Indonesia, August 24, 2022

UNIVERSITAS AMIKOM YOGYAKARTA

5th ICOIACT 2022

International Conference on Information and Communications Technology

A NEW WAY TO MAKE AI USEFUL FOR EVERYONE IN THE NEW NORMAL ERA

PROCEEDING

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PREFACE

Let us expressed our gratitude to Allah SWT because, with His permission, we can organize the 5th International Conference on Information and Communications Technology 2022 (The 5th ICOIACT 2022) 24th - 25th August 2022. This conference is an annual event jointly organized by Universitas Amikom Yogyakarta, Amikom IEEE Student Branch, and technically co-sponsored by IEEE Indonesian Section.

Conference Committee would like to express our gratitude to the honorable keynote speakers for sharing their knowledge in the plenary session of this conference. We are also very grateful to all participants coming from various institutions from 15 countries. Besides from Indonesia, the paper also came from Malaysia, India, Iraq, Peru, China, Thailand, United Kingdom, Turkey, Taiwan, Saudi Arabia, Japan, Singapore, Bangladesh, and USA. High appreciation is also addressed to all committee members who have worked hard for this conference's success.

We congratulate all the presenters who have been successfully accepted into this conference after being reviewed by at least 3 reviewers using a blind review system. The acceptance rate at this conference is 36.70%.

This conference program is designed to help participants to find relevant information related to this conference, such as schedule and paper abstracts in this conference. However, should there be any confusion associated with this conference, please feel free to approach one of our committee members.

At last, we apologize for any mistakes in managing this conference, from the paper submission process until the post-conference activity.

Yogyakarta-Indonesia, August 2022

The 5th ICOIACT 2022 Committee

WELCOME SPEECH FROM THE GENERAL CHAIR OF ICOIACT 2022

On Behalf of ICOIACT 2022, I would like to express my gratitude to all keynote speakers, reviewers, IEEE Indonesia section, and happy participants. International Conference of Information and Communication Technology (ICOIACT) is one of initiative to provide research community an event to share their work, open wider international network between academia and industrial researchers.

This conference has been organized since 2018 and today we are proud to welcome all participant in the 5th ICOIACT 2022. Under the theme of the conference "A new way to make artificial intelligence useful for everyone in the new normal era", we invite researcher to deal with current world problem due to two years COVID 19 pandemics. During pandemic COVID 2019, this conference has moved online and this year we dare to invite all of you to come in person to our historic city of Yogyakarta Indonesia. However, we understand the last two years we have been learns how to deal with all travel restriction and make use of online facility, under strict IEEE conference rule and regulation, ICOIACT still allow participants to present their work online.

ICOIACT 2022 has received 248 submission and accept only 91 papers after rigorous reviews with 36,7% acceptance rate. Therefore, I would like to congratulate all selected papers, based on double blind reviews. I would also take this opportunity to suggest all author's rejected papers to address reviewers comment to improve their papers and resubmit to another academic conference. ICOIACT committees maintains conference quality in every year conference series, the acceptance rate is recorded 48%, 45%, 42%, 44% and 36% for 1st to the 5th conference respectively. Again, congratulation for all authors, we very much hope everyone enjoy the conference and find fruitfull discussion and collaboration.

To all members of the organizing committees, the international technical program committee, IEEE Indonesia section, and Amikom IEEE Student branch we would like to thank all of them for their great efforts to organize this conference successfully. We look forward to having a successful conference, and we hope that all the attendees enjoy and benefit from this conference.

The General Chair of 5th ICOIACT 2022

Dr. Arief Setyanto, S.Si., MT.

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Time	Room A (offline)	Room B (Offline)	Zoom A (Online)	Zoom B (Online)	Zoom C (online)	Zoom D (Online)	Zoom E (Online)	Zoom F (online)
Wednesday, August 24								
06:30 am-07:00 am	Preparing and Join to Zoom Meeting: Registration and Join to Zoom Meeting							
07:00 am-08:30 am			1A: Parallel Session 1-A	1B: Parallel Session 1-B	1C: Parallel Session 1-C	1D: Parallel Session 1-D	1E: Parallel Session 1-E	
08:30 am-12:00 pm	Opening Ceremony + Plenary Speakers							
12:00 pm-01:00 pm	Break: Break Time							
01:00 pm-03:00 pm	2A: Parallel Session 2-A	2B: Parallel Session 2-B			2C: Parallel Session 2-C	2D: Parallel Session 2-D	2E: Parallel Session 2-E	2F: Parallel Session 2-F
03:00 pm-03:30 pm	Break: Break Time							
03:30 pm-04:30 pm			3A: Parallel Session 3-A	3B: Parallel Session 3-B	3C: Parallel Session 3-C	3D: Parallel Session 3-D	3E: Parallel Session 3-E	
04:30 pm-05:00 pm	Closing Ceremony: Awarding + Closing Ceremony, and Another Announcement							

Wednesday, August 24

Wednesday, August 24 6:30 - 7:00 (Asia/Jakarta)

Preparing and Join to Zoom Meeting: Registration and Join to Zoom Meeting

Rooms: room a (offline), Room B (Offline), Zoom A (Online), Zoom B (Online), zoom c (online), Zoom D (Online), Zoom E (Online), zoom f (online)

Meet with The Committee Team.

Preparing for Conference Day.

Simulation and Check Connection for Zoom Meeting.

Contact Center : Open Q & A all about conference.

Etc

Wednesday, August 24 7:00 - 8:30 (Asia/Jakarta)

1A: Parallel Session 1-A

Room: Zoom A (Online)

7:00 ***True-Time-Delay Line of Chipless RFID Tag for Security & IoT Sensing Applications***
Mohammad Ehsanul Alim (University of Delaware, USA); Ali Maswood (Nanyang Technological University, Singapore); Nazmus Sakib Bin (North South University, Bangladesh)

7:15 ***Design and Analysis of Optical Fiber Network Deployment on Soekarno Hatta Airport Railroad***
Eria Tri Utamy, Ainamardiah Putri Fatikah, Irfaan Fadhlullah, Jeremia June Caesar Parsinabul, Malvin Samuel Martino, Rafif Fadhilah Ushaim and Catur Apriono (Universitas Indonesia, Indonesia)

7:30 ***5G mobile wireless network threats and its mitigation methods***
Vinay M and Purushotham U (PES University, India)

7:45 ***Efficient ECC Architecture for Data Storage Memory Applications***
Nithesh Gupta Chebrolu and Sumanth Sakkara (PES University, India); Cyril Raj (MS College of Engineering, India); Purushotham U (PES University, India)

8:00 ***Accuracy Comparison of Different Machine Learning Models in Phishing Detection***
Anthony Chandra (BINUS University & None, Indonesia); Gregorius Gregorius and John I. M. Seumahu (BINUS University, Indonesia); Alexander Agung Santoso Gunawan (Bina Nusantara University & University of Indonesia, Indonesia); Anderies Anderies (BINUS University, Indonesia)

8:15 ***Software-Defined Networking (SDN): A Review***
Quadri Waseem and Wan Isni Sofiah Wan Din (Universiti Malaysia Pahang, Malaysia); Afrig

Aminuddin (Universitas Amikom Yogyakarta, Indonesia); Muzammil Hussain Mohammed (Taif University, Saudi Arabia); Rifda Faticha Alfa Aziza (Universitas Amikom Yogyakarta, Indonesia)

1B: Parallel Session 1-B

Room: Zoom B (Online)

7:00 ***Covid-19 Variants Survivability Simulation With Genetic Algorithm***
Cornelius M Sarungu (Bina Nusantara University, Indonesia)

7:15 ***Trust-Chain-Based Certificate Revocation Control in Autonomous Vehicle Networks***
Gizem Erceylan and M. Ali Akcayol (Gazi University, Turkey)

