CENIM 2022

CONFERENCE PROCEEDINGS

INTERNATIONAL CONFERENCE ON COMPUTER ENGINEERING, NETWORK AND INTELLIGENT MULTIMEDIA 2022

CENIM 2022

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Proceeding
of
The International Conference on Computer Engineering, Network and Intelligent Multimedia (CENIM)

CENIM 2022

November 22th – 23th, 2022
Surabaya, Indonesia

MESSAGE FROM THE GENERAL CHAIR

Dear all,

Welcome to the 2020 International Conference on Computer Engineering, Network, and Intelligent Multimedia (CENIM 2022). We thank all TPC members and associates who helped process and review the manuscript submitted to CENIM 2022.

This year's conference theme is "Technological Trends Shaping The Post-Pandemic Future Of Humanity", which was chosen due to uncertain conditions after the pandemic. The conference has been approved by IEEE, IEEE Indonesia, and IEEE-IES Indonesia for technical co-sponsorship. We received around 140 manuscripts and after a careful review of the manuscript, we accepted 70 manuscripts that will present their works at the main conference event.

The conference is held in a hybrid mode which accommodates more large audiences around the world. The presenter can choose whether present their work via zoom or offline at the ITS campus.

We would like to thank all of the remarkable four keynote speakers, Prof. Amagasaki from Kumamoto University Japan, Prof. Pitoyo from Chukyo University Japan, Prof. Erma Suryani, and Dr Norma Hermawan from ITS, for joining our conference event. We also thank all colleagues at the Dept. of Computer Engineering-ITS for their support of the CENIM 2022 conference.

Lastly, we hope that you can have a great time at the conference.

Reza Fuad Rachmadi
General Chair of CENIM 2022

MESSAGE FROM HEAD OF COMPUTER ENGINEERING DEPARTMENT ITS

Distinguished guests and keynote speakers, colleagues and all participants,

It is a pleasure to welcome you all to the hybrid event of the 2022 International Conference on Computer Engineering, Networks and Intelligent Multimedia, CENIM.

Due to the ongoing Covid-19 pandemic, the CENIM organizing committee decided to use a hybrid platform. Although most presenters still use virtual sessions, I hope this networking and collaboration can be established and maintained even better.

Ladies and gentlemen, the vision of ITS 2020-2030 is to become a world-class university that contributes to the independence of the nation and becomes a reference in education, research and community service as well as the development of innovation, especially in the supporting and maritime industries. One of the concrete stages of this vision is the development of innovation and the creation of innovative science and technology products. To achieve this, ITS has 10 research centers, 4 innovation centers, and 5 community research centers, as well as many innovation research laboratories in the Department.

Ladies and gentlemen, through this conference, I hope that you will not only have the opportunity to see ideas and findings from other researchers, but also to get to know ITS better. We have many cooperation programs for partners in Indonesia or abroad, we have started an international undergraduate program last year and will launch a master by research program this year.

Finally, I wish the CENIM 2022 conference a great success. I wish you all the best.

Thank you

Dr. Supeno Mardi Susiki Nugroho

Departement Head of Computer Engineering – ITS

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Eko Yuniarno	Institut Teknologi Sepuluh November
Ahmad Zaini	Institut Teknologi Sepuluh Nopember

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KEYNOTE LECTURES

KEYNOTE LECTURE

Introduction to synthesizable eFPGA

Prof. Motoki Amagasaki
Kumamoto University

"Introduction to synthesizable eFPGA"

Providing optimized hardware acceleration for specific applications, from edge devices to cloud servers, has become an important approach to improving the efficiency of computing systems. Traditionally, many systems employ commercial field-programmable gate arrays (FPGAs) to implement dedicated hardware accelerators as co-processors for CPUs. However, since commercial FPGAs are designed with a general-purpose architecture and provided in the form of discrete chips, it is difficult to provide reconfigurable hardware resources for specific applications efficiently or to embed them in customers' SoCs as IP-cores. In this talk, I introduce an eFPGA generation suite with a customizable architecture and integrated development environment (IDE) that covers eFPGA design generation, testing, and utilization. eFPGA design generation uses an IP generation flow to explore the optimal logic cell, routing, and array structures for target applications. For testability, we have already proposed a shipping test method that detects stuck-at failures of the entire eFPGA with 100% accuracy. Furthermore, based on the NODE-RED development framework, we propose a user-friendly and customizable web-based IDE framework for the generated eFPGAs. An evaluation of the eFPGA prototype with a 55nm test element group chip design is shown.

