ARTIFICIAL INTELLIGENCE: MODELS, ALGORITHMS AND APPLICATIONS

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Artificial Intelligence: Models, Algorithms and Applications

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Artificial Intelligence: Models, Algorithms and Applications

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CONTENTS

PREFACE

This book entitled **'Artificial Intelligence: Models, Algorithms and Applications'** consists of eight chapters. The book focuses on new achievements in AI and how AI may be introduced in different application areas, and how these areas may be changed when AI models and algorithms are used.

AI introduces new approaches to solve complex problems. It is interesting to note that AI introduces a significant shift in new models and algorithms. Advances in instrument technologies have seen a significant shift as far as the tools and techniques are concerned. Subsequently, it has made and is going to make equally powerful impact on the process and manufacturing industry through Industry 4.0.

The aim of this book is to give an introduction to the field of AI, its models and algorithms and how this may be used to solve problems in different application areas.

The book is primarily intended for students, researchers and engineers that are interested in AI and how it may be used to solve concrete problems. The structure of the book is organized as several different topics. We hope that technology developers and companies also find it interesting to be used in industry.

We do not yet have any chapter about how to use AI in Robotics and in Natural Language Processing (NLP). These are important fields where AI methods are very relevant to use and also give good results. NLP is also the field where I started to use AI algorithms for about twenty years ago. If there is going to be a new edition of the book it should be natural to extend it with these chapters.

The book consists of eight chapters which have been described concisely one by one below:

1. *From AIS Data to Vessel Destination Through Prediction with Machine Learning Techniques by Wells Wang, Chengkai Zhang, Fabien Guillaume, Richard Halldear, Terje Solsvik Kristensen, Zheng Liu*

The destination of vessels is an important decision maker in maritime trading. However, shipping companies keep this kind of data inclusively, which results in the absence of complete information of destination for every vessel. However, other information such as the position can be available due to Automated Identification Systems (AIS). Hence, predicting the vessels' destination port becomes possible. To give a baseline of how to make use of AIS data for vessel destination prediction with machine learning, several AIS data preprocessing approaches and machine learning approaches for vessel destination prediction are introduced in the literature. The chapter aims to give the audience an idea of how to link between AIS data, trajectories, and numerous machine learning models for the purpose of predicting arrival ports for maritime services. Furthermore, the discussion points out the current state of research on this topic and where the potential future work may possibly lie in.

2. AI in Mental Health by Suresh Kumar Mukhiya, Amin Aminifar, Fazle Rabbi, Violet Ka I Pun and Yngve Lamo

Managing the prevalence of mental health problems is both socially and economically challenging. Technological advancement in recent decades has provided potential solutions to this issue. In particular, Artificial Intelligence (AI) is one of the research areas that has expanded into behavioural, neurological and mental healthcare by fulfilling the main objectives of P4 medicine - personalized, predictive, preventive and participative medicine. In this chapter, we give an overview of recent applications of AI for screening, detection, and treatment of mental health problems; summarize the economic and social implications; present a systematic overview of which AI technologies are used for the different mental disorders and identify challenges for further development. Based on this, we identify some future research questions that could be solved with the use of AI in mental healthcare. The chapter concludes with an in-depth discussion on the key challenges of the application of AI in mental health interventions.

3. Deep Learning in Radiology by Madhura Ingalhalikar

Recent developments in artificial intelligence (AI), particularly deep learning (DL) algorithms have demonstrated remarkable progress in image recognition and prediction tasks. These are now being applied in the field of radiology on medical images to quantify, characterize, classify as well as monitor various pathologies. Such DL based quantifications facilitate greater support to the visual assessment of image characteristics that is performed by the physician. Furthermore, it aids in reducing inter-reader variability as well as assists in speeding up the radiology workflow. In this chapter, we provide an insightful motivation for employing DL based framework followed by an overview of recent applications of DL in radiology and present a systematic summary of specific DL algorithms pertaining to image perception and recognition tasks. Finally, we discuss the challenges in clinical implementation of these algorithms and provide a perspective on how the domain could be advanced in the next few years.

4. AI in Instrumentation Industry by Ajay V. Deshmukh

Artificial intelligence (AI) as the name suggests is a new way of automatically deciding upon the operation and control of real time machines and processes in industry. The advantages of using artificial intelligence in industry are many. First of all the decisions are dynamic and real time without any human intervention. Next, it is not based on any formula which in the past required updating for different process conditions and time. Operational technologies did not deploy complete intelligence systems and there used to be much more complexity in tuning the processes and systems together. Training of the operational people was very much crucial and required periodic updates from time to time as the operational technologies changed. AI can overcome most of these complexities, due to the fact that it obtains a data driven solution in real time. Intelligence could be distributed right from the sensory levels to higher levels of distributed computerized systems. Internet of Things (IoTs) and data analytics can provide dynamic information on the performance of machines and processes. Industries which would benefit from technologies based on Artificial Intelligence (AI), Machine Learning (ML) and Deep learning (DL) are in general any process or manufacturing industries including healthcare, petroleum, power sector, automotive etc. In fact, this would lead to applicability of Industry 4.0. In this chapter different concepts and applicability of AI in industry have been described. Off course it is possible due to the powerful computational tools, which help not only in doing computations, but also in terms of the capability of communication control, plus data storage, transmission and intelligent decision making.

5. *AI in Business and Education by Tarjei Alvaer Heggernes*

In recent years, the interest for artificial intelligence has gone from the computing department to the board room. Business leaders are in a rush to explore the possibilities presented by the abundance of data, processing power and the methods of AI to create business value and business opportunities. In this chapter we will adapt the view of a manager and explore some of technologies used in machine learning. We will also look at how managers should approach artificial intelligence. The chapter will close with a discussion of some use cases of the different technologies. On case will come from marketing and discusses the use of reinforcement learning in real-time bidding on an e-commerce platform. The next two cases are from the education industry, one case will discuss reinforcement learning in intelligent tutoring systems, and the final case will discuss neural networks in grading of tests and assignments. There are many exciting use cases for artificial intelligence, it is important for business managers to understand the possibilities, and equally important for programmers to understand how businesses create value.

6. *Extreme Randomized Trees for Real Estate Appraisal with Housing and Crime Data by Junchi Bin, Bryan Gardiner, Eric Li, and Zheng Liu*

Real estate appraisal plays a vital role in people's daily life. People rely on the estimation of decisions on buying houses. It is well recognized that the criminal activities around the house have significant impacts on house prices. House buyers can make more reasonable decisions if they are aware of the criminal activities around the house. Therefore, a machine learning-based method is proposed by combining house attributes and criminal activities. Specifically, the method firstly infers the intensity of criminal activities from historical crime records. Then, a novel machine learning algorithm, extremely randomized trees (ExtraTrees), is implemented to estimate the house price based on the extracted comprehensive crime intensity and real-world house attributes. The experimental results show that the proposed method outperforms contemporary real estate appraisal methods by achieving higher accuracy and robustness.

