Review Article

Artificial Intelligence and Its Application in the Early Detection of Oral Cancers

Abstract

Dentistry has transformed, and digitization in Dentistry is now possible through Artificial Intelligence. Artificial Intelligence is an emerging field of technology, which simulate human intelligence in machines that are programmed to think like humans and mimic our actions. Although in the recent past several articles have highlighted the applications of Artificial Intelligence in screening and detecting oral cancers, less is known about how the technology helps in that aspect. In high-risk countries like India, Pakistan, Sri Lanka, Bangladesh, etc. oral cancer is the most common cancer in men, with up to 25% of all new cases. Early diagnosis of oral cancer is necessary since most patients report late and are diagnosed at a late stage of the disease, leading to a poor prognosis. Artificial intelligence can help in the early detection of oral cancer, thus helping in early diagnosis and possible help in the prediction of the prognosis of the disease. This article focuses on the lesser-known side of Artificial Intelligence, its role in the early detection of oral cancers, and how it actually can be put to use for the benefit of the dental profession and society at large. The concept of Artificial Intelligence is explained in this operative technique article with the help of the technology provider through unique diagrams for ease of understanding.

Keywords: *Artificial intelligence, Oral cancer, Early detection, Dentistry*

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Introduction

The entire world is in the midst of a "Digital Transformation" revolution. Real-world applications and computer systems have moved from digitization to digitalization and now to digital transformation. While Digitisation involved converting all the data stored in physical/hard form (eg. patient data stored as information in ledgers, registers, files, folders, and or films) to soft form through scanning and other modalities, digitalization involved leveraging the digital data for process improvement (eg. storing patient data on the cloud for easy retrieval (individually or simultaneously) by multiple users located at different areas/locations). Digital Transformation on the other hand aims at transforming the whole system using digital technologies to improve efficiency, manage risks and improve monetization all with very limited human input. All this has become a reality with the help of Artificial intelligence.

A much-talked-about and sought-after breakthrough in the field of technology is Artificial Intelligence (AI). Every field has applied AI in several ways and so the field of dental science is no exception. The field of Dentistry is also going through a transformation with AI through digitization. Although much focus has been on the applications of AI in the various specialties of Dentistry in recent times.[1-5] This mini-review focuses on the lesser-known side of Artificial Intelligence, its role in the early detection of oral cancers, and how it actually can be put to use for the benefit of the dental profession and society.

What is artificial intelligence?

Artificial intelligence (AI) is an emerging field of technology, which simulate human intelligence in machines that are programmed to think like humans and mimic our actions.[1-6] AI has numerous subfields with applications in diverse areas and domains **(Figure 1)**, various additional prominent constructs of AI are machine learning (ML), artificial neural networks (ANNs), convolutional neural networks (CNNs), and deep learning (DL).[5,7]

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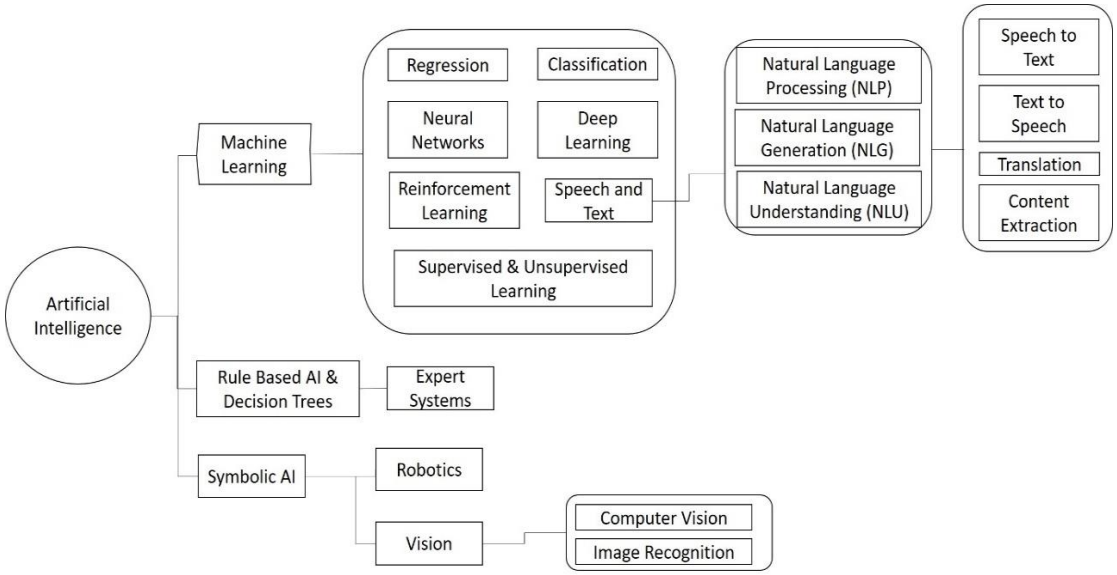

