



Republic of the Philippines  
 Southern Luzon State University  
**COLLEGE OF ENGINEERING**  
 Lucban, Quezon



March 1, 2023

DORACIE B. ZOLETA-NANTES, Ph.D  
 University President  
 Southern Luzon State University  
 Lucban, Quezon

Thru: MARISSA L. CADAO-ESPERAL, Ph.D  
 Vice-President for REDPI  
 Southern Luzon State University  
 Lucban, Quezon

NICANOR L. GUINTO, Ph.D  
 Director, Office of Research Services  
 Southern Luzon State University  
 Lucban, Quezon

Southern Luzon State University	
Office of the President	
<b>Received</b>	
Date:	3/13/23
Time:	7:00am
Received By:	

*[Signature]*

Dear Sir/Madam,

Good day! We humbly request for presentation financial assistance (PHP 11,274) if the funds still warrant for an accepted paper for this year's IEEE 13<sup>th</sup> Annual Computing and Communication Workshop and Conference (CCWC) to be held in Las Vegas, Nevada, USA (sponsored by UNLV) with provisions of virtual presentations.

The IEEE is arguably the most prestigious organization worldwide for Engineers and Technologists that aims to advance science further for the benefit of humanity.

We firmly believe that presentations (leading to publications) of our hard-earned work in knowledge generation can contribute to our future SUC leveling progress, the accreditation status of engineering programs, and other critical academic metrics of our University. Participation to world-class conference such as this has led to two collaborative Q1 Journal Publications as a result of professional networking activity during the event.

Moreover, we will make sure that the absolute ownership of the research primarily belongs to Southern Luzon State University during the process of IEEE research licensing and publications.

Attached in this letter are all the documents pertaining to the conference and the papers.

We are humbly requesting this matter in the overall interest of our university and we are hoping for a positive response on this request.

Thank you very much.

Very truly yours,

*[Signature]*  
 RENATO R. MAALIW III, DIT  
 Dean, College of Engineering  
 Southern Luzon State University

Noted:

*[Signature]*  
 NICANOR L. GUINTO, Ph.D  
 Director, Research Services  
 Southern Luzon State University

+Note: When approved by the president,  
 please charge to ONS GAA fund for  
 Training expense (Research presentation)

APPROVED / DISAPPROVED

*[Signature]*  
 Doracie B. Zoleta-Nantes, PhD  
 University President

Recommending Approval:

*[Signature]*  
 MARISSA C. ESPERAL, Ph.D  
 VP-REDPI  
 Southern Luzon State University

*[Signature]*  
 MAR 13 2023



Republic of the Philippines  
**SOUTHERN LUZON STATE UNIVERSITY**  
Lucban, Quezon

Office of Research Services

**AUTHORITY TO PARTICIPATE  
IN A RESEARCH CONFERENCE**

This is to certify that

**Renato R. Maaliw III, Zoren P. Mabunga & Ma. Rossana D. De Veluz**  
(name/s of researcher/s)

is/are hereby authorized to attend/present the paper entitled

**An Enhanced Segmentation and Deep Learning Architecture for  
Early Diabetic Retinopathy Detection**  
(Title of Paper)

in

**IEEE – 13<sup>th</sup> Annual Computing and Communication Workshop and Conference,**  
**March 9 – 12, 2023 (Philippine Date) in Las Vegas, Nevada, USA & Virtual**  
(Conference, Date, Venue)

on recommendation of the Office of Research Services and the Institutional  
Research Evaluation Committee.

**Nicanor L. Guinto, Ph.D**  
Director, Office of Research Services  
Co-Chair, IREC

**Marissa C. Esperal, Ph.D**  
Vice President, Research, Extension,  
Production, Development & Innovation  
Chair, IREC

**Doracie B. Zoleta-Nantes, Ph.D**  
University President  
Date: March 1, 2023



## **IEEE CCWC 2023**

**VIRTUAL CONFERENCE**

**The 2023 IEEE 13th Annual Computing and Communication  
Workshop and Conference**



# **CERTIFICATE OF PRESENTATION**

THIS IS HEREBY PRESENTED TO

**RENATO R. MAALIW III**

**(SOUTHERN LUZON STATE UNIVERSITY, PHILIPPINES)**

FOR THE PAPER TITLED

**AN ENHANCED SEGMENTATION AND DEEP LEARNING  
ARCHITECTURE FOR EARLY DIABETIC RETINOPATHY  
DETECTION**

IN THE SESSION

**PATTERN RECOGNITION AND ANALYSIS  
(SESSION 5)**

AT IEEE CCWC 2023

ON 8TH - 11TH MARCH 2023

LAS VEGAS, USA

A handwritten signature in black ink that appears to read "Son Vuong".

