Innovative Development in Educational Activities ISSN: 2181-3523 VOLUME 2 | ISSUE 23 | 2023
Scientific Journal Impact Factor (SJIF): 5.938 http://sjifactor.com/passport.php?id=22323

THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN MEDICINE

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Annotation: *This article delves into the transformative role of Artificial Intelligence (AI) in reshaping healthcare, with a focus on its historical roots, current applications, and future potential. It navigates through the evolution of AI, from its conceptualization in the 1950s to its contemporary applications in medicine, particularly in drug discovery, medical diagnosis, and dentistry. The narrative highlights the challenges and ethical considerations accompanying AI integration in healthcare and emphasizes the collaborative relationship between human expertise and machine precision. The comprehensive exploration of AI's impact in diverse medical domains underscores its pivotal role in advancing patient care and medical innovation.*

Key words: *Medical diagnosis, Disease detection, Treatment planning, Personalized medicine, Drug discovery, Machine learning, Deep learning, High-Performance Computing (HPC), Pharmaceutical companies Digital dentistry, Image-based disease detection, Diagnosis support systems, Robotic support in dentistry, Oral healthcare.*

Introduction

Artificial Intelligence (AI) has gained significant attention in recent years, particularly for its potential to revolutionize various industries, including healthcare. AI involves machines, especially computer systems, simulating human intelligence processes, such as learning from data, recognizing patterns, and making informed decisions.The growing interest in AI within the medical field is evident as researchers and healthcare professionals acknowledge its capacity to transform healthcare. AI can analyze large sets of medical data, make predictions, and enhance patient care, from diagnosing diseases to creating personalized treatment plans.However, as AI technology advances in medicine, it brings forth challenges and ethical considerations that demand attention. These include issues like data privacy, algorithmic bias, and potential impacts on the doctor-patient relationship. It is crucial for healthcare professionals and policymakers to carefully consider and address these challenges as they incorporate AI into medical practices.

What is artificial intelligence?

Artificial Intelligence is a branch of computer science focused on creating systems that can perform tasks that would typically require human intelligence. These tasks include: problem-solving, learning, understanding natural language, recognizing patterns, and adapting to new situations. AI aims to develop machines or software that can exhibit traits like reasoning, perception, and decision-making.According to James H. Fetzer The field of artificial intelligence (AI) presents a captivating challenge in precisely defining its subject matter. This challenge comprises two aspects: understanding the nature of the artificial and having a suitable comprehension of intelligence. The term "artificial" in artificial intelligence refers to its origin and creation through human invention and ingenuity, as opposed to arising from natural, especially biological or evolutionary, influences. Essentially, artificially intelligent entities distinguish themselves from naturally intelligent ones as creations with specific attributes not typically found in non-artificial entities. In other words, these entities possess a particular property, intelligence, as a result of a specific process—being intentionally created, designed, or manufactured. (Fetzer, 1990) " "As we embark on an exploration of Artificial Intelligence (AI) and its transformative potential in healthcare, it is imperative to trace the historical roots that have shaped this dynamic field. The burgeoning interest in AI, as discussed earlier, is part of a continuum that spans several decades. The evolution of AI can be traced back to the 1950s, gaining momentum over the years. Over the last five decades, AIM has changed considerably. Since the advent of ML and DL, AIM applications have grown, allowing for individualized care rather than algorithm-only therapy. In the future, predictive models could be utilized for disease diagnosis, therapeutic response prediction, and perhaps preventative medicine.7 AI may increase diagnostic accuracy, provider workflow and clinical operations efficiency, disease and treatment monitoring, procedure accuracy, and overall patient outcomes. The progression of the AI platform in medicine is tracked and arranged below by distinct time periods of crucial shift. (J.K. Ruffle, A.D. Farmer, Q. Aziz, 2019)

The roots of artificial intelligence

The historical roots of computer science date back to 1843 when Ada Lovelace formulated the initial algorithm for Charles Babbage's analytical engine, serving as a precursor to modern computers. This era can be considered the prehistoric phase of computer science. Despite the absence of programmable machines, the invention of

Jacquard's loom in 1801, utilizing perforated cards for mechanical control, hinted at the potential of computational control.

