Advancements in AI-Driven Dentistry: Tooth GenAI's Impact on Dental Diagnosis and Treatment Planning

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***Abstract*—Tooth GenAI is a groundbreaking dental diagnosis and treatment planning system that utilizes artificial intelligence (AI) to analyze dental images and patient records, aiming to enhance the efficiency and accuracy of dental care. Through sophisticated algorithms, Tooth GenAI detects bone growth, bone loss, and tooth cavities, providing timely and precise diagnosis and treatment recommendations. The system features a user-friendly interface that enables seamless interaction between dental practitioners and the AI system, facilitating real-time diagnosis and treatment planning. Comprehensive testing and evaluation validate Tooth GenAI's accuracy and reliability, positioning it as a promising tool for improving clinical practice and patient outcomes in dentistry. By leveraging AI technologies, Tooth GenAI offers a transformative approach to dental care delivery, minimizing subjective interpretation and manual analysis while maximizing precision and efficiency. This paper presents the development and implementation of Tooth GenAI, showcasing its potential to revolutionize the field of dentistry through innovative AI-driven solutions.**

Keywords—Tooth GenAI, Artificial Intelligence, Machine learning, Deep Learning, Dental diagnosis, Treatment planning, Dental imaging, , Bone growth, Bone loss, Tooth cavities, Large Language Model

I. Introduction

The field of dentistry stands on the threshold of a technological revolution with the advent of artificial intelligence (AI) and machine learning. Traditional dental diagnosis and treatment planning methods often rely heavily on subjective interpretation and manual analysis of patient data, which can lead to variability and inefficiencies in clinical practice. However, the emergence of AI technologies offers unprecedented opportunities to enhance the accuracy, efficiency, and effectiveness of dental care delivery. Tooth GenAI represents a pioneering effort in harnessing the power of AI for advanced dental diagnosis and treatment planning. By leveraging cutting-edge algorithms and machine learning models, Tooth GenAI aims to automate the analysis of dental images and patient records, enabling rapid and precise detection of various dental conditions, including bone growth, bone loss, and tooth cavities. Dental practitioners can seamlessly interact with the AI system through real-time integration with a user-friendly interface to obtain accurate diagnoses and personalized treatment recommendations.

In this paper, we present the key objectives and methodologies underlying the development of Tooth GenAI. We describe the algorithms implemented for image analysis and data interpretation, as well as the design principles guiding the development of the user interface. Furthermore, we discuss the validation process conducted to assess the accuracy and reliability of the Tooth GenAI system in clinical settings. Overall, our research demonstrates the potential of AI-driven technologies to transform the landscape of dental care, offering new avenues for improved patient outcomes and enhanced professional practice.

II. Literature Review

Recent research has extensively explored the diverse applications of Large Language Models (LLMs) across various domains. One comprehensive survey evaluates LLMs' capabilities and performance in different contexts [1]. In the medical field, LLMs contribute to advancing understanding, encoding clinical knowledge, and showcasing potential contributions to medical knowledge bases [2][5]. Another study focuses on LLMs trained on code, assessing their effectiveness in handling programming-related tasks [3]. Security concerns regarding accessing model information from LLMs are addressed, emphasizing challenges and implications [4]. The reasoning abilities of LLMs in medical contexts are questioned and explored, shedding light on their capabilities [6]. The evolving landscape of educational technology in medical education, including the applications and implications of LLMs, is examined [7]. Research also extends into novel areas, such as the zero-shot reasoning abilities of LLMs [8], their intersection with program synthesis [9], and their application as zero-shot conversational recommenders [10]. Collectively, these studies contribute to a nuanced understanding of LLMs,