KEYNOTE LECTURE

The Role of Information and Communication Technology (ICT)
In Smart City

Prof. Erma Suryani
Institut Teknologi Sepuluh Nopember

"The Role of Information and Communication Technology (ICT) In Smart City"

Internet of Things (IoT), 5G networks, big data, AI, and robots are the enabler technologies of Society 5.0. This technology helps create a forward-looking society that overcomes the limitations of humans, society, and existing systems.

Along with economic development by providing high-tech products and services, society is equally focused on solutions to address social problems such as increasing demand for energy and foodstuffs, safety and security, climate change, an aging population, and economy disparity. A mechanism has been established to implement Smart Society that enable the world to promote economic development while addressing common social challenges. In cyberspace, big data is analyzed by Artificial Intelligence (AI), and the results will be returned to the physical area for use by the community. Indonesia needs to continue developing digital infrastructure, making policies and regulations that encourage efficient and progressive industrial growth.

Becoming a smart city requires a comprehensive plan at the city level and a large amount of support from the wider community. Some important steps to develop a smart city, which include: 1) determine the immediate need, 2)define smart community, 3)identify business models, 4)perform a gap analysis , 5) determine financing and budget, 6)identify and group existing assets that are readily scalable to city-wide use, 7)develop and implement pilot projects. Some of the challenges in smart city are as follows:

KEYNOTE LECTURE

Tissue Elasticity Imaging Technology: Trends and Current Development with A Commercial Ultrasound Machine

Prof. Norma Hermawan
Institut Teknologi Sepuluh Nopember

"Tissue Elasticity Imaging Technology: Trends and Current Development with A Commercial Ultrasound Machine"

Imaging tissue elasticity has been evolved for recent decades. The health state of human organs is often related to tissue elasticity and various techniques are used to image this biomechanical property, namely Vibrational sono-elastography, Acoustic Radiation Force Impulse (ARFI), and the color doppler imaging. It is commonly known that many diseases are associated with a distinct elasticity. Some research suggests using measurement method which requires a special device with a very fast imaging capability. Therefore, development of a novel elastography method that can be implemented in a common commercial machine is a quite important. There are numerous methods to assess tissue elasticity, such as by measuring attenuation and velocity of shear wave propagation as in vibrational sono-elastography and color Doppler elastography respectively. This keynote speech highlighted the fundamental principles, the developments of different categories of elastographic imaging and presents recent method of elasticity imaging by using a commercial ultrasound machine.

KEYNOTE LECTURE

Topics on Machine Learning for Adaptive Robotics and Smart Interface

Prof. Pitoyo Peter Hartono
Chukyo University

“Topics on Machine Learning for Adaptive Robotics and Smart Interface”

Over the past few years, robots have been utilized not only in industrial settings but also in various environments, such as disaster-stricken areas, hospitals, airports, hotels, and entertainment facilities. Shortly robots will have much more important roles in space explorations and our homes. While in their traditional usages in industry robots’ moving policies are hand-designed by humans, in their new environments it will be prohibitively difficult to do the same due to the environment's complexity and dynamical nature. One way to alleviate the problem of designing robots’ policies is by implementing learning mechanisms that allow the robots to autonomously adapt their policies through their interactions with the environment. Over the past decades, a vast collection of machine learning for training physical robots has been proposed.

In this talk, some recent machine learning mechanisms will be reviewed. A new model of topological neural network that allows not only traditional training for robots but also intuitive interpretations of the acquired policy will be explained. The explainability of the neural network is an important factor in increasing the accountability of autonomous robots and thus allows their deployment in more safety-concerned situations. The neural network also allows a novel transfer learning where human common-sensical prior knowledge can be transferred prior to the learning process of the robots. The transferability will not only alleviate the learning difficulty for the robots but also potentially allow new human-robot relations. This talk will also cover new development in smart interfaces for connecting humans and robots

