JOURNAL OF DATA-DRIVEN ENGINEERING SYSTEMS

A Hybrid Approach for Dental Diagnosis: Dental Diagnosis System (DDS) Based on Segmentation, Classification, and Decision Making

Mahmood Al-Khabiri [1*], Fatih Osman [2], Abeed Habashi [1]

[1] Engineering Department, University of Sulaimani, Sulaymaniyah, Iraq
[2] Electrical and Electronic Engineering Department, Komar University of Science and Technology, Sulaymaniyah, Iraq

(Received: 25th June 2021; Accepted: 5th September 2021; Published on-line: 8th September 2021)

Abstract

Computerized medical diagnosis systems utilizing X-ray images are crucial for accurate decision-making in disease identification and treatment. Subclinical diseases often lack recognizable clinical findings, making it essential to segment dental X-ray images into distinct groups. This study proposes a novel framework, the Dental Diagnosis System (DDS), which employs a hybrid approach combining segmentation, classification, and decision-making techniques. The DDS utilizes a state-of-the-art dental image segmentation method based on semi-supervised fuzzy clustering for accurate segmentation. Additionally, a new graph-based clustering algorithm, APC+, is introduced for classification. Finally, a decision-making procedure is designed to identify the final disease from segmented groups. The DDS is evaluated using a dataset from Hanoi Medical University, Vietnam, consisting of 87 dental images encompassing five common diseases: root fracture, incluse teeth, decay, missing teeth, and resorption of periodontal bone. The results demonstrate the DDS's superior accuracy of 93.24% compared to other methods, including fuzzy inference system (90.07%), fuzzy k-nearest neighbor (81.25%), prim spanning tree (57.26%), kruskal spanning tree (57.56%), and affinity propagation clustering (97.08%). In conclusion, the empirical findings confirm the DDS's outstanding performance compared to related methods. The results of this study have the potential to significantly assist dental clinicians in their professional work.

Keywords: Dental diagnosis, X-ray image analysis, dental image segmentation, classification, decision making, hybrid approach.

I. Introduction

Dental X-ray image analysis and processing play a crucial role in diagnosing, treating, and studying dental diseases and conditions, as well as predicting early-stage dental issues. X-rays provide detailed information about teeth, soft tissues, and bones, enabling the detection of buried dental structures, cavities, and bone loss that may go unnoticed during visual examinations [1-2]. Fuzzy inference system (FIS) is a commonly used approach in dental diagnosis, employing fuzzy logic to determine output data sets based on input data sets. Other techniques, such as Bayesian networks, support vector machines (SVM), and fuzzy neighbor k-nearest neighbor (FKNN), have also been applied in dental diagnostics. However, these methods often require expert knowledge to create accurate and meaningful fuzzy rules, posing challenges of duplicate or conflicting rules. To overcome these issues and ensure precise diagnosis, a combination of segmentation, classification, and decision-making algorithms can reduce ambiguity and improve rule determination. The initial step in this process involves segmenting dental X-ray images into distinct groups for further examination. Dental X-ray image segmentation aims to create groups in which pixels exhibit greater similarity within each group than between different groups. Numerous studies have addressed this problem, employing semi-supervised algorithms that utilize additional information. For instance, semi-supervised fuzzy c-mean algorithms incorporate a membership matrix, while others introduce entropy factors or apply semi-supervised classifier-based clustering algorithms [3-4].

Once the segmentation is completed, a classification algorithm matches the segmented images with disease patterns in the database, determining whether the image represents a diseased or healthy condition. Finally, a decision-making algorithm selects the final disease image from the segmented groups.

images into distinct groups, enabling further analysis to determine the presence or absence of diseases. Dental X-ray image segmentation aims to create groups in which pixels within each group exhibit greater similarity than those in other groups.

REFERENCES

[1] Chattopadhyay S, Davis RM, Menezes DD, Singh G, Acharya RU, Tamura T. Application of Bayesian classifier for the diagnosis of dental pain. Journal of medical systems. 2012 Jun;36:1425-39.

[2] Soofi AA, Awan A. Classification techniques in machine learning: applications and issues. J. Basic Appl. Sci. 2017 Aug 29;13:459-65.

