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ORIGINAL

Application of Machine Learning in Dentistry

Aplicación del aprendizaje automático en odontología

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ABSTRACT

One of the key components of artificial intelligence, machine learning is used in many processes, including analysis, modeling, and forecasting, and it spans many industries. In addition to physical sectors such as manufacturing, human-centric sectors (such as medicine) are already continuing to expand the application of artificial intelligence and adapt to the digitalization environment. One of the primary medical subspecialties, dentistry, is a relatively new industry that heavily utilizes artificial intelligence and its potential. However, the field of dentistry is also expanding its use of AI and machine learning as their potential grows.
The use of machine learning in dentistry is examined in this article. Furthermore, the use of machine learning and artificial intelligence in healthcare was also discussed.

Keywords: Healthcare; Dentistry; Diagnostics; Machine Learning; Artificial Intelligence.

RESUMEN

Uno de los componentes clave de la inteligencia artificial, el aprendizaje automático, se utiliza en muchos procesos, incluidos el análisis, el modelado y la previsión, y abarca muchas industrias. Además de los sectores físicos como la fabricación, los sectores centrados en el ser humano (como la medicina) ya siguen ampliando la aplicación de la inteligencia artificial y adaptándose al entorno de la digitalización. Una de las principales subespecialidades médicas, la odontología, es una industria relativamente nueva que utiliza en gran medida la inteligencia artificial y su potencial. Sin embargo, el campo de la odontología también está ampliando su uso de la IA y el aprendizaje automático a medida que crece su potencial.
En este artículo se examina el uso del aprendizaje automático en odontología. Además, también se discutió el uso del aprendizaje automático y la inteligencia artificial en la atención médica.

Palabras clave: Atención Médica; Odontología; Diagnóstico; Aprendizaje Automático; Inteligencia Artificial.

INTRODUCTION

The fields of application of Artificial Intelligence differ from each other, being mainly industrial or human-centered. Artificial intelligence, which was initially applied in production areas, has proven itself and has already started to be applied in human-centered areas as well. One of them is the medical sector.

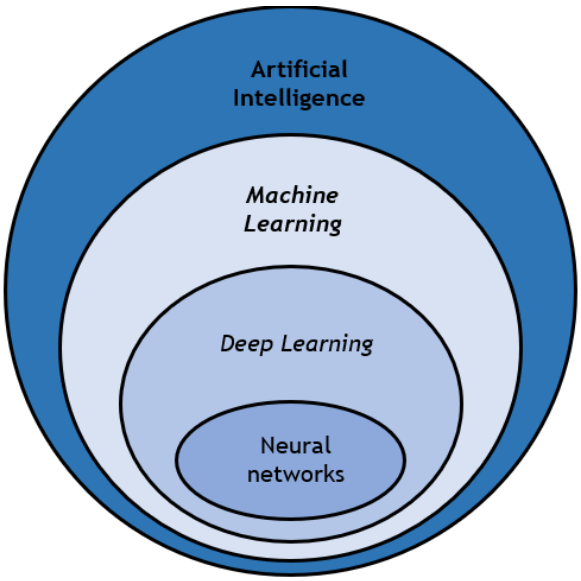


Figure 1. Relationships among AI, ML, DL and NN

As the figure illustrates, machine learning, deep learning, and neural networks are the three primary components of artificial intelligence. These 3 components complement each other and artificial intelligence. And it gets more and more specific and down to the finer details. So, if Artificial Intelligence is a larger concept, neural networks take on a more specific case, containing more different details.[1,2,3]

Each of these is used in medicine in different forms for different purposes. Modern services are offered by modern healthcare. Many of these services use technology to be implemented. in particular with smart technologies. The modern services provided by healthcare include robotic medical assistants - patient caregivers, implementation of virtual operations with AR and VR technologies, telemedicine services, analysis of diagnoses, analysis of treatments, creation of common treatment methods with the analysis of successful treatments and their application on other patients, and with the help of this the possibility of faster recovery of other patients occurs.[4,5,6]

