in speech recognition based on a huge and cumulative amount of data. An important AI revolution started within the last 2-3 decades in parallel with the revolution of internet and microprocessors development (Renzi et al., 2014). In the 1990s and early 2000s, AI entered more and more into the challenge to solve for example problems in information technology (IT) and business applications (Barzilay et al., 2002; Bartlett et al., 2001; Tennenholtz, 2002). The field of AI has also become very important in manufacturing and service systems for the last three decades affecting the daily life (Oke, 2008).

Meanwhile, the AI technology has achieved very high success and popularity in the scientific community due to the great connection with the development of smart processors enabling advanced functionalities (Shabbir and Anwer, 2018).
Nowadays, there are a lot of amazing AI results that reduce human effort and impact our lives in a positive way (such as assisting systems in vehicles with the potential to reduce traffic accidents and hence the associated death rate). Benefits are not only found in engineering and industrial fields (e.g. precise robotics), but for example also in medical applications. In other words, AI can make human life more pleasant and safe (Ashok et al., 2016). Oke (2008) classifies the areas of AI into 16 areas of application: Programming, artificial life, data mining, distributed AI, expert systems, machine learning, and neural networks are considered the most important areas according to Oke (2008).
To summarize, the success of AI can be explained by two steps: First, important basics and principles of AI were developed showing its big potential and the expected advantages (Brooks, 1999; Patel-Schneider and Sebastiani, 2003; Zanuttini, 2003). This led to a growing

worldwide interest and to an ongoing increase of investments in AI technology. Applying an AI strategy often optimizes the performance and helps to achieve a deeper understanding of the considered discipline. (Rosati, 1999; Kaminka et al., 2002; Bod, 2002; Acid and De Campos, 2003; Walsh and Wellman, 2003). On the other side, there are still many challenges in the AI field related to unexpected behavior.

GOAL OF THIS PAPER AND APPROACH

The goal of this paper is to present the main ideas of AI as well as current applications and developments in different fields of science, society, and engineering involving trends. For this purpose, current references are considered. The paper shows how our everyday life is already impacted by AI, how mankind already benefits from this development, and which steps and further applications may come in the future. In this context, the authors also discuss the idea of an advanced device that could help to preserve a human's personality.

The paper also provides a good basement and starting point for people and engineers interested in technological trends. The paper itself discusses several relevant fields, involving both applications in engineering (e.g. robotics, communication systems), and in science and society. By understanding the state-of-the-art and upcoming trends in the year 2020, this may help to make technical decisions, but also to understand the impact of AI in private life.

2 THEORETICAL BACKGROUND AND MODELLING APPROACHES

Nowadays, AI has sometimes become a catchphrase for technologies that realize a clever behavior. For example, AI can take over more control in complex systems leading to less end-user interactions and/or increased efficiencies in processes and implementations. To achieve an AI behavior, the following approaches are typically applied: probability-based methods, logic principles, numerical methods, and mathematical optimization (Ashok et al., 2016; Shabbir and Anwer, 2018). This chapter provides a short overview of some theoretical background and modelling approaches related to AI, without claiming to be complete as the field of AI is wide.

In order to judge if AI should be applied in an existing classical model (i.e. reference model) for better performance, several steps have to be considered: In general, the first step is to explore and study the area of the business domain and the expansion opportunities. This means to understand the requirements to build up an AI-based system. The next step is to check the available information, data and the current classical method applied. The decision of developing an AI system according to the user requirements is the next step forward. The final step is to face and solve the technical problem based on AI and to handle the possible unintended behavior. The basic steps of a general AI system are shown in Fig. 1 (Jim Whitehurst, 2019).

Figure 1: AI basic steps

When a reference model is modified by an AI approach, a lot of information and data is required as a necessary input for the modelling process. After developing the AI model, its performance is compared to the reference model for further optimization (Shabbir and Anwer, 2018). During the development phase of the AI model, dedicated rules have to be defined for decision making.

AI is applying three tasks within its formation to generate results: identification, prediction, and execution. These results obtained in different applications are often much better performant compared to those of classical models. (Otani et al., 2017). The tasks can be briefly explained in Fig. 2:

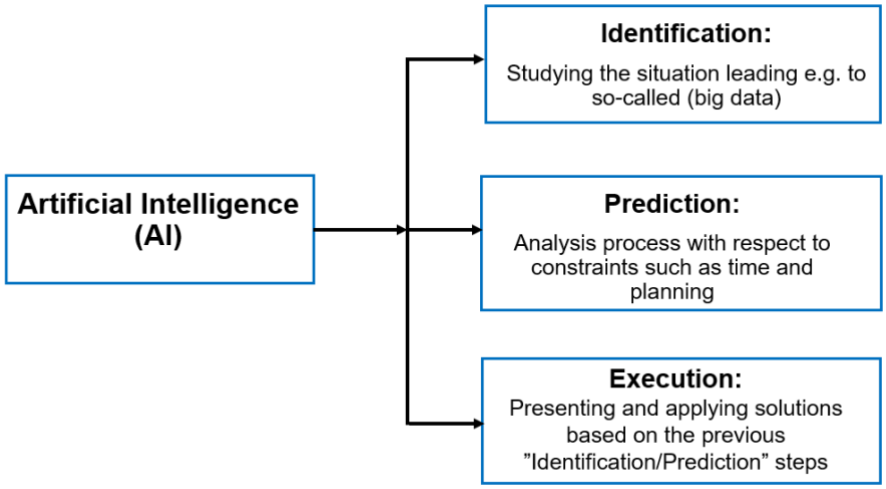

Figure 2: The major stages of AI system formation

To solve a dedicated problem by application of AI, suited AI approaches have to be chosen. The task is to apply an AI method leading to an optimized performance which may be even better than achievable by human interaction or human thinking. In a modern project, even multiple AI approaches may be applied simultaneously (hybrid system) such as machine learning, neural networking, expert systems, etc.

The following sections present some important terms related to AI that are often used in literature.

2.1 Expert System

An important term related to AI is the Expert System (ES), which simply means that a computer software system based on human expertise to make decisions and deal with/solve problems has either a high degree of knowledge complexity or incomplete information. (Uraikul et al., 2007; Oke, 2008). For example, control technology normally applies an ES as it very useful in active processes. The applied so-called rule-based

knowledge which requires deep understanding of the inputs decides the action based on the actual situation. Expert systems typically use the following items: knowledgebase, user interface, database, reasoning machine, machine interpretation, and knowledge acquisition (Uraikul et al., 2007).

An early study related to AI and ES was done by De Toni et al. (1996) that concerned the production scheduler. De Toni et al. applied a hybrid multi-stage (production and inventory) ES technology approach to schedule the push/pull orders and the results were encouraging (De Toni et al., 1996). Exemplary references related to AI expert systems in imaging applications can be found in (Varela et al., 2016.; Chen et al., 2016) and in (Shabbir and Anwer, 2018).

2.2 MACHINE LEARNING

One of the main AI fields is Machine Learning (ML) as these fields are often cooperating together in a lot of applications such as data processing, image recognition, security, and search engines (Portugal et al., 2018). ML is for example often used to recognize patterns in data. This learning is based on some reference knowledge and leads to dedicated skills such as detection or classification. These skills improve over time resulting in reliable results (Goldberg and Holland, 1988) when manual interaction with a programmer is applied.

There are a lot of studies and research about ML that serve AI technology, especially in the last three decades (Gamberger and Lavrac, 2002; Meek, 2001; Walker, 2000). One of the earliest ML studies was done by Soderland and Lehnert (1994) where a system was built for acquiring knowledge in high-level information extraction processing and the results were well comparable to the manual ones (Soderland and Lehnert, 1994). Another study by Blockeel et al. (2002) focused on the development of a new inductive logic programming based on the query packs application to improve the efficiency.

The ML field is widely connected to other fields, for example, ML takes the leading role in solving the so-called knowledge acquisition (KA) bottleneck through applying expert systems (Goldberg and Holland, 1988). Originally, the knowledge acquisition (KA)

bottleneck problem started from the fact that the experts are really good at data collecting and archiving but they have some weaknesses in presenting their experience in a qualified production rule (Wong and Wang, 2003). ML methods are applied to extract the knowledge from data automatically and to solve the bottleneck problem (Bakshi and Stephanopoulos, 1994).

Within the start of the current century, a revolution of ML-based studies and researches shined more in the industrial field (Oke, 2008). In 2002, Nock (2002) presented a concluding voting classifier based on his theoretical results, approximation algorithms and experiments. The obtained results were based on a weak learning framework which resulted in simplicity and accuracy (Nock, 2002). Lerman et al. (2003) had another important study regarding ML which carried out the Wrapper maintenance problem through presenting an efficient algorithm that extracts data from positive structural information examples only (Lerman et al., 2003). A wrapper function is a computer software application used to extract information from a semi-structured source and to convert it to a structured format with little or no additional computation.

A further application of ML is the field of adaptive agents: In his study, Gordon (2000) presented developed ML-based agents to obtain a higher degree of efficient re-verification after learning with a fast response time. The developed system was very adaptive, prospective, and precise (Gordon, 2000). So-called reinforcement learning algorithms were an interesting study done by Brafman and Tennenholtz (2003): for example, in gaming applications where dedicated goals can only be achieved when multiple players cooperate in an intelligent way, the mentioned authors could achieve very good results and solutions through applying simple model-based algorithms (Brafman and Tennenholtz, 2003).
In general, ML became very interesting and popular due to the increased research in the AI field as a lot of researchers had the idea of how machines can learn from data. Since the 1990s, ML has become more and more popular worldwide (Langley, 2011). However, some researchers insist that ML is a sub-field of AI but some others deal with AI and ML as separate fields.