7. *The Knowledge Based Firm and AI by Ove Rustung Hjelmervik, and Terje Solsvik Kristensen*

Radical innovation is disruptive. It is a change that sweeps away much of a firm's, or an entire industry's, existing investment in technological assets, skills and knowledge. Such innovation has occurred throughout history and wealth has been accumulated in its wake. Companies have flourished as a result of such ingenuity, yet there is no evidence in the literature that radical innovation is a result of senior management's decision, rather it takes place through learning. In order to understand what drives a knowledge-based organization, one has to look at the inside of the firm where implemented structures and tools are supporting employees' empowerment to unleash their creativity. What the firm knows is stored in the employees' head and in the firm's procedural structure, and the firm learns in two ways - by its employees and through hiring new employees. Thus, development of radical innovation, such as artificial intelligence (AI), will either be learned by the firm's employees and/or through hiring experts. Whenever management prevents new methods from being applied, or employees refuse to acknowledge and learn new techniques, productivity suffers, resulting in firm and industry obsolescence. This is exactly what's happening in the case of AI. Almost eighty years after Alan Turing introduced AI theory, we see a world flabbergasted by its potential impact on productivity. Our case study is based on interviews of a dozen or so R&D managers in private and public sectors. Although our observations are not a guarantee to lead to a consistent agreement or interpretation, valid knowledge that can lead to better performance and organizational survival, may nevertheless provide useful learning for relevant readers.

8. *A Mathematical Description of Artificial Neural Networks by Hans Birger Drange*

After a short introduction to neural networks generally, a more detailed presentation of the structure of a feed forward neural network is done, using mathematical language, functions, matrices and vectors. Further, emphasis has been made on perceptrons and linear regression done by using ANN. Central concepts like learning, including weight updates, error minimization with gradient descent are introduced and studied using these simple networks. Finally, multilayer perceptrons are defined with their error functions and finally backpropagation is described precisely using composite functions and the concept of error signals.

The editor would also like to thank Bentham Science Publishers for all help during the writing of this book and specifically Asst. Manager for Publications, Mariam Mehdi, for all support during the publication process. I would also thank all the authors from different countries that have contributed to this book. At last, I would thank my prior student Kenneth Langedal for his help with the writing.

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CHAPTER 1

From AIS Data to Vessel Destination Through Prediction with Machine Learning Techniques

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Abstract: The destination of vessels is important decision makers of maritime trading. However, shipping companies keep this kind of data inclusively, which results in the absence of complete information of destination for every vessel. However, other information such as the position can be available due to Automated Identification Systems (AIS). Hence, predicting the vessels' destination port becomes possible. To give a baseline of how to make use of AIS data for vessel destination prediction with machine learning, several AIS data preprocessing approaches and machine learning approaches for vessel destination prediction are introduced in the literature. The chapter aims to give the audience an idea of how to link between AIS data, trajectories, and numerous machine learning models for the purpose of predicting arrival ports for maritime services. Furthermore, the discussion points out the current state of researches on this topic and where the potential future work may possibly lie in.

Keywords: AIS, Bayesian estimation, Deep learning, Destination prediction, Machine learning, Maritime analysis, Nearest neighbor search, Sequence to sequence, Similarity measures, Spatial-temporal data, Trajectory.

INTRODUCTION

Since ancient times, maritime transportation has been a major part of transporting passengers and commodities. According to United Nations, around 70-80 percent of world trade is carried through this mean. In 2016, the total volume of the worldwide seaborne trade had reached 10.3 billion tons.

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The global maritime transportation occupies around 90 percent of global trading by volume and 70 percent by value [1]. With the increasing demands of global shipping service, the naval transportation industry calls for a more reliable source of predicting vessels' destinations.

The advancement of technologies and availability of maritime data makes it possible to keep track of most vessels. Nowadays, automatic identification system (AIS) data are widely adopted for its capability in vessel tracking [2].

Furthermore, with the AIS data combined with computational intelligence, the destination of those vessels can be predicted [3]. Upon making the correct predictions for vessels' destinations, the efficiency of the overall supply chain management will boost.

(a) Vessel records (b) Vessel destination

Fig. (1). Illustration of vessel destination prediction.

To illustrate how vessel destination is predicted, this chapter uses an example of an on-the-way vessel on the northwestern side of Australia, which is shown in Fig. (**1**). Given a two-day record from the vessel (Fig. **1a**), the goal is to predict its destination (Fig. **1b**). The records on Fig. (**1a**) can be viewed as a part of a trajectory of the vessel, and the records on Fig. (**1b**) (from one port to another) can be viewed as a complete trajectory. To predict the destination of an on-th--way trajectory, machine learning techniques needs to be combined with historical trajectories for model training. With the help of AIS data, researchers can acquire enough historical trajectories around the globe as a source of constructing the model that is capable of predicting the destination of any new coming trajectories.

This chapter focuses on implementing trajectory data mining and machine learning techniques on AIS data-driven vessel destination prediction. In the context of this chapter, the discussion will introduce several AIS data preprocessing approaches and will elucidate some aspects of the existing machine learning approaches regarding vessel destination prediction.

AIS DATA PREPROCESSING APPROACH

The Automatic Identification System was initially designed for safety and security of navigation purposes [4]. As the messages transmitted by AIS systems are broadcasted in a non-secured channel, these AIS messages could be gathered by Vessel Traffic Services. Hence, AIS messages being collected could be used in other dimensions, such as destination prediction. However, with the nature of AIS data, some preprocessing procedures need to be done before conducting further analysis.

Among the 27 types of AIS messages, most of the messages are position reports (type 1, 2, and 3) or static reports (type 5). Discussion in this section lies in the position type AIS data, where some important parameters regarding destination prediction are listed in Table **1**. The complete version of Table **1** is in [5].

Table 1. Parameters of Position Type AIS messages regarding destination prediction.