Figure 1. Subfields of Artificial Intelligence (AI)

ANNs try to simulate/model the networks formed by the neurons in human brains thereby trying to create computer algorithms that can self-learn and make intelligent decisions akin to human beings. The basic building block of ANNs are neurons, several of which are arranged in different layers to form the ANN. ANNs in their simplest form are made of three basic layers namely an input layer, an output layer, and a hidden layer.[5] This layered approach is also modeled on the layered processing approach that is evident from studies on the functioning of the human brain. Each neuron in a layer is interconnected (associated) with all other neurons of the next/subsequent layer and each piece of information processed results in an immense amount of computation load due to this interconnectivity.[5]

The CNN is a type of ANN, which has been developed to surmount this problem. The significant difference between the ANN and CNN is that in CNN, only the last layer of a neuron is completely associated thereby reducing the number of computations required for processing information along with increasing the computational efficiency of the entire system. CNN is particularly considered effective while working with image data and have established widespread applications in the area of computer vision and digital image processing in object identification and classification. CNN is designed to act as an effective pattern recognition filter. The CNN is easy to train, if an adequate amount of image data is available, easy to deploy, and provides results in real-time. This deep learning tool would be of great help to identify and classify various types of cancers from image/video data from intraoral photography.

Machine learning (ML) is a part of the broader field denoted by AI **(Figure 2)**, and it facilitates computers to act without being explicitly programmed. Thus ML, using the constructs of neural networks and deep learning, makes it possible for a computer system to solve various issues without explicit human help/input. [7,8] Dentistry has transformed, digitization in Dentistry is now possible through AI, and Machine Learning (ML) is now fast becoming an emerging topic in dentistry.[6-8]

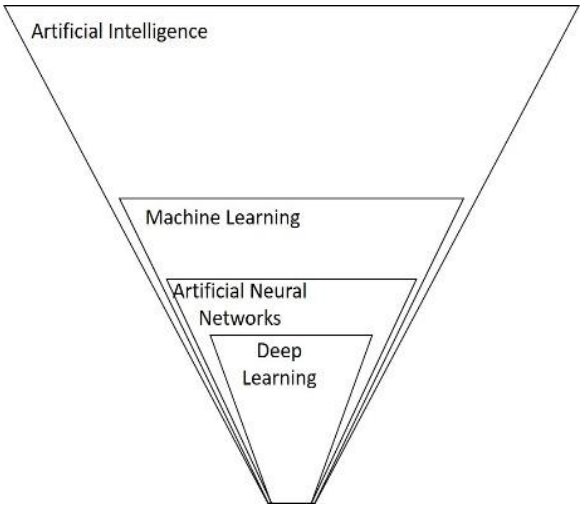

Figure 2. AI constructs and their relationship

Early detection of oral cancer through AI

Dental diseases (Oral Cancer) are found to be a major public health concern worldwide. The survival rate of the early-stage disease (Stage I) is around 80%, and unfortunately for the late-stage disease (Stage II and III), it is less than 20%.[9-13] Among OC, oral squamous cell carcinoma (OSCC) of the oral cavity is the most common type and comprises 90% of the disease.[9-13] Early diagnosis of OC is necessary since most patients report late and are diagnosed at a late stage of the disease, leading to a poor prognosis. AI, especially Deep Learning applied to intraoral photographs, can help in the early detection of OC, thus helping in early diagnosis and possible help in the prediction of the prognosis of the disease.[14-19]