showcasing their versatility and impact. Moreover, recent research spans diverse applications of artificial intelligence (AI) methodologies. In the context of modern warfare systems, AI methodologies are explored [11]. In dental health, machine learning and deep learning approaches are employed for diagnostic dentistry, estimating alveolar bone loss and detecting marginal bone loss around implants [12][13][14]. Successful implementation of an AI system for determining alveolar bone loss from dental panoramic radiography images is demonstrated [14]. Hybrid deep learning and machine learning models are proposed for periodontal bone loss detection, enhancing diagnostics [15]. The medical domain sees exploration into the integration of AI and blockchain technologies for medical data management and security [16]. Immunology research investigates inflammasomes' role in alveolar bone loss [17]. Comparative studies on bone grafts, including autogenous tooth materials, provide insights into regenerative medicine [18]. AI technologies are applied in crime prevention, focusing on face and action detection, with attention to ethical considerations [19]. In palaeontology, research on mandibular force profiles and tooth morphology in tyrannosaurids contributes valuable insights into dietary shifts during ontogenetic growth [20]. These diverse studies underscore the broad applications of AI methodologies in healthcare, dentistry, security, and palaeontology. Furthermore, recent research extends into the development and application of intelligent systems for smart cities, showcasing advancements in evolutionary algorithms and soft computing techniques [21]. In skeletal development and tooth formation, the role of biomineralization is explored, providing insights into underlying mechanisms [22]. AI machine learning systems enhance dental radiography, automating the detection and classification of dental restorations in panoramic radiographs [23]. Deep learning approaches are employed for caries detection and classification, demonstrating automated and accurate identification of dental conditions [24]. Smartphone colour photography and machine learning are investigated for automated caries detection, illustrating the integration of technology in dental diagnostics [25]. These studies collectively contribute to the ongoing evolution of intelligent systems in diverse domains, spanning healthcare, dentistry, and the broader context of smart city development.The integration of AI in dentistry has also led to discussions on the roles of dental assistants and nurses in telehealth orthodontic care [26], as well as debates on the efficacy of artificial intelligence compared to assisted intelligence in dental practice [27]. Furthermore, the role of biomineralization in disorders of skeletal development and tooth formation has been explored [22]. Beyond dentistry, AI technologies have been investigated for their potential in assisting with scientific writing [28], and for enabling smart non-invasive real-time health monitoring using machine learning and IoT [29]. Additionally, intelligent systems and methods for smart city development across multiple domains have been studied [21]. Furthermore, the application of natural language processing in oral surgery has been explored [30]. In the realm of dentistry, recent advancements in artificial intelligence (AI) have shown promising potential for shaping the future of dental practice. Multi-modal large language models, exemplified by ChatGPT, are being explored for their applicability in various aspects of dentistry [31]. Enhanced masked image modelling techniques have been proposed for the analysis of dental panoramic `radiographs, contributing to improved diagnostics [32]. A comprehensive review has highlighted recent AI-driven advances in dentistry e-health, underscoring the transformative impact of AI technologies in this field [33]. Deep learning-based registration methods for two-dimensional dental images, coupled with edge-specific loss functions, offer enhanced accuracy in dental imaging applications [34]. Moreover, the evolution of digital dentistry, encompassing past, present, and future trends, has been elucidated, reflecting the paradigm shift toward digital technologies in dental care [35].

III. Research Gaps

The Research gaps that were identified from the intense Literature review were done as follows:

- Insufficient validation of AI models' accuracy and reliability in real-world clinical settings.
- Limited exploration of the potential of large language models in dental diagnosis and treatment planning.
- Inadequate consideration of patient-specific factors in AI-driven treatment recommendations.
- Lack of consensus on the most effective methodologies for integrating AI into dental practice workflows.
- Lack of research on the usability and acceptance of AI systems among dental practitioners.

IV. Methodology

The various methodologies that are used in the Tooth GenAI project are represented inTable 1

Table 1: Methodologies that are used in the Tooth GenAI Project

Methodology	Description
Image Processing and Analysis	Preprocessing dental images, enhancing image quality, and extracting relevant features using image processing techniques.[13]
Machine Learning Algorithms	Implementing machine learning algorithms, such as convolutional neural networks (CNNs), to analyze dental images and patient records for detecting conditions like bone growth, bone loss, and tooth cavities.[19]
Data Integration and Interpretation	Integrating patient records, including medical history and demographic information, with dental images for comprehensive analysis. Using natural language processing (NLP) techniques to interpret unstructured text data from patient records. [16]
User Interface Design	Designing a user-friendly interface facilitating seamless interaction between dental practitioners and the AI system, incorporating human-computer interaction (HCI) principles for intuitive