Parameter	Description
User ID	Unique identifier such as MMSI number
Longitude	Longitude in 1/10000 min (±180°, East=positive (as per 2's complement), West=negative (as per 2's complement))
Latitude	Latitude in 1/10000 min (±90°, North = positive (as per 2's complement), South = negative (as per 2's complement))
Time stamp	UTC second when the report was generated by the electronic position system (EPFS)

The following introduces several approaches to turn raw AIS data into trajectory data for the purpose of training vessel destination prediction models. The data should be in the forms of vessel trajectories that are ready to be trained after procedures of trajectory extraction, trajectory resampling, noise filtering, and trajectory segmentation.

Trajectory Extraction

Raw AIS data contains various data points that represent the status of different vessels at different times. As mentioned in [6], trajectory data can be classified into four major categories: *mobility of people, mobility of transportation vehicles,*

CHAPTER 2

Artificial Intelligence in Mental Health

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Abstract: Managing the prevalence of mental health problems is both socially and economically challenging. Technological advancement in recent decades has provided potential solutions to this issue. In particular, Artificial Intelligence (AI) is one of the research areas that has expanded into several behavioural, neurological and mental healthcare areas by fulfilling the main objectives of P4 medicine - personalized, predictive, preventive, and participative medicine. In this chapter, we give an overview of recent applications of AI for screening, detection, and treatment of mental health problems; summarize the economic and social implications; present a systematic overview of which AI technologies are used for the different mental disorders and identify challenges for further development. Based on this, we identify some future research questions that could be solved with the use of AI in mental healthcare. The chapter concludes with an in-depth discussion on the key challenges of the application of AI in mental health interventions.

Keywords: Affective Computing, Ambient Intelligence, Artificial Intelligence, Cognitive Based Therapy, Deep Learning, Internet Delivered Treatment, Machine Learning, Mental health, P4 medicine.

INTRODUCTION

Recent studies conducted by WHO [1] as well as EU Green Papers [2, 3] reveal that the prevalence of having mental or neurological disorders has escalated over the past few decades. Dealing with mental health issues can be economically, physically, and emotionally challenging for the patients, their families and friends, and the society. For instance, the healthcare costs in the United States of America had a rise from 27.2 billion dollars (only 5 percent of GDP) in 1960 to 3200

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billion dollars (17.8 percent of GDP) in 2015 [4, 5]. According to the report from World Economic Forum in 2010, the global cost of mental illness was approximated to be $2.5 trillion US dollars and is anticipated to be more than $6 trillion dollars by 2030 [6]. The same report justifies that mental health costs are the biggest health-related global economic burden. In addition to this, the patients' quality of life and standard of living are affected, they suffer from reduced productivity, problems with social interactions, and even suicidal tendencies.

It is not uncommon that healthcare systems operate on limited resources with a shortage of healthcare professionals and inadequate funding. Physicians do not have the luxury to spend much time investigating individual patients' cases. To cope with this situation, one must improve the existing healthcare system with efficiency and automation. We need a healthcare system that supports a flexible and interoperable information exchange that facilitates innovation in wellness and healthcare. However, this task is challenging due to the complex nature of health problems, which entails dynamic processes in terms of both the treatment being delivered and the cognitive process of the clinicians and the patients [7]. In addition to continuously observing the patients and evaluating the treatment decisions, the clinicians also need to prescribe different medications and adjust the treatments accordingly. Applying artificial intelligence (AI) in the mental health domain is a potential means to provide more efficient and adaptive treatments for mental health problems. The use of AI has the potential to reduce treatment time and cost and increase the effectiveness and the quality of the procedure. In brief, AI in mental healthcare provides exciting opportunities and benefits, including:

- Methodologies for learning, understanding, and reasoning to assist healthcare professionals with clinical decision-support, testing, diagnostics, and care management.
- To find a better correlation between the patient's symptoms and treatment outcome and adapt the treatment to the patients' needs.
- Introduction of self-management treatment programs using ambient intelligent m-health1 apps that can learn and adapt according to user preferences, user needs, and user contexts.
- Improvement in public health by assisting in the detection of health risks and intelligent recommendations of appropriate interventions.

In this book chapter, we give an overview of recent applications of AI for screening, detection, and treatment of mental health problems, we identify challenges for further development, and summarize the economic and social implications. We present a systematic overview of which AI technologies are used for different mental disorders. Based on this, we identify some future research questions that could be solved with the use of AI in mental health. Note that we have limited our work to discuss the use of AI for screening, and therapeutic interventions, hence the use of AI-related to psychopharmacology is out of the scope of this work.

The outline of the rest of this chapter is as follows: In Section Mental Health Treatment, we present some background information related to mental health treatments and artificial intelligence. Motivational factors of using AI in the mental health domain are further discussed in Section Motivation. In Section Data Collection and Preparation, we present an overview of data collection and preparation methods for AI in mental health. In Section Mental Health and AI, we outline some of the key AI technologies being used in the mental health domain. Section Challenges is dedicated to discussions and results. Finally, in Section Discussion about Future Development, we summarise our findings and propose potential future directions of research in AI and mental health.

MENTAL HEALTH TREATMENT

Current treatment approaches to mental health morbidities involve psychopharmacology, Cognitive Based Therapy (CBT), Cognitive Remedial Therapy (CRT), mindfulness, music therapy, gamification, and meditation, *etc.* All these approaches follow a common workflow where one starts by assessment and diagnosis in the form of a screening of the patient, then one decides and executes the treatment before one evaluates and monitors the treatment outcome [8]. The screening phase of the mental health practice includes the acquisition of relevant information from the patient and compare it with the current knowledge base for establishing a diagnosis and treatment paradigm. The elicitation of pertinent information involves the application of standardized psychometric questionnaires like PHQ-9[2], MADRS[3], MADRAS-S[2] for depression, in-person interviews, or use of ICT technologies including emails, chat, instant messaging, mobile phones and client peer support system.

MOTIVATION

Traditional medical practice has been reactive, meaning that doctors intervene when there is a disease [9]. However, the advancement in technologies, theories, and concepts over the last decades has preluded the transition towards anticipatory medicine centered on health and not disease. This is referred to as P4 medicine

CHAPTER 3

Deep Learning in Radiology

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Abstract: Recent developments in artificial intelligence (AI), particularly deep learning (DL) algorithms have demonstrated remarkable progress in image recognition and prediction tasks. These are now being applied in the field of radiology on medical images to quantify, characterize, classify as well as monitor various pathologies. Such DL based quantifications facilitate greater support to the visual assessment of image characteristics that is performed by the physician. Furthermore it aids in reducing inter-reader variability as well as assists in speeding up the radiology workflow. In this chapter, we provide an insightful motivation for employing DL based framework followed by an overview of recent applications of DL in radiology and present a systematic summary of specific DL algorithms pertaining to image perception and recognition tasks. Finally, we discuss the challenges in clinical implementation of these algorithms and provide a perspective on how the domain could be advanced in the next few years.