In high-risk countries like India, Pakistan, Sri Lanka, Bangladesh, etc. Oral cancer is the most common cancer in

men, with up to 25% of all new cases.[9,13] Currently, a specialist Dentist predicts the likelihood of pre-cancerous changes in an oral cavity developing into oral cancer by assessing a biopsy on 15 different criteria to establish a score. This score decides the treatment plan. However, this score is subjective, and often variations exist in how patients with similar biopsy results are treated. The application of AI can lessen the challenges in the disease diagnosis, as well as aid in predicting the prognosis of oral cancers thus helping to tailor patient-specific treatment approaches which might have the potential of being more effective than traditional approaches.

The development of an AI for a particular application starts with the design of the neural network architecture. Once the architecture has been finalized then the network is ready to undergo the training process, which is effectively the learning phase for the AI system. There are three popular methods of learning employed for AI systems namely supervised learning, unsupervised learning, and reinforcement learning. The dataset might come from various sources including the data from patients or data from hospital records (which is retrospective by nature). The dataset is divided into three distinct classes, namely training data, validation data, and testing data **(Figure 3)**. The training data is used to train the AI model which means tuning the ANN parameters. The model is then presented with the validation dataset and the hyper parameters are trained based on the results obtained. This dataset is not used for training but for evaluating a model after each training run. Once the desired accuracy is obtained the model is presented with the test dataset which provides the ultimate accuracy that can be expected from the new model. The difference between the test and validation datasets is that the test dataset is only run once while the validation dataset may be run many times. Various studies have been done in recent times that describe the prognostic factors of OC detected through AI by using several biomarkers. Early diagnosis of the malignant lesion is good for patient survival rate and proper treatment therapy.[20,21]

