SMILED
(**S**mart **M**achine for **I**dentifying Dental **Le**sion in **D**ental Radiograph)

SMILED is an innovative system that accurately segments dental lesions in radiographs using advanced image processing and machine learning. It addresses challenges in dental caries diagnosis by employing hybrid U-Net architectures and integrating various convolutional neural network models. Privacy concerns are addressed through differential privacy, protecting sensitive medical data during the training process. SMILED also incorporates MLOps methodologies, enabling continuous improvement of the models through validation by dental practitioners. By streamlining workflows and automating processes, SMILED improves dental diagnosis and treatment planning, which aligns with SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation, and Infrastructure), revolutionizing dental diagnostics and enhancing patient care.

(100 Words)

The Innovation in SMILED
(**S**mart **M**achine for **I**dentifying Dental **Le**sion in **D**ental Radiograph)

SMILED (Smart Machine for Identifying Dental Lesion in Dental Radiograph) is an innovative system designed for accurate segmentation of radiolucent lesions in dental radiographs. It utilizes Cone Beam Computed Tomography (CBCT) images along with advanced image processing techniques and machine learning algorithms. The primary objective of SMILED is to employ computer vision methodologies to efficiently partition radiolucent lesions and assess the intersection of union using various convolutional neural network architectures.

Precise segmentation of dental radiographs is essential for effective dental caries diagnosis. However, deep networks used for this purpose face challenges due to the diverse traits exhibited by oral carious lesions. The segmentation process becomes difficult due to various factors such as diverse lesion topologies, complex medical structures, and poor image quality caused by low contrast, noise, irregularities, and fuzzy borders. To address these challenges, SMILED introduces a novel approach by employing hybrid U-Net architectures including U-Net, DoubleU-Net, U2-NET, and SA-UNET. Each architecture is specifically designed for the segmentation of radiolucent lesions. The innovative aspect lies in the integration of these advanced models, which significantly enhances the accuracy and efficiency of the segmentation process.

Privacy of sensitive medical data is of utmost importance in healthcare applications. To address privacy concerns, SMILED implements a focus on differential privacy during model implementation. Differential privacy ensures that even with minor changes to the data, the query outputs generated cannot reveal significant information about any individual. This methodology provides robust privacy guarantees during the training process.

To further enhance the performance of the U-Net models, SMILED incorporates MLOps (Machine Learning Operations) frameworks. This integration enables continuous improvement and optimization of the models through efficient data management, reproducibility, and automated deployment. By leveraging these cutting-edge techniques, SMILED aims to significantly advance the accuracy and efficiency of radiolucent lesion segmentation in CBCT images. The integration of hybrid U-Net architectures, along with considerations for privacy

and the adoption of MLOps methodologies, contributes to the comprehensive and robust nature of the proposed solution.

The deployed instance of SMILED provides a comprehensive end-to-end solution for dental professionals. It allows practitioners to upload CBCT and Segmentation images, facilitating model training. A validation module enables the verification of results, while a visualization interface enhances the interpretability of the segmentation output and augmentation process. By streamlining the workflow and harnessing automation, SMILED contributes to improving the effectiveness and accuracy of dental diagnosis and treatment planning.