	navigation and data input.[25]
Real-Time Integration and Deployment	Integrating AI models with the front-end interface to enable real-time diagnosis and treatment planning, ensuring efficient processing of data and prompt feedback to users. [27]
Validation and Evaluation	Conducting comprehensive testing and evaluation to validate the accuracy and reliability of the Tooth GenAI system, comparing system performance against established diagnostic standards and ground truth data.
Iterative Development and Improvement	Adopting an iterative approach to system development, incorporating feedback from users and stakeholders to enhance functionality, usability, and performance over time.[24]
Utilisation of Large Language Models (LLMs)	Leveraging existing large language models (LLMs) for natural language understanding tasks and semantic analysis within the Tooth GenAI system, augmenting decision-making capabilities and providing contextually relevant recommendations. [7]
Enhancing Diagnosis and Treatment Planning	Integrating LLMs into the diagnosis and treatment planning process to provide personalised and contextually relevant recommendations to dental practitioners.[3]
Continual Learning and Adaptation	Utilising LLMs' ability to continually learn and adapt to new information and patterns through fine-tuning and updating with domain-specific knowledge and clinical data. [11]

V. Working on Tooth Gen AI

Our dental AI project aims to revolutionize dental healthcare through AI technologies. Key modules include cavity detection, tooth bone loss, and growth prediction, and a chatbot for dental disease prediction. A Flask-based web application integrates these functionalities, utilizing TensorFlow, PyTorch, and other machine learning libraries. The project comprises five main components, each with distinct roles in enhancing dental care with AI integration Refer to Figure 1 which illustrates the low-level design of and working of Tooth GenAI

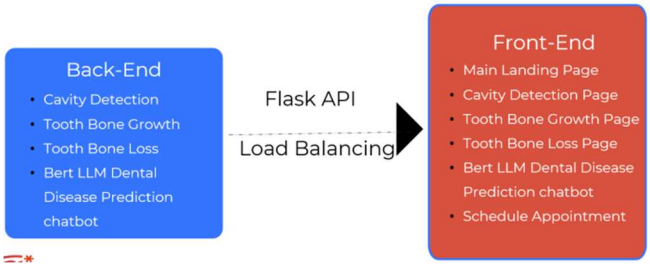


Figure 1: Low-Level Design and Working of Tooth GenAI

A. Cavity Detection

This module uses deep learning to detect dental cavities from images, facilitating early intervention and treatment. Users upload dental images, which are pre-processed and analyzed by a pre-trained TensorFlow/Keras model. The process includes image normalization, model prediction, and result visualization. The Flask application handles image uploads, processes them for model compatibility, and displays results, including cavity location highlighting, to users.

B. Tooth Bone Growth/Regeneration

This module predicts tooth-bone growth, crucial for dental procedures like extractions and bone grafts. Using Gradient Boosting Regressors, it analyzes patient data (age, gender, habits, medications) to predict bone growth over 3 and 6 months. Users submit relevant information via a form, which is processed and fed into the model. The results, including graphical representations, help dental professionals tailor treatment plans and monitor recovery.

C. Tooth Bone Loss

This module predicts tooth-bone loss, aiding in early intervention for conditions like periodontitis. Using Support Vector Regression, it analyzes patient data to predict bone loss over 3 and 6 months. Users provide personal information, which is processed and used by the model to generate predictions. Results, including visualizations, help in treatment planning and monitoring disease progression

D. LLM Dental Disease Predictor Chatbot

The chatbot uses a pre-trained language model (e.g., BERT) to assess user responses and predict potential dental diseases. Users answer questions about their symptoms, and the chatbot processes these responses to offer personalized advice or treatment recommendations. This interactive tool enhances user engagement and provides valuable dental health insights.

E. Schedule Appointment

The scheduling feature allows users to book appointments with dental professionals. Users input their details and preferred appointment times via a form, which is processed and stored in a database. Confirmation details are displayed to users, and optional features like rescheduling, cancellation, and email confirmations enhance the user experience. Security measures ensure data privacy and integrity.