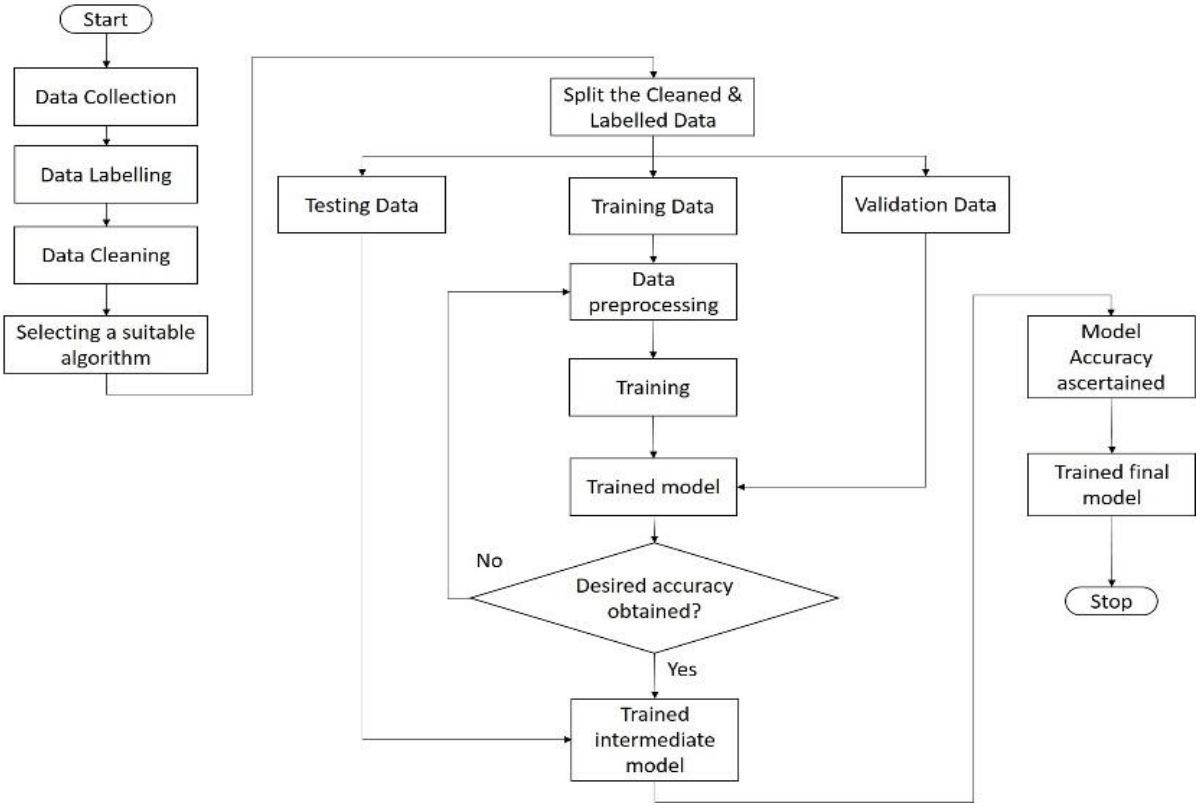

Figure 3. Supervised Learning methodology for AI

Many studies have been conducted using image analysis to smartphone-based OC detectors, based on AI algorithms.[22-24] A general architecture of the smartphone-based OC detection is shown in **Figure 4**. The AI technology reduces workload, complex data, and fatigue among dentists for easy diagnosis. Machine learning and AI can aid in diagnostics (if biopsy samples are taken at an early stage) by removing subjectivity and using automation and quantification to guide diagnosis and treatment. Late diagnosis and high death rates of cancer are a challenge. AI has more advantages over existing techniques for detecting OC. As AI gets information from new patients, it can merge this information to reduce the burden of treatment and cost for patients.[5, 22-24]

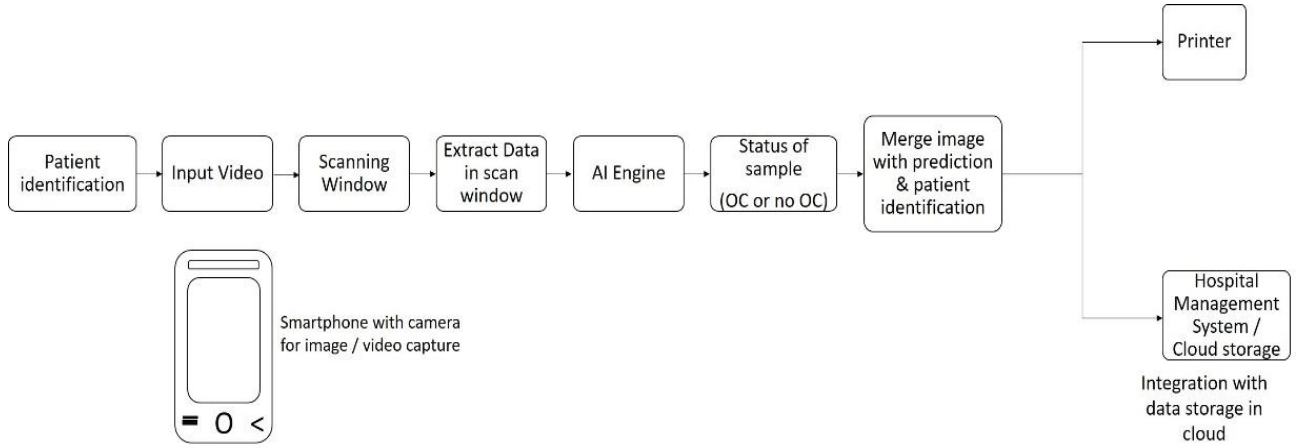

Figure 4. Smartphone-based AI system for detecting oral cancer (OC)

