DETECTING DENTAL CARIES THROUGH CAPTURED IMAGES USING THE MACHINE LEARNING TECHNOLOGY TEACHABLE MACHINE.

ABSTRACT

Objective: The objective is to utilize open-source artificial intelligence tool Teachable Machine to detect dental caries.**Subjects and research methods:**cross-sectional description.The research involved analyzing a total of 2,063 digital images, comprising 1,563 images showing dental caries and 500 images depicting teeth without any signs of dental caries. **Results:**Among the 1,563 images featuring dental caries, the recognition tool accurately identified 1,512 images (96%), while 51 images remained undetected, representing 4% of the total.Among the entire set of 2,063 images, encompassing both those with and without dental caries, 1,512 images were accurately identified (73.3%), while 551 images (26.7%) were not detected to have dental caries. **Conclusion:**The study on 1,563 images with dental caries using the Teachable Machine learning tool yielded promising results, achieving a high accuracy rate of 96%. However, when applied to the mixed dataset of 2,063 images, the accuracy rate for identifying images with dental caries dropped to only 73.3. The variance is ascribed to the initial stages of dental caries, which closely resemble the color of healthy tooth enamel. Therefore, the research team proposes the necessity for additional data on this form of decay to enhance classification and identification accuracy.

Keywords:*artificial intelligence; machine learning; dental caries; teachable machine,*dental caries,tooth enamel,X-ray

I. INTRODUCTION

In modern times, the notion of Artificial Intelligence (AI) is commonplace. First termed by Arther Samuel in the 1950s, AI has gained notable momentum, particularly with Google's launch of Machine Learning (ML) systems in 2014.Machine Learning, a subset of AI, involves the research and construction of data repositories enabling systems to autonomously "learn" from the data provided, thus performing tasks previously exclusive to human capability. AI is being applied and supported across various domains including manufacturing, services, transportation, healthcare, entertainment, and information technology[1], [2], [3]. In Dentistry and Maxillofacial fields, AI is increasingly utilized to support oral disease consultations, dental caries diagnoses, treatment plan simulations for implant surgery, and outcome predictions post-orthodontic treatment. This contributes to improving the efficiency of examinations and treatments while simultaneously enhancing the quality of care provided.To accomplish this goal, it's crucial to create comprehensive datasets that allow machine learning systems to offer highly accurate diagnostic recommendations, ultimately saving time, effort, and improving workflow efficiency.Worldwide, researchers such as Srivastava have investigated and utilized machine learning tools to aid in the automated diagnosis of oral diseases using X-ray images[4]. Berdouses and colleagues also conducted research in 2015 on diagnosing

dental caries using a machine learning tool on 103 images[5]. In Vietnam, author Vo Truong Nhu Ngoc has also published research on the method of automatically diagnosing complications of wisdom teeth based on X-ray images[6]. However, the accessibility and proficiency in the AI domain for healthcare professionals continue to be intricate, often relying heavily on the expertise of information technology teams. Hence, the authors conducted research on utilizing the open-source tool Teachable Machine[7] to generate a dataset on dental caries pathology. The objective is to train machine learning models that can support healthcare professionals and aid in their initial diagnostic procedures.

II. SUBJECTS AND METHODS

2.1. Research Subjects:

Intraoral images diagnosed with dental caries.

Inclusion Criteria: Digital images diagnosed by clinicians with clinical evidence of dental caries lesions, clearly showing details such as color changes like yellow, brown, black spots, and deep cavities exposing dentin.

Exclusion Criteria: Images that do not meet standards (noisy images, blurry images, images with unclear lesions, images in incorrect formats) and do not meet the selection criteria mentioned above.