[3] Langarizadeh M, Moghbeli F. Applying naive bayesian networks to disease prediction: a systematic review. Acta Informatica Medica. 2016 Oct;24(5):364.

[4] M. Cheraghifard, G. Taghizadeh, M. Akbarfahimi, A. M. Eakman, S.-H. Hosseini, and A. Azad, "Psychometric properties of Meaningful Activity Participation Assessment (MAPA) in chronic stroke survivors," Topics in Stroke Rehabilitation, vol. 28, no. 6, pp. 422-431, 2021.

[5] Tuan TM, Fujita H, Dey N, Ashour AS, Ngoc VT, Chu DT. Dental diagnosis from X-ray images: an expert system based on fuzzy computing. Biomedical Signal Processing and Control. 2018 Jan 1;39:64-73.

[6] M. Amini, A. Hassani Mehraban, M. Pashmdarfard, and M. Cheraghifard, "Reliability and validity of the Children Participation Assessment Scale in Activities Outside of School–Parent version for children with physical disabilities," Australian Occupational Therapy Journal, vol. 66, no. 4, pp. 482-489, 2019.

[7] Ngan TT, Tuan TM, Son LH, Minh NH, Dey N. Decision making based on fuzzy aggregation operators for medical diagnosis from dental X-ray images. Journal of medical systems. 2016 Dec;40:1-7.

[8] Farook TH, Jamayet NB, Abdullah JY, Alam MK. Machine learning and intelligent diagnostics in dental and orofacial pain management: A systematic review. Pain Research and Management. 2021 Apr 24;2021:1-9.

[9] A. Najari, F. Shabani, and M. Hosseynzadeh, "INTEGRATED INTELLIGENT CONTROL SYSTEM DESIGN TO IMPROVE VEHICLE ROTATIONAL STABILITY USING ACTIVE DIFFERENTIAL," Acta Technica Corviniensis-Bulletin of Engineering, vol. 14, no. 1, pp. 79-82, 2021.

[10] Asiri SN, Tadlock LP, Schneiderman E, Buschang PH. Applications of artificial intelligence and machine learning in orthodontics. APOS Trends Orthod. 2020 Jan;10(1):17-24.

[11] Tuan TM, Duc NT, Van Hai P. Dental diagnosis from X-ray images using fuzzy rule-based systems. International Journal of Fuzzy System Applications (IJFSA). 2017 Jan 1;6(1):1-6.

[12] S. Izadi, K. Jabari, M. Izadi, B. Khadem Hamedani, and A. Ghaffari, "Identification and Diagnosis of Dynamic and Static Misalignment in Induction Motor Using Unscented Kalman Filter," in 2021 13th Iranian Conference on Electrical Engineering and Computer Science (ICEESC), 2021.

[13] Iqbal K, Yin XC, Hao HW, Ilyas QM, Ali H. An overview of bayesian network applications in uncertain domains. International Journal of Computer Theory and Engineering. 2015 Dec 1;7(6):416.

[14] Dutta D, Modak S, Kumar A, Roychowdhury J, Mandal S. Bayesian network aided grasp and grip efficiency estimation using a smart data glove for post-stroke diagnosis. Biocybernetics and Biomedical Engineering. 2017 Jan 1;37(1):44-58.

[15] Dutta D, Modak S, Kumar A, Roychowdhury J, Mandal S. Bayesian network aided grasp and grip efficiency estimation using a smart data glove for post-stroke diagnosis. Biocybernetics and Biomedical Engineering. 2017 Jan 1;37(1):44-58.

[16] Yaduvanshi V, Murugan R, Goel T. An automatic classification methods in oral cancer detection. Health Informatics: A Computational Perspective in Healthcare. 2021:133-58.

[17] Kavitha G, Muthulakshmi M, Latha M. Image segmentation using contour models: dental X-ray image segmentation and analysis. InResearch Anthology on Improving Medical Imaging Techniques for Analysis and Intervention 2023 (pp. 892-915). IGI Global.

[18] Chattopadhyay S, Sahu SK. A predictive stressor-integrated model of suicide right from one's birth: a Bayesian approach. Journal of Medical Imaging and Health Informatics. 2012 Jun 1;2(2):125-31.