

Revolutionizing Dentistry with Artificial Intelligence

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The origins of artificial intelligence can be traced back several decades, as it represents a technology that has undergone years of development and research. In 1950, Alan Turing posed the question, "Can machines exhibit intelligence?" within his essay titled "Computing machinery and intelligence."¹ Another forerunner in the field of Artificial Intelligence (AI) emerged with John McCarthy and Marvin Minsky, who established the Artificial Intelligence Laboratory at Massachusetts Institute of Technology (MIT) in the United States.² While the attribution of coining the term "artificial intelligence" varies, some credit John McCarthy in 1956, while others associate it with Marvin Minsky.³ Nonetheless, they collaborated in this laboratory. In 1957, Newell and Simon pioneered one of the earliest artificial intelligence programs known as the "General Problem Solver," marking an early milestone in AI system development. Fast forward to 1997, where chess grandmaster Garry Kasparov was defeated by IBM's supercomputer, Deep Blue, a significant event in AI history. Today, artificial intelligence has become an integral part of our contemporary narrative.⁴


Artificial intelligence, or AI, represents a field of computer science focused on developing systems and machines capable of mimicking human learning, thinking, and decision-making processes. It achieves this through the utilization of artificial neural networks, consisting of layers of synthetic neurons. In essence, AI pertains to the concept of machines performing specific tasks that were traditionally associated with human capabilities.⁵

AI is defined by the Association for the Advancement of Artificial Intelligence as the fundamentals of machine intelligence. Bruno López Takeyas, from the Technological Institute of Nuevo Laredo, described AI as a subset of computer science that mimics human intelligence through functions like reasoning and language

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processing with deep neural networks.⁶ AI, once a sci-fi concept, is now real, enabling machines to perceive their environment, make decisions, and learn like humans, integrated into daily life through office software. Examples include voice-controlled devices like Siri and Alexa, as well as image recognition systems. Stuart Russell and Peter Norvig categorize AI into reactive machines (e.g., IBM's chess-playing supercomputer), limited memory (e.g., driverless cars), and theory of mind AI (interacting with humans beyond language).⁷ Artificial intelligence offers a range of concrete benefits, such as enhanced healthcare access, where AI technologies, including drones, are improving access to healthcare services. It also contributes to precision and quality, enhancing service quality. Moreover, AI plays a crucial role in safety improvement across various applications and streamlines procedures, benefiting patients by leading to faster examination and treatment times. Additionally, it provides invaluable support for medical and dental research by gathering vast diagnostic and treatment data. Furthermore, AI, when combined with technologies like blockchain, helps safeguard privacy, ensuring privacy protection.⁸ Sub-branches of AI, like machine learning and deep learning, enable scalability, making it easier to apply AI solutions across various domains. AI also ensures enhanced analysis accuracy, particularly in tasks such as radiographic assessments during dental diagnosis. It further aids in error reduction by providing precise image and sample analysis, ultimately reducing human errors. Lastly, AI plays a crucial role in process automation, automating tasks like the design of prostheses. These advantages collectively highlight the significant impact of AI on various sectors, including healthcare and technology.⁹

Artificial intelligence, often referred to as dental AI, has brought several significant benefits to the field of dentistry. These advantages include quicker and more accurate identification of dental caries and oral diseases, leading to more precise diagnoses. AI's predictive capabilities can analyze unstructured patient history data, identifying patterns that may indicate other health issues, particularly in image-based diagnosis. Additionally, AI enhances the production of various dental prostheses by analyzing patient data obtained through systems like CAD-CAM. Moreover, it can help in determination of a suitable type of restorative material for a patient along with prediction of appropriate color matching.¹⁰ It can also analyze radiographs as an alternative to traditional methods for detecting anomalies in root canals, improving endodontics. Moreover, AI helps in location of apical foramen for working length determination and detection of vertical root fracture.¹¹ Furthermore, AI can distinguish between aggressive periodontitis and chronic periodontitis with high accuracy, employing artificial neural networks, and it analyzes radiographs to detect abnormalities and related issues during dental diagnosis. AI aids in the diagnosis and prediction of periodontal disease.¹² In oral implantology, AI helps in predicting the success rate of the dental implants.¹³ In orthodontics, AI helps in predicting the sizes of unerupted canines and premolars during in mixed dentition as well as predicting if extraction is needed prior to orthodontic treatment. Moreover, AI aids in diagnosis of whether to extract or not to extract teeth.¹⁴ In oral pathology and medicine, AI helps in diagnosis and progression of the temporomandibular disorders (TMDs).¹⁵ In maxillofacial surgery, AI helps in determination of oral cancers.¹⁶ In forensic dentistry, AI aids in the identification of individuals through automated techniques based on convolutional neural networks, offering promising results compared to experienced evaluators. Finally, AI can accurately determine a person's age from panoramic radiographs.¹⁷ These advancements in dental AI not only improve the accuracy and efficiency of dental procedures but also extend its applications to various areas of dentistry and healthcare.

Artificial intelligence has had a profound impact on the medical field, with various applications. For example, a collaboration between the UK National Health Service and Google's DeepMind has resulted in an AI system designed to reduce radiotherapy times for head and neck cancer patients. This system aims to cut the mapping time for cancer areas from 4 hours to just 1 hour, improving treatment efficiency.¹⁸ Additionally, at Cincinnati Children's Hospital Medical Center, researchers are developing a machine learning system that assesses the likelihood of a patient participating in clinical trials. This innovation has the potential to significantly expedite research and provide important benefits to healthcare by streamlining the clinical trial recruitment process.

Artificial intelligence offers additional healthcare benefits, including the prevention of diabetic vision loss. Volunteers at the California HealthCare Foundation have created an image analysis algorithm that swiftly and accurately identifies retinal damage in diabetic patients, outperforming traditional human analysis by 85%.¹⁹ In the realm of pancreatic cancer detection, the pharmaceutical company Berg employs AI to analyze extensive oncological data, generating a model that enhances our understanding of the workings of pancreatic cancer. Moreover, researchers at the MIT have harnessed AI to discover a new antibiotic called halicin. They achieved this by evaluating the structures of over 2,500 drugs and other compounds, showcasing AI's potential in drug discovery. Overall, AI accelerates the process of drug discovery across various domains, reducing associated costs and providing significant advancements in the field.

AI remains a developing technology, and for reliability, it should require human oversight, involving monitoring, validation, and feedback mechanisms, with evaluation and regulation based on scientific evidence. AI should also ensure fairness and non-discrimination in its applications. Specialized personnel should be trained to work with AI systems. It is important to establish standards for medical and dental research employing artificial intelligence. International organizations like the International Telecommunication Union and the WHO have initiated focus groups to standardize AI applications in healthcare.

Conclusion

Artificial intelligence, especially in dentistry and healthcare, promises more accurate diagnostics, faster predictive analyses, and improved patient care. Embracing AI can lead to higher-quality treatments and increased patient confidence. AI is closely linked to machine learning, efficiently utilizing data through progressive learning algorithms. Looking ahead, we foresee the emergence of "Smart Dentistry" driven by AI, transforming how dentistry is practiced and learned, benefiting both practitioners and patients. While AI offers significant advantages, there are concerns about overreliance. Dental professionals must use AI judiciously and receive proper training to mitigate risks. In summary, AI is already revolutionizing dentistry and healthcare, offering numerous opportunities for diagnostic, treatment, and patient care improvements.

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