RECENT ADVANCEMENTS IN COMPUTATIONAL INTELLIGENCE

CONCEPTS, METHODOLOGIES AND APPLICATIONS

PART 1

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Recent Advancements in Computational Intelligence: Concepts, Methodologies and Applications

(Part 1)

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Recent Advancements in Computational Intelligence: Concepts, Methodologies and Applications ***(Part 1)***

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FOREWORD

In the rapidly evolving landscape of technology, computational intelligence stands out as a beacon of innovation and promise. The term itself encompasses a broad spectrum of techniques and methodologies that have revolutionized our approach to solving complex problems and understanding intricate systems. As we navigate through the 21st century, the importance of computational intelligence continues to grow, driving advancements across various domains and shaping the future of numerous industries.

It is with great pleasure that I introduce **"Recent Advancements in Computational Intelligence: Concepts, Methodologies, and Applications,"** a comprehensive volume that encapsulates the latest developments and breakthroughs in this dynamic field. This book is not merely a collection of papers but a testament to the vibrant and ever-expanding realm of computational intelligence. It serves as a crucial resource for both seasoned researchers and newcomers alike, offering valuable insights into the evolving paradigms and practical applications of computational intelligence.

The book is structured to provide readers with a thorough understanding of the foundational concepts that underpin computational intelligence, while also delving into cutting-edge methodologies that are reshaping the landscape. Each chapter is precisely crafted to offer a blend of theoretical rigor and practical relevance, ensuring that readers are equipped with the knowledge to apply these advancements in real-world scenarios.

From neural networks to evolutionary algorithms, and from fuzzy systems to hybrid intelligent systems, the breadth of topics covered in this volume reflects the diverse and interdisciplinary nature of computational intelligence.

As we stand at the point of an era where computational intelligence is becoming increasingly integral to our daily lives, this book serves as a valuable guide to understanding its current state and future directions. It is a call to action for researchers, practitioners, and students to engage with the transformative potential of computational intelligence and to contribute to its ongoing evolution.

I would like to extend my gratitude to the editors and contributors for their dedication and hard work in bringing this important work to fruition. Their expertise and commitment have ensured that this volume is both insightful and impactful.

In closing, I invite you to immerse yourself in the pages of this book, explore the myriad advancements in computational intelligence, and envision the possibilities that lie ahead. The future is being shaped by the innovations discussed within these chapters, and I am confident that this book will be a valuable resource for anyone seeking to understand and contribute to the exciting field of computational intelligence.

PREFACE

As robust intelligent computational methodologies have been successfully deployed for resolving several real-world challenges, innovative optimization approaches and underlying techniques have drawn the attention of decision-makers, executives, engineers, academicians, and active researchers to a greater extent. The edited book volume namely, **recent advancements in computational intelligence: concepts, methodologies, and applications** focuses on the most recent advancements in the domains of computer science, engineering, information technology, management, and finance as well. This book is an important resource for postgraduate students, decision-makers, and researchers in the public and private sectors who are looking for research-based methods for modeling uncertain and unpredictable real-world problems due to its focus on a variety of methods and systems as well as practical examples.

The future of computational intelligence with the advancements of AI-based technologies has a clear mandate for deploying large-level intelligent computational models toward solving complex problems. By offering a forum for scholars and professionals to explore these subjects, the book hopes to promote a more profound comprehension of the prospects and positive implications of new technologies in various domains by establishing a knowledge reservoir between the chapter contributors and readers of the book. In this perception, the edited book volume will be a priceless resource for researchers and practitioners to experience different viewpoints and insights into the far-reaching impact of developing technologies.

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CHAPTER 1

Recent Advancements and Applications of Computational Intelligence

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Abstract: Computational Intelligence (CI) is a subfield of Artificial Intelligence (AI) that represents the application of algorithms designed to address specific problems by automating tasks that traditionally require human intelligence. Utilizing algorithms capable of learning and recognizing patterns within data, AI achieves quicker results. With the rapid advancement of CI, its applications have become essential components across diverse domains, transforming industries and reshaping task execution methodologies. This research conducts a thorough examination of the varied techniques and applications of CI, aiming to provide a nuanced understanding of their current status and future potential. The initial segment of the study delves into the foundational tools pivotal for AI development, forming its backbone. Subsequent sections concentrate on the widespread applications of CI in sectors such as healthcare, finance, education, manufacturing, and autonomous systems. The study delivers a comprehensive overview of CI advancements and applications, offering valuable insights for researchers, practitioners, and policymakers. By comprehending the present landscape and anticipating forthcoming developments, stakeholders can navigate the evolving AI ecosystem with informed decision-making, ensuring the responsible and ethical progression of this transformative technology.

Keywords: Computational intelligence, Computer vision, Machine learning, Natural language processing, XAI.

INTRODUCTION

With the advancement of technology, computational intelligence (CI) has expanded significantly in recent years. CI is gradually taking over as the primary force that is constantly changing the virtual environment. Information consumption is evolving as a result of the digital age. With more and more people

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turning to digital devices for their day-to-day needs, businesses have started utilizing various models for content creation, social media, education, recruitment, sales, marketing, and decision-making [1, 2].

AI tools encompass a diverse range of software and hardware technologies designed to empower machines to execute tasks traditionally associated with human intelligence. By harnessing algorithms, data, and computational capabilities, these tools emulate cognitive functions like learning, reasoning, problem-solving, perception, and language comprehension. Their pivotal role extends to process automation, extensive data analysis, and the facilitation of intelligent decision-making.

The key components of CI techniques include machine learning, Natural Language Processing (NLP) tools that facilitate the understanding, interpretation, and generation of human language, Computer Vision tools for enabling machines to interpret and decide based on visual data, and Explainable AI (XAI) tools aiming to enhance the interpretability of AI models for human understanding. The rapid evolution of CI techniques is playing a significant role in driving progress across diverse industries. As technology advances further, the prevalence and impact of CI techniques in development and integration are expected to grow substantially.

Machine Learning Tools

Machine learning (ML) plays a vital role in computational intelligence by enabling systems to learn and enhance their performance through experience, eliminating the need for explicit programming. The spectrum of machine learning tools is extensive, encompassing traditional algorithms to deep learning architectures. Their application in AI is diverse and depends on the specific problem at hand. The iterative process of the machine learning pipeline empowers AI systems to continually learn and adapt to evolving conditions, making them potent instruments across a broad array of applications [3].

These tools find utility in various stages of model development, including data collection, preprocessing, feature engineering, model selection, and beyond. Numerous tools serve these purposes, each contributing to the robust construction and deployment of effective models.

Scikit-learn

Scikit-learn (Sklearn) is the most usable and robust machine-learning library. It utilizes a consistency interface to provide a set of proficient tools for machine learning and statistical modeling, which includes classification, clustering, regression, and dimensionality reduction.

Tensorflow

TensorFlow is a differentiable programming infrastructure layer. TensorFlow can use GPUs and TPUs as hardware accelerators and can compute the gradient of any differentiable tensor expression automatically. TensorFlow computation can be distributed to a large number of devices, and a large number of machines can be distributed to a single machine [4].

Keras

TensorFlow's high-level API is called Keras. Deep learning employs keras as its user interface to deal with layers, models, optimizers, loss functions, and metrics. In Keras, the Layer class is the most basic abstraction. A Layer includes weights and few computations [5, 6].

Pytorch

PyTorch provides Tensors that may run on either the CPU or the GPU, greatly speeding up the computation. Slicing, indexing, math operations, linear algebra, and reductions are a few of the tensor routines offered to help improve speed and match scientific computation needs.

NLP Tools

Natural Language Processing (NLP) tools assume a pivotal role, empowering machines to comprehend, interpret, and generate human language. The implementation of these tools frequently involves the utilization of machine learning and deep learning techniques, with their efficacy hinging on the quality and volume of the training data. The evolution of NLP tools remains dynamic, propelled by ongoing advancements in research, thereby enhancing language understanding and generation capabilities. CI is applied in diverse NLP tasks such as tokenization, POS tagging, stemming, lemmatization, and more.

Content Creation

Utilizing natural language processing (NLP) and machine learning algorithms, AI-powered content generators create articles, blog posts, and written content that are coherent, contextually relevant, and aligned with specific styles and tones. The effectiveness of content writing is maximized when it serves as a supportive tool for human writers rather than a substitute. AI contributes to content creation by

CHAPTER 2

Unleashing AI at the Edge: Transforming Computing

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Abstract: The convergence of edge computing with Artificial Intelligence (AI) constitutes a watershed point in technological growth, with transformational implications for a wide range of sectors. This chapter explores the mutually beneficial interaction between edge computing and AI, as well as the inherent difficulties and broad implications for the direction of computing in the future. With its decentralized processing model, edge computing puts data analysis closer to the point of origin, facilitating improved efficiency and real-time insights. Edge devices enable sophisticated cognitive processes and autonomous decision-making through seamless integration with AI algorithms. However, this integration creates architectural challenges that call for creative solutions to handle privacy and security issues and strike a balance between processing power and other resources. The chapter examines how edge computing-enabled AI can revolutionize manufacturing, transportation, healthcare, and smart cities. It shows how AI can change predictive maintenance, individualized healthcare monitoring, and urban infrastructure optimization. New advances offer avenues for collaborative applications and decentralized AI training. Federated learning models, the spread of edge AI chips and algorithms, and the democratization of AI capabilities are some of these themes. In summary, this chapter provides direction on navigating the rapidly evolving area of artificial intelligence (AI) facilitated by edge computing, encouraging collaboration and innovation to fully achieve AI's transformative potential and address digital age concerns.

