Caries Detection in Panoramic Dental X-ray Images With Deep Learning

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Abstract ---The most common dental issue among the general population is dental caries, which is often known as tooth decay or dental decay. This condition impacts the solid structures of the teeth and is caused by microorganisms residing in dental plaque, which consume fermentable carbohydrates, primarily sugars. Dental caries can cause excruciating pain or infections, which can reduce a person's quality of life. Early treatment may result from using machine learning algorithms to automatically detect dental cavities. Deep Convolutional Neural Network (CNN) methods are widely recognized for their ability to automatically identify dental caries by classifying panoramic X-ray images of patients. Dental radiography (X-rays) is capable of detecting dental caries before they become visibly apparent, especially in the interdental spaces. While smaller lesions can be challenging to detect, larger dental caries are typically visible to the naked eye. Dental X-rays are visual representations of the teeth, adjacent bones, and soft tissues, serving as valuable tools for the detection of oral, dental, and jaw-related problems. These images can unveil issues that might not be apparent through a mere visual inspection, including cavities, concealed dental structures, and bone deterioration. This research paper focuses on the utilization of panoramic X-rays among the three primary types of dental X-rays: bitewing, periapical, and panoramic.

Keywords— CNN, Deep Learning, panoramic X-ray, dental caries, dentistry

I. Introduction

An estimated 2.3 billion people globally are believed to experience persistent dental caries, making it one of the oral ailments that affect approximately 50% of the world's population. Dental caries, commonly known as tooth decay, is a dental condition characterized by the deterioration of teeth due to the activity of oral bacteria that produce lactic acids, leading to direct damage to the tooth enamel. Not all caries lesions can be visibly or tactually identified. As a result, imaging techniques are commonly employed to enhance the rate of detection.

Dental informatics is a developing field that includes saving time and enhancing the process of diagnosis and treatment and lowers stress during daily activities. Medical imaging, analysis, and intervention techniques and procedures that produce visual representations of the body's internal processes are used to identify and treat diseases. Medical imaging technologies like computed tomography (CT) and X-rays have recently made it simpler to treat and diagnose a variety of illnesses. One of the key areas of study in medical imaging and diagnostic radiology is computer-aided diagnostics (CAD). CAD aids physicians and radiologists in decision-making by taking the computer output into account. Using X-rays to take dental radiographs makes it easier to find problems with root canals, bone loss, and caries that aren't visible during a physical examination. A panoramic x-ray that shows the entire mouth and teeth together and a periapical x-ray that shows individual teeth are the two radiographic techniques that are frequently used for radiological diagnosis. Dentists use panoramic dental radiography to see issues that are difficult to see or have poor visibility inside the buccal cavity.

Recent years have seen a rise in interest in deep learning in dentistry, particularly for the detection of dental caries. Utilizing data augmentation techniques can potentially enhance the accuracy of deep learning-based tooth classification approaches by up to 5%. These studies are all aimed at enhancing caries detection abilities. Convolutional neural network (CNN)-based algorithms have recently made significant advancements in the field of computer vision. CNNs have found extensive applications across various clinical domains and are the preferred choice for analyzing medical imaging. CNNs have been used in the field of dentistry to identify apical lesions and periodontal bone loss. CNNs can also be utilized to identify various structures, categorize them into different groups. When supervised learning is used, on an image, neural networks must be trained and optimized database to produce a precise outcome.

II. Related Work

Various techniques for caries detection have been introduced, encompassing both conventional image processing approaches and deep learning (DL)-based methods. Statistical features derived from operations like Laplacian/Gaussian filters, image dilation, and erosion are employed in combination with a multilayer perceptron (MLP) for caries detection. [2]

In the classification phase, a diverse range of classifiers can be employed, including support vector machines (SVM), Naive Bayes (NB), deep learning models, decision trees

(DT), XG-Boost, k-nearest neighbor (KNN), and random forests (RF) [3]. To achieve high accuracy, these techniques frequently use massive datasets and extremely deep networks [5]. Finding high-quality labelled datasets for model training is, however, not always easy in the real world simple. [4]. It's also widely known that manually labelling a dataset is time-consuming a very difficult and error-prone task. Thus, we suggest that this work's early warning learning strategy be examined using a classification based on CNNs. CNN can be used to analyze and categorize the patterns in radiographs. [6]

III. Method Of Detection

In this study, tooth X-ray images will be utilized for conducting a classification task. The classification in this context involves a single class, which is "Dental caries." The initial stage of the proposed approach involves data augmentation and subsequent preprocessing. Following this, the dataset is divided into training and validation subsets. Lastly, a CNN model is developed as the output model. This model is used for compiling and training.
A visual representation of this process is depicted in Figure 1, as shown in the flowchart of the proposed methodology.

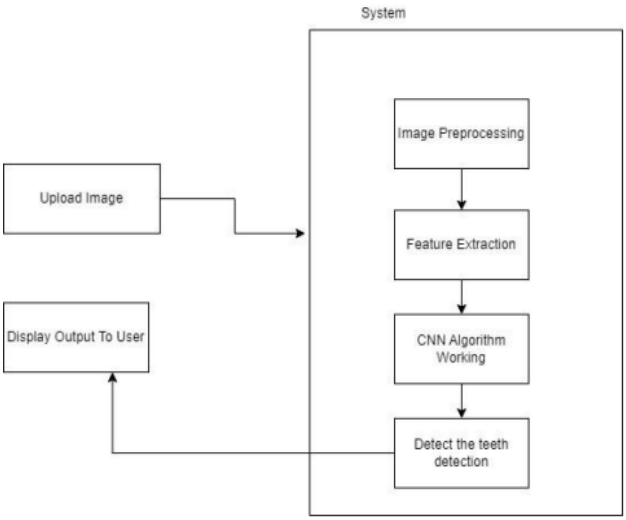

Figure 1: Flowchart of the proposed work

Convolutional Neural Network:

The two stages of the CNN model's operation are feature extraction and classification [2].

FEATURE EXTRACTION

Feature extraction is the process of extracting information and features from images. Following the feature extraction phase, the images are sent to the classification phase, where they are categorized in accordance with the target variable of the problem.

CLASSIFICATION

The classification module serves to categorize the input image into an appropriate label. It acts as a bridge that integrates the information gathered from previous stages and ultimately assigns the input to the correct category. A standard CNN model structure typically includes the following components:

- Input layer
- Convolutional layer with an activation function
- Pooling layer
- Fully Connected layer

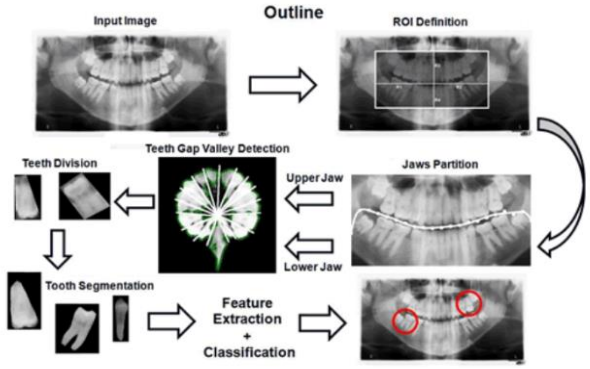

Figure 2: Convolutional Neural Network

IV. Data Preprocessing

The Mendeley Data platform is the source of the dataset used in this study and article on dental caries detection, which consists of multiple tagged images. There are 116 panoramic dental radiography images in this dataset, with 107 of them measuring 2964 × 1464. Two dental clinics on Sidi Bouzid, Tunisia, provided the data for all of the studies. Dental caries can already be seen in the images thanks to pretraining. The Dental caries level that was ascertained will therefore be included in the image's label.

Preprocessing typically includes operations such as resizing, normalization, and other transformations that make the data consistent and suitable for your model. Augmentation involves expanding a dataset to suit our requirements. To achieve this, we employed the image data generator function with the following parameters:

- Rotation range
- Horizontal flip
- Vertical flip

The dataset augmentation was carried out to enhance dataset size, aiming for improved accuracy in the results. [1]
Figure 3 provides visual representations of the images after undergoing preprocessing.