Keywords: Artificial intelligence, Convolutional neural nets, CT, Deep learning, MRI, Radiology, X-rays.

INTRODUCTION

Recent discoveries in Artificial Intelligence (AI) have illustrated exceptional performance in complicated tasks by allowing machines to better characterize and interpret the underlying complex information. These discoveries include the area of deep learning (DL) that is loosely inspired by how the human brain works during learning and execution [1, 2]. DL algorithms usually employ a large number of interconnected neurons that learn the complex data patterns to create a "trained" model which can then be applied to perform the task under consideration on new data. DL algorithms have a specialty that they do not require pre-programmed instructions, have the ability to extract features and learn

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these automatically from a large amount of data. Results from multiple performance tasks have demonstrated that DL algorithms perform better than humans. For example, DL based creation of automated image captions is highly efficient [3, 4]. Similarly, many other problems such as localizing objects in images [5], sentiment analysis [6], language translation tasks [7], planning and control of autonomous vehicles [8, 9] *etc.* have been resolved more effectively using DL. Moreover, with the power of modern computational hardware, DL learning frameworks can be built effortlessly. Overall, this has led to major advances in applications ranging from natural language processing [10], web searching [11], self-driving vehicles and creating automated systems and support in every possible field of work that includes agriculture [12, 13], military [14] as well as medicine [15, 16]. Within the healthcare and medicine domain DL has been driving multiple applications such as virtual assistants in hospital management, patient monitoring [17], and drug discovery [18 - 20] as well as is used in medical diagnostics and imaging [21 - 23]. Further, bioinformatics studies that include large datasets pertaining to genome, RNA and DNA employ a plethora of AI techniques for analysis and to gain an understanding into the pathological genotypes [24 - 26]. Medical imaging is at the forefront of using AI techniques as these not only support precise processing and quantification of images, but hold promise to overcome the limitations of subjective visual inspection [27]. In addition, the predictive power of these methods can facilitate finding specific markers that relate to the pathology under consideration. These models are being integrated into clinical workflow as a tool to assist clinicians.

As mentioned earlier, unlike earlier AI techniques, DL models are non-deterministic where explicit feature extraction is not required. These algorithms learn directly by maneuvering through the data space and therefore can be considered as a fundamentally different paradigm in machine learning [2]. Although the techniques have existed for a while, only with the advent of state-o--art computational hardware and collection of enormous amounts of digital data these have become relevant and are being applied. To this end, multiple DL algorithms have been developed in the past few years; however convolutional neural nets (CNNs) are the most prevalent type of architecture when working directly on images [28]. CNNs are a modern adaptation of the traditional artificial neural network with multiple neuronal layers that act directly on the images through millions of 2D or 3D convolutional filter parameters where each layer is followed by a pooling operation that down-samples the image (Fig. **1**). These filter parameters are computed for each hidden layer that helps extract fine, intermediate as well as coarse imaging features. Finally, these are connected to fully connected layers that provide high level reasoning before the output layer facilitates the predictions. The complete model is transformed into the desired output by using end-to-end optimization [28]. The CNN can therefore be considered as a multi-layer automated feature extraction tool with a classifier in the final stages. To this date, CNNs have demonstrated ground-breaking performance in image classification tasks often becoming the new state of art in several use cases. For example, the ImageNet competition proved that on a database of 14,000,000 images of cars, buildings and multiple other categories, the CNN based architectures dramatically improved the error-rate to be comparable or even better than human performance and also at a very high computational speed [28]. The ability of CNNs in extracting such discriminative pixel based features, automatically, is striking as it often accounts for better classification performance, especially on large datasets, when compared to a similar task on empirically drawn features. Other than CNNs, other DL models such as auto-encoders, recurrent neural nets, generative adversarial networks, deep belief nets *etc.* have also been employed in radiology. Some of these have been described in the following sections.

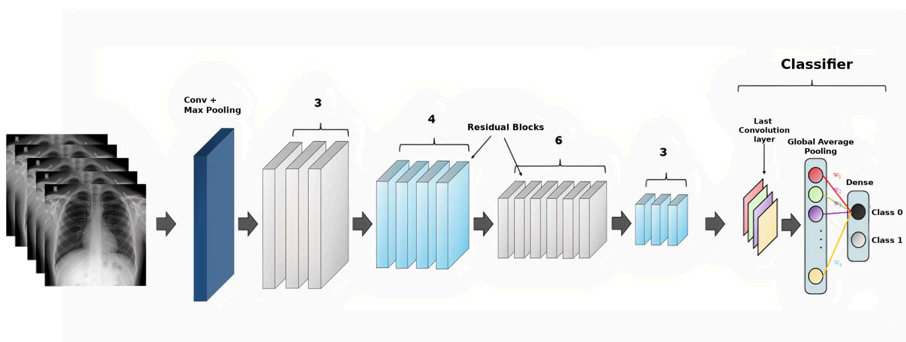

Fig. (1). A schematic representation of a CNN architecture showing chest X-rays as input that are being classified either as normal (class 0) or abnormal (class 1). The convolutional layers filter the input images at multiple-resolutions and extract features that are optimized via end-to-end optimization.

Overall, this chapter aims to provide an overview of the recent applications of AI in radiology – that include image pre-processing, segmentation, registration and prediction of pathology. Section 2 discusses the underlying motivation for AI in radiology while section 3 presents applications for various problems with diverse imaging modalities and organs. In section 4 we discuss about the confounding factors, challenges and limitations of AI in radiology and potential solutions for the way forward.

MOTIVATION

Radiology is a medical specialty that employs medical images such as X-rays, ultrasound sonography (USG), computed tomography (CT), Positron emission

CHAPTER 4

AI in Instrumentation Industry

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Abstract: Artificial intelligence (AI) as the name suggests is a new way of automatically deciding upon the operation and control of real time machines and processes in industry. The advantages of using artificial intelligence in industry are many. First of all the decisions are dynamic and real time without any human intervention. Next, it is not based on any formula which in the past required updating for different process conditions and time. Operational technologies did not deploy complete intelligence systems and there used to be much more complexity in tuning the processes and systems together. Training of the operational people was very much crucial and required periodic updates from time to time as the operational technologies changed. AI can overcome most of these complexities, due to the fact that it obtains a data driven solution in real time. Intelligence could be distributed right from the sensory levels to higher levels of distributed computerized systems. Internet of Things (IoTs) and data analytics can provide dynamic information on the performance of machines and processes. Industries which would benefit from technologies based on Artificial Intelligence (AI), Machine Learning (ML) and Deep learning (DL) are in general any process or manufacturing industries including healthcare, petroleum, power sector, automotive *etc*. In fact this would lead to applicability of Industry 4.0. In this chapter different concepts and applicability of AI in industry have been described. Off course it is possible due to the powerful computational tools, which help not only in doing computations, but also in terms of the capability of communication control, plus data storage, transmission and intelligent decision making.

