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Peer Reviewer of *World Journal of Clinical Cases*, Dimitra Bacharaki, MD, PhD, Consultant Physician-Scientist, Department of Nephrology, Attikon University Hospital, Chaidari 12462, Greece. bacharaki@gmail.com

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LETTER TO THE EDITOR

Classification and detection of dental images using meta-learning

Pradeep Kumar Yadalam, Raghavendra Vamsi Anegundi, Mario Alberto Alarcón-Sánchez, Artak Heboyan

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Pradeep Kumar Yadalam, Raghavendra Vamsi Anegundi, Department of Periodontics, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 600077, Tamil Nadu, India

Mario Alberto Alarcón-Sánchez, South Pacific Dental Institute, Chilpancingo de los Bravo 39022, Guerrero, Mexico

Artak Heboyan, Department of Prosthodontics, Faculty of Stomatology, Yerevan State Medical University after Mkhitar Heratsi, Yerevan 0025, Armenia

Corresponding author: Artak Heboyan, DDS, MD, MSc, PhD, Associate Professor, Department of Prosthodontics, Faculty of Stomatology, Yerevan State Medical University after Mkhitar Heratsi, Yerevan 0025, Armenia. heboyan.artak@gmail.com

Abstract

Meta-learning of dental X-rays is a machine learning technique that can be used to train models to perform new tasks quickly and with minimal input. Instead of just memorizing a task, this is accomplished through teaching a model how to learn. Algorithms for meta-learning are typically trained on a collection of training problems, each of which has a limited number of labelled instances. Multiple X-ray classification tasks, including the detection of pneumonia, coronavirus disease 2019, and other disorders, have demonstrated the effectiveness of meta-learning. Meta-learning has the benefit of allowing models to be trained on dental X-ray datasets that are too few for more conventional machine learning methods. Due to the high cost and lengthy collection process associated with dental imaging datasets, this is significant for dental X-ray classification jobs. The ability to train models that are more resistant to fresh input is another benefit of meta-learning.

Key Words: Artificial intelligence; Meta-learning; Dental diagnosis; Image segmentation; Medical image interpretation; Dental radiography

Core Tip: Meta-learning offers a promising approach for achieving high-accuracy detection and diagnosis in dental radiographic image classification. This method holds significant promise for accurate and reliable prediction with less bias by leveraging its capability to learn from limited training data and generalize effectively to unseen dental X-ray categories.

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TO THE EDITOR

X-ray imaging is low-cost and less harmful to patients in clinical applications. Clinicians can sometimes misinterpret and variability among clinicians is wide. Therefore, artificial intelligence (AI) is being used to reduce these limitations. However, existing AI models have two issues. First, most models adapt supervised learning methods and pre-training is needed to initialize these models. Second, X-ray patient dataset categories are often skewed. Besides, there are other difficulties in obtaining domain experts to undertake annotations, heterogeneous data, and a significant difference between expert and novice annotations. Additional difficulties arise from the shortage and heterogenicity (*e.g.*, poor quality) of publicly accessible oral image datasets[1].

Convoluted neural networks (CNNs) have improved oral radiographic image segmentation accuracy and stability. However, existing CNNs depend on quality training data due to high manual annotation costs and privacy constraints [2]. Besides, widely used supervised deep learning techniques need a lot of labelled training samples and frequently fall short in generalization when tested on other datasets because of data shifts brought on by various data distributions. Population fluctuation, acquisition disparities, prevalence shifts, and selection bias can all cause image data to change[3]. These difficulties cause a reduction in the trained model's ability to generalize to new situations upon deployment. Additionally, several biases are introduced throughout the data gathering process, which might result in data shifting during testing and impair the performance of the trained model during a clinical deployment. Future research should focus on ways to shorten training times by utilizing prior knowledge about feature embedding from each challenge[4]. Besides, emphasis should be given to the resemblance of meta-tasks to enhance the capability of prior knowledge transfer across different tasks in different domains. Meta-learning can facilitate transfer learning, where knowledge learned from one cancer type or dataset can be transferred to improve the diagnosis of another cancer type or dataset. By leveraging the learned features, representations, or models from previous diagnostic tasks, transfer learning enables faster and more accurate diagnosis, especially when there is a scarcity of labelled data for a specific cancer type.