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Keywords: Cognitive edge devices, Decentralized processing, Edge AI chips, Federated learning, Predictive maintenance, Real-time analytics.

INTRODUCTION

With the arrival of the digital age, the technical environment has undergone a deep transition that has completely changed how we interact with data and information. The intersection of edge computing and artificial intelligence (AI) is at the front of this transformation, signifying a paradigm change with broad ramifications for a variety of sectors. According to a study [1], edge computing is typified by decentralized processing that occurs closer to the data sources. This approach promises to reduce latency and allow for real-time processing. In today's data-driven environment, when fast insights are critical for making decisions, this architectural approach is indispensable. When edge computing and AI are combined, new possibilities arise, allowing edge devices to do sophisticated cognitive tasks on their own. According to another study [2], this closeness to data sources makes it easier to integrate AI algorithms smoothly, giving edge devices the ability to carry out predictive analytics, anomaly detection, and decision-making with previously unheard-of efficiency. These capabilities, which allow for real-time insights and intelligent decision-making, have significant potential for a variety of industries, including manufacturing and healthcare. The combination of edge computing with AI is not without difficulties, though. Architectural complexity is a major obstacle, as [3] emphasized in a study. This includes the balance of processing resources and power limits in edge devices. Concerns about security and privacy are also quite real, especially in light of the rise in popularity of edge devices. To effectively address these concerns, the need for strong methods for threat mitigation and data encryption has been underlined in a study [4]. Notwithstanding these difficulties, edge computing-enabled AI has numerous and exciting applications in a variety of industries. Numerous applications in industries like manufacturing, transportation, healthcare, and smart cities are examined [5]. The potential for innovation and improvement is enormous, ranging from individualized healthcare monitoring and predictive maintenance to optimizing urban infrastructure. The possibility for this convergence is further strengthened by emerging trends.

The spread of edge AI chips and algorithms, as covered in a study [6], democratizes AI capabilities and speeds up the implementation of intelligent edge solutions. Federated learning models also present interesting paths for collaborative applications and decentralized AI training. In conclusion, this chapter seeks to offer a thorough analysis of the combination of edge computing and AI, examining its potential for collaboration, underlying difficulties, and important implications for computing's future.

UNDERSTANDING EDGE COMPUTING

Edge computing is a distributed computing paradigm that moves processing and data storage closer to the point of demand, resulting in quicker reaction times and lower bandwidth use. It decentralizes data processing by enabling data to be processed closer to the source rather than relying solely on centralized data centers. This method is extremely beneficial in applications where real-time processing and low-latency replies are important, such as industrial automation systems, driverless automobiles, and Internet of Things (IoT) devices [7 - 9]. Low-latency responses and real-time processing are essential; this tactic is highly beneficial. Edge computing works by bringing computing resources closer to where the data is kept, minimizing the amount of time the data needs to travel before being processed. Greater closeness results in reduced latency and quicker processing times, which boost performance overall. Additionally, edge computing improves scalability and performance by lessening the strain on network infrastructure and central data centers. An efficient way to disperse the burden is to share processing power across edge devices. The following essential components help to validate the decentralized processing ideas of edge computing:

Edge Devices: Sensors, actuators, mobile phones, and IoT devices are examples of endpoints for data generation or collection. Edge devices have a limited computing capacity when compared to normal servers, although they can do basic processing tasks.

Edge Servers: Edge servers, as opposed to centralized data centers, function as intermediate processing nodes closer to edge devices. Edge servers enable more complex computations to be executed locally by providing higher processing power and storage capacity.

Edge Gateways: These devices provide a link between edge devices and the cloud or centralized data centers. Edge gateways take data from different edge devices, preprocess it as necessary, and deliver it to the cloud for further processing or archiving.

Edge Computing Infrastructure: The software and hardware components that allow edge computing capability include edge operating systems, analytics platforms, and edge-specific networking protocols.

The Decentralized Processing Principles of Edge Computing: Key Benefits are as follows:

CHAPTER 3

Secured Edge Cloud Data Management in Autonomous Vehicles Powered by Deep Learning Technologies

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Abstract: With the rapid development of the social economy and industrialization, the trend in autonomous vehicles (AV) is growing dramatically. This trend will significantly change the car industry, making sensors indispensable. This chapter addresses the challenges and opportunities in securely collecting, storing, and processing AV data. AV technologies must make fast decisions based on diverse data, including moral dilemmas, and optimize processing for systems like Advanced driver-assistance systems (ADAS), Lane Keeping Assist (LKA), and Traffic Jam Assist (TJA). Data security is crucial to avoid threats associated with AV and Edge Cloud technology. The proposed solution involves Edge Cloud Assisted Data Management using secure deep learning algorithms. Data from cameras and sensors in AVs is processed in the cloud and with the help of an advanced deep learning algorithm, Faster R-CNN, for accurate object detection and classification. These processed results notify control systems and actuators for safe and efficient vehicle operation. Additional sensors monitor vehicle behavior and can intervene in difficult situations. Edge Cloud technology enhances data processing efficiency and optimization. Deep learning algorithms accurately identify objects, including in blind spots, providing optimal solutions in complex situations. Object detection and instance segmentation with Faster R-CNN offer fast and accurate object location predictions. Data security is ensured through novel encryption techniques. This chapter explores the data handling units in AV technologies and emphasizes the importance of adopting edge cloud computing for the safe and efficient operation of autonomous vehicles. The metrics considered in the proposed object detection algorithm are intersection over union and mean average precision. Combining efficient neural network architectures with techniques like pruning, quantization, and edge computing significantly enhances performance while maintaining safety and reliability.

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Keywords: Autonomous vehicle, Cyber-physical system, Deep reinforcement learning, Edge cloud computing, Faster R-CNN, IoT.

INTRODUCTION

Connected and autonomous vehicle (CAV) is a transformative technology that has great potential for reducing traffic accidents, enhancing quality-of-life, and improving the efficiency of transportation systems [1, 2]. Although the near future will be influenced by CAV's, current challenges like data collection, data storage and processing, and data security continue to postpone the public implementation of this technology. The CAV uses sensors and a wireless network to obtain relevant and vital information while its performance and driving controls are regulated by one of the six levels of automation (SAE International, 2016). The evolution of automation levels in cars is summarized as follows:

Level 0: The human driver performs all driving tasks.

Level 1: An advanced driver assistance system (ADAS) assists the human driver with either steering or braking/accelerating.

Level 2: An ADAS controls both steering and braking/accelerating under certain conditions. The human driver must remain fully attentive and handle all other driving tasks.

Level 3: An automated driving system (ADS) handles all driving tasks under specific conditions. The human driver must be ready to take control if requested by the ADS. In other conditions, the human driver is responsible for driving.

Level 4: An ADS performs all driving tasks and monitors the environment in specific conditions, without requiring the human to pay attention.

Level 5: An ADS performs all driving tasks in all conditions. Human occupants are merely passengers and are not involved in driving.

Autonomous vehicles make use of sensors and complex algorithms to detect and respond to surroundings. Modern technologies employed in autonomous vehicles are Computer vision, Artificial intelligence, Machine learning, and Edge Cloud computing which assist efficiently even in complex journeys [3 - 5]. Multiple autonomous vehicles in the same network can communicate with each other for traffic performance improvement and also for obstacle avoidance through the data collected through the Sensors and LIDARs. Autonomous vehicles are driven by data intelligence, both figuratively and literally. More than ever, the growing volume of data produced by autonomous vehicles drives automotive companies to improve the capture and management of the data [6]. Machine learning and Deep learning algorithms are used to identify and analyze the data for further processing and research works are taking place to increase prediction accuracy. As self-driving cars produce data volume every second in zetabytes, it requires an efficient distributed environment for storing and processing such a huge volume of data [7]. Cloud computing is a distributed environment that provides huge space for storing the collected data and processing the data for further decisions [8]. Edge computing computes the data in the nearby edges where the data is collected. But the problem in adopting the cloud is if the hacker accesses the cloud database of a car, the hacker would be able to activate/disable vehicle brakes, and steering wheels, and increase the vehicle speed remotely through the data collected [9, 10]. Hackers can exploit unsecured networks and devices to gain unauthorized access to AV systems. Thus to overcome the security issues, the security portion of the vehicle needs to be focused. Thus it is necessary that if AV has taken the roads, all the above-mentioned challenges need to be addressed. Therefore this chapter discusses the challenges and opportunities pertaining to the difficulties that arise in collecting, storing, and processing data in a secure manner in autonomous vehicles (AV). Also, this chapter aims to provide an overview of edge-cloud assisted data management in connected and autonomous vehicles using secured and deep learning Algorithms in autonomous vehicle environments. Fig. (**1**) represents the various building blocks of an autonomous vehicle. Each block is described elaborately in the proceeding sections.

