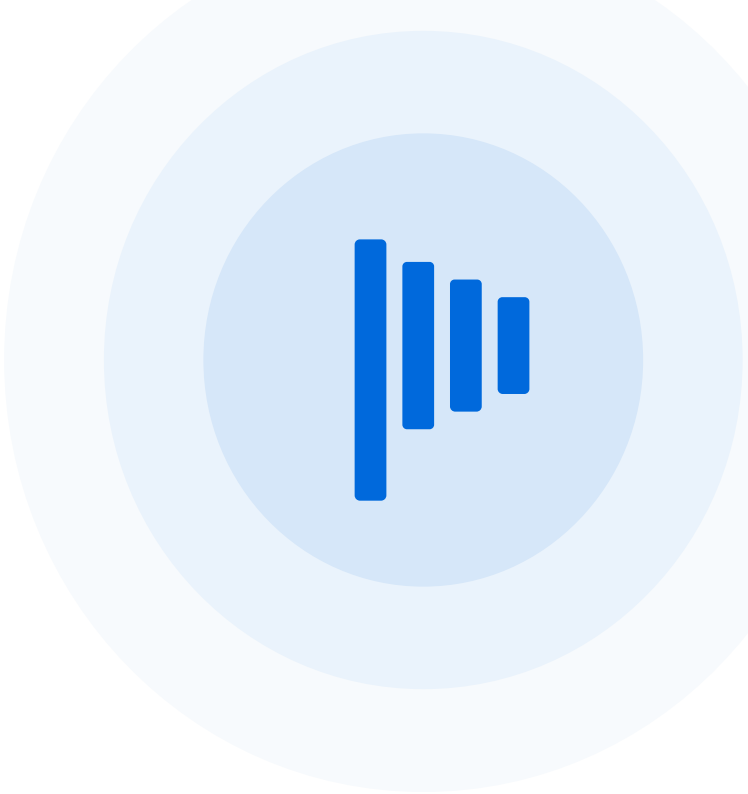
LOOKING AHEAD

Artificial Intelligence

in Dentistry

planet DDS

Contents



Introduction

For some individuals, the concept of artificial intelligence might seem like something straight from a sci-fi movie. These days, though, you'll find artificial intelligence in use in numerous industries, from technology and retail to manufacturing, agriculture, energy, insurance, and more.

Typically referred to simply as AI, artificial intelligence is the ability of a computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. Using computer algorithms to copy a human's capability to learn and subsequently make predictions, it is sometimes characterized as machine (ML) or deep learning (DL) or natural language processing (NLP).

Other subcategories of AI include cognitive computing, robotics, expert systems, and fuzzy logic. While machine learning enhances automated learning without human arbitration, deep learning utilizes multilayered (deep) neural networks to learn hierarchical features in data. Overall, AI can be helpful in many fields where humans may be assisted and helped by new technologies.

Just how prominent is the use of AI in the United States? The global AI market size was valued at $93.5 billion in 2021 and is projected to surpass $ 1.5 trillion by 2030. Almost 40 percent of businesses and organizations already employ AI, and more than 90 percent of leading businesses are actively investing in AI technology.

How AI is Being Used in Healthcare

With medical spending so high in the U.S., it's not surprising that the healthcare industry has been one of the biggest adopters of AI. In addition to the capability of AI to process large volumes of data to inform decisions that drive health improvements, reduce costs and streamline resource allocation, its combination with key clinical health applications potentially could create $150 billion in annual savings[1] for the U.S. healthcare economy in the next few years.

According to numerous research studies[2], AI can perform as well as or better than humans at key healthcare tasks. Top AI applications in healthcare[3] consist of robot-assisted surgery, virtual nursing assistance, administrative workflow assistance, fraud detection, and dosage error reduction.

The use of AI has enabled healthcare providers across the U.S. to streamline key financial and administrative aspects of their business to improve patient care while lowering costs. Another bonus is eliminating manual, paper-based administrative and clinical processes that are often repetitive and labor-intensive.

More advantages of implementing AI-based systems in healthcare[4] include:

1. More curated, systematic, and structured collection of a patient's data
2. The ability to overcome variations in a patient's examination and facilitate effective care while lowering costs of the treatment by reducing routine tasks
3. The facilitation of research and development by introducing experimentation options
4. Reduction of the tedious task of collecting patient's details before treatment, thus increasing more time of face-to-face discussion between patient and clinician
5. The reduction in diagnostic and treatment costs

The Dental Industry's Adoption of AI

Although a little slower than the healthcare system overall to realize some of the advantages of AI, the dental industry is now applying AI to multiple areas[5], from the identification of normal and abnormal structures and diagnosis of diseases and prediction of treatment outcomes to dental education. Before providing more information on these areas, it's important to understand the two primary types of AI employed by the dental profession: artificial neural networks (ANNs) and convolutional neural networks (CNNs).