**SON VUONG**

General Chair, CCWC 2023

A handwritten signature in black ink that appears to read "Satyajit Chakrabarti".

**SATYAJIT CHAKRABARTI**

President, SMART Society



# IEEE CCWC 2023

The 2023 IEEE 13th Annual Computing and Communication Workshop and Conference

Las Vegas, USA & Virtual

8th – 11th March, 2023

All the timings are given in Pacific Standard Time (PST (UTC-08))

# TECHNICAL SCHEDULE

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DAY	EVENT DETAILS	TIMING	PAGE NUMBER
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	KEYNOTE 1: THE MEGA VANDERTEST	8:30 AM – 9:15 AM	6
	KEYNOTE 2 : ETHOMICS - THE AI ENABLED WAY TO UNDERSTAND HUMAN BEHAVIOUR	9:15 AM – 10:00 AM	6
	-----BREAK-----	10:00 AM – 10:15 AM	6
	SESSION 1: ALGORITHMS AND THEORY	10:15 AM – 11.45 AM	8
	SESSION 2: ALGORITHMS AND THEORY	10:15 AM – 11.45 AM	9
	SESSION 3: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	10:15 AM – 11.45 AM	10
	SESSION 4: BIG DATA AND BIOMEDICAL COMPUTING	10:15 AM – 11.45 AM	11
	SESSION 5: PATTERN RECOGNITION AND ANALYSIS	10:15 AM – 11.45 AM	12
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	SESSION 6: CLOUD COMPUTING ,COMPUTATIONAL INTELLIGENCE AND COMPUTER ARCHITECTURE	12:00 PM – 1:30 PM	13
	SESSION 7: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:00 PM – 1:30 PM	14
	SESSION 8: COMPUTER GRAPHICS, SIMULATION AND MODELING , CRYPTOGRAPHY AND APPLIED MATHEMATICS	12:00 PM – 1:30 PM	15
	SESSION 9: EMBEDDED SYSTEMS, GREEN AND WIRELESS COMPUTING	12:00 PM – 1:30 PM	16
	SESSION 10: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:00 PM – 1:30 PM	17

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DAY	EVENT DETAILS	TIMING	PAGE NUMBER
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	KEYNOTE 4: DISTRIBUTED AI SUPERCOMPUTING: FROM LARGE-SCALE TRANSFORMERS TO GRAPH NEURAL NETWORKS	8:45 AM – 9:30 AM	18
	KEYNOTE 5: INITIALIZING DEEP FULLY-CONNECTED NEURAL NETWORKS WITH CLOSED-FORM SOLUTIONS.	9:30 AM - 10.15 AM	18
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	SESSION 13: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	10:30 AM – 12:00 PM	22
	SESSION 14: SECURITY,TRUST AND PRIVACY	10:30 AM – 12:00 PM	23
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	SESSION 15: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:15 PM – 1:45 PM	24
	SESSION 16: SECURITY,TRUST AND PRIVACY	12:15 PM – 2:00 PM	25
	SESSION 17: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:15 PM – 1:45 PM	26
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DAY	EVENT DETAILS	TIMING	PAGE NUMBER
DAY 3  (10 <sup>th</sup> MARCH 2023)	KEYNOTE 6: ACCELERATING ILL-CONDITIONED LOW-RANK ESTIMATION VIA SCALED GRADIENT DESCENT	8:00 AM - 8:45 AM	28
	KEYNOTE 7: AI MODEL INSPECTOR: TOWARDS HOLISTIC ADVERSARIAL ROBUSTNESS FOR DEEP LEARNING	8:45 AM - 9.30 AM	28
	KEYNOTE 8: SUPERMAN VISION: FULLY INTEGRATED TERAHERTZ IMAGING RADAR IN CMOS	9.30 AM- 10.15 AM	28
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	SESSION 21: BIOMEDICAL COMPUTING AND CLOUD COMPUTING	10:30 AM – 12:00 PM	32
	SESSION 22: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	10:30 AM – 12:00 PM	33
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	SESSION 23: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:15 PM – 1:45 PM	34
	SESSION 24: COMPUTER ARCHITECTURE AND VLSI, GRAPHICS, SIMULATION AND MODELING	12:15 PM – 1:45 PM	35
	SESSION 25: CLOUD COMPUTING AND AI	12:15 PM – 1:45 PM	36
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All the timings are given in Pacific Standard Time (PST (UTC-08))