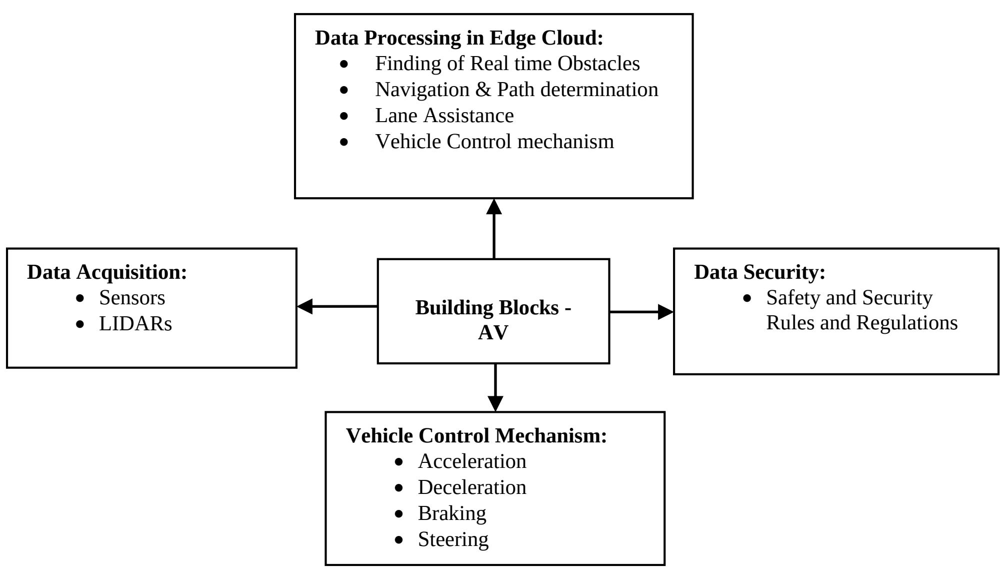

Fig. (1). Building blocks - autonomous vehicle.

CHAPTER 4

Hybrid Filter Denoising and Dehazing for Enhancing Low-Quality Images

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Abstract: In the presence of fog, photographs often suffer from poor visibility due to the atmospheric conditions. This reduction in visibility stems from the obscuring effect of fog on the surrounding environment. Additionally, the presence of particles, dust, and pollutants further contributes to color dilution and diminished contrast in analyzed images, an inevitable consequence of these contaminants. As this phenomenon persists, distinctions between individuals may gradually blur in their collective consciousness. Within the context of this investigation, a novel method is proposed for single-image processing, leveraging a hybrid filter. Specifically, it suggests the adoption of GGIF (Globally Guided Image Filtering) in conjunction with smoothening filters such as Weighted Least Squares (WLS) and Two-Dimensional Bilateral Filters. The experimental results demonstrate enhanced haze removal and denoising across all images, showcasing the method's efficacy with an overall perceptual fog density (PFD) reduction improvement of 55.39% and the flexibility to adjust parameters, including the sigma variable in GGIF, for improved performance.

Keywords: Dehazing, Denoising, Globally Guided Image Filtering (GGIF), Two-dimensional bilateral filter, Weighted least squares.

INTRODUCTION

The study of dehazing photographs is one of the many subfields within the larger fields of image processing and computer vision, both of which are seeing explosive growth in the academic community. When attempting to recover the original information type of an image from a hazy picture, there are several obstacles to overcome because of the vast amount of fog, haze, and air dispersion that happens within an area. The challenges that have arisen may be traced back to a variety of different causes. The employment of older methods, on the other hand, requires a high level of computer expertise and has the potential to result in

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the original pictures being damaged in some manner, such as via the appearance of halo effects or oversaturation [1].

Image haze reduction has emerged as an important study path in computer vision as a direct result of the tremendous advancements that have been made in the field as well as the rising need for the applications of computer vision [2]. The quality of images taken outdoors when the weather is terrible, such as when there is a lot of noise or haze, is worse than the quality of photographs taken when the weather is good.

Soft computing techniques play a crucial role in addressing these challenges by offering adaptive and flexible approaches to image processing tasks. Unlike traditional binary or deterministic computing methods, soft computing encompasses a range of methods including fuzzy logic, neural networks, and evolutionary algorithms. These techniques excel in handling uncertainty, imprecision, and incomplete data, which are prevalent in real-world image dehazing scenarios.

The visibility of the image is significantly altered by the presence of certain components, which contribute in major ways. The sensor and circuitry of image-capturing equipment like cameras may sometimes create impulsive noise, which can be observed in the pictures that these devices produce. Examples of such equipment include cameras. It is also possible for haze to be present in a picture because of the interaction of two fundamental processes, namely attenuation and air light. When both components are present in a picture, a haze effect is produced. Attenuation and air light both have the effect of increasing the quantity of white in the picture, which has the combined effect of making the pictures less clear [3].

Need for Dehazing and Denoising

As of right now, the weather in the great majority of regions in India is foggy, which makes it fairly tough for people to travel by public transportation, particularly during the winter. This is especially the case throughout the months of October till March. The suspension of operations at the air traffic control facility and the shutdown of high-speed roadways will both have an impact on the ways in which individuals can commute. In addition to this, it should be noted that a day marked by such thick fog significantly raises the probability that individuals would be engaged in automobile accidents. The pictures that are taken by surveillance, intelligent vehicle, and remote sensing systems always have limited visibility, which makes them vulnerable to the impacts of weather conditions that are unfavourable [4].

It does not make a difference where we are since this is something that occurs consistently. As the threshold is reached, vision becomes blurrier. This is because the incoming light is affected by several reflections before it reaches the camera, in addition to the attenuation that is caused by the presence of certain aerosols. As a consequence of this, the hues of the objects start to lose their vibrancy and start to take on a quality that is comparable to the fog that surrounds them. The degree to which the colors of the things fade and become much more like the fog is determined by two factors: the closeness of the seen items to the camera, on the one hand, and the impurity concentration of their immediate surroundings, on the other. To facilitate easier travel, the primary focus must be resolving the current issue at hand. In addition, people seldom make efforts to slow down the rate at which investigations are carried out.

The fine structure of the picture is not retained in modern imaging methods, resulting in a greater perceptual fog density (PFD) than in previous systems. This issue must be solved to resolve the fine structure problem and minimise the parameter of perceptual fog density. Globally directed image filtering and weighted guided image filtering approaches are two presently available strategies that have failed to achieve this goal. In this case, the equation basis is more important than the amount of noise present in the photos since the procedures are heavily dependent on it. This work proposes a novel single-image processing method using a hybrid filter combining GGIF with smoothening filters (WLS and Two-Dimensional Bilateral Filter).

RELATED WORKS

Srinivasa G. Narasimhan and Shree K. Nayar discuss the importance of vision systems functioning effectively in adverse weather conditions [5]. It emphasizes the necessity of incorporating air-scattering models to enhance reliability. A geometric framework is introduced to analyze the chromatic effects of air scattering, focusing on fog and haze. The research validates a color model and establishes geometric constraints on scene color variations due to changing atmospheric conditions. Algorithms are developed for color computation, depth segmentation, and extracting three-dimensional structures from photographs taken in different weather conditions. Traditional picture-enhancing methods are deemed ineffective, highlighting the need for atmospheric scattering principles. The research proposes a dichromatic model and algorithms for recovering scene details and colors in bad weather, validated through both artificial and real-world scenarios.

Nawaz *et al.* highlight the challenge of low visibility in images and recordings taken in foggy conditions. Recent studies indicate the effectiveness of guided

CHAPTER 5

A Generative Adversarial Model IGAN for Intrusion Detection Systems in the Industrial Internet of Things Environment

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Abstract: The Industrial Internet of Things (IIoT) has emerged as a prominent area of research, leveraging sensors, actuators, and computing capabilities to revolutionize data collection, communication, and processing. This has led to the development of innovative Industry 4.0 applications across various sectors such as mining, energy, healthcare, agriculture, and transportation. Despite its numerous benefits, security and privacy remain significant challenges in IIoT design, necessitating the integration of intrusion detection systems (IDS) for mitigation. Recent advancements in machine learning (ML) and deep learning (DL) algorithms offer promising avenues for the development of effective IDS techniques tailored to the IIoT environment. However, the scarcity and imbalance of attack datasets pose obstacles to existing IDS models. In response, this paper proposes a deep learning-enabled privacy-preserving technique aimed at improving classification accuracy. The proposed Fused IGAN-IDS model comprises three key components: (i) Generative Adversarial Networks (GAN) for generating high-quality samples to address data imbalance; (ii) An extremely randomized tree-based feature selection algorithm for identifying significant features from the dataset; and (iii) The Sparse Stacked Autoencoder (SSAE) algorithm for selecting relevant features to optimize the attack detection process's timing efficiency. By incorporating adversarial data samples into the original dataset, the fused IGAN-IDS model reached an accuracy of 99.6%, sensitivity of 99.5%, specificity of 99.7%, precision of 98.4%, and a Jaccard Similarity Score (JSS) of 99.7%. This approach also resulted in a lower false alarm rate, with a 4% False Positive Rate (FPR) and a 3% False Negative Rate (FNR).

