

## SMILED (Smart Machine for Identifying Dental Lesion in Dental 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 (Smart Machine for Identifying Dental Lesion in Dental 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.

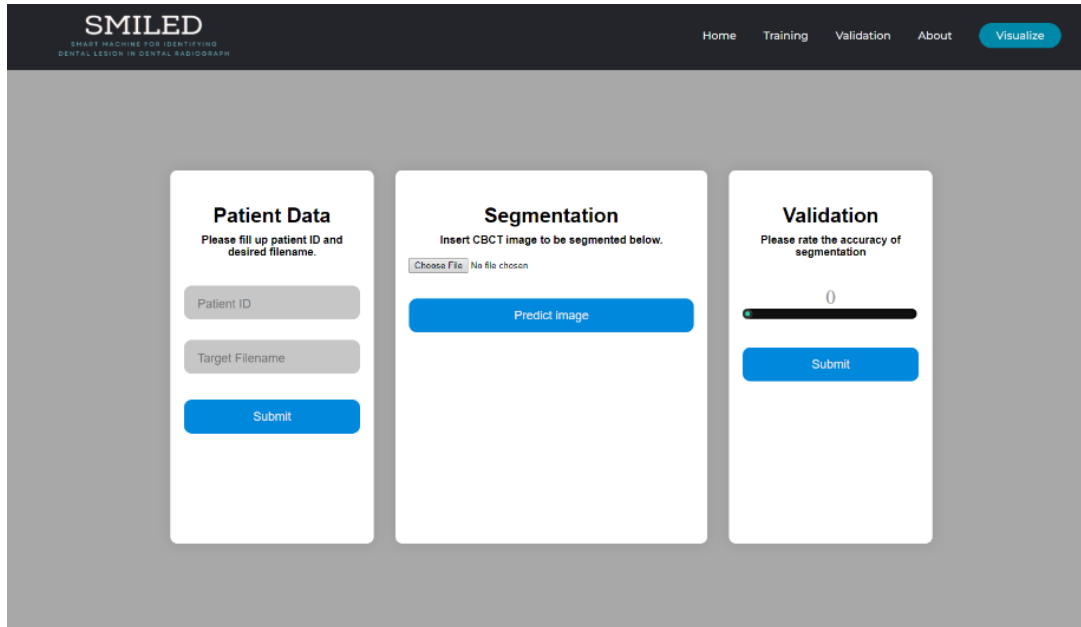
In summary, SMILED integrates cutting-edge image processing techniques, machine learning algorithms, and hybrid U-Net architectures to achieve accurate radiolucent lesion segmentation. By addressing privacy concerns and employing MLOps methodologies, SMILED contributes to the advancement of dental diagnostics, 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)**

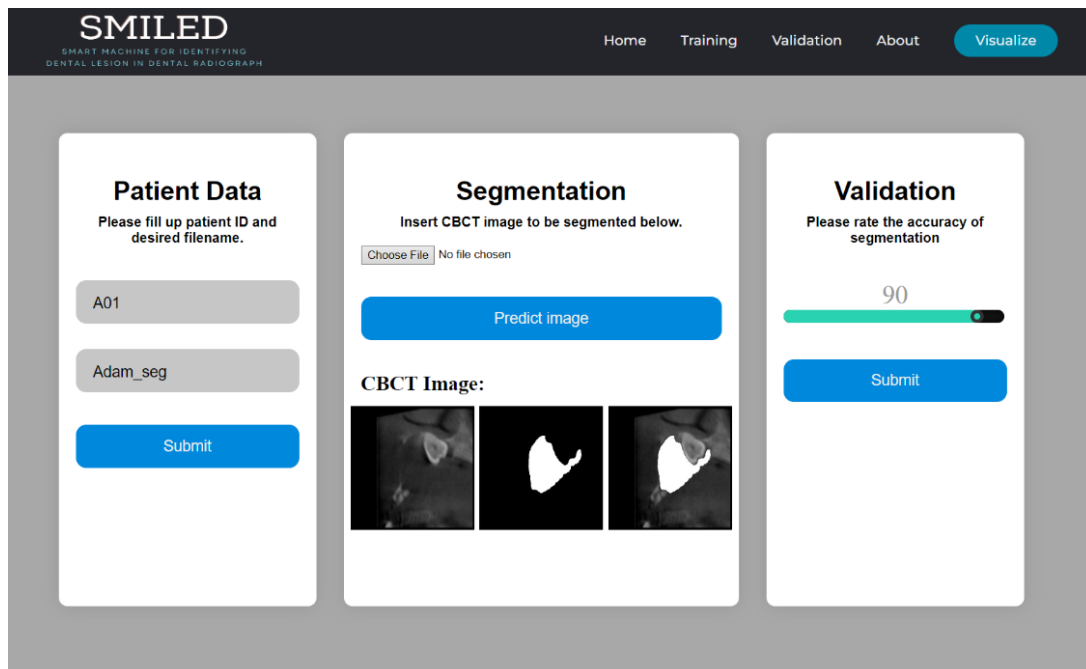
# SCREENSHOT DEPLOYMENT

<http://Dvision.live>

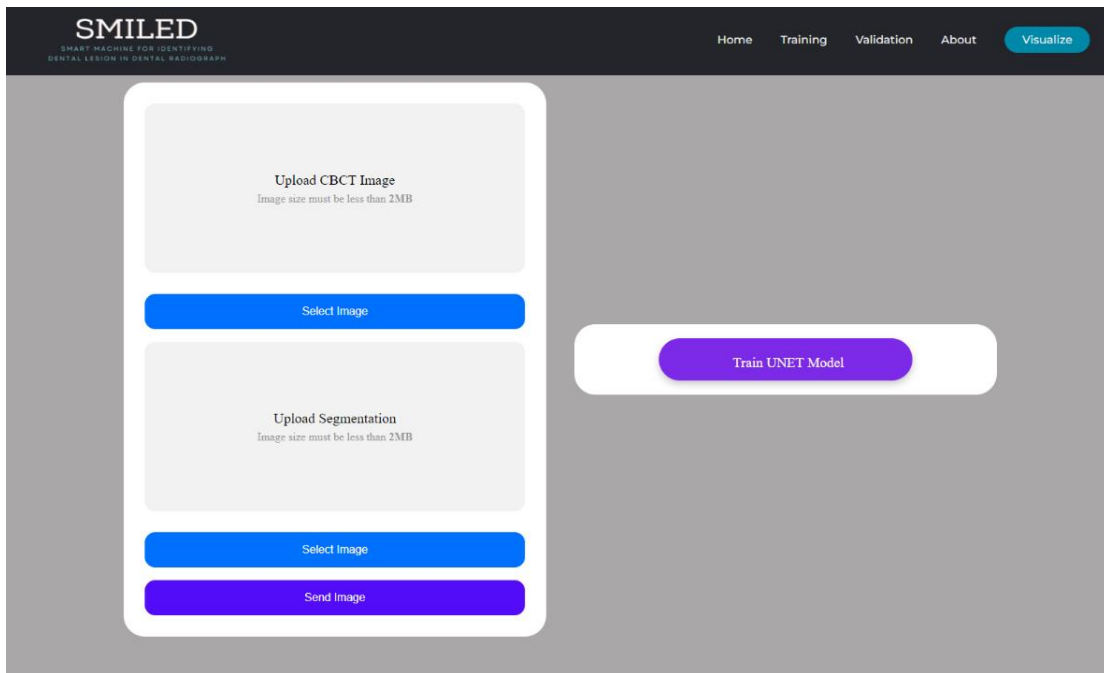
Home page - 1



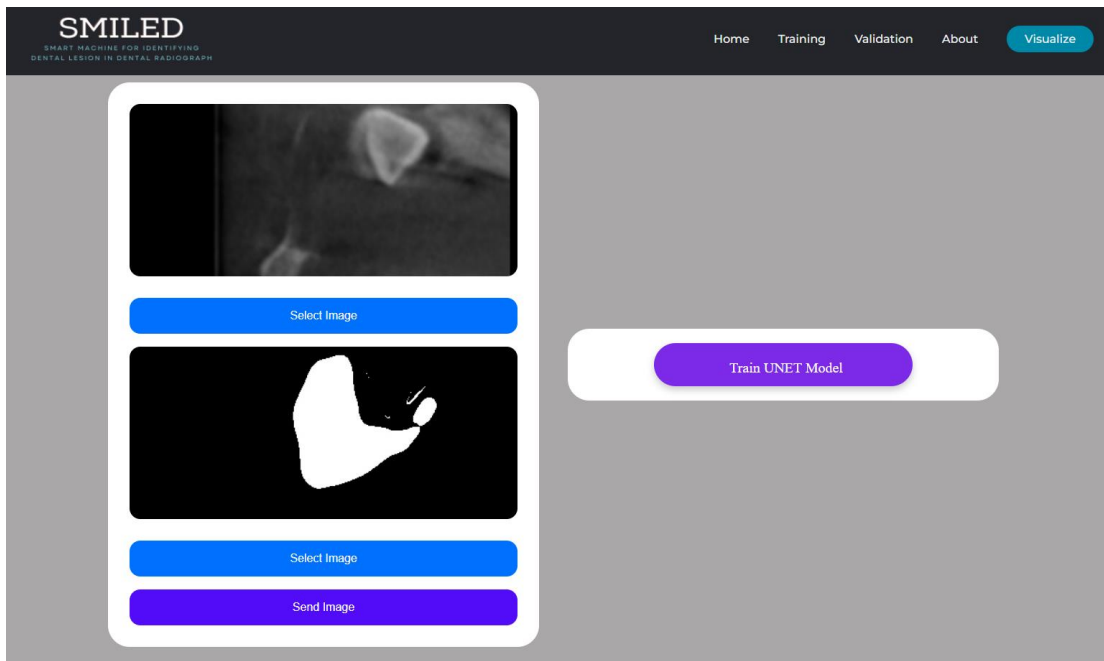
Home page - 2



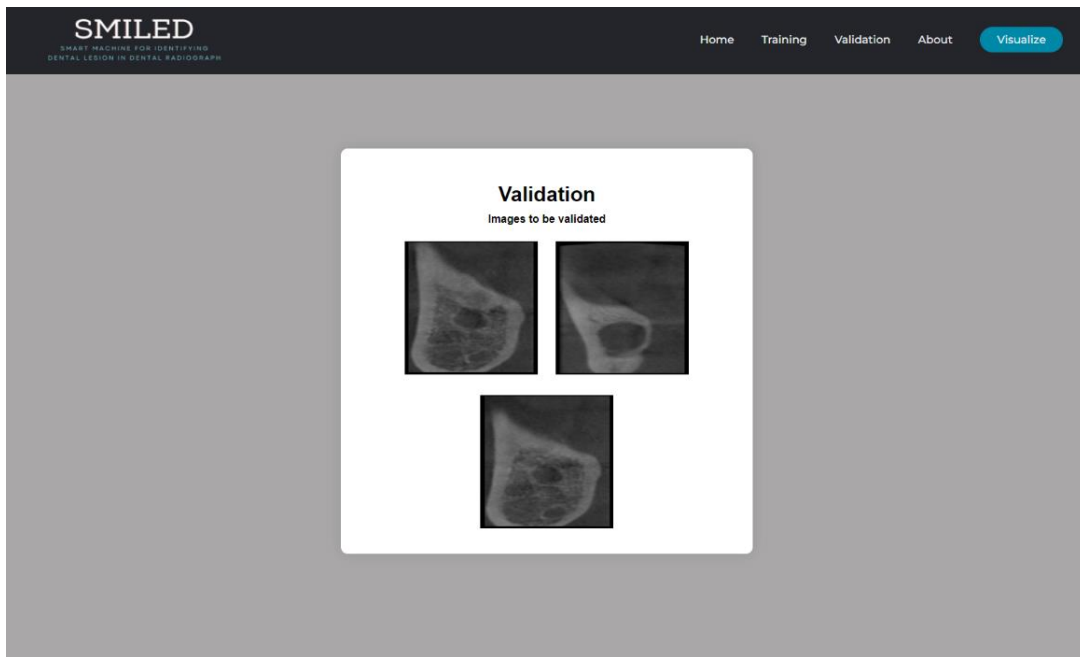
## Training Page – 1



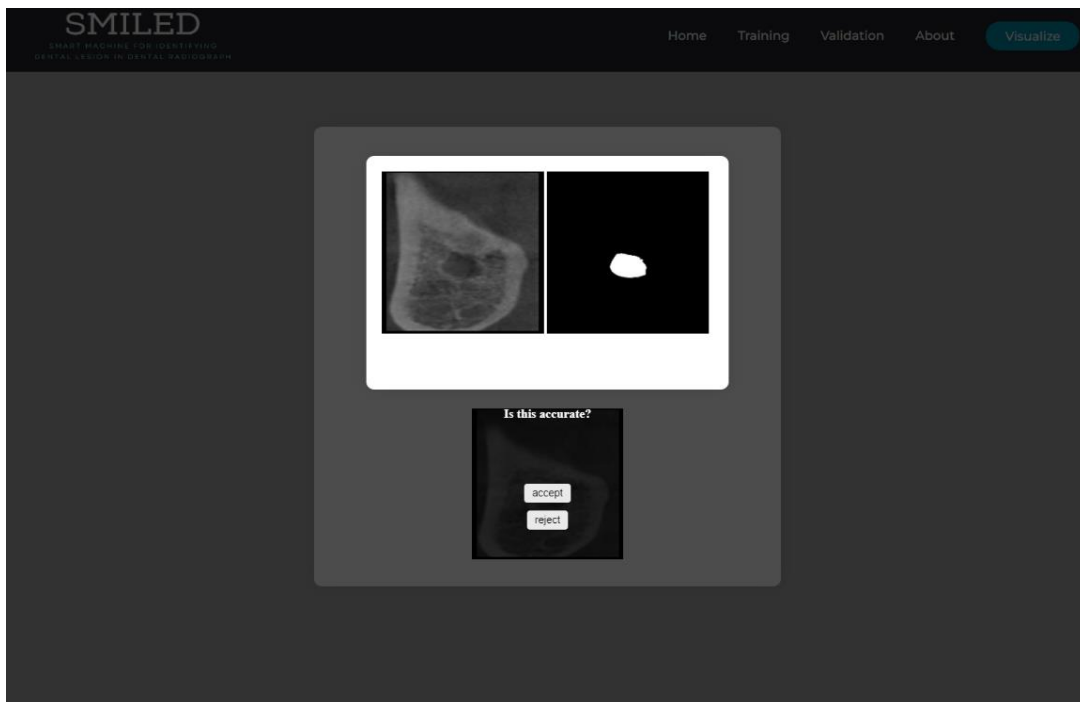
## Training Page – 2



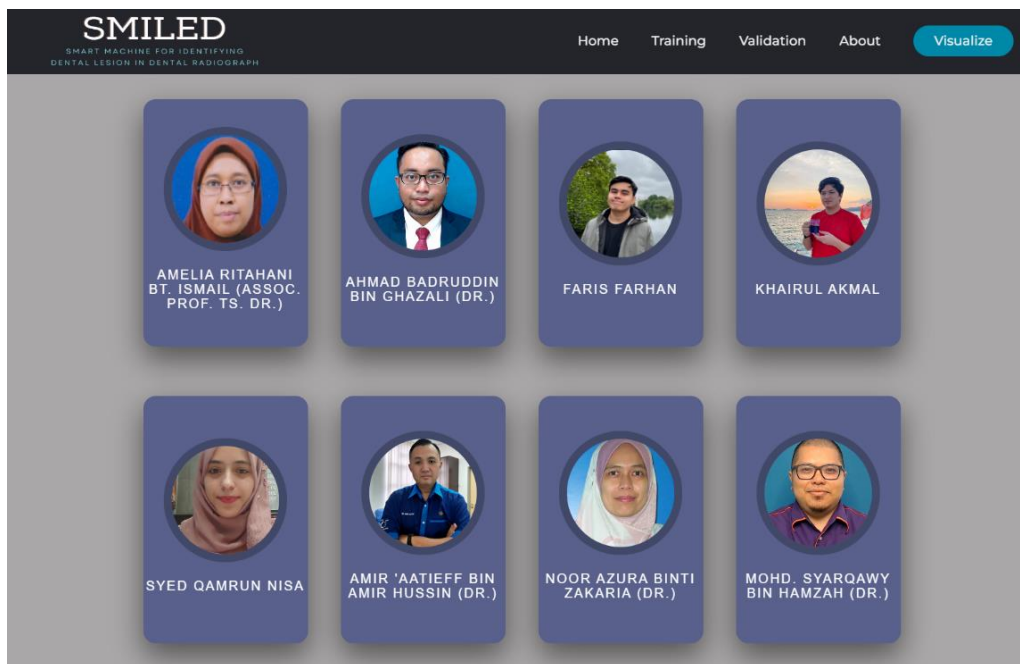
## Validation Page – 1



## Validation Page - 2



## About Page



The screenshot shows the 'About' page of the SMILED application. The header includes the logo 'SMILED' with the tagline 'SMART MACHINE FOR IDENTIFYING DENTAL LESION IN DENTAL RADIOGRAPH' and navigation links for 'Home', 'Training', 'Validation', 'About', and a 'Visualize' button. The main content area features eight team members, each with a circular portrait and their name and title below it:

- AMELIA RITAHANI BT. ISMAIL (ASSOC. PROF. TS. DR.)
- AHMAD BADRUDDIN BIN GHAZALI (DR.)
- FARIS FARHAN
- KHAIRUL AKMAL
- SYED QAMRUN NISA
- AMIR 'AATIEFF BIN AMIR HUSSIN (DR.)
- NOOR AZURA BINTI ZAKARIA (DR.)
- MOHD. SYARQAWY BIN HAMZAH (DR.)

## Visualization Page



The screenshot shows the 'Visualization' page of the SMILED application. The header is identical to the About page. The main content area displays two sets of images illustrating the system's output:

- Segmentation Output:** Two side-by-side dental radiograph images. The left image is labeled 'without segmentation' and the right image is labeled 'with segmentation', showing a white mask overlaid on the teeth.
- Augmentation Process:** Two side-by-side dental radiograph images. The left image is labeled 'original image' and the right image is labeled 'augmented duplicates', showing the original image with multiple copies of itself overlaid to demonstrate data augmentation.

PUBLICATIONS

Details	Evidence
<p><b>Dual U-Net with Resnet Encoder for Segmentation of Medical Images</b></p> <p><b>January 2022</b></p> <p><b>International Journal of Advanced Computer Science and Applications</b> 13(12)</p> <p><b>DOI:10.14569/IJACSA.2022.0131265</b></p>	<p><b>Dual U-Net with Resnet Encoder for Segmentation of Medical Images</b></p> <p><small>IJACSA: International Journal of Advanced Computer Science and Applications, Vol. 13, No. 12, 2022</small></p> <p><b>Syed Qamran Nisa, Amelia Rihanaul Hamid*</b> Department of Computer Science, Kolej Poly-Tek dan Komunikasi (Cotek), Universiti Islamiah Malaysia, P.O. Box 10, 50756, Kuala Lumpur, Malaysia</p> <p><b>Abstract</b>—Segmentation of medical images has been the most demanding and growing area currently in the world of medical images. Segmentation of polyp images is a huge challenge because of the variability of their depth and morphology by polyp throughout endoscopy imaging. For segmentation, in this work, we have used a dataset of images of the gastrointestinal polyp. The algorithm used in this paper for segmentation of gastrointestinal polyp images depend on pretrained deep convolutional neural network architecture: FCN, Dual U-Net with Resnet Encoder, U-Net, and Last Net. In segment for gastrointestinal data segmentation is performed on the dataset. The efficiency of the algorithm is measured by using metrics such as Dice Similarity Coefficient (DSC) and Intersection Over Union (IOU). The algorithm Dual U-Net with Resnet Encoder outperforms a higher DSC of 0.87 and IOU of 0.84 and better than other algorithms U-Net, FCN, and Last Net in segmentation of gastrointestinal polyp images.</p> <p><b>Keywords</b>—Segmentation, Medical Images, Deep Convolutional Neural Network, FCN, U-Net, ResNet, Dual U-Net with Resnet Encoder</p> <p><b>1. INTRODUCTION</b></p> <p>Image segmentation is one of the most widely and effectively used techniques for image analysis. Image analysis is a method of extracting data from images by analyzing the features within an image. There are a variety of image processing techniques that are used for image analysis, including edge detection, image processing, and image segmentation [1]. The fundamental purpose of image segmentation is to improve the image or extract relevant information from the image [2]. Segmentation is a useful yet challenging aspect of image processing for a number of image processing applications. Segmentation is the technique of isolating digital images into several segments to improve image quality.</p> <p>Segmentation of medical images, as an emerging medical image processing method, has made a significant contribution to the diagnosis and treatment of various diseases. In medical segmentation, performed to locate the area of interest [3]. Before an illness could be diagnosed, medical images must be through successive processes. Initially, images are captured from the microscope process. Initially, images that data must be stored in memory. That demands a significant memory space and a processing time. It is required to process images in medical applications in real-time process [4].</p> <p><small>*Corresponding Author.</small></p> <p><small>www.ijacsa.iaes.org</small></p>
<p><b>Comparative Performance Analysis of Deep Convolutional Neural Network for Gastrointestinal Polyp Image Segmentation</b></p> <p><b>April 2021</b></p> <p><b>International Journal of Innovative Research in Science Engineering and Technology</b> 8(4):8</p>	<p><b>Comparative Performance Analysis of Deep Convolutional Neural Network for Gastrointestinal Polyp Image Segmentation</b></p> <p><small>IEEE: International Journal of Innovative Research in Science Engineering &amp; Technology, Vol. 8, Issue 4, April 2021</small></p> <p><b>Syed Qamran Nisa and Amelia Rihanaul Hamid</b> Department of Computer Science, Kolej Poly-Tek dan Komunikasi (Cotek), Universiti Islamiah Malaysia, P.O. Box 10, 50756, Kuala Lumpur, Malaysia</p> <p><b>Abstract</b></p> <p>Image segmentation is the most challenging and emerging field currently in the medical image analysis. Polyp image segmentation is a significant task due to its variability in the appearance and morphology of polyp images. In this paper, we use a dataset of gastrointestinal polyp images for segmentation. The segmentation method for gastrointestinal polyp images in this paper are based on pretrained deep convolutional neural network architecture: FCN, Dual U-Net with Resnet Encoder, U-Net, and Last Net. In segment for gastrointestinal data segmentation is performed on the dataset. The efficiency of the algorithm is measured by using metrics such as Dice Similarity Coefficient (DSC) and Intersection Over Union (IOU). The algorithm Dual U-Net with Resnet Encoder outperforms a higher DSC of 0.87 and IOU of 0.84 and better than other algorithms U-Net, FCN, and Last Net in segmentation of gastrointestinal polyp images.</p> <p><b>1. Introduction</b></p> <p>Gastrointestinal polyps are the irregular development of cells in colon and colorectal tissues. The irregular development is a gradual process and in most cases, it does not cause symptoms until it reaches a large size. Description of polyp could be classified early, cancer is preventable and treatable [1]. Polyp segmentation is a difficult task due to differences in the form and color intensity of polyp images [2].</p> <p>Segmentation is one of the most widely and effectively used techniques for image analysis. Image analysis is a method of extracting data from images by analyzing the features within an image. There are a variety of image processing techniques that are used for image analysis, including edge detection, image processing, and image segmentation [1]. The fundamental purpose of image segmentation is to improve the image or extract relevant information from the image [2]. Segmentation is a useful yet challenging aspect of image processing for a number of image processing applications. Segmentation is the technique of isolating digital images into several segments to improve image quality.</p> <p>Segmentation of medical images, as an emerging medical image processing method, has made a significant contribution to the diagnosis and treatment of various diseases. In medical segmentation, performed to locate the area of interest [3]. Before an illness could be diagnosed, medical images must be through successive processes. Initially, images are captured from the microscope process. Initially, images that data must be stored in memory. That demands a significant memory space and a processing time. It is required to process images in medical applications in real-time process [4].</p> <p>Image analysis is a technique of obtaining information by measuring objects within an image. For image analysis, there are various image processing techniques such as preprocessing of images, edge detection, and segmentation of images [5].</p> <p><b>2. Literature Review</b></p> <p>Medical images play an essential role in diagnosis and monitoring the condition of the patient's health [6]. Medical images such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), X-ray, Ultrasound, and Endoscopy images. These images contain rich features, they are the images with high resolution, massive amounts, and various features [7]. The medical images have been used and used increasingly for diagnosis as well as research purposes [8].</p> <p>In the process to extract the information from images, image analysis has become very useful for industrial purposes and in research because of its ability to process digital images and objectively, without disturbing the source, output parameters such as size, color, distance, and a number of pixels [9]. The various image processing techniques for image analysis are image preprocessing, image compression, edge detection, and image segmentation [5]. Image processing is used to enhance background noise to enhance data image prior to computer processing. Image</p> <p><small>www.ijacsa.iaes.org</small></p>
<p><b>Medical Image Analysis using Deep Learning: A Review</b></p> <p><b>December 2020</b></p> <p><b>DOI:10.1109/ICETAS51660.2020.9484287</b></p> <p><b>Conference: 2020 IEEE 7th International Conference on Engineering Technologies and Applied Sciences (ICETAS)</b></p>	<p><b>Medical Image Analysis using Deep Learning: A Review</b></p> <p><small>2020 IEEE 7th International Conference on Engineering Technologies and Applied Sciences (ICETAS)</small></p> <p><b>Syed Qamran Nisa*, Amelia Rihanaul Hamid*, N. A. H. M. Ali*, Muhammad Shadiq Shah*</b> Department of Computer Science, Kolej Poly-Tek dan Komunikasi (Cotek), Universiti Islamiah Malaysia, P.O. Box 10, 50756, Kuala Lumpur, Malaysia</p> <p><b>Abstract</b>—Over the recent past, deep learning is one of the core research directions which has gained a great deal of attention due to its outstanding performance in the area of medical image analysis. This paper aims to review the current state-of-the-art deep learning methods in medical image analysis. The review is divided into two main parts: the first part is a survey of the state-of-the-art deep learning methods for medical image analysis including segmentation, object detection and classification. Deep learning techniques including convolutional neural networks (CNN), recurrent neural networks (RNN) and auto-encoders (AE) are also discussed in this paper.</p> <p><b>1. INTRODUCTION</b></p> <p>Deep learning (DL) is one of the most significant parts of machine learning that have accomplished excellent results in numerous areas such as image segmentation, object detection, speech recognition and natural language processing (NLP). In the recent years, the achievements of algorithms used in deep learning for numerous domain problems comes at a price that often medical data is progressively digitized. Current requirements for deep learning and numerous datasets have improved algorithms to understand the operation of medical experts as a exhaustive assessment of medical imaging tasks including data cancer classification, lymph node metastasis detection and diabetic retinopathy detection [1]. Nevertheless, most research applications require a number of image acquisition methods. Segmentation, object detection and classification using images produced from a wide range of modalities in clinical imaging [2]. Medical image analysis is one area of research for machine learning, comparatively of the fact that the data is generally organized and categorized [3]. The objective of the medical image analysis is to help clinicians and radiologists to enhance the right medical imaging method, for example, Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Ultrasound (US) are generally utilized for the diagnosis of abnormalities like cancer, heart, and so forth [4].</p> <p><b>II. MEDICAL IMAGES</b></p> <p>Medical images are generally used in radiographic methods in clinical studies, diagnosis and defining the time of treatment [5]. Medical images contain the Region of Interest (ROI) from the enhanced region in the human body and are available both in light and dark channel detection and labeling for diagnostics as well as in planning the line of treatment [6]. In the present days, medical imaging has</p> <p>accomplished a major improvement in the area of medicine. Medical imaging technology is classified because of its application prior to the surgery [7]. There are several types of medical imaging such as X-ray, Magnetic Resonance Imaging (MRI), Ultrasound (US), Mammography, Endoscopy, Angiography and Computed Tomography (CT). X-ray is the first that the image can be acquired. X-ray is a form of electromagnetic radiation that passing the entire image at the same time as there will be error in the image which is too coarse an information. It is better to concentrate on a specific area in medical imaging. The first goal of the image segmentation is to determine the area that applies an important part of the object for further analysis [8]. Segmentation methods for medical images can be classified into global, local and hybrid methods. Global methods apply segmentation techniques for the entire image. Local methods apply segmentation techniques for a specific part of the image. Hybrid methods apply segmentation techniques for the entire image and a specific part of the image. The various segmentation techniques implemented on medical images includes FCN, U-Net, ResNet, and Last Net [9].</p> <p><b>A. Segmentation</b></p> <p>Segmentation is a widely applicable subcategory in medical image analysis. An exact segmentation of medical images is a significant step in sharing during the course of radiology research. The process of sharing image results can be used in many different applications. Segmentation is a significant and important part in application of medical image analysis.</p> <p><b>B. Image Classification</b></p> <p>Image classification is the process of identifying and labeling of images into one of the various predefined categories. Classification has an important role in medical</p> <p><small>www.ijacsa.iaes.org</small></p>

# LETTER OF INTENTION



B7/1/1, One Ampang Avenue Business Centre,  
Jalan Ampang Utama 1/2 , Taman Ampang Utama,  
68000, Ampang, Selangor  
03-4256 8444, 013-366 8444  
[mydentistampangplt@gmail.com](mailto: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,

A handwritten signature in black ink, appearing to read 'Dr. Abu Razali Bin Saini', is written over a horizontal line.

Dr Abu Razali Bin Saini  
BDS ( Mal )  
Principal Dentist

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



# COPYRIGHT

Appendix 1

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



## Dar al-Hikmah Library

### COPYRIGHT DISCLOSURE FORM

#### Copyright Unit

Tel: 03-6421 3826 / 3866 Fax: 03-6421 4855 email: [crlib@iium.edu.my](mailto:crlib@iium.edu.my)

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

#### PART 1: IDENTIFICATION |

##### 1. Principal Inventor Identification

<b>NAME OF PRINCIPAL INVENTOR &amp; STAFF NO.</b>	Amelia Ritahani Ismail
<b>IC / PASSPORT NO.</b>	780212-10-6182
<b>DEPARTMENT &amp; KULLIYAH</b>	Dept. of Computer Science, Kulliyah of Information and Communication Technology, IIUM
<b>CORRESPONDENCE ADDRESS</b>	Dept. of Computer Science, Kulliyah of Information and Communication Technology, IIUM
<b>EMAIL</b>	amelia@iium.edu.my
<b>OFFICE TEL. NO. &amp; H/P TEL. NO.</b>	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 <input checked="" type="checkbox"/> in the box)	Sub Type (Please tick <input checked="" type="checkbox"/> in the box)		
<input checked="" type="checkbox"/> Copyright	<input type="checkbox"/> Literary	<input type="checkbox"/> Musical	<input type="checkbox"/> Artistic
	<input type="checkbox"/> Film	<input type="checkbox"/> Sound	<input checked="" type="checkbox"/> 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.	<p><i>-Literary, Musical or Artistic Works</i> 50 years after the death.</p> <p><i>-Film, Sound Recordings and Performer</i> 50 years from the work was published.</p> <p><i>-Broadcasts</i> 50 years from which the broadcasts was first made.</p>	<p>Works Eligible for Copyright</p> <ul style="list-style-type: none"> <li>literary works;</li> <li>musical works;</li> <li>artistic works;</li> <li>films;</li> <li>sound recordings;</li> <li>broadcasts; and</li> <li>derivative works</li> </ul>	

## 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)

- |                                     |                                                                                                                                                        |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input checked="" type="checkbox"/> | Detail backgrounds, description, and the document file.                                                                                                |
| <input checked="" type="checkbox"/> | The originality report by plagiarism software ( <i>TurnItIn</i> ) 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)  
Kulliyah 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** : Kulliyah of Dentistry IIUM  
SASMEC  
Kulliyah 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 Kulliyah of Dentistry, IIUM
3. Principal Investigator's CV

