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# Assessing the Efficacy of Deep Learning in Automated Tooth Detection and Numbering on Pediatric Panoramic Radiographs: A Comparative Study against Traditional Methods

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**ABSTRACT**:

**Background**: Computer-based technologies play an important role in all aspects of our daily life as well as in dentistry. Artificial intelligence is changing the way we look at dentistry. It has helped in reducing the time it takes for a procedure, cost and error overall. It has been able to provide a system that has enough intelligence to perform, validate, evaluate, predict and analyze tasks with marginal accuracy in a predefined environment.**Aim**: This study aims to evaluate the performance of a deep learning system for automated tooth detection and numbering on pediatric panoramic radiographs and compare the same with the traditional approach.**Materials & Methodology:** This study with a sample size of 200 orthopantomograms was randomly allocated as Group I: observed by AI and Group II: observed by dental surgeons. Image Data Set for the study was collected from patients aged 5-13 years of age and a comparison was done between the accuracy performance by the AI and dental surgeons.**Result** : The results revealed that there was no statistically significant difference between group I and group II.

**Conclusion:** This study reveals that the combination of artificial intelligence with the practice of dental surgeons shall help to provide better treatment outcomes and accurate diagnosis of diseases in less time.

**KEYWORDS:**Artificial Intelligence, Orthopantomograms, Pediatric Dentistry

## I. INTRODUCTION

As stated by Sudipto Ghosh, “Artificial Intelligence is not a Man versus Machine saga; it’s in fact, Man with Machine synergy.” Artificial Intelligence (AI) refers to developing computer systems performing tasks that typically require human intelligence. It is a multidisciplinary field that combines computer science, mathematics, psychology, and other domains to create intelligent machines capable of simulating human thinking and decision-making processes.[1]The proliferation of large datasets, improved computational capability, and algorithmic breakthroughs have all contributed to the notable improvements in AI. Many businesses, including healthcare, finance, transportation, and manufacturing, have found it easier to implement.

Artificial intelligence (AI) has significantly advanced in various industries, including dentistry. AI technology has been leveraged to improve diagnostic processes, treatment planning, patient care, and dental research.[2] AI technology in dentistry enhances patient care, treatment planning, diagnosis, and oral health education. Artificial intelligence (AI) systems are able to analyse dental pictures, such as CT and X-rays, more precisely in order to identify anomalies, cavities, and other oral diseases. It helps with early diagnosis and targeted therapy planning. In order to maximise fit and aesthetics, AI-powered systems also help in the design and fabrication of dental restorations including crowns and bridges. Using AI to simulate orthodontic outcomes during virtual treatment planning facilitates decision-making. AI virtual assistants and chatbots also improve patient education, offer individualised oral health information, and expedite administrative duties.

One of the most important aspects of the oral examination in clinical dentistry practice is the valuation of dental radiographs. For dental examinations, panoramic radiography has been

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utilised often includes benefits such low radiation dosage, quick and simple application, and less discomfort for the patient. Interpretation of panoramic radiographs by a dental practitioner is an important step of the diagnosis which involves teeth detection and numbering. Dental professionals can make better diagnoses when all teeth on panoramic photographs are correctly identified and numbered, but this manual process takes time and depends on the training of the practitioners. Automated tooth recognition and numbering can save dentists time and reduce errors associated with weariness, allowing them to undertake more effective treatment

alternatives. Therefore, this study aims to evaluate the performance of a deep learning system for automated tooth detection and numbering on pediatric panoramic radiographs and compare the same with the traditional approach.

## II. MATERIALS AND METHOD

A total of 200 panoramic radiographs of pediatric patients aged 5-13 years were collected from Department of Oral and Maxillofacial Radiology, Sathyabama Dental College and Hospital, Chennai. Each panoramic radiograph was anonymized and saved as different image formats like .png,.bmp, .jpg etc. The images were then subjected for tooth identification and numbering by two groups where Group 1 i.e. the dentists labelled the teeth in the software and similarly, Group 2 i.e., the AI model was exposed to same set of images for identification. Annotation of each permanent and primary tooth in the maxilla and the mandible was manually performed by a dental surgeon (Group 2) using labelling of bounding box. Detecting the location of a tooth was carried out by the bounding box and all teeth were labelled according to FDI tooth numbering system. YOLO is a real-time object recognition algorithm that detects multiple objects and draws bounding boxes around each object to indicate the area of detection. Hence, YOLO V4 (Group 1) was used in this study because of its extreme speed and accuracy for object detection. The detection and classification accuracy of YOLO V4 model is based on three standard metrics. These metrics are: true positive (TP), false positive (FP), and false negative (FN) in which a correctly detected and numbered tooth will be indicated as TP; a correctly detected but incorrectly numbered tooth will be indicated as FP; a missing detection will be indicated as FN. This is also called the confusion matrix, which helped in evaluating the precision of the AI model. Finally,the detection accuracy of the AI model to that of the dentist was done using the mean intersection-over-union (MIoU)metric.