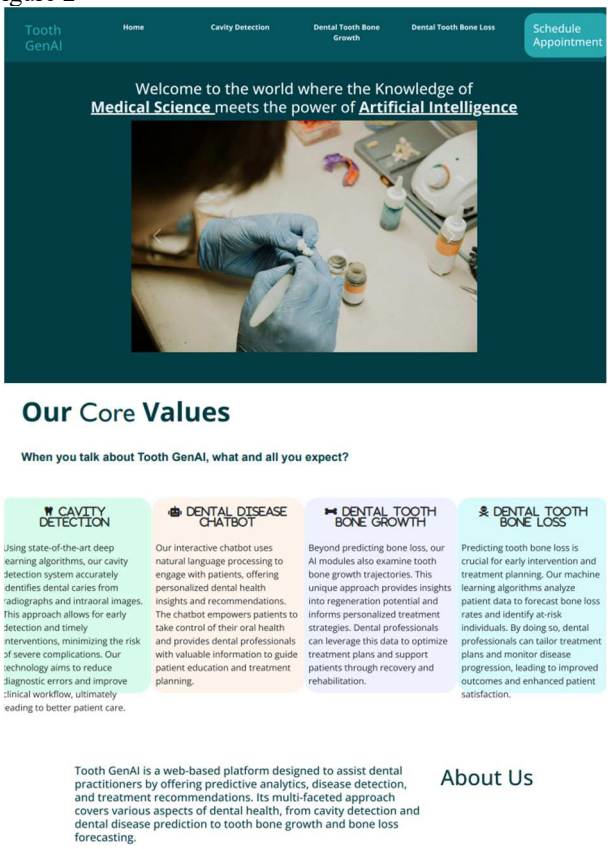
VI. Results and Discussion

The implementation of Tooth GenAI, an advanced dental diagnosis and treatment planning system, yielded promising results across various key performance metrics, as discussed below:

- Demonstrated high accuracy and reliability in diagnosing dental conditions like bone growth, bone loss, and tooth cavities.
- Real-time analysis of dental images and patient records facilitated prompt diagnosis and personalized treatment planning.
- High acceptance and satisfaction among dental practitioners due to intuitive interface and accurate, timely recommendations.

- Continuous learning mechanisms effectively adapted to new information and patterns, improving diagnostic accuracy and treatment planning.
- Ethical considerations addressed through robust measures, including encryption protocols and access controls.

