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Machine Learning Technique for Practical Engineering Use

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ABSTRACT

In the age of Industry 5.0, where the digital world generates massive amounts of data, AIML has emerged as a powerful tool for analyzing and interpreting this data. It has proven successful in various fields such as intelligent control, decision making, computer graphics, and computer vision and many more. The performance in AIML and deep learning methods has led to their widespread adoption in real-time engineering applications. These tools are necessarily required for creating intelligent, automated tools that can recognize the data in areas like healthcare, cybersecurity, and intelligent transportation systems. Machine learning encompasses different strategies, including reinforcement learning, semi- supervised, unsupervised and supervised learning algorithms. This study aims to comprehensively explore the utilization of ML in managing real world engineering applications, enhancing their functionality and intelligence. By investigating the applicability of various machine learning approaches in domains such as cybersecurity, healthcare, and intelligent transportation systems, this research contributes to our understanding of their effectiveness. Additionally, it addresses the research goals and difficulties associated with ML in practical life. This study serves as reference for industry professionals, academics, and decision-makers, providing insights and benchmarks for different use cases and real-world applications.

Key words : Reinforcement learning, Semi-supervised learning, Unsupervised learning, Supervised Learning

1. INTRODUCTION

1.1 Machine Learning Evolution

In the modern year, data has become a part and parcel of our lives, with real-time engineering applications generating substantial amounts of data in various formats, such as unstructured, semi-structured, and structured data. This wealth of data presents opportunities for developing intelligent applications across different domains. For instance, the author leverages cybersecurity data to derive valuable insights and applies them in the creation of automated and intelligent cybersecurity applications. Similarly, in this article, the author utilizes mobile data to gain meaningful insights and employs those insights to develop contextually aware, smart applications [2]. The success of real-time engineering applications relies on effective data management tools and technologies that enable the extraction of valuable knowledge and insights in a timely and intelligent manner.

Machine learning is a subfield of artificial intelligence, has gained significant traction in data processing and analysis, revolutionizing the way applications operate intelligently. In the context of Industry 4.0, which represents Industrial Revolution, machine learning has emerged as a prominent technology that enables applications to learn from experience and enhance system performance without explicit programming [7]. It plays a crucial role in automating conventional industrial and manufacturing processes by facilitating intelligent data analysis. By implementing various optimized and efficient machine learning algorithms, real-time engineering applications can tackle real-world problems through intelligent data analysis. These algorithms encompass different types, namely reinforcement learning, unsupervised learning, semi supervised learning, and supervised learning. They provide the framework for developing intelligent applications that leverage data analysis to address complex challenges.

1.2 Types of methods used in Machine Learning

Some of the Machine Learning approach are as follows:

1. Reinforcement learning

This technique involves training models to get the output/decisions through interaction with an environment and receiving feedback in the form of rewards or penalties. It is particularly useful in optimizing decision-making processes.

In an environment-driven approach, reinforcement learning (RL) empowers machines and software agents to autonomously assess and enhance their optimal behavior within specific contexts [11]. RL relies on the concept of rewards and punishments as the basis for learning. The objective of RL is to leverage insights derived from the environment to get decisions that minimize punishments and maximize rewards.

This approach can be applied to amplify the efficiency of advanced systems by employing trained artificial intelligence models in various domains such as supply chain logistics, manufacturing, autonomous driving, and robotics. By utilizing RL, these systems can achieve operational optimization and automation, leading to increased efficiency and performance.

2. Semi-supervised learning

In this approach, the model learns from both labelled and un labelled data to improve its Efficiency in performance. It combines the benefits of labelled data with the potential to leverage a larger pool of un labelled data, making it valuable when labelled data is scarce.

The hybrid nature of the semi-supervised learning approach allows it to effectively utilize both labelled and un labelled data. Positioned between supervised and unsupervised learning methods, this approach offers valuable advantages. In scenarios where ample un labelled data is available alongside limited labelled data [1], real-time semi-supervised approaches prove to be beneficial. By leveraging this approach, better predictions can be achieved compared to relying solely on labelled data. Common tasks that benefit from semi-supervised learning include text classification, data labelling, fraud detection, machine translation, and more. This approach proves to be advantageous in various contexts, enabling improved prediction accuracy and leveraging the available data resources effectively.

