
SCIENTIFIC DISCOVERIES IN THE AGE OF ARTIFICIAL INTELLIGENCE

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Abstract: The age of artificial intelligence (AI) has ushered in a new era of scientific exploration and discovery. AI, as a transformative and powerful technology, has permeated various domains of research, revolutionizing traditional scientific methodologies and unlocking unprecedented avenues of knowledge. In this abstract, we delve into the remarkable impact of AI in scientific discovery, showcasing its applications across diverse fields, from medicine and astronomy to climate research and neuroscience.

AI has accelerated drug discovery by predicting potential drug interactions, identifying disease-associated genes, and even repurposing existing drugs for new therapeutic indications. In astronomy, AI has enabled the detection of gravitational waves, automated celestial object classification, and refined cosmological simulations. In the realm of climate research, AI has facilitated climate data analysis, extreme weather forecasting, and sustainable energy optimization. Moreover, AI's integration in neuroscience has enhanced brain imaging analysis, enabled brain-computer interfaces, and simulated neural networks, offering profound insights into brain functions and neurological disorders. In genetics and genomics, AI has aided in genome sequencing, disease gene identification, personalized medicine, and gene editing techniques like CRISPR.

Throughout this abstract, we highlight the collaborative efforts between AI and traditional scientific approaches, underscoring the significance of responsible and ethical AI use to ensure its potential is harnessed for the betterment of humanity. As AI technologies continue to advance, their synergy with scientific inquiry will undoubtedly fuel further discoveries, propelling us into an era of limitless exploration and progress.[17,19,22,23]

Keywords: scientific discovery, artificial intelligence, AI-driven research, age of AI.

1. Introduction

The age of artificial intelligence (AI) has ushered in a new era of scientific exploration and discovery. AI has transformed various fields of research by enabling faster data analysis, pattern recognition, and predictive modeling. With its ability to process massive amounts of information and learn from it, AI has become a powerful tool for scientists to unravel complex mysteries, formulate new hypotheses, and push the boundaries of human knowledge. In this article, we will explore some of the groundbreaking scientific discoveries made possible by AI and its potential impact on future research. The dawn of the age of artificial intelligence (AI) has heralded a new era of scientific exploration and discovery, reshaping the landscape of research across various domains. AI, as a powerful and transformative technology, has become an indispensable tool for scientists, augmenting their capabilities and revolutionizing traditional scientific methodologies. With its ability to process vast amounts of data, recognize intricate patterns, and make accurate predictions, AI has unlocked previously inaccessible realms of knowledge and fueled groundbreaking discoveries.

In this article, we delve into the remarkable scientific breakthroughs that have emerged as a consequence of AI's integration into diverse fields of research. From healthcare and drug discovery to astrophysics, climate research, neuroscience, genetics, and beyond, we explore how AI's transformative potential has propelled humanity's understanding of the universe and ourselves.

Advancing at an unprecedented pace, AI has significantly expedited and optimized complex scientific processes that once demanded substantial time and resources. By unleashing the power of machine learning algorithms, researchers can now harness the potential of immense datasets to unearth hidden insights, identify correlations, and develop sophisticated models that enable them to tackle intricate challenges.

Yet, along with its promise, the advent of AI in scientific discovery raises important ethical and societal considerations. As we navigate this evolving landscape, it is essential to strike a balance between innovation and responsibility, ensuring that AI is leveraged for the collective good, while safeguarding against unintended consequences.

In the following sections, we will explore specific examples of how AI has catalyzed scientific breakthroughs, transforming the realms of medicine, space exploration, environmental sustainability, neuroscience, and genetics. From uncovering novel drug candidates to deciphering cosmic mysteries, AI's presence is felt across the scientific spectrum, illuminating the path towards a future of limitless exploration and knowledge. As we journey through these captivating advancements, we will also reflect on the potential challenges and opportunities that lie ahead in the age of artificial intelligence and its impact on scientific inquiry.[16,18,20]

2. Accelerating Drug Discovery

The process of drug discovery is a complex and time-consuming endeavor that involves identifying and developing new pharmaceutical compounds to treat various diseases and medical conditions. Traditionally, drug discovery has relied on a combination of empirical approaches, trial and error, and extensive laboratory testing. However, in recent years, the integration of artificial intelligence (AI) has emerged as a powerful tool in expediting and enhancing drug discovery processes. This

literature review explores the impact of AI in accelerating drug discovery and highlights key studies that showcase the potential and challenges of AI-driven approaches in this critical domain.

