MACHINE LEARNING AND ITS APPLICATION: A QUICK GUIDE FOR BEGINNERS

Indranath Chatterjee

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PREFACE

Over the past two decades, the evolution of Machine Learning has risen to a great extent. With the invention of Artificial Intelligence, things were getting more comfortable and accessible. Artificial intelligence needs a system to be fed with pre-defined conditional statements to perform some tasks on behalf of human beings. Gradually human needs a more stable and autonomous system that can learn on its own. There comes a lack of another technology that drastically changes the concept of artificial intelligence. With the invention of machine learning, advancements are going on every single day. With ever-increasing data sources and automated computation, technologies based on machine learning are coming alive very often.

The purpose of writing 'another book on machine learning is always a challenging task to attract the reader's attention. Machine learning is the most discussed topic of this decade and for a few more decades. The basic knowledge of machine learning is very needed. Most people are unaware of the fundamental theories and applications of machine learning.

Among many books available in the market on this topic, this book targets reaching all the corners of the reading society. From naïve learners to professional machine learning experts will find this book handy and helpful for everyday application. Most books are written in challenging mathematical perspectives, which pose incomprehensibility for most readers, especially students and industry engineers.

This book aims to cover most of the Machine Learning curriculum prescribed in most of the top universities. It also covers advanced topics like Deep Learning and Feature Engineering. This book's added feature is the entire chapter on real-world machine learning applications using Python programming, which will be truly beneficial for all the researchers and engineers, with open-ended ideas on new problems and their solutions in a Pythonic way.

This book is written effortlessly and straightforwardly with enriched theories and more minor mathematical complications, but more easily comprehensive application aspects. In every chapter, topics are described in such a way, keeping in mind readers from all sections. Every topic and subtopic is described with examples and Python code snippets for a more accessible explanation. The chapters are presented with a well-explained illustration and flowchart for a better understanding of the topic. Thus, this book on machine learning will surely catch the beginners' attention in the Machine Learning domain. The audience will include, University students, Young Researchers, Ph.D. students, Professors, and software engineers who want to gain knowledge in Machine learning from scratch. I believe this book will be in demand of most of the University libraries and bookstores.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

A single author entirely writes this book. So, the conflict of interest does not apply to this book.

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DEDICATION

This book is dedicated to my parents,
Maa and Babai.
Thank you for everything… ☺

There is no knowledge in nature; all knowledge comes from the human soul. Man manifests knowledge, discovers it within himself, which is pre-existing through eternity.

Swami Vivekananda

CHAPTER 1

Introduction to Machine Learning

Abstract: The introduction chapter summarizes various necessary topics on artificial intelligence and machine learning. It introduces the readers with a strong foundation on the basic concepts of advanced usage of artificial intelligence, which led to the beginning of an era of machine learning. Here, the readers will learn different aspects of machine learning concisely which are described in detail in the coming chapters. Firstly, this chapter discusses the dimensions of AI and the reasons for the transition of traditional AI to modern-day machine learning techniques. Secondly, it discusses the benefits of machine learning in day-to-day life. Thirdly, it discusses the machine learning algorithms' main pillars for training and developing prediction models. Finally, this chapter will give a broad outline of this book in a concise chapter-wise description.

Keywords: Artificial Intelligence (AI), Evolution of AI, Learning, Machine Learning, Self-supervised Learning, Supervised Learning, Unsupervised Learning.

1.1. WHAT IS ARTIFICIAL INTELLIGENCE?

Artificial intelligence or AI refers to the simulation of human intelligence of computers designed to think and imitate their behavior like humans. The word can also be extended to any system that shows features linked to a human mind, such as understanding and problem-solving.

When most people use the word artificial intelligence, robots are usually the first to come to mind. In this way, big-budget films and novels have created a story about a robot that destroys earth and humans. However, it is not far from the facts.

Authors Stuart Russell and Peter Norvig discuss the topic in their pioneering textbook Artificial Intelligence: A Modern Approach [1] by unifying their work around the theme of intelligent agents in computers. The authors described AI as:

"the study of agents that receive percepts from the environment and perform actions" (Russel and Norvig viii) [1].

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Artificial intelligence originated from the idea that it is possible to describe human intelligence so that a computer can effectively imitate it and perform tasks, from the easiest to those that are much more complicated. Artificial intelligence's purposes include knowledge, logic, and understanding.

Previous standards that described artificial intelligence became obsolete as technology progresses. Machines that measure fundamental functions or identify text through optical character recognition, for example, are no longer thought to embody AI since this function is now taken for granted as an innate machine function.

To support several varied sectors, AI is constantly developing. AI is everywhere using a cross-disciplinary approach focused on math, computer science, linguistics, psychology, and more.

Artificial intelligence's perfect feature is the capacity to rationalize and perform decisions with the most excellent chance of fulfilling a particular purpose. Machine learning refers to the impression that computer programs can automatically learn from and respond to new data without human help. It is a branch of artificial intelligence. Deep learning techniques make this automated learning by ingesting vast quantities of unstructured data such as text, images, or video.

1.1.1. Evolution of AI

Artificial intelligence is certainly not another idea; its narrating roots go as far back as Greek relics. Notwithstanding, it was not precisely a century before the mechanical upset took off, and AI went from fiction to truly conceivable reality.