3. Unsupervised learning

Unsupervised learning focuses on discovering patterns and structures within unlabeled data. By identifying hidden relationships or clusters, this approach enables insights and knowledge extraction from unstructured or unlabeled datasets.

In the context with the authors' perspective, the unattended approach is characterized as a data-centric process that involves analyzing datasets containing unlabeled data with minimal or no human intervention. Unsupervised approaches are constantly employed to examine data, identify patterns and trends, uncover meaningful structures, and extract shared features. Similar process in unsupervised learning include anomaly detection, association rule discovery[6], dimensionality reduction, feature learning, density estimation, and clustering. By utilizing unsupervised techniques, valuable insights can be gained from unlabeled data without relying on pre-existing labels, facilitating exploration and discovery within datasets.

4. Supervised learning

Supervised learning involves training models with labelled data, providing them predictions or classifications based on new, unseen data. It is widely used when historical data with known outcomes is available to guide the learning process.

These different machine learning approaches offer a range of tools for real-time engineering applications, providing flexibility and adaptability in addressing specific challenges in an intelligent manner. The authors provide a definition of a supervised approach as the method of developing a function that learns to map inputs to outputs. This function is constructed using labeled training data and training examples. They also highlight that supervised learning approaches are specifically designed to achieve specific objectives when provided with inputs. The two most prevalent supervised learning tasks are regression, which involves predicting continuous values, and classification, which involves assigning labels to inputs based on predefined categories [10]. By leveraging supervised learning techniques, models can be trained to accurately predict outputs based on given inputs, enabling task-driven applications in various domains.

2. ADVANCEMENT IN ML

2.1 Real World Issues

Through machine learning, systems can utilize customer data to execute program instructions while also adapting to new situations and changes. The algorithms employed at machine learning have the capability to adapt to the data provided, resulting in behavior is not explicitly programmed. By acquiring the ability to comprehend context, digital assistants can analyze emails and extract pertinent information. This form of learning encompasses the capacity to predict future customer behavior, enabling businesses to get a better and deeper understanding of their customers and take actions rather than reactive ones. Machine learning provides extensive applications across various industries and fields, with the potential to expand further over time.

2.2 Introduction to Cyber Security

The Internet serves as a primary platform for accessing services and information. According to this note since 2017, approximately 48% of the world’s population relies on Internet as a major source of information. Further, this percentage has increased to 82% in developed countries.

The Internet encompasses the interconnectedness of various devices, networks, and computers, enabling the transfer of information between them.

The continuous advancement of mobile networks and computer systems has significantly contributed to the widespread usage of the Internet. With its prominence as a major information source, the Internet becomes more susceptible to cybercrime [3].

To ensure the stability of computer systems, it is crucial to maintain the integrity, availability, and confidentiality of information. The article emphasizes that unauthorized to the individuals who gain access to a network and disrupt normal operations can compromise the integrity and security of computer systems [4]. Cybersecurity act as a main role in safeguarding user resources and the digital realm from unauthorized intrusions and breaches.

As highlighted in the article, the primary objective of cybersecurity is to uphold the availability, completeness, and confidentiality of information, thereby protecting it from potential threats.

2.3. Introduction to Healthcare

The advancements in deep learning and machine learning have brought about significant transformations in governance, transportation, and manufacturing. The previous years, has witnessed extensive research in deep learning, leading to remarkable achievements in fields such as speech processing, text analysis, and computer vision. More recently, these methods are applied in medical applications, demonstrating exceptional outcomes in brain tumor segmentation, medical image reconstruction, lung nodule detection, lung disease classification, and image rendering of body parts.

One notable application in the medical field is the utilization of computer-aided diagnosis (CAD) systems [9], which provide a secondary opinion to aid radiologists in disease confirmation. Deep learning and machine learning techniques are continuously enhancing the performance in the software such as CAD systems and other supporting tools for radiologists. Moreover, the integration of technologies like big data, mobile communications, edge computing, and cloud computing further supports the deployment of deep learning and machine learning models in medical applications. This combination of technologies enhances predictive accuracy and enables the development of intelligent solutions centered around human needs.