2.2.1 DEEP LEARNING

Originally, the so-called deep learning concept was derived from Artificial Neural Network (ANN) research and now forms a part of ML (Lecun et al., 2015). Details related to the term ANN are explained in a section 2.4. The term deep learning can be defined as the deep structured learning typically involving neuronal networks so that the learning process improves without interaction by a programmer. It is a very modern part of AI and based on understanding and learning the intrinsic structure of data (Zhong et al., 2016). This leads to so-called data representation. (Alpaydin, 2020). Deep learning exists in three general forms: supervised, semi-supervised, or unsupervised which is not considered in more detail in the frame of the paper. Instead, some applications related to deep learning are shortly presented:

When studying the processes of a biological nervous system, it can be found that these processes can be modelled by deep learning approaches that help to explain the relationship between different stimuli and the related neural responses in the brain. This involves the interpretation of information processing and communication patterns through applying a neural network. (Uraikul et al., 2007).

Recently, deep learning has also been applied in so-called big data applications. Hereby, the idea is to form new efficient systems that learn data representations from unlabeled data sets and large-scale data. Deep neural networks, deep belief networks, and recurrent neural networks are considered as the newly developed versions of deep learning. These new forms allow for a wider range of fields to be applied such as for example computer vision, natural language processing, speech and audio recognition, and mobile communications. Deep learning is usually providing a result which is comparable to what can be achieved by human experts and professionals.

2.3 PATTERN RECOGNITION

Pattern recognition is defined as an automated process of recognizing patterns in data which means for example to find some kind of repetitions, similarities and regularities. As an example, pattern recognition is applied to identify cars in sensed video data, and the

technology is also often used in monitoring applications. Pattern recognition applies a data classification process. Criteria have to be defined for this classification while it can be distinguished between a knowledge-based approach (involving for example object dimensions to be found for identification purposes) and a statistical approach (statistical criteria to be defined). Some methods of pattern recognition applying ML or an ANN are presented in (Uraikul et al., 2007).

There are a lot of applications based on pattern recognition. The following paragraph briefly presents an example aiming in understanding human intuition by means of AI pattern recognition. In Frantz (2003), the author describes his ongoing research w.r.t. the question if human behavior such as decision making, way of thinking and creativity is just mysterious or analytic and describable by pattern recognition. Frantz (2003) performs a comparison study between his own findings and those of the expert Herbert Simon. Herbert Simon presents a lot of studies covering different fields such as AI, decision theory, psychology, cognitive science, and organization theory, and these studies are based on the human mind and human thinking (Frantz, 2003).

To summarize: The pattern recognition field is basically focusing on and explaining the requested pattern, and ML tends to focus more on increasing the recognition rates. Both of them cooperate a lot and are increasingly involved in AI and statistical approaches. The pattern recognition algorithm can be divided into either supervised or unsupervised or in another way to either statistical or non-statistical.

2.4 NEURAL NETWORK

The neural network simply means a network of electrically built cells called neurons. A modern subgroup of a neural network is an Artificial Neural Network (ANN) which consists of artificial neurons (Hopfield, 1982). The original idea of neural networks was to imitate the processes occurring in the human brain by using some microchips. These microchips consist of artificial neurons that are internally connected and that communicate with each other for data exchange. In general, a neural network can be distinguished as either a ‘biological neural network’ which deals with biological neurons or an ANN which is used as

an AI solution. The ANN is a computational structure of artificial neurons that are interconnected and arranged in layers and provide the connection between the inputs and the outputs of the system through certain algorithms (Ashok et al., 2016). The interconnections between artificial neurons and the type of network topology are the key elements influencing the ANN behavior (Hassoun, 1996). Modern developments in the field of ANNs are for example so-called Generative Adversarial Networks (GAN).

There are a lot of ANN-based approaches to apply AI technology, especially in fault detection, diagnosis, and control systems. An important study was written by Cubillos and Lima (1998) where they presented a hybrid system using knowledge and a neural network to implement control strategies based on the related so-called fuzzy parameters. Another study was presented by Tsai et al. (2003) that investigated process control in chemistry applications. The authors achieved to model a predictive control architecture and analyzed dynamic artificial neural network models. Another interesting study was done by Power and Bahri (2005) as they presented a two-step supervisory fault detection system based on neural networks, to identify the exact location of faults to solve the problem with high efficiency.

A neural network can be found in different applications. Four exemplary groups of applications are considered hereafter: The first group is Character Recognition where the neural network is used to recognize handwriting as a useful example. The second type of neural network-based applications is Image Compression and Recognition as the neural network utilizes and processes the piles of information data leading to encouraging results. Stock Market Prediction is the third group of neural network applications as the neural network method can use the market information and history to predict the right time of fall/rise price and the amount of product consumption. Finally, there are a lot of successful solutions given by neural networks in the fourth group of applications, namely Medicine and Security systems (Ashok et al., 2016).

2.5 GENETIC PROGRAMMING (GENETIC ALGORITHM)

A genetic algorithm can be defined as a search algorithm based on a certain mechanism that leads to natural selection comparable to processes in genetics. Genetic algorithms are considered as a major field of AI. The procedure of genetic algorithms is repetitive in order to keep certain structures as candidate solutions for the problem of interest. Each generated structure in any domain is built based on certain genetic operators (i.e. reproduction and mutation) and then analyzed for the final assessment based on criteria such as effectiveness (Oke, 2008).

There is a lot of research concerning the importance of AI and genetic algorithm and their grown relation between them. Turney (1994) presents a very good study about Inexpensive Classification with Expensive Tests (ICET) as an ideal example of a genetic algorithm-based AI approach. In this study, the author investigates an approach to "balance the costs of various possible medical tests with the expected benefits of the tests for the patient." (Turney, 1994). The ICET applies a genetic algorithm to develop a so-called decision tree induction algorithm, and the author shows a comparison with another four classical algorithms in regard to cost-sensitive classification (Turney, 1994).

2.6 KNOWLEDGE REPRESENTATION

Knowledge Representation (KR) is a very important approach in modelling knowledge and providing an easy access to stored data. The basic idea is to develop models that collect information about a dedicated topic or area of interest in order to solve complex problems within that field. For example, a KR can help to diagnose a medical condition based on certain knowledge data. There are even examples where a small knowledge base leads to highly qualified and powerful services (Franklin, 2003).

Exemplary research related to KR can be found in (Calvanese et al., 1999; Cadoli et al., 2000; Kusters and Borgida, 2001).

3 EXEMPLARY APPLICATIONS IN SCIENCE, SOCIETY, AND ENGINEERING

This chapter considers exemplary applications of AI in different fields of science, society, and engineering. This involves, e.g., speech recognition, also in combination with intelligent home appliances affecting our daily life. Furthermore, image processing is an important field of application: For example, AI is used in modern cameras, television, object detection, and image reconstruction. In the medical sector, AI helps e.g. to provide optimal medical treatment and to model biological processes with better understanding. In the industrial sector, intelligent so-called predictive maintenance is possible, and logistics can be optimized. AI is also beneficial in the banking and business field, e.g. supported by intelligent cybersecurity approaches. AI has also become established in the creative sector impacting arts, gaming, and music. Last but not least: Many applications of AI are of course related to engineering in general, e.g. to robotics, energy, and the automotive sector.

3.1 IMPORTANT TECHNOLOGIES

While chapter 2 has considered theoretical approaches related to AI, section 3.1 deals with important resulting technologies, namely with speech recognition, smart sensing, smart image processing, classification and predictive maintenance. Of course, these technologies can be used in different context: for example, image proessing may be used in engineering applications, but also in medicine. Therefore, the subsequent section 3.2 will then have a look into dedicated fields such as science, society and engineering.

Speech recognition

Speech Recognition is applied in many devices (such as Amazon's Alexa, The Google Assistant or Apple's Siri). The technologies typically work very well for special applications based on human instructions ("switch on the radio", "navigate to ..", "tell me the weather", "put s.th. on the shopping list"). Of course, the idea of a system that understands a deeper meaning or the sense outside a dedicated task is a challenge (Sivadasan, 2008), but there is continuous progress and evolution in this approach. Modern applications of speech recognition are speech assistants in cars (Ingenieur.de website, 2020).

Smart sensing in intelligent home appliances

The idea is that advanced home appliances automatically optimize the desired result by the means of intelligent sensing and/or AI. In many cases, optimizing the required resources is a necessary constraint. An example is an intelligent washing machine that recognizes the laundry (e.g. weight, colors) and automatically chooses the correct washing program to save time and resources (Ingenieur.de website, 2020). Another example is an autonomous vacuum cleaner which remembers the local distribution of dirt to adapt the intensity of cleaning in the future (Ingenieur.de website, 2020).

Image processing

An important area of AI applications is Image processing. Some selected applications involving AI are described hereafter:

An important application is computer vision: Hereby, digital images (or arrays of images) taken by a camera are analyzed and processed to extract relevant information. Computer vision plays a significant role in robotics, but also in the field of self-driving cars, enabling navigation or recognition of objects, persons, etc.

Another example related to AI in image processing is the upscaling of images: The image resolution is improved by intelligent extrapolation of the available data. Hereby, the actual image is compared to millions of reference patterns in order to apply a dedicated formula for upscaling. For example, this procedure is applied to generate a computational 8K resolution for an image with lower quality (Ingenieur.de website, 2020). An exemplary contribution related to image upscaling can be found in Sharmila and Leo (2016). Upscaling is e.g. used in television: In Samsung Newsroom website (2020), Samsung reports about the capabilities of the Q950's next-generation Quantum Processor 8K in modern TV, featuring for example:

- improved AI upscaling based on ML
- Object Tracking Sound+ function, an AI-based technology which "matches the movement of audio sound with the movement of objects on the screen" (Samsung Newsroom website, 2020)
- AI ScaleNet function, a method which optimizes the available network bandwidth to ensure a smooth streaming connection

Further applications of AI in the field of image detection and processing are AI-powered cameras (Analytics India Magazine, 2019): These cameras may for example support upscaling, a special night mode in a low-light environment, or scene detection which means that only the best photo is taken out of a set of photos. According to Analytics India Magazine (2019), exemplary mobile phones with AI cameras are Google Pixel 3, Huawei Honor 10, Samsung A50, iPhone XS Max, OnePlus 7 Pro, Vivo V15 Pro, and Oppo R15 Pro. In modern mobile phones such as the Samsung Galaxy S20 (launched February 2020 in Germany), AI is also used to perform motion analysis for video stabilization (Zou et al., 2019).