Keywords: AEDLN, BSA, Deep learning, Deep learning, Fused IGAN, Feature selection, GAN, IGAN, Randomized tree, Sparse stacked auto encoder.

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INTRODUCTION

IIoT connects people, smart machines, and other industrial equipment with real-time data analytics as well as communication systems. It facilitates automation in the entire industrial applications to bring numerous potential benefits such as improved functional performance, increased productivity, reduced cost and resource downtime, effective monitoring, optimized production scheduling, and reduction of human error.

In recent years, spurred by the conception of Industry 4.0, the Industrial Internet of Things (IIoT) has undergone significant expansion. A projection suggests that the price generated by the IIoT could go above USD 12 trillion by 2030. The core premise of IIoT is to leverage Internet of Things (IoT) methodologies within the industrial control system (ICS) framework.

The IIoT networks comprise smart sensors, actuators, instruments, and embedded software that can track and record data, and distributed communication networks that procure, process, and analyze, massive data, which makes them alluring targets for cyber threats, where malevolent agents can easily gain access to insecure IIoT devices [1]. ICS holds a pivotal role within critical infrastructure and has long been employed to oversee industrial processes and machinery. Hence, it finds applications in several industries [2]. Therefore, many public and private organizations have experienced challenges in the adoption of the IIoT. Industries need to handle these problems to transform their processes from the core with the application of IIoT. If the obstacles to IIoT implementation are not addressed, it will make it challenging to leverage this technology to its fullest potential.

An intrusion detection system (IDS) is an effective tool intended for recognizing malignant network events in IIoT networks. It enables a secure environment for industry and senses abnormal events [3]. The notion of triad security in IIoT is intended to protect the network from exterior assailants, who should not have access to the system. Numerous prevailing paradigms integrate distributed and coordinated computing facilities using AI methods in designing effective security tools [4]. Though DL-based IDSs perform better in identifying novel cyberattacks they are often hampered by some restrictions including higher false alarm ratios, inefficient against new threats, poor dependability, and lower classification performance owing to class imbalance problems. Therefore, an effective IDS model is required to identify cyber-attacks in IIoT networks.

Due to the uniqueness of components used in IIoT networks, the threats and attack patterns also differ from each other. Different effective IDSs have been extensively employed to protect these networks against these cyber attacks.

Hence, the IIoT networks should be fortified with efficient processing elements to sense network intrusive events, and categories of cyber-attacks, and apprise their models routinely in real-time. However, most IDS systems struggle with a lack of datasets for training and testing, which makes the implementation process challenging to identify the probable cyber attacks with expected accuracy.

The functional data gathered from real-world datasets have the features of less intrusive activities and a higher sample size. Hence, it is challenging for prevailing IDS models to correctly identify the cyber-attack in IIoT networks, and the huge volume of data will upturn the cost of training and testing processes. To handle these two issues, this work uses a fused IGAN-IDS model, which integrates the concepts of IGAN with an extremely optimized tree-based feature selection algorithm. Initially, a small number of attack samples are given into GAN, and the new sample approximate to the attack sample is produced by learning the feature distribution of the dataset, so as to handle the class imbalance problem in attack detection. Then, the ERT-FS algorithm is used to select significant features of the dataset to handle the problems related to high-dimensional data. Finally, an SSAE is used to classify the data samples to identify cyber-attacks. The results on two real-world datasets prove that the intended Fused IGAN-IDS model can efficiently balance the dataset and increase the classification accuracy of the IDS model in case of inadequate attack data [5].

The IDS serves as an important component in network security, monitoring network traffic to detect abnormal or suspicious activities and preemptively address intrusion risks. IDS can be broadly categorized into two main types: Host-based IDS (HIDS) and Network-based IDS (NIDS). NIDS is usually set up at strategic network places to cover areas where traffic is most vulnerable to attacks, while HIDS operates on individual devices within the network, including those with internet access [6]. Several deep learning (DL) methods have been proposed for Intrusion Detection Systems (IDS), with some specifically tailored for the Internet of Things (IoT) [7]. Each method incorporates design choices that may limit its ability to achieve optimal efficiency and effectiveness. The goal of DL-based IDS solutions for IoT is to develop modules that excel in terms of both efficiency and effectiveness. However, certain DL-based IDS solutions for IoT overlook critical factors such as overfitting, unbalanced datasets, and the absence of feature engineering, which can detrimentally impact their efficiency.

Numerous researchers have advocated the use of IDS to detect and mitigate attacks. However, IDS in the IIoT context presents several challenges:

Device Diversity and Decentralization: IIoT comprises various devices connected through the Internet. Due to the decentralized nature of IIoT devices,

CHAPTER 6

Enhancement *via* User Engagement and Evaluation within Video Content

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Abstract: This chapter discusses advanced strategies and evolving technologies in the domain of video processing and analysis using VisualBERT. It explores techniques such as object identification, and understanding, with a specific light on the applications such as video summarization and search. The research emphasizes the integration of visual, audio, and textual information through multimodal fusion and attention mechanisms to enhance video exploration. The role of edge computing in real-time video processing is examined, highlighting its potential applications in on-the-fly summarization and searching capabilities. Furthermore, the paper evaluates the integration of blockchain technology for secure content distribution, particularly in secure video streaming and video-on-demand (VOD) services. Additionally, it delves into hyper-personalization and AI-driven content recommendations, investigating methods to tailor video experiences according to individual user preferences. The study concludes by proposing future research directions for advancing the field of video processing and exploration across these domains.

Keywords: Multimodal fusion, Object tracking, Visual BERT, Video processing, Video summarization.

INTRODUCTION

In the rapidly evolving domain of video processing and analysis, advancements in technology are paving the way for increasingly sophisticated methods of video exploration and interaction. The emergence of VisualBERT, a cutting-edge multimodal model, has significantly enhanced our ability to process and analyze video content by integrating visual, audio, and textual information. This paper delves into the forefront of video processing and analysis, exploring a range of advanced strategies and emerging technologies that harness the power of VisualBERT to revolutionize the field.

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At the core of this exploration are techniques such as object detection, tracking, and recognition, which are fundamental to extracting meaningful insights from video content. Object detection and tracking enable the identification and monitoring of entities within a video, while recognition algorithms facilitate the categorization of these entities. These capabilities are instrumental in applications such as video summarization, where the goal is to condense lengthy video content into concise summaries, and video search, where precise retrieval of relevant clips is essential [1].

ADVANCED VIDEO PROCESSING AND ANALYSIS

VisualBERT, a pre-trained transformer model, can be used for advanced video processing tasks such as object identification, and understanding. This model is designed to process visual and textual data simultaneously, making it well-suited for the following tasks:

Object Detection: First, videos are split into frames, and each frame is processed separately. Next, VisualBERT can be adjusted to work with datasets like COCO or ImageNet, which are labeled for object detection tasks. The model's visual encoders examine each frame, identifying and categorizing objects within the frame. Finally, the model predicts bounding boxes around detected objects and assigns them confidence scores.

Object Tracking: Keeping Track Over Time: Once objects are spotted in separate frames, VisualBERT can work together with tracking algorithms like SORT (Simple Online and Realtime- Tracking) or DeepSORT to maintain consistency over time. Matching Features: VisualBERT identifies important features of recognized objects, which are then used to match objects across frames, ensuring a consistent identity over time [2].

Object Recognition: VisualBERT creates object embeddings for comparison with a database of known objects for recognition. The model can process textual descriptions and match them to visual features to improve recognition tasks. Once objects are spotted in separate frames, VisualBERT can work together with tracking algorithms like SORT (Simple Online and Realtime Tracking) or DeepSORT to maintain consistency over time. VisualBERT identifies important features of recognized objects, which are then used to match objects across frames, ensuring a consistent identity over time.

APPLICATIONS OF VISUALBERT

Key Frame Extraction: VisualBERT identifies important frames based on object presence, actions, and scene changes.

Shot Detection: The model segments the video into meaningful parts by detecting transitions between scenes.

Summary Generation: Summaries are created by selecting representative frames or short clips from each segment to cover major events and actions in the video. VisualBERT creates object embeddings for comparison with a database of known objects for recognition. The model can process textual descriptions and match them to visual features to improve recognition tasks. Once objects are spotted in separate frames, VisualBERT can work together with tracking algorithms like SORT (Simple Online and Realtime Tracking) or DeepSORT to maintain consistency over time [3]. VisualBERT identifies important features of recognized objects, which are then used to match objects across frames, ensuring a consistent identity over time as shown below in Fig. (**1**).