Keywords: Artificial Intelligence (AI), Industry 4.0., Industry Applications, Machines and Processes, Manufacturing, Process and Healthcare Industries.

INTRODUCTION

Advances in instrument technologies have seen a significant shift as far as the tools and techniques are concerned. Subsequently, it has made and is going to make equally powerful impact on the process and manufacturing industry through Industry 4.0. This is possible with the help of powerful computational tools, communication protocols, for example using wireless communication, as well as

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much more decision making capacity. This is possible due to the data driven methods and powerful techniques with the help of AI, ML, DL [1 - 3]. Therefore, today almost any complex algorithm could be used for the control of machines and processes. Over and above it has also been IoTs and Data Analytic applications which make decisions on process plants as a whole in real time. This allows monitoring and supervising the performance of process and machines or individual units in a plant. The new top up technologies over the past automation systems do not necessarily require removal or replacement of sensors, transmitters and automation systems however, the data could be made available for the existing data management systems. This would further be sent either over a cloud or there could be edge analytics [4] confined to the boundaries of the process plants. Edge analytics include all the devices like cell phones, camera, except those which are not connected to cloud. Data security and safety are an essential part of the modern instrumentation systems.

It becomes important now to investigate what has changed or changing when AI techniques are applied. Industry 4.0 [5, 6] makes use of cyberphysical systems, so-called smart factories. Important aspect of such systems is that the automation systems are part of physical systems, the cyber layer is going to get added. This requires that there could be a data collection from the existing systems and rest of the things including big data processing [7] and decision making can be done by using AI [8, 9]. This is the first important direction to apply the concept of Industry 4.0 to process or manufacturing industries.

New hope for the future business in this field is to design and deploy AI, ML and DL techniques by applying a slightly top up or higher level electronics and software systems. There is a scope to apply newer and newer communication protocols, reduce the cost of the electronics and software systems, making it more reliable, user friendly and safe, immediate access to operational data, condition monitoring, preventive and predictive maintenance, reduced down times, on line report generation making use of data analytics [5] as applied to a process or manufacturing industry. This is going to help the top management or plant heads to take better decisions like reduced inventories, better supply chain management, and even the plant economy. Business analytics along with plant analytics would survey the whole purpose. In this chapter, sustainable solutions have also been considered in addition to the applicability of the AI to process and manufacturing industries. It would help if a reader can work out Data Analytics and IoT requirements for other industry sector like Health care, Power Sector, Oil and Gas, in order to know the complexities involved in managing such giant industries.

A SYSTEMATIC APPROACH TO APPLIED AI

Industry looks for its own objectives, but responds very quickly to contemporary technologies, as it is going to help in improving the whole business. During Industry 3.0, where only computerization and communication technologies were available, have also seen changes in terms of automation and data management and presentation systems. However, most of those systems landed up with technical data or technical trends and the rest of the economics was not dynamically addressed, due to the complexity of managing big data. In spite of the availability of literature on data analytics and artificial intelligence several years ago, the computational tools and techniques were not capable of handling real time calculations of big data. Neither many experts thought of working on faster algorithms, as it would not serve the purpose to meet the objectives which today AI, ML, and DL methods can fulfill. Uncertainties in building models [11] and even model predictive systems were not sufficient to take care of the whole plants and with respect to time as well. Therefore, there were many unknown parameters, which did not appear. Although the data was available, it was not possible to find out meaningful information quickly for decision making. Most of the data collected even did not contain any meaningful information. Empirical methods did work to a limited capacity but did not provide complete solutions.

Today, in the newer approach, data driven methods making use of AI, ML and DL methods can provide meaningful reports about the process or manufacturing plant, with any complexities and uncertainties.

ARTIFICIAL INTELLIGENCE AND ITS NEED

For better understanding of the need of AI, a simple approach is to consider a chemical industry with processes like distillation column, fermentation units or chemical reactors. The first question such an industry asks is ‘what are IoTs? Then how data analytics or AI based systems would overcome the present problems? A clear picture of IoTs and Data analytic systems can provide answers to these questions. Ultimately, one is trying to define AI requirement including other systems like electronics for data collection and processing.

Some of the problems that would be immediately addressed are operation and process control [10, 11] and measurements [12]. This was done earlier and even in many of the present methods in industries with measurement systems, operational technologies, process control and automation including the use of programmable logic controllers, supervisory control and data acquisition systems (SCADA), or using large distributed control systems (DCS). Field bus technologies and variants are normally used for field communication. Modern devices and instruments use wireless communication systems. These industrial communication systems could

CHAPTER 5

AI in Business and Education

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Abstract: In recent years, the interest for artificial intelligence has gone from the computing department to the board room. Business leaders are in a rush to explore the possibilities presented by the abundance of data, processing power and the methods of AI to create business value and business opportunities. In this chapter we will adapt the view of a manager and explore some of technologies used in machine learning. We will also look at how managers should approach artificial intelligence. The chapter will close with a discussion of some cases of usage of the different technologies. One case will come from marketing and discusses the use of reinforcement learning in real-time bidding on an e-commerce platform. The next two cases are from the education industry, one case will discuss reinforcement learning in intelligent tutoring systems, and the final case will discuss neural networks in grading of tests and assignments. There are many exciting use cases for artificial intelligence, it is important for business managers to understand the possibilities, and equally important for programmers to understand how businesses create value.

Keywords: Artificial Intelligence, Deep learning, E-commerce, Education technology, Machine Learning, Neural networks, Real-time bidding, Reinforcement learning, Supervised learning, Unsupervised learning.

INTRODUCTION

There is a lot of talk about artificial intelligence (AI), such as Machine learning and neural networks. These are some of the subsets of AI that have received increased attention from 2016 until today. AI as a concept has been discussed since the 50s, most famously by Turing [1]. The recent years' development in both the cost and capacity for processing of data, as well as for collecting large amounts of data, has made previously theoretical concepts technically feasible and useful.

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Science fiction writer Arthur C. Clarke once said that any technology advanced far enough is impossible to distinguish from magic [2]. It is easy to think of artificial intelligence as magic, but it is important to remember that it is software. In each AI project, engineers are working on and improving the set of rules and algorithms needed to make artificial intelligence appear magic.