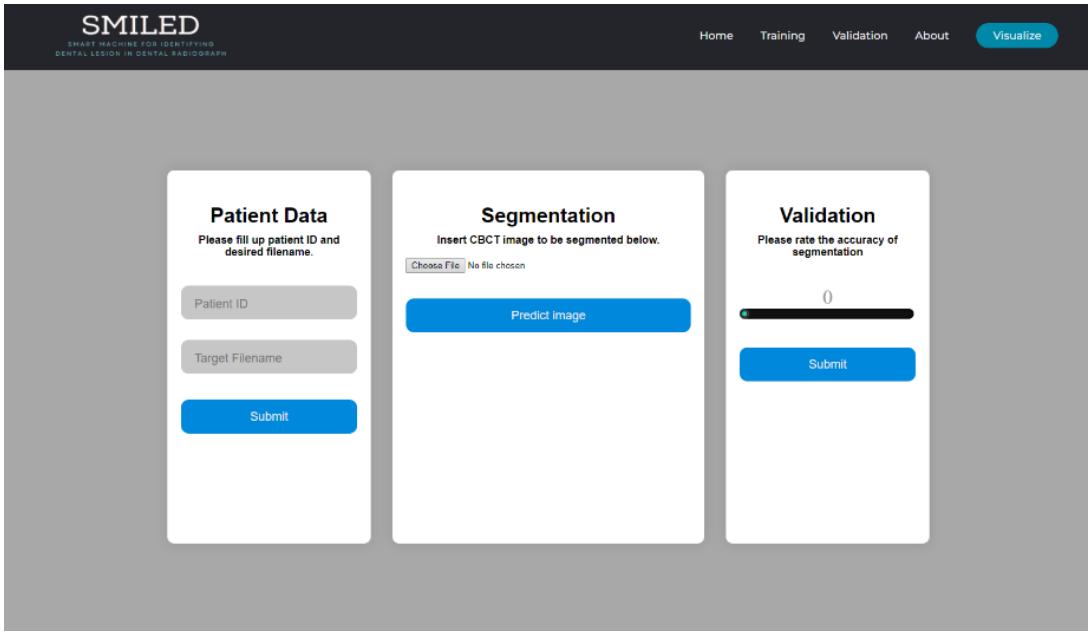
In summary, SMILED integrates cutting-edge image processing techniques, machine learning algorithms, and hybrid U-Net architectures to achieve accurate radiolucent lesion segmentation. By addressing privacy concerns and employing MLOps methodologies, SMILED contributes to the advancement of dental diagnostics, aligning with SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation, and Infrastructure). This integrated system provides dental professionals with a comprehensive solution, enabling efficient and reliable dental lesion identification and treatment planning. By revolutionizing the field of dental diagnostics, SMILED sets the stage for improved patient care and outcomes.

(500 Words)