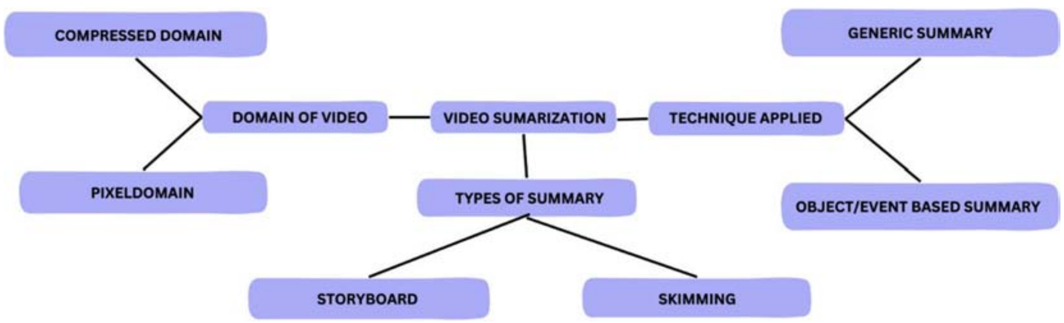

Fig. (1). Generic Video Summarization using deep visual features.

Content-Based Search: VisualBERT enables searching within videos by matching textual queries with visual content, allowing users to search for specific objects, actions, or scenes described in natural language.

Semantic Search: The model's context understanding enables semantic search capabilities, returning relevant video segments for queries like "a person running" or "a cat on a sofa." Tagging and Indexing: Automatic tagging of objects and actions within the video creates a searchable index, improving retrieval times and accuracy for video search queries. Key Frame Extraction: VisualBERT identifies important frames based on object presence, actions, and scene changes.

Shot Detection: The model segments the video into meaningful parts by detecting transitions between scenes.

Summary Generation: Summaries are created by selecting representative frames or short clips from each segment to cover major events and actions in the video.

By considering the above application, a conclusion has been drawn to choose

CHAPTER 7

A Hybrid Deep Learning-Based Intelligent Model for Academic Support Chatbot

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Abstract: Chatbots are now widely employed across various applications, especially in systems designed to provide intelligent user support. The chatbots are capable of understanding user requests and delivering appropriate responses promptly and accurately. Traditional systems lack true comprehension and generate results based solely on predefined rules, limiting their use to casual chatting and providing information accessible on the internet. Such systems are inadequate for the specific needs of a college intelligent inquiry system. This work introduces a chatbot system within the educational domain, specifically designed to assist university students with their inquiries. The primary objective is to develop a dedicated architecture, formulate a communication management model, and ensure the delivery of accurate responses to the students. To achieve this, a system is created leveraging Artificial Intelligence (AI) techniques and Natural Language Processing (NLP) to recognize and address any type of query. An experimental campaign is conducted on the implementation of the proposed generative and retrieval-based models to evaluate their feasibility and efficiency. This work explores various chatbot platforms, applications, and potential implementations in college settings, aiming to create a user-friendly and efficient inquiry system.

Keywords: Chatbot, Dialog flow, Generative chatbot, Natural language processing, Retrieval-based chatbot.

INTRODUCTION

People of this generation expect quick information as part of their everyday needs. People used to contact query support desks and call centers to resolve their questions and queries over the last few decades, but the problem is that it involves a lot of physical labor and human engagement. The main purpose is to use a chatbot to automate the procedure. A chatbot is a program intended to interconnect with humans through speech or text messages. Enhanced with AI and

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NLP, it can intelligently respond to human-specific questions. Chatbots are typically built on knowledge bases related to specific subjects, addressing topics and issues for personal or business purposes. Chatbots serve as information providers in various online services by simulating conversations through messaging or voice commands. NLP has significantly advanced chatbots by enabling them to deliver more sophisticated and responsive interactions beyond merely pre-programmed replies. AI-based chatbots have the potential to revolutionize certain practices within educational institutions. There are two types of chatbot applications: web-based chatbots, which run on the cloud and can be retrieved using web interfaces, and standalone chatbot applications, which operate on individual computers. Chatbot interactions involve users inputting natural language text and the chatbot responding intelligently to continue the conversation. Deep learning algorithms offer faster test runtimes compared to machine learning algorithms, where the test times increase with data size. Unlike deep learning, machine learning does not require high-end, costly machines or high-performing GPUs. "Deep" in deep learning denotes the numerous processing layers that data must pass through to achieve accurate outputs. NLP is a field of AI that allows us to effectively examine, comprehend, and interpret human language. It supports practical applications, including sentiment analysis, automatic text summarization, extraction of topics, named entity recognition, parts-of-speech tagging, extraction of relationships, and stemming. NLP is widely employed in text mining, machine translation, and automated question-answering. The development of NLP algorithms follows data preprocessing, with two main types of algorithms commonly utilized. Chatbots, powered by AI and NLP, facilitate intelligent human-computer interactions and hold significant promise for enhancing various domains, including education.

Rules-Based System: A rule-based system utilizes carefully designed linguistic rules to process natural language. This method represents one of the earliest approaches in the field of natural language processing.

Machine Learning-Based System: Machine learning-based systems employ statistical methods to perform tasks. These algorithms learn from provided training data and enhance their methods as they process additional data. By incorporating machine learning, deep learning, and neural networks, NLP algorithms progressively refine and develop their own rules through iterative processing and learning.

ELIZA: In 1966, German computer scientist Joseph Weizenbaum developed ELIZA, which is widely recognized as the first chatterbot in computer history. Created at the MIT Artificial Intelligence Laboratory from 1964 to 1966, ELIZA was an NLP program capable of convincingly simulating human conversation, often deceiving users into thinking they were interacting with a real person. The program functioned as a therapist by rephrasing users' statements and responding with questions. Weizenbaum designed ELIZA to determine the superficial nature of communication between humans and machines.

ALICE: The Artificial Linguistic Internet Computer Entity (ALICE) is an award-winning, open-source chatbot that uses AIML (Artificial Intelligence Markup Language) to generate responses. Built on natural language understanding and pattern matching, ALICE has received the Loebner Prize three times for its contributions to AI. The chatbot employs pattern-matching rules to formulate answers to user queries. For example, the Chatbot FAQs of Manipal University use this technology to provide students with crucial information, including availability of services, activity updates, university rankings, campus environment details, and academic-related queries.

Need for a chatbot system

The necessity for a college chatbot system arises from several challenges, including the slow navigation of the college website, the difficulty outsiders face in locating specific information, and the challenge of extracting information from outside the college's domain. A chatbot can effectively serve as a helpdesk, providing essential information such as subject timetables, result dates, faculty details, and more. The implementation of a college chatbot addresses these issues with a smart solution. The system will respond by summarizing user queries and providing specific information related to several domains, such as admissions, the notice board, examination cell, attendance details, placement cell information, and other miscellaneous areas. The admissions process can be complicated for staff, parents, and students. Typically, students gather information through the college website, phone calls, or personal visits. A chatbot can streamline this process by assisting students and parents with information on admission dates, course cut-offs, and eligibility requirements. Additionally, chatbots can send notifications about important deadlines, thereby reducing the workload of admission staff during peak admission periods.

An AI-powered virtual assistant designed for college-related inquiries serves as a machine for College Oriented Intelligence. This virtual assistant is prepared to address students' questions about a varied range of college-related topics by providing prompt and accurate information. A chatbot's database contains information that allows it to recognize phrases and make decisions on its own in response to an inquiry.

CHAPTER 8

A Chatbot-based Assistant for Mental Health Disorders Using Transformers

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Abstract: In recent years, mental healthcare has emerged as a critical global concern, with escalating rates of stress, anxiety, and depression affecting individuals across diverse demographics. However, conventional approaches to treatment and support often face significant barriers, including stigma, limited accessibility, and resource constraints. In order to tackle these obstacles, we suggest creating a transformative mental health voice generative assistant, harnessing the power of state-of-the-art Transformer models and cutting-edge Artificial Intelligence (AI) technologies. The envisioned solution seeks to revolutionize mental healthcare by offering a readily accessible, personalised, and empathetic support system to individuals in need. This assistant attempts to offer real-time guidance, coping mechanisms, and companionship that are specific to the needs and emotions of each user by combining sophisticated AI algorithms, Natural Language Processing (NLP), and emotional intelligence skills. By leveraging deep learning techniques, the assistant will continuously adapt and evolve its responses based on user interactions, fostering a sense of connection and understanding.

Keywords: Artificial intelligence, Chatbot, Mental health, Natural language processing, Transformer.