In the initial portion of the twentieth century, sci-fi acquainted the world with the idea of robots. By the 1950s, we had an age of researchers, mathematicians, and scholars who were socially acclimatized in their brains with the idea of human-made consciousness (or artificial intelligence). One such individual was Alan Turing, a British scientist who investigated the numerical chance of human-made consciousness. Turing recommended that people utilize accessible data to take care of issues and decide why the machines cannot do something very similar? This was the consistent system of his 1950 paper, "Computing Machinery and Intelligence," in which he examined how to assemble intelligent machines and test their knowledge.

From 1957 to 1974, AI got importance. Personal computers could store more data and turned out to be fast, less expensive, and more available. AI calculations additionally improved, and individuals improved at knowing which calculation to apply to their concerns. Early exhibits, for example, Newell and Simon's General Problem Solver and Joseph Weizenbaum's ELIZA, showed promising results toward the objectives of critical thinking and the translation of communication in language individually. These victories, just as the promotion of driving specialists (particularly the participants of the DSRPAI) persuaded government offices, for example, the Defense Advanced Research Projects Agency (DARPA), to subsidize AI research few organizations. The public authority was especially inspired by a machine that could interpret and decipher communication in language just as high throughput information handling. Idealism was high, and assumptions were considerably higher. In 1970 Marvin Minsky revealed to Life Magazine, "from three to eight years we will have a machine with the general intelligence of an average human being." However, while the essential rule verification was there, there was far to go before the ultimate objectives of standard language preparation, conceptual reasoning, and self-acknowledgment could be accomplished.

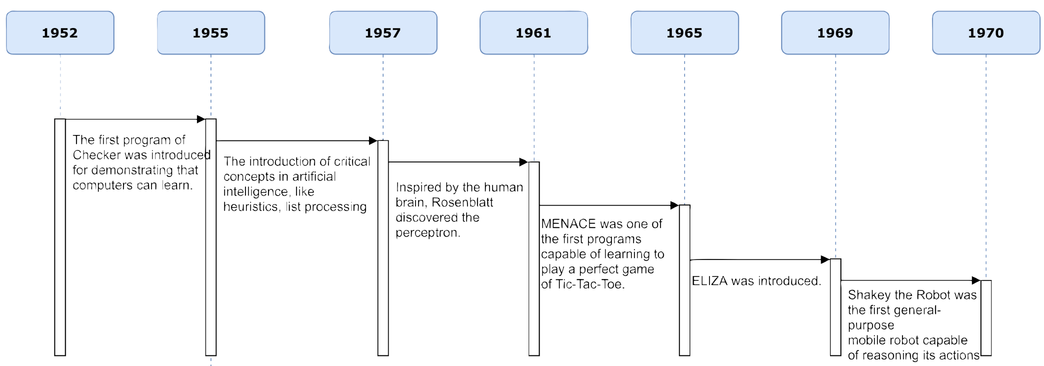

Fig. (1.1). Evolution of AI from 1950's to 1970's.

As we see in Fig. (**1.1**), it shows the evolution of artificial intelligence from the year 1952 to 1970.

The great scientist Simon and Minsky stated AI as:

Herbert Simon stated in 1957 that "*It is not my aim to surprise or shock you, but the simplest way I can summarize is to say that there are now in the world machines that think, that learn, and that create. Moreover, their ability to do these things is*

CHAPTER 2

Supervised Machine Learning: Classification

Abstract: This chapter introduces supervised machine learning algorithms. In this chapter, the popular classification algorithms such as decision tree, random forest, k-nearest neighbor, Naïve Bayes classifier, and support vector machine are described in detail. Each algorithm is defined starting with its overview, followed by an algorithmic framework and a hands-on example. A detailed Python program is given at the end of each algorithm to support the precise understanding of the working behavior of the classifiers. The Python code is executed on a real dataset, which eventually gives the reader in-depth knowledge about the algorithm's applicability.

Keywords: Classifier, Decision Tree, Machine Learning, Random Forest, K-nearest Neighbor, Naïve Bayes Classification, Supervised Learning, Support Vector Machine.

2.1. INTRODUCTION TO SUPERVISED MACHINE LEARNING

2.1.1. Supervised Machine Learning

Supervised machine learning algorithms are used to predict future events using labeled examples to define what you previously learned from new data. Starting with an analysis of available training data, the learning algorithm performs an approximate function to predict the output value. The system can provide output for new inputs after proper training. The learning algorithm can look for errors to compare the output to the exact intended output and correct the model accordingly.

The training dataset is used to explain the model to get the desired product through supervised learning. This training dataset contains inputs and appropriate outputs so that the model can train over time. The algorithm calculates the accuracy with a loss function by adjusting the loss to a minimum value.

Supervised models can be used to build and enhance multiple business applications, including the following businesses:

1. Image and Object Identification: Supervised learning algorithms can be used to detect, distinguish, and classify objects in video or images, which can be applied to various computer vision techniques and image analysis.

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2. Predictive Analytics: A broad use case of supervised learning models lies in developing predictive analytics systems that provide in-depth insights into various business data points. This enables entrepreneurs to expect specific outcomes based on given output variables, allowing business leaders to make decisions or give critical support to the company's benefit.

3. Customer Sentiment Analysis: With supervised machine learning algorithms, any company can extract and classify much information, including context, sentiment, and motivation, with minimal human intervention. This can be very useful to understand customer interactions better and can be used to improve one's brand investment trial.

4. Spam Detection: Spam detection is another instance of a supervised machine learning model. Using supervised classification algorithms, organizations can effectively organize spam and non-spam-related communications by training their databases to identify patterns or inconsistencies in new data.