The emergence of machines with computation and programming capabilities occurred towards the late 19th century, notably during the US census. The creation of the ENIAC in 1945, exactly a century after Ada Lovelace's algorithm, marked a significant milestone in computer science, effectively serving as a starting point for the field and paving the way for rapid advancements.In 1950, a mere five years after the introduction of the ENIAC, Alan Turing coined the term "artificial intelligence" for the first time. This groundbreaking concept garnered significant attention, leading to the swift proposal of numerous AI algorithms in subsequent years (Nicolas SabouretLizete De Assis, 2021)Following these years, the Dartmouth Workshop of 1956, organized by influential figures such as Marvin Minsky, John McCarthy, and senior scientists Claude Shannon and Nathan Rochester of IBM, was predicated on the proposition that "each facet of the process of learning or any other attribute of intelligence can be articulated with such precision that a machine can be designed to replicate it" (McCorduck, 2004) (Crevier, 1993) (Stuart J. Russell and Peter Norvig, 2003) (Newquist, 1994) (Allen Newell and H. A. Simon, 1963)During the 1980s, corporations globally embraced a type of AI program known as "expert systems," and there was a shift in mainstream AI research towards emphasizing knowledge. Simultaneously, the Japanese government strongly supported AI through its fifth-generation computer project. Another positive development in the early 1980s was the resurgence of connectionism in the contributions of John Hopfield and David Rumelhart. Once more, AI experienced notable achievements. (Newquist H. , 1994)An expert system is a software application designed to respond to inquiries or address issues within a particular field of expertise, employing logical rules derived from the knowledge of experts. The initial instances of such systems were pioneered by Edward Feigenbaum and his students. Dendral, initiated in 1965, could recognize compounds based on spectrometer readings, while MYCIN, created in 1972, specialized in diagnosing infectious blood diseases. These early examples substantiated the viability of this approach. (McCorduck, 2004) (Crevier, 1993) (Newquist H. , 1994) (Stuart J. Russell and Peter Norvig, 2003)Expert systems confined their scope to a narrow domain of specialized knowledge, thereby sidestepping the challenge of dealing with common-sense knowledge. Their straightforward design facilitated the creation of programs and subsequent modifications once implemented. In summary, these programs demonstrated utility, a feat that had eluded AI until that juncture. (Crevier, 1993) (Stuart J. Russell and Peter Norvig, 2003)In 1980, the completion of an expert system named XCON at CMU for the Digital Equipment Corporation marked a significant triumph. By 1986, this system had proven immensely successful, contributing to annual savings of 40 million dollars for the company (Crevier, 1993)By 1985, companies globally initiated the creation and implementation of expert systems, with expenditures exceeding a billion dollars on artificial intelligence. The majority of these funds were directed towards in-house AI departments. (Newquist H. , 1994)An entire industry emerged to cater to their needs, encompassing hardware firms like Symbolics and Lisp Machines, along with software companies such as IntelliCorp and Aion. (McCorduck, 2004) (Crevier, 1993) (Newquist H. , 1994) (Stuart J. Russell and Peter Norvig, 2003) "On May 11, 1997, Deep Blue achieved a historic milestone by becoming the first computer chess-playing system to defeat the reigning world chess champion, Garry Kasparov. Developed as a specialized iteration of an IBM framework, this supercomputer demonstrated a substantial improvement in performance, processing twice as many moves per second compared to the initial match it had lost, handling a reported 200 million moves per second.In 2005, a robot from Stanford University achieved victory in the DARPA Grand Challenge by autonomously covering 131 miles along an unscripted desert trail. This marked a notable advancement in autonomous vehicle technology. Two years later, a Carnegie Mellon University team triumphed in the DARPA Urban Challenge, navigating autonomously through 55 miles in an urban setting while adhering to traffic regulations and hazards.In February 2011, during a Jeopardy! quiz show exhibition match, IBM's question-answering system, Watson, outperformed the two top Jeopardy! champions, Brad Rutter and Ken Jennings, by a significant margin. This success showcased AI's ability to comprehend and respond to natural language queries in a broad knowledge domain."The narrative of Artificial Intelligence (AI) traces an intricate path through the historical corridors of computer science, from the visionary insights of Ada Lovelace in 1843 to Alan Turing‘s seminal introduction of the term "artificial intelligence" in 1950. This evolutionary journey, reflective of an unwavering pursuit of innovation, transitions into a contemporary chapter where AI assumes a pivotal role in the realm of medicine, fundamentally reshaping the landscape of healthcare.In this modern epoch, the applications of AI in medicine emerge as tangible embodiments of its transformative potential. Navigating through this convergence of historical context and contemporary progress, distinct applications come to the fore, each playing a decisive role in redefining the parameters of patient care and healthcare delivery. Let us embark on an exploration of these applications, elucidating their contributions to the current tapestry of AI in medicine:

Drug Discovery and Development

The extensive chemical space, encompassing over 10^60 molecules, facilitates the generation of a substantial array of drug molecules. (Mak, K.-K. Pichika, M.R., 2019)Nevertheless, the absence of advanced technologies hampers the drug development process, rendering it a laborious and costly endeavor. This challenge can be mitigated through the application of artificial intelligence(AI). (Vyas, 2018) AI has the capacity to identify potential hit and lead compounds, enabling a more expeditious validation of drug targets and streamlining the optimization of drug structure designs. (Mak, K.-K. Pichika, M.R., 2019) (Sellwood, 2018) Despite its merits, artificial intelligence (AI) encounters notable challenges related to data, including issues of scale, expansion, diversity, and uncertainty. "In pharmaceutical companies' datasets for drug development, which may encompass millions of compounds, conventional machine learning (ML) tools often struggle with extensive data sets. While computational models based on quantitative structure-activity relationship (QSAR) can rapidly predict physicochemical parameters, they fall short when predicting intricate biological properties such as efficacy and adverse effects. Challenges faced by QSAR-based models include limited training data, errors in experimental data, and a lack of experimental validations.To address these hurdles, contemporary AI approaches, such as deep learning (DL), and relevant modeling studies are applied for the comprehensive evaluation of drug molecules' safety and efficacy, leveraging big data modeling and analysis. In 2012, Merck conducted a QSAR ML challenge to assess the potential advantages of DL in the drug discovery process within the pharmaceutical industry. DL models demonstrated notable predictive capabilities compared to traditional ML approaches across 15 absorption, distribution, metabolism, excretion, and toxicity (ADMET) datasets of drug candidates (Zhu, 2020; Ciallella, H.L. Zhu, H., 2019).The virtual chemical space is vast and can be visualized as a map representing the distributions of molecules and their characteristics. The concept behind mapping the chemical space is to gather positional data about molecules within it, facilitating the exploration for bioactive compounds. Virtual screening (VS) is instrumental in this process, aiding in the identification of suitable molecules for subsequent testing. Various open-access chemical spaces, such as PubChem, ChemBank, DrugBank, and ChemDB, are available for exploration.Several in silico techniques for screening compounds within virtual chemical spaces, coupled with structure and ligand-based methodologies, offer enhanced profile analysis, contributing to the swift elimination of nonlead compounds and the selection of potential drug molecules, leading to cost savings (Mak, K.-K. Pichika, M.R., 2019). "The process of discovering and developing pharmaceutical drugs is a complex and lengthy journey, often exceeding a decade and costing an average of US$2.8 billion. Despite these substantial investments, the road is marked by a high failure rate, with nine out of ten therapeutic molecules falling short during Phase II clinical trials and regulatory approval (Alvarez-Machancoses, O. and Fernandez-Martinez, J.L, 2019).To enhance the drug discovery process, various algorithms, such as Nearest-Neighbor classifiers, Random Forest (RF), extreme learning machines, Support Vector Machines (SVMs), and deep neural networks (DNNs), are commonly used for virtual screening (VS). These algorithms assess synthesis feasibility and predict in vivo activity and toxicity (Alvarez-Machancoses, O. and Fernandez-Martinez, J.L, 2019) (Dana, 2018).In a collaborative effort, major biopharmaceutical companies like Bayer, Roche, and Pfizer have partnered with IT firms to create dedicated platforms for discovering therapies, particularly in fields such as immuno-oncology and cardiovascular diseases (Mak, K.-K. Pichika, M.R., 2019).The drug development process extends beyond molecule discovery to integrating it into a suitable dosage form with specified delivery characteristics. Artificial intelligence (AI) offers a valuable alternative to the traditional trial-and-error approach (Guo, 2002). Computational tools, guided by Quantitative Structure-Property Relationship (QSPR) techniques (Mehta, 2019), address formulation design challenges, including stability issues, dissolution, and porosity. Decision-support tools, employing rule-based systems, select excipients based on physicochemical attributes, with a feedback mechanism overseeing the entire process and making intermittent modifications as needed (Zhao, 2006).The application of various mathematical tools, including computational fluid dynamics (CFD), discrete element modeling (DEM), and the Finite Element Method, has been instrumental in understanding the flow characteristics of powder during die-filling and tablet compression (Rantanen, J., Khinast, J., 2015) (Ketterhagen, W.R., et al., 2009). Additionally, CFD is employed to analyze the impact of tablet geometry on dissolution profiles (Chen, W., et al., 2016). Integrating these mathematical models with artificial intelligence holds the potential to significantly expedite pharmaceutical manufacturing."