DAY	EVENT DETAILS	TIMING	PAGE NUMBER
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	KEYNOTE 10: A MACHINE LEARNING FRAMEWORK FOR DISTRIBUTED FUNCTIONAL COMPRESSION OVER	9.15 AM – 10.00 AM	38
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	SESSION 28: ROBOTICS AND SECURITY	11.00 AM – 12.15 PM	41
	SESSION 29: SYSTEMS AND SOFTWARE ENGINEERING, COGNITIVE NETWORKS AND CONTROL SYSTEMS	11.00 AM – 12.15 PM	42
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	SESSION 32: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	12:30 PM – 1:45 PM	45
	SESSION 33: WIRELESS COMMUNICATION	12:30 PM – 1:45 PM	46
	SESSION 34: CONTROL SYSTEMS AND APPLICATION, HUMAN COMPUTER INTERACTION AND INTERFACE	12:30 PM – 1:45 PM	47
	<b>Valedictory Session</b>	2:15 PM – 3:15 PM	48

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**SESSION 5: PATTERN RECOGNITION AND ANALYSIS****SESSION CHAIR : ASAI ASAITHAMBI (UNIVERSITY OF NORTH FLORIDA, USA)****SESSION TIME: 10.15 AM – 11:45 AM (DAY 1: 8<sup>th</sup> MARCH 2023)****PARTICIPATION LINK : <https://zoom.us/j/2997723153>**

TIME ALLOTTED	PAPER ID	PAPER NAME	AUTHORS WITH AFFILIATION & COUNTRY
10:15 AM – 10:30 AM	1570879671	Using Reinforcement Learning to Train Generative Adversarial Networks for Image Generation	Austin Nguyen and Rong Jin (California State University, Fullerton, USA)
10:30 AM – 10:45 AM	1570876810	An Enhanced Segmentation and Deep Learning Architecture for Early Diabetic Retinopathy Detection	Renato R. Maaliw III (Southern Luzon State University, Philippines); Zoren P Mabunga (Southern Luzon State University, Philippines & Mapua University, Philippines); Maria Rossana D. De Veluz (Southern Luzon State University, Philippines); Alvin Sarraga Alon (Batangas State University, Philippines); Ace Lagman and Manuel B. Garcia (FEU Institute of Technology, Philippines); Luisito L. Lacatan (Pamantasan Ng Cabuyao, Philippines); Rhowel M Dellosa (University of Northern Philippines, Philippines)
10:45 AM – 11:00 AM	1570879275	Explainable Neural Network Recognition of Handwritten Characters	Paul Whitten, Christos Papachristou and Francis Wolff (Case Western Reserve University, USA)
11:00 AM -11:15 AM	1570879001	A Systematic Review on Artificial Intelligence Models Applied to Prediction in Finance	Otman Hijazi and Kawtar Tikito (Rabat National Higher School of Mines, Morocco); Khadija Ouazzani-Touhami (Mohammed V University in Rabat & EMI - SIWEB Team, ENSMR - Rabat, Morocco)
11:15 AM – 11:30 AM	1570879252	Deep Learning Applications in BCI Based Lie Detection	Mohammad A Khalil, Johnny Can and Kiran George (California State University, Fullerton, USA)
11:30 AM -11:45 AM	1570877931	Road Curb Detection Based on a Deep Learning Framework	Min Zou and Yoichi Kageyama (Akita University, Japan)

**All the timings are given in Pacific Standard Time (PST (UTC–8))**

11:45 AM – 12:00 PM	<b>BREAK</b>
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**SESSION 10: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING****SESSION CHAIR : RENATO R. MAALIW III (SOUTHERN LUZON STATE UNIVERSITY, PHILIPPINES)****SESSION TIME: 12:00 PM – 1:30 PM (DAY 1: 8<sup>th</sup> MARCH 2023)****PARTICIPATION LINK : <https://zoom.us/j/2997723153>**