Deep data insights and improved automation can benefit your supervised learning business, but building a sustainable supervised learning model presents some challenges. Some of these challenges are:

- Supervised learning models may require some degree of expertise to be accurately designed.

- Early model training through learning can be time-consuming.

- The data set is more likely to have human errors, resulting in algorithmic learning errors.

- Supervised learning cannot cluster or classify data on its own.

2.1.2. What is Classification?

In machine learning, classification refers to a predictive modeling problem in which class labels are predicted for a given example of input data. Classification is the task of using a machine learning algorithm that learns what class labels should be for instances in the problem domain. Categorizing it as "spam" or "no-spam" makes the example easier to understand.

A variety of classification features can give everyone a unique approach to machine learning and modeling used.

Classification algorithms are used to assign test data to specific categories accurately. It tries to draw conclusions on identifying particular elements in a data set and labeling or defining those elements. Standard classification algorithms are linear classification decision tree, random forest, k-nearest neighbor, and support vector machine (SVM) described in more detail below.

Examples of classification problems include:

- Classification of emails as to whether it is spam or not.
- Given a handwritten letter, classify it as one of the known letters.

Classification requires training and a database to learn a lot of information. The model takes a set of training data and calculates how to map instances of the input data at a specific class label. By the way, the training dataset should be sufficiently representative of the problem, and each class label should have multiple instances.

Class labels are often String values. "Spam", "No-Spam", and numerical values need to be mapped before providing the modeling algorithm. This is often mentioned as label encoding, and each class label is assigned a unique integer. "Spam" = 0, "No-Spam" = 1.

There are several types of classification algorithms that model problems to predict modeling classification.

They have no fixed solution on how to map the algorithm to the problem type. Instead, it is generally recommended that practitioners conduct controlled experiments and find the best algorithm and configuration for a given classification task.

The classification prediction algorithm is evaluated based on the outcomes. Classification accuracy is a standard system of measurement used to assess model performance based on predicted labels. The classification accuracy is not perfect, but it is a good starting point for many sorting tasks.

Instead of class labels, some operations may require an estimate of the class member potential for each instance. This provides additional uncertainty in the

CHAPTER 3

Unsupervised Machine Learning: Clustering

Abstract: This chapter introduces the readers to clustering algorithms as a part of unsupervised machine learning algorithms. This chapter describes the state-of-the-art clustering algorithms. This chapter gives an elaborative definition of k-mean clustering, hierarchical clustering, and self-organizing map. It also defines the algorithmic framework of each algorithm with hands-on examples with detailed Python codes and outputs.

Keywords: Machine Learning, Unsupervised Learning, Clustering, K-means Algorithm, Hierarchical Clustering, Self-organizing Map.

3.1. INTRODUCTION TO UNSUPERVISED MACHINE LEARNING

The unsupervised machine learning algorithms are primarily used for training, while the information used is not classified or labeled. Research into how systems determine the ability to explain hidden structures in unlabeled data arises from unsupervised studies. The system does not search for the correct output, but it can explore the data and search the dataspace to explain the hidden structure in the data and label them.

3.1.1. What is Clustering?

Back in the 1850s, John Snow, a London physician, developed a map where he plotted Cholera deaths. With the help of these maps, he identified that majority of deaths were reported near a well. Thus, this map exposed the problem and solution altogether.

Clustering is a fundamental task, where n numbers of data points are differentiated based on similarity and dissimilarity between them. From scattered data, smaller groups are formed, known as a cluster. The points in one cluster are similar to each other but different from the points in another cluster.

Clustering is a unique method that helps us identify the group among all the available scattered data. There is no fixed pattern or steps to perform clustering on the given set of data. The users are free to use their preferred clustering method

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according to their needs. Clustering algorithms do make some assumptions depending on the provided data and make clusters accordingly [5].

3.1.2. Types of Clustering Methods

Several clustering methods could be used for different available data:

1. Density-based Methods: This is one of the best methods to merge two different clusters because such methods only consider a dense cluster with similar points. The different points are situated at a low, dense region in the same space. DBSCAN and OPTICS are some of their examples.

2. Hierarchical-based Methods: Forming a tree-like structure, the hierarchical-based method uses the previously formed data to form all the new clusters. There are two categories in this method:

- Agglomerative (bottom-up approach)
- Divisive (top-down approach)

CURE and BIRCH are some examples of hierarchical-based methods.

3. Partitioning Methods: Working on these methods is different from other methods. The available data is parted into k clusters in this method, and all the partitions form one cluster. This technique is used to optimize an objective function. Like k-Means, CLARANS is one example of partitioning methods.

4. Grid-based Methods: These methods are fast and independent because the entire data space is divided into a smaller finite number of cells like a grid. The clustering operation becomes very easy in such data space. Sting and clique are some examples of grid-based methods.

3.1.3. Real-life Applications of Clustering

- **Natural Disasters**: The study of disasters like earthquake and tsunami helps us determine dangerous zones and take different precautions.
- **Marketing**: It helps in discovering the customer segments for better marketing strategies.

• **Planning a City**: It helps in the identification of geographical locations for better housing plans and other infrastructure.

• **Insurance**: It helps in the identification of frauds.

• **Biology**: It helps in the identification and classification of different species of flora and fauna.

• **Libraries**: It helps in the classification of different books based on topics and information.