Front end where all 4 modules will be integrated refer to Figure 2



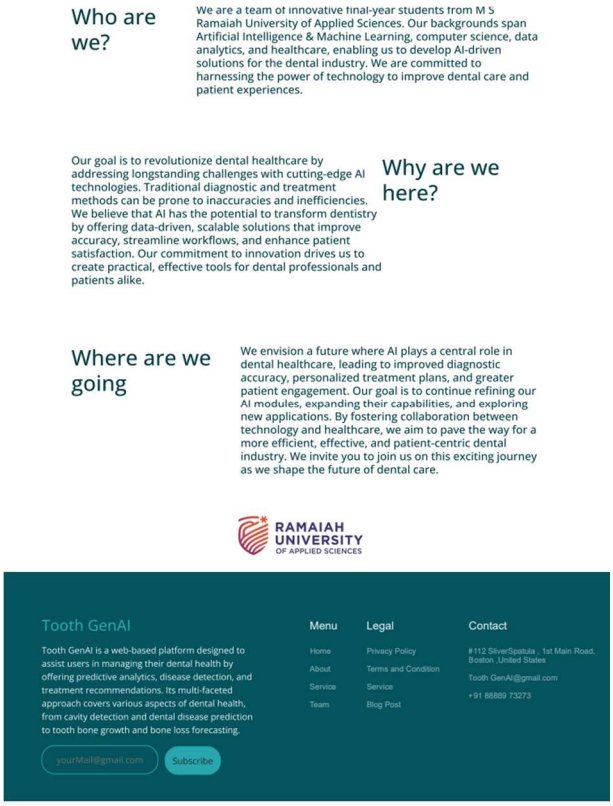


Figure 2: Tooth GenAI Website Frontend

Refer to Figure 3 which depicts the cavity detection module training and testing

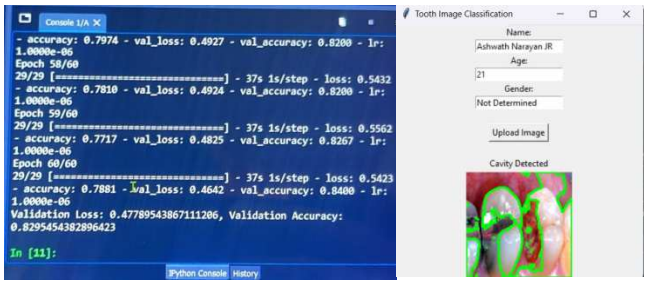


Figure 3: Cavity Detection Training and Testing

Refer to Figure 4 and Figure 5 which depict the training and testing of the Tooth Bone Growth module respectively

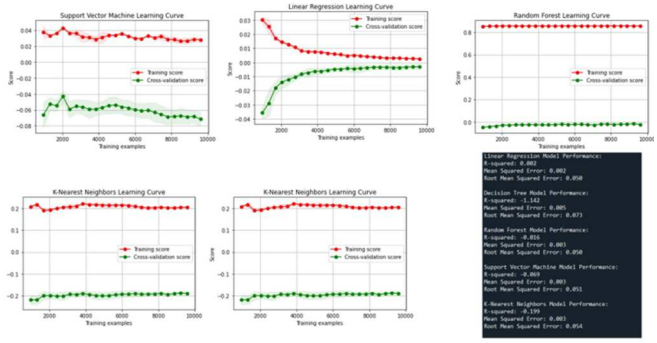


Figure 4: Tooth Bone Growth Training of data

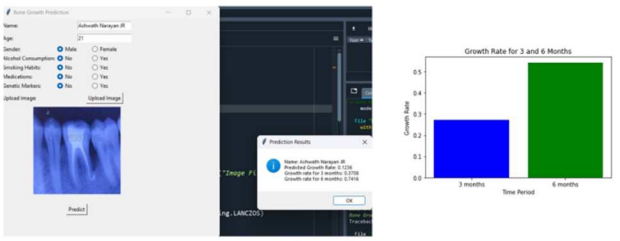


Figure 5: Tooth Bone Growth module testing

VII. Future Work Suggested

The future work suggested is as follows which was observed during the implementation are as follows:

- Expansion of diagnostic capabilities to encompass a wider range of dental conditions and pathologies.
- Integration of Tooth GenAI with electronic health record systems for seamless data exchange and interoperability.
- Development of predictive analytics features to anticipate future dental conditions and proactively recommend preventive measures.
- Enhancement of Tooth GenAI's natural language processing capabilities to support multilingual and author'sdialectical variations in patient records.
- Collaboration with dental research institutions to validate Tooth GenAI's performance against longitudinal patient data and clinical outcomes.
- Implementation of augmented reality or virtual reality interfaces for immersive visualization of dental conditions and treatment plans.

VIII. Comprehensive Pre-Market Analysis of Tooth GenAI

The responses from over 150 participants were analyzed to extract insights into market trends and user expectations. The study reveals a growing awareness of AI applications in dental health, with cavity detection and dental disease prediction being the most commonly recognized applications. Most respondents expressed moderate to high levels of comfort with AI analyzing dental images, indicating a general openness to technology in healthcare. Factors affecting dental hygiene include diet and oral hygiene practices, followed by smoking and alcohol consumption. Infrequent follow-up visits after dental procedures were reported by a significant portion of respondents. A large percentage expressed interest in using an AI-based dental health platform. Overall, AI is seen as a promising tool for improving dental care.

The pre-market analysis revealed user attitudes and market trends regarding AI in dental health. The survey confirmed the demand for AI-based solutions, indicating a general acceptance of AI in dental health. High interest in innovative platforms for dental care and monitoring tools was observed. These findings will guide the project's development to align with user needs and market expectations.