Meta-learning in machine learning refers to using Machine Learning techniques for model optimization and training. The meta-learning image model is usually trained after numerous steps of base model training. Each meta-gradient parameter is computed after the meta-loss[5]. Most meta-learning methods perform static data mining. Blending continual learning with meta-learning may overcome this problem. As raw data is not readily available in real applications, learning with limited or no data on target-task will be an open issue for meta-learning[6]. Moreover, meta-learning can be successfully applied even with poor quality images.

There are two severe shortcomings concerning humans: Sample efficiency for deep learning is weak and poor transferability. They do not learn from previous experience or knowledge. Recently, meta-learning, also learning how to learn, has arisen as a viable paradigm for learning that can effectively generalize information from one task to other tasks that have not yet been encountered *i.e.*, learning from the previous experience, similar to the human brain[7].

Meta-learning presents a promising avenue for advancing dental diagnostics and treatment planning[8]. Its application in dental radiography holds particular significance. For instance, the identification of dental caries through X-ray image analysis can be significantly enhanced using meta-learning models, even under data-restricted conditions. Moreover, the detection of periapical pathologies, such as abscesses and bone lesions, can be improved through meta-learning algorithms, facilitating more accurate and timely clinical decision-making. Additionally, assessing the integrity and performance of dental implants *via* X-ray image analysis is a potential application for meta-learning, enabling enhanced implant monitoring and early complication detection.

Within the realm of orthodontics, meta-learning offers potential for substantial impact. Accurate prediction of tooth movement, including root position changes and the risk of root resorption, is critical for optimal treatment planning. Meta-learning algorithms could be developed to analyze radiographic images and provide insights into these factors, enabling orthodontists to make more informed treatment decisions and potentially reduce complications.

While meta-learning shows great promise, it is essential to acknowledge its current limitations. Challenges such as data scarcity, variability in image quality, and the complexity of dental imaging can hinder model performance. Additionally, the clinical implementation of meta-learning models requires careful consideration of factors like explainability, interpretability, and integration into existing workflows. To address these challenges, future research should focus on developing robust data augmentation techniques, exploring hybrid approaches that combine meta-learning with other machine learning methods, and prioritizing the development of user-friendly interfaces. By overcoming these hurdles, the full potential of meta-learning can be realized in dental imaging.

APPLICATIONS

Recent advancements in deep learning have demonstrated significant potential for addressing challenges in dental image analysis. Deep learning models have achieved impressive results in tasks such as classifying the stages of periodontitis

[9], aiding in early detection and treatment planning, and identifying and classifying dental implant systems, supporting implant planning and evaluation[10]. While these developments are promising, they also highlight the need for further research to address issues like data quality, model interpretability, and clinical validation. To fully utilize the potential of AI in dentistry, combining the strengths of meta-learning and deep learning is essential. Future research should explore hybrid approaches that leverage the advantages of both techniques to develop more robust and effective AI-driven solutions.

Beyond image analysis, meta-learning holds significant potential for diverse applications within the dental field. It can be instrumental in predictive analytics, forecasting treatment outcomes, identifying patient risk factors, and predicting treatment compliance. Furthermore, meta-learning can contribute to personalized oral health education by developing tailored educational materials based on individual patient data. In the realm of dental practice management, it can optimize appointment scheduling, resource allocation, and patient flow. Finally, meta-learning can be employed to explore potential links between oral health and systemic diseases, expanding our understanding of overall patient well-being.

For researchers interested in advancing this field, exploring the development of large-scale, annotated dental image datasets, investigating novel meta-learning architectures tailored for dental applications, and conducting rigorous clinical evaluations are essential steps. By collaborating with clinicians and dental professionals, researchers can ensure that meta-learning solutions effectively address the needs of the dental community.

The images available in the current image databases are low quality images which are hard to detect, making it challenging to train with supervised meta-learning. This issue makes transfer learning difficult and leads to poor model performance in multi-class classification recognition. The meta-learning model does not need pre-training and requires a few samples every cycle, solving sample quality and data imbalance in the X-ray dataset. Meta-learning (or learning to learn) is an active research area in medical X-ray imaging because it promises to apply successfully with limited training data. Meta-learning consists of a learner and a meta-learner who trains the learner. Meta-learning overcomes learning's weaknesses by optimizing model weights with a meta-optimizer[4].