A further application of AI in the field of image processing is face reconstruction based on a poor-quality image, e.g. taken by a security camera at airports or railway stations (Railway Technology website, 2017). In the latter use case, this can help authorities to find dedicated or missing persons.

Another application of AI related to image processing is the possibility to perform colorization of black and white photos based on deep learning: To train the AI algorithm, a large set of reference black and white photos is used where the corresponding color information is available. As a result, the reconstructed colors can be compared to the original ones. The delta between original colors and reconstructed colors is then used to optimize the estimation process. The website https://demos.algorithmia.com/colorize-photos offers the possibility to upload private black and white photos and to download the colorized versions. The applied deep learning algorithm is described in detail in Zhang et al. (2016). Concurrent work can e.g. be found in Larsson et al. (2016). Fig. 3 shows an exemplary colorization of a photo: Original and reconstructed colors are very similar.

Colorization of black and white photos can also be combined with an AI-based reconstruction of a poor quality image: Hereby, details of the original scene are estimated (e.g. details of a face) although the relevant information is only partly available: Since 2020, such a service is offered at the MyHeritage website for paying customers, leading to amazing results.

Finally, AI is also used in image search: By means of intelligent classification, the AI application may browse the world wide web or a database to provide similar photos based on a dedicated uploaded photo. For example, search engines such as Google support this function. Furthermore, in November 2018, the German eBay app has added a function that

allows users to upload a photo and eBay will search for comparable products. This function applies to image recognition based on ML (Ebay Press Room, 2018).

Figure 3: Exemplary colorization of a photo by applying the algorithm as per (Zhang et al., 2016): three pictures: the original in colors (on top), then a converted version in black and white (middle photo) as an input to the colorization process, and finally the photo with reconstructed colors (last photo).

Smart classification of documentation

The idea of smart classification of documentation is that an AI approach reads (e.g., unsorted) documents and performs identification and/or categorization. For example, available clinical data from the past can be sorted (IBM website, 2020), evaluated, and used to improve medical treatments for similar actual patients. Another example is the legal environment: relevant judgments for an actual case are found by an AI-based smart classification system which helps lawyers and judges to get a better idea of strategy. However, the results have to be checked in detail as they rely on the past and may not be compatible anymore with recent developments in the case of law. There is also the danger

that hidden discrimination of social groups that may have occurred in the past is applied again by the algorithm (Deutsche Welle, 2019).

Classification of documentation can also be combined with speech recognition: In a first step, voice commands are recognized and translated into text. In a second step, an AI algorithm performs a classification of documentation based on the text. An exemplary application is the production environment: An employee working in the production line may for example search a dedicated installation guide. Instead of searching it manually, he speaks to a "smart glass" which finds the required document automatically and may display its content. (Elektrotechnik Automatisierung website, 2019). A manual search is hence not required anymore which helps to increase efficiency.

Predictive maintenance

The idea of predictive maintenance is to monitor the health (in the sense of the status) of a technical system (called condition monitoring) by dedicated parameters, to analyze the collected data (data analytics), to derive the health status by an AI algorithm, and to issue a maintenance of the system in case of an anomaly before the system fails. Hereby, a technical system can be for example a dedicated machine, a driving train, or a production line. Exemplary parameters for assessment can be the voltage, temperature, pressure, or acoustic information. For example, anomalies may result in the generation of heat or additional noise. In the production environment, predictive maintenance helps to both increase the reliability and to minimize the corresponding downtime/repair time. (Elektrotechnik Automatisierung website, 2019).

3.2 APPLICATIONS IN SCIENCE, ECONOMY, AND SOCIETY

The subsequent consideration presents some actual applications of AI in science, society, and economy. Considering science, exemplary applications in the medical sector and genomics are shown. Regarding the economy, the impact of AI in logistics and banking is considered. Finally, some applications of AI are described that affect cultural life and leisure behavior: AI in arts, music, and gaming.

Medical applications and healthcare

An exemplary application of AI in this field is the prediction of the spread of a virus: Hereby, an algorithm automatically collects dedicated information about the actual occurrence of a virus in reports, networks, etc. to get the actual status. This information is used to feed prediction models and to generate warning notices for authorities. As a consequence, countermeasures can be undertaken to limit the spread of the virus (Tech News website, 2020). A well-known algorithm in this field is the so-called BlueDot algorithm. Currently, the prediction of the spread of the Coronavirus is of great interest. Coronavirus (Covid-19) started to spread worldwide possibly at the end of the year 2019 and extended more and more as a pandemic in 2020. Researchers and some scientific institutes started to apply AI-based techniques to predict where the virus will spread and how long it will take; the idea is to instruct an early alarm for this threatening virus spread. Relevant AI studies are based on the obtained information from online sources, medical reports, and the World Health Organization (WHO) numbers. These studies rely on the SARS virus spread in the 2000s which killed 774 people all over the world (Time website, 2020).

Another important application in the medical field is the Blue Brain project which has been founded in 2005 in Switzerland. A result of this project was to model about 11% of the total human brain (85.9 billion neurons) in a supercomputer based on the AI state of the art (Markram, 2006; Eliot, 2009). This project has opened the way for further medical studies and applications based on AI technologies.

Further applications in the field of medicine are for example the detection of skin cancer by AI-based dermatologic image analysis (Reiter et al., 2009). In the biopharmaceutical field, AI is applied in drug discovery (Nature website, 2018). Finally, AI is also applied to derive clinical diagnoses or to suggest treatments. The latter two topics and further medical applications are described in more detail in (Chan et al., 2018).

Genetics

In the field of genetics, AI has become an important method to understand relevant processes that help for example in health surveillance and therapy, but also in genealogy. Science Daily website (2019) reports about research in genomes (genetic material of an organism) and the discovery of a new hominid that had once lived in the past; this conclusion was derived by combining both a deep learning and a statistical approach.

Emerj website (2019) gives a good overview of current AI applications based on ML in the field of genetics. In so-called genome sequencing, two strategies can be distinguished: the first has an emphasis on research to achieve for example progress in individual therapies and to understand an individual risk of disease. A second strategy is to focus more on the business case: For example, analysis of individual DNA for paying customers lets them know about the genetic impact on weight (Emerj website, 2019). Further applications are the prediction of so-called pattern changes in DNA structures by deep learning (Zou et al., 2019).

In the field of genealogy, a DNA analysis can help to understand the personal origin, e.g. in the sense that it is estimated how typical the DNA would be for certain geographical regions in the world. Hereby, the group of people in a certain region is called an ethnicity. Hence it can be estimated in which parts of the world the ancestors may have lived. To derive such a conclusion, individual results are compared to the results of reference persons with typical patterns of a certain geographical region. By applying this process, the personal distribution of ethnicities is revealed. By mapping individual results with those of other people who have done a DNA test, so-called DNA matches can be found. In the case of a DNA match, the probability is high that there is a common ancestor.

Companies such as MyHeritage or Ancestry offer a dedicated service showing, among others, both the individual ethnicities and DNA matches. Ancestry Support website (2020) provides a link to dedicated white papers explaining the applied methodologies. In a typical case, several thousand DNA matches are found nowadays. Of course, the number of DNA matches depends on the number of users that have done a DNA test. Furthermore, the degree of relationship is estimated (e.g., father, mother, uncle/aunt 3rd grade, etc.). As users can also upload a public family tree, this information simplifies the identification of the common ancestor. It is also possible to include relevant family trees of other users into the own tree and to upload and share additional information (e.g. old photos and documents). All these functions contribute to deepen the knowledge of the family roots. Typically, a smart algorithm supports the users in finding relevant family branches to be included into a family tree. This is done by comparing the individual tree to other trees. MyHeritage service also offers the possibility to improve old black and white photos: AI algorithms improve the quality, detect faces, estimate missing information, and apply colorization.

Logistics

AI is also applied in logistics. It helps to ensure smooth processes, to optimize cost, efficiency, safety, and customer satisfaction. Towards Data Science website (2019) gives a good overview of current applications, projects, and involved companies in the field of AI-supported logistics. For example, Towards Data Science website (2019) considers automated warehousing: Hereby, an AI approach estimates the required number of goods in different warehouse stocks which optimizes the transportation effort between the warehouses. In a warehouse itself where workers (so-called pickers) have to find ordered goods, AI can be applied to guide the pickers, to optimize the route and time. SSI-SCHAEFER website (2018) describes a dedicated approach applied at Zalando company.

Another field of application is autonomous vehicles for good transportation in indoor or outdoor environments. Inside a warehouse, these autonomous vehicles can be equipped with appropriate sensors and devices for navigation purposes. If all vehicles communicate with each other and share relevant information such as actual position and operational capability, an AI approach can be applied to make decisions based on optimization goals. For example, the swarm can decide which vehicle will move to a destination of interest while optimizing the required time or the length of the route (SSI-SCHAEFER website, 2018). Considering outdoor scenarios, another idea related to logistics is a smart transport route that supports the driver or the vehicle itself as a function of environmental conditions. Exemplary ideas described in (Towards Data Science website, 2019) are the provision of locally generated power or assisting lights as a function of brightness.

Banking

An overview of actual AI methods applied in banking is e.g. given in Der Bank blog website (2020). According to Lionbridge website (2020), AI in banking is applied in the following fields:

- Customer analysis and interaction: Hereby, banking customer behavior is analyzed to offer e.g. a tailored investment portfolio or credit. This can be realized by a dedicated chatbot.
- Automated trading: This helps to optimize the profit.