Healthcare has benefited greatly from artificial intelligence technology and its related fields, including computer vision, big data, blockchain, RPA, virtual and augmented reality, and the Internet of Things. Along with their incorporation into healthcare, a variety of digital technologies and tailored medical services have emerged in the medical area.[7,8,9]

The field of diagnostic imaging in healthcare is undergoing significant change due to artificial intelligence (AI).[10,11,12] This technology is a major advancement in the interpretation and application of medical images, including X-rays, MRIs, and CT scans, by combining advanced algorithms and machine learning. AI enhances the precision and effectiveness of disease diagnosis, which is a fundamentally different function of AI in diagnostic imaging than simply automating processes.[12,13,14] ML can assist with workflow management, decision-making, and the timely and economical automation of tasks. Convolutional Neural Networks (CNN) and data mining techniques are used in deep learning layers to help find patterns in the data. In large datasets, these are very useful for finding underlying disease detection patterns. These tools are highly applicable in healthcare systems to diagnose, predict or classify diseases.[15,16]

Machine Learning is applied in various medical fields, which have been briefly mentioned above. One of these areas is dentistry.

Today, dentistry continues to evolve and adapt to the new digital environment. In particular, the development and integration of artificial intelligence is also evident in this field.

The era of digitization in dentistry

Dentistry is rapidly embracing digital technology and modernizing. Making dental models, taking dental impressions, and putting together dental laboratory prostheses used to take a long time. However, the advent of intraoral scanning, digital radiography, Computer-Aided design (CAD)/Computer-Aided manufacturing (CAM), 3D printers, and artificial intelligence (AI) software revolutionized dentistry as we know it today.[17,18,19]

Digital dentistry also makes extensive use of other imaging methods, such as facial scanning, cone beam computed tomography (CBCT), and even digital camera photography. After the image is acquired, software must be used to create the dental restoration or appliance based on the “digital models” obtained from the image acquisition.[20,21]

The most important tool in the era of digitization in dentistry is Artificial Intelligence. Artificial intelligence-based robots, technologies, algorithms allow this field to adapt and develop to the digital environment. In

general, artificial intelligence is primarily involved in the digitalization of all stages in dentistry as well as in medicine.

The table below provides a description of the primary features and applications of artificial intelligence in dentistry.

Table 1. Integrating Artificial Intelligence and dentistry

Integrating Artificial Intelligence and dentistry			
Diagnostics			
X-ray images	Machine Learning and Deep Learning algorithms	3D analysis, Image analysis, data analysis, patient history analysis, etc.	Caries diagnostics, oral cancer diagnostics, etc.
Decision making			
Review of results	Selection of alternatives	Choosing the optimal solution	Decision support systems
Treatment planning			
Orthodontics		Implantation	
Prediction			
Dental problems		Oral diseases	

In addition, artificial intelligence is applied to management, RPA, virtual assistants, and will also influence the development of telestomatology in the future.

Teledentistry - Although the field of dentistry requires especially physical treatment, this may partially change in the future. So, it will be possible to plan the treatment, monitor the patient, and initially apply consultations remotely, in other words, by applying telemedicine (artificial intelligence) to dentistry.

Machine Learning and Dentistry

Machine Learning – Like AI, it is modeled on humans, focuses on using data and algorithms to mimic the way humans learn, and gradually improves its accuracy.[22,23,24] Like Artificial Intelligence, machine learning is being applied for a number of purposes in medicine as well as dentistry (figure 2).