A recent systematic review by García-Pola, M[25] compiles 36 studies conducted in different parts of the world that applies AI to detect Oral Cancer based on images (photographs (optical imaging and enhancement technology, and cytology. Many studies mentioned in this systematic review were heterogeneous. Each article mentioned in the review involved a different algorithm with potential training data bias and few comparative data for AI interpretation. The authors concluded that Artificial intelligence may help in predicting the development of oral cancer.

Another systematic review by Alabi RO *et al*.[26] outlines 34 studies that have used ML to analyze imaging and radiomics and to develop models that have the potential to assist clinicians to make informed and guided decisions that can assist to improve oral cancer-related patient outcomes. The majority of the studies mentioned in this review used a convolutional neural network (CNN). This review showed that a range of imaging modalities such as computed tomography images and spectra data have significant applicability to improve OSCC outcomes. In this review, the average specificity, sensitivity, area under receiving operating characteristics curve (AUC), and accuracy for studies that used spectra data were 0.97, 0.99, 0.96, and 96.6%, respectively when compared to the corresponding average values for these parameters for computed tomography images were 0.84, 0.81, 0.967, and 81.8%.

Artificial intelligence approaches combined with imaging can have a considerable impact on oral cancer outcomes and the quality of life of the patient community if oral cancer can be detected early or predicted based on demographic details. With applications like low-cost screening using smartphone-based probes, the use of combined imaging and artificial intelligence approaches can improve oral cancer outcomes through improved detection and diagnosis.[27-30]

Advantages of using AI in dentistry

Machine Learning and AI aid the dentist to help with his diagnosis. This type of collaborative architecture between a human caregiver and an assistive AI has the following advantages:

1. The AI algorithm combines knowledge from a multitude of data sources and experiences from many experts which will be definitively more than any person's experience.
2. There is the possibility of a quicker diagnosis.
3. The disease prognosis can be predicted and visualized. Additional work in modeling could help in devising a patient-specific treatment plan and even individual medicine dosages can be decided based on various parameters like ethnography, genetics, demography, sex, age, and various other relevant parameters. This has the potential to bring about a better treatment outcome.
4. Systems designed to have self-learning will help keep the AI updated and probably its accuracy and efficiency could improve over time as more data is collected and used.
5. The AI system holds the promise of benefiting all the stakeholders like -
   Patients: early detection will result in the early start of treatment and reduction in mortality),
   Dentists: reduces the load of diagnostics, makes diagnosis quicker and more effective and the AI system also helps in visualizing disease prognosis. This would help in devising individual treatment plans that promise to optimize medication and improve health and quality of life.
   Society: Social health can be improved with more people being treated in a particular period as compared with the number of people being treated using the traditional approach (we can cite our paper here) as there would generally be a reduction in diagnosis time. Even dental practitioners who are new/inexperienced can also provide effective diagnosis and treatment at remote locations like tribal belts or possible remote disaster/accident sites.

Conclusion

AI is more accurate in diagnosing oral cancer as compared to conventional methods. Artificial intelligence (AI) may help Dentists better predict the risk of patients developing oral cancer by ensuring accuracy, consistency, and objectivity.

Retrospectively based hospital data on patients may also help in improving the AI-based diagnosis. Recent systematic reviews have shown that AI-based algorithms have accurate results in predicting OC occurrence. More studies using large data are needed to conduct AI-based algorithms to predict OC. Additionally, a multimodal fusion approach where information from different sources (image data, demographic data, genetic data, and the like) is fused and provided to the AI system would yield better accuracies than a system dependent on a single modality.

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Conflict of interest
None.

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None.

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