3.2. K-MEANS CLUSTERING

3.2.1. Overview

Unlike supervised learning, k-means clustering is an unsupervised learning algorithm. In k-mean clustering, we cluster a set of data into different clusters. Each cluster has similar data, which is closely arranged, whereas the dissimilar data is placed away from that particular cluster. The similarity and dissimilarity of the data are checked through nature and characteristics. The 'k' in the k-mean clustering stands for the number of clusters to be formed. There are various methods to find the optimum value of k. Let us see some real-life examples of k-mean clustering:

• Grouping articles (for example: google news)

• Grouping people with similar taste

• Identification of patients with high-risk health issues

• Classification of criminals from ordinary people

3.2.2. Algorithmic Framework

As discussed in the previous section, K-Mean is one of the simplest methods to solve clustering problems. Thus, now it is essential to understand the K-Mean Algorithm in depth.

3.2.2.1. Introduction to K-means Algorithm

In the K-Mean clustering algorithm, first, we calculate the optimum centroid for the given data. This is done by the iteration method. The first assumption here is that we know the K-value, *i.e*., the number of clusters. This algorithm type is also

CHAPTER 4

Regression: Prediction

Abstract: This chapter introduces the readers to the in-depth knowledge of regression analysis. Regression is a concept used both in statistics and computer science, specifically in machine learning. However, the concept remains unaltered, but the applications. This chapter will learn about two primarily used regression analysis algorithms, linear regression and logistic regression. Here, each of the algorithms will be described in detail, with hands-on application. We will also learn linear and logistic regression in a more elaborative way while demonstrating through Python program on a real-world dataset.

Keywords: Machine learning, Regression, Linear regression, Logistic regression, Regressor, Logit, Prediction, Time-series analysis.

4.1. INTRODUCTION TO REGRESSION

4.1.1. What Is Regression?

Regression analysis is a statistical method for studying and comprehending the connection between two or more variables of interest. The method used for regression analysis aids in determining the variables which are significant and which may be ignored. It is a statistical technique used in finance, investing, and other fields to assess the strength and nature of a connection between one dependent variable (typically represented by Y) and a set of other variables (known as independent variables), as seen in Fig. (**4.1**).

We must grasp the following terms for regression analysis to be an effective method:

- Dependent Variable: It is the one that we are attempting to figure out or predict.
- Independent Variables: These are variables that impact the analysis or target variable and offer us information about the variables' relationships with the target variable.

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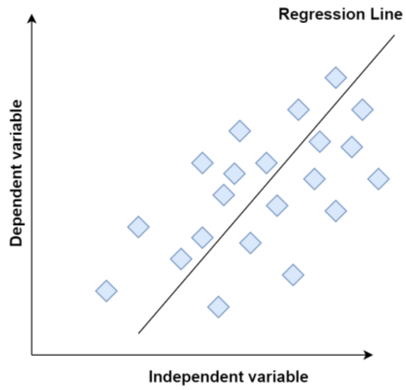

Fig. (4.1). The regression model.

The connection between a dependent variable and one or more independent variables is estimated using regression analysis. This approach is commonly used to predict outputs, forecast data, analyze time series, and determine causal effect relationships between variables. Based on the number of independent variables, the dimensionality of the regression line, and the kind of dependent variable, there are various types of regression procedures available. Linear regression and logistic regression are the two most used regression techniques. Some assumptions must be addressed for various forms of regression analysis and a grasp of the nature of variables and their distribution [8].

4.1.1.1. Linear Regression

Linear Regression is the most basic of all regression methods, attempting to establish connections between independent and dependent variables. The dependent variable is typically continuous in this case.

4.1.1.2. Logistic Regression

A supervised learning technique for classification, Logistic Regression, commonly known as Logit, Maximum-Entropy classifier, is a supervised learning method for classification. It uses regression to establish a relationship between dependent class variables and independent factors.

When it comes to regression analysis, what are the most common blunders? When dealing with regression analysis, it is critical to have a thorough understanding of the issue statement. We should presumably utilize linear regression if the issue description mentions forecasting. We should apply logistic regression if the issue description mentions binary categorization. Similarly, we must assess all of our regression models based on the issue statement.

4.1.2. How is it Different From Classification?

The distinction between classification and regression issues is significant. Fundamentally, classification and regression are both about predicting a label and a quantity.

Classification aims to predict a discrete class label. Regression, on the other hand, is the challenge of predicting a continuous variable. There is some overlap between the classification and regression techniques. A classification algorithm may predict a continuous value in the form of a probability for a class label. In contrast, a regression method may predict a discrete value in the form of an integer number.

Some algorithms, such as decision trees and artificial neural networks, may be utilized for classification and regression with minor tweaks. Some methods, such as linear regression for predictive regression modeling and logistic regression for classification predictive modeling, cannot readily be utilized for both issue types.

4.1.3. Applications of Regression

For prediction and forecasting, regression analysis is employed. This is closely related to the subject of machine learning. This statistical approach is utilized in a variety of sectors, including:

1. Stock market analysis: Understand the trend in stock prices, predict prices, and assess risks in the insurance sector in the financial industry.
2. Business: Understand the efficacy of marketing efforts, foresee pricing, and product sales.

CHAPTER 5

Reinforcement Learning

Abstract: This chapter introduces the readers to a new concept of machine learning, other than supervised and unsupervised learning. This concept is popularly known as reinforcement learning. Reinforcement learning is a kind of machine learning algorithm, where the model learns itself based on surrounding behavior and new technique of rewarding. This chapter will gradually teach the readers about each concept for understanding reinforcement learning in-depth, alongside a basic application with Python. This chapter will look at the concepts to understand why it is getting so much attention these days. This serves as a beginner's guide to reinforcement learning. Reinforcement learning is undoubtedly one of the most visible study areas at the moment, with a promising future ahead of it, and its popularity is growing by the day.

Keywords: Machine Learning, Reinforcement Learning, Environment, Reward, Agent, Learning.

5.1. INTRODUCTION TO REINFORCEMENT LEARNING

Reinforcement learning (RL) is a component of machine learning that instructs an agent to select an action from its action space inside a given environment for maximizing rewards throughout time.

Its purpose is to teach the model how to conduct certain activities in a specific environment, leading to the discovery of the best actions to take in various scenarios to reach the ultimate objective. Using repeated trials to maximize a cumulative reward, the agent learns to attain a goal in an unpredictable and complicated environment. The agent uses a trial-and-error approach to find a solution to the problem, and the actions it takes, earn it either rewards or penalties. Reinforcement Learning is used to determine the optimum behavior or course to follow in a particular circumstance.

Let us now understand the concept in a more elaborative way, rather than just mentioning the terminologies. Reinforcement learning is a new technique of machine learning, not a very old concept. So, it is still under the research and development phase for utilizing its capacity at most.

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5.1.1. Overview

As we know, reinforcement learning is part of a machine learning algorithm, which is pretty advanced. So, let us quickly overview the other algorithms and reinforcement learning, too.

Machine learning is a section of computer science dealing with the creation and development of algorithms that enable computers to learn from data sources, such as sensor data or databases. Detecting complicated patterns and making intelligent judgments based on data is a crucial focus of machine learning research.

- **Supervised Machine Learning**: Immediate feedback is available with supervised learning.

- **Unsupervised Machine Learning**: There is no feedback in unsupervised learning.

- **Reinforcement Learning**: Scalar feedback is delayed in reinforcement learning (a value called reward).

RL is about agents who must notice and react to their surroundings. This method combines traditional AI and machine learning methods. It is a complete problem-solving environment.

Let us consider the following examples:

1. A robot is cleaning a room while its battery is being recharged.

2. Soccer played by robots

3. How to invest in a stock market smartly.

4. Using rational agents to model the economy

5. Learning to fly a helicopter is a challenging task.

6. Planes are scheduled to arrive at their destinations.

5.1.1.1. Meaning of Reinforcement

The occurrence of an event in the context of a reaction increases the likelihood of the reaction occurring again in the same scenario.

The challenge that an agent encounters while learning behaviour in a dynamic environment through trial-and-error is known as reinforcement learning. It is a method of figuring out how to perform to maximize a monetary return.

It is neither a sort of neural network nor a substitute for neural networks. Instead, for the learning device, it is an orthogonal technique. Reinforcement learning provides feedback that evaluates the learner's performance without establishing criteria of accuracy in the form of behavioral objectives. For example, we can consider bicycle training.

5.1.1.2. How RL Differs from Supervised Learning

The model is trained with a training dataset that includes a correct response key in supervised learning. The decision is based on the initial input, which contains all the data necessary to train the computer. Because the judgments are distinct from one another, each one is represented by a label.

There is no response in reinforcement learning; thus, the reinforcement agent determines what to do to complete the job. Since the training dataset was unavailable, the agent had to rely on its own experience to learn. It all comes down to making judgments in a logical order. Simply put, the output depends on the current input state, and the following input depends on the output of the previous input. It labels the dependent decisions in order.

5.1.2. Element of Reinforcement Learning

Before getting deeper into the working model of reinforcement learning, let us first understand the key terminologies used in RL. Fig. (**5.1**) states the overall architecture of reinforcement learning. We observe two significant elements, agent and environment. In this diagram, we observe that these two blocks are connected with three arrows; the first one is the state, which connects the agent from the environment. The second one is action, which relates the environment from the agent and is supported by a policy. The third one is the reward, which connects the

CHAPTER 6

Deep Learning: A New Approach to Machine Learning

Abstract: The chapter will introduce the readers to the latest state-of-the-art deep learning algorithms from scratch. Deep learning is a modern field of machine learning capable of understanding the underlining patterns in the data on its own and identifying the nature of the data. This chapter will travel through all the algorithms, from basic neural network structure to advanced neural networks, such as convolution neural networks and recurrent neural networks. It covers artificial neural networks, perceptron learning algorithms, convolution neural networks, recurrent neural networks, long short term memory, and essential concepts such as backpropagation, gradient descent, activation functions, and optimizations. With the hands-on example and Pythonic approach to real-world applications, this chapter will enhance the readers' knowledge of advanced technologies.

Keywords: Deep Learning, Neural Network, Perceptron Learning Algorithm, MLP, ANN, Convolutional Neural Network, Random Forest, K-nearest Neighbor, Naïve Bayes Classification, Support Vector Machine.

6.1. INTRODUCTION TO NEURAL NETWORK

Deep learning is a subclass of machine learning that uses neural networks to learn from unstructured or unlabeled data in a manner comparable to that of the human brain. Giving the system vast data will eventually learn to comprehend it and respond in meaningful ways.

Deep learning is a kind of machine learning that learns to represent the world as a layered hierarchy of concepts. Each concept is defined in more straightforward concepts and more abstract representations calculated in less abstract representations. Each concept is represented in connection to other concepts. This provides it with an ample amount of power and flexibility.

We basically move to deep learning for getting the following:

- Deep learning works well with unstructured data.