The same Clarke wrote in Playboy in 1968 that within our lifetime, super-intelligent computers - almost impossible to distinguish from humans - would give us the mixed blessing of a life without work [3]. Now, 50 years later we humans seem to be working more than ever, so that claim is exaggerated. Even so, we can see computers doing more and more tasks that were previously done by humans. A challenge for managers is figuring out which part of a task should be done by machines, and which part is better done by humans.

THE INDUSTRIAL REVOLUTION AND THE LONG ECONOMIC WAVES

With the Industrial Revolution, beginning around 1789, started a global economic process counting five long economic waves, with an average duration of 50-55 years [4]. The technological developments in the different periods have always substituted human power with the power of machines. The first, what we today call the industrial revolution, replaced the organic power of humans and animals with steam power, then came the mass transport period such as the railroad, followed by more power through electricity and manufacturing technology. The fourth economic wave was based on electronics and individual mobility through the proliferation of the automobile. It is during the early part of the fifth economic wave, starting around 1995, that we get the information and communication period. One of the hallmarks of this current period is computer technology, enhancing production technology, robots and the internet.

ARTIFICIAL INTELLIGENCE AND INDUSTRY 4.0

Internet was introduced at the start of the 5th economic wave. As internet became global things started to get linked together, and around 2000 we got The Industrial Internet of Things (iIoT), which is also known as Industry 4.0, when applied to the manufacturing industry. It is a concept of integrating smart manufacturing machinery, AI-powered automation, and advanced analytics to help make every worker and every factory more efficient.

In addition to helping with the heavy lifting, computer technology could also help humans with calculations and remembering. With the advent of I4.0 [5] – the information and communication period, software, computing power, data collection and storage, and data communication made it possible for separate systems to work together in new ways, and to do even more of the heavy mental lifting of mankind by using artificial intelligence.

What can AI do?

What tasks can artificial intelligence perform just as well, or better than humans? In an overview of AI milestones where AI outperforms humans from 1980 until 2015, most of the examples are of computer programs outperform people in all kind of games from chess to advanced computer games. Impressive of course, but in itself not very useful [6]. In 2016, however, an artificial intelligence technique that classifies images in the image database 'Image' managed to classify images with a margin of error of 3%, against the average human error margin of 5%. After this, there have been good improvements in both image recognition and speech recognition, and in 2018, Google developed a deep learning system that could recognize prostate cancer with 70% accuracy, against 61% accuracy in a panel of certified pathologists.

However, it is important not to attach too much weight to these milestones, because so far there are no good ways to transfer artificial intelligence from one application to another. On the other hand, there is a great potential for being able to use AI in business operations, as most tasks performed in a business are neither as complex nor as vital as diagnosing prostate cancer.

Looking at the research that is done in 2018 in the field of artificial intelligence, the main area of research is focused on health and medicine, at least in the western parts of the world. The result of the research will help us stay healthy longer. China has had a tremendous development in AI research in recent years, a lot of the research is applied in the field of agriculture, in other words, to help feed the people efficiently.

During the writing process, a project using sensors to prevent patients in psychiatry from taking suicide is mentioned on the news [7]. The sensors measure sleep rhythm, pulse and presence in the bathroom, and based on the collected data the probability of the patient committing suicide is predicted. In addition to hoping that this can save human life, this case reminds us of two important features of artificial intelligence: The use of data, often from sensors, and the ability of the program to predict probable outcomes in the future. See also [8] on digital suicide prevention.

CHAPTER 6

Extreme Randomized Trees for Real Estate Appraisal with Housing and Crime Data

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Abstract: Real estate appraisal plays a vital role in people's daily life. People rely on the estimation of decisions on buying houses. It is well recognized that the criminal activities around the house have significant impacts on house prices. House buyers can make more reasonable decisions if they are aware of the criminal activities around the house. Therefore, a machine learning-based method is proposed by combining house attributes and criminal activities. Specifically, the method firstly infers the intensity of criminal activities from historical crime records.Then, a novel machine learning algorithm, extremely randomized trees (ExtraTrees), is implemented to estimate the house price based on the extracted comprehensive crime intensity and real-world house attributes.The experimental results show that the proposed method outperforms contemporary real estate appraisal methods by achieving higher accuracy and robustness.

Keywords: Ensemble learning, Extremely randomized trees, Machine learning, Real estate appraisal.

INTRODUCTION

For most people in the world, house transaction is one of the most substantial expenses in their life. Buying or investing houses is a high involving a decision. To be more informative, people usually consult real estate agents before making actual transactions. From the real estate agents, house buyers can receive a comprehensive report of house and the estimated market values of the house. Relying on the estimated market values, house buyers can make reasonable decisions during the actual transactions in the housing market. This service is

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called real estate appraisal in housing market. To meet with the rapid growing demands from housing market, real estate agents have been developing automated online service of real estate appraisal [1 - 3]. This online service is called automated valuation model (AVM).

Empirical studies concentrate on improving the accuracy of AVM by developing machine learning algorithms such as artificial neural network (ANN) and regression trees [4 - 6]. The implemented data only contains the house attributes like numbers of bedrooms and the size of the house. Beyond the house attributes, academic researchers also regard the demographic and social factors of community as major influential factors in real estate appraisal [5, 7, 8]. For example, the safety of the neighborhood also plays a vital role while people are picking houses. The safety of neighborhoods can be reflected as the reversed values of crime intensity around a house. House buyers always prefer to living in a house with a low risk of being offended as well as well as low crime intensity.

Some studies discovered inappropriate correlation between the crime intensity and house prices [8 - 10]. The evidence indicates that the crime intensity around the house significantly influence house prices. However, none of the previous AVMs investigated the method to extract the crime intensity from raw crime data. Moreover, there is lack of research on suitable computational model for employing both house attributes and the crime intensity in real estate appraisal.

In this study, we employ a novel statistical method to extract comprehensive crime intensity (CCI) in terms of two categories: crime occurrence entropy (COE) and consecutive crime severity (CCS) [11]. First, crime occurrence entropy (COE) represents the spatial severity of crime around a house. Second, consecutive crime severity (CCS) represents the temporal severity of crime around a house. Finally, COE and CCS are combined to represent the comprehensive crime intensity (CCI). On the other hand, a novel machine learning model, extremely randomized trees (ExtraTrees) [12], is proposed to estimate the house prices by combining house attributes and CCI. In summary, our contributions are highlighted as follows:

- A novel statistical crime data analysis method to extract the comprehensive crime intensity (CCI) in terms of different perspectives by exploiting the crime data. The experimental results show that the CCI can increase the accuracy of real estate appraisal.
- A novel machine learning model, extremely randomized trees (ExtraTrees), is proposed to estimate the house price. The experimental results indicate that the proposed model outperforms contemporary methods. To the best of authors' knowledge, this is the first implementation of ExtraTrees in real estate appraisal.