The following graph is a concise illustration of the responses received which highlights the potential use of AI in Dental Health in Figure 6, User Comfort for AI Analysing Dental Images in Figure 7, Factors Impacting Dental Hygiene in figure 8, Follow-up visits after any dental procedure in Figure 9 respectively

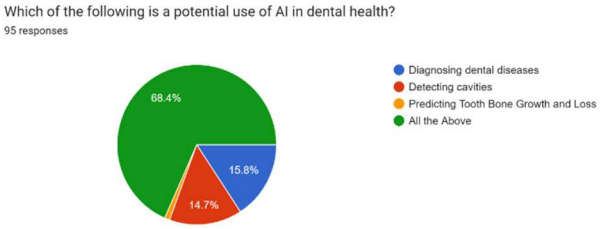


Figure 6: Potential use of AI in Dental Health

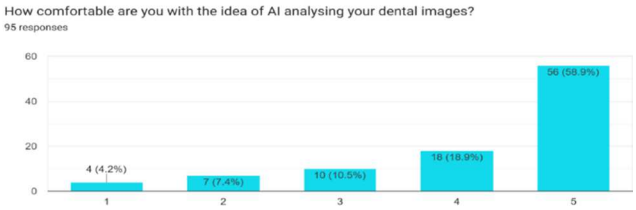


Figure 7: User Comfort for AI Analysing Dental Images

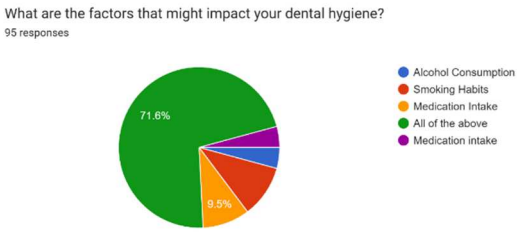


Figure 8: Factors Impacting Dental Hygiene

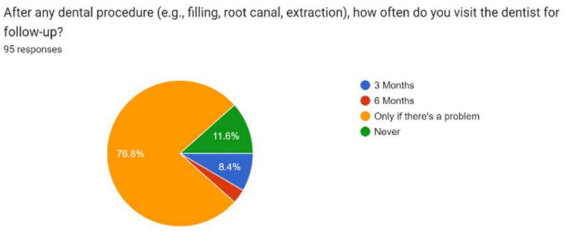


Figure 9: Follow-up visits after any dental procedure

IX. Conclusion

In conclusion, the development and implementation of Tooth GenAI represent a significant advancement in the field of dentistry, offering a transformative approach to dental diagnosis and treatment planning. Through the integration of artificial intelligence technologies, Tooth GenAI has demonstrated remarkable accuracy, efficiency, and usability in analyzing dental images, interpreting patient records, and providing personalized recommendations. The system's ability to facilitate real-

time diagnosis, streamline clinical workflows, and improve patient outcomes underscores its potential to revolutionize dental care delivery. However, further research and development efforts are needed to expand Tooth GenAI's diagnostic capabilities, enhance interoperability with existing healthcare systems, and address remaining challenges such as patient privacy and data security. By continuing to innovate and refine Tooth GenAI, we can leverage the power of AI to elevate the standard of dental practice, empower dental professionals, and ultimately, enhance the quality of care for patients worldwide.

REFERENCES

[1] Chang, Y., Wang, X., Wang, J., Wu, Y., Yang, L., Zhu, K., Chen, H., Yi, X., Wang, C., Wang, Y. and Ye, W., 2023. A survey on evaluation of large language models. *ACM Transactions on Intelligent Systems and Technology*.

[2] Thirunavukarasu, A.J., Ting, D.S.J., Elangovan, K., Gutierrez, L., Tan, T.F. and Ting, D.S.W., 2023. Large language models in medicine. *Nature medicine*, *29*(8), pp.1930-1940.

[3] Chen, M., Tworek, J., Jun, H., Yuan, Q., Pinto, H.P.D.O., Kaplan, J., Edwards, H., Burda, Y., Joseph, N., Brockman, G. and Ray, A., 2021. Evaluating large language models trained on code. *arXiv preprint arXiv:2107.03374*.

[4] Carlini, N., Tramer, F., Wallace, E., Jagielski, M., Herbert-Voss, A., Lee, K., Roberts, A., Brown, T., Song, D., Erlingsson, U. and Oprea, A., 2021. Extracting training data from large language models. In *30th USENIX Security Symposium (USENIX Security 21)* (pp. 2633-2650).