AI for Target Identification and Drug Design:

AI has shown remarkable promise in aiding target identification and drug design, thereby shortening the early stages of drug discovery. A study by Chen et al. (2018) demonstrated the application of deep learning models to predict the binding affinity between compounds and specific protein targets. The researchers used a vast dataset of molecular structures and associated biological activities to train the model, achieving impressive accuracy in predicting target interactions. Such AI-driven target identification can significantly reduce the time and cost involved in screening potential drug candidates.

Virtual Screening and Compound Prioritization:

Virtual screening involves the computational evaluation of vast chemical libraries to identify potential drug candidates that may interact with a specific target. AI-driven algorithms, such as molecular docking and machine learning approaches, have been instrumental in performing virtual screening more efficiently. For instance, a study by Unterthiner et al. (2020) demonstrated the use of generative adversarial networks (GANs) to generate novel molecular structures with desired properties, thereby expanding the pool of potential drug candidates.

Predicting Drug-Drug Interactions and Side Effects:

AI has also shown promise in predicting drug-drug interactions and potential side effects, mitigating the risk of adverse reactions during the drug development process. In a study by Aliper et al. (2016), deep neural networks were employed to predict the side effects of various drugs accurately. The AI model identified previously unknown drug interactions, facilitating better drug combination strategies and reducing the likelihood of harmful interactions during clinical trials.

AI for Drug Repurposing:

Drug repurposing, or repositioning, involves identifying new therapeutic uses for existing drugs. AI-based approaches have been instrumental in analyzing large datasets of drug interactions and disease data to identify potential repurposing opportunities. A study by Lavecchia (2019) explored the use of machine learning to predict drug-target interactions and successfully repurposed existing drugs for new therapeutic indications.

AI in Clinical Trials and Personalized Medicine:

AI's impact on drug discovery extends to the clinical trial phase, where it can aid in patient selection, monitoring, and data analysis. By analyzing patient data, genetic profiles, and treatment responses, AI models can identify subpopulations that are more likely to respond positively to a specific drug, enabling personalized medicine approaches. A study by Kang et al. (2021) utilized AI to predict patient responses to immunotherapy in lung cancer, highlighting the potential for AI-driven precision medicine in oncology.

The integration of artificial intelligence in drug discovery holds enormous promise for accelerating the development of new pharmaceuticals and improving patient outcomes. AI-driven approaches have demonstrated their efficacy in target identification, drug design, virtual screening, predicting drug interactions, drug repurposing, and facilitating personalized medicine. However, challenges

such as data quality, interpretability of AI models, and ethical considerations remain critical areas for ongoing research and development. As AI technologies continue to evolve, their synergy with traditional drug discovery methods will undoubtedly lead to transformative advancements in medical science, ushering in a new era of more efficient and effective drug development processes.[14,16,17]

3. Unraveling the Mysteries of the Universe

The exploration of the universe and its mysteries has captivated scientists and astronomers for centuries. With the advent of artificial intelligence (AI), researchers now have a powerful tool at their disposal to accelerate the pace of discovery and gain deeper insights into the cosmos. This literature review examines how AI has been employed in various astronomical and cosmological endeavors, from analyzing massive datasets to predicting cosmic phenomena, revolutionizing our understanding of the universe.

Gravitational Wave Detection with AI:

The detection of gravitational waves, ripples in the fabric of spacetime caused by cataclysmic cosmic events, has been one of the most significant discoveries in modern astrophysics. AI has played a crucial role in enhancing the sensitivity and accuracy of gravitational wave detectors. In a study by George et al. (2018), deep learning algorithms were employed to filter and identify gravitational wave signals from background noise, enabling more efficient and precise detection of these elusive events.

AI-driven Image Analysis in Astronomy:

AI has been instrumental in automating and streamlining the analysis of vast amounts of astronomical images captured by telescopes and satellites. Convolutional neural networks (CNNs) have been applied to classify and identify celestial objects, such as galaxies, stars, and quasars, with remarkable accuracy. A study by Dieleman et al. (2015) demonstrated the effectiveness of CNNs in galaxy morphology classification, enabling faster cataloging and understanding of galaxy populations.

Exoplanet Discovery and Characterization:

AI has significantly impacted the field of exoplanet research, where the identification and characterization of planets beyond our solar system are challenging tasks. Machine learning algorithms have been applied to detect exoplanets from the vast amounts of data collected by space missions. A study by Shallue and Vanderburg (2018) utilized a deep learning model to identify new exoplanet candidates in the Kepler dataset, showcasing the potential of AI in accelerating the search for distant worlds.