- Optimization of banking processes: This application can perform an automatic compilation of required or missing documents, e.g. for completing administrative processes. This helps to minimize the workload on the employee's side.
- Prediction and estimation: This topic concerns the prediction of the default risk on loans and the estimation of the profit opportunities.
- Fraud detection: Fraud detection means to identify attempts that intentionally manipulate banking processes. This is a very important application of AI in banking, e.g. based on ML (Der Bank blog website, 2020).

Arts

AI can be used in arts to generate paintings in a specific style, e.g. by imitating famous painters based on deep learning. To generate the painting, also robots can be used. An actual painting robot project is called "Artonomo.us" (Cloud Painter website, 2020). This robot first selects an image to paint, then applies a dedicated style based on various AI methods, and finally starts the painting process.

Music

A further application of AI is the composition of songs. For example, Sony's "Flow Machines" applies ML and has created the song "Daddy's Car" based on Beatles songs (Stay Relevant website, 2017). Another example is the technology developed by the AIVA company. The AIVA software can compose soundtracks of different styles (Stay Relevant website, 2017) such as Electronic, Pop, Rock, Jazz, and classical music. Concerning classical music, tens of thousands of musical scores written by the most popular composers (such as Mozart, Bach, and Beethoven) have been used to train the algorithm. Applications of AIVA outputs are for example soundtracks for films and video games. To get a better idea of the results, exemplary songs have been uploaded on "YouTube". AIVA is also the first virtual artist whose songs have been registered with an author's rights society (SACEM).

Gaming

According to AITHORITY website (2020), the application of AI in gaming aims at providing a realistic gaming experience in a virtual environment. This can e.g. be achieved by virtual characters that behave in an intelligent way, that learn from experience, adapt their strategies to achieve a certain goal, and/or compete with the player's skills (Wikipedia website, 2020). The application of AI in gaming can lead to matching actions, reactions, or

responses, e.g. expressed by an emulated human voice. As adaptive behavior is a key element in nature, games emulating such a world are seen as realistic. The degree of challenge rises to a higher level when applying such an AI approach. This also leads to a higher level of satisfaction for the player (AITHORITY website, 2020).

However, AI in gaming is not limited to the idea of simulating a smart behavior. The scenery itself should appear in a realistic way as well. This can be achieved by an AI deep learning algorithm that learns from real-world photos or videos (The New Stack, 2020). For example, real-world driving sequences can be used as training data to generate a virtual ride in a computer game (The New Stack, 2020). According to Synced website (2020), future games will collect visual information of the player (such as emotions) as an input to derive a matched response. Furthermore, classical controllers such as joysticks enabling the interaction with the virtual scene will be more and more replaced by interaction through human voice and physical movements.

3.3 ELECTRICAL ENGINEERING, ROBOTICS AND IT

In the field of engineering, there are plenty of applications related to AI. The following paragraphs focuses on exemplary fields related to electrical engineering and information technology (IT), namely automotive, energy and power, robotics, and cybersecurity. Basic ideas and relevant applications are shortly presented.

Automotive

AI is widely applied in the automotive sector. For example, this concerns both the development of a vehicle itself (e.g., AI is applied in the design and manufacturing process) and the realized driving behavior. In addition, AI-based simulations can mimic realistic driving situations and help to test and optimize the driving behavior prior to any physical test that involves a vehicle on the road.

Nowadays, the development and the production of a vehicle is often supported by AI. Benefits are, e.g., rapid prototyping (Global Market Insight Website, 2020) and an improved efficiency in the production line. For example, involved equipment in the production line is constantly monitored (VHR Company website, 2020), and AI algorithms realize predictive maintenance in the production line to optimize efficiency, time and cost. Built In website (2020) mentions an approach based on ML where the normal behavior of a machine is

learned as a reference. Built In website (2020) also reports about another application of AI in the production line: Collaborating robots (so-called co-bots) are able to replace humans in case they are absent to due illness etc.

As already mentioned, the smart behavior of a vehicle is often realized by AI. For example, modern vehicles are equipped with many sensors that collect relevant information as an input to driver-assistance systems. Exemplary driver-assistant systems using AI are driver behavior monitoring (e.g., eye tracking), road condition awareness, and lane tracking (Global Market Insight Website, 2020). They help to make driving more safe and enjoyable. These systems often use AI to make decisions based on the sensed data applied in the algorithm. As the number of involved sensors is constantly growing in modern cars, it is also important to efficiently process the resulting "big data" within short time. This is achieved by AI approaches (Benčić et al, 2018). Benčić et al. (2018) also provide an overview of AI trends in the automotive sector based on an actual patent analysis.

In case there is no driver anymore (self-driving car), AI plays a more dominant role compared to state-of-the-art vehicles. The applied AI has not only to assist, e.g. to prevent human driving errors, but it has to understand the driving situation in a way that road casualties are rather zero. Hence, the AI does not only mimic human behavior, but the obtained performance has to be better. Typically, the involved solutions make use of deep learning to train neural networks (VHR Company website, 2020; Global Market Insight Website, 2020). In self-driving cars, the observation of the vicinity of a car is a key task and realized by dedicated technology. According to Teslamag website (2020), e.g. Tesla does not make use of LiDAR (Light Detection and Ranging) or high-resolution maps to realize self-driving capabilities but relies on cameras. By continuous learning, false alarms are minimized over time. The actual Tesla Autopilot engine includes 48 neural networks (Heartbeat website, 2020), where each network solves dedicated tasks. As Tesla relies on cameras, computer vision plays a significant role. In 2019, Tesla has e.g. acquired DeepScale which is a start-up from Silicon Valley involved in Deep Neural Network technologies and computer vision. Electrek News website (2020) reports that the acquisition of DeepScale pays off, advances the development of the Autopilot, and has led to a dedicated patent called "Systems and Methods for Training Machine Models with Augmented Data" in April 2020 (Cooper et al., 2020).

Finally, some applications in the field of simulation are considered. As already mentioned, vehicle simulation is an important element to virtually test the capabilities of AI-based vehicles. For example, a virtual time-varying scenario can be created involving possible situations such as passing pedestrians, traffic, etc. Both the generation of the scene and the situations may be supported by AI as well, e.g. based on deep learning methods. In this context, the Automotive Artificial Intelligence website (2020) mentions an AI-trained traffic agent populating the streets. By involving sensor simulation, the software applied in the vehicle can then be tested in the virtual world (Automotive Artificial Intelligence website, 2020). A good example of such a type of software is recognition software that detects traffic signs, obstacles, traffic participants, lane changes, etc. (Global Market Insight Website, 2020). An exemplary company involved in traffic and scenario simulation, as well as sensor simulation, is Automotive Artificial Intelligence (AAI) (Motor Zeitung website, 2019): The virtual ride also encompasses traffic participants with different types of behavior involving aggressive and dangerous overtaking so that the software under test can learn from these situations. It is also possible to simulate different road conditions. By applying simulation-based virtual rides, much effort can be saved regarding the subsequent physical testing on the road. This helps to speed up development processes (Motor Zeitung website, 2019).

Energy and power

In the field of energy and power, AI is applied in planning, control, operations, automation, and analysis.

- As a starting point, planning processes are considered that require information about energy consumption and energy generation as a necessary input. In the recent past decades, AI-based models have been widely applied in the forecast of energy consumption. Basically, AI-based models are separated into either ANN-based models or co-called Support Vector Machine (SVM) based models. An innovative grid optimization approach based on an ANN is for example described in (Wenzel, 2019). The results in Wei et al. (2019) show that the AI-based models are very robust and comprehensive in the investigated forecast scenarios (called forecasting horizons). Hereby, a forecasting horizon may be a short-term or a long-term prediction. According to (Wei et al., 2019), the robustness is achieved due to

an evaluation process between the models' performance in various forecasting horizons.

Of course, forecasting the energy consumption is not the only application of AI in the field of power. Slideshare website (2017) presents an overview of further applications: AI is applied in a variety of fields involving e.g. planning of power systems, operations, and control.

According to Sivadasan (2008), planning issues involve e.g. an optimized positioning of a wind turbine, optimization of feeder routing, and a smart reactive power control. The latter task can be achieved by dedicated placement of compensation devices to realize the required voltage profile (Bansal et al., 2003).

- In the field of control, items to be controlled are e.g. voltage, voltage stability, power flow, and load frequency.
- In power operations, AI is e.g. applied to minimize power losses, to perform load management, and to control Flexible Alternating Current Transmission Systems (FACTS) (Sivadasan, 2008).
- Slideshare website (2017) also mentions the automation of power systems as an application of AI: Hereby, AI is e.g. beneficial in fault analysis, predictive maintenance, and network security.
- According to Slideshare website (2017), AI is even applied in the electricity market, e.g. to derive optimal strategies for bidding and market analysis. Finally, AI can also be beneficial in the field of technical analysis, helping e.g. to minimize harmonic distortions (Sivadasan, 2008).

Robotics

Nowadays, the world sees some millions of operating robots where many of them are already based on AI approaches. In a production line for modern cars, robots are typically involved in about 80% of the manufacturing steps with marvelous results (Ashok et al., 2016).

As already mentioned, computer vision plays a significant role in robotics enabling the understanding of the environment, safe navigation, and recognization of objects and persons. RSIP Vision website (2020) gives a good overview of different applications of robots supported by AI. Industry robots are e.g. applied in warehouses and often perform so-called “pick and place” tasks (Electrek News website, 2020) or even collaborate with

humans (co-bots). In the semiconductor industry, (visual) defect detection of a component is a further possible task (Electrek News website, 2020). In agriculture, robots assist e.g. in navigation and proper growing and sorting of agricultural products (Electrek News website, 2020).

There are also AI-based robots designed to look like a human: They support and interact e.g. with customers in supermarkets (Electrek News website, 2020), with patients in hospitals (Electrek News website, 2020), or senior living homes (Time website, 2019), and even with guests in restaurants. In restaurants, chat-bots can be applied to support the customer in the selection and ordering process and for entertainment issues (World Economic Forum, 2019). For example, the fast-food chain KFC even applies face recognition so that information about last orders can be used for the service.

