Analysis of Oral Cancer Detection based Segmentation and Classification using Deep Learning Algorithms

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Abstract

Oral cancer is deadly cancer which is majorly spread in less and middle-income countries. The early diagnosis of oral cancer may attained through automatic detection of cancerous and malignant mouth lesions. Various researches developed a Machine Learning (ML) method which detects oral cancer from images. Though, there still lack in huge precision in the detection of oral cancer. Recently, development of Artificial Intelligence (AI), Deep Learning (DL) algorithms effectively detects the oral cancer in early and maximizes a patient's survival rate. This survey analysis different DL algorithms such as Modified K-Means and Fuzzy C-means (modified KFCM), UNet depended Bayesian Deep Learning (BDL), Capsule network and CariesNet which was used for segmentation of oral cancer. Then, AlexNet, Enhanced Grasshopper Optimization Algorithm (EGOA) depended Deep Belief Network (DBN), Convolutional Neural Network (CNN) and Deep CNN was used for classification of oral cancer. The performance metrics used for evaluating the algorithms are Dice coefficient, Jaccard, Accuracy, Mean IoU, Precision, Weighted IoU, Specificity, Recall, Sensitivity, Error rate, F1-score and AUC.

Keywords: Artificial Intelligence, Convolutional Neural Network, Classification, Deep Learning, Oral Cancer and Segmentation

1. Introduction

Oral cancer is a major common deadly disease and takes huge a serious health issue around world. The late detection of oral cancer maximizes illness and a huge rate of death. Around semi of entire classes happen in south Asia and two-thirds of entire classes happen in less and middle-income countries [1]. Main general problem leads to oral cancer, high smoking and drinking. Survival rates are less due to two-thirds of human in less and middle-income countries that take oral lesion appeared in the final phase [2]. That is excessively for treating cancer, particularly in their phases. The late diagnosis led to integration of medical professional and patient avoidance around oral lesions [3]. The screening process concentrated much on diagnosis of Oral Potentially Malignant Disorders (OPMD) because of serious cancerous transformation, that several score in minimizing mortality and morbidity along oral malignant and their prevalence [4].

The main cancer rising along the sub categories are Squamous Cell Carcinoma (SCC) and predicted through clear mucosal lesions called OPDMs. The initial detection of Oral SCC minimizes cancer particular mortality and illness [5]. Though, despite enhancement in understanding in molecular algorithms within a pathogenesis of oral SCC and malignant modification of OPMD, main oral cancers continue identified in the final phase [6]. That is uncertain why oral cancer is frequently identified lately, then probable reasons included a public lack and awareness of professional, unfamiliar health professionals along variable and non-particular medical representation of oral SCC and reliable absence and practice of adjacent diagnosis methods [7]. Artificial Intelligence (AI) is referred to as utilizing

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machines for mimicking cognitive processes which huma associate along human mind like learning and resolving problems. The utilization of AI is to maximize attention in different areas of medicine.

The remaining section of survey is organized as: Section 2 summarizes a literature review of oral cancer detection. Section 3 explains briefly about the taxonomy. Section 4 stated the problem statement related to oral cancer and section 5 compared the advantages and disadvantages of existing algorithms. Finally, section 6 summarizes the survey of oral cancer.

2. Literature Review

The recent existing literatures in oral cancer detection using DL algorithms were discussed in this section with its advantages and drawbacks.

Pandia Rajan Jeyaraj *et al.* [8] implemented Deep Boltzmann Machine (DBM) and Support Vector Machine (SVM) fusion classification to learn and classify a previous, post cancer and normal tissue along hyperspectral images. Integrated pixel along background was predicted to detect cancer part. The outcome of patient hypercube was represented a validation of Deep Learning (DL) method for possibility of pixel-wise mapping of cancer and normal healthy tissue in hyperspectral images. The method reduces the overfitting, however, the SVM method was high computational cost.