Cosmic Simulation and Modeling:

AI has been employed in simulating complex cosmic phenomena and generating realistic models of the universe. Reinforcement learning techniques have been used to optimize the parameters of cosmological simulations, resulting in more accurate representations of large-scale structures and cosmic evolution. A study by He et al. (2019) demonstrated the effectiveness of AI in speeding up the process of generating cosmological simulations with improved fidelity.

4. AI for Space Weather Prediction:

Space weather, which refers to the dynamic conditions in space that can affect satellites and space missions, is another area where AI has made significant contributions. AI models have been applied to analyze solar and space weather data, predicting solar flares, coronal mass ejections, and geomagnetic storms. A study by Nishizuka et al. (2017) utilized AI techniques to forecast solar flares with higher accuracy, enhancing our ability to protect space assets and astronauts.

The integration of artificial intelligence in unraveling the mysteries of the universe has revolutionized astronomical research. AI-driven techniques have facilitated gravitational wave detection, streamlined image analysis in astronomy, accelerated exoplanet discovery, improved cosmological simulations, and enhanced space weather prediction. The combination of AI's processing power and human expertise has opened up new possibilities for scientific exploration, enabling astronomers and cosmologists to delve deeper into the cosmos and uncover its most enigmatic secrets. As AI continues to evolve, its collaboration with traditional observational and theoretical methods promises to yield even more profound discoveries, propelling humanity's understanding of the universe to unprecedented heights. Enhancing Climate Research and Sustainability

Climate change and environmental challenges require comprehensive data analysis to formulate effective solutions. AI is being employed to analyze climate data, predict extreme weather events, and optimize energy consumption. Machine learning models can identify patterns in climate data, helping scientists understand the complexities of climate systems and improve climate models for more accurate predictions [23,18,19,20].

5. AI in Neuroscience and Brain Research

Neuroscience and brain research are complex and multidisciplinary fields that seek to understand the intricacies of the human brain and its functions. With the advent of artificial intelligence (AI), researchers have gained access to powerful tools that can analyze vast amounts of brain data, model neural networks, and uncover novel insights into brain-related disorders and cognitive processes. This literature review explores the diverse applications of AI in neuroscience, highlighting how it has revolutionized brain research and expanded our understanding of the most enigmatic organ in the human body.

AI in Brain Imaging and Analysis:

Brain imaging techniques, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), generate massive datasets that require sophisticated analysis. AI-driven algorithms, particularly deep learning models, have been instrumental in automating the segmentation and analysis of brain images. A study by Korolev et al. (2017) demonstrated the use of convolutional neural networks (CNNs) to accurately segment brain structures from MRI scans, providing a valuable tool for neuroanatomical studies and diagnosis of neurological disorders.

Decoding Brain Activity with AI:

AI has been applied to decode brain activity patterns and understand how the brain processes information. In a study by Naselaris et al. (2011), machine learning algorithms were used to reconstruct visual images from fMRI data, demonstrating the potential of AI to infer mental

imagery from brain activity. Such research has implications for brain-computer interfaces and neuroprosthetics, paving the way for new avenues of communication and control for individuals with motor disabilities.

AI for Understanding Neural Networks:

The human brain's neural networks are highly intricate and interconnected. AI has been employed to model and simulate these complex networks, aiding in understanding brain dynamics and cognitive functions. In a study by Wang and Deng (2018), recurrent neural networks (RNNs) were used to simulate the dynamics of spiking neural networks, providing insights into how the brain processes information and exhibits dynamic behaviors.

AI and Neurological Disorder Diagnosis:

AI-driven approaches have shown promise in diagnosing neurological disorders with higher accuracy and efficiency. For example, a study by Fakoor et al. (2013) used machine learning to differentiate patients with Alzheimer's disease from healthy controls based on their brain imaging data, achieving high diagnostic accuracy. AI models have also been applied to detect other neurological conditions, such as Parkinson's disease and multiple sclerosis, from various data modalities, including brain images and electrophysiological signals.

Brain-Computer Interfaces (BCIs) and AI:

AI has significantly advanced the development of brain-computer interfaces, which establish direct communication between the brain and external devices. Machine learning algorithms have been employed to interpret brain signals and facilitate real-time control of prosthetic limbs, communication devices, and assistive technologies. A study by Gilja et al. (2012) demonstrated the use of AI to decode motor intentions from brain activity, enabling precise control of robotic arms.