RELATED WORKS

Machine Learning in Real Estate Appraisal

Researchers have researched the problem of real estate appraisal for decades. Linear regression has been used for real estate appraisal since the last century [13]. Assuming house prices have a linear correlation between house attributes, the linear regression model is trained and optimized by the least-square method. After entering the era of big data, linear regression is challenging to fit a massive amount of housing data. Moreover, many research papers revealed the existence of a non-linear correlation between house values and real estate [14 - 17]. Without further techniques to explore the non-linearity, it is difficult to achieve a more accurate and robust estimation by purely using linear regression.

Machine learning is a data-driven solution to automatically discover features and establish a non-linear correlation to complex data and its corresponding target for computer vision and financial techniques. Real estate agents are also aware of the power of machine learning and research its application in real estate appraisal. Currently, machine learning methods are thriving in real estate appraisal. Multilayer perceptron (MLP), is one of the most common techniques in AVM. MLP is famous for its feature learning ability, which allows the model to achieve more accurate performance [18]. On the other hand, the MLP is capable of exploring non-linearity among features by selecting different types of activation functions in neurons [19]. Some studies report their successful application of MLP in AVM [4, 14, 20 - 25].

However, many papers also reveal that MLP is the lack of robustness in real-world applications [16, 17, 21, 22, 26 - 29]. On the other hand, the optimizing problem of MLP also prevents from advanced development in real estate appraisal [6]. To obtain more robust performance, real estate researchers bring the technique of regression tree in real estate appraisal. As described in [5, 30], a single regression tree can achieve outstanding performance in assessing house prices. However, the regression trees are relatively easy to overfit, which prevents its application in property value assessment [5]. Random forest (RF) and boosted regression trees (BRT) are the ensemble methods to combine many weak regression trees for the robust and accurate performance of assessment [5, 31, 32]. In the empirical studies presented in [5, 21, 22, 24, 26, 28, 30], the BRT and RF are applied to house attributes and achieve state-of-the-art predictive results. To enhance the robustness of tree induction algorithms, extremely randomized trees (ExtraTrees) are developed to reduce the variance of model outputs by explicit randomization of the split-point of trees [12]. Moreover, the randomization

CHAPTER 7

The Knowledge-based Firm and AI

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Abstract: Radical innovation is disruptive. It is a change that sweeps away much of a firm's, or an entire industry's, existing investment in technological assets, skills, and knowledge. Such innovation has occurred throughout history and wealth has been accumulated in its wake. Companies have flourished because of such ingenuity, yet there is no evidence in the literature that radical innovation is a result of senior management's decision, rather it takes place through learning. To understand what drives a knowledge-based organization, one must look at the inside of the firm where implemented structures and tools are supporting employees' empowerment to unleash their creativity. What the firm knows is stored in the employees' head and in the firm's procedural structure, and the firm learns in two ways - by its employees and through hiring new employees. Thus, development of radical innovation, such as artificial intelligence (AI), will either be learned by the firm's employees and/or through hiring experts. Whenever management prevents new methods from being applied, or employees refuse to acknowledge and learn new techniques, productivity suffers, resulting in firm and industry obsolescence. This is exactly what is happening in the case of AI. Almost eighty years after Alan Turing introduced AI theory, we see a world flabbergasted by its potential impact on productivity. Our case study is based on interviews of a dozen or so R&D managers in private and public sectors. Although our observations are not a guarantee to lead to a consistent agreement or interpretation, valid knowledge that can lead to better performance and organizational survival, may nevertheless provide useful learning for relevant readers.

Keywords: Bounded rationality, Creative destruction, Gødel's incompleteness theorem, Organizational learning, Radical innovation, The knowledge-based firm, The resource-based view of the firm, Turing groundbreaking technology, Turing machine, Turing test.

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INTRODUCTION

Artificial Intelligence (AI) is a disruptive and radical innovation, which, until a few years ago, most business and organizational leaders were unacquainted with. Why is this a problem, you may ask? In 2017 Kliner Perkins [1] reported that there had been a dramatic shift in the top ten global firms, ranked by capitalization (value), during the last five years. Among the top ten global firms in 2012 there were three technology firms using AI technology in their business model: Apple, Microsoft, and IBM. In 2017, the number has grown to seven: Apple, Google/Alphabeth, Microsoft, Amazon, Facebook, Tencent and Alibaba. While in 2012 all three were US-based, in 2017 five were US-based while the last two were China-based. Furthermore, IBM, the global technology flagship, with its Watson AI technologies, were relegated from the seventh place in 2012 to out of the top 20 list for 2017.

In 1879 George Eastman succeeded in developing a photosensitive celluloid film and thus disrupted a complete industry having made its living from photography for more than 50 years. But, on January 19th, 2011, after 132 years with the 'Kodak moment' and due to the electronics development, Eastman Kodak came to a grinding halt as they filed for chapter 11 [2]. General Motors, once the world's largest automaker, established in 1908, files for chapter 11 on June 1st, 2009 [3]. Both companies had failed to develop technology which could compete in the new marketplace. Thus, IBM could well have followed into the mire where industry giants such as Eastman Kodak (failed to digitize photography) and General Motors (failed to produce more fuel-efficient vehicles) already had gone.

Norway is, by some standards, seen as a digitalized nation. However, during the last year or so researchers and economists are concerned about Norway's cavalier attitude to digitalization, and specific "Big Data" technology. According to a leading economist at the Norwegian School of Economics and Business Administration [4] these changes will be disruptive, and "we are not prepared". Furthermore, "it is difficult to get management teams to ram up enthusiasm for the digitalization process". A participant in an IBM Norway seminar in 2018, where the manager of its Norwegian office gave a talk on digitalization, reported that "the participants were skeptical about his message on Big Data" [5]. Today's leading industries, making a living from obsolete technologies, do not necessarily adapt well to the business environment created by new technologies, as these corporations are more concerned with the quarterly earnings than the technological development [6].

In our contact with leaders of R&D companies and institutions in the city of Bergen, we found little interest for them to apply AI in their businesses. In 2016 we started interviewing [7] what they knew about AI, and what they did in relation to AI technology.

