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PREFACE



It is my great pleasure to warmly welcome you to the Eighth International Conference on Informatics and Computing (ICIC 2023) held for the first time, in Hybrid mode, with online participation will be held via the Zoom Meeting platform.

The ICIC is a conference series which is conducted annually by APTIKOM, the Indonesian Association of Higher Education in Informatics and Computing. This year the main theme of the conference is "*Empowering Education and Research on Artificial Intelligence for Improving National Competitiveness*", with an intention to bring up more awareness in our society on the importance of Artificial Intelligence in the current era and beyond.

The ICIC conference series as a flagship conference of APTIKOM serves as an arena for academicians and their students, experts and practitioners from the industry to meet, present, and have fruitful discussions on their research works, ideas, and papers in the wide areas of Computing which covers Computer Science, Information Systems, Information Technology, Software Engineering, and Computer Engineering. The conference is set to provide opportunities for participants from both academia and industry to share and exchange knowledge as well as the cutting-edge development in the computing field. It is expected that the ICIC participants will be able to take away new thinking and horizon from this confederal meeting to further their works in the area.

There are 330 papers submission and only 158 papers are accepted which is around 47,8% acceptance rate. The accepted papers will be presented in one of the 9 regular parallel and tracks sessions and will be published in the conference proceedings volume. The diversity of authors come from 9 different countries.

All accepted papers are submitted to IEEE Xplore. IEEE Conference Number: #60109. Catalog Number: CFP23G52-ART ISBN: 979-8-3503-4260-4

On behalf of the ICIC 2023 organizers, we wish to extend our warm welcome and would like to thank for all Keynote Speakers, Reviewers, Authors, and Committees, for their effort, guidance, contribution and valuable support. We would like to also extend our gratitude to IEEE Indonesia Section for technically co-sponsored this event.

I wish you all a most wonderful, enjoyable, and productive conference in this ICIC 2023. Thank you.

Wa billahi taufiq wal hidayah. Wallahul muwaffiq ila aqwamit tharieq.

Wasalaamu 'alaykum warahmatullahi wabarakaatuh.

Yusuf Durachman, M.I.T

Conference Chair

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Table of Contents

Regression Based Machine Learning Model for Rainfall Forecasting on Daily Weather Data.....	1
<i>Evi Triandini, I Nyoman Rudy Hendrawan and Agus Yarcana</i>	
Implementing Minimum Message Length to the Modelling of Denpasar City Inflation Rate	7
<i>Yudi Agusta</i>	
On Improving Widyantoro's Dynamic Programming for Forward-Backward Combination Method	13
<i>Mochamad Nizar Palefi Ma'Ady</i>	
Analysis of CNN Method for Image Classification of Coconut Ripeness Levels	18
<i>Luthfi Luthfi, Imam Muslem R, Dedy Armiaady, Sriwinar Sriwinar, Riyadhul Fajri and Iqbal Iqbal</i>	
Combining Haar transform and row-column directional RLE in image compression.....	24
<i>Anik Das Emon, Pronab Chandra Roy, Laiphrakpam Dolendro Singh and Anish Kumar Saha</i>	
Social Media Platforms Utilization Influence on The Vocational High School Students' Learning Interests and Learning Outcomes in Computer Network Subjects.....	30
<i>Admaja Dwi Herlambang</i>	
Feature Selection Implementation on High-Dimensional Data using Firefly Algorithm.....	37
<i>Tessy Badriyah, Iwan Syarif and Danang Jehan Lukmanto Prakoso</i>	
Neural Network for Classification of Student Performance in Exams	42
<i>Nur Azmi Karim and Yudi Ramdhani</i>	
Content is Fire and Virtual Reality is Gasoline: Understanding Users Attention, Comprehension, and Attitude in Destination Promotion	48
<i>Halim Budi Santoso, Andhika Galuh Prabawati, Jyun-Cheng Wang, Nila Armelia Windasari, Gabriel Indra Widi Tamtama and Lussy Ernawati</i>	
Singular Value Decomposition with Optimal Rank Thresholding and RUSTICO in Burr Classification.....	55
<i>Valerie Vanora Susilo, Naramia Wijaya, Vachell Christiansen Chai and Dyah Erny Herwindiati</i>	
Harvesting Natural Disaster Reports from Social Media with 1D Convolutional Neural Network and Long Short-Term Memory	61
<i>Irwan Budiman, Mohammad Reza Faisal, Dodon Turianto Nugrahadi, Muliadi, Mera Kartika Delimayanti and Septyan Eka Prastyana</i>	
Exploring Customer-based Determinants of Social Media Marketing Activities for Local Brands.....	67
<i>Tatik Suryani, Mochamad Nurhadi and Abu Amar Fauzi</i>	
Implementation Of Hierarchical Finite State Machine for Controlling 2D Character Animation in Action Video Game	73
<i>Euis Nur Fitriani Dewi, Andi Nur Rachman and R. Haitsam Zahir Hartadji</i>	

Comparison of Air Quality Prediction using Random Forest and Gradient Boosting Tree..	79
<i>Triando Hamonangan Saragih and Muhammad Itqan Mazdadi</i>	
Data Augmentation Method on Drone Object Detection with YOLOv5 Algorithm	84
<i>Ariel Yonatan Alin, Kusri Kusri and Kumara Ari Yuana</i>	
Design And Build A Hijaiah Letter Recognition Application For Early Children Using The Markerless Method Based Augmented Reality	90
<i>Assaf Arief, R. Dwi Nurani and Syarifuddin N Kapita</i>	
Particulate Matter Indoor Data Analysis Related to South Jakarta Temperature and Relative Humidity	94
<i>Soni Rudi Hartanto, Ramadhani Ulansari, Desmiwati Desmiwati, Andi Susilo, Muhammad Agni Catur Bhakti and Wandy Wandy</i>	
Optimizing Random Forest Classification Using Chi-Square and SMOTE-ENN on Student Drop-Out Data	99
<i>Andri, Roni Yunis and Tanti</i>	
Implementation of Sentiment Analysis of Shopee E-Commerce Reviews using Naïve Bayes, N-Gram, and Information Gain	104
<i>Andriana Sunjaya, Novresia Wijaya, Poi Wong Ng and Sunaryo Winardi</i>	
IndoBerea: Evolving Semantic Search in Theological Context	110
<i>Feliks Victor Parningotan Samosir and Serius Mendrofa</i>	
GRU for Overcoming Seasonality and Trend in PM2.5 Air Pollution Forecasting	116
<i>Aji Gautama Putrada, Nur Alamsyah, Mohamad Nurkamal Fauzan, Ikke Dian Oktaviani and Doan Perdana</i>	
Thorough Evaluation of the Effectiveness of SMOTE and ADASYN Oversampling Methods in Enhancing Supervised Learning Performance for Imbalanced Heart Disease Datasets	122
<i>Anis Fitri Nur Masruriyah, Hilda Novita, Cici Emilia Sukmawati, Ahmad Fauzi, Deden Wahiddin and Hanny Hikmayanti Handayani</i>	
Comparison analysis of Jetpack Compose and Flutter in Android-based application development using Technical Domain	129
<i>Mandahadi Kusuma, Ahmad Haris Rifani and Bambang Sugiantoro</i>	
Quality of Service Analysis for Internet of Vehicle	134
<i>Dewanto Rosian Adhy, Mohd Fairuz Iskandar Othman and Yahaya Abd Rahim</i>	
Artificial Intelligence in Natural Disaster: Data Crawling and Text Mining-Based Literature Review	140
<i>Zhafran Ramadhan and Ariana Yunita</i>	
Neutral Class Handling for Customer Sentiment Analysis: A Comparative Study of Machine Learning Algorithm in Binary Classification	146
<i>Murahartawaty Arief and Noor Samsudin</i>	
Split-Conv: 1HD Depth Estimation Deep Learning Model	154
<i>Henokh Lugo Hariyanto, Arif Wicaksono Septyanto and Haidar Dzaky Sumpena</i>	

Survey of Feature Selection in Imbalanced Data for Software Defect Prediction	160
<i>Frieyadie Frieyadie, Munaisyah Abdullah and Foni Agus Setiawan</i>	
Unveiling Motivations behind Purchasing Loot Boxes: A Study on the Online Gaming Behavior toward Micro-Spending Game-Items	166
<i>Brian Thio and Christian Haposan Pangaribuan</i>	
Video Object Motion Tracking using Dense Optical Flow Techniques	172
<i>Hari K.C., Sushil Shrestha and Manish Pokharel</i>	
Bee Colony Algorithm for Flow Shop Scheduling Problem	176
<i>Samuel Lukas, Dion Krisnadi, Eric Jahja and Petrus Widjaja</i>	
Stunting Malnutrition Classification Using Hybrid Grey Wolf Optimization-Random Forest	180
<i>Ramdhansyach Sasmita, Muhammad Sam An, Luqman Assafaat, Akhmad Faturrohman and Safuan Safuan</i>	
Optimizing Computational Efficiency in Feature Selection for Machine Learning Models: A Study Crime Detection Based on Criminal Data	187
<i>Nur Alamsyah, Budiman Budiman, Venia Restreva Danestiara, Imannudin Akbar and Elia Setiana</i>	
Lord Forgive Me for I Have Shopped: An Online Impulsive and Compulsive Buying Analysis	193
<i>Alifa Khadijah and Christian Haposan Pangaribuan</i>	
Enhancing Password Manager Application Security By Root Detection with Usability and Security Evaluation	199
<i>Galih W. W. Mukti and Rusdianto Roestam</i>	
Poultry Disease Detection in Chicken Fecal Images Through Annotated Polymerase Chain Reaction Dataset Using YOLOv7 And Soft-Nms Algorithm	206
<i>Devi Fajar Wati and Rusdianto Roestam</i>	
AHP-TOPSIS-Based Decision Support System(DSS) for Assessing The Salt Quality for Indonesian Salt e-Farming	213
<i>Makhjud Efendy, Aang Kisnu Darmawan, Kartini Kartini, Busro Akramul Umam, Anik Anekawati and Agus Komarudin</i>	
The Effect of Adding the Heuristic Evaluation Method to the Usability Evaluation Method of Design Thinking in the UNSIL Vclass Application	220
<i>Faisal Al Isfahani, Alam Rahmatulloh, Rahmi Nur Shofa and Irfan Darmawan</i>	
License Plate Localization and Character Recognition using YOLOv8 and Convolutional Neural Network	226
<i>Ilham Mafani Nadif and Kusrini Kusrini</i>	
Stock Price Prediction using Long-Short Term Memory and Temporal Convolutional Network	232
<i>Caroline Caroline, Ronsen Purba and Muhammad Fermi Pasha</i>	
Comparison of Dynamic Weighted Centroid and Optimization Model to Predict Mobile Device Location	238
<i>Rifki Kosasih and Ahmad Sabri</i>	

Developing Conceptual Design of Internet Network for Digital Village	242
<i>Darius Antoni, Dedy Syamsuar, Mariska Putri Pratiwi, Febrianty Febrianty, Astuti Astuti and Andi Agusman</i>	
Implementation of Support Vector Machine Method for Customer Segmentation.....	249
<i>Jefri Junifer Pangaribuan, Okky Putra Barus, Fiona Tjia, Romindo Romindo, Jusin Jusin and Ade Maulana</i>	
Preserving Individual Privacy from Inference Attack in Transaction Data Publishing.....	255
<i>Dedi Gunawan, Diah Priyawati, Yusuf Sulistyo Nugroho, Fatah Yasin Al Irsyadi, Ilham Andreansyah and Syful Islam</i>	
Model Prediction Using Random Forest Algorithm and Time Series Analysis Parts Distribution with in Indonesia Automotive Industry	261
<i>Andy Achmad Hendharsetiawan, Arief Ramadhan, Warnars Harco Leslie Hendric and Widodo Budiharto</i>	
Response Time Prediction of M/M/1SRPT Queuing System Using Simulation Modeling and Artificial Intelligence.....	267
<i>Ahmad Saikhu, Rully Soelaiman, Sheinna Yendri and Wahyuddin S</i>	
Customer Behavior Using RFM Model and K-Means Algorithm in Aesthetic Clinic	272
<i>Sinarring Laga, Iqbal Ramadhani Mukhlis, Deny Hermansyah, Gaguk Suprianto, Mochammad Anang Karyawan and Hariadi Yutanto</i>	
Virtual Avatar Representation in the Digital Twin: A Photogrammetric Three-Dimensional Modeling Approach.....	277
<i>Nugrahardi Ramadhani, Mochammad Fachri, Didit Prasetyo, Fardani Annisa Damastuti, Mochamad Hariadi and Intan Rizky Mutiaz</i>	
Topic Modeling of Natural Disaster in Indonesia Using NMF	284
<i>Muhammad Zhafran Ghaly and Arif Dwi Laksito</i>	
Usability Analysis of "SiPasar", a Web-Based Application for Mapping Traditional Markets in Yogyakarta	290
<i>Agata Filiana, Maria Nila Anggia Rini and Andhika Galuh Prabawati</i>	
Implementation of Environmental Monitoring and Controlling for The Oyster Mushroom Based on The Internet of Things.....	296
<i>Rian Ferdian, Rifki Abdullah Fattah and Tati Erlina</i>	
Digital Twin Framework for Human to Environment Interaction in Interactive Spaces	301
<i>Didit Prasetyo, Moch Fachri, Nugrahardi Ramadhani, Fardani Annisa Damastuti, Mochamad Hariadi and Intan Rizky Mutiaz</i>	
K-Means Using Dynamic Time Warping For Clustering Cities in Java Island According to Meteorological Conditions	307
<i>Teny Handhayani and Zyad Rusdi</i>	
Myocardial Infarction Classification with 15 Lead Electrocardiogram (ECG) Signal using Hybrid Convolutional Neural Network (CNN) and Bidirectional Long Short-Term Memory (BiLSTM)	313
<i>Ahmad Haidar Mirza, Siti Nurmaini, Radiyati Umi Partan and Muhammad Izman Herdiansyah</i>	

Predictive Modeling for Disaster Event Detection using Support Vector Machine.....	319
<i>Anas Fikri Hanif and Arif Dwi Laksito</i>	
Design and Evaluation of a Similarity Checking Tool for Indonesian Documents	326
<i>Kusrini Kusrini, Alva Hendi Muhammad, Irwan Oyong and Arif Nur Rohman</i>	
Automated Congestive Heart Failure Detection Using XGBoost on Short-term Heart Rate Variability.....	332
<i>Gregorino Al Josan, Alhadi Bustamam, Devi Sarwinda, Hermawan, Astuti Giantini, Wibowo Mangunwardoyo and Firdaus Rosean Rony</i>	
Classification of Alzheimer’s Disease Using Random Oversampling and Alumentations on Convolutional Neural Network	338
<i>Calvin Kamardi, I Kadek Perry Bagus Laksana, Maria Susan Anggreainy, Nora Fitriawati, Michiko Amaya Yonatan, Tesalonika Abigail Eikwine Mangkang and Vianny Pangesa</i>	
Prediction of Hypertension in the Upcoming Year: Feature Correlation Analysis and Handling Imbalanced Based on Random Forest.....	344
<i>Nur Ghaniaviyanto Ramadhan, Adiwijaya Adiwijaya, Warih Maharani and Alfian Akbar Gozali</i>	
Improvement of Imbalanced Data Handling: A Hybrid Sampling Approach by using Adaptive Synthetic Sampling and Tomek links	350
<i>Fhira Nhita, Adiwijaya and Isman Kurniawan</i>	
Comparing Decentralized File Storage on Ethereum with InterPlanetary File System	355
<i>Pujianto Yugopuspito, Eugene Ekaputra and Julinda Pangaribuan</i>	
Analysis of User Behavioural Intentions on Receiving Health Information from TikTok Short Videos.....	361
<i>Mutia Maulida, Yuslena Sari, Nurul Fathanah Mustamin, Andreyan Rizky Baskara, Eka Setya Wijaya and Siti Sheilawati</i>	
Evaluating the Effects of Mobility Restrictions during COVID-19 on Land Surface Temperature with GIS and Satellite Data	367
<i>Herlawati Herlawati, Rahmadya Trias Handayanto, Ika Dewi Sartika Saimima, Muhammad Khaerudin, M. Hadi Prayitno, Prio Kustanto, Ismaniah Ismaniah, Ajif Yunizar Pratama Yusuf and Arman Andrian</i>	
Transforming Tradition: Utilizing MUNIT for Sasirangan Fabric’s Color Pattern Generation.....	372
<i>Nurul Fathanah Mustamin, Mutia Maulida, Yuslena Sari, Andreyan Rizky Baskara, Eka Setya Wijaya and Irvan Aulia Luthfi</i>	
Signal Strength, Delay, and Throughput Performance Comparison of 4G, 5G, and 6G Networks in VANET	378
<i>Asoni Asoni, Selo Sulistiyo, Sigit B. Wibowo, Ronald Adrian and Harry Nur Hidayat</i>	
The New Smart Government Software Quality Framework Uses Modifications to ISO/IEC 25010	384
<i>Winny Purbaratri, Kristoko Dwi Hartomo, Hendry Hendry and Johan J.C Tambotoh</i>	

Decision Support System of Sustainable Supplier Selection for Micro Small Medium Enterprise in Apparel Industry	390
<i>Ari Basuki, Andharini Dwi Cahyani, Hanifudin Sukri, Faikul Umam, Ika Oktavia Suzanti and Bain Khusnul Khotimah</i>	
Classification of User Reviews for Software Maintenance in Indonesian Language Using IndoBERT-BiLSTM (Case Study: MyPertamina)	396
<i>Andreyan Rizky Baskara, Muhammad Ardhy Satrio Jati, Mutia Maulida, Yuslena Sari, Nurul Fathanah Mustamin and Eka Setya Wijaya</i>	
Optimal Decision Tree for Early Detection of Bipolar Disorder based on Crowdsourced Symptoms	402
<i>Ni Luh Putu Satyaning Pradnya Paramita, Hasri Wiji Aqsari, Wilda Melia Udiatami, Ayu Sadewo, Whinda Yustisia, Dwy Bagus Cahyono and Putu Hadi Purnama Jati</i>	
A Comprehensive Framework of Role Data Governance in Ensuring Data Quality: Literature Review	408
<i>Fadhil Rozi Hendrawan, Tien Fabrianti Kusumasari and Dhata Praditya</i>	
Dental Patient Chief Complaint Classification	414
<i>Aryo Handono and Ade Romadhony</i>	
Respinos Health: A Mobile Health App Designed Using User-Centered Design Method to Use with Respinos	418
<i>Difa Habiba Rahman, Jonet Wira Murti, Muhammad Raihan Iqbal, Ayu Purwarianti and Trio Adiono</i>	
Spelling Correction in Rule Based Virtual Assistant for a MSME Business	424
<i>Viny Christanti Mawardi, Valerie Vanora Susilo and Vachell Christiansen Chai</i>	
Mechatronic System for ESP32CAM OpenCV Rice Plant Pest Detection	429
<i>Tukino Tukino, Rizki Aulia Nanda, Ahmad Fauzi, Ade Suhara and Muhammad Khaerudin</i>	
A Mobile Application CODEC (Color Detection) for Color-blind People using KNN	435
<i>Karisa Zihni Lutfian, Anggilia Nur Safitri, Khairun Nisa Maulani, Eko Didik Widiyanto and Arseto Satriyo Nugroho</i>	
Enhancing Restaurant Recommendations through User-Based Collaborative Filtering	441
<i>Moch Kautsar Sophan, Iwan Santoso and Kurniawan Eka Permana</i>	
Assessment of External Factors on the Accuracy of Ultrasonic Sensors for Water Level Measurement in Peatlands	445
<i>Yuslena Sari, Yudi Firmanul Arifin, Novitasari Novitasari, Ferry Pratama, Eka Setya Wijaya, Ricardus Anggi Pramunendar, Mutia Maulida, Nurul Fathanah Mustamin, Andreyan Rizky Baskara and Erika Maulidiya</i>	
Performance Analysis of Face Verification through the Decision Fusion using Several of Face Recognition Models	452
<i>Munawarah Munawarah, Taufik Fuadi Abidin and Kahlil Muchtar</i>	
Interaction Design of Academic Analysis Module Mobile App to Enhance Student Academic Performance Monitoring	458
<i>Herman Tolle, Retno Indah Rokhmawati and Erika Khoirunisa</i>	

Design of Job Placement Center Dashboard for Monitoring Alumni Performance in Job Fair Application	464
<i>Herman Tolle, Lutfi Fanani and Septia Andriani Pasaribu</i>	
Advancing Towards IT Maturity Governance Excellence: COBIT 2019 in Higher Education (Indonesia).....	470
<i>Widia Febriyani, Fadhil Rozi Hendrawan and Tien Fabrianti Kusumasari</i>	
ABC-optimized deep learning approach to rainfall forecasting in Serang City	476
<i>Albaar Rubhasy, Andrianingsih Andrianingsih and Rayyan Rayyan</i>	
User Satisfaction Factors Self-Service Technology In Fast Food Restaurants Using The Heuristic Evaluation Method	482
<i>Shinta Oktaviana R, Eni Heni Hermaliani, Nurmalasari Nurmalasari, M Rangga Ramadhan Saelan and Eggie Pandu Tamara</i>	
Transfer Learning Method for Malaria Identification	487
<i>Cecilia Audrey Herli, Daniel Zerge Wijaya, Hansen Hansen, Michelle Angela, Zakaria Berlam Pragusma, Maria Susan Anggreainy and Ajeng Wulandari</i>	
E-Learning and Organizational Support: Investigation of Quality and Behavior	493
<i>Leni Susanti and Doni Purnama Alamsyah</i>	
Student Enrollment Performance of Telkom Schools in 23/24 schoolyear using k-Means Clustering	499
<i>Tora Fahrudin, Ibnu Asror and Yanuar Firdaus Arie Wibowo</i>	
Harnessing The Power of Random Forest in Predicting Startup Partnership Success	504
<i>Chandra Lukita, Ninda Lutfiani, Arop Ria Saulina Panjaitan, Bhima Bhima, Untung Rahardja and Muhamad Lutfi Huzaiyah</i>	
Consumer Adoption of Artificial Intelligence in Air Quality Monitoring: A Comprehensive UTAUT2 Analysis	510
<i>Rahmat Salam, Qurotul Aini, Betari Ayu Almadania Laksmiingrum, Bintang Nandana Henry, Untung Rahardja and Ananda Alifia Putri</i>	
Usability Measurement of Aswaja Chatbot with System Usability Scale (SUS)	516
<i>Arief Hidayat, Ma'As Shobirin and Akhmad Pandhu Wijaya</i>	
APPLICATION OF DEEP LEARNING FOR MOBILE-BASED DETECTION OF LEAF DISEASES IN AMORPHOPHALLUS MUELLERI BLUME USING SSD-MOBILENET	521
<i>Rossy Nurhasanah, Fikri Fadhlillah, Niskarto Zandrato and Melly Bangun</i>	
Visualizing Attitudinal Dynamics of Moving Objects via Android: Capturing Pitch, Roll, and Yaw Parameters	527
<i>Purnawarman Musa, Suhartini Suhartini, Remi Senjaya, Puji Sularsih, Witari Aryunani and Novrina Novrina</i>	
Enhancing Educational Innovation: A Comparative Analysis of Blockchain Adoption Strategies in Smart Learning Environments	535
<i>Mochamad Heru Riza Chakim, Daelami Ahmad, Umi Rusilowati, Fitra Putri Oganda, Yulia Putri Ayu Sanjaya and Po Abas Sunarya</i>	

Implementation of Deep Learning Using Convolutional Neural Network for Skin Disease Classification with DenseNet-201 Architecture	541
<i>Evita Pramesti, Achmad Benny Mutiara and Rina Refianti</i>	
Implementation of Convolutional Neural Network With EfficientNet-B0 Architecture for Brain Tumor Classification	547
<i>Vinsensius Haryo Bhaskoro Hadi, Achmad Benny Mutiara and Rina Refianti</i>	
Analysis of Factors that Influence Non-Fungible Token (NFT) Digital Content Purchase Intention	553
<i>Erwin Halim, Abrar Arkananta Putra Denny, Kevin Samuel Pratama Simanjuntak, Christian Christian and Richard Richard</i>	
Hybridization of Whale Optimization Algorithm for Multi-objective Flow Shop Scheduling Problems	559
<i>Cecilia Esti Nugraheni, Luciana Abednego and Craven S. Saputra</i>	
Why People Want To Use E-money Card based On RFID Technology ?	565
<i>Freza Fathur Nur Purnomo and Cadelina Cassandra</i>	
Understanding Factors Influencing the Adoption of AI-enhanced Air Quality Systems: A UTAUT Perspective	571
<i>Mochamad Heru Riza Chakim, Qurotul Aini, Po Abas Sunarya, Nuke Puji Lestari Santoso, Dhiyah Ayu Rini Kusumawardhani and Untung Rahardja</i>	
The Digital Revolution of Startup Matchmaking: AI and Computer Science Synergies	577
<i>Ari Pambudi, Ninda Lutfiani, Marviola Hardini, Achani Rahmania Az Zahra and Untung Rahardja</i>	
Blockchain for Transparent Academic Records: Implications for Higher Education Institutions	583
<i>Chandra Lukita, Nana Sutisna, Abdul Hamid Arribathi, Fitra Putri Oganda, Sheila Aulia Anjani and Adam Faturahman</i>	
From Desire to Purchase: Uncovering the Influencing Factors on Impulse Buying of Augmented Reality Photocard Featuring Korean Artists	589
<i>Zaenal Abidin and Cholilah Lateefa Bambang</i>	
Comparison of Support Vector Machine (SVM) and Linear Regression (LR) for Stock Price Prediction	594
<i>I Putu Candra Purnama, Ni Luh Wiwik Sri Rahayu Ginantra, I Wayan Agus Surya Darma and I Putu Agus Eka Darma Udayana</i>	
Classification of COVID-19 Disease From Chest X-Ray Images Using the SqueezeNet and Bayesian Optimization Methods	600
<i>Rima Tri Wahyuningrum, Ach. Halimi Firdaus Zuhron, Cucun Very Angkoso, Budi Dwi Satoto, Amillia Kartika Sari and Anggraini Dwi Sensusiati</i>	
Resolving Artificial Intelligence Hallucination In Personalized Adaptive Learning System .	606
<i>Decwind Skylar Susanto, Erwin Halim, Richard Richard, Anderes Gui and Nelly Nelly</i>	

Overcoming Language Barriers in MOOCs with Artificial Intelligence: An AI-based Approach for Multilingual Education	612
<i>David Kennedy, Erwin Halim, A Raharto Condrobimo, Dedy Syamsuar and Ferdianto Ferdianto</i>	
Software Effort Estimation with Use Case Point Approach on Website Builder Project: A Systematic Performance Evaluation	618
<i>Khairun Nisa Meiah Ngafidin, Yudha Saintika and Sena Wijayanto</i>	
Identification of Waste in Program Management at the IT Department of a Higher Education Institution (HEI) through Lean Six Sigma (DMAIC)	624
<i>Devi Pratami, Mochammad Doddy Al Fawzi, Sigit A. Wibowo and Nor Hasrul Akhmal</i>	
Improving Land Cover Segmentation Using Multispectral Dataset	631
<i>Herlawati Herlawati, Rahmadya Trias Handayanto, Yaya Heryadi, Edi Abdurachman, Haryono Soeparno, Edy Irwansyah and Eka Miranda</i>	
Construction Formula for Biological Age Estimation using Principal Component Analysis in Imbalanced Dataset	636
<i>Annisa Zahra, Angelica Patrica Djaya Saputra, Devvi Sarwinda, Alhadi Bustamam, Agian Jeffilano Barinda and Rheza Meida Marliau</i>	
Exploring COVID-19 Vaccine Hesitancy Through Topic Modeling: A Systematic Literature Review	642
<i>Tedo Hariscandra, Sri Handika Utami and Achmad Nizar Hidayanto</i>	
Cluster Analysis and Seismicity of The Samosir Using Machine Learning Approach	648
<i>Marzuki Sinambela, Eva Darnila, Indra Kelana Jaya, Indra M Sarkis and Alex Rikki</i>	
Deep Learning Approach for Aspect-Based Sentiment Analysis on Indonesian Hospitals Reviews	654
<i>Muhamad Fahmi, Faturahman Yudanto, Naurah Nazhifah, Yunita Sari and Afiahayati</i>	
ArchiMate's Strengths and Weaknesses as EA Modeling Language : A Systematic Mapping Study	660
<i>Aisha Edna Alicia Sanyoto and Mochamad Chandra Saputra</i>	
Fire Detection System Using Transfer Learning Mobiledets with Google Coral USB Accelerator Based on Raspberry Pi 4	666
<i>Nenny Anggraini, Aulia Rahman, Anif Hanifa Setianingrum and Saepul Aripriyanto</i>	
Tackling an Unbalanced Dataset for Classifying Indonesian E-Commerce Reviews Using Multi Word Embedding Model	672
<i>Rizky Adi, Bassamtiano Renaufalqi Irnawan and Jiyi Li</i>	
Evaluation of User Experience on Learning Management System for Programming Course Through User Experience Questionnaire Method	678
<i>Wahyu Nur Hidayat, Tiara Amalia Putri, Nazhiroh Tahta Arsyillah, Muhammad Aslam Bahriss, Hary Suswanto and Achmad Hamdan</i>	
E-Readiness of North Penajam Paser Regency Regional Apparatus as Supporting City of Indonesian New Capital City	684
<i>Sri Rahayu Natasia, M. Gilvy Langgawan Putra, Aidil Saputra Kirsan and Tazkya Humaira</i>	

U-Net Based Vegetation Segmentation for Urban Green Space (UGS) Regulation in Yogyakarta City.....	691
<i>Delfia Nur Anrianti Putri, Raden Bagus Muhammad Adryanputra Adhy Wijaya, Nailfaaz and Wahyono</i>	
Modeling Urban-Suburban-Rural (USR) Segmentation and Mapping of Special Capital Region of Jakarta and West Java, Indonesia: A Geospatial Big Data Approach	697
<i>Widhelia Echa Pramesthy, Salwa Rizqina Putri and Arie Wahyu Wijayanto</i>	
Classification Driver Emotion with Deep Learning Method for Driver Safety Detection....	703
<i>Kurniawan Indra Jaya and Fitra Abdurrachman Bachtiar</i>	
The Use of LSTM Model with Lagged Daily Inputs for Waste Disposal Prediction	709
<i>Maimunah Maimunah, Joko Lianto Buliali and Ahmad Saikhu</i>	
Integrated Academic Service Digitalization at Universities Utilizing Blockchain Technology.....	715
<i>Chandra Lukita, Marsani Asfi, Sudadi Pranata, Amroni Amroni, Taufan Huneman and Chairun Nas</i>	
Land classification based on drone observations using Depth-Wise Separable Convolution with Residual Network Connection	721
<i>Budi Dwi Satoto, Tutuk Dwi Indriyani, Budi Irmawati, Muhammad Yusuf, Devie Rosa Anamisa and Mochammad Kautsar Sophan</i>	
Design and Development of the Aceh Biodiversity Android Application.....	728
<i>Muhammad Subianto, Alim Misbullah, Razief Perucha Fauzie Afidh, Essy Harnelly, Muhammad Irfan and Zulfan Zulfan</i>	
Optimizing CNNs for Facial Paralysis Detection: A Hyperparameter Tuning Approach ...	734
<i>Salamet Nur Himawan, Adi Suheryadi and Muhamad Mustamiin</i>	
Key Challenges and Recommendation in Managing Hybrid Work Collaboration for Agile Teams: A PRISMA Systematic Literature Review	739
<i>Wiwin Nur'Aini and Teguh Raharjo</i>	
Virtual Reality-Based Traffic Sign Education for Early Childhood	745
<i>Taufiqurrakhman Nur Hidayat, Fendi Aji Purnomo, Eko Harry Pratisto, Ksatria Tirta Nusantara and Yudho Yudhanto</i>	
Internet of Things on Automatic Watering Systems for Papuan Black Orchids	750
<i>Sukarwoto Sukarwoto, Ayub Wimatra, Jemi V Palpialy, Indri Sulistianingsih, Ahmad Akbar and Darmeli Nasution</i>	
UI/UX Prototype of Visually Interactive Communication and Reading Aid for Autistic Children with Speech Disability	757
<i>Lely Hiryanto, Marchella Angelina, Jonathan Jonathan, Hersinta Hersinta, Olivia Deliani Hutagaol and Tony Tony</i>	
Factors Influencing Participation in Data Crowdsourcing: A Systematic Literature Review	763
<i>Re. Miracle Panjaitan and Budi Darma Setiawan</i>	

Analysis of the Best Optimizer Used by Convolutional Neural Network Algorithms in Detecting Masked Faces	769
<i>Syahida Usama Firdaus, Silvy Zafira Putri, Lailil Muftikhah and Pradiptya Kahvi Sugiharto</i>	
IoT-based Smart Irrigation for Allium ascalonicum using Fuzzy Logic	774
<i>Henning Titi Ciptaningtyas, Irzal Ahmad Sabilla and Mohammad Ibadul Haqqi</i>	
LSTM Variants Comparison for Exchange Rate IDR/USD Forecasting with Rolling Window Cross Validation	780
<i>Nurhayati Nurhayati, Fitri Mintarsih, Muhammad Ashlah Rasyidi, Wilda Nurjannah, Dewi Khairani and Husni Teja Sukmana</i>	
Waste Bank Information System Integrated with IoT-Based Scales	784
<i>Isna Wardiah, Subandi Subandi, Agus Setiyo Budi Nugroho, Bryan Teven, Dicky Hananta and Rifqi M Gani</i>	
The Importance of E-Leadership in Higher Education Institutions Determined by Advanced Information Technology	790
<i>Herlino Nanang, Husni Teja Sukmana, Yusuf Durachman, Viva Arifin, Dewi Khairani, Siti Ummi Masruroh, Muhamad Azhari and B. Herawan Hayadi</i>	
Binary PSO-GWO for Feature Selection in Binary Classification Using K-Nearest Neighbor	795
<i>Dwi Kartini, Muhammad Itqan Mazdadi, Irwan Budiman, Fatma Indriani and Rahmat Hidayat</i>	
Design Parental Involvement Monitoring Students' Academic Performance on University Mobile Apps	801
<i>Nabila Adelia Yusuf, Herman Tolle and Ismiarta Aknuranda</i>	
Harnessing DNA Cryptography with the Kyber Algorithm for Enhanced Data Security ...	807
<i>Harjito Bambang, Faisal Rahutomo, Dwiko Satriyo. U. Y. S and Heri Pras</i>	
Smart Food Box Design with IoT Based Android Monitoring System	813
<i>Hendro Widiarto, Iwan Koswara, Darmeli Nasution, Sri Wahyuni and Indri Sulistianingsih</i>	
Capacity of Multi-layered Cellular Networks of Beyond 5G with Fractional Frequency Reuse	819
<i>Muhammad Yaser, Khoirul Anwar, Iskandar and Mohammad Sigit Arifianto</i>	
Machine Learning Structure for Box-plus Operation with Soft Information Processing	825
<i>Okzata Recy, Khoirul Anwar and Gelar Budiman</i>	
Predicting Consumer Secondhand Luxury Preferences for Marketing Strategy in Post Pandemic Using Machine Learning: A Case Study of Consumer in Indonesia	830
<i>Mutiara Auliya Khadija, Abdul Aziz and Wahyu Nurharjadmo</i>	
Developing an Expert System for Mobile-based Gastroenteritis Detection Using ESDLC and Best First Search Methods	836
<i>R. Rizal Isnanto, Catur Edi Widodo, Ike Pertiwi Windasari and Misik Puspajati Saputri</i>	

LoRa-Based Waste Bin Monitoring for Making Decision Waste Disposal Using C 4.5 Method	841
<i>Aa Zezen Zaenal Abidin, Mohd Fairuz Iskandar Othman, Aslinda Hassan, Yuli Murdianingsih, Usep Tatang Suryadi and Muhammad Faizal</i>	
DC - DRC Optimization using Load Balancer (Case Study: Karawang Regional Hospital)	848
<i>Lila Setiyani and Cutifa Safitri</i>	
Energy Efficiency Strategies in Information-Centric Networking	854
<i>Feri Fahrianto, Firman Munthaha, Siti Ummi Masruroh, Ahmad Fadlan Ramadhan, Dewi Khairani and Waki Ats Tsaqofi</i>	
Classification of Popular Music Genre Using Convolutional Neural Network Method with Data Augmentation	859
<i>Siti Ummi Masruroh, Aditya Sidhiq Pratama, Luh Kesuma Wardhani, Feri Fahrianto, Waki Ats Tsaqofi and Rizka Amalia Putri</i>	
Expert System Using Forward Chaining to Determine Freshwater Fish Types Based on Water Quality and Area Conditions	863
<i>Hidayati Mustafidah, Bagus Restu Alfiansyah, Suwarsito Suwarsito, Purnomo Purnomo and Nurul Hidayat</i>	

Author Index

Abd Rahim, Yahaya	134
Abdullah, Munaisyah	160
Abdurachman, Edi	631
Abednego, Luciana	559
Abidin, Taufik Fuadi	452
Abidin, Zaenal	589
Achmad Hendharsetiawan, Andy	261
Adelia Yusuf, Nabila	801
Adi, Rizky	672
Adiono, Trio	418
Adiwijaya,	350
Adiwijaya, Adiwijaya	344
Adrian, Ronald	378
Afiahayati,	654
Afidh, Razief Perucha Fauzie	728
Agusman, Andi	242
Agusta, Yudi	7
Ahmad, Daelami	535
Aini, Qurotul	510, 571
Akbar, Ahmad	750
Akbar, Imannudin	187
Akhmal, Nor Hasrul	624
Aknuranda, Ismiarta	801
Al Fawzi, Mochammad Doddy	624
Alamsyah, Doni Purnama	493
Alamsyah, Nur	116, 187
Alfiansyah, Bagus Restu	863
Alin, Ariel Yonatan	84
Amalia Putri, Tiara	678
Amroni, Amroni	715
Andreansyah, Ilham	255
Andri,	99
Andrian, Arman	367
Andrianingsih, Andrianingsih	476
Anekawati, Anik	213
Angela, Michelle	487
Angelina, Marchella	757
Anggraini, Nenny	666
Anggreainy, Maria Susan	338, 487
Angkoso, Cucun Very	600
Anjani, Sheila Aulia	583
Annisa Damastuti, Fardani	277
Antoni, Darius	242
Anwar, Khoirul	819, 825

Aqsari, Hasri Wiji	402
Arief, Assaf	90
Arief, Murahartawaty	146
Arifin, Viva	790
Arifin, Yudi Firmanul	445
Aripiyanto, Saepul	666
Armiady, Dedy	18
Arribathi, Abdul Hamid	583
Aryunani, Witari	527
Asfi, Marsani	715
Aslam Bahris, Muhammad	678
Asroni, Asroni	378
Asror, Ibnu	499
Assafaat, Luqman	180
Astuti, Astuti	242
Ayu Sanjaya, Yulia Putri	535
Az Zahra, Achani Rahmania	577
Azhari, Muhamad	790
Aziz, Abdul	830
B. Wibowo, Sigit	378
Bachtiar, Fitra Abdurrachman	703
Badriyah, Tessy	37
Bambang, Cholilah Lateefa	589
Bambang, Harjito	807
Bangun, Melly	521
Barinda, Agian Jeffilano	636
Barus, Okky Putra	249
Baskara, Andreyan Rizky	361, 372, 396, 445
Basuki, Ari	390
Bhakti, Muhammad Agni Catur	94
Bhima, Bhima	504
Budiharto, Widodo	261
Budiman, Budiman	187
Budiman, Gelar	825
Budiman, Irwan	61, 795
Buliali, Joko Lianto	709
Bustamam, Alhadi	332, 636
Cahyani, Andharini Dwi	390
Cahyono, Dwy Bagus	402
Caroline, Caroline	232
Cassandra, Cadelina	565
Chai, Vachell Christiansen	424
Chakim, Mochamad Heru Riza	571
Christian, Christian	553
Christiansen Chai, Vachell	55
Ciptaningtyas, Henning Titi	774

Condrobimo, A Raharto	612
Damastuti, Fardani Annisa	301
Darma, I Wayan Agus Surya	594
Darmawan, Aang Kisnu	213
Darmawan, Irfan	220
Darnila, Eva	648
Delimayanti, Mera Kartika	61
Denny, Abrar Arkananta Putra	553
Desmiwati, Desmiwati	94
Dewi, Euis Nur Fitriani	73
Durachman, Yusuf	790
Dwi Hartomo, Kristoko	384
Dwi Satoto, Budi	721
Efendy, Makhfud	213
Ekaputra, Eugene	355
Emon, Anik Das	24
Erlina, Tati	296
Ernawati, Lussy	48
Fachri, Moch	301
Fachri, Mochammad	277
Fadhilillah, Fikri	521
Fahmi, Muhamad	654
Fahrianto, Feri	854, 859
Fahrudin, Tora	499
Faisal, Mohammad Reza	61
Faizal, Muhammad	841
Fajar Wati, Devi	206
Fajri, Riyadhul	18
Fanani, Lutfi	464
Fathur Nur Purnomo, Freza	565
Fattah, Rifki Abdullah	296
Faturahman, Adam	583
Faturrohman, Akhmad	180
Fauzan, Mohamad Nurkamal	116
Fauzi, Abu Amar	67
Fauzi, Ahmad	122, 429
Febrianty, Febrianty	242
Febriyani, Widia	470
Ferdian, Rian	296
Ferdianto, Ferdianto	612
Filiana, Agata	290
Firdaus Arie Wibowo, Yanuar	499
Firdaus, Syahida Usama	769
Fitriawati, Nora	338
Frieyadie, Frieyadie	160

Gani, Rifqi M	784
Ghaly, Muhammad Zhafran	284
Giantini, Astuti	332
Ginantra, Ni Luh Wiwik Sri Rahayu	594
Gozali, Alfian Akbar	344
Gui, Anderes	606
Gunawan, Dedi	255
Hadi, Vinsensius Haryo Bhaskoro	547
Halim, Erwin	553, 606, 612
Hamdan, Achmad	678
Hananta, Dicky	784
Handayani, Hanny Hikmayanti	122
Handayanto, Rahmadya Trias	367, 631
Handhayani, Teny	307
Handono, Aryo	414
Hanif, Anas Fikri	319
Hansen, Hansen	487
Haqqi, Mohammad Ibadul	774
Harco Leslie Hendric, Warnars	261
Hardini, Marviola	577
Hariadi, Mochamad	277, 301
Hariscandra, Tedo	642
Hariyanto, Henokh Lugo	154
Harnelly, Essy	728
Hartadji, R. Haitsam Zahir	73
Hartanto, Soni Rudi	94
Hassan, Aslinda	841
Hayadi, B. Herawan	790
Hendrawan, Fadhil Rozi	408, 470
Hendry, Hendry	384
Henry, Bintang Nandana	510
Herdiansyah, Muhammad Izman	313
Herlambang, Admaja Dwi	30
Herlawati, Herlawati	367, 631
Herli, Cecilia Audrey	487
Hermaliani, Eni Heni	482
Hermansyah, Deny	272
Hermawan,	332
Hersinta, Hersinta	757
Herwindiati, Dyah Erny	55
Heryadi, Yaya	631
Hidayanto, Achmad Nizar	642
Hidayat, Arief	516
Hidayat, Nurul	863
Hidayat, Rahmat	795
Hidayat, Taufiqurrakhman Nur	745

Himawan, Salamet Nur	734
Hiryanto, Lely	757
Humaira, Tazkya	684
Huneman, Taufan	715
Hutagaol, Olivia Deliani	757
Huzaifah, Muhamad Lutfi	504
Indriani, Fatma	795
Indriyani, Tutuk Dwi	721
Iqbal, Iqbal	18
Iqbal, Muhammad Raihan	418
Irfan, Muhammad	728
Irmawati, Budi	721
Irnanan, Bassamtiano Renaufalgi	672
Irsyadi, Fatah Yasin Al	255
Irwansyah, Edy	631
Isfahani, Faisal Al	220
Iskandar Othman, Mohd Fairuz	841
Iskandar,	819
Islam, Syful	255
Ismaniah, Ismaniah	367
Isnanto, R. Rizal	836
Jahja, Eric	176
Jati, Muhammad Ardhy Satrio	396
Jati, Putu Hadi Purnama	402
Jaya, Kurniawan Indra	703
Jonathan, Jonathan	757
Josan, Gregorino Al	332
Jusin, Jusin	249
K.C., Hari	172
Kamardi, Calvin	338
Kapita, Syarifuddin N	90
Karim, Nur Azmi	42
Kartini, Dwi	795
Kartini, Kartini	213
Karyawan, Mochammad Anang	272
Kautsar Sophan, Mochammad	721
Kelana Jaya, Indra	648
Kennedy, David	612
Khadija, Mutiara Auliya	830
Khadijah, Alifa	193
Khaerudin, Muhammad	367, 429
Khairani, Dewi	780, 790, 854
Khoirunisa, Erika	458
Khotimah, Bain Khusnul	390
Kirsan, Aidil Saputra	684

Komarudin, Agus	213
Kosasih, Rifki	238
Koswara, Iwan	813
Krisnadi, Dion	176
Kurniawan, Isman	350
Kusrini, Kusrini	84, 226, 326
Kustanto, Prio	367
Kusuma, Mandahadi	129
Kusumasari, Tien Fabrianti	408, 470
Kusumawardhani, Dhiyah Ayu Rini	571
Laga, Sinarring	272
Laksana, I Kadek Perry Bagus	338
Laksito, Arif Dwi	284, 319
Laksmingrum, Betari Ayu Almadania	510
Langgawan Putra, M. Gilvy	684
Li, Jiyi	672
Lukas, Samuel	176
Lukita, Chandra	504, 583, 715
Lutfian, Karisa Zihni	435
Lutfiani, Ninda	504, 577
Luthfi, Irvan Aulia	372
Luthfi, Luthfi	18
Ma'Ady, Mochamad Nizar Palefi	13
Maharani, Warih	344
Maimunah, Maimunah	709
Mangkang, Tesalonika Abigail Eikwine	338
Mangunwardoyo, Wibowo	332
Marliau, Rheza Meida	636
Masruriyah, Anis Fitri Nur	122
Masruroh, Siti Ummi	790, 854, 859
Maulana, Ade	249
Maulani, Khairun Nisa	435
Maulida, Mutia	361, 372, 396, 445
Maulidiya, Erika	445
Mawardi, Viny Christanti	424
Mazdadi, Muhammad Itqan	79, 795
Mendrofa, Serious	110
Mintarsih, Fitri	780
Miranda, Eka	631
Mirza, Ahmad Haidar	313
Misbullah, Alim	728
Muchtar, Kahlil	452
Muffikhah, Lailil	769
Muhammad, Alva Hendi	326
Mukhlis, Iqbal Ramadhani	272
Mukti, Galih W. W.	199

Muliadi,	61
Munawarah, Munawarah	452
Munthaha, Firman	854
Murdianingsih, Yuli	841
Murti, Jonet Wira	418
Musa, Purnawarman	527
Muslem R, Imam	18
Mustafidah, Hindayati	863
Mustamiin, Muhamad	734
Mustamin, Nurul Fathanah	361, 372, 396, 445
Mutiara, Achmad Benny	541, 547
Mutiaz, Intan Rizky	301
Nadif, Ilham Mafani	226
Nailfaaz,	691
Nanang, Herlino	790
Nanda, Rizki Aulia	429
Nas, Chairun	715
Nasution, Darmeli	750, 813
Natasia, Sri Rahayu	684
Nazhifah, Naurah	654
Nelly, Nelly	606
Ng, Poi Wong	104
Ngafidin, Khairun Nisa Meiah	618
Nhita, Fhira	350
Novita, Hilda	122
Novitasari, Novitasari	445
Novrina, Novrina	527
Nugrahadi, Dodon Turianto	61
Nugraheni, Cecilia Esti	559
Nugroho, Agus Setiyo Budi	784
Nugroho, Arseto Satriyo	435
Nugroho, Yusuf Sulisty	255
Nur Hidayat, Harry	378
Nur Hidayat, Wahyu	678
Nur'Aini, Wiwin	739
Nurani, R. Dwi	90
Nurhadi, Mochamad	67
Nurharjadmo, Wahyu	830
Nurhasanah, Rossy	521
Nurhayati, Nurhayati	780
Nurjannah, Wilda	780
Nurmaini, Siti	313
Nurmalasari, Nurmalasari	482
Nusantara, Ksatria Tirta	745
Oganda, Fitra Putri	535, 583
Oktaviana R, Shinta	482

Oktaviani, Ikke Dian	116
Othman, Mohd Fairuz Iskandar	134
Oyong, Irwan	326
Palpialy, Jemi V	750
Pambudi, Ari	577
Pangaribuan, Christian Haposan	166, 193
Pangaribuan, Jefri Junifer	249
Pangaribuan, Julinda	355
Pangesa, Vianny	338
Panjaitan, Arop Ria Saulina	504
Panjaitan, Re. Miracle	763
Paramita, Ni Luh Putu Satyaning Pradnya	402
Partan, Radiyati Umi	313
Pasaribu, Septia Andriani	464
Pasha, Muhammad Fermi	232
Perdana, Doan	116
Permana, Kurniawan Eka	441
Pokharel, Manish	172
Prabawati, Andhika Galuh	48, 290
Praditya, Dhata	408
Pragusma, Zakaria Berlam	487
Prakoso, Danang Jehan Lukmanto	37
Pramesthy, Widhelia Echa	697
Pramesti, Evita	541
Pramunendar, Ricardus Anggi	445
Pranata, Sudadi	715
Pras, Heri	807
Prasetyo, Didit	277, 301
Prastya, Septyan Eka	61
Pratama, Aditya Sidhiq	859
Pratama, Ferry	445
Pratami, Devi	624
Pratisto, Eko Harry	745
Pratiwi, Mariska Putri	242
Prayitno, M. Hadi	367
Priyawati, Diah	255
Purba, Ronsen	232
Purbaratri, Winny	384
Purnama, I Putu Candra	594
Purnomo, Fendi Aji	745
Purnomo, Purnomo	863
Purwarianti, Ayu	418
Putrada, Aji Gautama	116
Putri, Ananda Alifia	510
Putri, Delfia Nur Anrianti	691
Putri, Rizka Amalia	859
Putri, Salwa Rizqina	697

Putri, Silvy Zafira	769
Rachman, Andi Nur	73
Rahardja, Untung	504, 510, 571, 577
Raharjo, Teguh	739
Rahman, Aulia	666
Rahman, Difa Habiba	418
Rahmatulloh, Alam	220
Rahutomo, Faisal	807
Ramadhan, Arief	261
Ramadhan, Nur Ghaniaviyanto	344
Ramadhan, Zhafran	140
Ramadhani, Nugrahardi	277, 301
Ramadlan, Ahmad Fadlan	854
Ramdhani, Yudi	42
Rasyidi, Muhammad Ashlah	780
Rayyan, Rayyan	476
Recy, Okzata	825
Refianti, Rina	541, 547
Restreva Danestiara, Venia	187
Richard, Richard	553, 606
Rifani, Ahmad Haris	129
Rikki, Alex	648
Rini, Maria Nila Anggia	290
Riza Chakim, Mochamad Heru	535
Rizky Mutiaz, Intan	277
Roestam, Rusdianto	199, 206
Rohman, Arif Nur	326
Rokhmawati, Retno Indah	458
Romadhony, Ade	414
Romindo, Romindo	249
Rony, Firdaus Rosean	332
Rosa Anamisa, Devie	721
Rosian Adhy, Dewanto	134
Roy, Pronab Chandra	24
Rubhasy, Albaar	476
Rudy Hendrawan, I Nyoman	1
Rusdi, Zyad	307
Rusilowati, Umi	535
S, Wahyuddin	267
Sabilla, Irzal Ahmad	774
Sabri, Ahmad	238
Sadewo, Ayu	402
Saelan, M Rangga Ramadhan	482
Safitri, Anggilia Nur	435
Safitri, Cutifa	848
Safuan, Safuan	180

Saha, Anish Kumar	24
Saikhu, Ahmad	267, 709
Saimima, Ika Dewi Sartika	367
Saintika, Yudha	618
Salam, Rahmat	510
Sam An, Muhammad	180
Samsudin, Noor	146
Santoso, Halim Budi	48
Santoso, Iwan	441
Santoso, Nuke Puji Lestari	571
Sanyoto, Aisha Edna Alicia	660
Saputra, Angelica Patrica Djaya	636
Saputra, Craven S.	559
Saputra, Mochamad Chandra	660
Saputri, Misik Puspajati	836
Saragih, Triando Hamonangan	79
Sari, Amillia Kartika	600
Sari, Yunita	654
Sari, Yuslena	361, 372, 396, 445
Sarkis, Indra M	648
Sarwinda, Devvi	332, 636
Sasmita, Ramdhansyach	180
Satoto, Budi Dwi	600
Satriyo. U. Y. S, Dwiko	807
Senjaya, Remi	527
Sensusiati, Anggraini Dwi	600
Septyanto, Arif Wicaksono	154
Setiana, Elia	187
Setianingrum, Anif Hanifa	666
Setiawan, Budi Darma	763
Setiawan, Foni Agus	160
Setiyani, Lila	848
Sheilawati, Siti	361
Shobirin, Ma'As	516
Shofa, Rahmi Nur	220
Shrestha, Sushil	172
Sigit Arifianto, Mohammad	819
Simanjuntak, Kevin Samuel Pratama	553
Sinambela, Marzuki	648
Singh, Laiphrakpam Dolendro	24
Soelaiman, Rully	267
Soeparno, Haryono	631
Sophan, Moch Kautsar	441
Sriwinar, Sriwinar	18
Subandi, Subandi	784
Subianto, Muhammad	728
Sugiantoro, Bambang	129
Sugiharto, Pradiptya Kahvi	769

Suhara, Ade	429
Suhartini, Suhartini	527
Suheryadi, Adi	734
Sukarwoto, Sukarwoto	750
Sukmana, Husni Teja	780, 790
Sukmawati, Cici Emilia	122
Sukri, Hanifudin	390
Sularsih, Puji	527
Sulistianingsih, Indri	750, 813
Sulistiyo, Selo	378
Sumpena, Haidar Dzaky	154
Sunarya, Po Abas	535, 571
Sunjaya, Andriana	104
Suprianto, Gaguk	272
Suryadi, Usep Tatang	841
Suryani, Tatik	67
Susanti, Leni	493
Susanto, Decwind Skylar	606
Susilo, Andi	94
Susilo, Valerie Vanora	424
Suswanto, Hary	678
Sutisna, Nana	583
Suwarsito, Suwarsito	863
Suzanti, Ika Oktavia	390
Syamsuar, Dedy	242, 612
Syarif, Iwan	37
Tahta Arsyillah, Nazhiroh	678
Tamara, Eggie Pandu	482
Tambotoh, Johan J.C	384
Tamtama, Gabriel Indra Widi	48
Tanti,	99
Teven, Bryan	784
Thio, Brian	166
Tjia, Fiona	249
Tolle, Herman	458, 464, 801
Tony, Tony	757
Triandini, Evi	1
Tsaqofi, Waki Ats	854, 859
Tukino, Tukino	429
Udayana, I Putu Agus Eka Darma	594
Udiatami, Wilda Melia	402
Ulansari, Ramadhani	94
Umam, Busro Akramul	213
Umam, Faikul	390
Utami, Sri Handika	642

Vanora Susilo, Valerie	55
Victor Parningotan Samosir, Feliks	110
Wahiddin, Deden	122
Wahyono,	691
Wahyuni, Sri	813
Wahyuningrum, Rima Tri	600
Wandy, Wandy	94
Wang, Jyun-Cheng	48
Wardhani, Luh Kesuma	859
Wardiah, Isna	784
Wibowo, Sigit A.	624
Widianto, Eko Didik	435
Widiarto, Hendro	813
Widjaja, Petrus	176
Widodo, Catur Edi	836
Wijaya, Akhmad Pandhu	516
Wijaya, Daniel Zerge	487
Wijaya, Eka Setya	361, 372, 396, 445
Wijaya, Naramia	55
Wijaya, Novresia	104
Wijaya, Raden Bagus Muhammad Adryanputra Adhy	691
Wijayanto, Arie Wahyu	697
Wijayanto, Sena	618
Wimatra, Ayub	750
Winardi, Sunaryo	104
Windasari, Ike Pertiwi	836
Windasari, Nila Armelia	48
Wulandari, Ajeng	487
Yarcana, Agus	1
Yaser, Muhammad	819
Yendri, Sheinna	267
Yonatan, Michiko Amaya	338
Yuana, Kumara Ari	84
Yudanto, Faturahman	654
Yudhanto, Yudho	745
Yugospito, Pujianto	355
Yunis, Roni	99
Yunita, Ariana	140
Yustisia, Whinda	402
Yusuf, Ajif Yunizar Pratama	367
Yusuf, Muhammad	721
Yutanto, Hariadi	272
Zaenal Abidin, Aa Zezen	841
Zahra, Annisa	636
Zendrato, Niskarto	521

Zuhron, Ach. Halimi Firdaus
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600
728

Improving Land Cover Segmentation Using Multispectral Dataset

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Abstract—Computer vision has been used in many areas such as medical, transportation, military, geography, etc. The fast development of sensor devices inside camera and satellite provides not only red-green-blue (RGB) images but also multispectral dataset with some channels including RGB, infrared, short-wave, and thermal wave. Most of the dataset is panchromatic (black and white) and RGB, for example Google Map and other satellite-based map applications. This study examines the effects of multispectral dataset for semantic segmentation of land cover. The comparison between RGB with band 2 to band 7 of Landsat 8 Satellite shows an improvement of accuracy from 90.283 to 94.473 for U-Net and from 91.76 to 95.183 for DeepLabV3+. In addition, this research also compares two well-known semantic segmentation methods, namely U-Net and DeepLabV3+, that shown that DeepLabV3+ outperformed U-Net regarding to speed and accuracy. Testing was conducted in the Karawang Regency area, West Java, Indonesia.

Keywords—DeepLabV3+, Semantic Segmentation, Landsat, MATLAB, Deep Learning

I. INTRODUCTION

Computer vision is a branch of Artificial Intelligence (AI) that aims to mimic human capabilities in recognizing image patterns. Neural Networks, the fundamental building blocks of Deep Learning, have been utilized extensively in pattern recognition, gradually replacing models based on mathematical and statistical principles, such as Local Binary Pattern Histogram [1], Adaptive Feature Fusion [2], and others for face recognition. Rapid advancements in hardware have facilitated pattern recognition computations based on neural networks. Graphics Processing Units (GPUs) are quite effective in supporting neural networks with many layers, which are more commonly known as Deep Learning.

However, there exists a gap between the field of computer science and Remote Sensing and Geographic Information Systems (RS-GIS), where the use of multispectral satellite imagery is still limited among computer science researchers. This is evident from the scarcity of multispectral images in benchmarking sites. Most researchers still rely on Red, Green, and Blue (RGB) and grayscale images.

Deep Learning is very practical considering the preprocessing combined within a single neural network model. These preprocessing leverages convolution and has proven to be quite effective in its implementation under the name Convolutional Neural Networks (CNN). This method utilizes a set of filters to extract features from the images to be processed [3].

Research continues to develop CNN with several modifications to address issues that arise in the method [4]–[8], one of which is the vanishing gradient problem due to the large number of filtering effects on the convolution side. This issue can be addressed with the Residual Networks (ResNet) method, allowing layers to be increased to hundreds in a ResNet [9].

There are three problems in computer vision, namely classification, object detection, and segmentation. If classification aims to categorize images according to the training data, object detection will provide notifications (usually in the form of bounding boxes) around the detected objects. The research we are conducting focuses on segmentation, where its classification results are at the pixel level of the image with multiple colors representing their classes. All three of these problems still use the same method, which is convolution-based (CNN) known as U-Net [10].

Furthermore, other modifications for semantic segmentation have been researched [11]–[15].

This research aims to contribute to other researchers who want to apply multispectral datasets and determine which bands are suitable for use in semantic segmentation. This research also can serve as a reference for remote sensing researchers to leverage Deep Learning in the segmentation process. Additionally, the comparison between the U-Net and DeepLabV3+ models can serve as a reference for their implementation in the field, along with their pros and cons.

The rest of the paper is organized as follows. After detailing the dataset and methods, the results are analyzed and discussed, with a focus on the multispectral dataset used. Subsequently, the conclusion provides insights from the findings of this research.

II. MATERIALS AND METHODS

A. Datasets

For the dataset, all available bands were downloaded from the United States Geological Survey (USGS) [16] website for the Jakarta Metropolitan Region (JABOTABEK), which were then cropped to cover the entire area of Karawang Regency. Figure 1 shows the capture area (referred to as a 'tile').

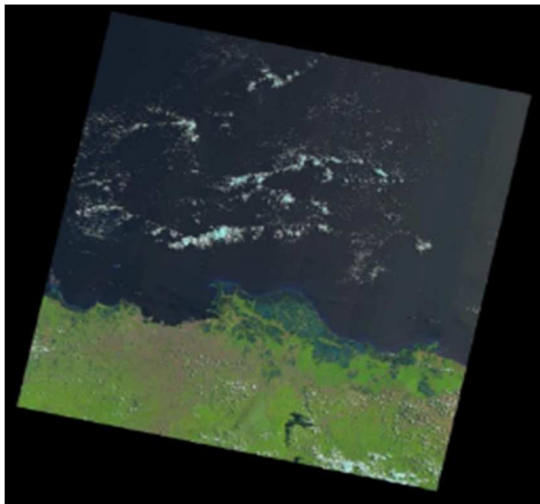


Fig. 1. The region downloaded (Tile) of Jakarta Metropolitan Region

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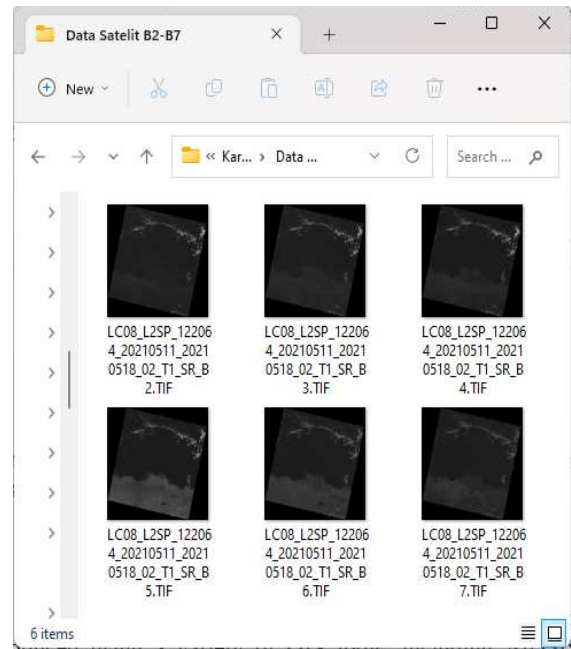


Fig. 2. Landsat capture data for July 2021

Landsat 8 has a resolution of 30 meters and is considered as Level 1 according to the standards [16], [17]. Considering that this research only investigates the effects of multispectral with RGB, the land cover to be segmented is urban, vegetation, and water. To calculate accuracy, ground truth data is required, representing the actual conditions of the urban, vegetation, and water segment classes, using the TerrSet software, which utilizes a semi-automatic process, namely Iterative Self-Organizing Clustering (ISOCCLUS) and the RECLASS function to manually reclassify them into three classes [18]. This research uses MATLAB as the programming language and Graphic User Interface (GUI) to facilitate experiments.

B. U-Net

U-Net is a semantic segmentation model that utilizes convolutional methods in CNN. The principle is to perform encoding processes with multiple filtrations followed by decoding, which is the reverse of convolution (deconvolution), where at each level, a copy and crop process is performed between the encoder and decoder sides to refine the resulting image into segments that match the training data (Figure 3).

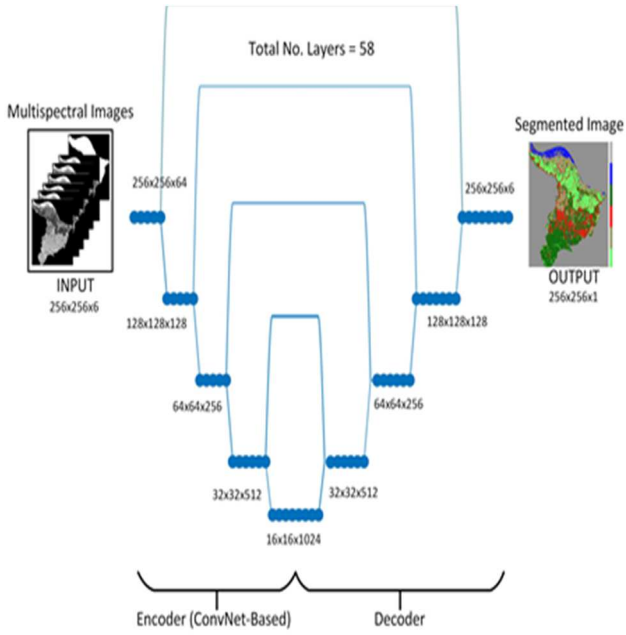


Fig. 3. U-Net Architecture

Equation 1 illustrates the principle of convolution with a 3×3 square filter. G , H , and F are convolution operator, image matrix, and filter, respectively. Variable k is the size of filter.

$$G[i, j] = \sum_{u=-k}^k \sum_{v=-k}^k H[u, v] F[i - u, j - v] \quad (1)$$

B. DeepLabV3+

One of the main challenges of U-Net, based on its foundation in CNN, is the issue of vanishing gradients. This occurs when attempts to improve accuracy by adding layers result in a slow convolution process. This can be especially time-consuming for large-sized images. Therefore, other models utilize ResNet, which performs convolution processes in its residual path rather than the main path. As a result, the process is faster, and the addition of many layers does not lead to vanishing gradients. The ResNet versions have many layers, ranging from 50 to 101, compared to CNN, which can only be developed up to 19 layers in the Visual Geometry Group (VGG19).

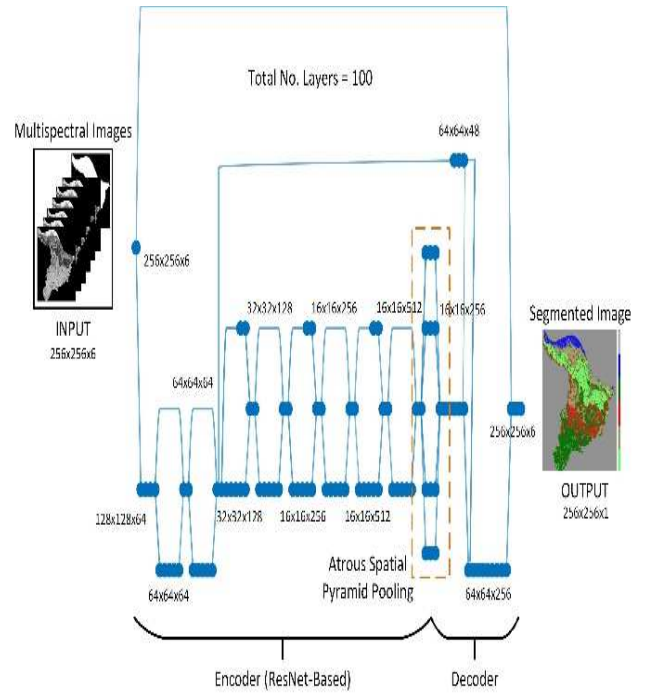


Fig. 4. DeepLabV3+ Architecture

DeepLab uses ResNet on both the encoder and decoder sides. Subsequently, several versions of DeepLab emerged, including DeepLabV3+, which implements Atrous Spatial Pyramid Pooling (ASPP) to expedite the process and address the classification issues of objects with significantly different sizes from one another.

The training process is conducted using a MATLAB live script. The process takes several days. Figure 5 shows the live script for both U-Net and DeepLabV3+ training processes.

The live script has the capability to run program code alongside the display of output and other information, both in text and image formats. The training results are U-Net and DeepLabV3+ models ready for land cover segmentation. A graphical user interface (GUI) was created to facilitate both experiments and user usage.

The GUI used for inference contains buttons to input both RGB and multispectral images, followed by ground truth images for accuracy calculations. The output includes land cover segmentation as well as accuracy and percentage for each segment class.

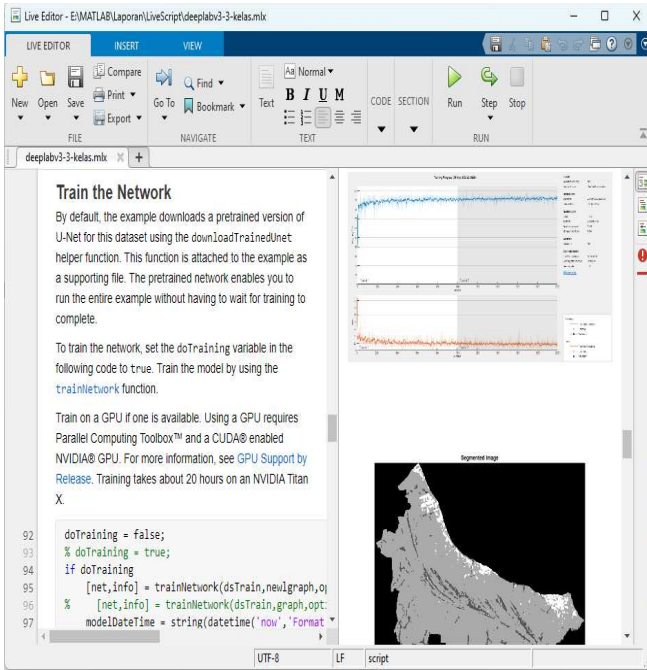


Fig. 5. Live Script for Training

Two trained models are generated, namely U-Net and DeepLabV3+, which are then used for inference on two types of data, namely RGB and multispectral data, before being checked for accuracy based on their respective ground truth datasets.

III. RESULT AND DISCUSSION

The training of the U-Net and DeepLabV3+ models took approximately 4 hours. The accuracy obtained for U-Net and DeepLabV3+ is 94% and 95%, respectively.

A. U-Net Segmentation Result

RGB satellite images are images that can be seen by the human eye. In Landsat 8, RGB is a combination of Band 4, Band 3, and Band 2. Figure 6 shows the segmentation accuracy based on RGB images and multispectral images in the U-Net model.

The testing results with U-Net show that multispectral images yield an accuracy that is 4 percent better than RGB. The urban and water segments, based on the experimental results, had the most significant impact, resulting in a decrease in accuracy. Table 1 shows the recapitalization of U-Net testing using RGB and Multispectral dataset.

TABLE I. U-NET SEGMENTATION

No.	Dataset	Accuracy (%)	Speed
1.	Multispectral	94.473	5 minutes
2.	RGB	90.283	5 minutes

RGB is slightly less accurate in detecting urban and water areas. The accuracy of RGB images is more than 4% lower than that of multispectral datasets.

The training results can be applied to other regions in Indonesia. For more segment classes such as wetlands, barren land, agriculture, forest, and others, a training process is required. This also includes regions with a subtropical climate and four seasons.

The GUI facilitates the input and output processes. Conversion into an executable program (EXE) can be done using the deployment module in MATLAB.

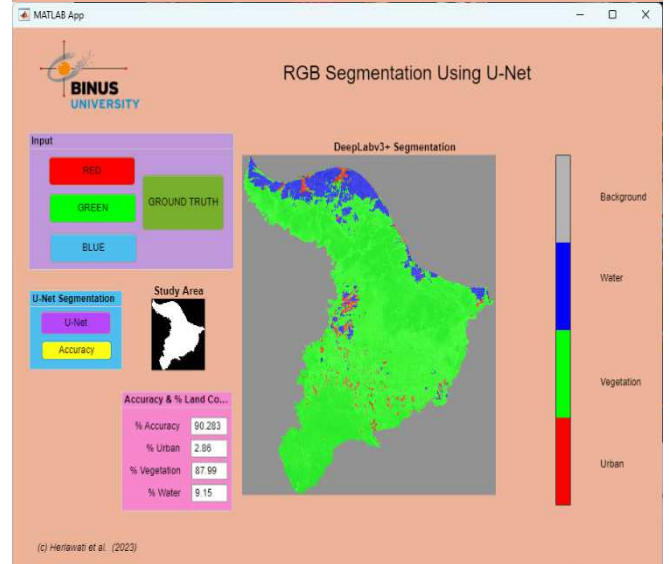
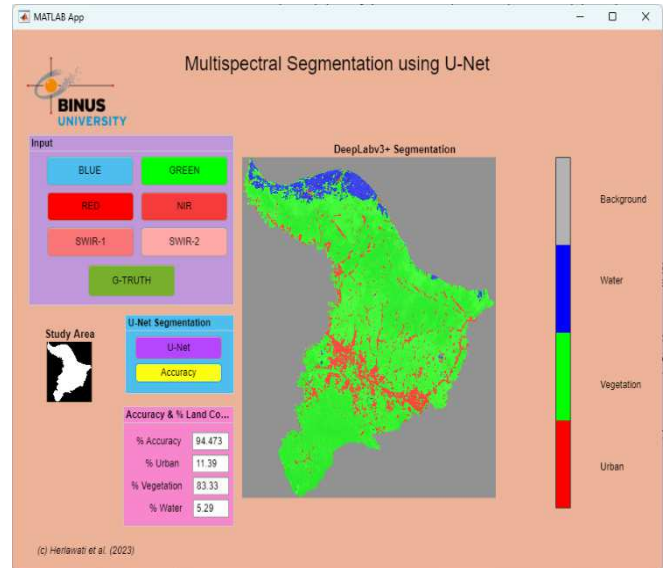


Fig. 6. U-Net Segmentation Result: Multispectral (above) and RGB (below)

B. DeepLabV3+ Segmentation Result

The testing results (Figure 7) with DeepLabV3+ show that multispectral images yield an accuracy that is 4 percent better than RGB. The urban and water segments, based on the experimental results, had the most significant impact, resulting in a decrease in accuracy.

With the same GUI, the process button directs to a MAT file, which is the result of training DeepLabV3+. For multispectral images, bands 2, 3, 4, 5, 6, and 7 represent blue, green, red, near-infrared, short-wave infrared-1 (SWIR-1), and short-wave infrared-2 (SWIR-2) images, respectively.

For RGB data, bands 4, 3, and 2 represent the red, green, and blue channels. Unlike U-Net, which takes about 5 minutes, DeepLabV3+ is much faster, taking less than 1 minute. Unlike U-Net, DeepLabV3+ with RGB is still able to detect most of the urban classes. In addition, DeepLabV3+ shows 1% higher accuracy compared to U-Net.

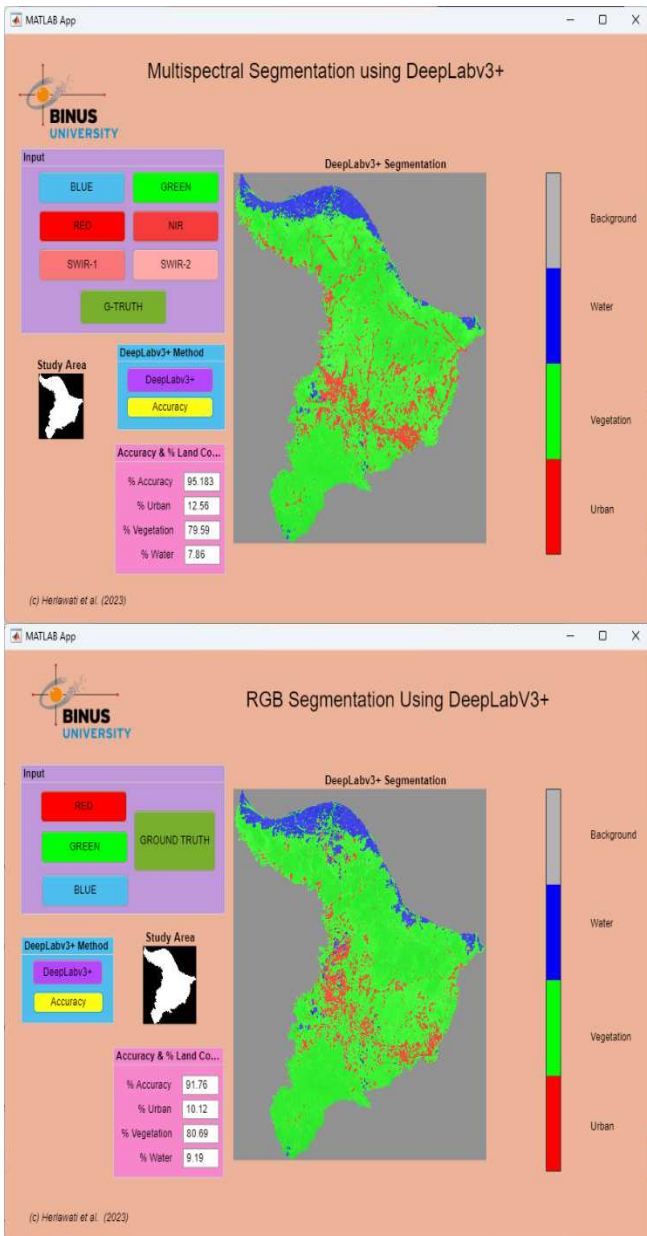


Fig. 7. DeepLabV3+ Segmentation Result: Multispectral (above) and RGB (below)

TABLE II. DEEPLABV3+ SEGMENTATION

No.	Dataset	Accuracy (%)	Speed
1.	Multispectral	95.183	30 second
2.	RGB	91.76	30 second

Although DeepLabV3+ has a slight advantage in terms of accuracy, the inference process shows that U-Net is four to five times slower than DeepLabV3+, depending on the user's processor capacity. Therefore, DeepLabV3+ is more suitable for satellite images implementation compared to U-Net, which is indeed suitable for small-sized images such as medical images (X-ray, MRI, etc.).

IV. CONCLUSIONS

The availability of satellite imagery should be utilized for land management. One of the advantages of satellite imagery is its sensors, which have many specific functions. Several channels in Landsat 8 each have the capability to capture specific frequencies, not only the frequency range visible to

the human eye but also infrared, short-wave infrared, and thermal. RGB has an advantage because most cameras can capture this kind of images, but experimental results show that multispectral images have better accuracy than RGB images. Additionally, DeepLabV3+, not only having better accuracy than U-Net, also has the advantage of inference speed. Future research needs to produce proposed models or additional features that outperform both DeepLabV3+ and U-Net.

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Improving Land Cover Segmentation Using Multispectral Dataset

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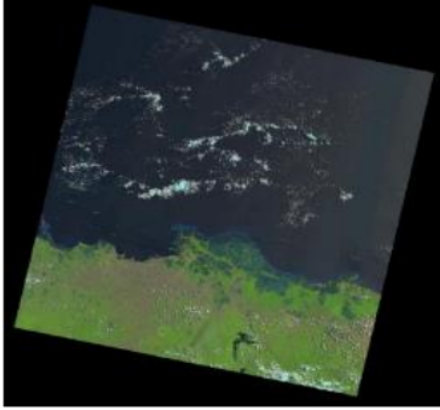


Fig. 1. The region downloaded (Tile) of Jakarta Metropolitan Region

To produce clear satellite captures, it is necessary to find a date during the dry season with minimal cloud cover. Figure 2 shows the Geo TIFF files for the required channels, which were taken in July 2021.

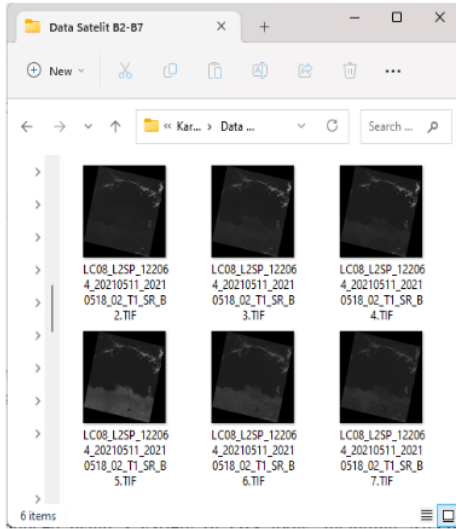


Fig. 2. Landsat capture data for July 2021

Landsat 8 has a resolution of 30 meters and is considered as Level 1 according to the standards [16], [17]. Considering that this research only investigates the effects of multispectral with RGB, the land cover to be segmented is urban, vegetation, and water. To calculate accuracy, ground truth data is required, representing the actual conditions of the urban, vegetation, and water segment classes, using the TerrSet software, which utilizes a semi-automatic process, namely Iterative Self-Organizing Clustering (ISOCCLUS) and the RECLASS function to manually reclassify them into three classes [18]. This research uses MATLAB as the programming language and Graphic User Interface (GUI) to facilitate experiments.

B. U-Net

U-Net is a semantic segmentation model that utilizes convolutional methods in CNN. The principle is to perform encoding processes with multiple filtrations followed by decoding, which is the reverse of convolution (deconvolution), where at each level, a copy and crop process is performed between the encoder and decoder sides to refine the resulting image into segments that match the training data (Figure 3).

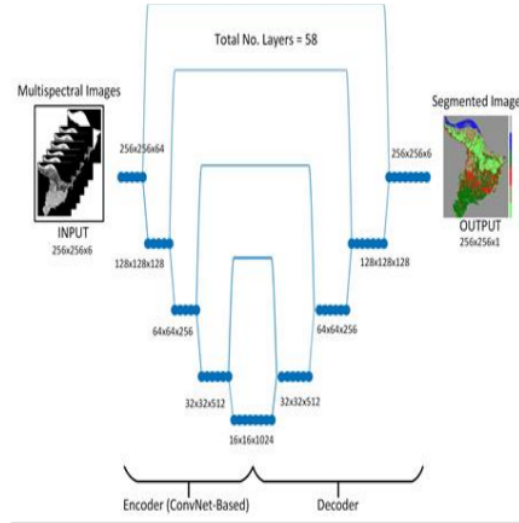


Fig. 3. U-Net Architecture

Equation 1 illustrates the principle of convolution with a 3x3 square filter. G, H, and F are convolution operator, image matrix, and filter, respectively. Variable k is the size of filter.

$$G[i, j] = \sum_{u=-k}^k \sum_{v=-k}^k H[u, v] F[i - u, j - v] \quad (1)$$

B. DeepLabV3+

One of the main challenges of U-Net, based on its foundation in CNN, is the issue of vanishing gradients. This occurs when attempts to improve accuracy by adding layers result in a slow convolution process. This can be especially time-consuming for large-sized images. Therefore, other models utilize ResNet, which performs convolution processes in its residual path rather than the main path. As a result, the process is faster, and the addition of many layers does not lead to vanishing gradients. The ResNet versions have many layers, ranging from 50 to 101, compared to CNN, which can only be developed up to 19 layers in the Visual Geometry Group (VGG19).

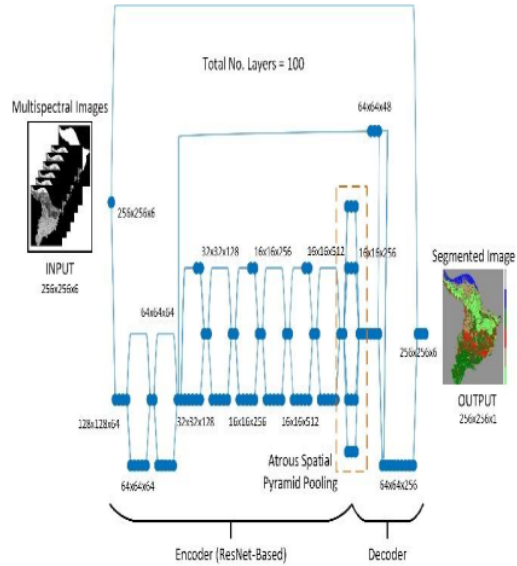


Fig. 4. DeepLabV3+ Architecture

DeepLab uses ResNet on both the encoder and decoder sides. Subsequently, several versions of DeepLab emerged, including DeepLabV3+, which implements Atrous Spatial Pyramid Pooling (ASPP) to expedite the process and address the classification issues of objects with significantly different sizes from one another.

The training process is conducted using a MATLAB live script. The process takes several days. Figure 5 shows the live script for both U-Net and DeepLabV3+ training processes.

The live script has the capability to run program code alongside the display of output and other information, both in text and image formats. The training results are U-Net and DeepLabV3+ models ready for land cover segmentation. A graphical user interface (GUI) was created to facilitate both experiments and user usage.

The GUI used for inference contains buttons to input both RGB and multispectral images, followed by ground truth images for accuracy calculations. The output includes land cover segmentation as well as accuracy and percentage for each segment class.

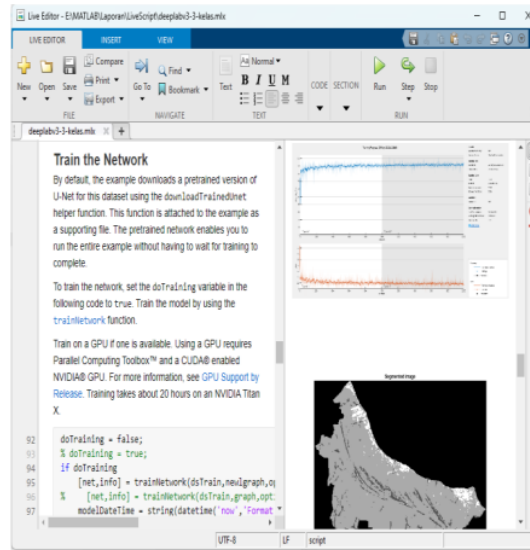


Fig. 5. Live Script for Training

Two trained models are generated, namely U-Net and DeepLabV3+, which are then used for inference on two types of data, namely RGB and multispectral data, before being checked for accuracy based on their respective ground truth datasets.

III. RESULT AND DISCUSSION

The training of the U-Net and DeepLabV3+ models took approximately 4 hours. The accuracy obtained for U-Net and DeepLabV3+ is 94% and 95%, respectively.

A. U-Net Segmentation Result

RGB satellite images are images that can be seen by the human eye. In Landsat 8, RGB is a combination of Band 4, Band 3, and Band 2. Figure 6 shows the segmentation accuracy based on RGB images and multispectral images in the U-Net model.

The testing results with U-Net show that multispectral images yield an accuracy that is 4 percent better than RGB. The urban and water segments, based on the experimental results, had the most significant impact, resulting in a decrease in accuracy. Table 1 shows the recapitalization of U-Net testing using RGB and Multispectral dataset.

TABLE I. U-NET SEGMENTATION

No.	Dataset	Accuracy (%)	Speed
1.	Multispectral	94.473	5 minutes
2.	RGB	90.283	5 minutes

RGB is slightly less accurate in detecting urban and water areas. The accuracy of RGB images is more than 4% lower than that of multispectral datasets.

The training results can be applied to other regions in Indonesia. For more segment classes such as wetlands, barren land, agriculture, forest, and others, a training process is required. This also includes regions with a subtropical climate and four seasons.

The GUI facilitates the input and output processes. Conversion into an executable program (EXE) can be done using the deployment module in MATLAB.

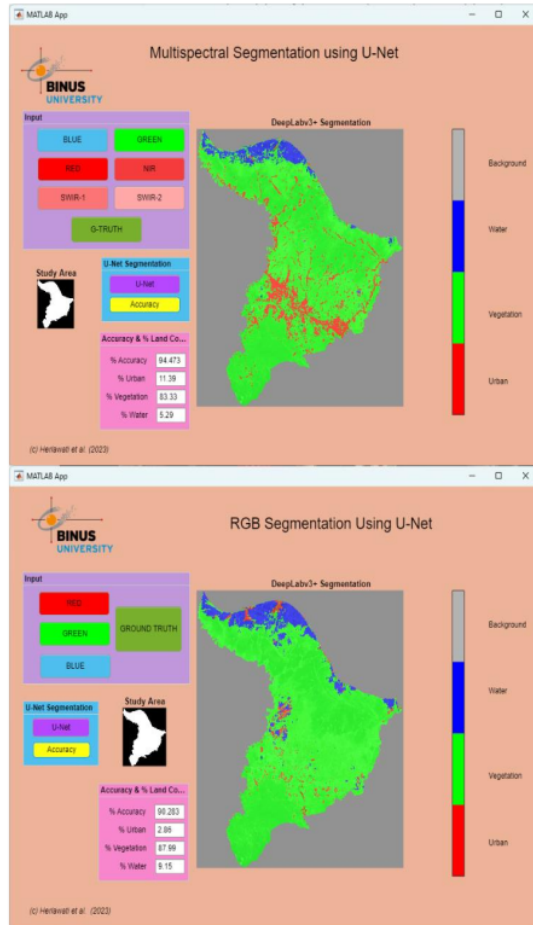


Fig. 6. U-Net Segmentation Result: Multispectral (above) and RGB (below)

B. DeepLabV3+ Segmentation Result

The testing results (Figure 7) with DeepLabV3+ show that multispectral images yield an accuracy that is 4 percent better than RGB. The urban and water segments, based on the experimental results, had the most significant impact, resulting in a decrease in accuracy.

With the same GUI, the process button directs to a MAT file, which is the result of training DeepLabV3+. For multispectral images, bands 2, 3, 4, 5, 6, and 7 represent blue, green, red, near-infrared, short-wave infrared-1 (SWIR-1), and short-wave infrared-2 (SWIR-2) images, respectively.

For RGB data, bands 4, 3, and 2 represent the red, green, and blue channels. Unlike U-Net, which takes about 5 minutes, DeepLabV3+ is much faster, taking less than 1 minute. Unlike U-Net, DeepLabV3+ with RGB is still able to detect most of the urban classes. In addition, DeepLabV3+ shows 1% higher accuracy compared to U-Net.

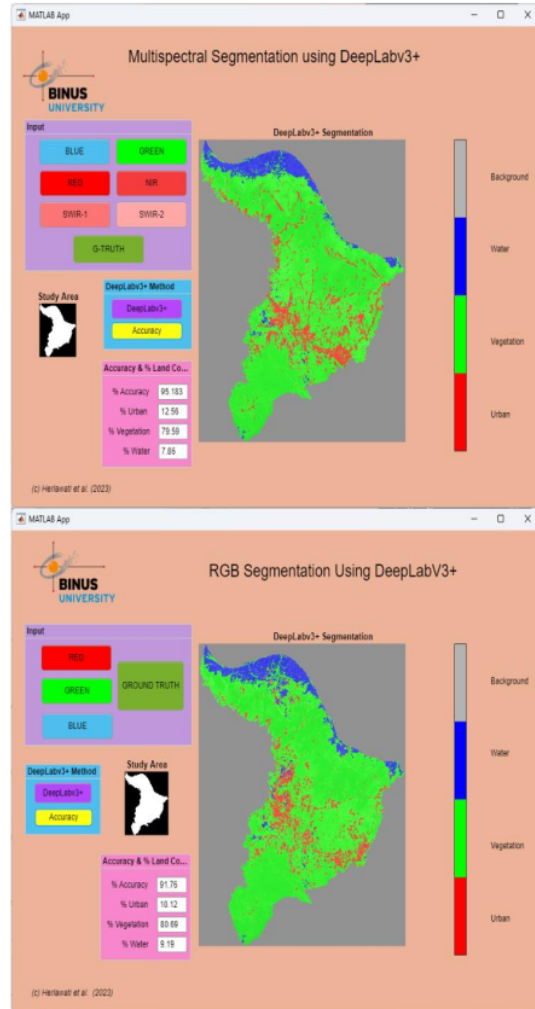


Fig. 7. DeepLabV3+ Segmentation Result: Multispectral (above) and RGB (below)

TABLE II. DEEPLABV3+ SEGMENTATION

No.	Dataset	Accuracy (%)	Speed
1.	Multispectral	95.183	30 second
2.	RGB	91.76	30 second

Although DeepLabV3+ has a slight advantage in terms of accuracy, the inference process shows that U-Net is four to five times slower than DeepLabV3+, depending on the user's processor capacity. Therefore, DeepLabV3+ is more suitable for satellite images implementation compared to U-Net, which is indeed suitable for small-sized images such as medical images (X-ray, MRI, etc.).

IV. CONCLUSIONS

The availability of satellite imagery should be utilized for land management. One of the advantages of satellite imagery is its sensors, which have many specific functions. Several channels in Landsat 8 each have the capability to capture specific frequencies, not only the frequency range visible to

the human eye but also infrared, short-wave infrared, and thermal. RGB has an advantage because most cameras can capture this kind of images, but experimental results show that multispectral images have better accuracy than RGB images. Additionally, DeepLabV3+, not only having better accuracy than U-Net, also has the advantage of inference speed. Future research needs to produce proposed models or additional features that outperform both DeepLabV3+ and U-Net.

4

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