ANNs are patterned after neural networks in the brain and can recognize patterns within data sets. In dentistry, they can perform helpful actions such as determining the precise length and anatomy of teeth. Facial recognition, weather prediction, and speech-to-text processing systems use this technology, too.

Conversely, CNNs work by analyzing visual images, making them highly suited for dental radiology. For example, CNN technology can quickly and precisely locate tooth caries in X-rays and other scans.

AI can be used to perform administrative tasks for dentists and their team members, including booking and coordinating regular appointments and assisting with the clinical diagnosis and treatment planning. And it can accomplish these tasks with greater precision, less staffing, and fewer errors[6] than human counterparts.

As noted in the Journal of Dental Research[7], the virtual component of AI, known as software-type algorithms, is the main component used in dentistry. Why? Because they're expected to improve the accuracy and efficacy of dental diagnosis, provide visualized anatomic guidance for treatment, simulate and evaluate prospective results, and project the occurrence and prognosis of oral diseases.

Benefits of Utilizing AI in Dentistry

Given its power to enhance the clinical, operational, and financial aspects of a dental practice, AI offers a myriad of advantages for both dental providers and their patients. For example, studies have illustrated[8] the accuracy of AI in dental analysis to reliably recognize a wide range of dental conditions, thereby helping to improve dental care by reducing the chance that issues are missed or misdiagnosed. Thus, it's been applied in various dental specialties to provide value-based care and predict and prevent the incidence of dental complications.

AI ADVANTAGES FOR DENTISTS	AI ADVANTAGES FOR PATIENTS
Performance of routine tasks in less time	Increased quality of care
Standardization of procedures	More face-to-face time with their dentist
Improved diagnostic accuracy	Lower dental care costs
More efficient administration	Quicker service
Facilitation of improved workflow	Improved oral health outcomes
Improved infection control	More precise care
Elimination of numerous task steps	Increased availability of advanced treatment plans

Use Cases in AI Dentistry

6 AI Applications to Improve Diagnostic Accuracy and Patient Outcomes

AI IN RADIOLOGY

Experienced clinicians identify dental caries by visual inspection, tactile exam and years of experience. However, one study[9] showed dentists and CNNs the same 8,000 radiographic images and found that dentists only agreed on the presence of decay in roughly four percent of cases. CNN technology proved far more accurate at identifying the existence of dental caries.

The study reminds us that radiographic scans leave room for interpretation, and that's where AI shines through its ability to analyze with higher accuracy based on "studying" millions of images. That doesn't mean we should abandon our clinical exams, but a CNN algorithm could help us confirm our findings.

CNNs also show potential for detecting periodontally compromised teeth by capturing patterns from photothermal coherence tomography (PCT) images and performing edge detection. This technology can be valuable in tracking the progression of the disease or catching early bone loss.

Because radiographic analysis is an area of great potential for AI in dentistry, applications and research in AI purposes in dental radiology focus on automated localization of cephalometric landmarks, diagnosis of osteoporosis, classification of maxillofacial cysts and/or tumors, and identification of periodontitis/periapical disease. AI can analyze a panoramic X-ray, segment the teeth into individual images and number the teeth. It can even be used to identify missing teeth and identify common pathologies and restorations in the image and populate it into a dental practice's practice management solution in the clinical charting screen.

Dentists can even benefit from the use of AI — deep learning specifically — to diagnose oral cancer. Along with clinical data, AI provides them with the ability to view hyperspectral, photographic and other types of medical images. For oral cancer diagnosis and prognosis, CNNs with hyperspectral images as input were used, reaching an accuracy of 91.4 percent[10] in the classification of images.

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AI IN ENDODONTICS

CNNs and ANNs can help endodontists get to the 'root' of the issue. Cone-beam computed tomography (CBCT) imaging helps reveal hidden lesions and bone morphology not detected on flat images, but **AI software elevates those capabilities and can analyze a radiographic image to determine:**

- Structure and anatomy
- Tissue viability
- Precise measurements
- Predictability of treatment success

Deep learning algorithms can help us discover fissures or lesions around the tooth and detect and classify variations from normal anatomy. Many dentists have used apex locators to estimate root length for years, but ANNs can precisely locate the apical foramen for optimal treatment outcomes.

