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Artificial Intelligence in Oral Cancer Detection: A Scooping Review of Advanced Dignostic Technique in the Detection of Oral Cancer

Ashvini Mali[1], S.A. Gaikwad[2], Mahesh Waghmare[3]

[11]M-Tech Student Dept. of Computer Science & Engineering College of Engg. Dharashiv
[2]Professor, Dept. of Computer Science & Engineering, College of Engg. *Dharashiv*
[3]Assi. Professor Dept.of Soil Science & Agricultural Chem. Govt. College of Agricuture, Dharashiv

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Abstract - *The prognosis of oral cancer has not significantly improved in recent years, presenting a persistent challenge in the biomedical field. In the field of oncology, artificial intelligence (AI) has seen rapid development, with notable successes being reported in recent times. The advancement of AI in oral cancer screening and detection requires a comprehensive and strategic approach. Technological integration, particularly with advanced imaging technologies and the amalgamation of multimodal data, ensures a more nuanced and precise analysis of oral lesions. The aim of the present study is to increase the evidence on the application of AI to the early diagnosis of oral cancer through a scoping review. Artificial intelligence may play an important role in precisely predicting the development of oral cancer, though several methodological issues need to be addressed in parallel to the advances in AI techniques, in order to allow large-scale transfer of the latter to population-based detection protocols.*

Key Words: Oral cancer, Artificial Intelligence, CNN etc...

1. INTRODUCTION

Oral cancer is a type of cancer that is defined as the uncontrollable proliferation of cells that invade and harm the surrounding tissue. Oral cancer is the type of cancer that ranks sixth in the world and is affecting globally. Oral cancer has a high incidence and fatality rate, making it a leading cancer killer. There were an expected 457,000 new instances of lip and oral cavity cancer in 2023, with almost 177,000 fatalities globally, as reported by the International Agency for Research on Cancer. Death rates from oral cancer have remained high over the previous few decades despite progress in oncology therapy. Most people diagnosed with oral cancer will not receive adequate care on time. Notably, they were leading to low survival rates in the countryside. Patients diagnosed with oral cancer have a 5-year survival rate of roughly 50%, albeit this varies by race and location.

In recent years, the integration of Artificial Intelligence (AI) into healthcare has emerged as a transformative force, promising enhanced accuracy, efficiency, and accessibility in disease detection. This scoping review explores the evolving landscape of AI applications in the detection of oral cancer, shedding light on modern diagnostic approaches and delineating future frontiers. By synthesizing current literature and insights, this review aims to provide a comprehensive overview of the state-of-theart technologies, their clinical implications, and the potential avenues for advancement in oral cancer detection. From computer-aided image analysis to novel biomarker detection platforms, the AI holds immense promise in revolutionizing the landscape of oral cancer diagnostics, paving the way for a future marked by precision, efficiency, and accessibility in healthcare delivery.

1.1 Emergence of AI in Medical Field

The first use of AI (artificial intelligence)-based systems in digitalized diagnostic pathology has shown that the diagnostic process and treatment plan can be improved when AI models work with pathologists to find abnormalities more accurately and better manage patients.There is evidence that deep learning models, especially neural network models, can help find oral cancer early. This makes AI a very useful tool for helping doctors get better at diagnosing and reducing mistakes made by humans when analyzing X-rays. A new method that uses feature extraction and a binary version of particle swarm optimization (BPSO) greatly improved the accuracy of classification and helped make sure that oral cancer diagnoses were made quickly and correctly

Over the years, researchers have focused on refining AI models for greater accuracy and reliability. This has led to the introduction of more sophisticated ML approaches that can interpret complex medical and dental data to aid in early detection, diagnose more accurately, and predict patient outcomes better. AI-powered tools can now offer a supplementary layer of analysis to traditional examinations, which is increasingly valuable in areas with limited access to specialist care.