In senior living homes, robots can e.g. be beneficial to bring meals or to alert the nursing staff in case of an identified danger or problem. For example, a robot with voice detection capability could be able to understand a call for help (Time website, 2019). Robots in senior living homes can also be applied for entertainment purposes: If a robot is able to recognize persons, it could play the person's favourite music or game. In case the robot can recognize emotions, this information might be used to recognize the person's needs. Another possible function is to utilize a mobile humanoid-looking robot in a videocall: The robot can replace its displayed face by the caller's face (Time website, 2019). Such a function is very beneficial when visits are not possible, restricted, or not recommended, e.g. due to the risk of an infection (e.g., Coronavirus) threatening a senior's life.

Cybersecurity

In the field of cybersecurity, AI plays an increasing role in defending systems against adversaries. On the other side, adversaries might apply AI as well (e.g. for attacking purposes), leading to a competition at a high level. Brookings Institution website (2020) and Babuta et al. (2020) provide interesting insights into current applications and dedicated challenges, involving both technical and political considerations.

According to Brookings Institution website (2020), defending applications typically involve ML methods to detect threats and to initiate dedicated countermeasures. When this defending process is done automatically, such an approach avoids time-consuming human interaction (ZD Net website, 2020) and the decision-making processes. Of course, such an approach has its pros and its cons: On the positive side, attacks can be stopped faster

(Babuta et al., 2020) limiting the possible damage compared to a delayed response. Furthermore, the application of ML can e.g. also detect variants of malware (ZD Net website, 2020). On the negative side, when AI takes over more control, systems to be defended are more vulnerable in case that the AI of the defending system is manipulated by adversaries. This could be applied in a so-called adversarial ML (Brookings Institution website, 2020; ZD Net website, 2020). In such a case, altered training sequences may be used to provoke wrong decisions, e.g. to cause a car accident (Brookings Institution website, 2020). Another exemplary application of AI in the field of cybersecurity is AI-based network monitoring: Hereby, users' behavior may e.g. be studied by ML as a reference to identify relevant changes in the behavior that may cause a threat (e.g. clicking on a phishing link) (ZD Net website, 2020).

4 APPLICATIONS IN COMMUNICATIONS

The relationship between AI and communication networks has a long history although dedicated applications have become very popular only in recent years. The roots of this relationship can be found in the 1980s and are linked with ANN theory that became famous worldwide with its first important applications at the start of the 2010s (Charzinski 2019). Nowadays, in Germany, there are about 45 million active subscribers within the German mobile communication network operators such as Telekom, Vodafone etc. (Charzinski 2019). Mobile networks deal with much data traffic and complex connections as there are about 840 mobile network operators in the world with a lot of challenges to be considered and solved to realize proper processes. Meanwhile, AI technology has become an excellent solution to realize modern functions and use cases in these mobile communication networks.

AI technology has taken a leading role in the revolution of the communication industry during the last decades as it has helped to add new services and to increase the network efficiency (Xu et al., 2017). In addition, AI is beneficial to realize autonomy in communication networks, e.g. to identify anomalies (for example interference) and to resolve them without human interaction. AI is also helpful to realize the required high data rates in modern mobile networks, for example by smart spectrum sharing AI approaches. Also in planning processes of mobile networks, AI is an advantageous method to predict data traffic (Otani et al., 2017).

The fast revolution of smartphones and the worldwide spread of mobile applications forced the industry to develop and update the wireless networking infrastructure (Zhang et al., 2019). The modern 5G systems are specially designed to cover the huge required mobile traffic volume, to manage the network resources softly, and consequently to be compatible with the rise of mobile users' expectations.

The advanced ML techniques are one of the practical solutions to achieve these goals in mobile environments that are increasingly complicated, diverse, and gradually developed (Zhang et al., 2019). Zhang et al. (2019) provides a summary of deep learning applications for mobile devices and systems as a survey paper. In this context, the paper also considers benefits, limitations, applied techniques within different deep learning approaches, applied optimization methods as well as architectures related to deep learning. For example, deep

learning has the potential to achieve an “appropriate balance between accuracy, latency, storage and energy consumption for deep neural networks on mobile platforms” (Zhang et al., 2019). Storage issues typically occur when “big data” streams contain similar content: A deep learning approach is helpful in identification of these situations.

There are plenty of deep learning-based applications in the mobile networking field, and the most common advanced applications can be summarized in Fig. 4:

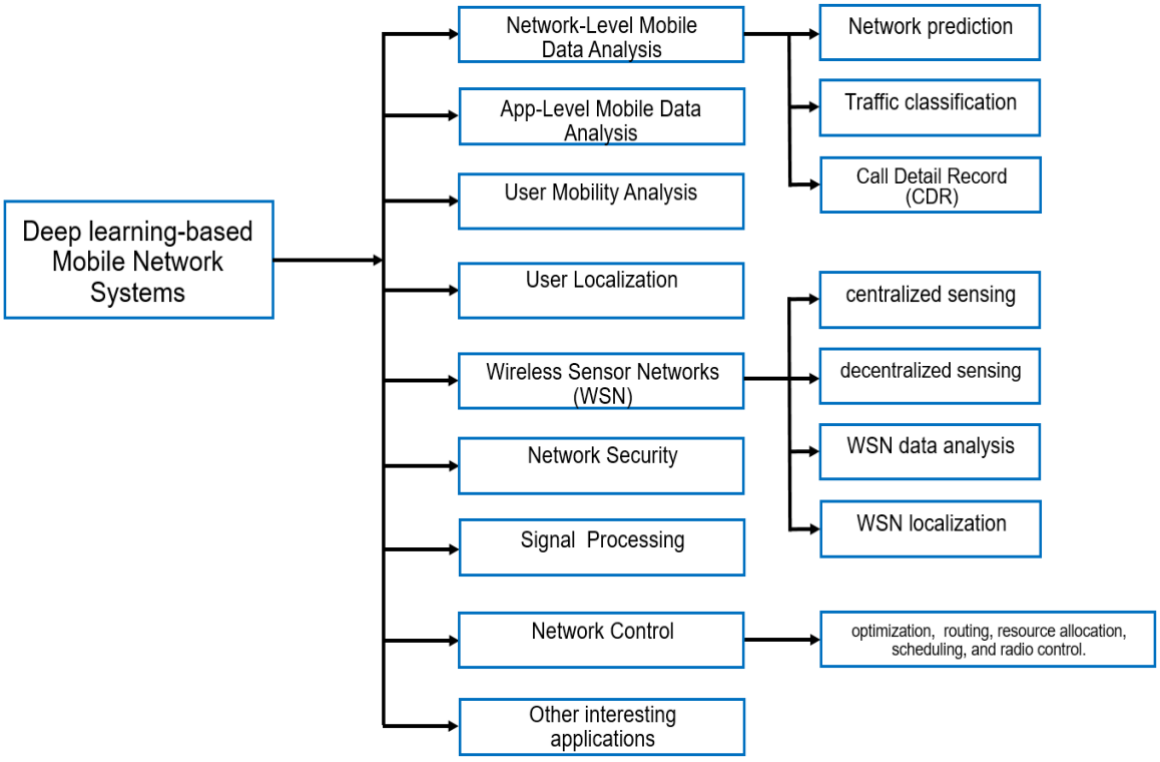

Figure 4: Deep learning – based Mobile Network Systems

Network operation also benefits from AI approaches. Some selected work revealing the advantages is shortly presented:

Kojić et al. (2006) suggested the optimization of routing in communication networks through the implementation of neural network technology. In another study, AI technology was applied to manage routing protocols in communication networks using a Software-defined Networking (SDN) (Sendra et al., 2017). Another work (Sui and Jin, 2011) presented an AI-based approach to control the possible reduction of quality of service in a network (called network congestion). AI technology can also provide a practical solution in communication networks based on the collaboration between the SDN and the Network Function Virtualization (NFV) as they behave as AI tools in reasoning, learning, networks service, and deep packet inspection (Xu et al., 2017). In recent years and parallel with the

huge development in AI technology, a lot of communication network operators have started to implement AI methods due to the ability to decrease capital expenditure and operating expense (Xu et al., 2017).

As mentioned above, another important aspect in modern mobile communication networks is the capability to realize high data rates. Increased data rates can typically be realized by an increased bandwidth, but bandwidth is physically limited and expensive. Therefore, smart AI approaches apply for example spectrum sharing to cope with minimum resources. Some theoretical background and an exemplary AI approach are considered in more detail hereafter:

AI can be used to optimize spectrum sharing in wireless communications between a set of wireless devices. Traditionally, wireless technologies use fixed, allocated frequency bands to avoid mutual interference. A better approach is the idea of frequency-hopping where frequencies are changed over time which can help to exploit the unused spectrum and to avoid interference. Hereby, an algorithm defines the frequencies over time. However, the performance of the frequency-hopping approach is limited by the availability of unused spectrum (Tilghman, 2019). When all involved devices transmit data, the overall achievable data throughput is not maximized by the frequency-hopping approach. To increase the overall throughput (optimization goal) while avoiding interference, dedicated approaches are described in Tilghman (2019): One approach applies dedicated AIs for the different involved radios, and each AI continuously adapts its own rules to target the overall optimization goal. Tilghman (2019) describes this process as an “evergrowing series of rules by mining them from a large volume of data”.

5 TRENDS AND FUTURE APPLICATIONS

AI is applied in many fields, and in each field, ongoing progress leads to specific trends and possible future applications. Some of them have already been considered in the previous sections. However, for the sake of clarity, the aim of this chapter is not to list all the trends. Instead, the authors would like to share some ideas and considerations related to an exemplary field of application, namely the intelligent home appliances.