Hadjouni Myriam *et al.* [9] presented Convolutional Neural Network (CNN) and Deep Belief Network (DBN) for detecting a oral cancer in medical images. The parameters of DBN and CNN were optimized by optimization algorithm that is introduced through hybridization of Particle Swarm Optimization (PSO) and AI-Biruni Earth Radius (BER) algorithms and was represented through PSOBER. The presented method able to detect oral cancer with high accuracy in medical images. However, the presented method suffered in numbering teeth in complex cases like high decayed teeth.

Kevin Chew Figueroa *et al.* [10] developed a Gradient-Weighted class activation map for inserting interpretability and explainability to CNN. In developed method, adopted two-phase training procedure along data augmentation methods and Guided Attention Inference Network (GAIN) for training images capture by customized oral screening systems. The GAIN structure has 3 streams of training network such as classification, attention mining and bounding box stream. Developed structure with attention maps provides complete and correct segmentation. However, the method has restricted dataset in size.

Mohanad A. Deif *et al.* [11] suggested a Computer-Aided Diagnosis (CAD) method for detecting oral cancer. The dataset has two classes like Oral Squamous Cell Carcinoma (OSCC) and Normal Epithelium Oral Cavity (NEOR) was utilized. The extraction of features were processed by DL methods such as VGG-16, ResNet-50, Inception V3 and AlexNet for realizing Artificial Intelligence of Medical Things (AIoMT). The features were selected by using Binary Particle Swarm Optimization (BPSO) and that was classified by using XGBoost. However, the suggested method minimizes the error in classifying and predicting the oral cancer.

Anum Fatima *et al.* [12] introduced a lightweight Mask Region based Convolutional Neural Network (Mask-RCNN) to detecting oral cancer. The introduced method has two stages such as lightweight modified MobileNet-V2 and Region based Network (RPN) were developed to localization of disease in little data. For calculating effecientness of introduced method was evaluated in custom annotated data has images of 5 various kinds lesions. The introduced method supported in processing pixelwise segmentation of visible light. However, the introduced method has computational complexity.

3. Taxonomy for Oral Cancer Detection

The taxonomy based oral cancer detection by using DL algorithms were discussed in this section. The taxonomy was described based on segmentation and classification methods used in detection of oral cancer. Figure 1 represents a taxonomy for oral cancer detection.

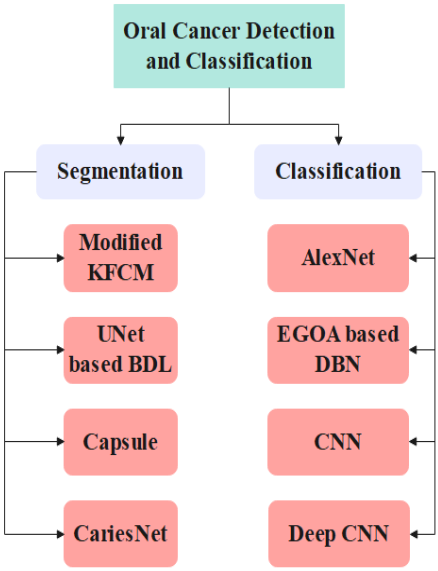

Figure 1 Taxonomy for Oral Cancer Detection

3.1 Segmentation

The existing methods used for oral cancer detection-based segmentation are Modified KFCM, UNet based BDL, Capsule Network and CariesNet which are described in this section.

Modified K-Means and Fuzzy C-means (modified KFCM)

Shilpa Harnale and Dr. Dhananjay Maktedar [13] presented a Modified K-Means and Fuzzy C-means (modified KFCM) method for segmenting oral cancer. The K-means method was utilized as clustering method for eliminating calibration time. The FCM method was utilized for minimizing a whole iteration produced through correct cluster initialization. Morphological process was utilized for excerpting an approximate field along FCM cluster and the lesion area was measured. The presented method maximized a precision of segmentation. However, the method suffered from computational complex and doesn't found a caries type.