One of the key technological advancements in dental AI and ML is the development of Convolutional Neural Networks (CNNs). These deep learning models are particularly well-suited for image recognition and have been repurposed for the analysis of medical and dental images. The ability of CNNs to learn from a large volume of data makes them effective for identifying patterns and anomalies in dental radiographs and visible light images indicative of oral cancer. In addition to CNNs, advances in digital imaging and the application of AI for real-time risk assessment have further elevated the potential for AI in oral cancer detection. Techniques such as computer-aided detection systems have been developed to assist in the analysis of oral lesions,

employing algorithms to help delineate suspicious areas from normal tissue.

1.2 Significance of CNNs in Image Analysis

CNNs are especially useful for computer vision tasks such as image recognition and classification because they are designed to learn the spatial hierarchies of features by capturing essential features in early layers and complex patterns in deeper layers. One of the most significant advantages of CNNs is their ability to perform automatic feature extraction or feature learning. This eliminates the need to extract features manually, historically a labor-intensive and complex process.

AI techniques, particularly CNN, excel in image analysis, analyzing dental radiographs, optical coherence tomography, and visible light images. These deep learning algorithms can detect anomalies indicative of oral cancer, classifying and segmenting images with greater accuracy than traditional methods. A range of studies have explored the use of AI in dental image analysis.

A method for automatic analysis using artificial immune systems, focusing on malocclusion detection, applied AI to classify panoramic radiographs, using a CNN and other image cognition algorithms provided a comprehensive review of AI methodologies in dental image analysis, including conventional ML and deep learning approaches tool pipeline for automated clinical quality evaluation of periapical dental X-ray images, achieving a high F1 score.

The study evaluated the performance of deep CNN algorithms for the classification and detection of Oral Potentially Malignant Disorders (OPMDs) and Oral Squamous Cell Carcinoma (OSCC) in oral photographic images, demonstrating high accuracy and potential as a diagnostic tool for assisting general practitioners in early cancer detection

1.3 Image Segmentation

Automatic segmentation of digitized histological images in regions that represent different types of tissues is of high importance in developing digital diagnosis, prognosis, and therapeutic tools. The segmentation technique is a computational procedure that processes digital images by grouping pixels with similar colorimetric properties in regions that probably represent objects of interest (for example, cells, vessels, and other structures in the tissue). These can then be characterized geometrically in order to obtain qualitative and quantitative information about the objects that they represent. The most commonly used soft-wares for applying this technique are ImageJ and FIJI, as we mentioned before, which are constantly developing new plugins and tools in order to achieve specific objectives; thresholding, StarDist, watershed transform, trainable WEKA segmentation, Labkit, among others, are some of the ones used, and also explained below, for image segmentation.

Pattern recognition techniques are other types of segmentation methods in which certain characteristics are selected, such as color, shape, and size, and afterward, results are clustered in regions that can correspond to histological classes. Algorithm-guided detection has proven to be a successful avenue for distinguishing between benign and malignant lesions, with a particular emphasis on crucial features such as oral lesion heterogeneity and margins, achieved remarkable accuracy, boasting a perfect 100% in diagnosing oral cancer through the implementation of textural pattern classification. Shed light on the substantial potential of CNN, demonstrating their efficacy in both clinical and histopathological image analysis.

The power of deep learning to automate the detection and classification of oral lesions, yielding consistently high F1 scores, In a distinct approach, an innovative method describing an approach for cancer detection and prevention based on analysis using association rule mining, unveiling promising results. These cumulative findings emphasize the pivotal role of AI in pattern recognition, making a substantive contribution to the early detection and diagnosis of oral cancer within the existing body of literature.

1.4 Predictive Modeling

Expanding the scope to oral cancer, predictive models in AI leverage patient data and historical outcomes to forecast the likelihood of oral cancer development, contributing signficantly to risk assessment provided a tangible example of success in the field of orthodontic treatment planning, achieving a commendable 84% accuracy rate through the application of ML predictive models. These models play a pivotal role in identifying individuals at higher risk who may benefit from more rigorous screening protocols. Incorporating extensive datasets encompassing demographic information, lifestyle factors, genetic predispositions, and clinical examination results predictive modeling in AI becomes a comprehensive tool.