7:30 ***Performance Analysis of Optical-CDMA via FSO effect on Li-Fi system utilizing L'Band frequencies***
Baker Khalid Alfaris (Aliraqia University, Iraq); Satea Hikmat Alnajjar (Al-Iraqia University, Iraq)

7:45 ***Systematic Literature Review and Qualitative Survey of Blockchain Impact on Social Media Security***
Shannya Michelia, Fendy Kurniawan, Victor Antonius, Jurike Moniaga and Bakti Amirul Jabar (Bina Nusantara University, Indonesia)

8:00 ***Impact Of Rain On Performance Of Visible Light Communication System In Vehicle-to-Vehicle Communication***
Triswiza Ariatama, Arfianto Fahmi and Brian Pamukti (Telkom University, Indonesia)

8:15 ***Design and Implementation Named Data Networking-Based Video Streaming System***
Ade Aditya Ramadha, Leanna Yovita and Tody Wibowo (Telkom University, Indonesia)

1C: Parallel Session 1-C

Room: zoom c (online)

7:00 ***An Intrusion Detection System (IDS) using Dimensional Reduction Based on Statistical and SDAE to Enhance SVM in Classification Task***
Muh Hanafi (Universitas Amikom Yogyakarta, Indonesia & Time Excellindo, Malaysia)

7:15 ***Development of A Smart Box Prototype for Mail and Parcel Posts Using IoT and Solar Energy***
Jaranin Kaewsrisuphawong, Vatcharakiat Waelun, Jiranuwat Parakawong Na Ayuthaya and Suwit Paengkanya (RMUTP, Thailand); Therdpong Daengsi (Rajamangala University of Technology Phra Nakhon, Thailand)

7:30 ***Classifying the Students' Behavior on e-Learning System using Fine-Tuning K-NN Method***
Yuni Yamasari, Anita Qoiriah, Naim Rochmawati and I Made Suartana (Universitas Negeri Surabaya, Indonesia); Oddy Virgantara Putra (Universitas Darussalam Gontor, Indonesia); Tohari Ahmad (Institut Teknologi Sepuluh Nopember (ITS), Indonesia)

7:45 ***Effect of Image Enhancement in CNN-Based Medical Image Classification: A Systematic Literature Review***

Vio A Ferdinand, Vinsen Nawir, Gregorius E Henry and Anderies Anderies (BINUS University, Indonesia); Alexander Agung Santoso Gunawan (Bina Nusantara University & University of Indonesia, Indonesia)

8:00 ***Determination of Land Suitability for Herbal Plants Using FMADM With Weighted Product***

Novianti Puspitasari, Haviluddin Haviluddin, Hamdani Hamdani, Anindita Septiarini and Joan Angelina Widians (Universitas Mulawarman, Indonesia)

8:15 ***Lumpy Skin Disease Prediction Based on Meteorological and Geospatial Features using Random Forest Algorithm with Hyperparameter Tuning***

Suparyati Suparyati (Universitas Amikom Yogyakarta, Indonesia & Kementerian Pertanian Republik Indonesia, Indonesia); Ema Utami and Alva Muhammad (Universitas Amikom Yogyakarta, Indonesia)

1D: Parallel Session 1-D

Room: Zoom D (Online)

7:00 ***Complexity Weights Parameter Optimization of Use Case Points Estimation using Chaotic PSO***

Ardiansyah Ardiansyah (Universitas Ahmad Dahlan, Indonesia); Ridi Ferdiana and Adhistya Erna Permanasari (Universitas Gadjah Mada, Indonesia)

7:15 ***Sentiment Analysis of Cooking Oil using Bidirectional Encoder Representations from Transformers***

Mochammad Haldi Widianto and Yaya Heryadi (Bina Nusantara University, Indonesia); Lukas Lukas (Universitas Katolik Indonesia Atma Jaya, Indonesia); Wayan Suparta (Institut Teknologi Nasional Yogyakarta, Indonesia & Bina Nusantara University, Indonesia); Antoni Wibowo (Bina Nusantara University & Jakarta, Indonesia)

7:30 ***Predictive Models Using Supervised Neural Network for Pollutant Removal Efficiency in Petrochemical Wastewater Treatment***

Varun Geetha Mohan, Al-Fahim Mubarak-Ali, Mohamed Ariff Ameedeen and Bincy Lathakumary Vijayan (Universiti Malaysia Pahang, Malaysia); Afrig Aminuddin and Wiwi Widayani (Universitas Amikom Yogyakarta, Indonesia)

7:45 ***Selection of Prospective Workers Using Profile Matching Algorithm on Crowdsourcing Platform***

Ahmad Cucus (Universitas Bandar Lampung, Indonesia); Luhur Bayuaji (FSKPP, Universiti Malaysia Pahang, Malaysia); Al-Fahim Mubarak-Ali (Universiti Malaysia Pahang, Malaysia); Afrig Aminuddin and Lilis Dwi Farida (Universitas Amikom Yogyakarta, Indonesia)

8:00 ***Comparative Analysis of the Characteristics of the yoy Inflation Rate Cities in Indonesia before and during the Covid-19 Pandemic***

Adi Setiawan (Universitas Kristen Satya Wacana & Vrije Universiteit Amsterdam, Indonesia)

8:15 ***The Comparison of Classification of Stress Level Related to Student's Menstrual Cycle Irregularities with Support Vector Machine and Decision Tree Algorithm***

Helena Nooraini and Umi Salamah (Sebelas Maret University, Indonesia); Heri Prasetyo (Universitas

Sebelas Maret, Indonesia)

1E: Parallel Session 1-E

Room: Zoom E (Online)

7:00 ***Classification of Hepatitis Disease Using Learning Vector Quantization 3(LVQ3)***
Yufika Sari Bagi (Sekolah Tinggi Manajemen Informatika dan Komputer (STMIK) Multicom, Indonesia); Mihuandayani Mihuandayani (STMIK Multicom Bolaang Mongondow, Indonesia)

7:15 ***Sentiment Analysis of Indonesian Government's Effort to Overcome the Unemployment Problem during COVID-19 Pandemic***
Pandu Maulana (University of Indonesia, Indonesia); Indra Budi (Faculty of Computer Science & Universitas Indonesia, Indonesia); Aris Budi Santoso (University of Indonesia, Indonesia)

7:30 ***Cephalometric Landmark Detection on Cephalograms using Regression CNN***
Aziz Fajar (Institut Teknologi Sepuluh Nopember, Indonesia); Gusti Pangestu (Binus University, Indonesia); Riyanarto Sarno (Institut Teknologi Sepuluh Nopember, Indonesia); I Gusti Ardani (Airlangga University, Indonesia)

7:45 ***Misogyny Speech Detection Using Long Short-Term Memory and BERT Embeddings***
Rizkyta Shainy Angeline, Dade Nurjanah and Hani Nurrahmi (Telkom University, Indonesia)

8:00 ***Spatial Hotspot Data and Weather for Forest Fire Data Clustering***
Prasetyo Mimboro (AMIKOM Yogyakarta & PT Perkebunan Nusantara IV, Indonesia); Kusrini Kusrini (AMIKOM Yogyakarta University, Indonesia); Arif Dwi Laksito (Universitas Amikom Yogyakarta, Indonesia)

8:15 ***Application of the Adaptive-Neuro Fuzzy Inference System (ANFIS) Method for Rapid Diagnosis COVID-19 Patient Cases***
Esti Suryani (University of Sebelas Maret, Indonesia); Handy Putra and Wiharto Wiharto (Universitas Sebelas Maret, Indonesia); Umi Salamah and Wisnu Widiarto (Sebelas Maret University, Indonesia)

Wednesday, August 24 8:30 - 12:00 (Asia/Jakarta)

Opening Ceremony + Plenary Speakers

Rooms: room a (offline), Room B (Offline), Zoom A (Online), Zoom B (Online), zoom c (online), Zoom D (Online), Zoom E (Online), zoom f (online)