UNet depended Bayesian Deep Learning (BDL)

Bofan Song *et al.* [14] suggested a UNet depended Bayesian Deep Learning (BDL) method for segmenting potential and malignant lesion fields in oral cavity. The method quantified indecision in the prediction. Additionally, implemented an efficient method which maximized speed of inference that was 6 times less and 2 times quicker than actual UNet. The dataset was gathered by platform of customized screening and was marked through specialist of oral oncology. Through eliminating uncertain pixels, the method produced much correct and reliable segmentation. However, The method provided low prediction of some areas.

Capsule Network

Santisudha Panigrahi *et al.* [15] implemented a Capsule network which was DL method to classify oral cancer. The dynamic routing and routing through capsule network made a much robust to rotate and transform

augmented oral dataset. The Otsu's thresholding method was used for segmentation of images based on color distribution of pixel values and it was utilized majorly because of effectiveness and simplicity. The capacity of network in handling poses, orientation and view made matchable in examination of oral cancer histopathological images in initial phase. The capsule network has superior ability to capture pose data and spatial relationship and effective favor among cancerous and non-cancerous images. However, method doesn't identified the caries kind to colored and X-ray images.

CariesNet

Haihua Zhu *et al.* [16] developed a CariesNet that was DL method for describing various degrees of caries from panoramic radiographs. Initially, gathered a huge quality panoramic radiograph data along 3127 caries lesions included shallow, moderate and deep caries. Next, develop CariesNet which was in U-shape network along addition whole scale axial attention module for segmenting 3 caries parts along oral panoramic images. The CariesNet produced effective process in segmenting slight lesions with huge X-ray images. However, dataset was sparse and various related metrics were not evaluated.

3.2 Classification

The existing methods used for oral cancer detection-based classification are AlexNet, EGOA based DBN, CNN and Deep CNN which are described in this section.

AlexNet

Atta-ur Rahman *et al.* [17] suggested a Transfer Learning method by AlexNet in CNN for extracting features along OSCC images for method training. Suggested method analyzed and predicted oral cancer by OSCC images. The customized AlexNet was called as transfer learning method and that method was important and attached to analyze and predict medical image diagnosing. The suggested method improved performance in automatic selection of image texture features and detected lesions without many pre-processing processes. However, a suggested method require complex system configuration, that resulted in executional expenses.

Enhanced Grasshopper Optimization Algorithm (EGOA) based Deep Belief Network (DBN)

Adwan A. Alanazi *et al.* [18] presented an Intelligent Deep Learning enable OSCC detection and classification (IDL-OSCDC) method by bio images. Method involved a classification and recognition of oral cancer in bio images. The presented method employes Gabor Filtering (GF) as pre-processing stage for removing noise. Additionally, NasNet method was used for producing of huge deep features with input images. Then, EGOA depended DBN method was used for detect and classify oral cancer. Hyperparameter tuning of DBN method was processed by EGOA method that maximizes the performance of classification. However, the presented method was time-consuming which resulted a delay in disease detection.

Convolutional Neural Network (CNN)

Madhusmita Das *et al.* [19] developed Convolutional Neural Network (CNN) to detection and classification of oral cancer. The primary detection of oral cancer kind OSCC, in their preliminary phase, provided much modifications to good treatment and correct therapy. The developed CNN method automatically detect the OSCC and for experimentation process, histopathological oral cancer images were taken. The developed method reduced the computational time. However, the developed method caused less prediction performance in testing.

Deep Convolutional Neural Network (Deep CNN)

Fahed Jubair *et al.* [20] introduced a Deep CNN which used the pre-trained EfficientNet-B0 as lightweight transfer learning method. The dataset of 716 medical images was utilized for training and testing an introduced method. The introduced method detected the cancerous or potential malignant oral lesions along huge sensitivity levels, specificity and accuracy along addition benefits of less size and require less execution power and capacity of

memory. However, the introduced method used medical images in tongue lesions and doesn't included lesions along mucosal areas.