INTRODUCTION

Nowadays, a mental disorder [1] is categorized by clinically substantial trouble in an individual's perception, emotions, or mental behavior. People are impacted when there is suffering or impairment in critical areas of functioning. Therefore,

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mental health conditions can also be used to refer to mental diseases. Psychosocial disabilities and (other) mental states associated with significant distress, impairment in functioning, or risk of self-harm areother kinds of mental disorders. As per the stated survey in 2019 [2], 1 in every 8 people was affected by this issue. As a result of COVID-19, there is a notable rise in the population with anxiety and depressive illnesses. Although there are options for effective prevention and therapy, most people who suffer from mental problems lack access to quality care. Many people also experience stigma, discrimination, and violations of human rights.

Anxiety disorders [3] are characterized by extreme fear and related behavioral disturbances. Symptoms are severe enough to result in significant distress or significant impairment in functioning. A total of 301 million individuals, including 58 million children and adolescents, suffered from an anxiety illness in 2019. There are several types [4], such as generalized anxiety disorder (excessive worry), panic disorder (panic attacks), social anxiety disorder (excessive fear and worry in social situations), separation anxiety disorder (excessive fear or anxiety about separation from those individuals to whom the person has a deep emotional bond), and others. Effective psychological treatment exists, and depending on the age and severity, medication may also be considered.

Another problem is depression [5], which is distinct from normal mood swings and transient emotional reactions to day-to-day obstacles. Suicide risk is higher in those who suffer from depression. However, there are effective psychological therapies available, and medication may also be taken into consideration based on the patient's age and severity. Likewise, bipolar disorder affected 40 million individuals. Manic symptoms alternate with depressed spells in people with bipolar illness. A person who is going through a depressive episode will typically feel down for most of the day, almost every day, and may also experience a loss of pleasure or interest in activities. Joy or agitation, heightened activity or vitality, as well as additional symptoms like heightened talkativeness, racing thoughts, elevated self-esteem, diminished need for sleep, distractibility, and rash, impulsive behaviour, are all examples of manic symptoms.

Need of Transformer

Neural network designs called transformers [6] are capable of converting an input sequence into an output sequence. In order to make decisions, the transformers are used to gather context for the issue and monitor the relationships between sequence components. Early deep learning models focused extensively on Natural Language Processing (NLP) tasks aimed at getting computers to understand and respond to natural human language. They guessed the next word in a sequence based on the previous word. This feature is called intelligence feature in AI. Much larger applications of this technology were made by early Machine Learning (ML) models [7]. The following word was attempted to be predicted by mapping the relationship frequency between various word groupings or pairings in their training dataset. Transformer models fundamentally changed NLP technologies by enabling models to handle such long-range dependencies in text.

In this chapter, we explore the evolution, architecture, training process, challenges, advancements, and applications of Transformer networks specifically tailored for mental health voice generative assistants. Through a comprehensive exploration of Transformer technology in the context of mental health support systems, we aim to provide valuable insights into its capabilities and implications for future research and applications in the realm of artificial intelligence-enhanced mental health care.

LITERATURE REVIEW

The impact of chatbot emotional disclosure on user satisfaction and intention to reuse a chatbot counselling service was investigated by Park *et al.* [8]. The authors investigated how user emotional disclosure intention and perceived intimacy with a chatbot function as separate and sequential mediators in the link between user happiness, chatbot emotional disclosure, and reuse intention for chatbot therapy. Using one of the two varieties of chatbots driven by artificial intelligence, 348 adult Americans were chosen to take part in a mental health counseling session. Among these were chatbots that would merely divulge factual data or that would reveal emotions similar to those of a human. The findings showed that user happiness and intention to reuse a chatbot therapy service were considerably raised by chatbot emotional disclosure. Further analysis of the data showed that user intention to disclose emotions to a chatbot and perceived intimacy with it both individually and sequentially influence the impact of emotional disclosure from the chatbot on user happiness and intention to use the chatbot counseling service again.

In order to overcome the obstacles of stigma, accessibility, and cost in mental healthcare, Abilkaiyrkyzy *et al.* [9] created a conversation system that evaluates each person's mental state. On the basis of the severity of the mental health issue, it also provides customised comments. A framework for classifying and assessing the severity of mental health issues has been developed by the authors. It is based on the idea of a Digital Twin for mental health and integrates new technological developments. Working with a clinical psychiatrist, the chatbot framework was created to detect different severity levels using pre-trained BERT models that have been optimised on the E-DAIC dataset.

CHAPTER 9

Exploring Reinforcement Learning Techniques in Generative Artificial Intelligence

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Abstract: This chapter delves into the intricate interplay between reinforcement learning (RL) techniques and generative artificial intelligence (AI), offering a thorough exploration of how RL can be leveraged to enhance generative models. Starting with a foundational overview of reinforcement learning, the chapter introduces essential concepts, including agents, environments, actions, states, and rewards, within the framework of Markov Decision Processes (MDPs). The exploration-exploitation dilemma, a pivotal aspect of RL, is discussed alongside prominent algorithms such as Q-learning, SARSA, Deep Q-Networks (DQN), and Policy Gradient methods. The core of the chapter focuses on the integration of RL techniques with generative AI models, highlighting both the advantages and inherent challenges. It examines how RL can be applied to various domains of generative AI, such as sequence generation in natural language processing (NLP) and music composition, as well as image synthesis through the enhancement of Generative Adversarial Networks (GANs) with RL-based training strategies. The discussion extends to the practical difficulties faced in training RL-based generative models, including issues related to stability, sample efficiency, and scalability. To provide a concrete understanding of these theoretical concepts, the chapter includes detailed case studies showcasing real-world applications of RL-enhanced generative models. These case studies encompass a range of applications, from RL-driven text generation models used in dialogue systems to RL-guided image synthesis for creative industries. Additionally, the chapter explores the application of RL in personalized recommendation systems and game design, illustrating the diverse potential of RL in generative AI. The chapter also addresses the current limitations and open challenges in this burgeoning field. It critically analyzes issues such as the computational demands of training RL models, the need for large and diverse datasets, and the difficulty in ensuring model robustness and reliability. Furthermore, the chapter contemplates future research directions, identifying emerging trends such as the fusion of RL with other machine learning paradigms and the potential of RL in enhancing model interpretability and fairness. Ethical considerations form a crucial part of the discussion, as the deployment of RL in generative AI raises significant societal and

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moral questions. The chapter reflects on the ethical implications of RL-driven generative systems, particularly concerning data privacy, algorithmic bias, and the broader impact on employment and creativity. The chapter synthesizes key findings, emphasizing the transformative potential of reinforcement learning in advancing generative artificial intelligence. It highlights the significance of this interdisciplinary approach in pushing the boundaries of what generative models can achieve, ultimately contributing to the fields of AI, machine learning, and beyond. The chapter provides valuable insights and practical knowledge for researchers, practitioners, and students, fostering a deeper understanding of the challenges and opportunities at the intersection of reinforcement learning and generative AI. Through this comprehensive exploration, the chapter aims to inspire future research and innovation, paving the way for new advancements and applications in this dynamic and rapidly evolving area of artificial intelligence.

Keywords: Deep Q-Networks (DQN), Generative AI, Generative Adversarial Networks (GANs), Markov Decision Process (MDP), Reinforcement Learning (RL).

INTRODUCTION

The fusion of reinforcement learning (RL) with generative artificial intelligence (AI) represents a powerful confluence that promises to significantly enhance the capabilities of generative models. This integration is driven by several compelling motivations: improved creativity, efficiency, personalization, and the ability to handle complex, high-dimensional tasks.

Improved Creativity: One of the foremost motivations for integrating RL with generative AI is to augment the creative potential of these systems. Traditional generative models, such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs), have demonstrated remarkable proficiency in generating realistic images, text, and other data types. However, their creativity is often limited by the static nature of their training paradigms. RL, with its dynamic learning approach, allows generative models to explore a broader range of possibilities and adaptively improve their outputs based on feedback. This can lead to the generation of more novel and diverse content, enhancing the overall creativity of AI systems.

Generative models typically require extensive datasets and computational resources to achieve high-quality results. RL can optimize the training process by intelligently navigating the parameter space and learning more efficiently from interactions with the environment. Techniques such as reward shaping and policy gradients enable RL to focus on the most promising areas of the parameter space, reducing the computational burden and accelerating the training process. The ability to personalize generative outputs is increasingly important in applications ranging from recommendation systems to custom content creation. RL provides a framework for adaptive learning, allowing generative models to tailor their outputs to individual user preferences or specific contextual requirements. By continuously interacting with users and receiving feedback, RL-enhanced generative models can fine-tune their behavior to deliver highly personalized experiences.

To appreciate the integration of RL with generative AI, it is essential to understand the historical context and evolution of both fields. The development of RL and generative models has followed distinct yet converging trajectories, each marked by significant milestones.

Early Developments in Reinforcement Learning: The origins of RL can be traced back to the mid-20th century, with foundational work in the field of animal behavior and learning theories. Notably, the concept of trial-and-error learning, as proposed by Thorndike and later formalized in the context of Markov Decision Processes (MDPs) by Bellman [1], laid the groundwork for modern RL. The introduction of temporal difference learning by Sutton [2] and the development of Q-learning by Watkins [3] further advanced the field, providing robust algorithms for learning optimal policies in uncertain environments.