1. We contacted several firms, primarily within the processing industry and strong on R&D, from small businesses to global leaders. They all said the same thing: we apply current technology, as for instance conventional statistical analysis. We see no reason to change such methods, and we do not know if others do it either. We are not interested in applying AI[1].

2. We contacted academic and research leaders. We asked whether they would be willing to change conventional statistical analysis methods to AI- methods. Although conventional statistical methods were the accepted norm[2], they had no plans to change methodology, neither at the unit level, nor at the organizational level, even though we pointed out a possible productivity gain, *i.e.* finishing a research project faster, with a possibly more reliable result, or higher degree of reproducibility [8]. One leader of a large institution asked specifically about what AI was, and one scientist was thinking of using Phyton at the TRL[3] [9] level 1 and 2.

All the interviewed organizations are knowledge-based [10], that is, their resources are people, processes, and stored knowledge representations. Summarizing our experience from the many interviews, we found a clear tendency:

- Unfamiliarity with AI/Machine learning, and possible productivity implication.
- Neither groups could see any benefits from applying such technology.
- No need to acquire such knowledge.

Our observations are in line with an online questionnaire[4] carried out by McKinsey & al [11] saying in their 2017 study that only 20 percent of the respondents say their companies have embedded at least one AI capability in their business processes. Furthermore, only a few companies have the foundational building blocks that enable AI to generate value at scale. The biggest challenges, and barrier, to adopting and implementing AI, according to McKinsey's study, is a lack of clear AI strategy followed by a lack of appropriate talent, functional silos that constrain end-to-end AI solutions, and a lack of leaders who demonstrate ownership of and commitment to AI. We believe that the information age, started in the early 1990s by promising greater productivity leaps, never materialized in a magnitude fashion because industry leaders never understood Alan Turing's contribution to computer science. This is an AI paradox.

CHAPTER 8

A Mathematical Description of Artificial Neural Networks

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Abstract: After a short introduction to neural networks generally, a more detailed presentation of the structure of a feed forward neural network is done, using mathematical language, functions, matrices and vectors.

Further, emphasis has been made on perceptrons and linear regression done by using ANN. Central concepts like learning, including weight updates, error minimization with gradient descent are introduced and studied using these simple networks.

Finally, multilayer perceptrons are defined with their error functions and finally backpropagation are described precisely using composite functions and the concept of error signals.

Keywords: Backpropagation, Chain rule, Composite functions, Computing neurons, Feedforward, Matrices, Multiple perceptron, Neural network, Perceptron, Transfer function, Vectors.

INTRODUCTION

The main intention with the chapter is to define the concepts and the mathematics used in Neural Networks in a precise way.

Neural Networks is a special case of Machine Learning. This latter term again means that you use a computer to obtain information from large data sets where you do not try to analyze these data sets in detail, the way you do in traditional programming. Instead mathematics is used more directly to extract the information you want.

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The reason that you do not use traditional programming methods is that this would be practically impossible because of the kind of information you intend to draw out.

Consider for example a firm that wants to get information about what customers would prefer in connection with specific issues. Would they prefer to buy cheap cars or cars that would last for long? The firm has collected a lot of data about the customers that are relevant for this purpose.

But how could they get the information they want from all these data clustering?

Another example, a bit different, is the problem of having a computer read handwritten characters. A natural way to attack this problem might be to try and find rules that characterize the different characters. This has been tried, but has turned out to be too difficult. There are too many situations to cover.

Instead the problem has been solved by the use of a mathematical model inspired by the way the human brain is working, that is by using Neural Networks.

Exactly how we do this is the theme of this writing, so we return to this shortly.

Now suffice it to say that the way one talks about these things is by saying for instance that we learn from data. This is achieved by establishing a learning algorithm that provides us with the knowledge we want.

Next, to realize this learning algorithm one uses a computer, that is a machine, hence the term machine learning makes sense. But this seems to be normally understood to mean that the machine is learning and not you.

Finally, we should emphasize that in addition to the word learning, the word training is also used here. Both of these words suggest that the algorithm we use to get knowledge is akin to the method humans use to get knowledge generally.

ARTIFICIAL NEURAL NETWORKS, ANN

We suggested above that to solve for instance the problem of recognizing handwritten characters, we can use a mathematical model inspired by how the brain is working.

Neurons in the Brain

We give here a short simplified explanation of how the brain works. It consists of *neurons*, specialized nerve cells, that are interconnected and which are sending nerve signals to other neurons as well as receiving signals themselves.

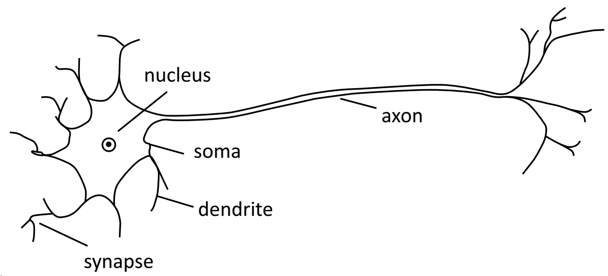

Fig. (1). The biological neuron.

The way this sending and receiving of signals is organized is as follows. Each neuron has dendrites, by which they receive signals from other neurons, a cell body where a signal received is processed, and an axon along which the processed signal is transmitted to one or more dendrites of receiving neurons.

The connection between the axon of a sending neuron and a dendrite of a receiving neuron is called a *synapse* and is a very important part of this system. A signal arriving at the synapse may be reinforced or weakened, or perhaps totally inhibited.

A Mathematical Model

We can model this mathematically in the following way. *The cell body*, also called the *soma*, is modelled by a *function*. Let us call this function F. We return later to the question of what it may look like. The function F is meant to simulate that the signal arriving at the soma is processed in some way.

The signal itself *arriving* at the cell body is modelled by a *number* S and the signal *leaving* the cell body and propagating down the axon, is represented by the value of the function F, that is $F(S)$,.. Let us name the value that this function takes by y. Then we have, $y = F(S)$, and the function itself is called *the transfer function*.

The Synapse

This is very important and is modelled by a number w, and the effect that the synapse has on the signal $\boldsymbol{x}$ arriving there from another neuron is simply obtained by the product $w{\cdot}x$. The number w is called the strength of the synapse and $w{\cdot}x$ is the signal entering the cell body.

Before leaving this point about the mathematical model of a neuron we should note that a neuron normally receives signals from many neurons, in keeping with the fact that a neuron has many dendrites, and that we denoted the signal entering a neuron by the letter S. This letter is chosen because we consider S to be the *sum*

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