Plenary

Wednesday, August 24 12:00 - 1:00 (Asia/Jakarta)

Break: Break Time

Rooms: room a (offline), Room B (Offline), Zoom A (Online), Zoom B (Online), zoom c (online), Zoom D (Online),

Zoom E (Online), zoom f (online)

Break Time

Wednesday, August 24 1:00 - 3:00 (Asia/Jakarta)

2A: Parallel Session 2-A

Room: room a (offline)

1:00 ***Comparison of Accuracy and Time of Naïve Bayes Algorithm With Support Vector Machine Algorithm in Twitter Sentiment Analysis of Peduli Lindungi Application***

Maulana Rizky Hidayat (Universitas AMikom Yogyakarta, Indonesia); Mulia Sulistiyono (Universitas Amikom Yogyakarta, Indonesia)

1:15 ***The Comparison Study of Matrix Factorization on Collaborative Filtering Recommender System***

Avis Priyati, Arif Dwi Laksito and Heri Sismoro (Universitas Amikom Yogyakarta, Indonesia)

1:30 ***BI-CARU Feature Extraction for Semantic Analysis***

Ka-Hou Chan and Sio-Kei Im (Macao Polytechnic University, China)

1:45 ***Sentiment Analysis of Review Sestyc Using Support Vector Machine, Naive Bayes, and Logistic Regression Algorithm***

Barka Satya, Muhammad Hasan S J, Majid Rahardi and Ferian Fauzi Abdulloh (Universitas Amikom Yogyakarta, Indonesia)

2:00 ***An Automatic Egg Quality Grading Using Nature-Inspired Algorithm Based Classification***

Cahya Rahmad (State Polytechnic of Malang, Indonesia); Septian Enggar Sukmana (Politeknik Negeri Malang, Indonesia); Arie Rachmad Syulistyo (State Polytechnic of Malang, Indonesia)

2:15 ***AIoT@Water- An Intelligent Water Resources Management System***

Jiann-Liang Chen and QingAn Wu (National Taiwan University of Science and Technology, Taiwan); Candra Ahmadi (ITB STIKOM BALI Jalan Raya Puputan No 86 Renon Denpasar Bali & ITB STIKOM Bali, Indonesia)

2B: Parallel Session 2-B

Room B (Offline)

1:00 ***Data Communication Design Based on Internet of Things Architecture for Smart Greenhouse Monitoring and Controlling System***

Aghus Sofwan, Sumardi Sumardi. and Febrio Rizky Adhipratama (Diponegoro University, Indonesia)

1:15 ***The Effect of the COVID-19 Pandemic on Nitrogen Dioxide (NO2) Gas Concentration in Yogyakarta Special Province***

Uni Khikmatul Khasanah (Amikom University Yogyakarta, Indonesia); Fitria Nucifera (AMIKOM University, Indonesia)

1:30 ***Shoreline Change Forecasting on Eretan Beach using Long Short Term Memory***
Iryanto Iryanto (Politeknik Negeri Indramayu, Indonesia); Putu Harry Gunawan and Z. k. a. Baizal (Telkom University, Indonesia); Ahmad Lubis Ghozali and Eka Ismantohadi (Politeknik Negeri Indramayu, Indonesia)

1:45 ***Kinematics Modeling and Motions Analysis of Non-holonomic Mobile Robot***
Nur Uddin and Hari Nugraha (Universitas Pembangunan Jaya, Indonesia); Auralius Manurung (Universitas Pertamina, Indonesia); Hendi Hermawan and Teddy Mohamad Darajat (Universitas Pembangunan Jaya, Indonesia)

2:00 ***Spatio-temporal Distribution of Heat Index and Land Cover Change in Tropical Cities of Southeast Asia***
Fitria Nucifera (AMIKOM University, Indonesia); Widiyana Riasasi (Universitas AMIKOM Yogyakarta, Indonesia); Kazuhito Ichii (Center of Environmental Remote Sensing (CeRES), Chiba University, Japan)

2:15 ***Nglanggeran 3D Modelling for Virtual Reality Asset with Oblique Close Range Photogrammetry***
Fitria Nuraini Sekarsih (University of Amikom Yogyakarta, Indonesia); Ali Mustopa and Kusnawi Kusnawi (Universitas Amikom Yogyakarta, Indonesia)

2:30 ***Performance Analysis of the Neural Network Solution of Advection-Diffusion-Reaction Problem***
Aditya Firman Ihsan and Putu Harry Gunawan (Telkom University, Indonesia)

2:45 ***Multi-Layer LSTM Implementation in Operational Condition Forecasting of a Natural Gas Transmission Pipeline Network***
Aditya Firman Ihsan (Telkom University, Indonesia); Darmadi Darmadi, Saladin Uttunggadewa, Silvya Dewi Rahmawati, Irsyad Giovanni and Salamet Nur Himawan (Institut Teknologi Bandung, Indonesia)

2C: Parallel Session 2-C

Room: zoom c (online)

1:00 ***Reclassify and Readjust Software Risk Taxonomy in Software Development Activities Context***
Renny Sari Dewi (Universitas Negeri Surabaya, Indonesia)

1:15 ***Digital Wallet Service Quality Analysis using Multiclass Classification and Sentiment Analysis***
Sirin Zahra and Andry Alamsyah (Telkom University, Indonesia)

1:30 ***Context-aware Embeddings for Stock Prediction with Visual Clues***
Jinghua Tan, Tongyi Guo, Junxiao Chen and Tao Shu (Southwestern University of Finance and Economics, China)

1:45 ***Hoax Detection on Indonesian Text using Long Short-Term Memory***
Rizaldi Yusuf and Suyanto Suyanto (Telkom University, Indonesia)

2:00 ***FHIR, BigchainDB, and GraphQL approach for interoperability between heterogeneous Health Information System***
Danang Kastowo (Amikom University Yogyakarta & PT. Dua Empat Tujuh, Indonesia); Ema Utami and Alva Muhammad (Universitas Amikom Yogyakarta, Indonesia)

2:15 ***Stock Price Prediction with Golden Cross and Death Cross on Technical Analysis Indicators Using Long Short Term Memory***

Arya Yudhi Wijaya (Institut Teknologi Sepuluh Nopember Surabaya, Indonesia); Chastine Fatichah and Ahmad Saikhu (Institut Teknologi Sepuluh Nopember, Indonesia)

2:30 ***A Model of E-commerce Recommender System using Enhancement Document Context Based on Attention and User Information Based on Auto Encoder and Latent Factor***

Muh Hanafi (Universitas Amikom Yogyakarta, Indonesia & Time Excellindo, Malaysia)

2:45 ***Decision Support System for Student Selection Recipients of COVID-19 Impacts using MOORA***

Noorlela Marcheta, Hata Maulana, Asep Muharram and Muhammad Rashyid Mishbahuddin Action (Politeknik Negeri Jakarta, Indonesia); Muhammad Faiz Bahyfallah (Jakarta State of Polytechnic, Indonesia)

2D: Parallel Session 2-D

Room: Zoom D (Online)

1:00 ***Integral State Feedback Controller with Coefficient Diagram Method for USV Heading Control***

Anggun Winursito (Universitas Negeri Yogyakarta, Indonesia); Oktaf Agni Dhewa (Universitas Gadjah Mada, Indonesia); Aris Nasuha and Gilang Nugraha Putu Pratama (Universitas Negeri Yogyakarta, Indonesia)

1:15 ***Designing Smart Restaurant for Reopening During the Relaxation of Lockdown in the Time of Corona Pandemic***

Ola A. Hasan, Zaineb Alhakeem, Marwan Armash, Mohammed Khazal, Ali Malik and Mujeeb Abdullah (Iraq University College, Iraq)

1:30 ***Systematic Literature Review on The Usage of IoT in The Metaverse to Support The Education System***

Dyandra Maheswari, Frangklyn Ndruru, Dewi Rejeki, Jurike Moniaga and Bakti Amirul Jabar (Bina Nusantara University, Indonesia)

1:45 ***Sentiment Analysis on Tripadvisor Hotel Review using Named Entity Recognition***

Rizki Elisa Nalawati, Dewi Yanti Liliana, Fitria Nugrahani, Faldan Abiyanka and Rhenald Karrel (State Polytechnic of Jakarta, Indonesia)

2:00 ***Classification of Complaint Categories in E-Commerce: A Case Study of PT Bukalapak***

Muhammad Yusuf Imam, Itsari (Universitas Indonesia, Indonesia); Indra Budi (Faculty of Computer Science & Universitas Indonesia, Indonesia)

2:15 ***Extraction of Person Entities Affiliated with Telkom University using Long Short-Term Memory (LSTM) on Related News Articles***

Muhammad Naufal Rizky (Telkom University, Indonesia); Donni Richasdy (Telkom University & Bandung Techno Park, Indonesia); Aditya Firman Ihsan (Telkom University, Indonesia)

2:30 ***Android Application For Analysis Review On Google Playstore Using Support Vector Machine Method***

Andrean Setiawan (Universitas Tarumanagara, Indonesia); Viny Christanti Mawardi (Taman Semanan Indah A2' / 12A, Indonesia)

2:45 ***Random Forest Algorithm for Meat Classification and Microbial Population Prediction***

Salman Hanif, Dedy Rahman Wijaya and Pramuko Aji (Telkom University, Indonesia)

2E: Parallel Session 2-E

Room: Zoom E (Online)

1:00 ***Impact Analysis of RGB Channels to the Quality of Imperceptibility in Image Steganography***

De Rosal Ignatius Moses Setiadi (Dian Nuswantoro University, Indonesia); Supriadi Rustad (Universitas Dian Nuswantoro, Indonesia); Pulung Nurtantio Andono (Dian Nuswantoro, Indonesia); Guruh Fajar Shidik (Universitas Dian Nuswantoro, Indonesia); Moch Arief Soeleman (Sepuluh Nopember Institute of Technology & Dian Nuswantoro University, Indonesia); Pujiono Pujiono and Purwanto Purwanto (Universitas Dian Nuswantoro, Indonesia)

1:15 ***Indonesian Seismic Mitigation using Earthquake Predicted Artificial Intelligence Model***

Usman Wijaya (Universitas AMIKOM Yogyakarta, Indonesia); Kusrini Kusrini (AMIKOM Yogyakarta University, Indonesia); Alva Muhammad (Universitas Amikom Yogyakarta, Indonesia)

1:30 ***Automatic Indonesian Image Captioning using CNN and Transformer-Based Model Approach***

Rifqi Mulyawan, Andi Sunyoto and Alva Muhammad (Universitas Amikom Yogyakarta, Indonesia)

1:45 ***Automatic Stop Line Violations Detection using Histogram of Oriented Gradients and Support Vector Machine***

Dwira Kurnia Larasati, Iwan Setyawan and Andreas Febrianto (Satya Wacana Christian University, Indonesia)

2:00 ***Block-based Fragile Image Watermarking based on SVD-LSB and Chaos System***

Nova Rijati (Universitas Dian Nuswantoro, Indonesia); De Rosal Ignatius Moses Setiadi (Dian Nuswantoro University, Indonesia); Pulung Nurtantio Andono (Dian Nuswantoro, Indonesia)

2:15 ***Gray Level Co-Occurrence Matrix Algorithm and Backpropagation Neural Networks for Herbal Plants Identification***

Muhammad Fikri Ihsan, Jr. (University of Amikom Yogyakarta, Indonesia); Andi Sunyoto and M. Rudyanto Arief (Universitas Amikom Yogyakarta, Indonesia)

2:30 ***An Event-based intelligent vehicle rerouting for efficient traffic management for connected vehicles***

Emmanuel O. Eze (University of Greenwich, United Kingdom (Great Britain)); Simeon Keates (External Research Supervisor, United Kingdom (Great Britain)); Kamran Pedram and Alireza Esfahani (Research Supervisor, United Kingdom (Great Britain)); Uchenna Odih (University of Greenwich, United Kingdom (Great Britain))

2:45 ***Simulation of an Automated Sorting System for Peruvian mangoes based on computer vision***
Jhon Rodrigo Ortiz Zacarias, Michael Cristhian Rivera Rojas, Maydelson Yanarico Estrella, Iraiz Quintanilla Mosquera, Yadhira Samhira Valenzuela Lino and Carlos Coaquira Rojo (Universidad Continental, Peru)

2F: Parallel Session 2-F

Room: zoom f (online)

1:00 ***Brain-Computer Interface of Emotion and Motor Imagery Using 2D Convolutional Neural Network - Recurrent Neural Network***
Satrio Ananda Setiawan, Esmeralda Contessa Djamal, Fikri Nugraha and Fatan Kasyidi (Universitas Jenderal Achmad Yani, Indonesia)

1:15 ***3D CNN for MicroExpression Detection***
Wahyu Suryo Putro Bayu (University of Amikom Yogyakarta, Indonesia); Arief Setyanto (Universitas AMIKOM Yogyakarta, Indonesia)

1:30 ***Implementation of the C4.5 Decision Tree Algorithm Method for Selection of Facial Mask Skin Care Products***
Masna Wati (Universitas Mulawarman, Indonesia); Heliza Rahmania Hatta (Mulawarman University, Indonesia); Ayunda Saputri and Anindita Septiarini (Universitas Mulawarman, Indonesia); Muh Jamil (Universitas Mulawarman & Departemen Of Information Technology And Computer Science, Indonesia)

1:45 ***Multi-Class Support Vector Machine for Arabica Coffee Bean Roasting Grade Classification***
Anindita Septiarini and Hamdani Hamdani (Universitas Mulawarman, Indonesia); Achmad Rifani and Zainal Arifin (Mulawarman University, Indonesia); Nurul Hidayat (Jenderal Soedirman University, Indonesia); Heru Ismanto (Universitas Musamus Merauke, Indonesia)

2:00 ***-TRIMAX Method with Silhouette Coefficient on Microarray Gene Expression Data for Early Detection of Heart Failure***
Wilhelmina A. N. Daeng (University of Indonesia, Indonesia); Titin Siswantining, Alhadi Bustamam and Prasnurzaki Anki (Universitas Indonesia, Indonesia)

2:15 ***An Optimized Rice Leaf Disease Classification using Transfer Learning and Balanced Class Weight Distribution based on Bandit Approach***
Oddy Virgantara Putra, Niken Trisnaningrum and Niken Sylvia Puspitasari (Universitas Darussalam Gontor, Indonesia); Agung Toto Wibowo (Telkom University - Indonesia, Indonesia); Ema Rachmawati (Telkom University, Indonesia)

2:30 ***Framework for Analyzing Intruder Behavior of IoT Cyber Attacks Based on Network Forensics by Deploying Honeypot Technology***
Michael Felix and Cutifa Safitri (President University, Indonesia); Rila Mandala (Institut Teknologi Bandung, Indonesia)

2:45 ***Lane Detection With Conditions of Rain and Night Illumination Using Hough Transform***
Astika Istiningrum (Universitas Sebelas Maret, Indonesia); Umi Salamah (Sebelas Maret University,

Indonesia); Nurcahya Pradana Taufik Prakisya (Universitas Sebelas Maret, Indonesia)

Wednesday, August 24 3:00 - 3:30 (Asia/Jakarta)

Break: Break Time

Rooms: room a (offline), Room B (Offline), Zoom A (Online), Zoom B (Online), zoom c (online), Zoom D (Online), Zoom E (Online), zoom f (online)

Break Time

Wednesday, August 24 3:30 - 4:30 (Asia/Jakarta)

3A: Parallel Session 3-A

Room: Zoom A (Online)