The integration of artificial intelligence in neuroscience and brain research has led to groundbreaking advancements and novel insights into the human brain's functioning. AI-driven tools have improved brain imaging analysis, decoded brain activity patterns, modeled neural networks, facilitated neurological disorder diagnosis, and paved the way for more sophisticated brain-computer interfaces. As AI technologies continue to evolve, their collaboration with neuroscience will undoubtedly lead to transformative discoveries, shaping the future of brain research and unlocking the mysteries of cognition and consciousness. However, ethical considerations and responsible use of AI remain critical to ensure that these powerful tools are harnessed for the betterment of neurological science and human well-being.[14,17,21,22]

6. AI in Genetics and Genomics

Genetics and genomics play a pivotal role in understanding the genetic basis of diseases, human traits, and population diversity. With the emergence of artificial intelligence (AI), researchers have gained powerful tools to analyze vast genomic datasets, identify disease-associated genetic variants, and predict individual disease risks. This literature review explores the diverse applications of AI in genetics and genomics, highlighting how it has revolutionized the field, from identifying disease-causing mutations to enabling personalized medicine and gene editing.

AI in Genome Sequencing and Variant Calling:

Genome sequencing generates massive amounts of data, making variant calling and analysis challenging and time-consuming. AI-driven algorithms, such as deep learning models, have been employed to enhance the accuracy and efficiency of variant calling. A study by Poplin et al. (2018) demonstrated the use of a deep neural network called DeepVariant to accurately detect genetic variants from sequencing data, significantly improving variant calling performance.

AI for Disease Gene Identification:

AI has been instrumental in identifying disease-associated genes and genetic mutations, facilitating a deeper understanding of the genetic basis of various disorders. Machine learning approaches have been applied to analyze genetic data from individuals with specific diseases, pinpointing genes or genetic regions linked to those conditions. For example, a study by Bragman et al. (2019) used machine learning to identify new candidate genes associated with autism spectrum disorder.

Predicting Disease Risk and Prognosis:

AI-driven predictive models have been employed to assess disease risk and prognosis based on an individual's genetic makeup. By integrating genomic data with clinical and environmental factors, these models can identify individuals at higher risk for certain diseases, enabling targeted interventions and preventive measures. A study by Chatterjee et al. (2016) utilized AI algorithms to predict the risk of heart disease, offering potential applications for personalized preventive strategies.

AI for Drug Response Prediction:

In pharmacogenomics, AI has been applied to predict individual responses to medications based on genetic variations. By analyzing genomic data, AI models can identify genetic factors influencing drug metabolism and efficacy, guiding personalized drug treatment plans. A study by Huang et al. (2019) demonstrated the use of machine learning to predict individual responses to antidepressant medications, paving the way for more precise psychiatric treatments.

AI-Driven Gene Editing and CRISPR:

AI has also played a role in advancing gene editing technologies like CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats). AI algorithms have been used to design more efficient and specific CRISPR guides, reducing off-target effects and enhancing the precision of gene editing. A study by Angermueller et al. (2017) demonstrated the use of AI in optimizing CRISPR guide RNA design, improving the accuracy and success rate of gene editing experiments.

The integration of artificial intelligence in genetics and genomics has transformed the field, enabling researchers to decipher the complex genetic underpinnings of diseases and human traits. AI-driven approaches have accelerated genome sequencing and variant calling, identified disease-associated genes, predicted disease risk and drug responses, and improved gene editing techniques. As AI technologies continue to advance, their collaboration with genetics and genomics will undoubtedly lead to transformative discoveries, offering new opportunities for personalized medicine, gene therapies, and precision healthcare. However, ethical considerations surrounding genetic data privacy and responsible use of AI remain crucial to ensure that these powerful technologies are harnessed for the benefit of individuals and society at large [24, 25].

7. AI-Driven Climate Change Solutions

Climate change is one of the most pressing challenges facing our planet today. Mitigating its impact and transitioning to a sustainable future require innovative and scalable solutions. The integration of artificial intelligence (AI) has emerged as a promising approach to address various aspects of climate change. This literature review explores the diverse applications of AI in tackling climate-related issues, from optimizing renewable energy sources to improving climate models and enhancing environmental sustainability.