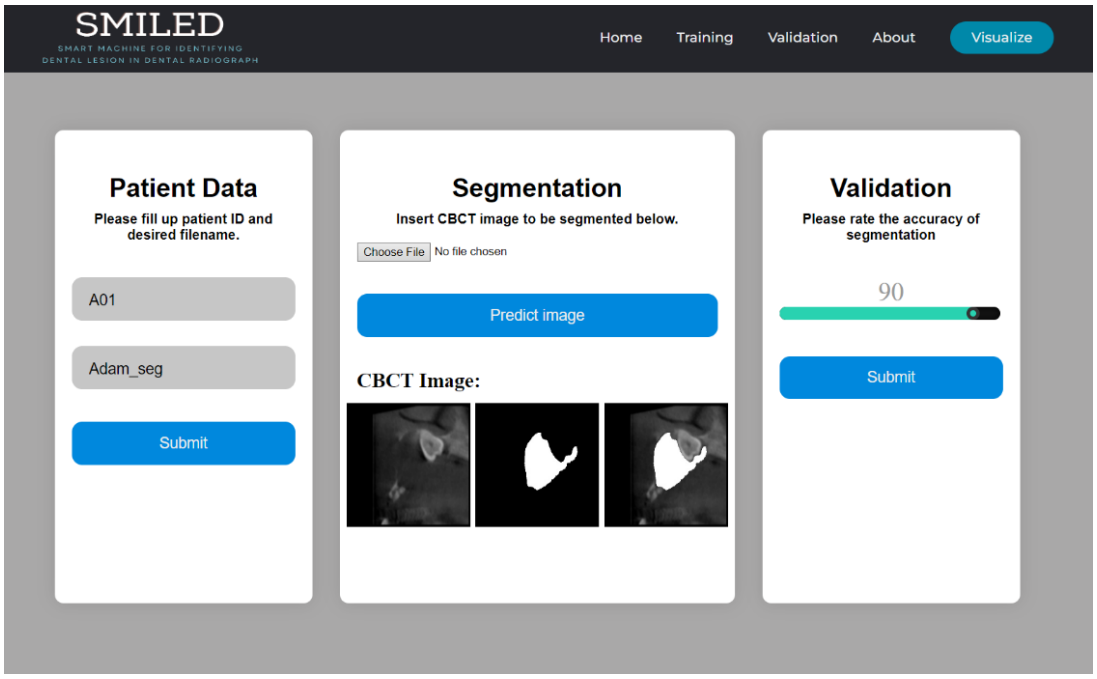
SCREENSHOT DEPLOYMENT

http://Dvision.live

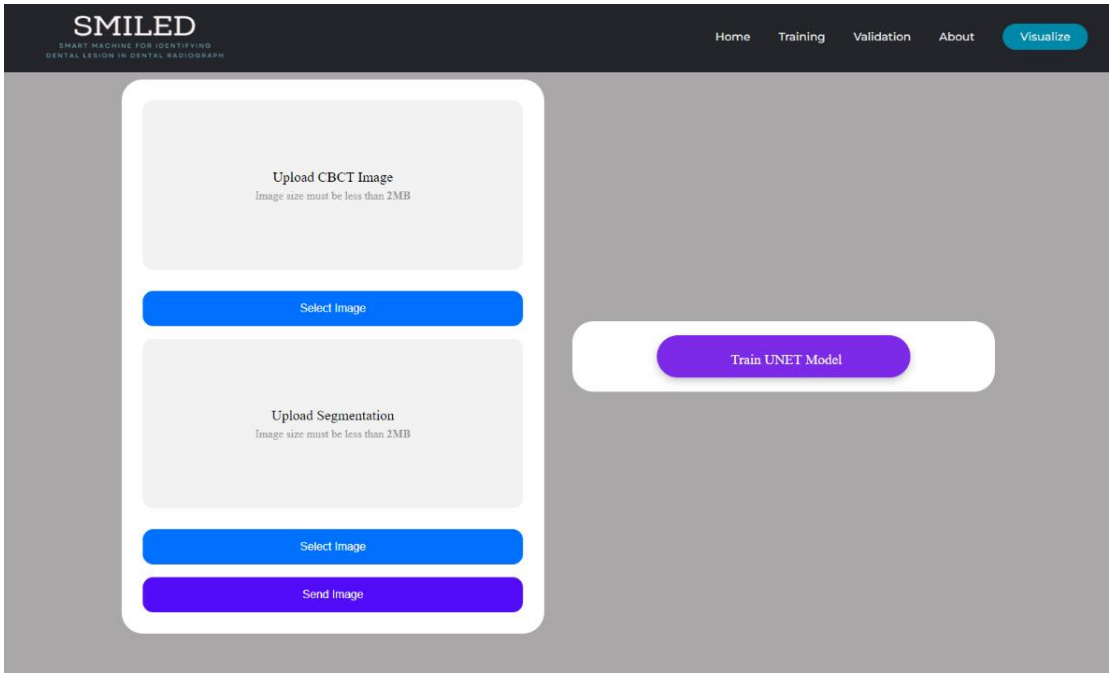
Home page - 1



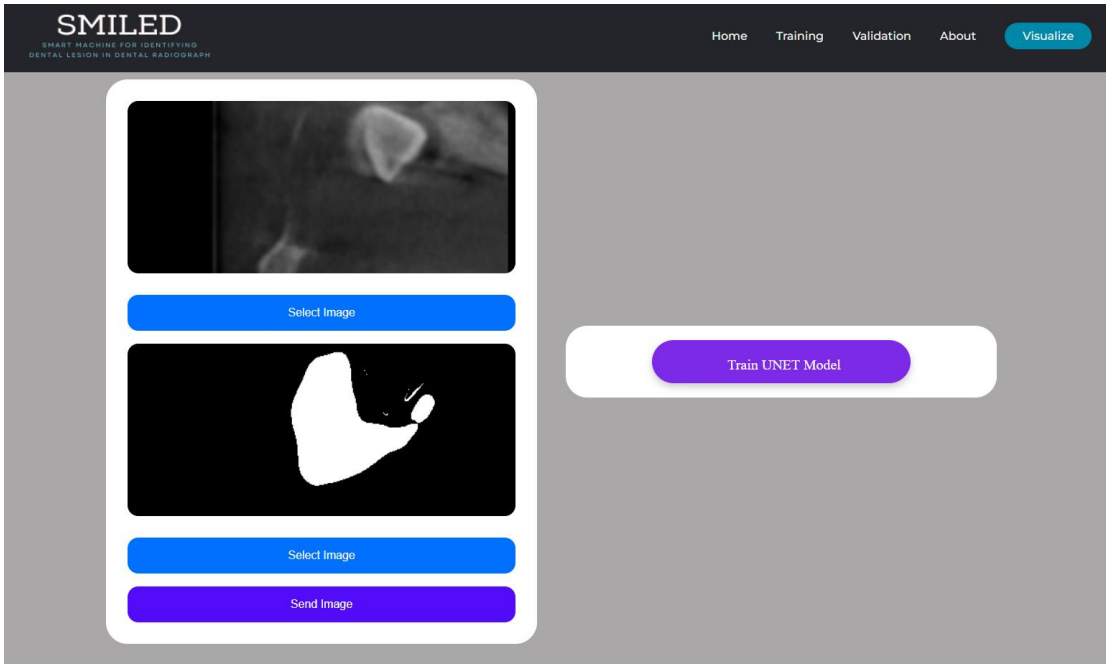
Home page – 2



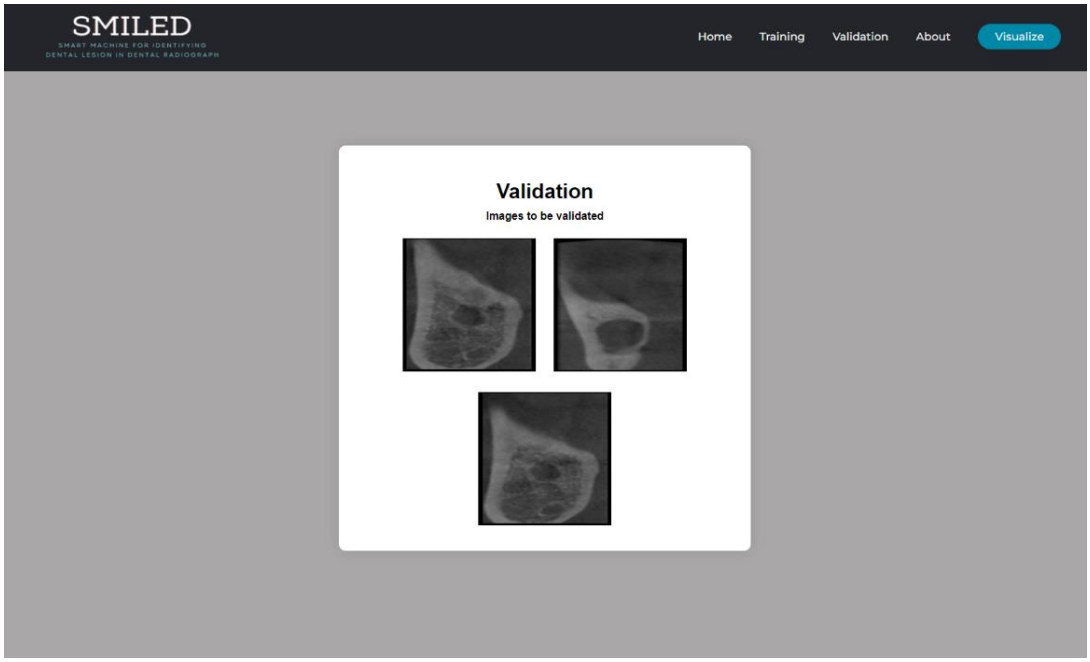
Training Page – 1



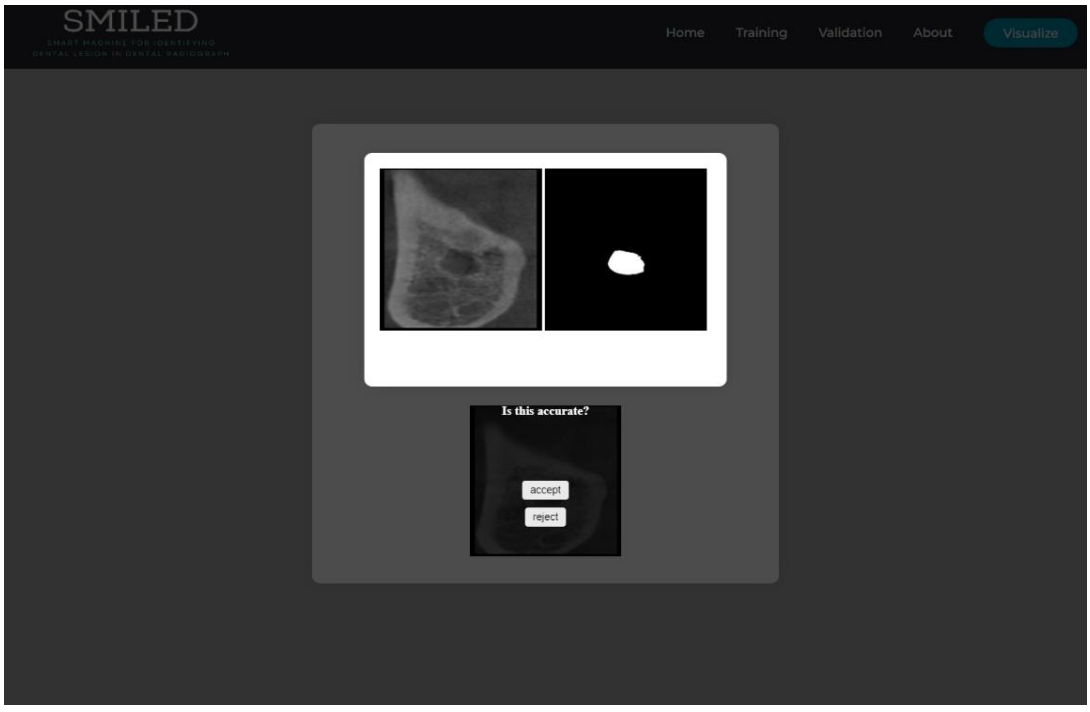
Training Page – 2



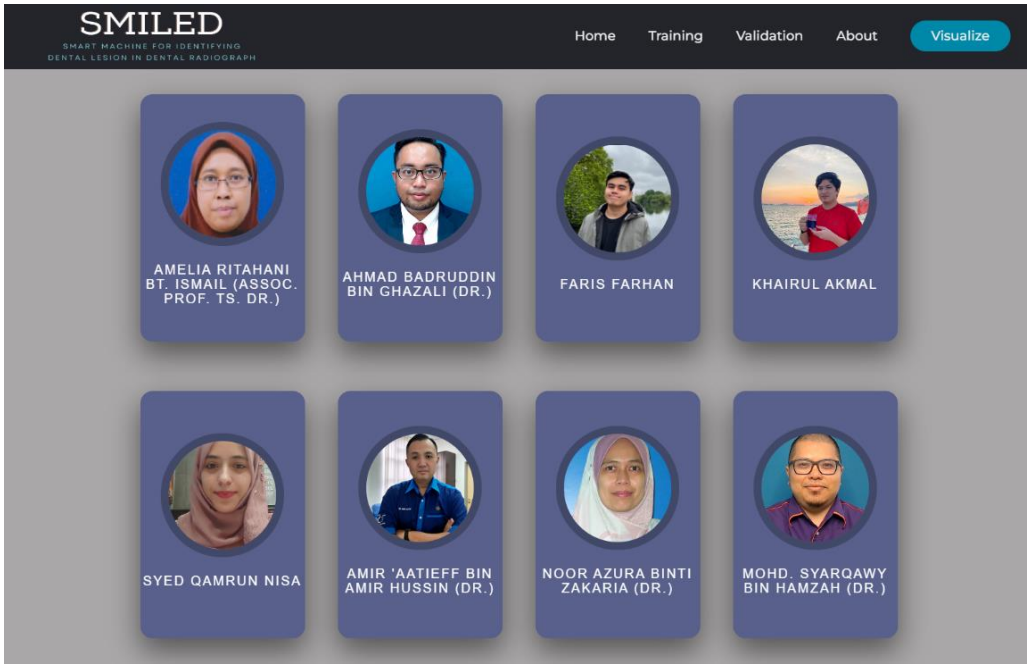
Validation Page – 1



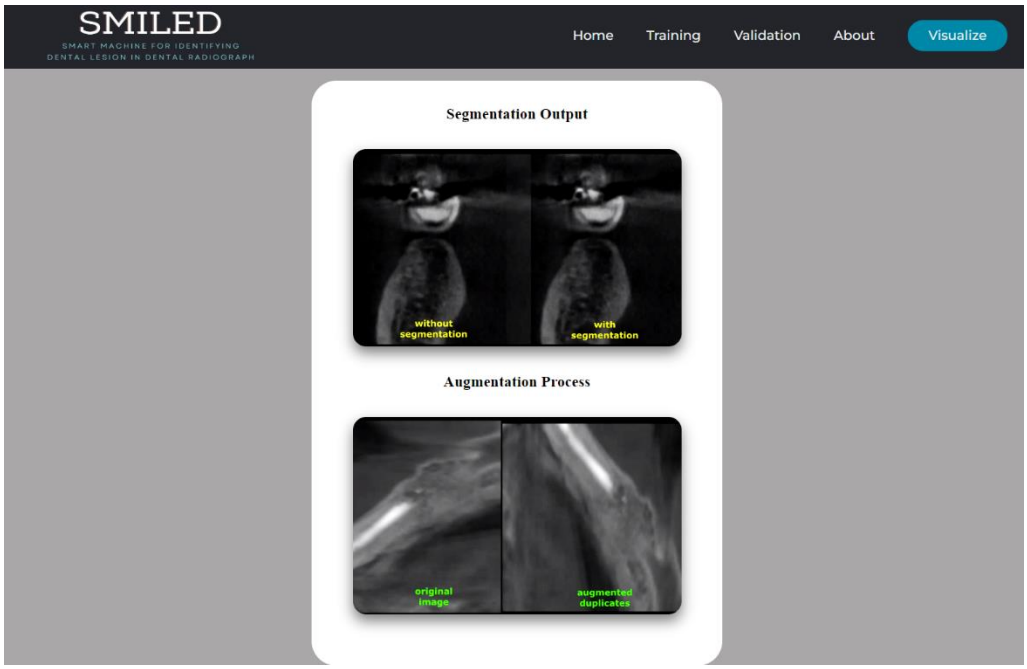
Validation Page - 2



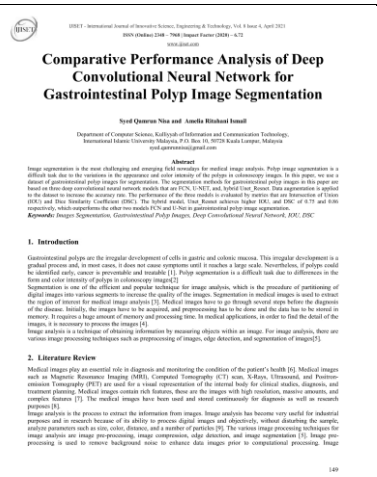
About Page



Visualization Page



PUBLICATIONS

Details	Evidence
Dual U-Net with Resnet Encoder for Segmentation of Medical Images **January 2022** **International Journal of Advanced Computer Science and Applications 13(12)** **DOI:10.14569/IJACSA.2022.0131265**	