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○ Deep learning can operate with structured and unstructured data, whereas machine learning works best with vast quantities of structured data.

• It can handle the complex operations.

○ Machine learning algorithms are unable to execute complicated processes, but deep learning algorithms can.

• It can do the features engineering on its own.

○ Machine learning methods detect patterns from labeled sample data, whereas deep learning algorithms receive a considerable volume of data as input and analyze it to extract characteristics from an object.

• Finally, it achieves better performance compared to machine learning algorithms.

○ Machine learning algorithms' performance degrades as the number of data increases. Thus we require deep learning to keep the model running.

6.1.1. Architecture of Deep Learning

When we discuss deep learning architecture, we need to understand its working principle. As we know, deep learning is capable of doing both feature engineering and classification. It identifies the underlining pattern in the data to categorize it to a specific class [15].

A deep neural network (DNN) comprises several layers, transforming the input data into more abstract representations (for example, edge - nose - face). To generate predictions, the output layer integrates such features.

It's a sophisticated neural network (having multiple hidden layers in between input and output layers). Non-linear connections can be modeled and processed by them.

Deep-learning architectures like deep neural networks, deep belief networks, neural graph networks, recurrent neural networks, and convolutional neural networks are employed in areas like natural language processing (NLP), machine translation, computer vision, bioinformatics, speech recognition, drug design, medical image analysis, material inspection, and board game programs. In deep learning, the term "deep" refers to the usage of several layers in the network. Deep learning is a more recent form with an infinite number of layers of fixed size, allowing for practical application and optimization while maintaining theoretical universality under moderate circumstances. In terms of efficiency, trainability, and understandability, deep learning layers are also heterogeneous and depart considerably from physiologically informed connectionist models, hence the "structured" component.

Like machine learning, deep learning can be of two types, supervised and unsupervised learning. Various algorithms can be listed in a supervised learning way, such as convolutional neural networks, recurrent neural networks, and various forms. The popular deep learning algorithms in the unsupervised part are neural-network-based self-organizing map, restricted Boltzmann machine, and autoencoders. The concept of supervised and unsupervised remains the same for both operations, as in machine learning algorithms.

6.1.2. Working Principle of Deep Learning

The working principle of deep learning algorithms lies in the architectural design of the model. It also depends on the kind of deep learning model, such as supervised and unsupervised. However, the basic working principle or algorithm can be framed in the following way:

1. First, to acquire the appropriate answer, we must identify the actual problem, which must be comprehended. The practicality of deep learning should also be evaluated.
2. Second, we must determine the pertinent facts that must relate to the actual situation and be adequately prepared.
3. Third, select a suitable deep learning algorithm.
4. Fourth, during training the dataset, an algorithm should be applied.
5. Fifth, the dataset should be subjected to final testing.

The recursive definition of an algorithm is as follows:

Step 1: Choose the initial weights at random.

Step 2: Apply the inputs to the network for each training pattern.

Step 3: Calculate the output for each neuron from the input layer to the output layer, passing through the hidden layer.

CHAPTER 7

Feature Engineering

Abstract: The chapter on feature selection techniques deals with most state-of-the-art feature selection techniques, which are being used alongside machine learning algorithms. The feature selection is a crucial element for the better performance of any machine learning algorithm. This chapter covers majorly two types of feature selection algorithms, namely, filter-based and evolutionary-based. This chapter covers two kinds of filter-based approaches in the filter-based algorithms, namely, hypothetical testing, such as t-test, z-test, ANOVA and MANOVA, and correlation-based such as Pearson's correlation, Chi-square test, and Spearman's rank correlation. This chapter also explains various methods such as genetic algorithms, particle swarm optimization, and ant colony optimization in evolutionary algorithms. For each of the algorithms, this chapter describes it in detail and the optimized algorithm for performing the feature selection approach.

Keywords: Feature Selection, Filter-based Approach, Wrapper-based Approach, Statistics, Hypothesis Testing, Correlation, Evolutionary Algorithm, T-Test, Z-Test, ANOVA, MANOVA, Pearson's Correlation Coefficient, Chi-Square Test, Spearman's Rank Correlation, Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization.

7.1. INTRODUCTION

We encounter a vast number of features while working with big sets of data. The most difficult challenge is to choose the most particular and relevant feature from all the characteristics in a dataset. As a result, the feature selection techniques assist us in doing so.

The feature selection technique aids in the identification of important characteristics from a dataset. If an extensive data collection includes $\boldsymbol{a}$ input features, the feature selection method will choose certain important features, such as $\boldsymbol{b}$. When selecting features, the condition is $\boldsymbol{b} < \boldsymbol{a}$.

In order to predict the target variable, feature selection approaches are used to minimize the number of input variables to those that are thought to be most beneficial to a model. The methods aid us in selecting the fewest number of features

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in a data collection, which allows us to train a machine learning algorithm more quickly [26]. It helps in reducing a model's complexity and making it easier to understand. It develops a practical model with greater predictive potential by choosing the proper features to reduce over-fitting.

7.1.1. Types of Feature Selection

As this hit-and-trial technique is a time-consuming way for feature selection, other feature selection methods may be employed to speed up the process:

1. Filter Techniques

Filter techniques are commonly employed as a stage in the preprocessing process. Machine learning techniques have no impact on this feature selection. Instead, characteristics are chosen based on their connection with the outcome variable measured by various statistical tests.