Other ways AI is being used[11] by some dental professionals, including researchers, include:

1. Location of minor apical foramen in cadavers
2. Characterization of gene expression of radicular cyst and periapical granuloma
3. Detection of vertical root fractures in intact and endodontically treated teeth
4. Evaluation of periapical lesions (bone repair) after treatment
5. Assessment of root morphology on radiographs

AI IN ORAL PATHOLOGY

Patients face a better prognosis with the early diagnosis of oral lesions. AI-powered software boosts dental professionals' capabilities by detecting tumoral tissues on radiographs and live tissue samples. Today's CNNs can diagnose cancer lesions[12] with 80-83 percent accuracy, a range almost perfectly rivals that of sampled specialists who achieved around 83 percent.

In a similar study[13], a CNN algorithm competed against specialists in diagnosing two tumors. The results in accuracy were a close match: the algorithm's accuracy was 81.8 and 83.3 percent, while the specialists were 81.1 and 83.2 percent.

The automated algorithms of AI excel by increasing the speed of diagnosis. The specialists took 23 minutes to detect the average tumor, but the CNN algorithm was able to detect it in 38 seconds. These results show that AI programs have the potential to drastically boost speed and efficiency in dental practices with consistent results.

Although this use of technology still needs refinement, there's massive potential for AI to help dentists better detect oral cancer and ultimately save lives.

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AI IN ORTHODONTICS

Orthodontists aren't excluded from the AI movement. In fact, AI software can help optimize treatment outcomes. In the most common application, ANNs offer the perfect technology for determining if a tooth extraction is necessary by analyzing space with various alignment scenarios. ANNs can also compute the best routes for teeth to reach optimal destinations.

Essentially, AI can help dentists move teeth into the right place with less trial and error. These more precise measurements and analytics lead to better final results and higher patient satisfaction.

Some dentists use AI-powered computer vision to diagnose bone pathologies and analyze bone density to help determine projected tooth movement. This technology also can diagnose osteoarthritis in temporomandibular disorders by deciphering condylar changes. Conventional TMJ imaging cases can be challenging to analyze, but AI brings more insights to clinicians for more effective interventions.

Other ways AI could be used[11] in orthodontics include:

1. Automated identification of cephalometric landmarks
2. Prediction of growth and mandibular morphology in class I, II, and III patients
3. Analysis of biological markers for orthodontic tooth movement
4. Understanding of aetiopathogenesis of craniofacial diseases
5. Automated identification of craniofacial syndromes
6. Prediction of treatment and outcomes models
7. Genetic risk assessment of orofacial cleft
8. Identification of epigenetic changes in the normal and abnormal craniofacial development

AI IN PERIODONTICS

ANNs continue to contribute to successful applications in dentistry, for categorizing patients into aggressive (AgP) and/or chronic periodontitis (CP) based on their immune response profile. Previously, various non-surgical and surgical methods have been developed for the treatment of periodontally-compromised teeth (PCT) and supporting structures, but not many strides were made in diagnosing and predicting the prognosis of PCT.

A study published by the Canadian Dental Association[5] outlined how an ANN was used to distinguish between AgP and CP in patients by using immunologic parameters, such as leukocytes, interleukins, and Immunoglobulin G (IgG) antibody titers. This ANN was 90–98 percent accurate in classifying patients as AgP or CP, and the best overall prediction was made by an ANN that included monocyte, eosinophil, neutrophil counts and CD4+/CD8+ T-cell ratio as inputs. The study authors therefore concluded that ANNs can be employed for accurate diagnosis of AgP or CP using relatively simple and conveniently obtained parameters, such as leukocyte counts in peripheral blood.

AI IN RESTORATIVE DENTISTRY

As in other areas, AI has been employed in restorative dentistry to suggest and detect the presence of dental caries. It also can be used to facilitate the choice of caries excavation method, detect and classify dental restorations, and even more precisely fit prostheses for patients. Because they're a less error-prone and time-consuming method of casting a dental prosthesis, AI-based solutions are being used to design inlays, onlays, crowns, and bridges.

Yet another benefit of AI for restorative dentistry is that such models have the potential[14] to provide a powerful tool for assisting in the diagnosis of vertical tooth fracture, detecting the tooth preparation margin, and predicting restoration failure. For color matching, AI technology provides a more accurate color matching of dental restorations.