TIME ALLOTTED	PAPER ID	PAPER NAME	AUTHORS WITH AFFILIATION & COUNTRY
12:00 PM – 12:15 PM	1570874335	Classification of Road Objects Using Convolutional Neural Networks	Mann Patel and Heba Elgazzar (Morehead State University, USA)
12:15 PM – 12:30 PM	1570878873	An IoT Intrusion Detection System Based on TON_IoT Network Dataset	Ge Guo, Xuefeng Pan, He Liu, Fen Li, Lang Pei and Kewei Hu (Wuhan Qingchuan University, China)
12:30 PM – 12:45 PM	1570879285	Airbnb Rental Price Prediction Using Machine Learning Models	Eman Abdelfattah and Alexander Lektorov (Sacred Heart University, USA); Shreehar Joshi (Ramapo College of New Jersey, USA)
12:45 PM – 1:00 PM	1570878327	Machine Learning in Embedded Systems: Limitations, Solutions and Future Challenges	Eleftherios Batzolis (International Hellenic University, Greece); Eleni Vrochidou (International Hellenic University (IHU), Greece); George A Papakostas (International Hellenic University, Greece)
1:00 PM – 1:15 PM	1570880964	Prompting Large Language Models With the Socratic Method	Edward Y Chang (Stanford University, USA)
1:15 PM – 1:30 PM	1570878330	Machine Learning Based Intrusion Detection for IoT Edge Devices	Maram Alsharif and Danda B. Rawat (Howard University, USA)

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## PARALLEL SESSIONS

### SESSION 11: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

SESSION CHAIR : RENATO R. MAALIW III (SOUTHERN LUZON STATE UNIVERSITY, PHILIPPINES)

SESSION TIME: 10:30 AM – 12:00 PM (DAY 2: 9<sup>th</sup> MARCH 2023)

PARTICIPATION LINK: <https://zoom.us/j/4109219194>

TIME ALLOTTED	PAPER ID	PAPER NAME	AUTHORS WITH AFFILIATION & COUNTRY
10:30 AM – 10:45 AM	1570879294	Recent Advances in Cybersecurity and Fraud Detection in Financial Services: A Survey	Aakriti Bajracharya, Barron Harvey and Danda B. Rawat (Howard University, USA)
10:45 AM – 11:00 AM	1570880386	Recent Advances in Artificial Intelligence Enabled Tutoring Systems: A Survey	Ismail Yesir and Danda B. Rawat (Howard University, USA)
11:00 AM -11:15 AM	1570875577	Classification Challenges and Analysis of Traffic Patterns for Highly Congested Areas in <>AREA<>	Eduardo Alonso, Daniel A Alonso and Damian Valles (Texas State University, USA)
11:15 AM – 11:30 AM	1570878341	Applying Deep Reinforcement Learning for Detection of Internet-Of-Things Cyber Attacks	Curtis Rookard and Anahita Khojandi (University of Tennessee Knoxville, USA)
11:30 AM – 11:45 AM	1570878540	IoT Security: AI Blockchaining Solutions and Practices	Hephzibah Rajan, John Burns and Chetan Jaiswal (Quinnipiac University, USA)
11:45 AM – 12:00 PM	1570881016	Forecasting of Air Quality Index in San Francisco Using Machine Learning	Barathwaja Subash Chandar and Prashanth Rajagopalan (University of North Dakota, USA); Prakash Ranganathan (University of North Dakota, United Kingdom (Great Britain))

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Zoom Meeting

Recording

Rajashree - Tech... Phil Bradford Satyajit Chakrabarti Smart Society\_Sujata Dharati Dholariya >

Sanghamitra Poddar Prof. Son Vuong, General Chair CCWC 2023

Participants (57)

- MG Malay Gangopadhyay
- NE Nada Elmaradny
- Piayali Chandra
- PG Pooja Goyal
- PS Pradipta Sarkar
- PK Prasenjit kr das CST UEMK
- PN Prof. Nirban Kumar Saha
- PSS
- S S
- SM SANJUKTA MISHRA
- Sarah Martel
- Saswati Barman
- SR Seshariana Rahma Melati
- Shambhu Chakrabarty
- SL Sonam Lowry
- Takako Hoshiyama
- TB Tania Bhowmik

Invite Unmute Me

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12:21 am  
09/03/2023

Zoom Meeting

Recording

Alex Bayen

Renato R. Maaliw III

Satyajit Chakrabarti

Prof. Son Vuong, General Chair CCWC 2...

Phil Bradford

Rajashree - Tech...

Dharati Dholariya

Smart Society\_S...

Brett Wiens

Austin Nguyen

Dr. Maumita Ch...

Tyler Ward

Dr. Sukalyan Go...

Curtis Rookard

William

lidong Wang

Dr.Sudipta Basu...

Translator

Takako Hoshiyama

Amartya Mukherjee

Chiradeep Mukh...

Aparajita Mukh...

Pooja Goyal

Pabak

Unmute Start Video Participants 55 Chat Share Screen Record Reactions Apps Whiteboards Leave

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ENG US

1:14 am 09/03/2023 1

**Participants (55)**

Find a participant

- Renato R. Maaliw III (Me)
- Smart Society\_Sujata (Host)
- Alex Bayen (Co-host)
- Phil Bradford (Co-host)
- Prof. Son Vuong, ... (Co-host)
- Aldo Faisal
- Rajashree - Techni... (Co-host)
- Satyajit Chakrabarti (Co-host)
- Aakriti Bajracharya
- Amartya Mukherjee
- Anindita Das
- Aparajita Mukherjee
- Asiri Gawesha
- Austin Nguyen
- Ayan Kumar Panja
- Brett Wiens
- Chetan Fadnis
- ...
- Invite Unmute Me

**Zoom Meeting**

**Participants (11)**

- Presenter 2 - Renato R. Maaliw III (Me) (Recording)
- NKS SMART Conference7 (Host)
- Presenter 3 - Paul Whitten
- NKS SMART Conference7 (Co-host)
- Asai Asaithambi
- HIZAII
- Presenter 1 - Austin Nguyen
- Rona Jin
- Mohammad Affan Khalil
- Presenter 1 - Austin Nguyen
- Presenter 3 - Paul Whitten

**2023 IEEE 13<sup>th</sup> Annual Computing and Communication Workshop and Conference (IEEE CCWC)**

# An Enhanced Segmentation and Deep Learning Architecture for Early Diabetic Retinopathy Detection

**Renato R. Maaliw III**  
College of Engineering  
Southern Luzon State University  
Lucban, Quezon, Philippines

**Zoren P. Mabunga**  
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**Luisito L. Lacatan**  
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**Rhowel M. Dellosa**  
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2:48 am 09/03/2023



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## An Enhanced Segmentation and Deep Learning Architecture for Early Diabetic Retinopathy Detection

**Renato R. Maaliwi III**  
College of Engineering  
Southern Luzon State University  
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**Zoren P. Mabunga**  
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Research Development Office  
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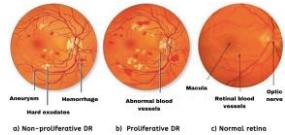
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## I. INTRODUCTION

**Diabetic (excessive sugar levels) retinopathy is a serious complication needing prompt diagnosis and medication to avert vision loss.**

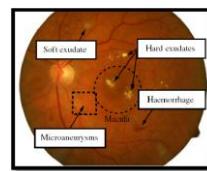


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**Lesions caused by the condition are **difficult** to track because they are hidden behind the eye's structures.**



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**Most of the time, ophthalmologists **manually** evaluates scans to spot the abnormalities**

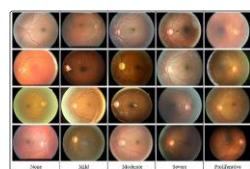


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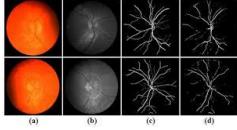
**Today, experts in computer vision are **starting to pay significant attention** to automated diabetic retinopathy (DR) detection.**



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Since the image segmentation's output is **critical** to classification success, it has been the subject of numerous papers based on literature.



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Existing literature cited different methods' advantages and disadvantages in DR detection, but we are confident that there are still **gaps in early detection**.

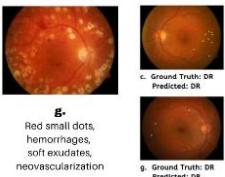


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In the advanced stage of DR, vascular markings are noticeable. However, it is **not the case for early and mild conditions**.



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As a contribution to science, we proposed a pipeline with extensive preprocessing techniques, **enhanced segmentation algorithms with atrous pyramid pooling**, and a modularized **attention aware deep CNN** for DR classification.



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Our study can assist eye expert in **reliably** predicting its progression at the **earliest possible time** for necessary treatment using AI.



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## II. METHODOLOGY

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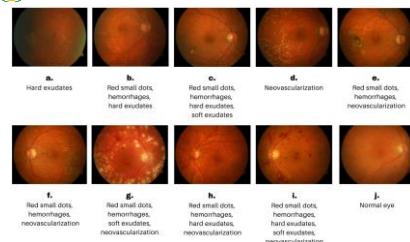
## A. Datasets & Preprocessing

- 388 high-resolution fundus images divided equally to two independent groups (DiaretDB0 & DiaretDB1) – 194 each (Normal & DR)
- Images are normalized into 512 x 512 pixels to compensate for size differences.

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## B. Data Augmentation

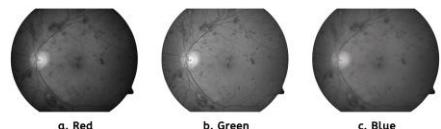
- We applied geometric transformation (flipping and rotations) to produce additional 1552 synthetic data with a total of 1940 images, **970 for each class**.
- **80/20 training and testing split**, with 10 early case of DR samples excluded using a **10-fold cross-validation**.

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## C. Color Adjustments for Maximum Feature Extraction



Prioritizing the **green channel** produced finer and greater information (b) than the other channels (a & c).

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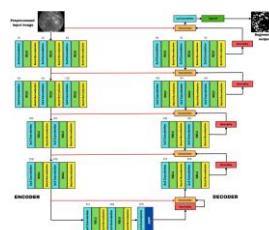
## D. Enhanced Segmentation Technique

- We **modified the U-Net architecture** to address lesion, exudates, and microaneurysms using semantic segmentation.
- **3 Major Parts:** Encoder, Bottleneck, and Decoder.

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Proposed DR-U-Net for lesion segmentation of DR in fundus images with 3 parts (**encoder, decoder & bottleneck**)

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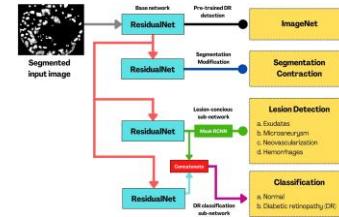
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## E. A Modified Attention-Aware Deep Convolutional Neural Network Architecture

- Three sections: **segmentation adjustment (SA), lesion-conscious (LC) and DR detection sub-networks** based on ResidualNets and MaskRCNN.



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Our attention-aware deep convolutional neural network with 3 sub-networks for detection of diabetic retinopathy

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## F. Evaluation Metrics

- **For segmentation:** Intersection over Union (IoU) and Dice similarity coefficient (DSC)
- **For classification:** Accuracy, Precision, Sensitivity, and Specificity

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## E. Evaluation Metrics (Equations)

$$IoU = \frac{|G \cap R|}{|G| + |R| - |G \cap R|} \quad (1)$$

$$DSC = \frac{2|G \cap R|}{|G| + |R|} \quad (2)$$

$$Accuracy (AC) = \frac{TP + TN}{TP + TN + FP + FN} \quad (3)$$

$$Precision (PR) = \frac{TP}{TP + FP} \quad (4)$$

$$Sensitivity (SE) = \frac{TP}{TP + FN} \quad (5)$$

$$Specificity (SP) = \frac{TN}{TN + FP} \quad (6)$$



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## III. RESULTS



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### A. Attention Aware DCNN's Hyperparameter Optimization via Baye's search optimization

TABLE I ATTENTION-AWARE DCNN'S OPTIMIZED CONFIGURATIONS

Hyperparameters	Settings
Batch size	16
Decay	0.001 per epoch
Environment	GPU
Epoch	100
Loss	Cross-entropy (Binary)
Learning rate	0.001
Optimizer	ADAM
Shuffling	Per epoch

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## B. Segmentation Performance

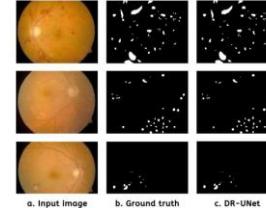
TABLE II. COMPARATIVE SEGMENTATION EVALUATIONS

K-fold	DR-UNET		U-NET		RES-UNET	
	IoU	DSC	IoU	DSC	IoU	DSC
1	0.863	0.850	0.721	0.778	0.803	0.818
2	0.882	0.849	0.713	0.743	0.799	0.815
3	0.861	0.843	0.749	0.734	0.813	0.809
4	0.863	0.842	0.811	0.789	0.821	0.813
5	0.871	0.848	0.789	0.812	0.834	0.814
6	0.872	0.853	0.748	0.787	0.817	0.821
7	0.874	0.847	0.758	0.787	0.813	0.820
8	0.861	0.842	0.748	0.791	0.809	0.818
9	0.889	0.839	0.801	0.813	0.818	0.826
10	0.878	0.841	0.812	0.812	0.805	0.821
Mean	<b>0.871</b>	<b>0.845</b>	0.765	0.786	0.813	0.817

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## B. Segmentation Performance (DR-UNet vs. Ground Truth)



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## C. Classification Performance (Benchmarks)

TABLE III. COMPARATIVE PERFORMANCE AGAINST DIFFERENT TECHNIQUES

Approach	AC	PR	SE	SP
Conventional DL [27]	0.861	0.790	0.840	0.820
Ensembles [28]	0.869	0.803	0.881	0.855
Lesion isolation [29]	0.920	0.820	0.88	0.831
Multi-Saving [30]	0.961	0.814	0.978	0.921
Modified AlexNet [31]	0.966	0.953	0.953	0.973
Circular Hough - CNN [17]	0.985	-	0.996	0.982
Hessian matrix + CNN with skip connection & bottleneck [18]	0.987	0.972	0.996	0.982
Proposed DR-UNet with ASPP - Attention-aware DCNN	<b>0.992</b>	<b>0.989</b>	0.994	<b>0.989</b>

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## C. Classification Performance (Confusion Matrix)

TABLE IV. CLASSIFICATION CONFUSION MATRIX  
(TRAINING = 1930, TESTING = 386 WITH HOLDOUT = 10)

		Normal	DR
Normal	191	2	
DR	1	192	

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## C. Classification Performance (Early DR Detection)

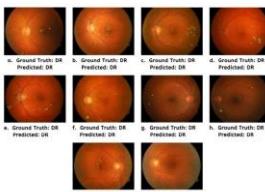


Fig. 8. The amplified segmentation technique and attention-aware DCNN recognized every signs of DR (i-e) except for (j).

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## D. Model Training-Validation Loss and Accuracy

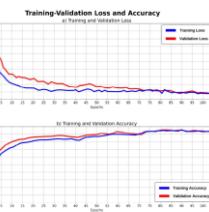


Fig. 9. A gradual convergence are achieved indicating no signs of under or overfitting.

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## V. DISCUSSIONS

This study introduced an **enhanced segmentation technique (DR-UNet)** and **attention aware DCNN** for DR detection.

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Based on benchmarks, our **DR-UNet with ASPP mechanism outperforms** standard U-Net and Res-UNet architecture with 0.871 (IoU) and 0.845 (DSC) – an improvement of 0.082 and 0.043.

Compared with different existing techniques, our proposed **attention-aware with multiple sub-networks** architecture attained **99.20%** classification accuracy.

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Furthermore, the model's **exceptional performance** was validated by its capability to detect DR's early **signs** according to validation sets.

Training/Validation loss and accuracy exhibited slow but gradual and smooth convergence rate showing no signs of over or under fitting.

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We encountered noisy and low-quality fundus images that can lead to segmentation and classification errors.

As per limitation, we did not examine methods for improving image quality, such as 'image dehazing' and spatial filtering.

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## V. CONCLUSIONS AND FUTURE WORKS

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DR is severe consequence of diabetes that can cause significant vision loss or even blindness if not detected and treated properly.

We developed two strategies to boost lesion detection in DR.

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Primarily, an enhanced segmentation framework (DR-UNet) with ASPP that can extract more relevant information and discards irrelevant regions from fundus images.

As compensation and solution, we incorporated a sub-network in our attention-aware DCNN for adjusted fitting.

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**Stacks of Rnets** with pre-trained base, segment contraction, lesion conscious (with MaskRCNN), and concatenation networks proved to be **robust** in DR's identification, including early stage cases.

Our research significantly contributed to the medical image prognosis to identify DR automatically and non-invasively.

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Artificial Intelligence is a valuable tool in healthcare industry and it should supplement human expertise.

By consolidating the strengths of both approaches, we can create a healthcare system that is more efficient and effective at meeting the patient's needs.

It is most effective when combined with traditional healthcare practices to provide patients with possible comprehensive care.

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We intend to create a better neural network design in the future to classify based on DR levels or severities.

Thank you very much for listening.

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**Authors** Renato R. Maaliw III (Southern Luzon State University, Philippines); Zoren P Mabunga (Southern Luzon State University, Philippines & Mapua University, Philippines); Maria Rossana D. De Veluz (Southern Luzon State University, Philippines); Alvin Sarraga Alon (Batangas State University, Philippines); Ace Lagman and Manuel B. Garcia (FEU Institute of Technology, Philippines); Luisito L. Lacatan (Pamantasan Ng Cabuyao, Philippines); Rhowel M Dellosa (University of Northern Philippines, Philippines)



**Paper title** An Enhanced Segmentation and Deep Learning Architecture for Early Diabetic Retinopathy Detection Only the chairs can edit

**Conference and track** 2023 IEEE 13th Annual Computing and Communication Workshop and Conference (CCWC) - CCWC Paper - Regular Research Paper

**Abstract**  Only the chairs can edit Diabetic retinopathy is a serious complication needing prompt diagnosis and medication to avert...

**Keywords** attention-aware DCNN; atrous spatial pyramid pooling; blindness; fundus images; lesion detection; ophthalmology Only the chairs can edit

**Topics** Artificial Intelligence and Machine Learning; Pattern Recognition and Analysis (Only the chairs can edit)

**Personal notes** Mar 2, 2023 19:20 Asia/Hong\_Kong [Alternate Video Presentation Link: https://youtu.be/h9p5NRCIYlk](https://youtu.be/h9p5NRCIYlk)

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**Final manuscript** [Presentation](#)



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completed

Comments for reviewers

In this paper, the authors created a robust pipeline using multiple preprocessing techniques and an attention-aware deep-learning convolutional network with different modules based on ResidualNet. The flow chart helps the reader understand the principle very well. The paper is well-organized and numerical result is reasonable.

completed

### Comments for reviewers

The importance of research is well established by how it can be an alternative to traditional diagnosis technique. The paper clearly explains the methodology involved in data collection, preprocessing and feature-engineering. The analysis of data and the results look promising in identifying the ailment in its early and advanced stages.

completed

### Comments for reviewers

Thanks for giving me an opportunity to review it. This study introduced an enhanced segmentation technique and attention-aware DCNN for identifying Diabetic retinopathy.

My suggestions are:

- 1-It should to add the link of the database.
- 2-Literature gaps of the discussed papers should be given.
- 3- What are your novelties and contributions? Please highlight them

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Research Acceptance x



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to me, Zoren, Maria, Alvin, Ace, Manuel, Luisito, Rhowel ▾

Fri, Jan 20, 2:36 PM



Dear Dr. Renato Maaliw:

Congratulations - your paper #1570876810 ('An Enhanced Segmentation and Deep Learning Architecture for Early Diabetic Retinopathy Detection') for CCWC 2023 has been accepted for virtual presentation. Please do the necessary changes according to the review report and upload the Camera-Ready Paper(Camera-Ready/Final Paper must be in doc or in pdf format). Please also register for IEEE CCWC 2023 before the registration deadline otherwise the paper will not be submitted for publication at IEEE Xplore Digital Library.

The reviews are below or can be found at <https://www.edas.info/showPaper.php?m=1570876810>.

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===== IEEE CCWC 2023 2 =====

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===== IEEE CCWC 2023 3 =====

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Regards,  
The conference chairs  
IEEE CCWC 2023



Renato Racelis Maaliw III <renatomaaliw3@gmail.com>  
to CCWC ▾

Fri, Jan 20, 2:41PM



Thank you. This is noted.

Dr. Renato R. Maaliw III  
Dean, College of Engineering  
Southern Luzon State University - Philippines

...

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