Comparative Performance Analysis of Deep Convolutional Neural Network for Gastrointestinal Polyp Image Segmentation **April 2021** **International Journal of Innovative Research in Science Engineering and Technology 8(4):8**	
Medical Image Analysis using Deep Learning: A Review **December 2020** **DOI:10.1109/ICETAS51660.2020.9484287** **Conference: 2020 IEEE 7th International Conference on Engineering Technologies and Applied Sciences (ICETAS)**	

LETTER OF INTENTION

myDENTIST @ ampang

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Jalan Ampang Utama 1/2 , Taman Ampang Utama,
68000, Ampang, Selangor
03-4256 8444, 013-366 8444
mydentistampangplt@gmail.com ,

16 March 2023

Dear Professor Dr. Zainul Ahmad Rajion,

Thank you for issuing the Letter of Intent to Collaborate in Digital Dentistry Research between the International Islamic University Malaysia , the Premier DigitalTech University with myDENTIST@ampang .

2. It is my pleasure to respond to your letter and express our keen interest in working together with you on this exciting collaboration.

3. We are delighted to learn that you share our interest in digital dentistry research and that your university is committed to exploring areas such as artificial intelligence, 3D printing, dental radiology, dental diagnostics, and others. At Premier DigitalTech University, we strongly believe that collaboration between academia and industry is vital to advancing research and innovation in various fields, and we are excited to embark on this journey with you.

4. We appreciate the opportunity to work together on this collaboration, and we look forward to exploring the various areas of research that you have identified. We will strive to make this collaboration a success by bringing our expertise and resources to the table and by ensuring open communication and effective coordination between our teams.

5. Thank you once again for considering us as your partner in this endeavor. We are eager to start this collaboration and look forward to a fruitful and mutually beneficial partnership.

Best regards,

Dr Abu Razali Bin Saini
BDS (Mal)
Principal Dentist

C.c Dr Ahmad Badruddin Ghazali
BDS (IIUM), MSc OMFR (Mahidol)

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Appendix 1

Doc. No.: IIUM/204/6/8/1 (COPY)/f-01
Version no.: 01
Revision no.: 03
Effective date: 07 April 2022

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Kindly disclose your invention through this Copyright Disclosure Form for Intellectual Property (IP) Protection and Registration.