4. Problem Statement

The problem statement related to oral cancer detection is given below:

- The existing methods has not focused on accurate objects to be detected, that causes false positive classification and less generalization performance.
- Existing ML methods required extraction of hand-crafted features and incapable to handle difficult queries.
- There has complex while choosing the parameters which control strength of spatial interactions, that required high computationally intensive.

5. Comparative Analysis

The oral cancer detection of existing methods are compared to represent the performance of methods. The comparative analysis included existing methods, advantages and limitations of existing methods with their performance metrics considered to evaluate the existing methods. Table 1 represents a comparative table for existing algorithms.

Table 1 Comparative table for Existing Algorithms

Author	Method	Advantages	Limitation	Performance Measure
Shilpa Harnale and Dr. Dhananjay Maktedar [13]	Modified KFCM	The presented method maximized a precision of segmentation.	However, the method suffered from computational complex and doesn't found a caries type.	Recall, Precision, Dice, Jaccard Index
Bofan Song *et al.* [14]	UNet depended Bayesian Deep Learning (BDL)	Through eliminating uncertain pixels, the method produced much correct and reliable segmentation.	However, the method provided low prediction of some areas.	Pixel accuracy, Mean IoU, Weighted IoU, Dice similarity coefficient
Santisudha Panigrahi *et al.* [15]	Capsule network	The capsule network has superior ability to capture pose data and spatial association and effective favor among cancerous and non-cancerous images.	However, method doesn't identified the caries kind for colored and X-ray images.	Accuracy, Sensitivity, Specificity, Precision, F1-score
Haihua Zhu *et al.* [16]	CariesNet	The CariesNet produced effective process in segmenting small lesions with huge X-ray images.	However, dataset was sparse and various related metrics were not evaluated.	Dice coefficient, Accuracy, F1-score, Precision, Recall
Atta-ur Rahman *et al.* [17]	AlexNet	The suggested method improved performance in automatic selection of image texture features and detected lesions without many pre-processing processes.	However, the suggested method require complex system configuration, that resulted in executional expenses.	Accuracy
Adwan A. Alanazi *et al.* [18]	EGOA based DBN	The hyperparameter tuning of DBN method was processed by EGOA method that maximizes the	However, the presented method was time-consuming which resulted a delay in disease detection.	Accuracy, Precision, Recall, F1-score

		performance of classification.		
Madhusmita Das *et al.* [19]	CNN	The developed method reduced the computational time.	However, the developed method caused less prediction performance in testing.	Accuracy, Precision, Recall, Specificity, F1-score, Error rate
Fahed Jubair *et al.* [20]	Deep CNN	The introduced method detected the cancerous or potential malignant oral lesions along huge sensitivity levels, specificity and accuracy along addition benefits of less size and require less execution power and capacity of memory.	However, the introduced method used medical images in tongue lesions and doesn't included lesions along mucosal areas.	Accuracy, Specificity, Sensitivity, AUC

6. Summary

Various researches developed a ML method which detects oral cancer from images. Though, there still lack in huge precision in detection of oral cancer. Recently, a development of AI, DL algorithms effectively detects the oral cancer in early and maximizes a patient's survival rate. This survey analysis different DL algorithms such as modified KFCM, UNet depended BDL, Capsule network and CariesNet which was used for segmentation of oral cancer. Then, AlexNet, EGOA based DBN, CNN and Deep CNN was used for classification of oral cancer. The performance metrics used for evaluating the algorithms are Dice coefficient, Jaccard, Accuracy, Mean IoU, Precision, Weighted IoU, Specificity, Recall, Sensitivity, Error rate, F1-score and AUC. The above analyzed techniques maximize the performance of detection efficiently.

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