2. Wrapper Techniques

We aim to utilize a subset of features in wrapper techniques and train a model with them. We determine whether to add or delete features from your subset based on the inferences drawn from the prior model. The problem may be simplified to a simple search problem. These approaches are generally highly time-consuming to compute.

3. Embedded Techniques

Filter and wrapper methods are combined in embedded methods. Algorithms with built-in feature selection techniques are used to build it. LASSO and RIDGE regression are two common examples of these techniques, both of which have built-in penalization mechanisms to reduce overfitting.

Before getting into individual algorithms of the filter-based approach, let us understand some proper feature selection techniques used in wrapper-based approaches. There are various feature selection approaches available, some of which treat the process as an art, others as a science, while, in reality, domain expertise and a disciplined approach are likely your best chance.

Wrapper techniques are disciplined approaches to feature selection that tie the feature selection process to the kind of model being produced, assessing feature subsets to identify model performance between features and then selecting the best performing subset [27].

The three primary techniques used to get the most optimal results under the wrapper method are:

1. Forward Selection

2. Backward Elimination

3. Bi-directional elimination

1. Forward Selection

Forward selection is an iterative approach in which no feature is included in the model at the start. We keep adding the feature that best improves our model in each iteration until adding a new variable no longer enhances the model's performance.

Forward feature selection begins by evaluating each individual feature and selecting the one that produces the highest performing algorithm model to consider the best set of features. The techniques depend on the assessment standards, such as accuracy, AUC, precision, recall, or error values. Following that, all potential combinations of the selected feature and the following feature are assessed. A second feature is chosen, and so on until the necessary predetermined number of features is chosen.

2. Backward Elimination

Backward elimination begins with all of the features and eliminates the least significant feature at each iteration, improving the model's performance. We repeat this process until no improvement is noticed when characteristics are removed. It is similar to forwarding selection in that it starts with the whole collection of features and works backward from there, eliminating features to find the best subset of a specific size.

CHAPTER 8

Applications of Machine Learning and Deep Learning

Abstract: Until now, we have covered all aspects of machine learning and deep learning models and understood their internal architecture in detail. This chapter familiarizes the readers with the state-of-the-art real-life applications of machine learning and deep learning algorithms. The chapter will cover real-world applications from every corner of the recent advancements, starting from daily usage of face recognition to object detection. Not only that, but this chapter also explains the application of machine learning and deep learning in day-to-day life usage. Amid many applications, this chapter will cover the essential applications covering pattern recognition, video processing, medical imaging, and computational linguistics. The chapter presents the Python implementation of all the applications. This chapter also mentions some of the other critical real-world applications used in our daily life.

Keywords: Machine Learning, Deep Learning, Pattern Recognition, Video Processing, Medical Imaging Computational Linguistic, Classification, Tumor Detection, Neuroimaging, Face Recognition, Optical Character Recognition, Sentiment Analysis, Python, Tensor Flow, Keras.

8.1. INTRODUCTION

So far, we have looked at every aspect of machine learning and deep learning models and have a strong knowledge of their design. This chapter presents cutting-edge real-world applications of machine learning and deep learning techniques.

The chapter has looked at real-world applications from every corner of recent advancements, from everyday usage of face recognition to object detection. Not only that, but this chapter also discussed how machine learning and deep learning are applied in real-life situations.

Till now, we have discussed many algorithms of machine learning and deep learning. Although the explanation of every algorithm was supported by Python application on actual data, this chapter elaborates more on each algorithm. The availability of enormous datasets, along with improvements in algorithms and exponential increases in computer power, has resulted in an unprecedented surge of interest in the field of machine learning in recent years. Machine learning

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techniques are now widely used for large-scale classification, regression, clustering, and dimensionality reduction problems involving high-dimensional input data. Other disciplines, such as image identification, have already been transformed by deep learning algorithms.

At first, we will cover machine learning applications and deep learning in pattern recognition, specifically for the most used daily applications such as face recognition, object detection, and optical character recognition [36]. After finishing all the image-related recognition applications, we will dig into video processing for identifying objects from a real-time or recorded video. An essential application of deep learning during the current time is a medical application, specifically medical imaging [37]. This chapter will teach how to apply machine learning and deep learning algorithms in neuroimaging to identify MRI and fMRI data patterns. Finally, we will visit another state-of-the-art application of deep learning, *i.e.*, the sentiment analysis using natural language processing, a computational linguistic part.

8.2. PATTERN RECOGNITION

In today's digital environment, the pattern is everywhere. A pattern can be physically detected or computationally observed *via* the use of algorithms. The automatic recognition of patterns and regularities in data is known as pattern recognition. Statistical data analysis, signal processing, picture analysis, information retrieval, bioinformatics, data compression, computer graphics, and machine learning are all areas where it may be used. It is the technique of applying a machine-learning algorithm to recognize patterns. The classification of data based on prior knowledge or statistical information collected from patterns and/or their representation is known as pattern recognition.

Pattern recognition has several characteristics. A pattern recognition system should be able to rapidly and accurately recognize patterns known to the user. It can adequately detect and categorize unknown things from various perspectives, allowing it to recognize and classify them. It can also detect patterns and things that are partially obscured. It automatically and rapidly identifies patterns.

8.2.1. Face Recognition

The technique of recognizing or validating a person's identification using their face is known as facial recognition. Patterns based on a person's facial features are captured, analyzed, and compared. It is a way of recognizing or validating an individual's identification by looking at their face. Face recognition software can identify persons in pictures, videos, or in real-time. During police stops, officers may utilize mobile devices to identify persons.