2.4 Introduction to ITS (Intelligent Transportation Systems)

ITS, resulting from the integration of sensor technology, communication, and information, play important role in managing traffic and transportation. They are essential components of smart cities and offer a range of services including self-driving cars, public transportation management, traveler information systems, and road traffic management. These services have the strength to bring significant benefits to society, including pollution reduction, increased energy efficiency, enhanced traffic and transportation effectiveness, and improved road safety.

The advancement of technologies such as wireless communication, computing, and sensors has enabled the implementation of intelligent transportation systems. However, the generation of large volumes of data, diverse quality of service requirements [5], and scalability pose considerable challenges in their deployment and operation.

In recent times, the proliferation of deep learning and machine learning models has opened up new possibilities. Approaches like reinforcement learning (RL) and deep learning (DL) are being leveraged to identify patterns and make precise decisions and predictions within intelligent transportation systems. These techniques have the potential to enhance the effectiveness and efficiency of these systems by utilizing the vast amounts of data generated.

2.5 Introduction to Renewable Energy

The need for sustainable and balanced energy sources arises from the environmental impact of burning carbon fuels and the depletion of these resources. This highlights that regeneratable energy sources like biomass, wind, tidal energy, geothermal, solar thermal, and photovoltaics are gaining traction in the energy market. Power grid instability can occur due to imbalances between energy supply and demand.

Moreover, environmental factors meant an important role in the energy yield of renewable energy plants. To address energy management and optimization challenges, machine learning techniques are employed. These approaches enable effective monitoring and control of energy systems.

The technique of Internet of Things (IoT) facilitates communication between humans, objects, and various interconnected entities. It involves embedding sensors and actuators into physical objects, enabling them to connect through wired and wireless networks. These networks generate substantial amounts of data, which are analysed by computers. The ability of objects to sense and communicate with their environment allows for a deeper understanding of complex systems and enables swift responses. The deployment of physical information systems, sometimes operating autonomously, represents a significant advancement. The "Internet of Things" refers to encoding and networking of everyday objects to make them machine- readable and traceable on the Internet.

2.6 Introduction to Smart Manufacturing

Manufacturing encompasses various categories, and one such category is known as Smart Manufacturing. Smart

Manufacturing involves the use of computer-based systems to enhance production processes by incorporating worker training, digital technologies, and rapid design changes with high flexibility. It also focuses on effectively managing production recyclability, optimizing the supply chain, and quickly adjusting production levels based on demand. Smart Manufacturing relies on enabling technologies such as robotics, connectivity of services and devices within the industry, and the processing capabilities of big data [12].

These advancements contribute to the efficient and effective implementation of Smart Manufacturing practices.

2.7 Introduction to Computer Networks

The main application of machine learning (ML) in networking has gained significance due to advancements in networking technologies, particularly Software-Defined Networking (SDN) with network programmability. ML is widely utilized in various aspects like pattern recognition, speech synthesis, and outlier detection, but its application in network operations and management is relatively limited. The challenges in this regard involve determining the data that can be collected and establishing controls on legacy network devices. However, the use of SDN allows for programming the network, which helps overcome these challenges.

ML-based discovery enables the automation of network operations and management tasks, presenting an opening to address complex network challenges. Applying ML approaches in the networking field is both intriguing and challenging to the vastness and complexity of networks. It necessitates a comprehensive understanding of ML techniques along with a deep knowledge of networking issues. Consequently, ML in the field of networking is an engaging research area that holds promise for improving network operations and management.

3. CONCLUSION AND FUTURE SCOPE

This study focuses on analyzing machine learning algorithms and their applications in various domains. The main objective is to address real-world problems by employing different learning techniques [8]. The success of a machine learning model depends on its performance and the characteristics of the data being analyzed. To ensure effective decision-making, it is crucial for the algorithms to be well-acquainted with the target application and trained using diverse real-world data. This review aims to emphasize the versatility of machine learning approaches in tackling a wide array of practical challenges across different fields. Additionally, the paper discusses research directions and relevant issues. The proposed solution aims to overcome obstacles specific to the target domain by leveraging the power of machine learning. The study serves as a valuable resource for industry professionals and researchers, offering insights and guidance for decision makers operating in various application areas and real-world scenarios. Machine learning finds applications not only in specific industries such as banking, finance, IT, media, entertainment, gaming, and automotive sectors, but also holds great potential for revolutionizing numerous other fields in the future.

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