Emergence of Deep Learning: The resurgence of interest in neural networks in the 2010s, driven by advances in deep learning, revolutionized many areas of AI, including RL. The advent of Deep Q-Networks (DQNs) by Mnih *et al.* [4], which combined Q-learning with deep neural networks, marked a significant breakthrough. DQNs demonstrated the ability to learn complex policies directly from high-dimensional sensory inputs, such as raw pixel data, achieving human-level performance in Atari games. This success spurred a wave of research into deep RL, leading to further innovations such as policy gradient methods and actor-critic architectures.

Development of Generative Models: Parallel to the advancements in RL, generative models have evolved to become sophisticated tools for data generation and transformation. Early generative models, such as Hidden Markov Models (HMMs) and Gaussian Mixture Models (GMMs), provided a probabilistic framework for modeling sequences and distributions. The introduction of VAEs by Kingma and Welling [5] and GANs by Goodfellow *et al.* [6] marked a significant leap forward, enabling the generation of high-fidelity images, text, and other data types. GANs, in particular, have gained widespread popularity due to their adversarial training approach, where a generator and a discriminator engage in a competitive process to produce increasingly realistic outputs.

CHAPTER 10

Reinforcement Learning for Power Distribution Grid Optimization

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Abstract: Reinforcement Learning (RL) has emerged as a transformative paradigm for optimizing power distribution grids, offering adaptive decision-making capabilities crucial for enhancing grid efficiency, reliability, and sustainability. This book chapter explores various facets of RL application in grid optimization, starting with foundational concepts and algorithms. It delves into diverse application areas, state representation, action space design, reward formulation, and performance evaluation metrics essential for effective RL deployment in real-world grid environments. The chapter also addresses implementation challenges and proposes solutions, leveraging advancements in algorithmic techniques, integration of edge computing and IoT, and ethical considerations. Through case studies and practical applications, it demonstrates RL's potential to revolutionize grid management. Finally, the chapter identifies future research directions, including enhanced algorithmic sophistication, socio-technical integration, regulatory frameworks, and collaborative research initiatives, paving the way for smarter, resilient, and sustainable energy systems of tomorrow.

Keywords: Grid optimization, Glgorithmic techniques, Power distribution grids, Reinforcement learning, Sustainability.

OVERVIEW OF REINFORCEMENT LEARNING

Reinforcement Learning (RL) has emerged as a pivotal area within the field of machine learning, providing innovative solutions to complex decision-making problems across various domains. This section presents a comprehensive overview of RL, laying the groundwork for its application to power distribution grid optimization. Reinforcement Learning is a type of machine learning paradigm where an agent learns to make decisions by interacting with its environment. Unlike supervised learning, where the model learns from a fixed

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dataset, RL is driven by trial and error, continuously improving its performance based on the rewards or penalties it receives. This iterative process enables the agent to learn optimal behaviors to maximize cumulative rewards over time. The conceptual foundation of RL can be traced back to behavioral psychology, particularly the work of B.F. Skinner on operant conditioning, where learning occurs through rewards and punishments. The formalization of RL in the context of computer science and artificial intelligence began with seminal contributions from researchers such as Richard Sutton and Andrew Barto, who provided a comprehensive theoretical framework for the field [1]. The core components of RL are:

Agent and Environment: In RL, the agent is the decision-maker, which interacts with the environment, encompassing everything external to the agent that it can sense and act upon. The environment provides feedback in the form of rewards, guiding the agent's learning process.

State (s): It represents the current situation or configuration of the environment. It encapsulates all the information necessary for the agent to make a decision.

Action (a): It is any operation or move made by the agent that affects the state of the environment. The set of all possible actions is termed the action space.

Reward (r): It is a scalar feedback signal received after taking an action, indicating the immediate benefit of that action. The goal of the agent is to maximize the cumulative reward over time. Fig. (**1**) shows the interaction between the components of the RL.

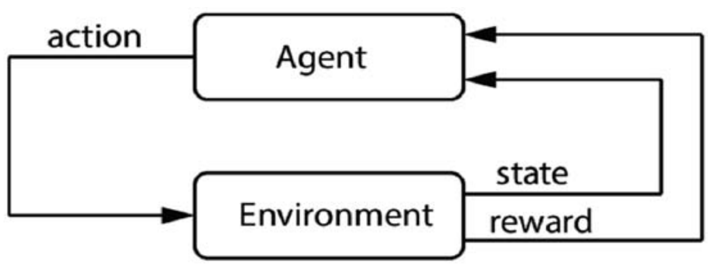

Fig. (1). Interaction between the agent and environment in RL.

Policy (π): It defines the agent's behavior, mapping states to probabilities of selecting each possible action. Policies can be deterministic ($\pi(s)=a$) or stochastic ($\pi(a|s)$).

Value Function (V): It estimates the expected cumulative reward starting from a state and following a particular policy. The value function helps the agent evaluate the desirability of states.

Action-Value Function (Q): It is similar to the value function but estimates the expected cumulative reward starting from a state, taking an action, and then following a policy.

Exploration vs. Exploitation: A fundamental challenge in RL is balancing exploration (trying new actions to discover their effects) and exploitation (choosing actions that are known to yield high rewards). Effective RL strategies typically require a mix of both to avoid local optima and discover the globally optimal policy [2].

Markov Decision Process (MDP): The RL problem is often modeled as a Markov Decision Process, characterized by a tuple (S,A,P,R,γ) [3]. The objective of an MDP is to find a policy π that maximizes the expected return $G_t = \sum_{k=0}^{\infty} \gamma^k r_{t+k+1}$. Where P is a State transition probability matrix $P(s'|s,a)$, representing the probability of transitioning to state s′ from state s after taking action a. γ is a discount factor, $0 \leq \gamma \leq 1$, which models the importance of future rewards.

Key Algorithms in RL

RL algorithms can be broadly categorized into value-based, policy-based, and actor-critic methods. Each category approaches the problem of learning optimal policies differently.

Value-Based Methods

Value-based methods focus on estimating the value function or action-value function.

Q-Learning: Q-Learning is a model-free RL algorithm that seeks to learn the optimal action-value function $Q^{*}(s,a)$, defined as the maximum expected return achievable from state s and action a, and thereafter following the optimal policy. The Q-Learning update rule is given by $Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha[r_{t+1} + \gamma \max_a Q(s_{t+1}, a) - Q(s_t, a_t)]$, where α is the learning rate [4].

Deep Q-Network (DQN): DQN extends Q-Learning by using deep neural networks to approximate the action-value function. This allows for handling high-dimensional state spaces. Key innovations in DQN include experience replay and target networks to stabilize training [5]. The architecture of the Deep Q-Network is illustrated in Fig. (**2**).

CHAPTER 11

Value Vue: AI-driven Price Prediction and Comparable Companion Using NLP and Cloud Computing

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Abstract: Consumers are constantly bombarded with options in a high-velocity environment, and big-ticket products, including cars, homes, laptops, *etc*., require major decision-making. It is crucial to assist consumers in effective decisions in line with their requirements and returns. As things stand today, there is no holistic service that can provide precise and immediate price estimates with the capability to offer similar products in the same price bracket as well. Value Vue is a groundbreaking and transformative solution website, which emerges as the answer to these existing gaps, accompanying a new era of precision and trust so consumers can make informed purchasing decisions. Value Vue boasts an intuitive and user-friendly website design, offering a seamless browsing experience that simplifies price predictions. At its core, Value Vue leverages the powerful synergy between advanced machine learning models and cloud computing, offering an unprecedented level of confidence and convenience to individuals navigating the complex world of significant purchases. Committed to data integrity and transparency, Value Vue is a price prediction model that relies on reliable and reputable sources to ensure accuracy, in addition to the trustworthiness of its information, while its cloud-powered scalability allows it to seamlessly handle extensive data sets, catering to various markets and user needs. Value Vue is an automation of valuation processes, enhanced market transparency, and personalized recommendations in a friendly environment.

Keywords: Artificial intelligence, Cloud computing, Machine learning, Natural language processing, Price prediction.

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INTRODUCTION

Nowadays, the consumer market is rather complex, which means that making a choice regarding major purchases, which may include cars, houses, and laptops, for instance, may be quite engaging as well as challenging. All these choices can determine how we live our lives, what we like, or even how we make our living. Consumers, therefore, need to be wise and informed on any product or service that they wish to engage themselves with. Nevertheless, given the emerging new markets and an overwhelming amount of information available, the demand for an efficient, unified, and, most importantly, live system capable of providing accurate price estimation and their subsequent comparison has been more apparent. Value Vue is, therefore, a platform that has been devised to fit specifically into the above gaps and offer consumers a level of confidence and guidance while making purchases. It is by integrating the profound machine learning and the almost infinite capabilities of cloud computing that Value Vue eliminates the randomness in favor of timely, personalized, and accurate results for cars, houses, and laptops.