1.5 Smartphone based probes with DL algorithms

In today's time smartphones are readily available which has a very user-friendly camera tool. The advancements in the pixel size and camera quality enable the operator to capture the digital images which are portable and transferrable. Smartphones having features of Bluetooth connectivity, simple touch screen interface and internet connectivity can be easily incorporated as a cancer screening device. Using smartphone data transfer capabilities, captured images can be uploaded to a central cloud server, where a panel of specialists from the fields of Oral Medicine & Oral Pathology can access these images and make appropriate diagnosis. Additionally, in-depth learning tools like Convolutional Neural Network (CNN) can be deployed in the cloud at the pre-processing phase which will be used for automated image analysis, fragmentation and differential diagnosis. Results from these investigations substantiated the efficacy of these systems in identifying cancerous

conditions within the oral cavity. A device designed to empower smartphones in the detection of oral cancer.
Building on this foundation, elevated the field through the development of a mobile-based image classification method and an Android application tailored for point-of-care oral cancer detection, boasting a commendable accuracy rate. Collectively, these studies showcase the considerable potential inherent in smartphonebased probes for enhancing the early detection of oral cancers.

1.6 Optical Coherence Tomography (OCT) with Machine learning & Deep learning

Optical coherence tomography (OCT) is one of the high-resolution imaging approaches being used in cancer screening. There are few drawbacks of this technology, being, difficulty in interpretation of the images, cost & size of the machine, operating software and user interfaces and requirement of a specialist. Principle of OCT image capturing is OCT image is basically a 2-D representation of a 3-D object through the virtue of optical reflection of a tissue sample which is very close to the histological resolution. The digital images can then be stacked up to provide a three-dimensional mapping of the lesion. The OCT images have the capacity to capture images at a depth of 2-3mm in oral tissues. The OCT makes use of a probe which can be kept close to the tissue surface to apprehend real time dynamic images of the epithelial and sub-epithelial surface.

To overcome the limitations of traditional OCT, DL-driven OCT prototype has been developed at only 10% of the total cost and has been successfully used at clinical setting. The prototype has been added with DL-algorithms so that end user don't find cumbersome to interpret the images. Recent study which made use of such a prototype revealed that DL- driven OCT was able to differentiate healthy lesions with that of lesions with dysplasia and frank malignancy with a sensitivity of 87% and specificity of 83%.

1.7 Machine Learning Application (CAD) in Oral Pathology

Computer-Assisted Diagnosis (CAD) can be very promising in the field of histopathology. In super specialty hospitals where there is excessive load on the histopathology tissue banks, CAD not only will reduce the subjective errors by pathologists, but it will also help in segmentation of area of interest, automated scoring of immune-staining, classifying & sub-classifying various features, automated cancer staging and detection of vascular invasion. Content Based Image Retrieval (CBIR) is based on such novel technology which using computerized algorithms compares & evaluates similar looking images to an image in question. In digital pathology, CBIR systems are very useful in numerous situations, especially in early diagnosis, for improved teaching methodologies, and for innovative research. ML methods can be used in discovering novel clinico-pathological relationships. In this digital world, when medical data like patient demographics, clinical history, genomic data, biomarkers, blood profile, digital pathological images, DICOM images of CT & MR are available online, using ML techniques will lead to new discoveries.

2. CONCLUSIONS

It is encouraging to see how AI is expanding its wings in various fields of dentistry especially in the field of oral cancer detection, prediction and outcome. Technological integration, particularly with advanced imaging technologies and the amalgamation of multimodal data, ensures a more nuanced and precise analysis of oral lesions. However, there will be requirement of pools of data to develop ML related techniques so that the devices which are made out of it are flawless. To interpret and analyze such a massive pool of data, it is impractical for an unaided human mind without computational assistance. One should also remember that AI cannot replace the job of an oral pathologist but on contrary will ease their job as they will be more equipped with tools of AI and DL which may lead to novel research ideas.

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