Having experience with intelligent home appliances currently on the market, some upcoming ideas were spread among the team of authors that are shared hereafter: As progress normally never stops, the authors think that it's rather a question of time when the next generation's intelligent home appliances will be available, combining at least already existing technologies in the field of AI to form a hybrid system. One idea shared in the team could be called the "preserved personality":

The vision starts with a device installed at home which is able to recognize a specific person, e.g. based on speech recognition. This is already possible, e.g. with Amazon Alexa. The goal of the device could be to learn the specific behavior of a person so that elements of the personality are preserved over time. By means of AI, imitation of the personality would become possible, and the device could be applied as a dialogue partner although the real person is absent. The possibility to hear the voice of a loved one in a known way may be beneficial for many persons. Furthermore, future generations of mankind could have an impression of the personality of their ancestors. The device would have to learn specific elements of a person's behavior such as speech, typical vocabulary, pronunciation, or emotional reactions from speech in the context of specific situations.

Such an approach based on speech recognition could be combined with advanced image recognition (hybrid device): In case the device is equipped with a camera, the device could perform image detection to recognize different persons and in parallel, it could study the behavior of each person. The latter case means to learn typical movements and the body language. For imitation purposes, a virtual person could appear on a display, or a hologram could be generated during conversations. Dedicated technologies could be applied to generate the required movements that are synchronized with speech: Relevant algorithms are already in development. Some relevant background and actual possibilities to distinguish virtually generated persons and real existing persons are for example described

in (Nguyen et al., 2019; Tolosana et al., 2020). To save changes in behavior over time (e.g. related to childhood, youth, etc.), the hybrid device has to generate several big data sets that cover the corresponding age groups. Of course, the ability to preserve and imitate a personality has its advantages and disadvantages:

- For private use, the hybrid device as described above might be beneficial to keep the memory of family members.
- On the other side, an access to people outside the family is not recommended as this would offer the possibility to know details about private life based on big data, e.g. obtained over a long time.

Similar ideas have currently been published for example in (Daily Sabah website, 2020), describing a “digital twin”, also called a digital avatar.

Last but not least, this chapter summarizes some trends related to AI: According to Forbes website (2020), more and more AI will be applied in more and more devices in the future. Some AI will interact with us, but we will not necessarily realize it. Examples where AI already interacts with people are personalized results originating from search queries in the world wide web, personal assistants such as Amazon Alexa, or chatbots in digital customer services. In future, the role of AI will become more dominant in films, music, and games (Forbes website, 2020): For example, the film “The Irishman” (year of publication: 2019) shows a de-aged Robert de Niro. Hereby, special effects have been applied based on AI (Forbes website, 2020; Vulture website, 2020).

Exemplary literature describing trends and possible future applications related to AI can be found in Forbes website (2020) and Techiexpert website (2019).

6 SUMMARY AND CONCLUSION

The paper has presented fundamentals related to AI to provide a basic understanding of classical and modern approaches. Hereby, some modelling approaches have been discussed. In the next step, the importance of AI technology has been highlighted by showing a variety of applications in science, society and engineering with some emphasis on communications. Finally, the authors have suggested a new hybrid device combining speech and image recognition that can easily be installed at home and can affect the daily life in a positive way.

As a conclusion, there are versatile applications of AI in both technical and non-technical context. AI is not only applied in science and engineering, but it also affects e.g. economical and legal decisions. It even impacts the daily behavior of persons as well as their decisions, although they may not expect a hidden guidance by AI: Some decisions may already be taken based on AI-supported search results or the presentation of products on a website. The behavior and way of thinking may be impacted by content proposed by AI, e.g. in social networks or streaming portals. And finally, it should not be forgotten that also the date matching industry already applies AI (Synced website, 2019). These examples show that AI plays a significant role in modern life. This guidance leads to amazing advantages in particular fields such as engineering, but the negative side should not be neglected.

ACKNOWLEDGMENT

We would like to express our special thanks to the review team for discussion and feedback. In addition, we thank our family members for their backing during the last weeks.

REFERENCES

Acid, S., & de Campos, L. M. (2003). Searching for Bayesian network structures in the space of restricted acyclic partially directed graphs. Journal of artificial intelligence research, 18(1), 445-490.

AITHORITY website. (2020). Understanding The Role Of AI In Gaming, https://aithority.com/computer-games/understanding-the-role-of-ai-in-gaming/ , Feb 19th, 2020 ; [accessed July 8th, 2020].

Alpaydin, E. (2020). Introduction to machine learning. MIT press.

Analytics India Magazine. (2019). A nirudh VK. Top 7 Smartphones With AI Cameras And Post-Processing, https://analyticsindiamag.com/top-7-smartphones-with-ai-cameras-and-post-processing/ , June 28th 2019 ; [accessed September 7th, 2020].

Ancestry Support website. (2020). AncestryDNA White Papers. https://support.ancestry.com/s/article/AncestryDNA-White-Papers ; [accessed September 9th, 2020].

Ashok, J., Suppiah, S., & VijiPriya, J. (2016). A review on significance of sub fields in artificial intelligence. International Journal of Latest Trends in Engineering and Technology (IJLTET), 6(3), 542-548.

Automotive Artificial Intelligence website. (2020). https://www.automotive-ai.com/ ; [accessed July 9th, 2020].

Babuta, A., Oswald, M., & Janjeva, A. (2020). Artificial intelligence and UK national security: Policy considerations.

Bakshi, B. R., & Stephanopoulos, G. (1994). Representation of process trends—III. Multiscale extraction of trends from process data. Computers & chemical engineering, 18(4), 267-302.

Bansal, R. C., Bhatti, T. S., & Kothari, D. P. (2003). Artificial intelligence techniques for reactive power/voltage control in power systems: A review. International journal of power & energy systems, 23(2), 81-89.

Bartlett, P. L., Baxter, J., & Weaver, L. (2011). Experiments with Infinite-Horizon, Policy-Gradient Estimation (No. arXiv: 1106.0666).

Barzilay, R., & Elhadad, N. (2002). Inferring strategies for sentence ordering in multidocument news summarization. Journal of Artificial Intelligence Research, 17, 35-55.

Benčić, F., Nemet, S., Barać, M., & Kukolj, D. (2018, November). Trends in AI based Automotive Industry using Patent Analysis. In 26th TELFOR 2018.

Blockeel, H., Dehaspe, L., Demoen, B., Janssens, G., Ramon, J., & Vandecasteele, H. (2002). Improving the efficiency of inductive logic programming through the use of query packs. Journal of Artificial Intelligence Research, 16, 135-166.

Bod, R. (2002). A unified model of structural organization in language and music. Journal of Artificial intelligence research, 17, 289-308.

Brafman, R. I., & Tennenholtz, M. (2003). Learning to coordinate efficiently: A model-based approach. Journal of Artificial Intelligence Research, 19, 11-23.

Brookings Institution website. (2020). Wolff J. How to improve cybersecurity for artificial intelligence, Brookings Institution's Artificial Intelligence and Emerging Technology (AIET), https://www.brookings.edu/research/how-to-improve-cybersecurity-for-artificial-intelligence/ ; June 9th, 2020 [accessed July 14th, 2020].

Brooks, R. A. (1999). Cambrian intelligence: The early history of the new AI. MIT press.

Built In website. (2020). Schroer A., Artificial Intelligence in Cars Powers an AI Revolution in the Auto Industry, https://builtin.com/artificial-intelligence/artificial-intelligence-automotive-industry , Dec 19th, 2019 ; [accessed July 9th, 2020].

Cadoli, M., Donini, F. M., Liberatore, P., & Schaerf, M. (2000). Space efficiency of propositional knowledge representation formalisms. Journal of Artificial Intelligence Research, 13, 1-31.

Calvanese, D., Lenzerini, M., & Nardi, D. (1999). Unifying class-based representation formalisms. Journal of Artificial Intelligence Research, 11, 199-240.

Cambridge dictionary website. (2020); https://dictionary.cambridge.org/de/worterbuch/englisch/artificial-intelligence ; [accessed Feb 3rd, 2020].

Chan, Y. K., Chen, Y. F., Pham, T., Chang, W., & Hsieh, M. Y. (2018). Artificial intelligence in medical applications. Journal of healthcare engineering, 2018.

Charzinski J. (2019). Artificial Intelligence in Mobile Communication Networks, Hochschule der Medien, http://maucher.pages.mi.hdm-stuttgart.de/ai/res/mobileNetworks.pdf.

Chen, J. C., Patel, V. M., & Chellappa, R. (2016). Unconstrained face verification using deep cnn features. In March 2016 IEEE winter conference on applications of computer vision (WACV) (pp. 1-9). IEEE.

Cloud Painter website. (2020). https://www.cloudpainter.com [accessed June 22th, 2020]

Cooper, M. J., Jain, P., & Sidhu, H. S. (2020). Systems and methods for training machine models with augmented data .U.S. Patent Application No. 16/598,956.

Crevier, D. (1993). AI: the tumultuous history of the search for artificial intelligence. Basic Books, Inc.

Cubillos, F. A., & Lima, E. L. (1998). Adaptive hybrid neural models for process control. Computers & chemical engineering, 22, S989-S992.

Daily Sabah website. (2020). S. Güner. AI and avatars: Are you ready for your digital twin?, https://www.dailysabah.com/life/ai-and-avatars-are-you-ready-for-your-digital-twin/news, March 18th, 2020 ; [accessed Nov 2nd, 2020].

De Toni, A., Nassimbeni, G., & Tonchia, S. (1996). An artificial, intelligence-based production scheduler. Integrated Manufacturing Systems.

Der Bank blog website. (2020). Seidl P., Kurz erklärt: Künstliche Intelligenz in der Finanzbranche, https://www.der-bank-blog.de/finanzbranche-kuenstliche-intelligenz/technologie/37663753/ , May 6th, 2020 ; [accessed Nov 2nd, 2020].

Deutsche Welle. (2019). D. Pundy. Wenn der Richter mit Softwarehilfe urteilt, https://www.dw.com/de/wenn-der-richter-mit-softwarehilfe-urteilt/a-47174579 , Dec 27th, 2019 ; [accessed Oct 3rd, 2020].