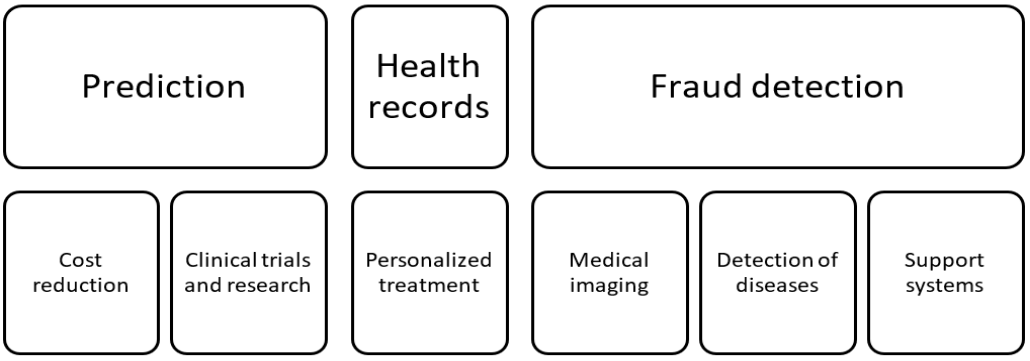


Figure 2. Application areas of Machine Learning in healthcare (dentistry)

Predicting diseases is another application for machine learning algorithms. Supervised machine learning algorithms are typically included in this. Any prediction uses these tools. Here are a few of them:

Linear regression

Usually used to forecast future events, linear regression analyzes the relationship between a dependent variable and one or more independent variables. It is referred to as simple linear regression when there is just one independent variable and one dependent variable. As the number of independent variables increases, this is called multiple linear regression.[25]

Logistic regression

Logistic regression can be thought of as an extension of ordinary regression and can only model a binary variable that usually represents the occurrence or non-occurrence of an event. A new sample's likelihood of belonging to a particular class can be determined with the aid of LR. The probability causes the result to fall between 0 and 1. Therefore, in order to use LR as a binary classifier, it is necessary to set a threshold to distinguish two classes.[26,27]

Support vector machine

Support vector machine are supervised learning machines based on statistical learning theory that can be used for pattern recognition and regression.[28] Numerous applications, including face and handwriting analysis, are also employed, particularly for regression-based and pattern classification applications. The basis of Support Vector Machines (SVM) was developed by a study and gained popularity due to many promising features such as better empirical performance.[29]

Decision tree

Decision tree, one of the supervised learning algorithms, is mainly designed for solving regression and classification tasks. The structure is composed of nodes and a body in a hierarchical fashion. By breaking up data sets into smaller pieces, a decision tree can be trained. In summary, it is an algorithm that incorporates the classification concept.

Random forest

A notable variation on bagging is random forests (Breiman, 2001), which creates a sizable collection of correlated trees and then averages them. Random forests are easier to train and tune, and they perform very similarly to boosting in many problems. As a result, random forests are popular and implemented in various packages.[30]

Naive Bayes

One of the supervised learning algorithms, Naive Bayes classifier is a probabilistic classifier based on Bayes theorem with independent assumptions. Despite the simplifying assumptions, the Naive Bayes classifier performs better than expected in real-world situations.[31]

K-nearest neighbor

The K-NN algorithm is particularly dominant in classification applications due to its advantages such as no training, easy to implement, analytically tractable, adaptive to local data, suitable for parallel execution, and robust to noisy training data.[32,33]

Artificial neural network

Artificial neural networks, which form the basis of Deep Learning, are also used for prediction. An algorithmic example that mimics the neurons in the human brain.

Clinicians can use machine learning (ML) to store and analyze patient data and medical knowledge that is updated on a regular basis. In addition to reducing human error, machine learning algorithms are skilled at identifying patterns in patient diagnostic data, enhancing current medical care, developing new medications, and precision medicine. To use dental and medical data for ML training, one must be very careful with its complex, sensitive and limited evaluation methods.[34,35] The integrity of dental and medical data from electronic records is usually low. Information is often not distributed systematically.[36]

In dentistry, ML is applied in various fields:

- Periodontal disease and tooth decay detection.
- The detection of oral cancer.
- Identification and diagnosis of dental caries.
- Endodontics.
- Arranging orthodontic procedures.