Face recognition is one of the fields of machine learning that has been studied for a long time. Moreover, it has developed into a common and popular technology that can easily recognize faces even in our hands in recent years. In particular, it is used in mobile phones as a way to maintain security easily. Based on this reality, in this section, we will see how to distinguish faces with CNN and Avengers image sets, which show excellent ability to process image data.

8.2.1.1. Python Implementation

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1. Technology used
•  CNN
•  Face recognition

2. Reference
•  https://medium.com/hyunjulie/%EC%BA%90%EA%B8%80%EA%B3%BC-
   %EA%B5%AC%EA%B8%80-colab-
   %EC%97%B0%EA%B2%B0%ED%95%B4%EC%A3%BC%EA%B8%B0-6a274f6de81d
•  https://www.kaggle.com/rawatjitesh/avengers-face-
   recognition
•  https://www.kaggle.com/ruslankl/brain-tumor-detection-v1-0-
   cnn-vgg-16/data
•  https://www.tensorflow.org/tutorials/keras/classification


3. Kaggle usage
•  kaggle main page -> (click top-right circle) -> Account ->
   (down scroll) -> API -> Create New API Token


4. Description
a) Import libraries
b) Preparing Kaggle
c) Download dataset
d) Split data
e) Dataset import
f) print dates
g) Make CNN model
```

CHAPTER 9

Conclusions

All of the chapters in this book are devoted to machine learning and deep learning architecture. As the name implies, it focuses on real-world machine learning applications and deep learning techniques. The following is a general outline of the book:

The introductory chapter introduced the fundamental concepts of artificial intelligence and the gradual growth of artificial intelligence, giving rise to machine learning and deep learning. It threw deep insights into the need for learning and the concept of learning in the machine learning framework. This chapter also stated the importance of AI and its various dimensions. In the end, this chapter introduces machine learning and its variants. It also shortly described each type of machine learning algorithm.

The second chapter introduced supervised machine learning algorithms. This chapter explained the algorithms such as Decision Trees, Random Forests, K-Neighbors, Name Bias Classifiers, and Support Vector Machines. Each algorithm begins with an overview, then is described with an algorithm framework and hands-on examples. A detailed program for Python is provided at the end of each algorithm to understand a practical understanding of the functional behavior of the classification. The Python code runs on real data sets and ultimately gives the reader an in-depth knowledge of algorithm applications.

The chapter on clustering algorithms was introduced to the readers as a part of unsupervised machine learning algorithms. This chapter described the state-of-the-art clustering algorithms. This chapter presented an elaborative definition of k-mean clustering, hierarchical clustering, and self-organizing map. It also defined the algorithmic framework of each algorithm with hands-on examples with detailed Python codes and outputs.

Next, the readers were given a thorough understanding of regression analysis in the introductory chapter. The notion of regression is used in both statistics and computer science, particularly in machine learning. The principle, on the other hand, hasn't changed, although the applications have. The two most used regression analysis techniques, linear and logistic regression, were covered in this chapter. Each algorithm is discussed in full here, along with examples on how to use them.

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In addition, we learned more in-depth about linear and logistic regression by showing them with a Python application on real-world data.

In the final part of section II, reinforcement learning (RL) was introduced. It a machine learning subfield similar to supervised or unsupervised learning but differs in numerous aspects. It is more difficult to apply to real-world business scenarios since it requires simulated data and surroundings. On the other hand, RL technology is promising since its learning process is inherent to sequential decision-making settings. This chapter clearly explained the algorithm and its usage.

The chapter on deep learning introduced the reader to the most up-to-date, state-of-the-art deep learning algorithms in this chapter. Deep learning is a contemporary discipline of machine learning capable of recognizing the nature of data and comprehending the underlying patterns in it on its own. This chapter covered everything from neural network structure to advanced neural networks like convolutional neural networks and recurrent neural networks. It covered artificial neural networks, feed-forward neural networks, convolutional neural networks, and recurrent neural networks, with key topics like backpropagation, gradient descent, activation functions, and optimizations highlighted. This chapter will undoubtedly improve the readers' knowledge of advanced technologies by providing hands-on examples and a Pythonic approach to real-world applications.

The chapter on feature selection approaches covered the most current feature selection strategies used in conjunction with machine learning algorithms. The selection of features is an essential factor in improving the performance of any machine learning system. The two types of feature selection algorithms discussed in this chapter were filter-based and evolutionary-based. This chapter discusses two types of filter-based algorithms: hypothetical testing, such as the t-test, z-test, ANOVA, MANOVA, and correlation-based, such as Pearson's correlation, Chi-square test, and Spearman's rank correlation. This chapter solely covered evolutionary methods, including genetic algorithms, particle swarm optimization, and ant colony optimization. This chapter goes through each of the methods in-depth and the optimized algorithm for conducting the feature selection technique.

We have gone through every facet of machine learning and deep learning models so far, and we have a good understanding of their underlying architecture. The readers were introduced to state-of-the-art real-world applications of machine learning and deep learning algorithms in this chapter. The chapter has explored real-world applications from every corner of recent developments, from the everyday use of facial recognition to object detection. Not only that, but this chapter also covered how machine learning and deep learning are used in everyday life. This chapter has addressed the most critical applications in the domains of pattern recognition, video processing, medical imaging, and computational linguistics, among others. The Python implementation of all of the applications was provided in this chapter. This chapter also discussed several additional essential real-world applications that we utilize regularly.

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