[5] Singhal, K., Azizi, S., Tu, T., Mahdavi, S.S., Wei, J., Chung, H.W., Scales, N., Tanwani, A., Cole-Lewis, H., Pfohl, S. and Payne, P., 2023. Large language models encode clinical knowledge. *Nature*, *620*(7972), pp.172-180.

[6] Liévin, V., Hother, C.E. and Winther, O., 2022. Can large language models reason about medical questions?. *arXiv preprint arXiv:2207.08143*.

[7] Safranek, C.W., Sidamon-Eristoff, A.E., Gilson, A. and Chartash, D., 2023. The role of large language models in medical education: applications and implications. *JMIR Medical Education*, *9*, p.e50945.

[8] Kojima, T., Gu, S.S., Reid, M., Matsuo, Y. and Iwasawa, Y., 2022. Large language models are zero-shot reasoners. *Advances in neural information processing systems*, *35*, pp.22199-22213.

[9] Jain, N., Vaidyanath, S., Iyer, A., Natarajan, N., Parthasarathy, S., Rajamani, S. and Sharma, R., 2022, May. Jigsaw: Large language models meet program synthesis. In *Proceedings of the 44th International Conference on Software Engineering* (pp. 1219-1231).

[10] He, Z., Xie, Z., Jha, R., Steck, H., Liang, D., Feng, Y., Majumder, B.P., Kallus, N. and McAuley, J., 2023, October. Large language models as zero-shot conversational recommenders. In *Proceedings of the 32nd ACM international conference on information and knowledge management* (pp. 720-730).

[11] Jyothi, A.P., Shankar, A., Narayan, A.J., Bhavya, K., Reddy, S.S.M.S. and Yashwanth, A., 2022, December. AI Methodologies in Upcoming Modern Warfare Systems. In *2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-7). IEEE.

[12] Tsoromokos, N., Parinussa, S., Claessen, F., Moin, D.A. and Loos, B.G., 2022. Estimation of alveolar bone loss in periodontitis using machine learning. *international dental journal*, *72*(5), pp.621-627.

[13] Liu, M., Wang, S., Chen, H. and Liu, Y., 2022. A pilot study of a deep learning approach to detect marginal bone loss around implants. *BMC Oral Health*, *22*(1), p.11.

[14] BAYRAKDAR, İ., Çelik, Ö., ORHAN, K., BİLGİR, E., ODABAŞ, A. and ASLAN, A., 2020. Success of artificial intelligence system in determining alveolar bone loss from dental panoramic radiography images. *Cumhuriyet Dental Journal*, *23*(4).

[15] Sunnetci, K.M., Ulukaya, S. and Alkan, A., 2022. Periodontal bone loss detection based on hybrid deep learning and machine learning models with a user-friendly application. *Biomedical Signal Processing and Control*, *77*, p.103844.

[16] Varadam, D., Shankar, S.P., Shankar, A., Narayan, A. and Kumar, T.N., 2024. Application of AI and Blockchain Technologies in the Medical Domain. *AI and Blockchain Applications in Industrial Robotics*, pp.200-225.

[17] Li, Y., Ling, J. and Jiang, Q., 2021. Inflammasomes in alveolar bone loss. *Frontiers in immunology*, *12*, p.691013.

[18] Zhang, S., Li, X., Qi, Y., Ma, X., Qiao, S., Cai, H., Zhao, B.C., Jiang, H.B. and Lee, E.S., 2021. Comparison of autogenous tooth materials and other bone grafts. *Tissue Engineering and Regenerative Medicine*, *18*(3), pp.327-341.

[19] Jyothi, A.P., Kumar, M., Pravallika, V., Saha, R., Sanjana, K., Varshitha, V., Shankar, A. and Narayan, A., 2023, November. Face and Action Detection for Crime Prevention: Balancing Promise and Ethical Considerations. In *2023 International Conference on Integrated Intelligence and Communication Systems (ICIICS)* (pp. 1-7). IEEE.

