Missing Teeth Count and Localization Methods in Dental Radiographs : A Review

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Abstract

This review explores the use of deep learning for detecting and locating missing teeth in dental panoramic radiographs, crucial for treatment planning and implant placement. It covers methodologies, strengths, and limitations of existing studies, offering a comparative analysis of recent advancements. The poster concludes by discussing future research directions and potential applications of deep learning in this field.

Introduction

Dental radiography is crucial for diagnosis and treatment planning. Panoramic radiographs provide a comprehensive view, aiding in assessing tooth morphology and bone structure. Detecting missing teeth is vital for implant placement and treatment planning. Traditional methods are time-consuming and subjective. Deep learning offers automated and accurate missing teeth detection, overcoming the limitations of manual and rule-based approaches.

Methodology

Deep learning algorithms are trained on extensive datasets of dental panoramic radiographs, along with annotated missing teeth information. These algorithms excel at extracting intricate patterns, allowing precise identification and localization of missing teeth. Commonly used architectures include CNNs for spatial feature extraction, RNNs and encoder-decoder networks for sequential data analysis and contextual information handling, and RCNNs primarily for teeth segmentation and numbering tasks.

Performance Analysis

Deep learning algorithms for missing teeth detection are assessed using metrics like accuracy, precision, recall, and F1-score to gauge their performance in correctly identifying missing teeth while minimizing errors. Reviewed studies highlight the substantial potential of deep learning, showcasing high accuracy and outperformance of traditional methods in dental radiography. Ongoing research in interpretability, computational efficiency, and ethical considerations aims to advance these technologies for responsible integration into dental practice.

Missing Teeth Count Analysis

Several studies, including Chen et al. (2022) and Park et al. (2022), showcased deep learning's accuracy in missing teeth count. Kim et al. (2020) and Hu et al. (2019) reported promising results, while Karaoglu et al. (2022) focused on tooth numbering, potentially adaptable for missing teeth count.

Chen et al. (2022): Achieved 93.28% accuracy in positioning teeth using GoogleNet, SqueezeNet, and AlexNet.
Park et al. (2022): Impressive performance with 92.14% mAP (0.5) in teeth segmentation and numbering, and 59.09% mAP (0.5) in detecting missing teeth regions.
Kim et al. (2020): Utilized tooth numbering approach, achieving 96.7% accuracy in teeth detection and 77.4% accuracy in tooth numbering.
Hu et al. (2019): Achieved 91.7% precision in numbering and predicting missing teeth, supporting the effectiveness of tooth numbering.
Karaoglu et al. (2022): Focused on tooth numbering, presenting a promising approach with 96.08% precision in segmenting and numbering teeth regions, potentially adaptable for accurate missing teeth count.

The studies highlight the potential of precise missing teeth count in panoramic radiographs, ensuring high accuracy through direct counting and indirect methods, promising improved dental diagnosis, treatment planning, and overall patient care.

Experimental Results

The experimental results reported by the studies demonstrate the effectiveness and efficiency of the proposed methods, as shown in the table 1.

Study	Method	Result
Chen et al. (2022) Teeth Positioning Accuracy	Transfer learning with CNNs	93.28%
Park et al. (2022) Missing Tooth Region Detection	CNN-based (Mask-RCNN/Faster RCNN)	59.09% (mAP (0.5))
Kim et al. (2020) Tooth region Detection Accuracy	Combination of CNN and heuristic algorithm (Faster RCNN)	96.7%
Hu et al. (2019) Missing Teeth Prediction	Object detection with CNN (Faster RCNN)	91.7%
Karaoglu et al. (2022) Teeth segmentation & numbering precision	Deep learning (Mask RCNN) and heuristic algorithm	96.08%

Table 1. Experimental Results

Visual Results

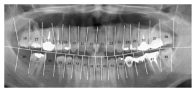

Figure 1. Chen et al. (2022)

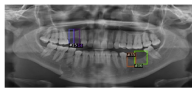

Figure 2. Park et al. (2022)

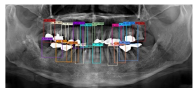

Figure 3. Kim et al. (2020)

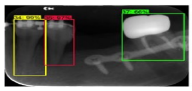

Figure 4. Hu et al. (2019)

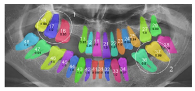

Figure 5. Karaoglu et al. (2022)

Future Directions

Explainable AI: Efforts are underway to create explainable AI, unraveling the inner workings of deep learning models for improved understanding, interpretability, and trust in decision-making processes.
Multimodal Learning: Integrating deep learning with 3D imaging and clinical data enhances the accuracy and robustness of missing teeth detection and localization.
Cloud-based Solutions: Utilizing cloud platforms provides scalable computing resources, making deep learning models more accessible for dental practices, regardless of size.
Revolutionizing Dental Radiography: Deep learning's potential in revolutionizing missing teeth detection and localization can be realized by addressing limitations and exploring future directions, ensuring reliable, accessible, and interpretable solutions for enhanced patient care.

Conclusion

Deep learning has emerged as a powerful tool for automated missing teeth detection and localization in dental panoramic radiographs. The reviewed studies demonstrate the effectiveness of deep learning-based approaches, achieving promising results in terms of accuracy and efficiency. Notably, several studies have successfully addressed the task of missing teeth count, providing valuable information for dental treatment planning and implant placement.

Summary

Deep learning offers a promising solution for automating missing teeth detection, localization, and count in dental panoramic radiographs. The reviewed studies showcase the effectiveness of deep learning-based methods, achieving significant advancements in accuracy and efficiency compared to traditional methods. As deep learning techniques continue to evolve, their potential for revolutionizing dental radiographic analysis is immense.

References

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