Ebay Press Room. (2018). Neue Bildersuche in eBay-App startet in Deutschland, https://www.ebayinc.com/stories/press-room/de/neue-bildersuche-in-ebay-app-startet-in-deutschland/ , press release, Nov 14th, 2018 ; [accessed Sept 3rd, 2020].

Electrek News website. (2020). Lambert F., Tesla's acquisition of DeepScale starts to pay off with new IP in machine learning, https://electrek.co/2020/04/17/tesla-acquisition-deepscale-new-ip-machine-learning/ , April 17th, 2020 ; [accessed July 13th, 2020].

Elektrotechnik Automatisierung website. (2019). K. Juschkat. Wie Künstliche Intelligenz in der Produktion helfen kann. https://www.elektrotechnik.vogel.de/wie-kuenstliche-intelligenz-in-der-produktion-helfen-kann-a-803174/ , Feb 26th 2019 ; [accessed Nov 2nd, 2020].

Eliot, L. (2009). Pink brain, blue brain: How small differences grow into troublesome gaps--and what we can do about it. Houghton Mifflin Harcourt.

Emerj website. (2019). Sennaar K., Machine Learning in Genomics – Current Efforts and Future Applications https://emerj.com/ai-sector-overviews/machine-learning-in-genomics-applications/ , Nov 28th, 2019 ; [accessed Nov 2nd, 2020].

Forbes website. (2020). Marr B. The Top 10 Artificial Intelligence Trends Everyone Should Be Watching In 2020. https://www.forbes.com/sites/bernardmarr/2020/01/06/the-top-10-artificial-intelligence-trends-everyone-should-be-watching-in-2020/#2344d39d390b , Jan 6th, 2020 ; [accessed Nov 2nd, 2020].

Franklin, J. (2003). The representation of context: ideas from artificial intelligence. Law, Probability and Risk, 2(3), 191-199.

Frantz, R. (2003). Herbert Simon. Artificial intelligence as a framework for understanding intuition. Journal of Economic Psychology, 24(2), 265-277.

Gamberger, D., & Lavrac, N. (2002). Expert-guided subgroup discovery: Methodology and application. Journal of Artificial Intelligence Research, 17, 501-527.

Global Market Insight Website. (2020). Wadhwani P., Kasnale S., Artificial Intelligence (AI) in Automotive Market Size, https://www.gminsights.com/industry-analysis/artificial-intelligence-ai-in-automotive-market , Dec 2019 ; [accessed July 10th, 2020].

Goldberg, D. E., & Holland, J. H. (1988). Genetic algorithms and machine learning.

Gordon, D. F. (2000). Asimovian adaptive agents. Journal of Artificial Intelligence Research, 13, 95-153.

Hassoun, M. H. (1995). Fundamentals of artificial neural networks. MIT press.

Heartbeat website. (2020). Cohen J., Computer Vision at Tesla, https://heartbeat.fritz.ai/computer-vision-at-tesla-cd5e88074376 ; [accessed Nov 2nd, 2020].

Hopfield, J. J. (1982). Neural networks and physical systems with emergent collective computational abilities. Proceedings of the national academy of sciences, 79(8), 2554-2558.

IBM website. (2020). Artificial Intelligence in medicine. https://www.ibm.com/watson-health/learn/artificial-intelligence-medicine ; [accessed Feb 12th, 2020].

Ingenieur.de website. (2020). Künstliche Intelligenz – versteckt in zahlreichen Geräten, https://www.ingenieur.de/technik/fachbereiche/elektronik/kuenstliche-intelligenz-versteckt-in-zahlreichen-geraeten/ , Dec. 30th, 2019 [accessed Feb 2nd 2020].

Jim Whitehurst. (2019). AN EXECUTIVE'S GUIDE TO REAL-WORLD AI Lessons from the Front Lines of Business. Harvard Business Review Analytic Services, https://enterprisersproject.com/sites/default/files/an_executives_guide_to_real_world_ai.pdf.

Kaminka, G. A., Pynadath, D. V., & Tambe, M. (2002). Monitoring teams by overhearing: A multi-agent plan-recognition approach. Journal of artificial intelligence research, 17, 83-135.

Kojić, N., Reljin, I., & Reljin, B. (2006). Neural network for optimization of routing in communication networks. Facta universitatis-series: Electronics and Energetics, 19(2), 317-329.

Kusters, R., & Borgida, A. (2001). What's in an attribute? Consequences for the least common subsumer. Journal of Artificial Intelligence Research, 14, 167-203.

Langley, P. (2011). The changing science of machine learning. 275-279.

Larsson, G., Maire, M., & Shakhnarovich, G. (2016, October). Learning representations for automatic colorization. In European conference on computer vision (pp. 577-593). Springer, Cham.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. nature, 521(7553), 436-444.

Lerman, K., Minton, S. N., & Knoblock, C. A. (2003). Wrapper maintenance: A machine learning approach. Journal of Artificial Intelligence Research, 18, 149-181.

Lionbridge website. (2020). Einsatzbeispiele für KI in der Finanzbranche, https://www.lionbridge.com/de/blog/data-services/einsatzbeispiele-fuer-ki-in-der-finanzbranche/ , April 16th, 2020 ; [accessed Nov 2nd, 2020].

Markram, H. (2006). The blue brain project. Nature Reviews Neuroscience, 7(2), 153-160.

McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A proposal for the dartmouth summer research project on artificial intelligence, august 31, 1955. AI magazine, 27(4), 12-12.

Meek, C. (2001). Finding a path is harder than finding a tree. Journal of Artificial Intelligence Research, 15, 383-389.

Motor Zeitung website. (2019). In Berlin machen die Autos blitzschnell ihren Führerschein, http://motorzeitung.de/news.php?newsid=547256 , Jan 15th, 2019 ; [accessed July 9th, 2020].

Muggleton, S. (2014). Alan Turing and the development of Artificial Intelligence. AI communications, 27(1), 3-10.

Nature website. (2018). Webb S., Deep learning for biology, https://www.nature.com/articles/d41586-018-02174-z , Feb 20th, 201 ; [accessed July 9th, 2020].

Nguyen, T. T., Nguyen, C. M., Nguyen, D. T., Nguyen, D. T., & Nahavandi, S. (2019). Deep learning for deepfakes creation and detection. arXiv preprint arXiv:1909.11573.

Nilsson, N. J. (2014). Principles of artificial intelligence. Morgan Kaufmann.

Nock, R. (2002). Inducing Interpretable Voting Classifiers without Trading Accuracy for Simplicity: Theoretical Results, Approximation Algorithms. Journal of Artificial Intelligence Research, 17, 137-170.

Oke, S. A. (2008). A literature review on artificial intelligence. International journal of information and management sciences, 19(4), 535-570.

Otani, T., Toube, H., Kimura, T., & Furutani, M. (2017). Application of AI to mobile network operation. ITU Journal: ICT Discoveries, Special Issue, 1, 1-7.

Parkes, D. C., & Wellman, M. P. (2015). Economic reasoning and artificial intelligence. Science, 349(6245), 267-272.

Patel-Schneider, P. F., & Sebastiani, R. (2003). A new general method to generate random modal formulae for testing decision procedures. Journal of Artificial Intelligence Research, 18, 351-389.

Portugal, I., Alencar, P., & Cowan, D. (2018). The use of machine learning algorithms in recommender systems: A systematic review. Expert Systems with Applications, 97, 205-227.

Power, Y., & Bahri, P. A. (2005). Integration techniques in intelligent operational management: a review. Knowledge-Based Systems, 18(2-3), 89-97.

Railway Technology website. (2017). Facing fears: should facial recognition technology be installed in railway stations?, https://www.railway-technology.com/features/featurefacing-fears-should-facial-recognition-technology-be-installed-in-railway-stations-5942494/ ; [accessed Sept 8th, 2020].

Reiter, O., Rotemberg, V., Kose, K., & Halpern, A. C. (2019). Artificial Intelligence in Skin Cancer. Current Dermatology Reports, 8(3), 133-140.

Renzi, C., Leali, F., Cavazzuti, M., & Andrisano, A. O. (2014). A review on artificial intelligence applications to the optimal design of dedicated and reconfigurable manufacturing systems. The International Journal of Advanced Manufacturing Technology, 72(1-4), 403-418.

Rich, E. (1983). Artificial Intelligence. McGraw-Hi11.

Rosati, R. (1999). Reasoning about minimal belief and negation as failure. Journal of Artificial Intelligence Research, 11, 277-300.

RSIP Vision website. (2020). Machine Vision For Robotics, https://www.rsipvision.com/machine-vision-for-robotics/ ; [accessed July 13th, 2020].

Samsung Newsroom website. (2020). Samsung Electronics Unveils 2020 QLED 8K TV at CES. Samsung press release, https://news.samsung.com/global/samsung-electronics-unveils-2020-qled-8k-tv-at-ces, Jan 6th, 2020 ; [accessed July 10th, 2020].

Science Daily website. (2019). Center for Genomic Regulation, Artificial intelligence applied to the genome identifies an unknown human ancestor. https://www.sciencedaily.com/releases/2019/01/190116122650.htm, Jan 16th 2019; [accessed July 10th, 2020].

Sendra, S., Rego, A., Lloret, J., Jimenez, J. M., & Romero, O. (2017, May). Including artificial intelligence in a routing protocol using software defined networks. In 2017 IEEE International Conference on Communications Workshops (ICC Workshops) (pp. 670-674). IEEE.

Shabbir, J., & Anwer, T. (2018). Artificial intelligence and its role in near future. arXiv preprint arXiv:1804.01396.

Sharmila, T., & Leo, L. M. (2016, April). Image upscaling based convolutional neural network for better reconstruction quality. In 2016 International Conference on Communication and Signal Processing (ICCSP) (pp. 0710-0714). IEEE.

Sivadasan, B. (2018). Application of Artificial Intelligence in Electrical Engineering. Global Research and Development Journal for Engineering, National Conference on Emerging Research Trend in Electrical and Electronics Engineering. 2455-5703.