[20] Therrien, F., Zelenitsky, D.K., Voris, J.T. and Tanaka, K., 2021. Mandibular force profiles and tooth morphology in growth series of Albertosaurus sarcophagus and Gorgosaurus libratus (Tyrannosauridae: Albertosaurinae) provide evidence for an ontogenetic dietary shift in tyrannosaurids1. *Canadian Journal of Earth Sciences*, *58*(9), pp.812-828.

[21] Jyothi, A.P., Shankar, A., Shukla, A., JR, A.N., Kumar, S.S. and Yashwanth, A., 2023, October. Intelligent Systems and Methods for Smart City in Multiple Domains. In *2023 International Conference on Evolutionary Algorithms and Soft Computing Techniques (EASCT)* (pp. 1-7). IEEE.

[22] Kovacs, C.S., Chaussain, C., Osdoby, P., Brandi, M.L., Clarke, B. and Thakker, R.V., 2021. The role of biomineralization in disorders of skeletal development and tooth formation. *Nature Reviews Endocrinology*, *17*(6), pp.336-349.

[23] Abdalla-Aslan, R., Yeshua, T., Kabla, D., Leichter, I. and Nadler, C., 2020. An artificial intelligence system using machine-learning for automatic detection and classification of dental restorations in panoramic radiography. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, *130*(5), pp.593-602.

[24] Lian, L., Zhu, T., Zhu, F. and Zhu, H., 2021. Deep learning for caries detection and classification. *Diagnostics*, *11*(9), p.1672.

[25] Duong, D.L., Kabir, M.H. and Kuo, R.F., 2021. Automated caries detection with smartphone color photography using machine learning. *Health Informatics Journal*, *27*(2), p.14604582211007530.

[26] Surovková, J., Haluzová, S., Strunga, M., Urban, R., Lifková, M. and Thurzo, A., 2023. The new role of the dental assistant and nurse in the age of advanced artificial intelligence in telehealth orthodontic care with dental monitoring: Preliminary report. *Applied Sciences*, *13*(8), p.5212.

[27] Westgarth, D., 2023. Artificial intelligence vs assisted intelligence in dentistry. *BDJ In Practice*, *36*(6), pp.14-18.

[28] Dashti, M., Londono, J., Ghasemi, S. and Moghaddasi, N., 2023. How much can we rely on artificial intelligence chatbots such as the ChatGPT software program to assist with scientific writing?. *The Journal of prosthetic dentistry*.

[29] Jyothi, A.P., Shankar, A., Narayan JR, A., Gaur, P. and Kumar, S.S., 2023, December. Smart Non-Invasive Real-Time Health Monitoring using Machine Learning and IoT. In *2023 IEEE International Symposium on Smart Electronic Systems (iSES)* (pp. 437-440). IEEE.

[30] Acar, A.H., 2024. Can natural language processing serve as a consultant in oral surgery?. *Journal of Stomatology, Oral and Maxillofacial Surgery*, *125*(3), p.101724.

[31] Huang, H., Zheng, O., Wang, D., Yin, J., Wang, Z., Ding, S., Yin, H., Xu, C., Yang, R., Zheng, Q. and Shi, B., 2023. ChatGPT for shaping the future of dentistry: the potential of multi-modal large language model. *International Journal of Oral Science*, *15*(1), p.29.

[32] Almalki, A. and Latecki, L.J., 2023, April. Enhanced Masked Image Modeling for Analysis of Dental Panoramic Radiographs. In *2023 IEEE 20th International Symposium on Biomedical Imaging (ISBI)* (pp. 1-5). IEEE.

[33] Shafi, I., Fatima, A., Afzal, H., Díez, I.D.L.T., Lipari, V., Breñosa, J. and Ashraf, I., 2023. A comprehensive review of recent advances in artificial intelligence for dentistry E-health. *Diagnostics*, *13*(13), p.2196.

[34] Kalla, M.P., Vagenas, T.P., Economopoulos, T.L. and Matsopoulos, G.K., 2023. Deep learning-based registration of two-dimensional dental images with edge specific loss. *Journal of Medical Imaging*, *10*(3), pp.034002-034002.

[35] Haidar, Z.S., 2023. Digital dentistry: Past, present, and future. *Digital Medicine and Healthcare Technology.*