GENERAL SCHEDULE

General Schedule, Day 1

Tuesday , 22nd November 2022

Time	Agenda	Venue
07:00 - 09:00	Registration	AJ201 / Online
09:00 - 09:10	Welcome Speech General Chairman CENIM 2022 Reza Fuad Rachmadi, Ph.D.	AJ201 / Online
09:10 - 09:20	Welcome Speech IEEE Indonesia Section Chair Prof. Gamantyo Hendrantoro	AJ201 / Online
09:20 - 09:30	Welcome Speech Dean of FTEIC-ITS Dr. I Ketut Eddy Purnama	AJ201 / Online
09:30 - 09:40	Welcome Speech Rector of Institut Teknologi Sepuluh Nopember Prof. Mochamad Ashari	AJ201 / Online
09:40 - 09:55	The Spouse Group of FTEIC-ITS Choir	AJ201 / Online
10:00 - 11:00	1st Keynote Speaker Prof. Motoki Amagasaki	AJ201 / Online
11:00 - 12:00	2nd Keynote Speaker Prof. Erma Suryani	AJ201 / Online
12:00 - 12:10	Best Paper Announcement	AJ201 / Online
12:10 - 13:00	Break, Lunch, and Pray	
13:00 - 15:00	Parallel Session I	AJ201 / Online
15:00 - 15:30	Coffe Break	
15:30 - 16:30	Parallel Session II	AJ201 / Online

- For paper presentations, please prepare the presentation file in the location 15 minutes before the scheduled time.

General Schedule, Day 2

Wednesday, 23rd November 2022

Time	Agenda	Venue
08:00 - 09:00	Registration	Online
09:00 - 10:00	3rd Keynote Speaker Prof. Norma Hermawan	Online
10:00 - 11:00	4th Keynote Speaker Prof. Pitoyo Peter Hartono	Online
11:00 - 13:00	Break, Lunch, and Pray	
13:00 - 15:00	Parallel Session I	Online
15:00 - 15:30	Coffe Break	
15:00 - 16:30	Parallel Session II	Online

- For paper presentations, please prepare the presentation file in the location 15 minutes before the scheduled time.

CENIM 2022: TECHNICAL SESSION SCHEDULE

Technical Session Schedule Day 1

2022-11-22

	Time		Room			
	Start	End	AJ201	Virtual 1	Virtual 2	Virtual 3
SESSION 1 (2022-11-22)	13:00	13:15	IS-AI-1	AI-1	BIO-1-1	REC-NLP-1-1
	13:15	13:30	IS-AI-2	AI-2	BIO-1-2	REC-NLP-1-2
	13:30	13:45	IS-AI-3	AI-3	BIO-1-3	REC-NLP-1-3
	13:45	14:00	IS-AI-4	AI-4	BIO-1-4	REC-NLP-1-4
	14:00	14:15	IS-AI-5	AI-5	BIO-1-5	REC-NLP-1-5
	14:15	14:30	IS-AI-6	AI-6		
	14:30	14:45	IS-AI-7	AI-7		
	14:45	15:00	IS-AI-8	AI-8		
	15:00	15:30	Break			
	15:30	15:45	IS-AI-9		BIO-2-1	RBT-IOT-1-1
	15:45	16:00	GT-VI-1		BIO-2-2	RBT-IOT-1-2
	16:00	16:15	GT-VI-2		BIO-2-3	RBT-IOT-1-3
	16:15	16:30	GT-VI-3		BIO-2-4	RBT-IOT-1-4
	16:30	16:45			BIO-2-5	RBT-IOT-1-5

Technical Session Schedule Day 2

2022-11-23

	Time		Room			
	Start	End	Virtual 1	Virtual 2	Virtual 3	Virtual 4
SESSION 2 (2022-11-23)	13:00	13:15	AI-2-1	IS-1	PWR-1-1	NET-1-1
	13:15	13:30	AI-2-2	IS-2	PWR-1-2	NET-1-2
	13:30	13:45	AI-2-3	IS-3	PWR-1-3	NET-1-3
	13:45	14:00	AI-2-4	IS-4	PWR-1-4	NET-1-4
	14:00	14:15	AI-2-5	IS-5	PWR-1-5	NET-1-5
	14:15	14:30	AI-2-6	IS-6	PWR-1-6	NET-1-6
	14:30	14:45	AI-2-7		PWR-1-7	NET-1-7
	14:45	15:00	AI-2-8			NET-1-8
	15:00	15:30	Break			
	15:30	15:45				
	15:45	16:00				
	16:00	16:15				
	16:15	16:30				
	16:30	16:45				

SESSION 1 – Track: Information System & Artificial Intelligence

IS-AI 2022 – 11 – 22 AJ201

13:00 – 15:00

Code	Paper ID	Title	Authors
IS-AI-1	1570848380	Synthesis Ensemble Oversampling and Ensemble Tree-Based Machine Learning for Class Imbalance Problem in Breast Cancer Diagnosis	Mr. Slamet Sudaryanto Nurhendratno; Prof. Mauridhi Hery Purnomo; Dr. Diana Purwitasari; Mr. Eko Mulyanto Yuniarno
IS-AI-2	1570840867	An Embedded Computer Vision Method to Extract Percentage of Eye Close for Detecting Drowsiness of a Safety Driving System	Mr. Sukma Firdaus; Dr. Achmad Arifin; Mr. Norma Hermawan; Mr. Fatdiansyah Fatdiansyah
IS-AI-3	1570849500	Classifying Composition of Software Development Team Using Machine Learning Techniques	Mrs. Umi Laili Yuhana; Mrs. Umi Saadah; Ms. Chandra Kirana Jatu Indraswari; Dr. Siti Rochimah; Mr. Maulidan Bagus Afridian Rasyid
IS-AI-4	1570849533	Classification Anterior and Posterior of Knee osteoarthritis X-Ray images Grade KL-2 using Deep Learning with Random Brightness Augmentation	Mr. Supatman Supatman; Mr. Eko Mulyanto Yuniarno; Prof. Mauridhi Hery Purnomo
IS-AI-5	1570840382	Control System of Drain, Bypass, and Dialysate Fluid Conditioning Mechanisms in Ultrafiltration Processes in Hemodialysis Machines	Mr. Raide Firdaus; Dr. Achmad Arifin; Mr. Muhammad Hilman Fatoni; Mr. Tri Sardjono
IS-AI-6	1570840396	Blood Leakage Detection System in Hemodialysis Machine Filtration Process	Mr. Mohammad Damaringrat; Prof. Mohammad Nuh; Mr. Muhammad Hilman Fatoni; Mr. Tri Sardjono
IS-AI-7	1570840485	Development of Mechanism to Create Dialysate Liquid In Hemodialysis Machine	Mr. Gusfatul Mukhairiq; Mr. Tri Sardjono; Mr. Muhammad Hilman Fatoni
IS-AI-8	1570848172	Auto Thresholding Sputum Color Image Segmentation For Tuberculosis Diagnosis Base on Intuitionistic Fuzzy	Mrs. Sari Ayu Wulandari; Dr. I Ketut Pumama; Prof. Mauridhi Hery Purnomo
IS-AI-9	1570848313	Mechanism Development of Blood Pump and Syringe Pump in Hemodialysis Machine	Ms. Tharatya Kartika Sadhana; Mr. Tri Sardjono; Mr. Muhammad Hilman Fatoni

SESSION 1 – Track: Game Technology & Vision

GT-VI 2022 – 11 – 22 AJ201

15:30 – 16:30

Code	Paper ID	Title	Authors
GT-VI-1	1570840518	A Systematic Literature Review on Personalized Adaptive Gamification	Ms. Tri Puspa Rinjeni; Dr. Nur Aini Rakhmawati; Mrs. Reny Nadlifatin
GT-VI-2	1570848210	Dynamic Sound Effect Based on Distance of Interactive Object using Linear Interpolation Method in Unity3D	Mr. Firadi Surya Pramana; Mr. Eko Mulyanto Yuniarno; Mr. Supeno Mardi Susiki Nugroho; Mr. Yoyon Suprapto
GT-VI-3	1570849678	Multi-Person Key Points Detection For Abnormal Human Behavior Analysis Using Convlstm-Ae Model	Ms. Sofia Ariyani; Mr. Eko Mulyanto Yuniarno; Prof. Mauridhi Hery Purnomo

SESSION 1 – Track: Artificial Intelligence – 1

AI-1 2022 – 11 – 22 Virtual Room 1

13:00 – 15:00

Code	Paper ID	Title	Authors
AI-1-1	1570839117	Comparison of Semantic Segmentation Deep Learning Methods For Building Extraction	Ms. Anisa Aizatin; Mr. I Gusti Bagus Baskara Nugraha
AI-1-2	1570840042	Flight Delay Prediction for Mitigation of Airport Commercial Revenue Losses Using Machine Learning on Imbalanced Dataset	Mr. Rae Sugara; Dr. Diana Purwitasari
AI-1-3	1570840475	Autism Spectrum Disorder Detection in Children Using Fuzzy Detection Support System	Ms. Patricia Amanda; Dr. Achmad Arifin; Mrs. Nada Fitrieyatul Hikmah; Prof. Mohammad Nuh
AI-1-4	1570840630	Development of Knowledge Based Assistive Technology Using Robot to Enhance Cognitive Ability for Intellectual Disability	Ms. Arsy Huda Fathaniard; Dr. Achmad Arifin; Mr. Muhammad Hilman Fatoni; Prof. Mohammad Nuh
AI-1-5	1570840949	Design of Teleconsultation System with Artificial Intelligence Based Chatbot Using Docker Platform	Mr. Norma Hermawan; Mr. Atar Fuady Babgei; Ms. Salsanabilah Salsanabilah
AI-1-6	1570848339	Design of Fuzzy-PI Controller for Shoulder Exoskeleton with Motoric Progress of Rehabilitation Subject Consideration	Ms. Khansa Nur Habiba; Dr. Achmad Arifin; Mr. Atar Fuady Babgei; Mr. Andra Risciwan; Mr. Moh. Ismarintan Zazuli
AI-1-7	1570849258	Color and Texture Feature based for Maize Leaf Disease Identification	Dr. Indah Agustien Siradjuddin; Mr. Arif Riandika; Dr. Wahyudi Agustiono
AI-1-8	1570849396	Semantic Segmentation of Rice Leaf Blast Disease using Optimized U-Net	Mr. Oddy Virgantara Putra; Mr. Moch. Nasheh Annafii; Mrs. Triana Harmini; Mrs. Niken Trisnaningrum

SESSION 1 – Track: Biomedical Signal and Image Processing & Analysis – 1

BIO-1 2022 – 11 – 22 Virtual Room 2

13:00 – 15:00

Code	Paper ID	Title	Authors
BIO-1-1	1570840573	Wearable FES System For Multi-Joint Movement Restoration With Cycle-To-Cycle Control Method	Ms. Rifqy Nurul Ilmi; Dr. Achmad Arifin; Mr. Muhammad Hilman Fatoni; Prof. Mohammad Nuh
BIO-1-2	1570847648	Electronic Nose using Convolutional Neural Network to Determine Adulterated Honeys	Mr. Misbah Misbah; Dr. Muhammad Rivai; Dr. Fredy Kurniawan; Dr. Djoko Purwanto; Ms. Sheva Aulia; Mr. Tasripan Tasripan
BIO-1-3	1570848163	Non-Invasive Detection System for Blood Sugar, Cholesterol, Uric Acid, and Body Temperature Using MAX30105 and MLX90614 Sensors	Mr. Rahmat Noor Fauzi; Ms. Nadia Ristiani; Ms. Nur Saida; Mr. Helmy Yusuf Darmawan; Mr. Agung Sanubari; Mrs. Prihatin Oktivasari; Mrs. Rika Novita Wardhani; Ms. Riandini Riandini
BIO-1-4	1570848447	Design and Engineering of sEMG-Controlled Multi-Actuator Prosthesis For Disabled Wrist-Amputee	Mr. Fadhli I Hatta; Mr. Eko Suprayitno; Mr. Rachmad Setiawan
BIO-1-5	1570840495	A Detection System for Center of Pressure Change and Lower Extremity Kinematics During Pregnancy for Welfare Design Recommendation of Pregnant Women	Ms. Aminy Widinal Hartiningrum; Dr. Achmad Arifin

SESSION 1 – Track: Biomedical Signal and Image Processing & Analysis – 2

BIO-2 2022 – 11 – 22 Virtual Room 2

15:30 – 16:30

Code	Paper ID	Title	Authors
BIO-2-1	1570841181	Wrist Rehabilitation Using A 3D Mouse-Joystick Prototype Base Virtual Reality Game With Myoelectric Signal Evaluation System For Post-Stroke Patients	Ms. Ariezqa Farasyfa; Dr. Achmad Arifin; Mr. Eko Suprayitno
BIO-2-2	1570848174	Hematocrit Measurement to Determine Blood Viscosity Value and Blood Volume Changes During Hemodialysis	Ms. Grace Lamria Pakpahan; Mr. Rachmad Setiawan; Mrs. Nada Fitrieyatul Hikmah
BIO-2-3	1570848237	Automatic Measurement of Spinous Process Angle on Ultrasound Spinal Column Image	Ms. Gabriela Zurliana Said; Mr. Tri Sardjono; Mrs. Nada Fitrieyatul Hikmah
BIO-2-4	1570848256	Venous Chamber Pressure Control and Air Bubbles Detection in Hemodialysis Delivery System Based on Fuzzy Logic	Mr. Muhammad Hilman Fatoni; Ms. Firdausi Nuzula Alghozali; Mr. Rachmad Setiawan
BIO-2-5	1570848090	Blood Leak Detection System in Hemodialysis Due to Venous Needle Dislodgement	Ms. Zahrotus Syarifah; Mr. Tri Sardjono; Mr. Muhammad Hilman Fatoni

SESSION 1 – Track: Recommender System & NLP – 1

REC-NLP-1 2022 – 11 – 22 Virtual Room 3

13:00 – 15:00

Code	Paper ID	Title	Authors
REC-NLP-1-1	1570840093	Classifying News Based on Indonesian News Using LightGBM	Mr. Arif Ridho Lubis; Ms. Santi Prayudani; Ms. Yulia Fatmi; Mr. Okvi Nugroho
REC-NLP-1-2	1570844406	OOV Handling using Partial Lemma-Based Language Model in LF-MMI Based ASR for Bahasa Indonesia	Mr. Agung Santosa; Mr. Asril Jarin; Mr. Eko Mulyanto Yuniarno; Prof. Hammam Riza; Prof. Mauridhi Hery Purnomo
REC-NLP-1-3	1570848182	The Implementation of Hybrid Semantic Ontology-based Model on Movie Recommendation System	Dr. Noor Ifada; Ms. Evinda Widia Cahyaningrum; Mrs. Fika Hastarita Rachman
REC-NLP-1-4	1570840507	Evaluation of Multi-Sensor Gloves Development as an Assistive Interpreter for Indonesian Sign Language	Ms. Dwisainstia Aponno; Dr. Achmad Arifin; Mr. Muhammad Hilman Fatoni; Prof. Mohammad Nuh; Dr. Takashi Watanabe
REC-NLP-1-5	1570842026	A New Annotation System for Dynamic Web Pages Driven by NLP	Dr. Mohammad Smadi; Dr. Mohammad Hawash; Dr. Omar Daqqa; Dr. Amjad W Hawash; Dr. Ahmed Awad

SESSION 1 – Track: Robotics - IoT and Smart City – 1

RBT-IOT-1 2022 – 11 – 22 Virtual Room 3

15:30 – 16:30

Code	Paper ID	Title	Authors
RBT-IOT-1-1	1570848144	Control Design of Quadcopter using Linear Quadratic Gaussian (LQG)	Prof. Mardlijah Mardlijah; Ms. Zahra Nur Alifah
RBT-IOT-1-2	1570848156	Control Design of Quadcopter using Output Feedback Control Pole Placement	Prof. Mardlijah Mardlijah; Ms. Dita Prihatini
RBT-IOT-1-3	1570839256	An IoT Garbage Monitoring System for Effective Garbage Management	Mr. Hanlin Cai; Mr. JiaQi Hu; Mr. Zheng Li; Dr. Wei Hong Lim; Dr. Mastaneh Mokayef; Dr. Chin Hong Wong
RBT-IOT-1-4	1570846942	Autonomous Surface Vehicle in Search and Rescue Process of Marine Casualty using Computer Vision Based Victims Detection	Mr. Achmad Zidan Akbar; Dr. Chastine Fatichah; Dr. Rudy Dikairono
RBT-IOT-1-5	1570848279	Detection of Dead Victims at Volcanic Disaster Location based on Drone and LoRa	Dr. Mochammad Zen Samsono Hadi; Mrs. Achmad Abie Dafa; Dr. Prima Kristalina