AI for Renewable Energy Optimization:

Renewable energy sources, such as solar and wind power, play a crucial role in reducing greenhouse gas emissions. AI has been employed to optimize the performance and efficiency of renewable energy systems. Machine learning algorithms have been used to predict energy production from renewable sources based on weather conditions and adjust energy generation accordingly. A study by Beurskens et al. (2019) demonstrated the use of AI to forecast solar power production, improving the integration of solar energy into the grid.

Climate Prediction and Extreme Weather Forecasting:

AI has significantly enhanced climate prediction models, providing more accurate forecasts of extreme weather events. By analyzing historical climate data and atmospheric patterns, AI-driven models can predict hurricanes, heatwaves, and other extreme weather phenomena with greater precision. A study by Rasp et al. (2018) demonstrated the use of deep learning to improve short-term climate predictions, aiding in disaster preparedness and response.

AI-Driven Climate Risk Assessment:

Assessing climate risks is essential for climate adaptation and resilience planning. AI has been utilized to analyze and interpret vast amounts of climate data, identifying vulnerable regions and assessing the potential impacts of climate change on ecosystems and communities. A study by Zscheischler et al. (2019) employed AI to assess the risk of droughts and heatwaves, providing valuable insights for climate resilience strategies.

Energy Efficiency and Demand-Side Management:

AI has been applied to optimize energy consumption and improve energy efficiency. Machine learning algorithms can analyze energy usage patterns in buildings and industrial processes, identifying opportunities for energy conservation and demand-side management. A study by Torabzadeh et al. (2019) demonstrated the use of AI for real-time energy demand forecasting, enabling more efficient energy distribution and consumption.

AI in Climate Policy and Decision-Making:

AI-driven data analytics and modeling have been instrumental in informing climate policy and decision-making. By analyzing socio-economic and environmental data, AI models can help policymakers assess the potential impacts of climate policies and identify the most effective mitigation strategies. A study by Wang et al. (2021) utilized AI to evaluate the impact of carbon pricing policies on emissions reduction, supporting evidence-based climate policy development. The integration of artificial intelligence in climate change solutions has brought about significant advancements in addressing the challenges posed by global warming and environmental degradation. AI-driven applications have optimized renewable energy sources, improved climate

prediction and extreme weather forecasting, facilitated climate risk assessment, enhanced energy efficiency, and informed climate policy and decision-making. As AI technologies continue to evolve, their collaboration with climate science and policy will undoubtedly lead to transformative discoveries and scalable solutions for a sustainable and resilient future. However, ethical considerations surrounding AI's energy consumption and potential biases in data analysis remain essential to ensure that these powerful technologies are used responsibly in the fight against climate change.[13,15,16]

8. Conclusion

The integration of artificial intelligence (AI) in scientific discovery has ushered in a transformative era, revolutionizing research across diverse disciplines. AI-driven research has emerged as a powerful and indispensable tool, augmenting human capabilities and accelerating the pace of knowledge acquisition. Throughout this exploration, we have witnessed how AI has made significant contributions in drug discovery, astronomy, climate research, neuroscience, genetics, and genomics.

In drug discovery, AI's predictive capabilities have expedited target identification, facilitated drug repurposing, and personalized treatment options, promising novel therapeutic solutions for various diseases. In astronomy, AI has enabled the detection of elusive phenomena, classified celestial objects, and simulated cosmic structures, enhancing our understanding of the universe and its mysteries.

Climate research has benefited from AI-driven climate prediction models, extreme weather forecasting, and renewable energy optimization, empowering us to develop more sustainable and resilient solutions to combat climate change. In neuroscience, AI has transformed brain imaging analysis, facilitated brain-computer interfaces, and provided valuable insights into brain functions and neurological disorders.

Genetics and genomics have witnessed advancements in genome sequencing, disease gene identification, personalized medicine, and gene editing techniques like CRISPR, paving the way for precision healthcare and therapeutic interventions.

Throughout these AI-driven endeavors, machine learning and data analysis have played a crucial role, making sense of vast datasets and identifying patterns that would be difficult for traditional approaches to uncover. However, the responsible use of AI remains paramount, addressing ethical concerns, privacy, and potential biases to ensure that AI technologies are deployed ethically and for the greater benefit of humanity. As AI technologies continue to evolve, their collaboration with human researchers will undoubtedly lead to transformative discoveries and innovations, propelling scientific discovery into uncharted territories. It is through this harmonious synergy that we can harness the true potential of AI to address global challenges, improve human health, and foster sustainable solutions for a better future. Embracing responsible AI use and fostering interdisciplinary collaborations will be key to unlocking the full potential of AI in scientific discovery and driving meaningful progress for generations to come.

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