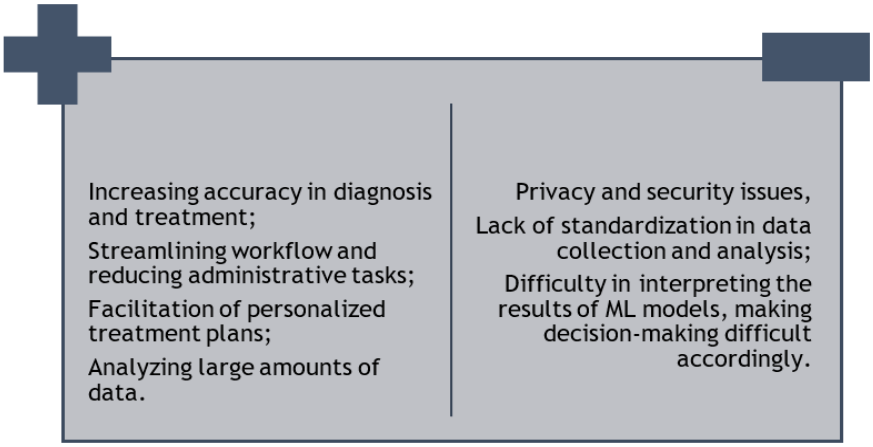


Figure 3. Advantages and disadvantages of Machine Learning in Dentistry

In these cases, ML works together with Computer Vision.

Advantages and disadvantages of Machine Learning in Dentistry include:[37] figure 3.

Diagnostic check with machine learning

Let's take a look at the sample images below.

Figure 4. Patient's teeth in x-ray format

The picture shows an image of a patient's teeth in x-ray format. It is possible to perform various operations on this image with Machine Learning algorithms.

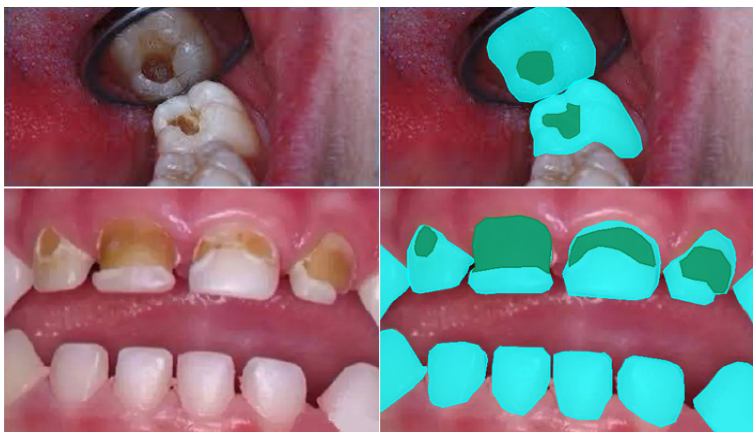
Figure 5. Segmentation of the same image obtained with the machine learning algorithm

In this image, the segmentation of the same image was obtained with the machine learning algorithm.

So, with the help of this, artificial intelligence technology can learn the problem in the teeth. For this purpose, the training and testing phase is carried out.

When working with Machine Learning, a black-and-white or grayscale representation of an image is basically obtained. Later, contour lines and features are extracted.

Or as in the other description. The image below shows the appearance of caries on the tooth.



Source: examples taken from https://datasetninja.com/ and https://www.kaggle.com/.

Figure 6. Caries on the tooth

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CONCLUSIONS

Along with the application of computer technology to dentistry, this field also began to adapt to digitization. Currently, the integration and development of intelligent systems, such as artificial intelligence, continues in this field.

Neural networks, deep learning, machine learning, and artificial intelligence are being incorporated into human-centric domains and are still used in various medical stages, including diagnostics. One of these fields, dentistry, is part of the ongoing integration.

Machine Learning is applied in this field for various purposes. This includes identifying and diagnosing dental caries, detecting oral cancer, and detecting tooth decay and periodontal diseases. Consequently, the benefits and drawbacks of using machine learning are also disclosed.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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