3:30 ***Unsupervised Feature Learning in Activity Recognition using Convolutional Denoising Autoencoders with Squeeze and Excitation Networks***

Ayokunle Olalekan Ige and Halim Noor (Universiti Sains Malaysia, Malaysia)

3:45 ***Evaluation of Machine Learning Performance Based on BERT Data Representation with LSTM Model to Conduct Sentiment Analysis in Indonesian for Predicting Voices of Social Media Users in the 2024 Indonesia Presidential Election***

Guna Mandhasiya (University of Indonesia, Indonesia); Hendri Murfi, Alhadi Bustamam and Prasnurzaki Anki (Universitas Indonesia, Indonesia)

4:00 ***Genetic Algorithm and K-Nearest Neighbors for Oil Palm Leaf Disease Classification***

Enda Putri Atika (AMIKOM Yogyakarta University, Indonesia); Andi Sunyoto (Universitas Amikom Yogyakarta, Indonesia); Emha Taufiq Luthfi (Universitas AMIKOM Yogyakarta, Indonesia)

4:15 ***ITE Law Enforcement Support through Detection Tools of Fake News, Hate Speech, and Insults in Digital Media***

Pratama Azmi Atmajaya (Telkom University, Indonesia); Fendi Irfan Amorokhman (& Telkom University, Indonesia); Made Diva Prasetya, Aditya Firman Ihsan and Danang Junaedi (Telkom University, Indonesia)

3B: Parallel Session 3-B

Room: Zoom B (Online)

3:30 ***Online Book Recommendation System Based on Optimized Collaborative Filtering Using Ant Colony Optimization***

Quezvanya Chloe Milano Hadisantoso, Gilbert Nathaniel and Felix Indra Kurniadi (Bina Nusantara University, Indonesia)

3:45 ***Employing YOLOv4 in a Vehicle Counting System Using Random Dataset***
Eric Prasetya Sentosa, Randy Julian Gunawan, Anatapindhika Anatapindhika, Nurhasanah Nurhasanah and Edy Irwansyah (Bina Nusantara University, Indonesia)

4:00 ***Improving Virus Colony Search Performance on Travelling Salesman Problem Case***
Zilfikri Yulfiandi Rachmat and Rila Mandala (Institut Teknologi Bandung, Indonesia)

3C: Parallel Session 3-C

Room: zoom c (online)

3:30 ***A Non-Invasive Cholesterol Measuring Device Using a Photodiode Sensor With a BLYNK Interface***
Nur Hasanah Ahniar (Politeknik Kesehatan Kemenkes Jakarta II, Indonesia); Gita Rindang Lestari (Poltekkes Kemenkes Jakarta II, Indonesia); Rinda Nur Hidayati (Politeknik Kesehatan Kemenkes Jakarta II, Indonesia)

3:45 ***Systematic Literature Review: Implementation Of Artificial Intelligence in Precision Agriculture***
Viola Patricia Harmani, Bryant Marcellino Himawan and Muhammad Ali Alhadi (Binus University, Indonesia); Alexander Agung Santoso Gunawan (Bina Nusantara University & University of Indonesia, Indonesia); Anderies Anderies (BINUS University, Indonesia)

4:00 ***Implementation of Object Detection and Recognition Based On Exploration Deep Neural Network Features for Quadcopter***
Suryo Adhi Wibowo and Syamsul Rizal (Telkom University, Indonesia)

4:15 ***Parameter Investigation in Low Computing Cost Model-Based EfficientDet for UAV Object Detection***
Iga Narendra Pramawijaya, Suryo Adhi Wibowo and Koredianto Usman (Telkom University, Indonesia)

3D: Parallel Session 3-D

Room: Zoom D (Online)

3:30 ***Texture-Based Covid-19 Images Detection System using Haar Wavelet Transformation Algorithm***
Yessi Jusman, Dimas wildan Mubarok and Widyasmoro Widyasmoro (Universitas Muhammadiyah Yogyakarta, Indonesia); Siti Nurul Aqmariah Mohd Kanafiah (Universiti Malaysia Perlis, Malaysia)

3:45 ***Query by Humming Music Information Retrieval using DNN-LSTM based Melody Extraction and Noise Filtration***
Andreas Novian Dwi Triastanto and Rila Mandala (Institut Teknologi Bandung, Indonesia)

4:00 ***Classification of gram-positive and gram-negative bacterial images based on machine learning algorithm***
Son Ali Akbar (Universitas Ahmad Dahlan, Indonesia); Kamarul Hawari Ghazali (Universiti Malaysia Pahang & Vision and Intelligent System Research Group, Malaysia); Doni Subekti (Universitas Ahmad Dahlan, Indonesia); Anton Yudhana (Ahmad Dahlan University, Indonesia); Liya Yusrina Sabila

(Universitas Ahmad Dahlan, Indonesia); Wahyu Sapto Aji (Ahmad Dahlan University, Indonesia); Habsah Hasan (Universiti Sains Malaysia, Malaysia)

4:15 ***Glucose content analysis using image processing and machine learning techniques***
Anton Yudhana (Ahmad Dahlan University, Indonesia); Son Ali Akbar and Andrio Farezi (Universitas Ahmad Dahlan, Indonesia); Kamarul Hawari Ghazali (Universiti Malaysia Pahang & Vision and Intelligent System Research Group, Malaysia); Phisca Aditya Rosyady (Universitas Ahmad Dahlan, Indonesia)

3E: Parallel Session 3-E

Room: Zoom E (Online)

Wednesday, August 24 4:30 - 5:00 (Asia/Jakarta)

Closing Ceremony: Awarding + Closing Ceremony, and Another Announcement

Rooms: room a (offline), Room B (Offline), Zoom A (Online), Zoom B (Online), zoom c (online), Zoom D (Online), Zoom E (Online), zoom f (online)

Closing Ceremony Awarding Best Paper

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D

3 5 A B C D E F G H I K L M N O P Q R S T U

E

3 5 A B C D E F G H I K L M N O P Q R S T U

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3 5 A B C D E F G H I K L M N O P Q R S T U

U

3 5 A B C D E F G H I K L M N O P Q R S T U

Kinematics Modeling and Motions Analysis of Non-holonomic Mobile Robot

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***Abstract*—A study on kinematics modeling of non-holonomic mobile robot and the motion analysis is presented. The robot is a four-wheeled robot with two active wheels and two passive wheels. Each active wheel is driven by an independent DC motor. The robot has two degrees of freedom (2-DOF) of motions including translation and rotation. Kinematics modeling is carried out to obtain a mathematics model representing the robot motions. The resulted model is verified through analyzing the robot motion using calculus of parametric equations. A computer program is built based on the model for numeric simulation and visualization of the robot motions. Executing the program resulted in numerical data of the robot motion that was confirmed by an animation of the robot movement. The numerical data includes the position, orientation, linear and angular velocities of the robot, and the corresponding DC motors speed.**

***Index Terms*—Non-holonomic robot, kinematics modeling, motion analysis, simulation.**

I. Introduction

Mobile robots are a type of robots that can move the whole body from one location to another location. The mobile robots are also known as the unmanned vehicles. Based on the operating area, mobile robots can be classified into four types: aerial mobile robot [1]–[3], water-surface mobile robot [4]–[6], underwater mobile robot [7]–[9], and ground mobile robot [10]–[12]. The mobile robots have been one of the hot research topics since the last three decades [13]. However, the mobile robots are still remaining many research challenges [14]–[16]. The challenges are driven by a high demand of applying mobile robots in many different fields, such as military, industries, logistic, medical, and transportation. The demand needs to be met by developing more advanced robots. Several aspects have been considered in the robot development, such as frame design, kinematics and dynamics modeling, motion analysis, control, navigation, implementation, and applications.