In Medical Diagnosis:

The examination of disease diagnosis in the healthcare domain is of paramount importance, encompassing factors leading to pain, illness, dysfunction, or mortality. Diseases manifest both physically and mentally, significantly influencing the affected individual's lifestyle. The systematic study of disease causes, known as the pathological process, plays a crucial role (Scully, 2004) (al., 2020).Diagnosis, defined as the systematic identification of a disease through the analysis of signs and symptoms, along with the determination of its pathology, involves discerning the specific disease based on an individual's presented symptoms and signs. This process relies on pertinent data derived from medical history and physical examinations, often accompanied by diagnostic procedures such as medical tests (R. H. Scheuermann, W. Ceusters, B. Smith, 2009) (P. Croft, D. G. Altman, J. J. Deeks, 2015). The comprehensive diagnostic framework meticulously followed by medical practitioners aims to collect maximal information.

The need for an automated diagnostic system that combines human expertise and machine accuracy became apparent. To achieve precise diagnoses while minimizing costs, an effective decision support system is essential. Disease classification based on diverse parameters poses a complex challenge for human experts, but AI can aid in detecting and managing such cases. Various AI techniques, including deep learning and machine learning, are employed in the medical field, with specific AI methods like rule-based intelligent systems serving as decision support systems (Lee, 1990), (J. Yen R. Langari, 1999).Discovering possibilities and making predictions in health matters pose challenges for physicians and surgical experts. Artificial Neural Networks (ANN) emerge as swift decision-making tools in healthcare, enabling systems to rapidly gather and comprehend data, pinpointing essential factors crucial for accurate predictions (C.-H. Weng, T. C.-K. Huang, R.-P. Han, 2016) (M. Chen, Y. Hao, K. Hwang, L. Wang, L. Wang, 2017).Deep learning, a branch of machine learning relying on algorithms, finds application in healthcare, aiding specialists in disease examination and contributing to improved medical decision-making. It offers advantages in drug discovery, medical imaging, genomics, and the detection of Alzheimer's disease. The prevailing trend in healthcare employing deep learning focuses on breast cancer detection, where AI matches or surpasses human radiologists' accuracy. AI continuously trains itself, improving precision over time. Another application is in the Internet of Medical Things (IoMT), facilitating healthcare data collection through IoT devices. AI-based software can identify diseases before onset by recognizing early symptoms. Neural networks, with efficient training, detect lung cancer, breast cancer, and strokes faster than trained radiologists. AI algorithms assist in analyzing medical images, aiding in the diagnosis of specific diseases. Disease detection and accurate treatment provision pose challenges due to symptom similarity; medical expert systems leverage AI for precise diagnoses and treatment recommendations. Modern AI algorithms assist doctors in orchestrating a comprehensive approach to disease management and enhance surgical robots for intricate operations. In conclusion, the intersection of artificial intelligence and healthcare, particularly in disease diagnosis, marks a pivotal epoch in medical history. The amalgamation of human expertise with the precision and efficiency of machine learning has propelled the field towards unparalleled advancements. As we navigate through the complexities of disease identification, the integration of AI, from expert systems to neural networks and deep learning, stands as a beacon of progress. The continuous evolution of AI techniques not only enhances diagnostic accuracy but also revolutionizes the landscape of medical decision-making. From predicting health outcomes to reshaping the future of medical imaging and treatment strategies, artificial intelligence remains an invaluable asset in the relentless pursuit of improved patient care and medical innovation. The journey unfolds with each breakthrough, promising a future where technology and human insight harmoniously converge for the betterment of healthcare.

Its application in Dentistry

Artificial Intelligence (AI) has become a revolutionary force in various fields of healthcare, and dentistry is no exception. In recent years, the integration of AI technologies has ushered in a new era of possibilities, transforming the landscape of dental care. The systematic examination of disease diagnosis gains unique significance in the realm of dental health. Oral conditions, encompassing a range of diseases affecting the teeth, gums, and surrounding structures, present distinct challenges. The intersection of human expertise and machine precision becomes particularly compelling in addressing these challenges, promising innovative solutions in disease identification, prevention, and treatment. While dentistry may not appear profoundly influenced by the strides in AI, specific domains, including image-based automated disease detection, diagnosis support systems, (D.H. Kim, S.N. Jeong, and S.H. Choi, 2018) (Hung M, Voss MW, Rosales MN,, 2019) and image segmentation for identifying oral traits, (Xu X, Liu C,Zheng Y, 2018) are experiencing notable enhancements due to AI. Moreover, improvements in resolution for dentistry-related images are being propelled by AI applications (Hatvani J, Horváth A, Michetti J, 2018). On the robotics front, various breakthroughs are facilitating the integration of robotic support in dentistry. In essence, the realm of dentistry holds considerable potential for AI techniques, spanning multiple areas and aligning with the evolving paradigm of digital dentistry. (Schwendicke F, Singh T, Lee JH, 2021) (Grischke J, Johannsmeier L, Eich L, Griga L, Haddadin S, , 2020) Various factors have contributed to the recent surge of AI revolution in biomedicine. Firstly, there has been an exponential increase in data collection over the past few decades. However, the sheer volume of data alone is insufficient. The progress in high-performance computing (HPC) has played a pivotal role by enabling powerful AI techniques for extracting valuable insights from the amassed data. This process of information extraction is commonly known as machine learning (ML), the data-driven facet of AI. ML aims to facilitate machines (algorithms executed in computer systems) in learning about a specific subject from a given dataset. Typically, supervised learning techniques are employed for this type of information extraction, demonstrating considerable success. Supervised learning involves the task of teaching a function that can map an input sample to a desired output, based on a database containing examples of input-output pairs. Once this function is learned using training data, it can be applied to make predictions on new samples. (Friedman J, Hastie T, Tibshirani R, 2001) In conclusion, the integration of Artificial Intelligence (AI) in dentistry represents a transformative force, introducing innovative solutions across various facets of dental care. Despite the initial perception that dentistry may not be profoundly influenced by AI, specific domains, including automated disease detection, diagnosis support systems, and image segmentation, are witnessing significant advancements. The potential for AI extends beyond these applications, encompassing resolution enhancements for dentistry-related images and breakthroughs in robotics for dental support.The recent surge in the AI revolution in biomedicine, including dentistry, is fueled by exponential growth in data collection over the past decades. However, the true power of this data lies in the advancements in high-performance computing (HPC), enabling powerful AI techniques for extracting valuable insights. Machine Learning (ML), a key component of AI, plays a pivotal role in facilitating machines to learn from vast datasets, with supervised learning techniques demonstrating considerable success.As dentistry aligns with the evolving paradigm of digital dentistry, the collaboration between human expertise and machine precision promises to deliver innovative solutions in disease identification, prevention, and treatment. The synergistic relationship between AI and dentistry is poised to shape the future of oral healthcare, offering a new era of possibilities and advancements.

CONCLUSION

In conclusion, the integration of Artificial Intelligence (AI) into the realms of healthcare and dentistry stands at the forefront of transformative innovation. The narrative weaves through the historical corridors of computer science, from Ada Lovelace’s visionary insights in 1843 to Alan Turing‘s introduction of the term "artificial intelligence" in 1950. This evolutionary journey reflects an unwavering pursuit of innovation, culminating in a contemporary chapter where AI assumes a pivotal role in reshaping the landscape of medicine and oral healthcare.AI’s applications in medicine, particularly in drug discovery, development, and medical diagnosis, showcase its potential to revolutionize patient care. From identifying potential drug compounds to providing accurate disease diagnoses, AI serves as a beacon of progress, enhancing efficiency, precision, and the overall patient experience. The intersection of human expertise with the capabilities of machine learning, deep learning, and expert systems promises a future where technology and human insight harmoniously converge for the betterment of healthcare.The journey continues into the field of dentistry, where AI introduces innovative solutions in disease identification, prevention, and treatment. Despite initial perceptions, dentistry benefits significantly from AI applications, ranging from automated disease detection to image segmentation and resolution enhancements in dentistry-related images. The collaboration between human expertise and machine precision in dentistry heralds a new era, promising advancements that redefine the parameters of oral healthcare.The recent surge in the AI revolution, fueled by exponential growth in data collection and advancements in high-performance computing, underscores the power of AI in extracting valuable insights from vast datasets. Machine Learning, as a key component of AI, plays a pivotal role in facilitating machines to learn from data, demonstrating considerable success in various applications.As we navigate through this intersection of technology and healthcare, the synergistic relationship between AI and human expertise holds the promise of improved patient care, enhanced diagnostic accuracy, and transformative advancements in medical decision-making. The continuous evolution of AI techniques ensures that the future of healthcare and dentistry remains dynamic, offering a spectrum of possibilities and contributing to the relentless pursuit of innovation for the well-being of individuals worldwide.

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