Need for Clinical Decision Support Systems

Value Vue has become a necessity as a result of the problems and increased difficulties in the modern consumer market environment. A host of factors, ranging from changes in market price and product differentiation to geographical differences in prices, complicate the process of purchase. Customers are left to sift through an ocean of content in order to find the right choices, all the while trying to avoid falling into the trap of ill-gotten products that may be overpriced or not worth the amount of money being paid for them.

Among the key questions for which Value Vue provides answers is the question of the high dependence of various processes on real-time data and information. Especially in today's world, where conditions on the market might shift in the period of time it takes to read this sentence, referential or stale data could be lethal. Even though ValueVue has the readiness to analyze data from several sources in real time, the consumers are assured latest information is portrayed to them, hence making the right decisions at the right time. Whether it is a car purchase influenced by fluctuating gas prices, a housing market affected by local economic changes, or the rapidly evolving features of laptops, Value Vue keeps consumers in the loop.

Another crucial need that Value Vue fulfills is the demand for customized price predictions. Traditional approaches often offer generic price estimates that may not align with a consumer's unique circumstances, preferences, or location. By leveraging advanced Machine Learning models, Value Vue tailors its predictions to individual users, ensuring that the estimates are a precise reflection of their specific requirements. This customization empowers consumers to make decisions with a high degree of confidence, knowing that their choices are synchronized with their personal needs and budgets.

Furthermore, ValueVue addresses the issue of comparative shopping. Often, consumers manually compare options, a time-consuming and daunting task, especially when considering major purchases. ValueVue simplifies this process by not only providing price predictions but also by offering a side-by-side comparison of products or properties within the same price range. This feature is invaluable, as it allows consumers to make well-informed choices, ensuring that they obtain the best value for their investments.

The main objectives of the proposed work are to ensure AI-driven price prediction of Value Vue, to ensure data accuracy and relevance for prediction and similar results with the same price by designing user-friendly interface, to predict accurate price prediction through the comparison of different datasets, to increase the unprecedented level of confidence to consumers in terms of purchasing decisions with privacy and security, to enhance the overall effectiveness of our prediction and recommendation system, and to develop a system that can adapt to these dynamics and provide up-to-the-minute insights is a complex endeavor.

Existing Approaches of VALUE-VUE

The current practices adopted for price forecasting and benchmarking, although useful for achieving to some extent the objectives anticipated, have limitations and do not answer a more general and systemic need. These approaches are characterized by conflicting elements, which make it difficult for the given approaches to satisfy the needs of consumers in today's society.

With a constantly changing market environment, conventional approaches like historically dated price formation and fixed pricing strategies provide inefficiency. This results in consumers being left with stale and erroneous expectation levels, which can make them perhaps overlook the possibility to invest in a service, product, or property at a more favorable rate than other competitors.

Similarly, comparative shopping tools in their current forms lack the sophistication and customization required to cater to individual consumer needs effectively. They often rely on basic filters and rigid categorization, making it challenging to identify the most suitable options within a given budget. Consumers are left to manually sift through extensive lists of options, leading to frustration and potential oversight of better choices. Moreover, the data sources

CHAPTER 12

Secure Password Generation Using GIBP and Multi-Factor Authentication

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Abstract: In today's digital world, it is increasingly important to generate secure passwords to protect against hacking and identity theft. The GIBP (Grassmann algorithm using Illusion pin with Brightness Password generation) approach creates secure passwords by using the Grassmann algorithm, which combines random characters and patterns to form unique passwords. The GIBP, with a strong password, adds an extra layer of security through multi-factor authentication. One popular multifactor authentication method is facial recognition technology, which involves scanning the user's face to confirm their identity. While combining GIBP with the Grassmann algorithm and facial recognition technology, users can generate highly secure passwords that are unique and difficult to crack. In addition, the use of multifactor authentication provides an extra layer of security, making it even more difficult for hackers to gain access to sensitive information. Overall, the GIBP with secure password generation and multifactor authentication is essential in today's digital world to protect against cyberattacks' ever-increasing threats. The evaluation parameters include time taken, speed of operation for clustering, speed for face recognition, and time taken for training. The proposed method provides 99% accuracy and takes less time to capture images that are less than 1 ms. The proposed method is compared with three other methods and produces good results.

Keywords: GIBP, Grassman algorithm, Multi-factor authentication, Password, Security.

INTRODUCTION

Any protocol or procedure that enables one entity to verify the identity of another is referred to as authentication.

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The realities of our physical world serve as the foundation for the old authentication methods. The physical world is used for basic human authentication. Essential human confirmation is determined by distinguishing the special actual qualities of another individual. When authentication must be carried out by a person who does not personally know the person to be authenticated, such methods are sometimes insufficient. The connecting party can be easily verified using authentication protocols [1, 2]. Society today is dependent on information technology, and technology makes it easier to access information. Due to the constantly growing network environment, various techniques for accessing and handling information have developed. One of the most used solutions to access and protect information is by using a password. The purpose of a password is to protect sensitive and important data from unauthorized users who intentionally or accidentally access the system. This can lead to unsolicited modifications of the original data as well as unauthorized access to confidential information [3]. Two-factor authentication is a widely recommended security mechanism and is already offered for different services. However, there is a lot of usability and customization in the physical implementations and known methods [4]. Two or more independent credentials are combined in multifactor authentication: what the user is familiar with, like a password; what the client has, like a security token; and who is using biometric verification methods. The integrated EPR information system enables e-medicine services that are quick and easy to use. A secure and efficient authentication scheme for the integrated EPR information system safeguards patients' electronic patient records (EPRs) and enables healthcare workers and medical personnel to quickly make correct clinical decisions [5]. A significant portion of the security research that is carried out is plagued by problems that prevent widespread adoption. The introduction of additional nodes into the communication architecture, which disrupts the simplicity of the typical client-server model, or fundamental reorganization of the Internet ecosystems significantly increases the user's and/or server operator's responsibilities and the risks surrounding sensitive data during the authentication process [6]. PINs and passwords are also vulnerable to smartcard loss problems. Biometric-based schemes require extra hardware for implementation and also raise privacy concerns. Passwords also have various drawbacks [7]. Forgetting passwords is very common among users, which arises due to fundamental limitations of human long-term memory. As a result, users tend to choose weak passwords like names of pets, date of birth, and dictionary words [8]. A hybrid approach to multifactor authentication combines smart cards and OTP (one-time password). The authors propose a system that uses smart cards for the secure storage of authentication information and OTP for generating dynamic passwords. The system is designed to be resistant to various types of attacks, including password-guessing attacks, replay attacks, and man-in-the-middle attacks [9]. A smart card and biometric-based password-based user authentication strategy is proposed. The proposed plot involves three elements for confirmation: something that the user is (biometric data), something that the user has (a smart card), and something that the user knows (a password). The proposed scheme is designed to be secure against various types of attacks, such as password guessing, replay, and man-in-the-middle attacks [10, 12, 14]. Authentication plays an important role in retaining security *via* unique access control procedures and is a significant factor in confirming security for diverse applications [11]. Cloud computing is a rapidly growing area that presents new security challenges. Multifactor authentication is one approach to enhancing security in cloud computing. In this paper, an enhanced multifactor authentication scheme for securing cloud computing is proposed. Online banking is rapidly becoming popular among users, but security concerns remain a major barrier to adoption. In this paper, a two-factor authentication scheme for online banking is proposed [13]. Efficient biometrics and smart cards are used in a password-based user authentication system. The safety of online systems is of the utmost importance in a world that is becoming increasingly digital. One of the basic aspects of securing these systems is the generation and management of strong, secure passwords. When it comes to password generation, traditional methods frequently lack the necessary level of security, making them susceptible to a variety of cyberattacks. This study proposes utilizing Multi-Factor Authentication (MFA) in conjunction with Genetic Improved Binary Particle Swarm Optimization (GIBP) for secure password generation to address these issues [15]. The Grassmann algorithm, rooted in the principles of Grassmannian spaces, provides a robust mathematical framework for generating complex passwords. By leveraging the properties of these spaces, the algorithm ensures that the generated passwords exhibit high entropy and resistance to common attack vectors such as brute force and dictionary attacks. This approach not only enhances the complexity of passwords but also maintains usability, which is often compromised in traditional high-security methods [16]. In addition to the Grassmann algorithm, this method incorporates the concept of an Illusion Pin. The Illusion Pin adds a layer of cognitive security by requiring users to identify and select a sequence of visual elements that appear deceptively simple yet are complex to deduce without proper knowledge. This technique capitalizes on the human brain's ability to recognize patterns and anomalies, making unauthorized access significantly more challenging.

Furthermore, the introduction of Brightness-based Password Generation provides an innovative dimension to password security. This method involves varying the brightness levels of visual elements to create unique password sequences. The subtle differences in brightness levels are easy for legitimate users to recognize and recall but are difficult for unauthorized users to replicate or guess. This

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