Recently, the developments of mobile robots have a trend toward autonomous mobile robots or autonomous vehicles. The autonomous vehicle is an intelligent vehicle that is able to control and navigate itself for moving automatically from a departure point to a desired destination point safely. Basically, the autonomous vehicle is built to have three basic capabilities [17]: 1) sensing and perception, 2) planning, and 3) control. The sensing and perceptron are to recognize the current location and environment around the robot. This recognition is done by collecting data through measurement using navigation sensors. The planning is to determine a path that the robot should follow to reach the destination. This path is usually obtained through optimization to produce the optimal path among the available path choices. The control is to obtain the best strategy for steering the vehicle such that move precisely on the determined path and arrive at the destination safely. The strategy is obtained through applying the available control theories.

Basically, the ground mobile robots are able to move on the ground due to locomotion tools such as wheels or legs. The ground mobile robots using leg locomotion are usually developed for humanoid robots or imitating-animal robots. Meanwhile, the ground mobile robots using wheel locomotion or shortly called as the wheeled robots are similar to the common ground vehicles, such as cars, military tanks, trains, motorcycles, and others. Based on the number of wheels, there are several types of wheeled robots, such as: one-wheeled robot [18]–[20], two-wheeled robot [21]–[23], three-wheeled robot [24]–[26], four-wheeled robot [27]–[29], and other robots with more wheels. The four-wheeled robot (FWR) is a type of ground mobile robot that is quite popular robotic studies [30]–[32]. The FWR has four wheels, where the wheels have two functions: support the robot's body and/or drive the robot movements. The wheel that only supports the robot's body is known as a passive wheel, while the wheel that also drives the robot's movement is known as an active wheel. The active wheel is able to drive the movement as it is connected to a force generator component, such as an electric motor. The FWR can have either two active wheels or four active wheels. An FWR with two active wheels is known as the two wheel drive FWR, and if each active wheel moves independently then the robot is known as a two wheel differential drive FWR, the same mention applies for the FWR with four active wheels.

Let us assume a FWR is on a flat ground surface. This flat surface is a two dimensional space and also known as the planar space. Ideally, an object in planar space can move with three degrees of freedom (3-DoF) of motion that include: 1) forward and backward motions, 2) left and right side motions, and 3) right and left turns. We can find this while playing

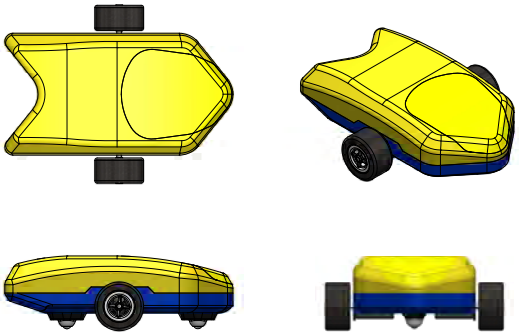

Fig. 1: A design of four-wheeled robot.

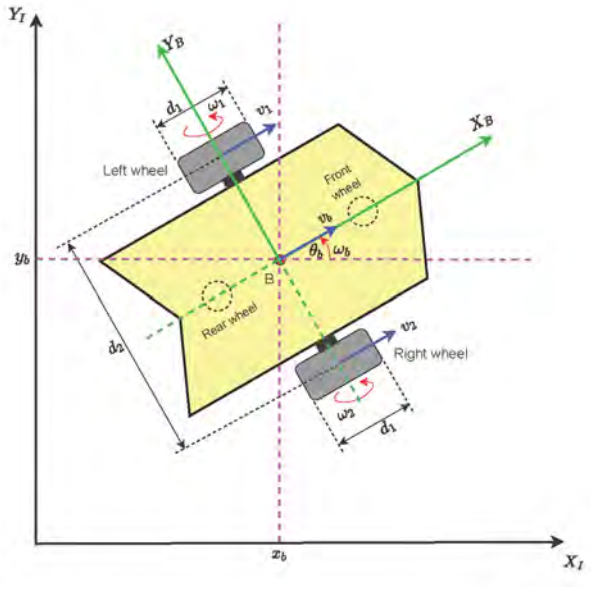

Fig. 2: A four-wheeled robot on the planar space.

football, but not while driving a car. A car that is not able to perform a side movement such that it has only 2-DoF of motion. The reason is that the car's wheels rotate at one axis only. Similar to the car, the FWR using conventional wheels with a single rotational axis has 2-DoF of motion. The FWR is being a system that has controllable DoF less then the total DoF. Such kind of this system is known as a non-holonomic system, where controlling the system is quite challenge [33]–[35]. The FWR can have 3-DoF if the robot utilizes unconventional wheels such as Swedish wheels. The Swedish wheel is an ideal wheel, but it is not practical in real applications. Most of the robots using the Swedish wheels are developed for a small scale application or academic research purpose [36]–[38] .

This study has a long-term goal to develop an autonomous mobile robot for real life application. A two wheel differential drive FWR with conventional wheels is of interest to be the platform. Since FWR is a non-holonomic system and controlling the robot's movement is a challenge. Prior to work in the control development, this study presents kinematics modeling and motion analysis of the robot. Kinematics modeling is to obtain mathematics model representing the robot motions. After the model was obtained, it is the verified through analysing the robot motion by applying the calculus of parametric function method. Based on the verified model, a computer program is built to demonstrate the robot motion in computer simulation. Presentation of the paper is organized as follows. Section I provide an introduction of the work. Section II presents a design of FWR, kinematics modelling, and motion analysis. Numerical simulations and the results are presented in Section III and followed by discussion. Finally, conclusion of the work is presented in Section IV.

II. Kinematics Modelling and Motion Analysis

Figure 1 shows a design of FWR that is being a platform for developing an autonomous mobile robot. The robot has two active wheels and two passive wheels. Both active wheels are located on the left and right sides of the center robot body. These active wheels are conventional wheels driven by two independent DC motors. Therefore, the designed FWR is a two-wheel differential drive FWR type. Rotational axis of both active wheels are inline and passing through the center point of the robot body. This center point is also the location of the robot's center of gravity. On another hand, both passive wheels are located at the front and rear of the robot body. Both passive wheels are located at the longitudinal-symmetric axis of the robot body and passing through the robot's center of gravity. The passive wheels are using the ball-caster wheel type, that has 3 DoF of motions. However, since the active wheels are using the conventional wheel, the designed FWR has only 3 DoF of motion and it is therefore a non-holonomic system.

A. Kinematic Model

Kinematics is a branch of mechanics that studies the motion of a body without considering the inertial force, inertia, and energy of the body. Kinematics of an object is represented by a kinematics model that consists of mathematics equations describing position, velocity, and acceleration of the object [39]. In robotics studies, a kinematics model of the robot is required to obtain a mathematics model representing the robot motions. This model can be used in many different purpose, such as motion analysis and control design of the robot.