Slideshare website. (2017). Joseph M. Artificial Intelligence In Power Systems, https://de.slideshare.net/mathewjoseph2811/artificial-intelligence-in-power-systems-seminar-presentation, ROLL NO: 21 REG. NO:14018761 , Sept 25th, 2017; [accessed July 13th, 2020].

Soderland, S., & Lehnert, W. (1994). Wrap-up: a trainable discourse module for information extraction. Journal of Artificial Intelligence Research, 2, 131-158.

SSI-SCHAEFER website. (2018). Fauland J., Artificial Intelligence in Logistics; White Paper SSI Schaefer; https://www.ssi-schaefer.com/resource/blob/566408/06d87a3eff1abfbdd7af3875404b724a/white-paper-artificial-intelligence-in-logistics--dam-download-en-16558--data.pdf, Oct 2018; [accessed Nov 2nd, 2020].

Stay Relevant website. (2017). Artificial Intelligence As a Music Composer, https://stayrelevant.globant.com/en/artificial-intelligence-composing-original-music/ , Sept 19th, 2017; [accessed Oct 2rd, 2020].

SUI, D., & JIN, X. H. (2011). Network Congestion Control Method Based on Artificial Intelligence. Computer Simulation, (9), 30.

Synced website. (2019). Li H. The Online Dating Industry Loves Artificial Intelligence, https://syncedreview.com/2019/06/15/the-online-dating-industry-loves-artificial-intelligence/ , June 15th, 2019 ; [accessed Sept 3rd, 2020].

Synced website. (2020). Lin Z., AI Offers Video Game Design Possibilities Far Beyond Virtual Reality, https://syncedreview.com/2020/06/13/ai-offers-video-game-design-possibilities-far-beyond-virtual-reality/ , June 13th, 2020; [accessed July 8th, 2020].

Tech News website. (2020). Scientists use artificial intelligence to fight the corona virus, https://www.gsmgotech.com/2020/01/scientists-use-artificial-intelligence.html , Jan 2020; [accessed May 3rd, 2020].

Techiexpert website. (2019). Ocampos J., Artificial Intelligence 2020: Trends, Predictions in the World of AI, https://www.techiexpert.com/artificial-intelligence-2020-trends-predictions-in-the-world-of-ai/ , 10/2019; [accessed Nov 2nd, 2020].

Tennenholtz, M. (2002). Competitive safety analysis: Robust decision-making in multi-agent systems. Journal of Artificial Intelligence Research, 17, 363-378.

Teslamag website. (2020). Teslas KI-Chef zeigt Videos mit geretteten Fußgängern und erklärt Autopilot-Software, https://teslamag.de/news/teslas-ki-chef-videos-

gerettete-fussgaenger-autopilot-software-erklaert-28107, April 23th, 2020; [accessed June 24th, 2020].

The New Stack. (2020). Mok K., Deep Learning AI Generates Realistic Game Graphics by Learning from Videos https://thenewstack.io/deep-learning-ai-generates-realistic-game-graphics-by-learning-from-videos/ , Jan 10th, 2019 ; [accessed July 8th, 2020].

Tilghman, P. (2019). Will rule the airwaves: A DARPA grand challenge seeks autonomous radios to manage the wireless spectrum. IEEE Spectrum, 56(6), 28-33.

Time website. (2019). Purtill C. Stop Me if You've Heard This One: A Robot and a Team of Irish Scientists Walk Into a Senior Living Home , https://time.com/longform/senior-care-robot/ , Oct 4th, 2019; [accessed July13th, 2020].

Time website. (2020). Coronavirus Researchers Are Using High-Tech Methods to Predict Where the Virus Might Go Next, https://time.com/5780683/coronavirus-ai/ , Feb. 2020 ; [accessed May 3rd, 2020].

Tolosana, R., Vera-Rodriguez, R., Fierrez, J., Morales, A., & Ortega-Garcia, J. (2020). Deepfakes and beyond: A survey of face manipulation and fake detection. arXiv preprint arXiv:2001.00179.

Towards Data Science website. (2019). Kuprenko V., How AI Changes the Logistic Industry, https://towardsdatascience.com/how-ai-changes-the-logistic-industry-3d55401778d, Jul 3rd, 2019; [accessed Nov 2nd, 2020].

Tsai, P. F., Chu, J. Z., Jang, S. S., & Shieh, S. S. (2003). Developing a robust model predictive control architecture through regional knowledge analysis of artificial neural networks. Journal of Process Control, 13(5), 423-435.

Turney, P. D. (1994). Cost-sensitive classification: Empirical evaluation of a hybrid genetic decision tree induction algorithm. Journal of artificial intelligence research, 2, 369-409.

Uraikul, V., Chan, C. W., & Tontiwachwuthikul, P. (2007). Artificial intelligence for monitoring and supervisory control of process systems. Engineering applications of artificial intelligence, 20(2), 115-131.

Varela, F. J., Thompson, E., & Rosch, E. (2016). The embodied mind: Cognitive science and human experience. MIT press.

VHR Company website, (2020). McKeon C., 6 Automotive Artificial Intelligence Trends to Watch, https://blog.v-hr.com/blog/6-automotive-artificial-intelligence-trends-how-

ai-is-already-changing-the-automotive-industry , June 21st, 2018 ; [accessed July 10th, 2020].

Vulture website. (2020). Lee C. 'We Were All Very Nervous': How The Irishman's Special Effects Team Got the Job Done. https://www.vulture.com/2020/01/how-the-irishman-used-cgi-and-special-effects-on-actors.html, Vulture Magazine, Jan 9th 2020; [accessed July 3rd, 2020].

Walker, M. A. (2000). An application of reinforcement learning to dialogue strategy selection in a spoken dialogue system for email. Journal of Artificial Intelligence Research, 12, 387-416.

Walsh, W. E., & Wellman, M. P. (2003). Decentralized supply chain formation: A market protocol and competitive equilibrium analysis. Journal of Artificial Intelligence Research, 19, 513-567.

Wei, N., Li, C., Peng, X., Zeng, F., & Lu, X. (2019). Conventional models and artificial intelligence-based models for energy consumption forecasting: A review. Journal of Petroleum Science and Engineering, 181, 106187.

Wenzel, A., Linke, M., Meßmer, T., Micard, G., Schubert, G., Minde, A., & Kindl, M. (2019). Innovative grid optimization approach based on artificial neural networks. In 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe) (pp. 1-4). IEEE.

Wikipedia website . (2020). https://en.wikipedia.org/wiki/Artificial_intelligence_in_video_games ; [accessed July 8th, 2020].

Wong, A. K. C., & Wang, Y. (2003). Pattern discovery: a data driven approach to decision support. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 33(1), 114-124.

World Economic Forum. (2019). Fleming S. The rise of the robo-restaurant: AI is ready to take your order, https://www.weforum.org/agenda/2019/09/the-rise-of-the-robo-restaurant/ , Sept 17th, 2019 ; [accessed July 13th, 2020].

Xu, G., Mu, Y., & Liu, J. (2017). Inclusion of artificial intelligence in communication networks and services. ITU J., ICT Discoveries, Special, (1), 1-6.

Zanuttini, B. (2003). New polynomial classes for logic-based abduction. Journal of Artificial Intelligence Research, 19, 1-10.

ZD Net website. (2020). Palmer D. AI is changing everything about cybersecurity, for better and for worse. Here's what you need to know, https://www.zdnet.com/article/ai-is-changing-everything-about-cybersecurity-for-better-and-for-worse-heres-what-you-need-to-know/, March 2nd, 2020 ; [accessed July 14th, 2020].

Zhang, C., Patras, P., & Haddadi, H. (2019). Deep learning in mobile and wireless networking: A survey. IEEE Communications Surveys & Tutorials, 21(3), 2224-2287.

Zhang, R., Isola, P., & Efros, A. A. (2016, October). Colorful image colorization. In European conference on computer vision (pp. 649-666). Springer, Cham.

Zhong, G., Wang, L. N., Ling, X., & Dong, J. (2016). An overview on data representation learning: From traditional feature learning to recent deep learning. The Journal of Finance and Data Science, 2(4), 265-278.

Zou, J., Huss, M., Abid, A., Mohammadi, P., Torkamani, A., & Telenti, A. (2019). A primer on deep learning in genomics. Nature genetics, 51(1), 12-18.

Prof. Dr.-Ing. Jens Christian Timmermann is professor at Baden-Wuerttemberg Cooperative State University at the technical campus of Friedrichshafen. He manages the B.Eng. study program "Communications with focus on traffic systems" within Electrical Engineering.

Research Interests: RF Propagation, Channel Modeling, Mobile Communications, Trends in (Electrical) Engineering

Address: Baden Wuerttemberg Cooperative State University (DHBW) Ravensburg, Campus Friedrichshafen, Fallenbrunnen 2, 88045 Friedrichshafen, Germany. Tel. +49 7541 2077-263,

E- mail: timmermann@dhbw-ravensburg.de

Dr.-Ing. Atheer L. Salih Al-Tameemi is research staff member in the field of Electrical Engineering at Baden-Wuerttemberg Cooperative State University at the campus of Friedrichshafen. He works in different areas of research within Electrical Engineering.

Research Interests: Simulation, Image Processing, Communication Engineering, Wave Propagation, Control systems, EMC Systems.

Address: Baden-Wuerttemberg Cooperative State University (DHBW) Ravensburg, Campus Friedrichshafen, Fallenbrunnen 2, 88045 Friedrichshafen, Germany. Tel. +49 7541 2077-227,

E- mail: al-tameemi@dhbw-ravensburg.de

Herausgeber

Prof. Dr. Heinz-Leo Dudek
Prorektor und Dekan der Fakultät für Technik

Duale Hochschule Baden-Württemberg Ravensburg
Baden-Wuerttemberg Cooperative State University
Marienplatz 2
88212 Ravensburg

ISBN 978-3-945557-09-9

ISSN 2199-238X

DOI 10.12903/ DHBW_RV_FN_03_2020_TIMMERMANN_AL-TAMEEMI