2.2. Research Methodology:

2.2.1. Study Period: From April 2023 to January 2024.

2.2.2. Study Location: The research was conducted at Becamex International Hospital, Binh Duong Province,Vietnam

2.2.3 Samples of dataset: 2063 intraoral images.

2.2.4. Methodology:cross-sectional description.We performed purposive sampling and assembled a dataset comprising 1,563 images displaying dental caries lesions. These images were clinically diagnosed by dentists who identified dental caries lesions during examinations, confirming their presence based on the images. Furthermore, we included 500 images of healthy teeth for comparative analysis.The characteristics of the imaging angles for dental caries lesions were: buccal, lingual, mesial, distal, occlusal.

2.2.5. Research Instruments:Intra-Oral Digital Camera GX-C300; Intraoral mirrors; Standard dental examination kit.

Figure 1. Intra-Oral Digital Camera GX-C300 (A); Intraoral mirror set (B).

The computer connected to the network utilizes the open-source platform Teachable Machine (TM) to train machine learning models with basic training parameters (epochs 50, Batch size 16; Learning rate 0.001). TM will utilize a pre-trained image recognition network named MobileNet to accurately identify patterns previously trained using the provided dataset [8].

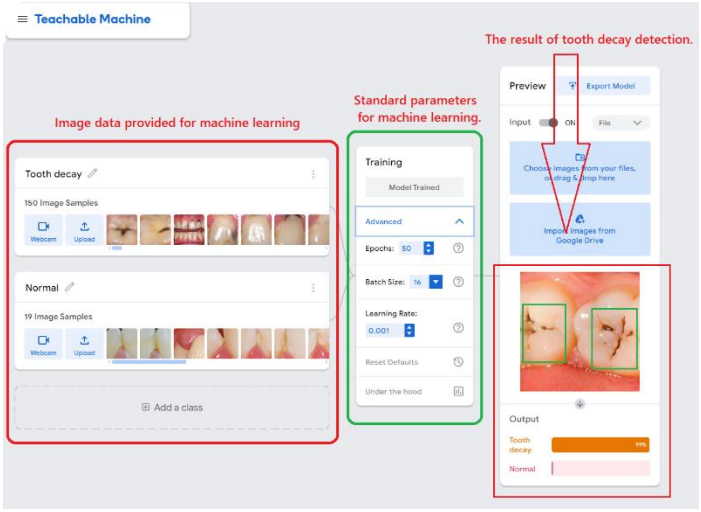

Figure 2. Model training process and results on Teachable Machine.

2.2.6. Data processing: SPSS 20.0 software and various statistical algorithms were utilized.

2.2.7

III. RESULTS:

3.1 Study sample: In this study, we conducted research with 1,563 images exhibiting dental caries lesions and 500 images of healthy teeth (for comparison).

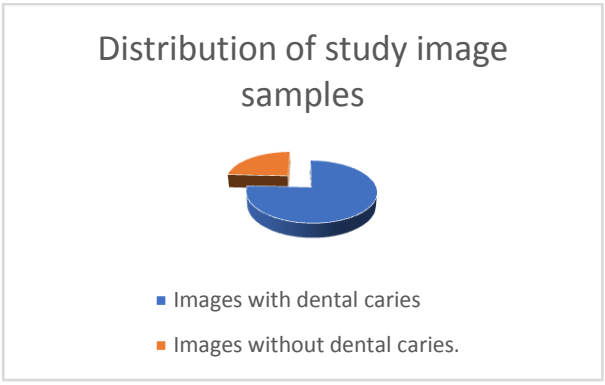

Chart 1. Distribution of the research sample.

3.2. Dental Caries Detection Rates Based on the Caries-Identified Dataset (n=1,563)

N=1563	Dental Caries	No Dental Caries
	1,512 (96%)	51 (4%)

Table 1. Detection rates of images with dental caries and without dental caries.

Among the 1,563 images featuring dental caries lesions, the Teachable Machine recognition tool accurately identified 1,512 images as having such lesions, constituting 96% of the dataset. However, 51 images were not detected to have dental caries lesions, making up 4% of the total.

3.3. Dental Caries Detection Rates Based on the Mixed Dataset (n=2,063)

N=2063	Dental Caries	No Dental Caries
	1,512 (73,3%)	551 (26.7%)

Table 2. Detection rates of images with dental caries and without dental caries.