PART 1: IDENTIFICATION

1. **Principal Inventor Identification**

NAME OF PRINCIPAL INVENTOR & STAFF NO.	Amelia Ritahani Ismail
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CORRESPONDENCE ADDRESS	Dept. of Computer Science, Kulliyyah of Information and Communication Technology, IIUM
EMAIL	amelia@iium.edu.my
OFFICE TEL. NO. & H/P TEL. NO.	018-2765072 03-6421 5642

IMPORTANT REMINDER: -
Please state the details of the inventor/originator/co-inventor(s) in Attachment 1.

Intellectual Property (IP) (Please tick √ in the box)	**Sub Type (Please tick √ in the box)**
[√] Copyright	[ ] Literary [ ] Musical [ ] Artistic [ ] Film [ ] Sound [√] Others

Definition	**Duration of Protection**	**Notes**
Copyright is the exclusive right to control creative works created by the author, copyright owner and performer for a specific period governed under the Copyright Act 1987.	*-Literary, Musical or Artistic Works* 50 years after the death. *-Film, Sound Recordings and Performer* 50 years from the work was published. *-Broadcasts* 50 years from which the broadcasts was first made.	Works Eligible for Copyright • literary works; • musical works; • artistic works; • films; • sound recordings; • broadcasts; and • derivative works

PART 2: DESCRIPTION OF DISCLOSURE

1. **Title of disclosure**

   SMILED : Smart Machine for Identifying Dental Lesion

2. **Brief Description of the Disclosure**

   SMILED is an innovative system that accurately segments dental lesions in radiographs using advanced image processing and machine learning. It addresses challenges in dental caries diagnosis by employing hybrid U-Net architectures and integrating various convolutional neural network models. Privacy concerns are addressed through differential privacy, protecting sensitive medical data during the training process. SMILED also incorporates MLOps methodologies, enabling continuous improvement of the models through validation by dental practitioners. By streamlining workflows and automating processes, SMILED improves dental diagnosis and treatment planning, which aligns with SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation, and Infrastructure), revolutionizing dental diagnostics and enhancing patient care

   Usage of the Disclosure

   SMILED integrates cutting-edge image processing techniques, machine learning algorithms, and hybrid U-Net architectures to achieve accurate radiolucent lesion segmentation. By addressing privacy concerns and employing MLOps methodologies, SMILED contributes to the advancement of dental diagnostics, aligning with SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation, and Infrastructure). This integrated system provides dental professionals with a comprehensive solution, enabling efficient and reliable dental lesion identification and treatment planning. By revolutionizing the field of dental diagnostics, SMILED sets the stage for improved patient care and outcomes.

4. **Please attach the document below (Please tick √ in the box if attached)**

√	Detail backgrounds, description, and the document file.
√	The originality report by plagiarism software (*TurnItIn*) for manuscript (Only originality report with green range (1-24%) will be considered)

IREC

Our Ref. : IIUM/504/14/11/2/ IREC 2022-152
Date : 27 September 2022

Dr. Ahmad Badruddin Ghazal (Principal Investigator)
Kulliyyah of Dentistry
IIUM Kuantan Campus
25200 Kuantan Pahang

Dear Dr.,

The IIUM Research Ethics Committee (IREC) has reviewed your study protocol as mentioned below:-

ID NO.	:	**IREC 2022-152**
RESEARCH TITLE	:	**Segmentation of Dental Radiolucent Lesions from Cone Beam Computed Tomography Using Deep Learning Networks**
REGISTRATION DATE	:	**07 Sep 2022**
CO-INVESTIGATOR	:	**1. Assoc. Prof. Dr. Amelia Ritahani Ismail** **2. Prof. Dr. Zainul Ahmad Rajion** **3. Asst. Prof. Dr. Noor Azura Zakaria** **4. Asst. Prof. Dr. Amir Aatieff Amir Hussin**
STUDY SITE	:	**Kulliyyah of Dentistry IIUM** **SASMEC** **Kulliyyah of ICT IIUM**
SAMPLE SIZE	:	**100 cbct radiograph**
ETHICAL EXPIRY DATE	:	**27 September 2023**

The IIUM Research Ethics Committee (IREC) operates in accordance to the Declaration of Helsinki, International Conference of Harmonization Good Clinical Practice Guidelines (ICH-GCP), Malaysia Good Clinical Practice Guidelines and Council for International Organizations of Medical Sciences (CIOMS) International Ethical Guidelines

The following documents have been received and reviewed to the above study:-

1. Study Proposal/Protocol: Version 1, dated 15 Aug 2022
2. Approval Letter from Kulliyyah of Dentistry, IIUM
3. Principal Investigator's CV