The FWR can be represented are a two dimensional system on planar space as shown in Figure 2. It is assumed that the center of the robot body is also located at the robot's center of mass which is shown by the point B in the Figure 2. Each active wheel is driven by a DC motor. Rotations of the active wheels push the robot to move linearly and/or rotate. While both active wheels rotate at the same speed and direction, the robot moves linearly forward or backward. This linear movement is represented by a linear velocity defined as follows:

$$v_b = \frac{d_1(\omega_2 + \omega_1)}{4}, \tag{1}$$

where v_b is the robot's linear velocity, ω_1 is the angular velocity if the left active wheel, ω_2 is the angular velocities of the right rear-wheels, d_1 is the active wheel diameter, and d_2 is the distance between center points of the active wheels. However, if both active wheels rotations are not equal in the rotational speed and direction, the robot makes angular movement with the angular velocity defined as follows:

$$\omega_b = \frac{d_1(\omega_2 - \omega_1)}{d_2}, \tag{2}$$

where ω_b is the robot's angular velocity. The equations (1) and (2) can be expressed in a matrix equation as follows:

$$\begin{bmatrix} v_b \\ \omega_b \end{bmatrix} = \begin{bmatrix} \frac{d_1}{4} & \frac{d_1}{4} \\ \frac{-d_1}{d_2} & \frac{d_1}{d_2} \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \end{bmatrix} \tag{3}$$

or simply expressed by:

$$u_b = S_b u_\omega \tag{4}$$

where

$$u_b = \begin{bmatrix} v_b \\ \omega_b \end{bmatrix}, S_b = \begin{bmatrix} \frac{d_1}{4} & \frac{d_1}{4} \\ \frac{-d_1}{d_2} & \frac{d_1}{d_2} \end{bmatrix}, u_\omega = \begin{bmatrix} \omega_1 \\ \omega_2 \end{bmatrix}.$$

In order to show the robot's velocities, define a coordinate system $O_B X_B Y_B$ as the body coordinate system, where the origin O_B is located at the robot's center of mass, the point B. The X_B axis is inline to the robot forward moving direction, and a Y_B axis inline to the robot side moving direction to the left as shown in the Figure 2. This body coordinate system sticks on the robot body and moves along the robot movements. Since the body coordinate system is moving, another coordinate system that is fixed and independent of the robot's motion is required to determine the robot's position and orientation. Therefore, a fixed coordinate system $O_I X_I Y_I$ is introduced as shown in the Figure 2. The $O_I X_I Y_I$ is known as the inertial coordinate system.

The position and orientation of FWR can be calculated based on both coordinate systems. The robot position is defined as the position of the robot's center of mass with respect to the inertial coordinate $O_I X_I Y_I$ and denoted by (x_b, y_b). The robot orientation is defined as the deviation angle of the $O_B X_B Y_B$ with respect to the $O_I X_I Y_I$ and denoted by θ_b, which is also known as the heading angle. The position and orientation of the robot is called as the robot posture which can be defined by the following vector:

$$p_b = \begin{bmatrix} x_b \\ y_b \\ \theta_b \end{bmatrix} \tag{5}$$

where p_b is the robot posture. Changes in the robot posture indicate the movement of the robot. Therefore, the robot motions can be represented by the time derivative of the robot posture and given as follows:

$$\dot{x}_b = v_b \cos\theta_b \tag{6}$$
$$\dot{y}_b = v_b \sin\theta_b \tag{7}$$
$$\dot{\theta}_b = \omega_b, \tag{8}$$

where $\dot{x}_b$ and $\dot{y}_b$ are the robot's linear velocity along X_I and Y_I axis, respectively, and $\dot{\theta}_b$ is the angular velocity of the robot.

B. Motions Analysis Based on Calculus of Parametric Function

The mobile robot moves on paths on the ground surface. In this study, it is assumed that the robot moves on a path with the same elevation such that the path can be represented in a two dimensional space. In this space, an inertial coordinate system $OX_I Y_I$ is defined as the reference for determining the robot posture. The position of robot is expressed by coordinate (x_b, y_b) in the inertial coordinate system. For a moving robot, the position is a function of time such that it can be represented as follows:

$$x_b = g(t) \tag{9}$$
$$y_b = h(t), \tag{10}$$

where $g(t)$ and $h(t)$ represents the robot position along X_I and Y_I, respectively, with respect to time. The equations (9) (10) are known as the parametric equation. The parametric equation is one of the interesting topics in Calculus that is very useful for analyzing motion of a moving object [40].

By using the concept of Calculus, the linear velocity of the robot along X_I and Y_I axis are defined as follows, respectively:

$$\dot{x}_b = \frac{dg(t)}{dt} \tag{11}$$
$$\dot{y}_b = \frac{dh(t)}{dt}, \tag{12}$$

where the $\dot{x}_b$ and $\dot{y}_b$ are the projection of the robot's linear velocity along the X_I and Y_I axis. The robot's linear velocity can be expressed in vector form with respect to the inertial coordinate system as follows:

$$\vec{v}_b = \dot{x}_b \hat{i}_0 + \dot{y}_b \hat{j}_0 \tag{13}$$

where the $\hat{i}_0$ and $\hat{j}_0$ are the unit vectors along the X_I and Y_I axis, respectively. The linear velocity value and orientation of the robot can be obtained by calculating the magnitude and direction of the velocity (13) as follows:

$$v_b = \sqrt{(\dot{x}_b)^2 + (\dot{y}_b)^2} \tag{14}$$
$$\theta_b = \tan^{-1}\left(\frac{\dot{y}_b}{\dot{x}_b}\right). \tag{15}$$

The angular velocity of the robot can be obtained by differentiating (15) with respect to the time as defined in (8). The travel distance of the robot at time t is obtained by integrating the velocity and given as follows:

$$L(t) = \int_0^t \sqrt{(\dot{x}_b)^2 + (\dot{y}_b)^2}\, dt \tag{16}$$

where L is the travel distance.

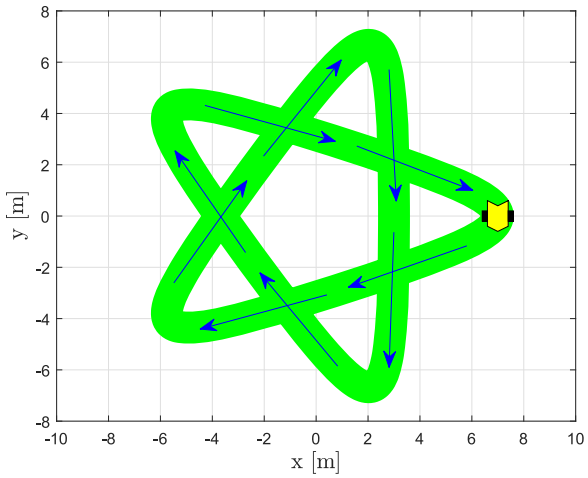

Fig. 3: Route for the mobile robot where the arrows show the moving direction.

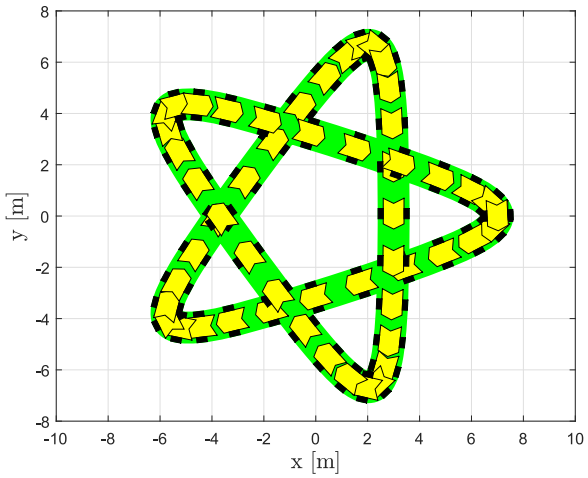

Fig. 4: Simulation of the robot to move for one cycle of the route takes 108 seconds.

III. Simulation and Result

Numerical simulation are carried out to demonstrate the robot motions. The simulation scenario is given as follows. The robot is initially at idle position and located at the coordinate $(7, 0)$ with orientation $270°$. The initial posture of the robot can be defined as follows:

$$p_b(0) = \begin{bmatrix} x_b(0) \\ y_b(0) \\ \theta_b(0) \end{bmatrix} = \begin{bmatrix} 7 \\ 0 \\ 270° \end{bmatrix}, \tag{17}$$

where $p_b(0)$ is the initial posture. The robot is going to move on a path represented by the following parametric functions:

$$x(\alpha) = 2\cos\alpha + 5\cos\left(\frac{2}{3}\alpha\right) \tag{18}$$

$$y(\alpha) = 2\sin\alpha - 5\sin\left(\frac{2}{3}\alpha\right), \tag{19}$$

where x and y represent the path location in the inertia coordinate system. Both x and y are functions of parameter α, which is an independent parameter. The α has a range of $\alpha = [0, 6\pi]$ in this simulation. Plotting the values of x versus y for the whole values of α results in a green closed-curve shown in Figure 3. This curve is representing the path that will be passed by the robot.

The Figure 3 also shows the initial posture of the robot and moving direction on the path. The robot is represented by a robot icon which is the yellow object with a back wheel on the right and left sides. The blue arrows in the figure show the moving directions in the path. The robot is simulated to move on a cycle path. Simulation for a longer time will result in moving on the same path. Therefore, the robot-movement is demonstrated by simulating for one cycle. Define the variable t as the simulation time and assuming that it has linear relation to the parameter α as follows:

$$\alpha = kt, \tag{20}$$

where k is a constant. Substituting (20) into (18) and (19) results in the following equations:

$$x(t) = 2\cos(kt) + 5\cos\left(\frac{2}{3}kt\right) \tag{21}$$

$$y(t) = 2\sin(kt) - 5\sin\left(\frac{2}{3}kt\right). \tag{22}$$

Assuming that the robot has an ideal controller such that the robot is able to move and reach the position which is exactly at the same as the position on the path according to the simulation time,

$$x_b(t) = x(t) \tag{23}$$

$$y_b(t) = y(t). \tag{24}$$

Using that assumption, the robot position during the simulation can be expressed as follows:

$$x_b(t) = 2\cos(kt) + 5\cos\left(\frac{2}{3}kt\right) \tag{25}$$

$$y_b(t) = 2\sin(kt) - 5\sin\left(\frac{2}{3}kt\right), \tag{26}$$

where $x_b(t)$ and $y_b(t)$ represent the robot's position at simulation time t with respect to the inertia coordinate system.

For this simulation, define that the robot requires 108 seconds to move a completed cycle of the path such that the constant k can be calculated as follows:

$$k = \frac{6\pi}{108}, \tag{27}$$

where 6π is the value of α for one cycle and 108 is the simulation time for completing one cycle. The simulation is carried out and the result is shown in Figure 4. The robot moved exactly on the defined path with the correct orientation at each position. Postures of the robot are displayed every 2 seconds such that 54 different postures of the robot are shown

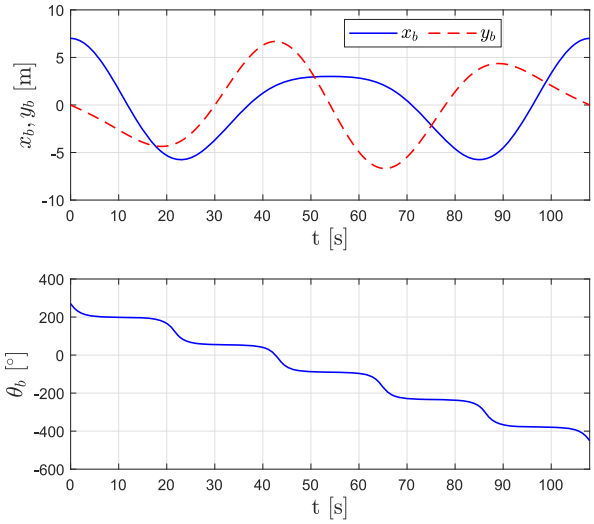

Fig. 5: The position and orientation of the robot versus the time resulted in the simulation of robot movement for completing one cycle of the route.

in the figure. The Figure 4 shows that the distances between the robots at the time interval are not equal. The robots are shown rarely at the straight track, but denser at the turning track. This indicates that the robot's velocities are varying, where the longer distances implicate the higher linear velocities of the robot.

Figures 5 shows the robot posture, including the robot position x_b and y_b and the robot orientation θ_b. At $t = 0$, the robot position is $(7, 0)$ and orientation $270°$ that describes the initial robot posture. After the simulation began, the posture changed as shown by variations on the position and orientation values. The graph of robot orientation includes some flat curves and descending curves periodically. The flat curve of $\theta_b(t)$ shows a constant orientation angle that indicates a straight line movement. The descending curve of $\theta_b(t)$ shows a decreasing orientation angle that indicates a left turn movement. For an example, let consider the $\theta_b(t)$ at the beginning of simulation, $t = 0$ to $t = 15$ seconds. The orientation angle decreased significantly from $\theta_b = 270°$ to $\theta_b = 200°$ at $t = 0$ to $t = 5$ seconds. This indicates the robot was turning left. After that, at $t = 5$ to $t = 15$ seconds, the orientation angle did not change significantly and almost constant that indicates the robot moved in almost straight line. These movements are visualized in the Figure 4, where the robot turned left after the departure and moved on a slightly straight track before made the next left turning.

Figures 6 show the robot's velocities, including linear and angular velocities, and angular velocities of the active wheels. It was mentioned that the robot made a small forward movement and large left-turn immediately after the simulation starts. This is confirmed by Figures 6 where the robot had linear velocity $1.34\ m/s$ and angular velocity -31.63 $°/s$ at

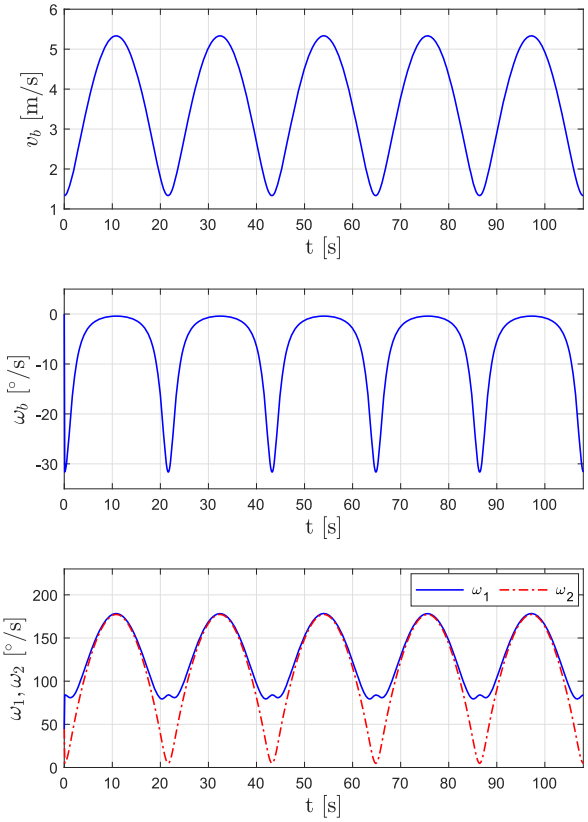

Fig. 6: The linear and angular velocities of the robot and the angular velocity of the active wheels versus the time resulted in the simulation of robot movement for completing one cycle of the route.

the beginning of simulation. The Figures 6 exhibits the robot's velocities changed periodically with time period 21.6 seconds. An example of the velocities change cycle is shown in the simulation result at 0 to 21.6 seconds. Both linear velocity and turning rate of the robot increased at 0 to 10.8 seconds and then decreased at 10.8 to 21.8 seconds. The robot reached the maximum linear velocity 5.33 m/s at 10.8 second where the robot was moving turning rate $-0.42°/s$ at that time. The turning rate $-0.42°$ was being the smallest of the turning rate magnitude in the simulation.

IV. Conclusion

Kinematics modeling of a four-wheeled mobile robot has been presented. The robot is a non-holonomic robot as it can only move in two DOF of motions instead of three on the ground. The movements include translation and rotation. The kinematics model resulted in mathematics equations representing the robot motions. The robot motions were numerically analyzed using the calculus of parametric equations. This resulted in numerical data of the robot motions. Computer

simulation presented a demonstration of the robot motions based on the kinematics model and numerical data. The simulation results confirmed the robot motions based on the kinematics model and numerical data were matched.

This study was done by assuming that the robot had an ideal controller to reach any desired position at a certain time. Obtaining the ideal controller is a remaining work. The ideal controller may not exist, but can be approached by a controller with sufficient performance. Designing such kind of controller is taken into account as a continuation of this study.

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