In the combined dataset of 2,063 images, including both those with and without dental caries lesions, the Teachable Machine recognition tool accurately identified 1512 images as having such lesions, making up 73.3% of the dataset. However, 551 images were not detected to have dental caries lesions, representing 26.7% of the total.

IV. DISCUSSION:

"Dental caries is one of the major oral health problems and is increasing rapidly among people of every age (children, men, and women). Deep learning, a field of Artificial Intelligence (AI), is a growing field nowadays and is commonly used in dentistry. AI is a reliable platform to make dental care better, smoother, and time-saving for professionals. AI helps the dentistry professionals to fulfil demands of patients and to ensure quality treatment and better oral health care. AI can also help in predicting failures of clinical cases and gives reliable solutions. In this way, it helps in reducing morbidity ratio and increasing quality treatment of dental problem in population. Computer-based diagnosis is increasing momentum because of its capabilities in diagnosis of lesion and caries". [19] The various techniques that are applied to dentistry especially for detection of caries include adaptive neural network architecture [9], deep learning [10], an artificial multilayer perceptron neural network [11], convolutional neural network [12], backpropagation neural network [13], and *k*-means clustering [14].

The application of artificial intelligence remains a relatively nascent and challenging domain for healthcare practitioners. The Teachable Machine machine learning toolkit, known for its simplicity and accessibility, offers a convenient solution for medical personnel to easily engage with and deploy effectively. With a remarkable accuracy rate of 96% in correctly identifying deep dental caries, this tool's effectiveness exceeds that of a study conducted by Hyunja Jeong in 2020, which achieved an accuracy rate of 92.1% in distinguishing between toothed and toothless tongues using Teachable Machine[15]. In the Vietnamese context, Tran Sinh Bien has successfully applied Teachable Machine to real-time facial recognition, achieving a flawless recognition rate of 100%[16].Zanella-Calzada et al. [17] used "different types of algorithms of machine learning (SVM, *k*-Nearest Neighbor, Random Forest Regression, and Logistic Regression) on 5,135 dental images. On each algorithm, they divide the dataset into 80% and 20% of training and testing, respectively. Among them, they concluded that support vector machine (SVM) shows the highest accuracy, approximately 97.1%". Hung et al. [18] used "smart phone color photographs, and they used support vector machine (SVM) algorithm on a total of 620 unrestored molar/premolar images. On the 80% training and 20% testing division of dataset, SVM shows 92.37% accuracy".

These findings underscore the robust reliability of Teachable Machine in the identification of bodily features overall, and dental pathologies in particular, thereby paving the way for preliminary explorations of its application across various medical domains.

V. CONCLUSION:

The research outcomes from analyzing 1,563 images featuring dental caries lesions with the Teachable Machine machine learning tool reveal promising results, achieving a detection accuracy rate of 96%. In the combined dataset of 2,063 images encompassing both images with and without dental caries lesions, the accuracy rate for detecting images with dental caries lesions stands at 73.3%. This difference is attributed to the presence of early-stage dental caries lesions, where the lesion color resembles that of normal tooth enamel. Considering our findings, further well-designed studies are needed to demonstrate the diagnosis of further types of dental caries that are based on progression (chronic, acute, and arrested), which tells us about severity of caries, virginity of lesion, and extent of caries. AI in the future will emerge as supreme technology to detect other diseases of oral region combinedly and comprehensively because AI will easily analyze big dataset that contain multiple records. All the AI models provide dental professionals reliable information, improving clinical decision making process. Using AI techniques, high-quality-based patient care and innovated research in dentistry can be established.

Ethical Approval and Consent:

Informed Consent: Using patient data for training AI systems necessitates informed consent. Patients know how their data will be used and the potential risks and consents .

The ethical approval for the study from the Institutional Ethics Committee of Becamex International Hospital, Binh Duong, Vietnam was granted on March 12, 2023

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