CONCLUSION

Dental radiographic image classification and detection using meta-learning offer a promising approach to enhance diagnostic accuracy and efficiency. From a clinician's perspective, meta-learning algorithms hold great potential to deliver reliable and unbiased predictions, aiding in clinical decision-making. Future research should prioritize expanding the scope of dental applications, addressing data limitations, improving model interpretability, facilitating real-world implementation, and addressing ethical considerations. By focusing on these areas, researchers can accelerate the translation of meta-learning into clinical practice, ultimately improving patient care and outcomes. The integration of meta-learning into dental imaging has the potential to significantly advance the field, providing clinicians with powerful tools for early disease detection, accurate diagnosis, and optimized treatment planning.

FOOTNOTES

Author contributions: Yadalam PK, Anegundi RV, Alarcón-Sánchez MA and Heboyan A contributed to this paper; Yadalam PK and Anegundi RV designed the overall concept and outline of the manuscript; Yadalam PK, Anegundi RV, Alarcón-Sánchez MA and Heboyan A contributed to the discussion and design of the manuscript; Yadalam PK, Anegundi RV, Alarcón-Sánchez MA and Heboyan A contributed to the writing, and editing the manuscript and review of literature.

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Country of origin: Armenia

ORCID number: Artak Heboyan 0000-0001-8329-3205.

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REFERENCES

1 **Miao R**, Dong X, Xie SL, Liang Y, Lo SL. UMLF-COVID: an unsupervised meta-learning model specifically designed to identify X-ray images of COVID-19 patients. *BMC Med Imaging* 2021; **21**: 174 [PMID: 34809589 DOI: 10.1186/s12880-021-00704-2]

2 **Kumar A**, Bhadauria HS, Singh A. Descriptive analysis of dental X-ray images using various practical methods: A review. *PeerJ Comput Sci* 2021; **7**: e620 [PMID: 34616881 DOI: 10.7717/peerj-cs.620]

3 **Ching T**, Himmelstein DS, Beaulieu-Jones BK, Kalinin AA, Do BT, Way GP, Ferrero E, Agapow PM, Zietz M, Hoffman MM, Xie W, Rosen GL, Lengerich BJ, Israeli J, Lanchantin J, Woloszynek S, Carpenter AE, Shrikumar A, Xu J, Cofer EM, Lavender CA, Turaga SC, Alexandari AM, Lu Z, Harris DJ, DeCaprio D, Qi Y, Kundaje A, Peng Y, Wiley LK, Segler MHS, Boca SM, Swamidass SJ, Huang A, Gitter A, Greene CS. Opportunities and obstacles for deep learning in biology and medicine. *J R Soc Interface* 2018; **15** [PMID: 29618526 DOI: 10.1098/rsif.2017.0387]

4 **Khadka R**, Jha D, Hicks S, Thambawita V, Riegler MA, Ali S, Halvorsen P. Meta-learning with implicit gradients in a few-shot setting for medical image segmentation. *Comput Biol Med* 2022; **143**: 105227 [PMID: 35124439 DOI: 10.1016/j.compbiomed.2022.105227]

5 **Sabaghi A**, Oghbaie M, Hashemifard K, Akbari M. Deep learning meets liveness detection: Recent advancements and challenges. 2021 Preprint. Available from: arXiv:211214796

6 **Sun J**, Li Y. MetaSeg: A survey of meta-learning for image segmentation. *Cognitive Robotics* 2021; **1**: 83-91 [DOI: 10.1016/j.cogr.2021.06.003]

7 **Cremer CZ**. Deep limitations? Examining expert disagreement over deep learning. *Prog Artif Intell* 2021; **10**: 449-464 [DOI: 10.1007/s13748-021-00239-1]

8 **Arsiwala-Scheppach LT**, Chaurasia A, Müller A, Krois J, Schwendicke F. Machine Learning in Dentistry: A Scoping Review. *J Clin Med* 2023; **12** [PMID: 36769585 DOI: 10.3390/jcm12030937]

9 **Li X**, Zhao D, Xie J, Wen H, Liu C, Li Y, Li W, Wang S. Deep learning for classifying the stages of periodontitis on dental images: a systematic review and meta-analysis. *BMC Oral Health* 2023; **23**: 1017 [PMID: 38114946 DOI: 10.1186/s12903-023-03751-z]

10 **Chaurasia A**, Namachivayam A, Koca-Ünsal RB, Lee JH. Deep-learning performance in identifying and classifying dental implant systems from dental imaging: a systematic review and meta-analysis. *J Periodontal Implant Sci* 2024; **54**: 3-12 [PMID: 37154107 DOI: 10.5051/jpis.2300160008]

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