SESSION 2 – Track: Artificial Intelligence– 2

AI-2 2022 – 11 – 23 Virtual Room 1

13:00 – 16:30

Code	Paper ID	Title	Authors
AI-2-1	1570852990	Deep Learning Approach for Loneliness Identification from Speech using DNN-LSTM	Ms. Ririn Tri Rahayu; Mr. Eko Mulyanto Yuniarno; Mr. Derry Pramono Adi; Mr. Andreas Agung Kristanto
AI-2-2	1570840585	Inductive Graph Neural Network with Causal Sampling for IoT Network Intrusion Detection System	Mr. Satriawan Rasyid Purnama; Prof. Jazi Eko Istiyanto; Dr. Muhammad Alfian Amrizal; Mr. Vian Handika; Mr. Syafiqur Rochman; Dr. Andi Dharmawan
AI-2-3	1570840592	Balinese Carving Ornaments Classification Using InceptionResnetV2 Architecture	Mr. Made Windu Antara Kesiman; Mr. Kadek Teguh Dermawan; Mr. I Gede Mahendra Darmawiguna
AI-2-4	1570844000	Fuzzy logic in suggesting the appropriate university major for students according to their preferences	Ms. Aseel Abdalnabi; Mrs. Suhad Daraghmeh; Dr. Amjad W Hawash
AI-2-5	1570847876	Behavior NPC Prediction Using Deep Learning	Mr. Adnan Maulana; Mr. Supeno Mardi Susiki Nugroho; Mr. Eko Mulyanto Yuniarno; Mr. Yoyon Suprapto
AI-2-6	1570849491	Implementation of MTCNN Facial Feature Extraction on Sleepiness Scale Classification Using CNN	Mr. Adima Mahardika Putra; Mr. Ahmad Zaini; Mr. Eko Pramunanto; Mrs. Susi Juniastuti; Mr. Surya Sumpeno
AI-2-7	1570848980	Skincare Recommender System Using Neural Collaborative Filtering with Implicit Rating	Ms. Chaira Qalbyassalam; Dr. Reza Fuad Rachmadi; Mr. Arief Kurniawan
AI-2-8	1570849555	Mobile Device Facial Beauty Prediction using Convolutional Neural Network as Makeup Reference	Mr. Muhammad Luthfi; Dr. Reza Fuad Rachmadi; Dr. I Ketut Pumama; Mr. Supeno Mardi Susiki Nugroho

SESSION 2 – Track: Information System

IS 2022 – 11 – 23 Virtual Room 2

13:00 – 16:30

Code	Paper ID	Title	Authors
IS-1	1570839358	Exploring Backlinks Profile in Defining Metrics for Enhancing University Websites Visibility Ranking	Ms. Ika Nurkasanah; Mr. Radityo Wibowo; Mr. Rahmatsyam Lakoro; Mrs. Umi Laili Yuhana; Mr. M. Farrel Arrizal Kusuma; Mr. Muh. Ichlasul Amal; Ms. Siti Aminatus Zehroh; Ms. Aura Febriyanti Puspa Sari; Mrs. Nurina Azyyati Riski; Mr. Tommy Nuril Hudha
IS-2	1570843496	Social Farming Development to Improve Farming Desire and Profit: A System Thinking Approach	Ms. Erma Suryani; Mr. Rully Hendrawan; Ms. Ulfa Rahmawati; Ms. Ariani Dwi Wulandari; Mr. Damanhuri Damanhuri; Dr. Shuo-Yan Chou
IS-3	1570848039	Reliability Evaluation of Microservices and Monolithic Architectures	Dr. Agus Budi Raharjo; Mr. Putu Krisna Andyartha; Mr. William Handi Wijaya; Mr. Yudhi Purwananto; Dr. Diana Purwitasari; Mr. Nyoman Juniarta
IS-4	1570848149	Medical Information System As Supporting Tele-Rehabilitation Of Post Stroke Patients Using Website - