

**ICORIS**



# PROCEEDING

**2024 6TH INTERNATIONAL CONFERENCE ON  
CYBERNETICS AND INTELLIGENT SYSTEM**

**ISBN: 979-8-3315-3960-3**

2024 6th International Conference on Cybernetics and Intelligent System (ICORIS) | 979-8-3315-3960-3/24/\$31.00 ©2024 IEEE | DOI: 10.1109/ICORIS63540.2024.10903942



# **2024 6<sup>th</sup> International Conference on Cybernetics and Intelligent System (ICORIS)**

**Surakarta, Indonesia  
(Hybrid Conference)**

**November 29-30, 2024**

**ISBN: 979-8-3315-3960-3**

# 2024 6th International Conference on Cybernetics and Intelligent System (ICORIS)

Surakarta, Indonesia (Hybrid)

Phone: +6281343512272

Email: [icoris2019@gmail.com](mailto:icoris2019@gmail.com)

Website: <https://icoris.org/>

November 29-30, 2024

**ISBN: 979-8-3315-3960-3**

# 2024 6th International Conference on Cybernetics and Intelligent System (ICORIS)

Copyright ©2024 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved.

## **Copyright and Reprint Permission**

Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law, for private use of patrons, those articles in this volume that carry a code at the bottom of the first page, provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

Other copying, reprint, or reproduction requests should be addressed to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

ISBN: 979-8-3315-3960-3

Additional copies of this publication are available from

Curran Associates, Inc.

57 Morehouse Lane

Red Hook, NY 12571 USA

+1 845 758 0400

+1 845 758 2633 (FAX)

# PREFACE



It is our great pleasure to present 6rd International Conference on Cybernetics and Intelligent Systems (ICORIS), which was organized on 29th - 30th November 2024 at Universitas Sahid Surakarta - Central Java province, Indonesia.

This years' theme is "Creating Datasets Based on Local Wisdom to Support National Sovereignty". ICORIS 2024 brings together an interdisciplinary community of experts to discuss innovative theories, methodologies, and applications across diverse areas such

as machine learning, robotics, neural networks, intelligent control systems, and cyber-physical systems. With a shared goal of advancing the frontiers of knowledge and promoting collaboration, this conference aims to bridge the gap between theoretical research and real-world applications.

There are 411 papers submitted from eight countries, and only 152 papers are accepted. The accepted papers will be presented in 7 regular sessions virtually and onsite. These papers will be published in the conference proceedings volume. All accepted papers are submitted to IEEEXplore. IEEE Conference Number: #63540.

On behalf of the ICORIS 2024 organizers, We extend our heartfelt gratitude to the authors, reviewers, and organizing committee for their invaluable contributions. A special thanks goes to our keynote speakers and sponsors, whose support and expertise have greatly enriched the conference. Finally, thanks to all lecturers and staff of Universitas Sahid Surakarta and other parties that directly and indirectly make this event successful.

Warm Regards.  
Evi Triandini (Organizing Chair)

# COMMITTEES

## STEERING COMMITTEE

- Dr. Y. Johny W. Soetikno, SE.,MM. ( Universitas Dipa Makassar, Indonesia)
- Marthen Sengkey, PhD (Universitas Klabat)
- Dr. Dadang Hermawan (ITB STIKOM Bali)
- Dr. Ir. Djoko Soetarno, D.E.A (Binus University)
- Prof. Dr. M. Suyanto, MM. (AMIKOM Yogyakarta)
- Prof. Dr. Ir. Harjanto Prabowo, M.M. (Rektor Universitas Bina Nusantara)
- Prof. Dr. Ir. Edi Noersasongko, M.Kom (Universitas Dian Nuswantoro Semarang)
- Dr. Rika Rosnelly, S.Kom., M.Kom. (Universitas Potensi Utama)
- Restu Adi wiyono, M.Sc., M.Kom. (STMIK Tasikmalaya)
- Dr. Po Abas Sunarya, M.Si. (STMIK Raharja)
- Dr Berlilana , M.Kom ( Univ Amikom Purwokerto, Indonesia)
- Dr Anthony Anggrawan, M.T., PhD ( Univ Bumigora Mataram, Indonesia)
- Mus Aidah, S.Pd., MM. (STMIK Adhi Guna Palu)
- Djuniarto, S.Kom., M.Kom( stmik PGRI, banyuwangi, Indonesia)
- Dr. Hj. Rosiyati Mh Thamrin, SE., MM. (STMIK Sepuluh Nopember Jayapura)
- M Hari Purwiantoro, S.Kom., M.Kom( STMIK AMIKOM Surakarta, Indonesia)
- Muchammad Naseer, M.Kom (STT Bandung, Indonesia)
- Benedictus Effendy, ST., MT ( STMIK Palcomtec Palembang, Indonesia)
- Dr. Hadi Santoso, S.Kom., M.Kom.( Institut Sains dan Bisnis ATMALUHUR, Indonesia)
- Suardi B Haruna, S.Si.,M.Si (STMIK PROFESIONAL, Makasar, Indonesia)
- Bob Subhan Riza, S.T, M.Kom ( Universitas Potensi Utama, Medan, Indonesia)
- Dr. Dina Fitria Murad., M.Kom., CEAA., SMIEEE (Bina Nusantara University, Jakarta, Indonesia)

## **ORGANIZING COMMITTEE**

### **General Chair**

- Chair : Dr. Evi Triandini ( ITB Stikom Bali, Indonesia)
- Co-Chair (local arrangement): Sri Huning Anwariningsih, M.Kom

### **Publication**

- Chair: Dr. Sandy Kosasi, MM., M.Kom. (STMIK Pontianak)
- Co-Chair: Farid Fitriyadi, M.Kom

### **Publicity**

- Publicity Chair: Erfan Hasmin, S.Kom.,MT. (Universitas DIPA Makassar)
- Publicity Co-Chair: Dr. Erwin Kartinawati, M.Ikom

### **Committee Members**

- Ir. Dahlan Susilo, M.Kom
- Hardika Khusnuliawati, M.Kom
- Diyah Ruswanti, M.kom
- Firdhaus Hari Saputro, M.Eng
- Astri Charolina, M.Cs
- Reno, S.Kom
- Ipong Setyawan, S.Kom
- Sukowati Novy Setyawan, S.Kom

## **PROGRAM COMMITTEE**

- Chair: Husni Teja Sukmana, PhD (Universitas Islam Negeri Syarif Hidayatullah), Indonesia
- Co-Chair: Dewi Khairani, M.Sc. (UIN Syarif Hidayatullah Jakarta, Indonesia)

### **Program Committee Members:**

- Prof. Joko Lianto Buliali, Msc, Phd ( Institut Teknologi Sepuluh Nopember(ITS)), Indonesia
- Prof. Ir. Arif Djunaidy M.Sc., Ph.D. (Institut Teknologi Sepuluh Nopember (ITS)), Indonesia
- Prof. Dr.rer.nat. Achmad Benny Mutiara, Q.N, Ssi, Skom ( Universitas Gunadarma), Indonesia
- Prof. Sri Hartati, M.Sc., Ph.D. (IndoCEIS/UGM)
- Prof. Dr. Muhammad Zarlis (Universitas Sumatera Utara), Indonesia.
- Prof. Dr Eri Prasetyo Wibowo, SSI, MMSI ( Universitas Gunadarma), Indonesia
- Prof. Dr. Ir. Untung Rahardja, M.T.I.,MM. ( Universitas Raharja), Indonesia
- Prof. Dr Kusrini ( Univ Amikom Yogyakarta, Indonesia)
- Rafał Dreżewski, Ph.D. (AGH University of Science and Technology), Poland
- Assoc. Prof. Huynh Thi Thanh Binh (Hanoi University of Science and Technology (HUST)), Viet Nam
- Prof. Dr. Mustafa Bin Mat Deris (Universiti Tun Hussein Onn Malaysia (UTHM)), Malaysia
- Assoc. Prof. Somnuk Phon-Amnuaisuk (Universiti Teknologi Brunei), Brunei Darussalam
- Amil Ahmad Ilham, ST.,MIT, PhD( Universitas Hasanuddin), Indonesia
- Daniel Oranova, S.Kom., M.Sc.PD.Eng. (Institut Teknologi Sepuluh Nopember (ITS)), Indonesia
- Arief Setyanto, S.Si., M.T., Ph.D. (AMIKOM Yogyakarta), Indonesia
- Andrew Tanny Liem, PhD (Universitas Klabat), Indonesia
- Dr. Bambang Krismon Triwijoyo( Universitas Bumigora), Indonesia

### **TPC Member:**



- Dr. Azrul Azwan Abdul Rahman (Universiti Teknikal Malaysia Melaka)
- Dr. Azian Azamimi Abdullah (Universiti Malaysia Perlis)
- Mr. Wisam Abed (University of Diyala)
- Dr. Zainul Abidin (Universitas Brawijaya)
- Dr. Ala' Aburumman (University of South Australia)
- Dr. Erkan Afacan (Gazi University)
- Dr. Naveen Aggarwal (Panjab University)
- Dr. Jitendra Agrawal (Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal)
- Ms. Rosliza Ahmad (Universiti Selangor)
- Prof. Nada Ahmedzeki (University of Baghdad)
- Dr. Ruma Ajeena (University of Babylon)
- Prof. Arwa Al-Aama (King Abdulaziz University)
- Dr. Ali Qusay Al-Faris (University of the People)
- Dr. Ahmad Al-Khalil (University of Duhok)
- Dr. Muhammad Raisul Alam (University of Toronto)
- Prof. Majida Alasady (University of Tikrit)
- Dr. Nidal AlBeirut (University of South Wales)
- Dr. Francesco Alesiani (NEC Laboratories Europe)
- Dr. Shahid Ali (NCEI)
- Dr. Wisam Ali (University of Technology)
- Mr. Irteza Ali Khan (National University of Sciences and Technology)
- Prof. Luis Alves (Polytechnic Institute of Bragança)
- Mr. Fikri Anza (Universitas Indonesia)
- Prof. Eraclito Argolo (Universidade Federal do Maranhão)
- Mr. Mohd Rosli Arshad (University Kuala Lumpur)
- Dr. Menaka Arthur (St Joseph's Institute of Technology)
- Mr. Arun Ashok (Forschungszentrum Jülich)
- Dr. Mehdi Assefi (USA)
- Mr. Aditya Awasthi (Qualcomm)
- Dr. Asrul Izam Azmi (Universiti Teknologi Malaysia)
- Dr. Abdel-Hameed Badawy (New Mexico State University)
- Dr. Aslina Baharum (Universiti Malaysia Sabah)
- Mrs. Rajitha Bakthula (MNNIT Allahabad)
- Dr. Mahdi Baradarannia (University of Tabriz)

- Ms. Rashmi C (University of Mysore)
- Dr. Cihat Cetinkaya (Mugla Sitki Kocman University)
- Dr. Sharkawi Che Din (Universiti Teknologi MARA)
- Dr. Uei-Ren Chen (Hsiuping University of Science and Technology)
- Prof. Zhe Chen (Northeastern University)
- Dr. Chidchanok Choksuchat (Prince of Songkla University)
- Mrs. Valentina Colla (Scuola Superiore Sant'Anna)
- Mr. Muhammad Cahya Daulay (Universitas Multimedia Nusantara)
- Prof. George Dekoulis (Aerospace Engineering Institute)
- Mr. Arif Djunaidy (Institut Teknologi Sepuluh Nopember)
- Prof. Arif Djunaidy (Institut Teknologi Sepuluh Nopember)
- Mr. Yusuf Durachman (UIN Syarif Hidayatullah Jakarta)
- Mr. Akhilesh Dwivedi (Graphic Era University Dehradun)
- Dr. Hosam El-Sofany (King Khalid University)
- Dr. Mir Shahriar Emami (The National University of Malaysia)
- Dr. Akaa Eteng (University of Port Harcourt)
- Dr. Yulong Fu (Xidian University)
- Dr. Sasanko Gantayat (GMR Institute of Technology)
- Prof. Nuno Garcia (Universidade da Beira Interior)
- Dr. Marco Gonzalez (National Autonomous University of Mexico)
- Dr. Burhan Gulbahar (Ozyegin University)
- Dr. Akhil Gupta (Lovely Professional University)
- Dr. Nalin Harischandra (University of Peradeniya)
- Prof. Sri Hartati (Gadjah Mada University)
- Dr. M. Udin Harun Al Rasyid (Politeknik Elektronika Negeri Surabaya (PENS))
- Mr. Hanny Haryanto (Universitas Dian Nuswantoro)
- Dr. Jun He (University of New Brunswick)
- Mr. Alexandre Heideker (Federal University of ABC)
- Dr. Edwin Hernandez (EGLA Communications)
- Dr. Masun Nabhan Homsí (Universty of Simón Bolívar)
- Dr. Hugeng Hugeng (Universitas Tarumanagara)
- Dr. Roy Huizen (STIKOM Bali)
- Dr. Mohammad Rezwanul Huq (East West University)
- Mr. Ahmed Hussein (Universtiy of Mustansiriyah)
- Mrs. Wan Irma Sabrina Idris (Universiti Tunku Abdul Rahman, Petaling Jaya)

- Dr. Kamarulafizam Ismail (Universiti Teknologi Malaysia)
- Dr. Mohammed Jarjees (Northern Technical University)
- Mr. Mohammed Kaabar (Moreno Valley College)
- Prof. Abdulkareem Kadhim (Al-Nahrain University)
- Mr. Nikos Kalatzis (Neuropublic S.A.)
- Mr. Keh-Kim Kee (University College of Technology Sarawak)
- Dr. Mansoor Khan (COMSATS Institute of Information Technology)
- Ms. Pinar Kirci (Istanbul University)
- Dr. Sandy Kosasi (STMIK Pontianak)
- Mr. Aswineshadri Krishnan (Satyabhama University – Chennai)
- Mr. Abhishek Kumar (Facebook)
- Prof. Dr Eng Harish Kumar (King Khalid University)
- Dr. Kusrini Kusrini (AMIKOM Yogyakarta University)
- Mr. Beomseok Lee (Chung-Ang University)
- Dr. Sang C. Lee (DGIST)
- Dr. Xia Li (Qualcomm)
- Mr. Andrew Liem (Yuan-Ze University)
- Dr. Shubhankar Majumdar (National Institute of Technology Meghalaya)
- Prof. Mustafa Man (University Malaysia Terengganu)
- Dr. Juan Martinez (University of Murcia)
- Dr. Maslin Masrom (Universiti Teknologi Malaysia)
- Dr. Morcouc Massoud (FCI Cairo University)
- Dr. Dan Milici (University of Suceava)
- Dr. Othman Mohd (Universiti Teknikal Malaysia Melaka)
- Mr. Taha Mokfi (University of Central Florida)
- Mr. Benoît Muth (Benoît Muth)
- Dr. Muhammad Nazir (Lahore College for Women University)
- Dr. Nurdin Nurdin (Institut Agama Islam Negeri (IAIN) Palu)
- Prof. Godwin Nyong (Universidade Federal do ABC)
- Mr. Luciano Ogiboski (UTFPR)
- Dr. Ahmad Fairuz Omar (Universiti Sains Malaysia)
- Dr. Varun P. Gopi (National Institute of Technology)
- Dr. Ramaswamy Palaniappan (University of Kent)
- Prof. Shashikant Patil (SVKM NMIMS Mumbai India)
- Dr. Indika Perera (University of Moratuwa)
- Dr. Linh Manh Pham (Inria Rennes)

- Prof. Anh Huy Phan (SKOLKOVO Institute of Science and Technology)
- Dr. Charalampos Pitas (Independent Power Transmission Operator SA)
- Mr. Harry Prabowo (Universitas Gadjah Mada)
- Mr. Heru Pranoto (Universitas Sumatera Utara)
- Dr. Emil Pricop (Petroleum-Gas University of Ploiesti)
- Dr. Betty Purwandari (Universitas Indonesia)
- Mr. Anggara Putra (Islamic University of Indonesia)
- Dr. M. Mustafa Rafique (Rochester Institute of Technology)
- Prof. Grienggrai Rajchakit (Maejo University)
- Dr. Karthikeyan Ramasamy (Anna University, Chennai)
- Dr. N Ramesh Babu (M Kumarasamy College of Engineering)
- Prof. Priya Ranjan (Amity University)
- Dr. Muhammad Raza Ul Mustafa (University Teknologi PETRONAS)
- Mr. Zairi Rizman (Universiti Teknologi MARA)
- Mr. Ahmad Roihan (STMIK Raharja)
- Dr. Muhammad Rusli (STMIK STIKOM Bali)
- Dr. Heru Agus Santoso (Dian Nuswantoro University)
- Dr. Riyanarto Sarno (Institut Teknologi Sepuluh Nopember)
- Mr. Arief Setyanto (Universitas AMIKOM Yogyakarta)
- Mr. Djoko Setyohadi (Universitas Atma Jaya Yogyakarta)
- Dr. Ahmed Shahin (Zagazig University)
- Dr. Abhijit Sharma (National Institute of Technology Durgapur)
- Dr. Poorani Shivkumar (ESEC)
- Dr. Daniel Siahaan (Institut teknologi Sepuluh Nopember)
- Mr. Rayinda Pramuditya Soesanto (Telkom University)
- Dr. Ir. Djoko Soetarno (Universitas Bina Nusantara)
- Dr. Johny W. Soetikno (Universitas Dipa Makassar)
- Mr. Steffen Späthe (Friedrich-Schiller-University Jena)
- Dr. A'ang Subiyakto (Universitas Islam Negeri Syarif Hidayatullah Jakarta)
- Dr. Husni Teja Sukmana (Syarif Hidayatullah State Islamic University Jakarta)
- Mr. Yuyan Sun (Institute of Information Engineering, Chinese Academy of Sciences)

- Mr. Andang Sunarto (Fakultas Ekonomi dan Bisnis Islam, IAIN Bengkulu)
- Mr. Cucut Susanto (Universitas Dipa Makassar)
- Mr. Edhy Sutanta (Institut Sains & Teknologi AKPRIND Yogyakarta)
- Prof. Srinivasulu Tadisetty (Kakatiya University College of Engineering and Technology)
- Dr. Ashraf Tahat (Princess Sumaya University for Technology)
- Mr. Ashutosh Tripathi (Vaasankatu, 14 A, 6)
- Dr. Tram Truong-Huu (National University of Singapore)
- Dr. Fasee Ullah (UTM)
- Prof. Ema Utami (University of AMIKOM Yogyakarta)
- Dr. Terlapu Vital (jntuK)
- Mr. Kapil Wankhade (G. H. Rasoni College of Engineering Nagpur, INDIA)
- Prof. Wei Wei (Xi'an University of Technology)
- Mr. I Made Marthana Yusa (STMIK STIKOM INDONESIA (STIKI))
- Dr. S Zafaruddin (BITS Pilani)
- Mr. Muhammad Zarlis (Universitas Sumatera Utara)
- Mr. Andrew Tanny Liem (Universitas Klabat)
- Mr. Husni Teja Sukmana, PhD (Universitas Islam Negeri Syarif Hidayatullah)
- Prof. Riyanarto/td> Sarno, PhD (Institut Teknologi Sepuluh Nopember (ITS), Indonesia)
- Prof. Pitoyo Hartono (Chukyo University, Toyota, Japan)
- Prof. Harold Teja Boley (Faculty of Computer Science, University of New Brunswick, NB, Canada)
- Mr. Rafal Drezewski, PhD (AGH University of Science and Technology, Poland)
- Assoc. Prof. Huynh Thi Thanh Binh (Hanoi University of Science and Technology (HUST)), Vietnam)
- Prof. Dr. Mustafa Bin Mat Deris (Universiti Tun Hessein Onn Malaysia (UTHM), Malaysia)
- Assoc. Prof. Somnu-Amnuaisuk (Universiti Teknologi Brunei, Brunei Darussalam)
- Prof. Ir Arif Djunaidy, MSc, PhD (Institut Teknologi Sepuluh November (ITS), Indonesia)
- Prof. Sri Hartati, MSc, PhD (IndoCEISS/Universitas Gadjah Mada, Indonesia)

- Prof. Dr. Muhammad Zarlis (Universitas Sumatera Utara, Indonesia)
- Mr. Daniel Oranova., SKom, MSc, PhD.Eng (Institut Teknologi Sepuluh November (ITS), Indonesia)
- Mr. Arief Setyanto, SSi, MT, PhD (AMIKOM Yogyakarta, Indonesia)
- Dr. Muhammad Rusli, MT (ITB STIKOM Bali, Indonesia)
- Mr. Aries Susanto, MMSI., Ph.D. (UIN Syarif Hidayatullah Jakarta, Indonesia)
- Mr. Andrew Pakpahan, Ph.D. (Universitas Advent Indonesia Bandung, Indonesia)
- Dr. Enny Itje Sela (Universitas Teknologi Yogyakarta)
- Mr. Stenly Adam, MSc (Universitas Klabat, Indonesia)
- Dr. Anastasia Rita Widiarti (Universitas Sanata Dharma, Indonesia)
- Dr. Andree E Widjaja, Ph.D., CEC (Department of Information System, School of Information Science and technology Indonesia)
- Mr. Mumammar Sadrawi (Indonesia International Institut For Life-Science (i3I))
- Mr. Arli Aditya Parikesit (Indonesia International Institut For Life-Science (i3I))
- Mr. David Agustriawan (Indonesia International Institut For Life-Science (i3I))
- Dr. Ridha Sefina Samosir, S. Si., M. Kom (Kalbe Institut)
- Dr. Puspa Setia Pratiwi, PhD (Indonesia International Intitut For Life-Science (i3I))

## Table of Contents

The antecedent of Impulsive Buying Decisions through Live Streaming Technology and Flash Sale in E-commerce .....	1
<i>Al Naufal Navitama Putra, Dinda Qurnatuain, Garrybaldi Haidar Nugraha and Lily Leonita</i>	
The Influence of Cultural Factors in Software Quality Assessment Models A Systematic Literature Review .....	7
<i>Ni Nyoman Utami Januhari, Arief Setyanto, K Kusrini and Ema Utami</i>	
Analysis and Optimizing Solar Panels for Offshore Remote Wellhead Platforms as a Sustainable and Renewable Energy Source .....	13
<i>Fauzi Khair and Rahmat Sabani</i>	
Comparative Analysis of Robotic Arm Efficiency: Evaluating PID and Fuzzy-PID Control using Printed Mechanical Structure and ESP8266 Integration .....	19
<i>Padma Nyoman Crisnapati, I Made Darma Susila, I Komang Agus Ady Aryanto, Jaturapith Krohkaew, Ricky Aurelius Nurtanto Diaz and I Made Suandana Astika Pande</i>	
Deep Learning in Financial Markets: A Systematic Literature Review of Methods and Future Direction for Price Prediction .....	25
<i>I Made Adi Purwantara, Kusrini Kusrini, Arief Setyanto and Ema Utami</i>	
Enhancing Financial Trading Strategies with Pattern Recognition: A Systematic Literature Review of Methods, Trend and Challenge .....	31
<i>I Ketut Dedy Suryawan, Kusrini Kusrini, Arief Setyanto and Ema Utami</i>	
Investigating the Effectiveness of Feature Extraction Techniques in Predicting Emotions from Indonesian Tweets Using Machine Learning .....	37
<i>Jeremy Simatupang, Julius Lie, Ghinaa Nabiilah and Jurike Moniaga</i>	
E-Tax Systems and Tax Knowledge Impact on Small, and Medium Enterprises Taxpayer Compliance In Indonesia .....	43
<i>Angela Fransiska, Michelle Siauw and Ilham Condro Prabowo</i>	
Thread User Sentiment Analysis Based on Text using LGBM, SVM, and Logistic Regression Algorithm .....	48
<i>Nicholas Chao, Rafael Jo, Ghinaa Nabiilaha and Jurike Moniaga</i>	
Establishing a Standard Operating Procedure (SOP) for Palm Oil Plantation FFB Image Capture: Utilizing YOLOv8 for Counting and Ripeness Classification .....	54
<i>Muhammad Rizky Hidayat, Pavel Azarya Sulisty, Hansen Oktario, Alexander A S Gunawan and Prasetyo Mimboro</i>	
Comparative Analysis of Fungal Infections Classification in Apple Leaves Using CNN and CNN with GLCM Features .....	60
<i>Hendrik Carlo, Kelvin Andreas, Alfi Yusrotis Zakiiyyah and Meiliana Meiliana</i>	
Performance Evaluation of Intrusion Detection System with SVM .....	66
<i>Ricky Aurelius Nurtanto Diaz, I Ketut Gede Darma Putra, Made Sudarma and I Made Sukarsa</i>	

Performance Comparison of the Invasive Weed Optimization K-Means Algorithm with Particle Swarm Optimization K-Means for Banking Data .....	73
<i>Ni Luh Gede Pivin Suwirmayanti, I Ketut Gede Darma Putra, Made Sudarma, I Made Sukarsa and Emy Setyaningsih</i>	
Integrated Lean Ecodesign and Green Performance: A Comprehensive Model for Sustainable Logistics .....	80
<i>Christopher Joshua Leksana, Novyandri Taufik Bahtera, Stefanus Rumangkit, Ivan Sangkereng and Ade Jamal Mirdad</i>	
Optimizing Automotive Cybersecurity with Cost-Sensitive Decision Forest Algorithm in IoV .....	86
<i>Salwa Umar Qureshi, Alireza Souri and Nihat Inanç</i>	
Enhancing Solar Energy Production Forecasting with Ensemble-based Learning Techniques .....	92
<i>Hany Abdelsalam, Alireza Souri and Nihat Inanç</i>	
Analysis of the Influence of Students' Learning Interest on the Implementation of Augmented Reality in the Education System in Indonesia: A Case Study of High Schools in Tangerang City, Indonesia .....	98
<i>Ricardo Laurent and Maryani</i>	
Adoption of Blockchain Technology to Prevent Misuse of School Operational Assistance Funds (BOS) in Indonesia .....	104
<i>Inayatulloh Inayatulloh, Loso Judijanto, Denok Sunarsi, Rofiq Noorman Haryadi, Sugeng Riyanto and Prasetya Cahya Saputra</i>	
Blockchain Technology Supports Employee Career Management to Increase Transparency of Employee Career Achievements .....	109
<i>Inayatulloh Inayatulloh, Yasri Yasri, Ahmad Fathurrozi, Muhammad Yasir, Fried Sinlae, Tyastuti Sri Lestari, Wowon Priatna, Indra Kusumadi Hartono and Achmad Noe'Man</i>	
AI-Driven Revolution: Effectiveness of Product Ads on Social Media Using Midjourney ...	114
<i>Christina Lorenza and Eriana Astuty</i>	
Comparing Machine Learning Algorithms with Ensemble Model using Random Oversampling for Predicting Student's Dropouts .....	120
<i>Ivan Setiawan, Yithro Paulus Tjendra, Alfi Yusrotis Zakiyyah and Meiliana Meiliana</i>	
Recognitions of Bahasa Isyarat Indonesia (BISINDO) Alphabets using SVM and Mediapipe .....	126
<i>Robert Wiliam, Charlie Lufian, Meiliana Meiliana and Alfi Yusrotis Zakiyyah</i>	
Leveraging Deep Learning for Early Detection of Stomach Cancer: A Convolutional Neural Network Approach .....	131
<i>Arya Maulana Bratajaya Akmal, Ghinaa Zain Nabiilah, Defara Putra Nurimaba and Jurike V Moniaga</i>	
Analysis of the Influence Wakuliner.com Website Quality on Customer Trust, Experience, and Loyalty Using WebQual 4.0 Method .....	137
<i>Faris Agastya, Maryani Maryani and Hendry Hartono</i>	



Detecting Hate Speech on Indonesian Twitter Using Logistic Regression . . . . .	143
<i>Jensen Ramadhaniel Putra Esene, Fabio Valentino William, Ghinaa Zain Nabiilah and Jurike Moniaga</i>	
Enhancing Business Agility: The Effects of IT Capability and Digital Transformation . . . . .	148
<i>Sandy Kosasi, Yudhi Fajar Saputra, Susanty Margaretha Kuway, I Dewa Ayu Eka Yuliani, Utin Kasma and Budi Susilo</i>	
Detecting Account Takeover (ATO) in Fintech Companies Using Machine Learning . . . . .	154
<i>Richard Santoso and Alexander A S Gunawan</i>	
Exploring the Effectiveness of Adding Sentiment Analysis and Trends into Random Forest Machine Learning Algorithm to Predict Bitcoin Price Action . . . . .	160
<i>Vincent Oei, Pieter Effendy, Lili Wulandhari and Islam Alam</i>	
Gold Price Prediction using Machine Learning and Deep Learning . . . . .	166
<i>Steven Liu Sentiko, Meiliana Meiliana and Alfi Yusrotis Zakkiyyah</i>	
Stunting Prediction in Children Using Random Forest Algorithm . . . . .	171
<i>Ahmad Fauzan Kanz, Luvky Pratama Johannes, Lili Ayu Wulandhari and Islam Nur Alam</i>	
Towards the Fun Therapy on People with Mental Disorder – Analysis on Serious Game for Mental Therapy . . . . .	175
<i>Galih Dea Pratama, Haryono Soeparno, Yulyani Arifin and Ford Lumban Gaol</i>	
Enhancing Auditing Quality through Big Data Analytics: A Study Leveraging the Technology Acceptance Model in Computing and Processing . . . . .	181
<i>Nicholas Pradana Harijanto, Veronica Veronica and Ignatius Edward Riantono</i>	
Implementation of OpenCV and CNN-Keras in Detecting Plastic Waste . . . . .	187
<i>Gabio Mega Handoko, Eileen Gunawidjaja, Hanis Amalia Saputri, Azani Cempaka Sari and Almuzhidul Mujhid</i>	
Palm Fruit Ripeness Detection and Counting Using YOLOv8 Algorithm in PTPN IV Medan North Sumatera, Indonesia . . . . .	192
<i>Rael Russel Hutapea, Samdo Jumar Purba, William Tandion, Erna Fransisca Angela Sihotang and Edy Irwansyah</i>	
InDRI: Intelligent Diagnosis Radiology Images . . . . .	198
<i>Mahmud Isnan, Gregorius Elwirehardja, Kuncahyo Setyo Nugroho, Imelda Liana Ritonga, Roby Pahala Januario Gultom, Elida Afni Lubis and Bens Pardamean</i>	
Improving DNS Server Resilience Against DDoS Attacks Through Anycast Routing . . . . .	204
<i>Julian D. Dzaky, Jason A. Saputra, Nicodemus N. Singale, Hanis A. Saputri and Azani C. Sari</i>	
Implementation of A* and Dijkstra Algorithms for optimal Pathfinding: A Case Study of Nearest Hospital Location from Bina Nusantara University . . . . .	210
<i>Samuel Bangun, Febrio Wijaya, Hanis Saputri and Azani Cempaka Sari</i>	
Systematic Literature Review on Metaheuristic Algorithms in SNP Analysis for Diseases .	215
<i>Jason Sulistyawan, Kuncahyo Nugroho and Bens Pardamean</i>	

Systematic Literature Review: Deep Learning and Machine Learning Analysis for Batik Peranakan Tionghoa Datasets .....	220
<i>Mochammad Haldi Widiyanto, Mulyani Karmagatri, Rachmi Kumala Widyasari, Aris Darisman and Hazmilah Hasan</i>	
Text Prediction using Attention Mechanism .....	225
<i>Teresa Sheryl, Anthonio Lais, Hanis Saputri, Azani Sari and Andien Novika</i>	
Analysis of Accuracy Between SVM and CNN Algorithms in Facial Expression Recognition .....	231
<i>Ihsaan Hardyanto, Reynaldo Marchell Bagas Adji, Jurike V Moniaga and Ghinaa Zain Nabilah</i>	
A Motor Activity Analysis as a Depression Indicator: Predictive Approach Using A Hybrid CNN and LSTM Network .....	237
<i>Vinsensius O. Sutedja, Frans Andreas, Jurike V. Moniaga and Ghinaa Z. Nabilah</i>	
Analysis of Sports Match Charts and Scoring Applications Based on Website and Mobile Using the System Usability Scale Method .....	243
<i>Putu Adi Guna Permana, Paula Dewanti and Komang Yuli Santika</i>	
Design and Analysis of Optical Fiber Network Link Design between Sendawar and Long Bagun .....	249
<i>Andrano Mario Hitipeuw, Yus Natali and Catur Apriono</i>	
Sign Language Translator for SIBI .....	254
<i>Ezra Arya Wijaya, Samuel Benediktus Meliala, Muhammad Fadlan Hidayat and Irene Anindaputri Iswanto</i>	
Mitigating Berkson's Paradox with Neural Propensity Score Matching in E-commerce Deals .....	260
<i>Nicholas Dominic and Bens Pardamean</i>	
ConvNeXt Model for Breast Cancer Image Classification .....	266
<i>Devin Setiawan, Andrea S. Karnyoto, Indo Intan and Bens Pardamean</i>	
Cancer Prediction using Clinical and Genomic Data Fusion: A Systematic Review .....	271
<i>Kelvin Julian, Kuncahyo Setyo Nugroho, Rudi Nirwantono and Bens Pardamean</i>	
Application of Augmented Reality in Early Childhood Education: A Case Study on Children's Cognitive and Motoric Development .....	277
<i>Shanna Carlynda Fernlie, Geovanka Thersia Kurniawan, Puti Andam Suri and Muhamad Fajar</i>	
Blaze Buster Augmented Reality Usability Evaluation .....	281
<i>Levina Jane Saputra, Karina Dwinovera Mulia, Puti Andam Suri and Muhamad Fajar</i>	
User Sentiment Analysis of Online Transportation Platforms Using K-Means and K-Nearest Neighbor .....	286
<i>Adila Nashira Yuhanas, Golda Salazar, Renaldy Fredyan and Muhammad Amien Ibrahim</i>	
Analyzing XSS Attack Information Content on Social Media .....	291
<i>Khaerunnisa Hanapi, Sitti Harlina, Suci Ramadhani Arifin, Arham Arifin, Michael Oktavianus and Ahyuna</i>	

The Impact Perceived Desirability, Propensity to Act, and Perceived Feasibility towards Technoprenurial Commitment Based on A Entrepreneurial Event Theory .....	297
<i>Stefanus Rumangkit, Aloysius Bagas Pradipta Irianto and Antonius Satria Hadi</i>	
MediaPipe’s Pose-Based Human Activity Recognition with LSTM.....	303
<i>Nicholas Hans Muliawan, Frederick Nathan Irmawan, Edbert Valencio Angky and Abram Setyo Prabowo</i>	
Towards a Preliminary Usability Analysis of an Augmented Reality Photo Booth Application for Gen Z: Insights on Users, System, and Interaction for Couples and Non-Couples .....	309
<i>Vincentia Catherine, Tiffany Joycelyn, Muhamad Fajar and Puti Andam Suri</i>	
Comparison of Sound Classification Algorithms on NIGENS Dataset .....	314
<i>Jolin Tiomar, Stephanie Angela, Justin Anthony Sudijanto, Gerry Ezekiel Liwe, Dani Suandi and Dany Eka Saputra</i>	
Analysis The Benefits of ChatGPT Implementation on Student Knowledge Development in Case-Based Learning (CBL) .....	320
<i>Samuel Tanuwijaya, Jerry Agustinus and Sulistyo Heripracoyo</i>	
Developing a Robust Face Recognition Algorithm with Anti Spoofing Using InceptionV3 and YOLOv8 .....	326
<i>Aaron Scott Buana, Anselyus Patrick Siswanto, Anderies Anderies and Andry Chowanda</i>	
User Experience Analysis On M-Bayar Electronic Money Application Using In-Person Usability Testing Method .....	332
<i>Muhamad Rayvan, Pio Simanullang, Rendy Trisukma, Riyan Leandros and Silvia Ayunda</i>	
Trend and Correlation Analysis of Instagram Activity Using Data Mining and Statistics ..	338
<i>Nadia Lempan, Nurliah Nurliah, Maechel Maximiliano Gabriel, Wilem Musu, Indra Samsie, Aldi Bastiatul Fawait and Sinar Sinar</i>	
Vehicle Detection Using You Only Look Once V8 Based On Architecture Modification Method .....	343
<i>Yudistira Dwi Permana, Kusrini Kusrini, Widya Mulyaningtyas and Rozikul Wijaya</i>	
A Dual-Parameter Sensing System for an Environmental Air Monitoring .....	349
<i>Kristoforus Naidu, Samuel Alfonsus, Bernard Fabian, Jason Yovan Hermanto and Selvi Lukman</i>	
Sedudo Nganjuk Website Usability Analysis Using User Experience Questionnaire .....	354
<i>Alif Kurnia, Hilmi Nugroho and Riyan Leandros</i>	
Decoding Financial Positivity: Sentiment Analysis of Mandiri Sekuritas’s Twitter Posts ..	360
<i>Dian Kurnianingrum, Isma Addi Jumbri, Mila Andria Savitri, Nugraha Nugraha, Disman Disman and Rachel Monica</i>	
Optimizing Diabetes Prediction using Machine Learning with Data Deviation .....	365
<i>Budi Triandi, Lili Tanti, Ratih Puspasari, Mas Ayoe Elhiyas and Marwan Marwan</i>	

The Effect of Social Media Influencers on Business Sustainability: Understanding Customer Behavior Change Towards Sustainable Usage Patterns .....	371
<i>Maria Grace Herlina, Alexandra Li Budiharto, Elizabeth Margaretha Lukito and Karto Iskandar</i>	
Benchmarking Multiple Machine Learning Algorithms for Sentiment Analysis on Sexual Violence .....	377
<i>Ririn Nurdiananti and Ema Utami</i>	
Low Cost Dual Sensing System for Soil Quality Enhancement Using Temperature and Humidity Monitoring.....	383
<i>Riki Akbar Mc.Dougall, Gian Guido Hibatulloh, Reyhan Seifan Safero, Wan Mohamad Axel Rinaldi and Selvi Lukman</i>	
Enhancing Infrastructure Monitoring: Pothole Detection in Road Images Using YOLOv8 and Open Datasets.....	388
<i>Jonathan Wijaya, Muhammad Abiyu'Ammaar, I Ketut Dharma Wijaya Kusuma and Alexander A S Gunawan</i>	
Software Quality Assessment Methods and Standards in Weld Defect Detection for Shipbuilding .....	394
<i>Yonky Pernando, Ford Lumban Gaol, Haryono Soeparno and Yulyani Arifin</i>	
Portuguese Meals Image Recognition Using CNN Models.....	400
<i>Devin Jonathan, Johanes Lie, Anderies Anderies and Andry Chowanda</i>	
Simulation-Based Optimization of Autonomous Vehicles using Genetic Algorithm.....	405
<i>Karldritz Farrel Hanson, Kara Kalani Al Biruni, Anderies Anderies and Andry Chowanda</i>	
YouTube Videos Clickbait Classification Utilizing Text Summarization and Similarity Score via LLM .....	411
<i>Delvin Hu, Anderies Anderies and Andry Chowanda</i>	
Detection and Classification Model for Respiratory Diseases Using Machine Learning Techniques.....	416
<i>Lili Tanti, Budi Triandi, Bob Subhan Riza, Yan Yang Thanri, Juli Iriani and Ratih Puspasari</i>	
Evaluation Model of Urban Regional Knowledge Management System in Indonesia for Natural Disaster Mitigation.....	422
<i>Wahyu Sardjono, Widhilaga Gia Perdana, Erma Lusia, Maryani Maryani, Astari Retnowardhani and Muhammad Zarlis</i>	
Determining Key Performance Indicators of IT Balance Scorecards for Measuring Information Technology Performance in Companies.....	428
<i>Wahyu Sardjono, Widhilaga Gia Perdana, Sarim Sarim, Astari Retnowardhani, Maryani Maryani and Erma Lusia</i>	
Enhancing Tourism Innovation Through Disruptive Technology and Strategic Alliances: Evidence from Popular Destinations In West Java .....	434
<i>Okky Rizkia Yustian, Chyntia Ika Ratnapuri and Desi Indrawati</i>	

Comparison of the Performance of Transformer Text Summarization Models in Indonesian Language: PEGASUS and GPT-2 .....	439
<i>Ashri Shabrina Afrah, Muhammad Faisal, Abdul Aziz and Supriyono Supriyono</i>	
Usability Analysis and UI Improvements of Museum Nasional Website Using Heuristic Evaluation Methodology .....	443
<i>Mei Sagala, Pratiwi Pandiangan, Rizal Firdaus, Riyan Leandros and Andika Hairuman</i>	
An Examination of the Possible Application of Artificial Intelligence Audit Process in Organizations .....	449
<i>Wahyu Sardjono, Dewi Sagita Pranata and Muhammad Isamesal</i>	
IoT-Enabled Systems for Automated Cat Care: A Comprehensive Literature Review .....	455
<i>Stephanie Angela, Jolin Tiomar, Justin Anthony Sudijanto and Mochammad Haldi Widianto</i>	
IoT-Based Monitoring of Chili Plant Growth .....	461
<i>Mas Rina Mustaffa and Norul Safinaz Norul Rizal</i>	
Networked Intelligence: The Mediating Impact of Social Network Applications on Organizational Learning and Knowledge Sharing in Indonesia .....	467
<i>Maria Grace Herlina, Karto Iskandar and Ika Triana</i>	
Improving Helpdesk Chatbot Performance using Levenshtein Distance and N-gram Similarity .....	473
<i>Gede Herdian Setiawan, Made Doddy Adi Pranatha, I Made Budi Adnyana and Komang Budiarta</i>	
Implementation of Adaptive Neuro-Fuzzy Inference System (ANFIS) Algorithm for Customer Credit Prediction .....	479
<i>Edy Victor Haryanto S, Nita Sari Br Sembiring, Mikha Dayan Sinaga and Noprita Elisabeth Sianturi</i>	
Implementing Robotic Arm for Efficient and Reliable Water Quality Monitoring in Aquaculture .....	485
<i>Iska Hazma Mulyadi, Muhammad Ikhsan Nuraid, Billy Christiandinata, Annisa Istiqomah Arrahmah and Rissa Rahmania</i>	
Clusterization Model of Hadith Topic in Bukhari Muslim Hadith using BERT Algorithm .	491
<i>Ahmad Hashim Asy'Ari, Mohammad Haris Muzakki and Muh Hanafi</i>	
Topic Modelling Analysis on Indonesian News Using BERT Topic Model .....	497
<i>Hanafi Hanafi, Muhammad Fuat Asnawi, Nanang Fitria Kurniawan, Adi Suwondo, Anas Nasrullah and Chendri Setyawan</i>	
Classification of Chili Varieties using Convolutional Neural Network Model .....	503
<i>Abdul Haris Rangkuti, Lie Melinda Putri Wardana, Angelina Quincy, Husni Iskandar Pohan and Fakhira Shafa Maheswari</i>	
Electrical Appliance Identification through Signal Processing of Electrical Wave Signal: A CNN-Based Approach .....	509
<i>Red Alistaire Cruz, Ryan Kyle Enriquez and Glenn Magwili</i>	

A Comprehensive Survey of Infant Cry Classification Research trends and methods: A Systematic Review .....	515
<i>Nuk Ghurroh Setyoningrum, Ema Utami, Kusrini Kusrini and Ferry Wahyu Wibowo</i>	
deESco-RC: Electric Scooter for Wheelchair with Remote Control .....	521
<i>Laurentius Kuncoro Probo Saputra, Dechrit Maneetham and Tenzin Rabgyal</i>	
Transforming Financial Services with Decentralized Finance and Blockchain Technology ..	527
<i>Arisyi Yusran, Marviola Hardini, Ihsan Nuril Hikam, Po Abas Sunarya and Untung Rahardja</i>	
Scalability and Security Challenges of Cloud Computing in the Banking Industry .....	533
<i>Eta Pradipta, Fitra Putri Oganda, Elang Tito Persada, Henderi Henderi and Untung Rahardja</i>	
Innovative Mobile Banking Solutions Powered by 5G: Ensuring Security and Seamless Connectivity .....	539
<i>Ferry Ariyanto, Nuke Puji Lestari Santoso, Muhammad Farhan Kamil and Untung Rahardja</i>	
A Review of Sentiment Analysis of Customer Reviews of Kopi Kenangan App: A Case Study on Customer Experience Improvement Approach .....	544
<i>Putu Ayu Devika Santini Vigneswari, Humaira Puteri and Ivan Diryana Sudirman</i>	
Open-Source Control System Platform for a 5-Axis Robot Using PID and IoT .....	550
<i>Martinus Bagus Wicaksono, Dechrit Maneetham and Petrus Sutiyasadi</i>	
Adoption of Various Topic Modelling Algorithm to Analysis Indonesian Tourism Customer Feed Back .....	556
<i>Muh Hanafi, Icha Nura Nugraha and Sumarni Adi</i>	
Classification of Lung and Colon Cancer using a Hybrid CNN Model .....	561
<i>Zakariya Oraibi and Amal Hasan</i>	
Driven Multivariate Regression - Feature Engineering with Random Forest and XGBoost for Accurate Weather Prediction .....	567
<i>Nur Alamsyah, Budiman Budiman, Venia Restreva Danestiara, Imannudin Akbar, Arnold Ropen Sinaga and Reni Nursyanti</i>	
Input Representation on Text Data for E-Commerce Product Review Summarization using Graph Convolutional Network .....	573
<i>Azani Cempaka Sari, Yaya Heryadi, Iman Herwidiana Kartowisastro and Widodo Budiharto</i>	
Systematic Literature Review on Deep Learning for Weather Phenomenon Classification ..	579
<i>Uswatun Hasanah and Chuan-Ming Liu</i>	
Influence of Information Quality by Recommendation System on Purchase Intention mediated by Perceived Ease of Use and Perceived Usefulness .....	585
<i>Kusumah Arif Prihatna, Agung Hari Sasongko, Hariyatno and Erland Barlian</i>	
A Survey On Indonesian Hoax Analyzer and Fake News Detection Using Deep Learning Techniques .....	591
<i>Wiwi Oktriani, Jonathan Toby Laimheheriwa, Irene Anindaputri Iswanto and Muhammad Fadlan Hidayat</i>	

Transforming Fashion Marketplaces: A Design Thinking Approach to AR and AI Integration .....	597
<i>Carola Basuki, Chairani Putri Pratiwi, Akbar Zaidan Rohman, Hasyid Fitra Hasaini, Leandro Nardphine Halomoan, Ricardo Cuthbert and Verdhinan Hendranata</i>	
Exploring the Efficiency of Various GNN Architectures for Node Classification in Social Networks.....	603
<i>Maulin Nasari and Alfi Zakkiyyah</i>	
Campus Parking System using YOLOv5 Object Detection Method .....	609
<i>Marchel Tombeng, Josua Limbu and Vito Korengkeng</i>	
Applying Multimodal Deep Learning for Identifying Mental Health Indicators in Instagram Content .....	615
<i>Putri Dhea Marsella, Nur Dina Lessy, Syekh Budi Syam, Rachel Ovelia Kadang, Sulaiman Hamzah and Muh Fadhil Rahmatullah</i>	
Thailand Food Price Forecasting: Comparative Analysis of Machine Learning Models.....	621
<i>Jululuk Watthananon, Prapas Thongrak, Yamin Thwe and Navarat Saekhow</i>	
Ideation and Simulation Roles in Identifying Functional Requirements of a Multi-Organizational Digital Library Platform.....	627
<i>Febrianta Surya Nugraha, Widiyanto Hadi and Muhammad Setiyawan</i>	
Comparison of K-means, Gaussian Mixture, and Hierarchical Clustering Models On Countries' Economic Freedom Index.....	628
<i>Nicholas Axel Tanujaya, Jose Gabriel Thendito, Marcell Risandi Putra, Fernando Barina, Owen Kartolo, Karli Eka Setiawan and Alfi Yusrotis Zakkiyyah</i>	
Effectiveness of Random Search in Enhancing CNN Performance for Rice Plant Disease Classification.....	634
<i>Tinuk Agustin, Indrawan Ady Saputro, Mochammad Luthfi Rahmadi, Fito Patria, Aradea Pinkan Kartiningtyas and Dicky Kurniawan</i>	
AI-Powered Steganographic Techniques: A Comparison of Traditional Methods and Modern Machine Learning Approaches .....	635
<i>Indrawan Ady Saputro, Moch. Hari Purwiantoro, Febrianta Surya Nugraha, Ina Sholihah Widiati and Sri Widiyanti</i>	
Using Server-side Processing Techniques to Optimize Data Presentation Responsiveness ..	636
<i>Gat Gat, Irawan Wingdes, Tri Widayanti, Tony Wijaya, Kusri Kusri and Muh. Jamil</i>	
Promoting Indonesian Batik as a Symbol of National Identity: A Bibliometric Approach..	642
<i>Adhi Murti Citra Amalia H, Nisrin Husna and Satria Fadil Persada</i>	
Evaluation of Information Security Governance in Educational Institutions Using the COBIT 5 Framework.....	648
<i>Irene Nur Arta Purba Siboro, Jamson Siallagan, Asmat Purba, Lasmah Ambarita, Sostenis Nggebu and Lasino</i>	
User Experience (UX) Evaluation of Application JMO BPJS Ketenagakerjaan at Pontianak Branch Office Using The PACMAD Method.....	654
<i>Muhammad Azwar Daembana, Maulana Ikhsan Kamil and Teguh Prasandy</i>	

Optimizing Economates: Lean UX-Driven Redesign for Enhanced Economic Literacy, User Satisfaction, and a Smarter Learning Experience .....	660
<i>Mayla Zida Rahma Izzati, Risma Ayu Dwi Septyani, Octaviera Nanda Aji Cahyani and Teguh Prasandy</i>	
Developing Campus Digital Twin with Integrated 3D Point Clouds and 3D Modeling Techniques .....	666
<i>Alexander A S Gunawan, Ryan Nathan Utama, Jonathan Sutjiatmadja, Fabrian Osmond, Lucas Stefan, Andry Chowanda, Edy Irwansyah and Fabian Surya Pramudya</i>	
Optimizing Cluster Methods: Combining K-Means with Hierarchical Techniques for Better Results .....	673
<i>Diyah Ruswanti, Ichwan Joko Prayitno and Firdhaus Hari Saputra Al Haris</i>	
Development of a Web-Based Forecasting System Using the Holt-Winters Exponential Smoothing Method to Improve Accuracy in Predicting Cut Flower Harvest Needs .....	678
<i>Farid Fitriyadi, Wayan Cishe Fransiska Saputri and Hardika Khusnuliawati</i>	
Optimizing Lighting Efficiency Through Automated Smart Lighting Systems: A Study on Network-Based Performance .....	679
<i>Lestari Ningratna Sari, Sri Huning Anwariningsih, Hardika Khusnuliawati and Dahlan Susilo</i>	
UI/UX Design for Triwindu Market Surakarta .....	684
<i>Alma Fikri Setya Nugraha, Farid Fitriyadi and Evelyn Henny Lukitasari</i>	
Development of a Public Complaint Classification Model to Support E-Government using IndoBERT .....	685
<i>Nova Agustina, Muchammad Naseer, Harya Gusdevi and Danny Aidil Rismayadi</i>	
Automatic Ventilation Scheme to Increase the Coolness Smart Buildings .....	691
<i>Muhammad Yusuf Arifin, Khairunissa Chandra Kinanti, Alif Zhafar, Dina Kristiana Seftianingsih, Marwahyudi Marwahyudi and Astri Charolina</i>	
Utilizing Transfer Learning For Brain Tumor Detection And Grad-Cam Visual Explanation .....	697
<i>Green Arther Sandag and Raissa Maringka</i>	
Employee Attendance Through Face Recognition Using The Haar Cascade Classifier Method .....	703
<i>Dionisius Yosa Ardhito, Dahlan Susilo, Diyah Ruswanti, Dwi Retnoningsih, Agus Kristianto and Setiyowati Setiyowati</i>	
Android-Based Restaurant Food Donation and Distribution App for Helping Hands Using Global Positioning System .....	708
<i>David Jonathan Kawengian, Novrando Natanael Hizkia and Semmy Wellem Taju</i>	
Deep Learning for Explicit Content Classification in Music Lyrics .....	714
<i>Raissa Maringka and Green Sandag</i>	
Preserving Balinese Culture Using Augmented Reality Technology for Ogoh-ogoh Art ....	715
<i>Evi Triandini, I Made Suandana Pande Astika, Djoko Kuswanto, Marlowe Bandem, Padma Nyoman Crisnapati and Sitti Rahmah</i>	



Review of Applications in Wheelchair Control Using Emotiv Insight and Emotiv Epoc Headsets .....	721
<i>Yamin Thwe, Dechrit Maneetham and Padma Nyoman Crisnapati</i>	
Upsampling RR-Interval, Is It Possible? .....	722
<i>Muhammad Zakariyah, Umar Zaky, Muhammad Falah Akbar Al Faiz, Sulistyo Dwi Sancoko, Moh. Ali Romli and Muhammad Rafi Basyari</i>	
Improvement of k-NN Algorithm Performance in Classifying High School Students' Majors .....	728
<i>Adityo Permana Wibowo and Donny Avianto</i>	
Developing Accurate Prediction Model Using Machine Learning and Business Intelligence on University Students GPA .....	733
<i>Michael Siek and Kenrick Lim</i>	
Analysis of Factors Influencing the Buyer Preferences on Goods and Services: Comparing E-Commerce and Retail Stores .....	739
<i>Michael Siek and Pasha Tadjoeidin</i>	
Analysis of News Sentiment for Stock Price Prediction Using Vader Sentiment .....	745
<i>Michael Siek and Vic Declan Chandra</i>	

## Author Index

Abdelsalam, Hany	92
Abiyu'Ammaar, Muhammad	388
Adi, Sumarni	556
Adji, Reynaldo Marchell Bagas	231
Afni Lubis, Elida	198
Afrah, Ashri Shabrina	439
Agastya, Faris	137
Agustin, Tinuk	634
Agustina, Nova	685
Agustinus, Jerry	320
Ahyuna,	291
Aidil Rismayadi, Danny	685
Akbar, Imannudin	567
Akmal, Arya Maulana Bratajaya	131
Alam, Islam	160
Alamsyah, Nur	567
Alfonsus, Samuel	349
Ambarita, Lasmah	648
Anderies, Anderies	326, 400, 405, 411
Andrano Mario Hitipeuw,	249
Andreas, Frans	237
Andreas, Kelvin	60
Angela, Stephanie	314, 455
Angky, Edbert Valencio	303
Anwariningsih, Sri Huning	679
Ardhito, Dionisius Yosa	703
Arifin, Arham	291
Arifin, Muhammad Yusuf	691
Arifin, Suci Ramadhani	291
Arifin, Yulyani	175, 394
Ariyanto, Ferry	539
Arrahmah, Annisa Istiqomah	485
Aryanto, I Komang Agus Ady	19
Asnawi, Muhammad Fuat	497
Astuty, Eriana	114
Asy'Ari, Ahmad Hashim	491
Avianto, Donny	728
Ayoe Elhiyas, Mas	365
Ayu Wulandhari, Lili	171
Ayunda, Silvia	332
Aziz, Abdul	439
Bahtera, Novyandri Taufik	80
Bandem, Marlowe	715

Bangun, Samuel	210
Barina, Fernando	628
Barlian, Erland	585
Basuki, Carola	597
Basyari, Muhammad Rafi	722
Br Sembiring, Nita Sari	479
Budi Adnyana, I Made	473
Budiarta, Komang	473
Budiharto, Alexandra Li	371
Budiharto, Widodo	573
Budiman, Budiman	567
Cahya Saputra, Prasetya	104
Cahyani, Octaviera Nanda Aji	660
Carlo, Hendrik	60
Catherine, Vincentia	309
Catur Apriono,	249
Chandra, Vic Declan	745
Chao, Nicholas	48
Charolina, Astri	691
Chowanda, Andry	326, 400, 405, 411, 666
Christiandinata, Billy	485
Crisnapati, Padma Nyoman	19, 721
Cruz, Red Alistaire	509
Cuthbert, Ricardo	597
Daembana, Muhammad Azwar	654
Darisman, Aris	220
Darma Putra, I Ketut Gede	66, 73
Dewanti, Paula	243
Diaz, Ricky Aurelius Nurtanto	19, 66
Disman, Disman	360
Doddy Adi Pranatha, Made	473
Dominic, Nicholas	260
Dzaky, Julian D.	204
Edward Riantono, Ignatius	181
Effendy, Pieter	160
Elwirehardja, Gregorius	198
Enriquez, Ryan Kyle	509
Esene, Jensen Ramadhaniel Putra	143
Fabian, Bernard	349
Faisal, Muhammad	439
Faiz, Muhammad Falah Akbar Al	722
Fajar, Muhamad	277, 281, 309
Farrel Hanson, Karldritz	405
Fathurrozi, Ahmad	109

Fauzan Kanz, Ahmad	171
Fawait, Aldi Bastiatul	338
Fernlie, Shanna Carlynda	277
Firdaus, Rizal	443
Fitriyadi, Farid	678, 684
Fransisca Angela Sihotang, Erna	192
Fransiska Saputri, Wayan Cishe	678
Fransiska, Angela	43
Fredyan, Renaldy	286
Gabriel, Maechel Maximiliano	338
Gaol, Ford Lumban	175, 394
Gat, Gat	636
Gia Perdana, Widhilaga	422
Gunawan, Alexander A S	54, 154, 388, 666
Gunawidjaja, Eileen	187
Gusdevi, Harya	685
H, Adhi Murti Citra Amalia	642
Hadi, Antonius Satria	297
Hadi, Widiyanto	627
Hairuman, Andika	443
Haldi Widiyanto, Mochammad	220
Halomoan, Leandro Nardphine	597
Hamzah, Sulaiman	615
Hanafi, Hanafi	497
Hanafi, Muh	491, 556
Hanapi, Khaerunnisa	291
Handoko, Gabio Mega	187
Hardini, Marviola	527
Hardyanto, Ihsaan	231
Hari Saputra Al Haris, Firdhaus	673
Hariyatno,	585
Harlina, Sitti	291
Hartono, Hendry	137
Haryanto S, Edy Victor	479
Hasaini, Hasyid Fitra	597
Hasan, Amal	561
Hasan, Hazmilah	220
Hasanah, Uswatun	579
Henderi, Henderi	533
Hendranata, Verdhinan	597
Henny Lukitasari, Evelyne	684
Herdian Setiawan, Gede	473
Heripracoyo, Sulisty	320
Herlina, Maria Grace	371, 467
Hermanto, Jason Yovan	349
Heryadi, Yaya	573

Hibatulloh, Gian Guido	383
Hidayat, Muhammad Fadlan	254, 591
Hidayat, Muhammad Rizky	54
Hikam, Ihsan Nuril	527
Hizkia, Novrando Natanael	708
Hu, Delvin	411
Husna, Nisrin	642
Ibrahim, Muhammad Amien	286
Inanç, Nihat	86, 92
Inayatulloh, Inayatulloh	104, 109
Indrawati, Desi	434
Intan, Indo	266
Iriani, Juli	416
Irianto, Aloysius Bagas Pradipta	297
Irmawan, Frederick Nathan	303
Irwansyah, Edy	192, 666
Isamesal, Muhammad	449
Iskandar, Karto	371, 467
Isnan, Mahmud	198
Iswanto, Irene Anindaputri	254, 591
Izzati, Mayla Zida Rahma	660
Jamil, Muh.	636
Januario Gultom, Roby Pahala	198
Jo, Rafael	48
Joko Prayitno, Ichwan	673
Jonathan, Devin	400
Joycelyn, Tiffany	309
Judijanto, Loso	104
Julian, Kelvin	271
Jumar Purba, Samdo	192
Jumbri, Isma Addi	360
Kadang, Rachel Ovelia	615
Kalani Al Biruni, Kara	405
Kamil, Maulana Ikhsan	654
Kamil, Muhammad Farhan	539
Karmagatri, Mulyani	220
Karnyoto, Andrea S.	266
Kartiningtyas, Aradea Pinkan	634
Kartolo, Owen	628
Kartowisastro, Iman Herwidiana	573
Kasma, Utin	148
Kawengian, David Jonathan	708
Khair, Fauzi	13
Khusnuliawati, Hardika	678, 679
Kinanti, Khairunissa Chandra	691

Korengkeng, Vito	609
Kosasi, Sandy	148
Kristianto, Agus	703
Krohkaew, Jaturapith	19
Kumala Widyasari, Rachmi	220
Kurnia, Alif	354
Kurnianingrum, Dian	360
Kurniawan, Dicky	634
Kurniawan, Geovanka Thersia	277
Kurniawan, Nanang Fitria	497
Kusrini, K	7
Kusrini, Kusrini	25, 31, 343, 515, 636
Kusuma, I Ketut Dharma Wijaya	388
Kusumadi Hartono, Indra	109
Kuswanto, Djoko	715
Kuway, Susanty Margaretha	148
Laimeheriwa, Jonathan Tobby	591
Lais, Anthonio	225
Lasino,	648
Laurent, Ricardo	98
Leandros, Riyan	332, 354, 443
Leksana, Christopher Joshua	80
Lempan, Nadia	338
Leonita, Lily	1
Lessy, Nur Dina	615
Liana Ritonga, Imelda	198
Lie, Johanes	400
Lie, Julius	37
Lim, Kenrick	733
Limbu, Josua	609
Liu, Chuan-Ming	579
Liwe, Gerry Ezekiel	314
Lorenza, Christina	114
Lufian, Charlie	126
Lukito, Elizabeth Margaretha	371
Lukman, Selvi	349, 383
Lusia, Erma	422, 428
Magwili, Glenn	509
Maheswari, Fakhira Shafa	503
Maneetham, Dechrit	521, 550, 721
Maringka, Raissa	697, 714
Marsella, Putri Dhea	615
Marwahyudi, Marwahyudi	691
Marwan, Marwan	365
Maryani,	98
Maryani, Maryani	137, 422, 428

Mc.Dougall, Riki Akbar	383
Meiliana, Meiliana	60, 120, 126, 166
Meliala, Samuel Benediktus	254
Mimboro, Prasetyo	54
Mirdad, Ade Jamal	80
Moniaga, Jurike	37, 143
Moniaga, Jurike V	131, 231
Moniaga, Jurike V.	237
Moniagaa, Jurike	48
Monica, Rachel	360
Mujhid, Almuzhidul	187
Mulia, Karina Dwinovera	281
Muliawan, Nicholas Hans	303
Mulyadi, Iska Hazma	485
Mulyaningtyas, Widya	343
Mustaffa, Mas Rina	461
Musu, Wilem	338
Muzakki, Mohammad Haris	491
Nabiilah, Ghinaa	37
Nabiilah, Ghinaa Z.	237
Nabiilah, Ghinaa Zain	131, 143, 231
Nabiilaha, Ghinaa	48
Naidu, Kristoforus	349
Nasari, Maulin	603
Naseer, Muchammad	685
Nasrullah, Anas	497
Nggebu, Sostenis	648
Ningratna Sari, Lestari	679
Nirwantono, Rudi	271
Noe'Man, Achmad	109
Noorman Haryadi, Rofiq	104
Norul Rizal, Norul Safinaz	461
Novika, Andien	225
Nugraha, Febrianta Surya	627, 635
Nugraha, Garrybaldi Haidar	1
Nugraha, Icha Nura	556
Nugraha, Nugraha	360
Nugroho, Hilmi	354
Nugroho, Kuncahyo	215
Nugroho, Kuncahyo Setyo	271
Nur Alam, Islam	171
Nurasid, Muhammad Ikhsan	485
Nurdiyanti, Ririn	377
Nurimaba, Defara Putra	131
Nurliah, Nurliah	338
Nursyanti, Reni	567
Nyoman Crisnapati, Padma	715

Oei, Vincent	160
Oganda, Fitra Putri	533
Oktario, Hansen	54
Oktavianus, Michael	291
Oktriani, Wiwi	591
Oraibi, Zakariya	561
Osmond, Fabrian	666
Pande Astika, I Made Suandana	715
Pande, I Made Suandana Astika	19
Pandiangan, Pratiwi	443
Pardamean, Bens	198, 215, 260, 266, 271
Patria, Fito	634
Patrick Siswanto, Anselyus	326
Paulus Tjendra, Yithro	120
Perdana, Widhilaga Gia	428
Permana, Putu Adi Guna	243
Permana, Yudistira Dwi	343
Pernando, Yonky	394
Persada, Elang Tito	533
Persada, Satria Fadil	642
Pohan, Husni Iskandar	503
Prabowo, Abram Setyo	303
Prabowo, Ilham Condro	43
Pradana Harijanto, Nicholas	181
Pradivta, Eta	533
Pramudya, Fabian Surya	666
Pranata, Dewi Sagita	449
Prasandy, Teguh	654, 660
Pratama Johannes, Luvky	171
Pratama, Galih Dea	175
Pratiwi, Chairani Putri	597
Priatna, Wowon	109
Prihatna, Kusumah Arif	585
Purba Siboro, Irene Nur Arta	648
Purba, Asmat	648
Purwantara, I Made Adi	25
Purwiantoro, Moch. Hari	635
Puspasari, Ratih	365, 416
Puteri, Humaira	544
Putra, Al Naufal Navitama	1
Putra, Marcell Risandi	628
Putri Wardana, Lie Melinda	503
Quincy, Angelina	503
Qureshi, Salwa Umar	86
Qurnatuain, Dinda	1



Rabgyal, Tenzin	521
Rahardja, Untung	527, 533, 539
Rahmadi, Mochammad Luthfi	634
Rahmah, Sitti	715
Rahmania, Rissa	485
Rahmatullah, Muh Fadhil	615
Rangkuti, Abdul Haris	503
Ratnapuri, Chyntia Ika	434
Rayvan, Muhamad	332
Restreva Danestiara, Venia	567
Retnoningsih, Dwi	703
Retnowardhani, Astari	422, 428
Rinaldi, Wan Mohamad Axel	383
Riyanto, Sugeng	104
Rohman, Akbar Zaidan	597
Romli, Moh. Ali	722
Ropen Sinaga, Arnold	567
Rumangkit, Stefanus	80, 297
Russel Hutapea, Rael	192
Ruswanti, Diyah	673, 703
Sabani, Rahmat	13
Saekhow, Navarat	621
Safero, Reyhan Seifan	383
Sagala, Mei	443
Salazar, Golda	286
Samsie, Indra	338
Sancoko, Sulisty Dwi	722
Sandag, Green	714
Sandag, Green Arther	697
Sangkereng, Ivan	80
Santika, Komang Yuli	243
Santoso, Nuke Puji Lestari	539
Santoso, Richard	154
Saputra, Dany Eka	314
Saputra, Jason A.	204
Saputra, Laurentius Kuncoro Probo	521
Saputra, Levina Jane	281
Saputra, Yudhi Fajar	148
Saputri, Hanis	210, 225
Saputri, Hanis A.	204
Saputri, Hanis Amalia	187
Saputro, Indrawan Ady	634, 635
Sardjono, Wahyu	422, 428, 449
Sari, Azani	225
Sari, Azani C.	204
Sari, Azani Cempaka	187, 210, 573

Sarim, Sarim	428
Sasongko, Agung Hari	585
Savitri, Mila Andria	360
Scott Buana, Aaron	326
Seftianingsih, Dina Kristiana	691
Sentiko, Steven Liu	166
Septyani, Risma Ayu Dwi	660
Setiawan, Devin	266
Setiawan, Ivan	120
Setiawan, Karli Eka	628
Setiyawan, Muhammad	627
Setiyowati, Setiyowati	703
Setya Nugraha, Alma Fikri	684
Setyaningsih, Emy	73
Setyanto, Arief	7, 25, 31
Setyawan, Chendri	497
Setyo Nugroho, Kuncahyo	198
Setyoningrum, Nuk Ghurroh	515
Sheryl, Teresa	225
Siallagan, Jamson	648
Sianturi, Noprita Elisabeth	479
Siauw, Michelle	43
Siek, Michael	733, 739, 745
Simanullang, Pio	332
Simatupang, Jeremy	37
Sinaga, Mikha Dayan	479
Sinar, Sinar	338
Singale, Nicodemus N.	204
Sinlae, Fried	109
Soeparno, Haryono	175, 394
Souri, Alireza	86, 92
Sri Lestari, Tyastuti	109
Stefan, Lucas	666
Suandi, Dani	314
Subhan Riza, Bob	416
Sudarma, Made	66, 73
Sudijanto, Justin Anthony	314, 455
Sudirman, Ivan Diryana	544
Sukarsa, I Made	66, 73
Sulistyawan, Jason	215
Sulistyoyo, Pavel Azarya	54
Sunarsi, Denok	104
Sunarya, Po Abas	527
Supriyono, Supriyono	439
Suri, Puti Andam	277, 281, 309
Suryawan, I Ketut Dedy	31
Susila, I Made Darma	19
Susilo, Budi	148

Susilo, Dahlan	679, 703
Sutedja, Vinsensius O.	237
Sutjiatmadja, Jonathan	666
Sutyasadi, Petrus	550
Suwirmayanti, Ni Luh Gede Pivin	73
Suwondo, Adi	497
Syam, Syekh Budi	615
Tadjoedin, Pasha	739
Taju, Semmy Wellem	708
Tandion, William	192
Tanti, Lili	365, 416
Tanujaya, Nicholas Axel	628
Tanuwijaya, Samuel	320
Thanri, Yan Yang	416
Thendito, Jose Gabriel	628
Thongrak, Prapas	621
Thwe, Yamin	621, 721
Tiomar, Jolin	314, 455
Tombeng, Marchel	609
Triana, Ika	467
Triandi, Budi	365, 416
Triandini, Evi	715
Trisukma, Rendy	332
Utama, Ryan Nathan	666
Utami Januhari, Ni Nyoman	7
Utami, Ema	7, 25, 31, 377, 515
Veronica, Veronica	181
Vigneswari, Putu Ayu Devika Santini	544
Watthananon, Julaluk	621
Wibowo, Adityo Permana	728
Wibowo, Ferry Wahyu	515
Wicaksono, Martinus Bagus	550
Widayanti, Tri	636
Widianto, Mochammad Haldi	455
Widiati, Ina Sholihah	635
Widiyanti, Sri	635
Wijaya, Ezra Arya	254
Wijaya, Febrio	210
Wijaya, Jonathan	388
Wijaya, Rozikul	343
Wijaya, Tony	636
William, Robert	126
William, Fabio Valentino	143
Wingdes, Irawan	636

Wulandhari, Lili	160
Yasir, Muhammad	109
Yasri, Yasri	109
Yuhanas, Adila Nashira	286
Yuliani, I Dewa Ayu Eka	148
Yus Natali,	249
Yusran, Arisyi	527
Yusrotis Zakiyyah, Alfi	120, 126
Yustian, Okky Rizkia	434
Zakariyah, Muhammad	722
Zakiyyah, Alfi	603
Zakiyyah, Alfi Yusrotis	60, 166, 628
Zaky, Umar	722
Zarlis, Muhammad	422
Zhafar, Alif	691

# Open-Source Control System Platform for a 5-Axis Robot Using PID and IoT

Martinus Bagus Wicaksono  
Mechatronics Engineering  
Rajamangala University of Technology  
Thanyaburi  
Pathum Thani, Thailand  
martinus\_b@mail.rmutt.ac.th

Dechrit Maneetham  
Mechatronics Engineering  
Rajamangala University of Technology  
Thanyaburi  
Pathum Thani, Thailand  
dechrit\_m@rmutt.ac.th

Petrus Sutiyasadi  
Mechatronics Department  
Faculty of Vocational Study  
Sanata Dharma University  
Yogyakarta, Indonesia  
peter@usd.ac.id

**Abstract**—Technological progress has brought about a revolution in several sectors by integrating automation, especially robots, to improve production efficiency. The 5-axis articulated robot is a popular option in the industry because to its exceptional flexibility and accuracy in managing intricate manufacturing processes, setting it apart from other robot kinds. However, creating control systems for these robots often requires costly hardware and software, which presents difficulties for academic institutions and small-scale researchers. Accessible and reasonably priced parts, such microcontrollers, are used to solve this problem. This work provides an open-source control system platform that combines Internet of Things (IoT) technologies with PID (Proportional-Integral-Derivative) control for a 5-axis articulated robot. The platform provides an adaptable, effective, and reasonably priced control solution by using the capabilities of Arduino microcontrollers. A detailed description is given of the system's architecture and implementation, which includes the hardware setup, software architecture, and the integration of PID control and IoT. This interface reduces setup time and enables remote access over the Internet of Things, according to testing. This open-source technology promotes wider acceptance and flexibility in educational and industrial robotics, possibly enhancing the practical training of robotics students. All code is freely available online.

**Keywords**—PID control, IoT, Open-source control system, Embedded system, Arduino microcontrollers, 5-axis articulated robot, Low-cost robot

## I. INTRODUCTION

Technological advances have changed the industry by introducing automation into some production processes. One of them is introducing robotics technology to increase production efficiency in the industry. Among the various types of robots, the 5-axis articulated robot is one of the most prominent because of its flexibility and precision in handling complex production processes [1], [2]. So, this type of robot is widely used in the industry to support the efficiency of the production process [3], [4]. However, developing a control system for these robots usually requires software and hardware elements. It might result in significant costs and limitations for researchers and developers working at a lower level. It presents a similar issue in educational institutions that need learning resources like 5-axis articulated robots. Robots with affordable prices for educational institutions have several limitations, such as low precision and service life. The precision of the robot's movement is greatly influenced by the reliability of the control system and the mechanical system on the robot [5], [6], [7]. Standard parts are used to make an economically viable industrial robot. One of them is a microcontroller that has become a fundamental component in

various embedded system applications today, especially in the robotics industry, which has experienced very rapid development [8], [9], [10].

Using microcontrollers in industrial robots allows for a more flexible, efficient, and affordable control system supported by a capable control system algorithm. As one of the most popular microcontroller platforms, Arduino has been used to control various types of manipulator robots [11]. In making a control system on a robotic arm, the PID algorithm is often used and embedded in an embedded system such as Arduino to control the movement of the robotic arm. Robotic arms such as 5-axis robotic arms will use more than one Arduino microcontroller as their controller [12]. The correct PID gain parameter setting is required for precise movement from the robotic arm. To meet this requirement, it is necessary to set the PID on each Arduino microcontroller used to control each joint on the robotic arm. This setting is a very tedious job and takes a relatively long time [13], [14], [15]. It would be better if there were a user interface that could access the entire control system in controlling all movements of each joint on the robotic arm so that testing the movement of each joint on the robot can be done faster without having to access the microcontroller one by one but simultaneously. To overcome this difficulty, scientists have looked at several ways to create a user interface that can access the whole control system and manage every joint movement on the robotic arm. Marsono et al. used GbrlGru as a user interface to control a 5-axis robot both in simulation and directly. However, this software can only be used to move joints on the robot using the G-Code language, and there is no manual jogging facility for testing PID setting results [16]. Vivekanandan et al. also developed a Graphical User Interface (GUI) using the MatLab programming language to control a 5-axis robot. However, this GUI is only used as a robot controller simulator [17].

There is a significant need for more open and cost-effective solutions that users can easily modify and extend to suit multiple applications. In response to this challenge, open-source platforms offer a promising alternative, providing accessible and customizable solutions that encourage innovation and collaboration. This paper presents an open-source control system platform for a robotic arm with a maximum number of axes of 5 that integrates PID (proportional-integral-derivative) control and IoT (Internet of Things) technology. This system aims to provide a time-effective and flexible solution that leverages the PID algorithm's control capabilities and the IoT's connectivity and data management advantages. A comprehensive description of the control system's design and implementation, including

the hardware's configuration, the software's architecture, and the incorporation of PID control and IoT capabilities is also presented in this paper. Furthermore, an empirical finding that illustrates the system's performance and deliberates on possible applications and future advancements is also provided. This platform promotes the wider use and innovation of robotic technology across various sectors by providing an easily navigable and adaptable control solution.

## II. METHOD

### A. SCORBOT ER 4U Robotic Arm

The object used in this study is the Robotic Arm Scorbote ER 4U, as shown in Fig. 1 below. This robotic arm initially used a computer as its controller; then several researchers replaced it using PC and EtherCAT-based control technology from BECKHOFF [18]. In this study, the control system used is an embedded system such as Arduino Microcontroller to compare the robot's performance using a different control system from the control system used by previous researchers. On the other hand, embedded systems have a lower price compared to computer control and BECKHOFF PLC.

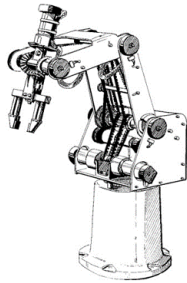


Fig. 1. SCORBOT ER 4U

In the following section we will discuss the kinematics of robots. Kinematics studies the motion of a body or set of bodies without considering mass or forces [19]. A kinematic diagram was constructed to facilitate the mathematical modeling of the SCORBOT ER4u robot arm, as illustrated in Fig. 2. The kinematic diagram will be utilized for determining the Denavit-Hartenberg parameters, as displayed in Table 1.

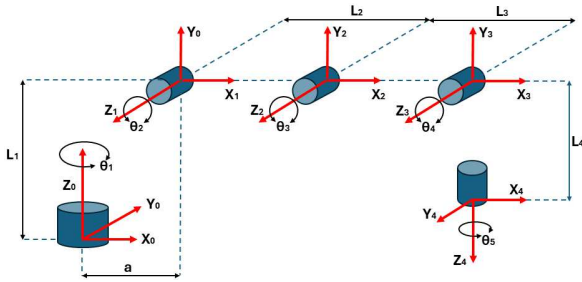


Fig. 2. Kinematic diagram of SCORBOT ER 4U

The Denavit-Hartenberg (D-H) parameter simplifies robotic manipulator calculations. The location and orientation of every joint and connection could be accurately defined, improving robot motion analysis and control. The D-H parameter utilizes four variables, consisting of  $\theta$  (joint angle),  $\alpha$  (link twist),  $r$  (link length), and  $d$  (link offset). Fig. 2 shows about kinematic diagram of SCORBOT ER4u which is relate to Table I.

TABLE I. DENAVIT-HARTENBERG PARAMETERS

Joint	$\theta_n$ (deg)	$\alpha_n$ (deg)	$r_n$ (cm)	$d_n$ (cm)
1	$\theta_1$	90	$a = 1.5$	$L_1 = 35$
2	$\theta_2$	0	$L_2 = 22$	0
3	$\theta_3$	0	$L_3 = 22$	0
4	$\theta_4$	90	0	0
5	$\theta_5$	0	0	$L_4 = 14$

A 4x4 homogeneous transformation matrix is used to obtain the forward kinematics [20] due to in the experiment, the rotation angle has been determined in advance. For easy development, consider frame  $\{n-1\}$  and frame  $\{n\}$ .

$$T_{n-1,n} = \begin{bmatrix} C\theta_n & -S\theta_n \cdot C\alpha_n & S\theta_n \cdot S\alpha_n & r_n \cdot C\theta_n \\ S\theta_n & C\alpha_n \cdot C\theta_n & -C\theta_n \cdot S\alpha_n & r_n \cdot S\theta_n \\ 0 & S\alpha_n & C\alpha_n & d_n \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

where  $C\theta_n = \cos\theta_n$ ,  $S\theta_n = \sin\theta_n$ ,  $C\alpha_n = \cos\alpha_n$ ,  $S\alpha_n = \sin\alpha_n$ . D-H parameters can be substituted into equation (1) to get the transform matrix of each link:

$$T_{0,1} = \begin{bmatrix} C_1 & 0 & S_1 & r_1 C_1 \\ S_1 & 0 & -C_1 & r_1 S_1 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad T_{1,2} = \begin{bmatrix} C_2 & -S_2 & 0 & r_2 C_2 \\ S_2 & C_2 & 0 & r_2 S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (2), (3)$$

$$T_{2,3} = \begin{bmatrix} C_3 & -S_3 & 0 & r_3 C_3 \\ S_3 & C_3 & 0 & r_3 S_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad T_{3,4} = \begin{bmatrix} C_4 & 0 & S_4 & 0 \\ S_4 & 0 & -C_4 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (4), (5)$$

$$T_{4,5} = \begin{bmatrix} C_5 & -S_5 & 0 & 0 \\ S_5 & C_5 & 0 & 0 \\ 0 & 0 & 1 & d_5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \text{Where :} \quad (6)$$

$$C_1 = \cos\theta_1 \quad S_1 = \sin\theta_1$$

The determination of the end effector transformation matrix  $T_{0,5}$  can be achieved by performing multiplication on equation (2), (3), (4), (5), and (6) as follow:

$$T_{0,5} = T_{0,1} * T_{1,2} * T_{2,3} * T_{3,4} * T_{4,5} \quad (7)$$

$$T_{0,5} = \begin{bmatrix} K_1 & K_2 & K_3 & P_X \\ K_4 & K_5 & K_6 & P_Y \\ K_7 & K_8 & K_9 & P_Z \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (8)$$

Where:

$$\begin{aligned} K_1 &= C_1 C_5 C_{234} & K_2 &= C_5 S_1 - S_5 C_1 C_2 C_{34} \\ K_3 &= C_1 S_{234} & K_3 &= C_1 (r_3 C_{23} + r_2 C_2 + d_5 C_2 S_{34} - S_2 C_{3,4} + r_1) \\ K_4 &= -C_1 S_5 + C_5 C_2 S_1 C_{34} - S_1 S_2 S_{34} & K_5 &= -C_1 C_5 - S_5 S_1 C_2 C_{34} - S_2 S_{34} \\ K_6 &= S_1 S_{34} (C_2 - S_2) & P_Y &= S_1 (r_3 C_{23} + r_2 C_2 + d_5 S_{234} + r_1) \\ K_7 &= C_5 (C_2 S_{34} + S_2 C_{3,4}) & K_8 &= -S_5 S_{345} \\ K_9 &= -C_{234} & P_Z &= r_3 S_{23} + d_1 - d_5 C_2 C_{34} + S_2 S_{34} + r_2 S_2 \end{aligned}$$

### B. Electronic Design

The embedded system used to control the robot is the Arduino MEGA WIFI microcontroller as the master controller and the Arduino UNO microcontroller as the slave controller. As the master controller, the Arduino MEGA microcontroller will send a trajectory in the form of setpoints to the slave controller, in this case, the Arduino UNO microcontroller. The slave controller will send this setpoint collection to the DC motor at each joint to move each joint to form a trajectory on the robot's end effector. To connect the embedded system controllers to the internet, an ESP8266 is used, which will connect to the IoT broker. An electronic system has been designed and implemented on the robot to meet these needs, as shown in Fig. 3.

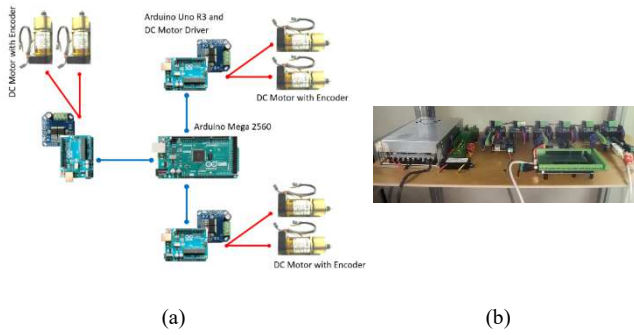


Fig. 3. a) The electronic control design. b) The design implementation

For the DC motor controller driver, we are using BTS7960, which is capable of flowing current up to 43A. An embedded system is selected because the hardware is straightforward to obtain in the commercial market at a relatively low price and is easy to install and program compared to a PLC or PC. Embedded systems such as Arduino have relatively small memory systems compared to other controllers such as PLC or PC. Still, it is sufficient for the needs of a robot arm controller. This robotic arm will be an educational tool for students to gain knowledge and skills. This robotic arm will be an educational tool for students to gain knowledge and skills.

### C. Web-based User Interface Application

The user interface used to control the manual jogging of the robot is based on a web application with an architecture as shown in Fig. 4 below. In general, this web application-based user interface is divided into three large parts [21], namely:

1. Nodes consisting of computers and gadgets as control devices and robots with embedded controllers as controlled devices,
2. Internet Connection, which is an access point device as a connection between devices on nodes and the internet,
3. Cloud, which is a web server as a website service provider that allows users to use website applications to access devices and brokers as service providers based on the MQTT (Message Queuing Telemetry Transport) protocol used by devices on nodes.

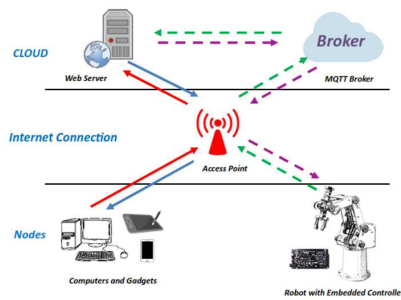


Fig. 4. The user interface system architecture

From the system architecture that has been designed, the user interface is created using Visual Studio Code as the program editor. The appearance of the user interface for manual jogging on the robot is shown in Fig. 5. There are five sliders representing each joint to set the angle as the motion path of each joint. Each slider can be moved in the negative or positive direction to provide an angle value that will be used to move each joint on the robot. The angle value set using this slider will be converted into a pulse value sent to the microcontroller to rotate the DC motor. The rotary encoder

will monitor the rotation of the DC motor to ensure the accuracy of the number of motor rotations to form an angle on the robot arm. The conversion of the angle value to the number of pulses to move the DC motor can be seen in Table II below.

TABLE II. NUMBER OF PULSES PER DEGREE OF EVERY JOINT

	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5
#pulses per degree	125	115	115	65	65

For monitoring, five graphic displays show the movement response of each joint based on the input set on each slider, as shown in Fig. 5. The Bootstrap framework is used to make the user interface more responsive. The MQTT JS library connects the IoT (Internet of Things) broker with the web server because the IoT protocol is MQTT. For internet communication networks using WLAN (Wireless Local Area Network), this is to make the system independent of the position of the LAN cable so that it can be used anywhere as long as it has an internet connection. This system has several data points related to the username and password and the robot's position while working. These data will be stored in the database to create a database on this system using MySQL. To access the manual jogging user interface, the user must go through the Login page, as shown in Fig. 6. This login page is used to authenticate users who will access the system. Each user must have a username and password to enter the system. There is a column on this page where the operator can input the username and password. If the username and password entered match the data in the database, the user can access the main page or the page to control the robot application. However, if the data entered does not match, a notification will appear informing that the username and password do not match. This login page aims to ensure that robot users who will access or use the robot through a web-based application do not collide with each other, considering that this robot can be accessed wirelessly using IoT technology.

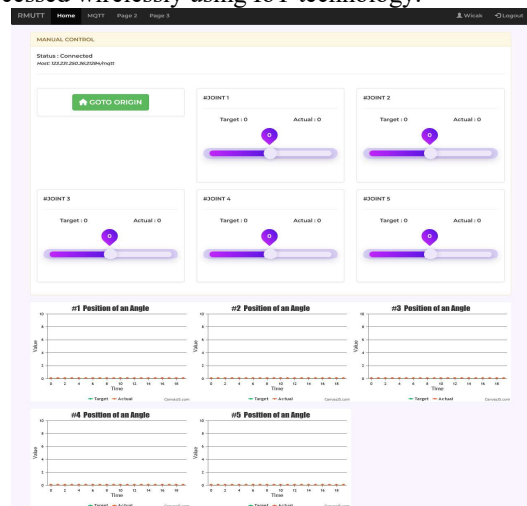


Fig. 5. The display of web-based manual jogging user interface

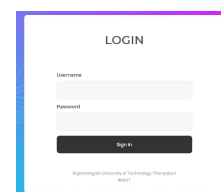


Fig. 6. Login page

To control the robot using the web-based user interface, an embedded system is needed to receive commands from the user interface online to move the DC motor on the robot as its actuator. The embedded systems used are Arduino MEGA 2560 + Wi-Fi R3 and Arduino UNO R3, as shown in Fig. 7 below. There is also ESP8266, which facilitates wireless internet connection on Arduino MEGA 2560 + Wi-Fi R3, which has a protocol for wireless internet access. This ESP 8266 microcontroller communicates serially with the MEGA 2560 microcontroller. In the SCORBOT ER 4U robotic arm system, these three microcontrollers communicate serially to control the movement of each arm. The functions of each microcontroller are:

1. The ESP8266 microcontroller connects the robot hardware with the software as a user interface via the internet through the IoT broker.
2. The Arduino MEGA2560 microcontroller, as the master controller, processes data sent by the software, namely the user interface, to the robot hardware. The data is translated into commands to drive the DC motor at each joint.
3. The Arduino UNO R3 microcontroller, as the slave controller, receives commands from the Arduino MEGA 2560 microcontroller to drive the DC motor at each joint and reports the motor's position periodically.



Fig. 7. a) Arduino MEGA2560+WiFi b) Arduino UNO R3

Data communication that occurs in embedded systems uses serial ports. Four serial ports on the Arduino MEGA 2560 are used, which are three hardware and one software serial port. Each serial port is used for communication between the ESP8266 and the MEGA 2560 (one hardware serial port) and the MEGA 2560 with three UNO R3 (two hardware serial ports and one software serial port). Fig. 8 shows the data communication flow in the control system. There are two data communications shown in Fig. 8, each separated using a red line, from the PC/Gadget to the joint robot controlled by the UNO R3 and from the UNO R3 to the PC/Gadget. The top left shows the type of data sent by the PC/Gadget to the ESP 8266 via the web browser to the IoT broker, then in the top middle is the type of data sent by the ESP 8266 to the MEGA 2560 via hardware serial port 2. The top right is the type of data sent from the MEGA 2560 to 3 UNO R3 via hardware serial ports 3 and 4 and 1 software serial port. In the second part, separated by a red line, is the data type sent from the UNO R3 to the PC/Gadget via the MEGA 2560, ESP 8266, and IoT broker and Web browser.

All firmware on the embedded system and source code of the GUI program as an open-source control system platform for a 5-axis robotic arm can be accessed for free in the online repository at the following address: [https://github.com/onoskaciwsugab/5\\_axis\\_robotic\\_arm\\_platform\\_for\\_manual\\_jogging](https://github.com/onoskaciwsugab/5_axis_robotic_arm_platform_for_manual_jogging).

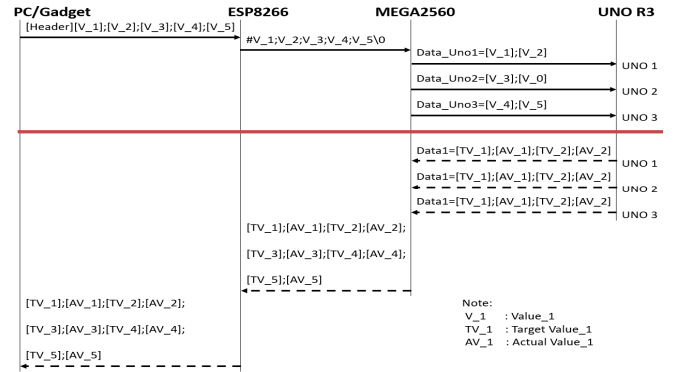


Fig. 8. Data communication

#### D. PID Controller

Proportional-Integral-Derivative (PID) control is a highly prevalent feedback control method in industrial and engineering applications. It is recognised for its robustness, efficacy, and simplicity in the regulation of a variety of processes [22]. The PID controller modulates its output by considering three factors: proportional, integral, and derivative terms [23].

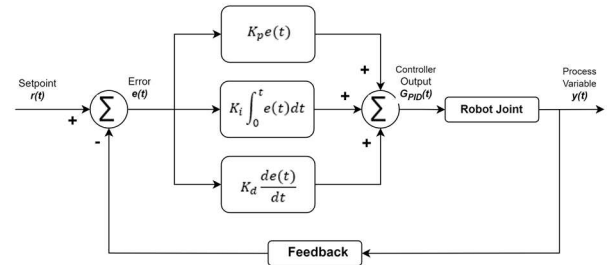


Fig. 9. The PID controller block diagram

Fig. 9 shows the PID controller block diagram, the PID controller aims to maintain a process variable  $y(t)$  at a desired setpoint  $r(t)$  by correcting for changes  $e(t)$  that occur. It generates control signals  $G_{PID}(t)$  to regulate the system so that it can reach the setpoint value quickly and precisely. The combine of the controller output is the sum of the proportional, integral, and derivative terms:

$$G_{PID}(t) = K_p \cdot e(t) + K_i \cdot \int_0^t e(t) dt + K_d \cdot \frac{de(t)}{dt} \quad (9)$$

- $G_{PID}(t)$  : PID controller output
- $K_p$  : Proportional gain
- $e(t)$  : Error signal
- $K_i$  : Integral gain
- $K_d$  : Derivative gain

$K_p$ ,  $K_i$ , and  $K_d$  are the three parameters of a PID controller that must be fine-tuned for the controller to work properly. Standard tuning methods [19] include manual tuning uses expertise and trial-and-error, the Ziegler-Nichols technique is a heuristic approach that provides initial parameter values by analysing the system's reaction to tests, and software-based tuning optimises settings using algorithms and simulations.

#### E. Design of Experiments

The system test design is carried out using the black box method, which means that this test design only assesses the functionality from the user's perspective. In the process, the user interface is used to test the results of the PID parameter settings on each joint sequentially by accessing all joints simultaneously. Each joint will be moved in two opposite



directions, and then the response of each control system will be seen by observing the output produced and whether it is following the given setpoint. Suppose the user interface for manual jogging can move the joint according to the intended direction and display the system response as output from each control on the joint. In that case, the user interface is functioning correctly. In testing, the work process time without using the user interface and when using the user interface will also be recorded to compare the process speed that can be used to assess the effectiveness of the work of using the user interface for manual jogging.

### III. RESULT AND DISCUSSIONS

This section will explain the results of the experiments by applying PID control to Arduino UNO R3 to control each joint, tested by using the user interface for manual jogging. Using manual tuning, the optimum gain coefficient used in PID control is as follows:  $K_p = 6.4$ ;  $K_i = 0.01$ ; and  $K_d = 0.4$ . After the optimum PID gain value has been obtained, the value is embedded in the embedded control system used. In this case, three Arduino UNO microcontrollers are used to control 5 joints on each axis of the SCORBOT ER4U. Furthermore, movement testing is carried out on each joint of the robot using the user interface for manual jogging, as shown in Fig. 5.

In the test to apply PID control on the open-source control system platform to control the movement of each joint in the manual jogging movement. To detect the angle achieved in each movement, a mobile phone with a Bubble Level application for angle measurement was attached to the joint being tested. Fig. 10 below shows the testing process on joint 3. The test was carried out 10 times, and the test results of all joints are recorded and shown in Table III below.

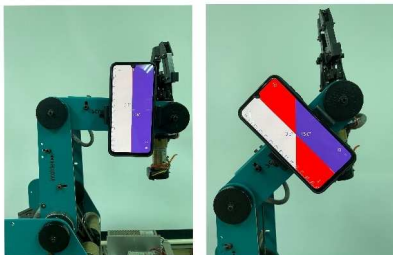


Fig. 10. Testing Open-source Control System Platform for Manual Jogging

TABLE III. MANUAL JOGGING MOVEMENT TESTING RESULT

No	Joint	Direction	Setpoint Angle	Output Angle in Average
1	1	cw	45	45.13
2	1	ccw	45	44.85
3	2	up	40	39.81
4	2	down	40	40.36
5	3	up	30	29.9
6	3	down	30	30.15
7	4	up	35	35.15
8	4	down	35	35.17
9	5	cw	35	35.14
10	5	ccw	35	35.19

As shown in Table III, each joint is moved in two directions according to the setpoint which has been set. From several experiments that have been carried out, the results obtained are precise enough to achieve the setpoint that has been set.

The prepared user interface, as shown in Fig. 5, allows for easy control of all movements. From the responses generated, joint two and joint three show different phenomena compared

to other joints such as joint 1, joint 4, and joint 5. Fig. 11-14 below show about the response of joint 2 and joint 3, those all figures show that the down movement takes less time than the up movement. The gravitational force acting on the system affects its movement speed [24]. Since joint 1 does not include gravitational force, this problem does not exist there. At the same time, joints 4 and 5 are carrying less weight than joints 2 and 3.

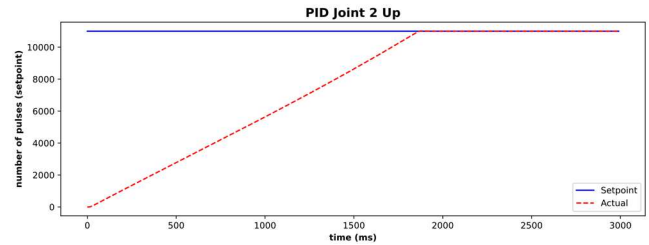


Fig. 11. Joint 2 response system moving upward

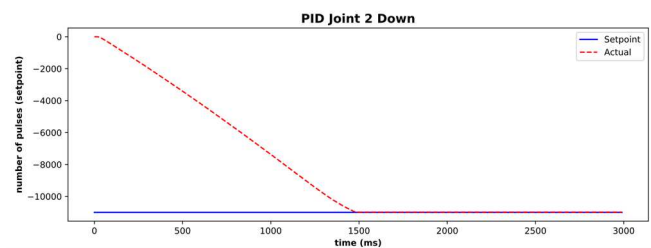


Fig. 12. Joint 2 response system moving downward

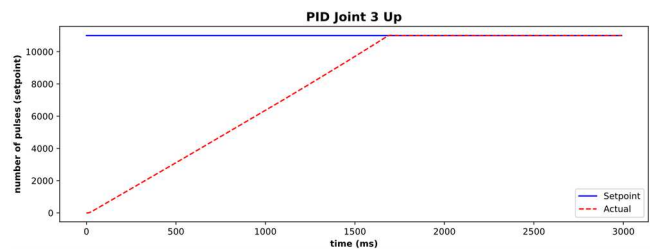


Fig. 13. . Joint 3 response system moving upward

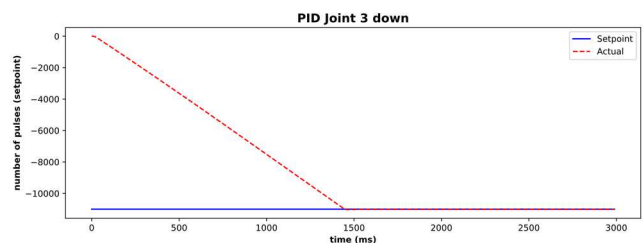


Fig. 14. Joint 3 response system moving downward

The following observation is related to the PID parameter setting process time and the response result testing. Table IV below shows the time records of each PID setup and testing process for each joint using the User Interface (UI) for manual jogging and without using the UI.

TABLE IV. PROCESS TIME RECORD

No	Activity	Used time (second)	
		Without UI	With UI
1	PID setup and testing for joint 1	138	47
2	PID setup and testing for joint 2	142	51

No	Activity	Used time (second)	
		Without UI	With UI
3	PID setup and testing for joint 3	136	45
4	PID setup and testing for joint 4	125	34
5	PID setup and testing for joint 5	125	34

As shown in Table IV above, the time used for each process decreases when the user interface for manual jogging is used to test the PID response. Thus, the user interface for manual jogging can speed up the PID testing process on the 5-axis robotic arm.

#### IV. CONCLUSION

The open-source control system platform for a 5-axis robot can work well to control the movement of each joint. In the PID testing process, it has proven to be effective in testing each robot joint. The shorter time needed to complete the testing process when using the user interface proves this. Utilizing IoT technology to do wireless manual jogging on each joint is quite advantageous, particularly when testing many robotic arms. This wireless control method will be advantageous if accessing the robot's control system is difficult due to cable constraints in the setup.

Future research will involve modifying the open-source control system platform for a 5-axis robot to create a user interface for the setup of point-to-point coordinates, which will be utilised by the robot's end-effector as part of its overall trajectory during operation.

#### ACKNOWLEDGMENT

The authors like to acknowledge the Rajamangala University of Technology Thanyaburi (RMUTT), Thailand, and Sanata Dharma University, Indonesia, for granting access to research facilities.

#### REFERENCES

- [1] M. A. N. Huda, S. H. Susilo, and P. M. Adhi, "Implementation of Inverse Kinematic and Trajectory Planning on 6-DOF Robotic Arm for Straight-Flat Welding Movement," *Log. J. Ranc. Bangun dan Teknol.*, vol. 22, no. 1, pp. 51–61, 2022, doi: 10.31940/logic.v22i1.51-61.
- [2] L. Pengcheng, "Application Analysis of Automated Production Technology Based on Industrial Robots," *J. Phys. Conf. Ser.*, vol. 1948, no. 1, 2021, doi: 10.1088/1742-6596/1948/1/012085.
- [3] S. K. L. Andersson, A. Granlund, M. Hedelind, and J. Bruch, "Exploring the Capabilities of Industrial Collaborative Robot Applications," *Adv. Transdiscipl. Eng.*, vol. 13, pp. 109–118, 2020, doi: 10.3233/ATDE200148.
- [4] J. Li, F. Ye, N. Shen, Z. Wang, and L. Geng, "Dimensional synthesis of a 5-DOF hybrid robot," *Mech. Mach. Theory*, vol. 150, p. 103865, 2020, doi: 10.1016/j.mechmachtheory.2020.103865.
- [5] H. Wang, W. Ren, C. C. Cheah, Y. Xie, and S. Lyu, "Dynamic Modularity Approach to Adaptive Control of Robotic Systems with Closed Architecture," *IEEE Trans. Automat. Contr.*, vol. 65, no. 6, pp. 2760–2767, 2020, doi: 10.1109/TAC.2019.2922450.
- [6] J. Han, P. Wang, F. Dong, X. Zhao, and S. Chen, "Optimal design of adaptive robust control for a planar two-DOF redundantly actuated parallel robot," *Nonlinear Dyn.*, vol. 105, no. 3, pp. 2341–2362, 2021, doi: 10.1007/s11071-021-06739-y.
- [7] B. Mauze et al., "Nanometer Precision with a Planar Parallel Continuum Robot," *IEEE Robot. Autom. Lett.*, vol. 5, no. 3, pp. 3806–3813, 2020, doi: 10.1109/LRA.2020.2982360.
- [8] B. Lian, J. Han, and L. Zhou, "Design of 4-DOF manipulator based on Arduino," *Acad. J. Eng. Technol. Sci.*, vol. 5, no. 6, pp. 24–27, 2022, doi: 10.25236/ajets.2022.050605.
- [9] O. Ogunbiyi, T. O. Idowu, and L. M. Adesina, "Development of Embedded Control for a Repetitive Pick and Placed Robotic Arm," *FUOYE J. Eng. Technol.*, vol. 8, no. 2, pp. 2–10, 2023, doi: 10.46792/fuoyejt.v8i2.976.
- [10] R. Hu, "Application of Microcontroller-Based Multipath Servos in Industrial Robot Control Systems," *J. Robot.*, vol. 2023, 2023, doi: 10.1155/2023/7235120.
- [11] S. Afroze, J. Hossain, and I. Hossain, "Arduino Based Pick and Place Robot with Robotic Arm for Industrial Use," vol. 5, no. 3, pp. 1–6, 2023.
- [12] Qolil Ariyansyah and A. Ma'arif, "DC Motor Speed Control with Proportional Integral Derivative (PID) Control on the Prototype of a Mini-Submarine," *J. Fuzzy Syst. Control*, vol. 1, no. 1, pp. 18–24, 2023, doi: 10.59247/jfsc.v1i1.26.
- [13] M. Huang, M. Tian, Y. Liu, Y. Zhang, and J. Zhou, "Parameter optimization of PID controller for water and fertilizer control system based on partial attraction adaptive firefly algorithm," *Sci. Rep.*, vol. 12, no. 1, pp. 1–15, 2022, doi: 10.1038/s41598-022-16425-7.
- [14] X. Mehmeti, "Adaptive PID controller design for joints of Humanoid Robot," *IFAC-PapersOnLine*, vol. 52, no. 25, pp. 110–112, 2019, doi: 10.1016/j.ifacol.2019.12.456.
- [15] T. A. M. Euzebio, M. T. D. Silva, and A. S. Yamashita, "Decentralized PID Controller Tuning Based on Nonlinear Optimization to Minimize the Disturbance Effects in Coupled Loops," *IEEE Access*, vol. 9, pp. 156857–156867, 2021, doi: 10.1109/ACCESS.2021.3127795.
- [16] Marsono, Yoto, A. Suyetno, and R. Nurmalasari, "Design and programming of 5 axis manipulator robot with grblgru open source software on preparing vocational students' robotic skills," *J. Robot. Control*, vol. 2, no. 6, pp. 539–545, 2021, doi: 10.18196/jrc.26134.
- [17] P. Vivekanandan, A. Vishnu, S. K. Narayanasamy, and R. Yasodharan, "Modelling, Simulation and Control of 5 Axis Industrial Robot using MATLAB," *Indian J. Sci. Technol.*, vol. 12, no. 23, pp. 1–7, 2019, doi: 10.17485/ijst/2019/v12i23/145415.
- [18] D. Maneetham and L. Sivhour, "Scorbot-ER 4U Using Forward Kinematics Modelling and Analysis," *Int. J. Mech. Mechatronics Eng.*, vol. 12, no. 2, pp. 162–168, 2018.
- [19] P. Corke, *Robotic Vision and Control Fundamental Algorithm in Matlab*, vol. 118. Cham: Springer Nature, 2017. doi: 10.1007/978-3-319-54413-7.
- [20] D. Maneetham and S. Leng, "PC - Based 5DOF industrial robotic arm with object color sorting by image," *SNRU J. Sci. Technol.*, vol. 10, no. 3, pp. 148–155, 2018, [Online]. Available: [https://ph01.tcithaijo.org/index.php/snru\\_journal/article/view/122172/104841](https://ph01.tcithaijo.org/index.php/snru_journal/article/view/122172/104841)
- [21] L. K. Probo Saputra, A. Filiana, M. N. Anggia Rini, G. Indra Widi Tamtama, L. Kurniawan, and H. Bastian Surya, "One Time Password Authentication for Machine Activation Monitoring System Based on Wireless Network," *Proc. - IEIT 2023 2023 Int. Conf. Electr. Inf. Technol.*, pp. 252–257, 2023, doi: 10.1109/IEIT59852.2023.10335513.
- [22] O. Ayokunle, K. Akingbade, and F. Dahunsi, "The dilemma of PID tuning ☆," *Annu. Rev. Control*, vol. 52, no. February, pp. 65–74, 2021, doi: 10.1016/j.arcontrol.2021.05.002.
- [23] R. P. Borase, D. K. Maghade, S. Y. Sondkar, and S. N. Pawar, "A review of PID control, tuning methods and applications," *Int. J. Dyn. Control*, vol. 9, no. 2, pp. 818–827, 2021, doi: 10.1007/s40435-020-00665-4.
- [24] P. Sutiyasadi, M. B. Wicaksono, and D. Maneetham, "Improvement Control of a Three Axis Articulated Robotic Arm Using PID Cascade Control," *2023 11th Int. Conf. Cyber IT Serv. Manag. CITSM 2023*, no. 1, pp. 1–4, 2023, doi: 10.1109/CITSM60085.2023.10455548.