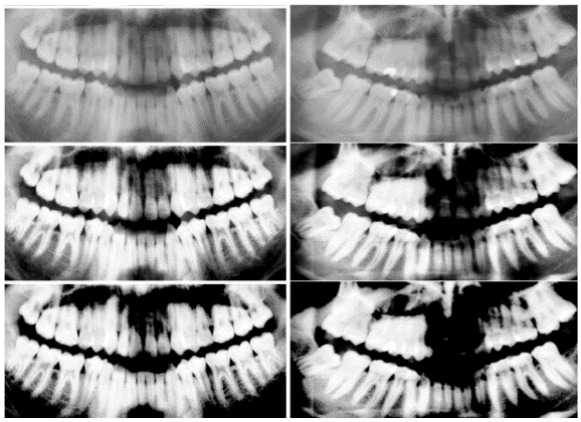

Figure 3: After preprocessing and augmentation

V. Segmentation

Image segmentation is recognized as one of the most complex tasks in image processing. It holds significant importance in various subsequent image-related analyses, especially in the realm of pattern recognition and matching. The process of image segmentation entails breaking down an image into its individual components, after which the regions of interest are isolated and extracted from those segments. Caries segmentation entails locating and separating the areas where carious lesions are present in an image. [1]

Figure 4: After segmentation

VI. Result

Input an image in the given text box after reading the name it can understand its classification based on the trained data set.

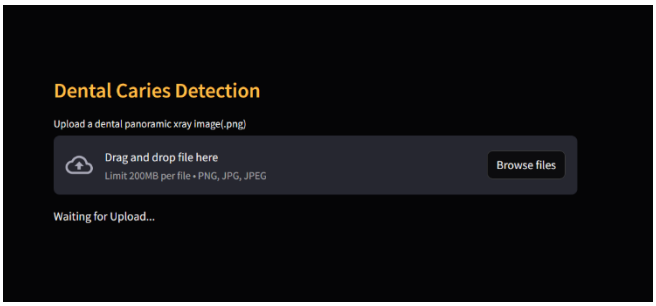

Figure 5: Enter an input image

Classification of the given image, it will be a panoramic dental x-ray image with dental caries or an image without dental caries.

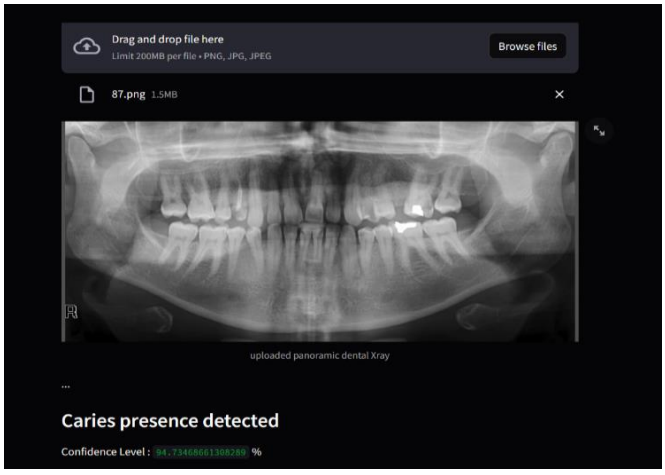

Figure 6: Output of the image

If we enter an image, it will produce a result like this, print whether it is Dental Caries or No Dental Caries along with its confidence level.

VII. Conclusion

Precise detection and diagnosis of dental caries have the potential to reduce the expenses associated with oral health care and enhance the likelihood of preserving natural teeth over the long term. The findings of this study underscore that a deep learning-based CNN algorithm exhibits significant effectiveness in identifying dental caries in periapical radiographs. In a clinical context, the utilization of more sophisticated deep learning algorithms and extensive, high-quality datasets could prove beneficial in the task of detecting and diagnosing dental caries.

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