## III. STATISTICAL ANALYSIS

The confusion matrix, a useful table that summarizes the predicted and actual situations, was used as a metric to calculate the success of the model. The following procedures and metrics were used to assess the success of the AI model:

Initially, true positive (TP), false positive (FP), and false negative (FN) rates were calculated. TP: the outcome in which the model correctly predicts the positive class (teeth correctly detected and numbered on panoramic radiographs).

FP: the outcome in which the model incorrectly predicts the positive class (teeth correctly detected but incorrectly numbered on panoramic radiographs).

FN: the outcome in which the model incorrectly predicts the negative class (teeth incorrectly detected and numbered on panoramic radiographs).

## IV. RESULTS

The deep convolutional neural network (CNN) system demonstrated effective performance in automated tooth detection and numbering on pediatric panoramic radiographs, aligning with the study's aim of evaluating deep learning efficacy compared to traditional methods. The system successfully identified and numbered teeth across all quadrants, as illustrated in Figures 1 and 2. Quantitative analysis revealed 131 true positives (TP), 30 false positives (FP), and 39 false negatives (FN), indicating reliable detection capabilities. The system achieved a sensitivity and precision rate suggestive of high diagnostic value. Furthermore, a mean Intersection-over-Union (MIoU) score of 56.4% was recorded, reflecting moderate spatial accuracy in segmentation and localization. These results affirm the potential of deep learning models in providing consistent, efficient, and automated support for pediatric dental radiographic analysis, with promising application in clinical workflows.

**Figure 1**

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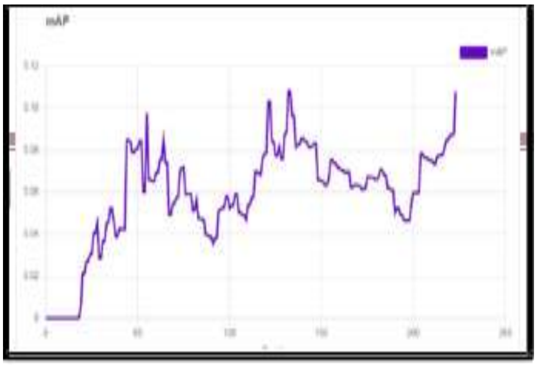

Figure 2

## V. DISCUSSION

The initial stage of radiographic examination is tooth detection and enumeration, which serves as the foundation for the automatic diagnosis of dental problems on radiographs. Automation of tooth detection and enumeration could simplify dentists' everyday work, even though it is difficult to transform tooth enumeration on radiographs into a learning process. Intraoral radiography, which offers more precise information about the relevant region, has been used in the majority of research on the deep learning performance of dental diagnosis. However, panoramic radiography provides a single annotated image that includes all teeth, a large number of anatomical features, and potential diseases, it has attracted a lot of scientific attention.

Tuzoff et al used Faster R-CNN architecture on 1352 randomly chosen panoramic radiographs of adults for tooth detection and numbering tasks and reported that the sensitivity and precision for the system and experts demonstrated similarity. The authors also recommended that thesesystems could be enhanced by applying additional techniques, such as advanced image augmentation, and using recent CNN algorithms.[3]

YOLO is one example of the one stage detectors that is used for detection and classification of objects with extreme speed and high accuracy. Furthermore, the feature of YOLO as performing real time object detection with its overall good performance in various object classes average values distinguishes it from other CNN algorithms.[4] We used YOLO V4 for tooth detection and numbering because of its speed and high accuracy level for object detection. In a study of Yuksel et al, YOLO was used to detect five different dental therapy options and number the teeth according to the FDI notation on 1005 panoramic radiographs of adults.[5]

## VI. CONCLUSION

In the present study, we have presented a deep learning-based method for analyzing pediatric panoramic radiographs, capable of accurately identifying and numbering both primary and permanent teeth. The proposed system demonstrated promising results, indicating its potential as a valuable diagnostic aid in pediatric dentistry. When integrated with the clinical expertise of dental professionals, such deep learning models can contribute to improved diagnostic accuracy, faster clinical decision-making, and more effective treatment planning.

However, there are certain limitations to consider. The model's performance may vary depending on the image quality, anatomical variations among children, overlapping structures, and the presence of developmental anomalies or missing teeth. Additionally, the dataset used for training may not encompass all possible variations seen in clinical practice, potentially limiting generalizability. While the mean Intersection-over-Union (MIoU) score of 56.4% reflects moderate accuracy, further enhancement in segmentation precision is needed for consistent clinical deployment. Future studies involving larger, more diverse datasets and integration with clinical decision support systems are essential to validate and improve the system's robustness and real-world applicability.

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