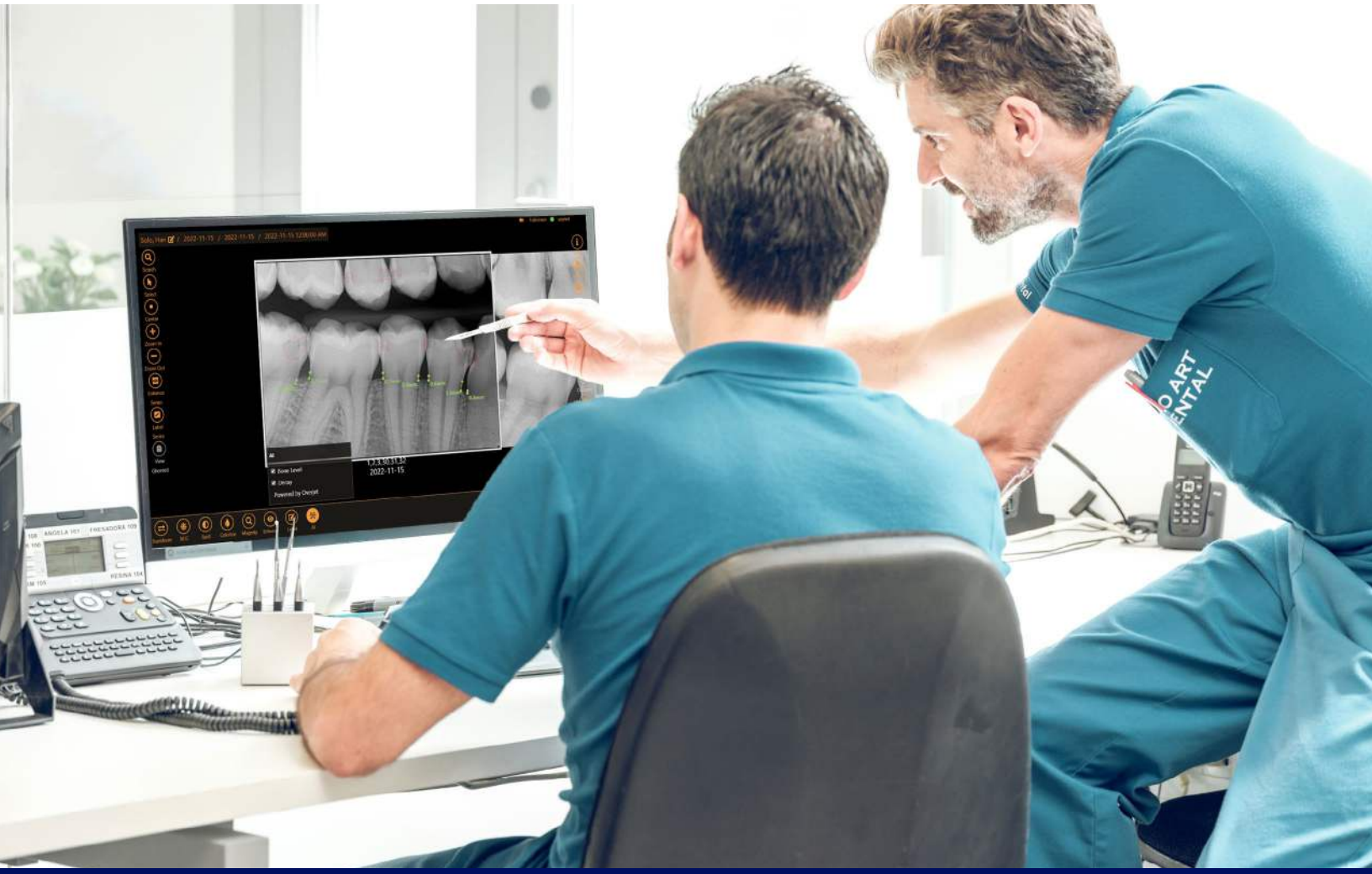
Other studies[11] show promising AI use cases in periodontics:

1. Classification and control of dental plaque
2. Segmentation of gingival diseases
3. Automated evaluation of periodontal pockets
4. Detection of malodor

The Future of AI in the Field of Dentistry

Additional applications of AI in dentistry continue to be developed, leading to patient care that is even more personalized, predictive, and preventive. The more "Big Data" available from a variety of sources, the more this information can be adopted into AI solutions for tasks such as dental diagnostics and research, treatment planning, records management, and more.

In the coming few years, AI-based technology in dentistry will likely become more commonplace in dental imaging and practice management solutions. However they're applied, the focus should be on augmenting existing digital dental technologies and streamlining provider workflow, resulting in continued benefits for both dental staff and their patients.



AI with Apteryx Cloud-Based Imaging Software

With advanced AI capabilities, practices can streamline workflows, increase case acceptance by up to 21%, and increase production by up to 18% through better provider-patient relationships.

As the leader in dental imaging, Apteryx continues to bring new innovations through its software.

With a subscription to Apteryx, reduce your reliance on servers, access X-rays from anywhere, and enjoy automatic updates and unlimited support for your team. Ask about how our cloud-based imaging solution combined with AI technology can give your patients more transparency and confidence in diagnosis and treatment planning.

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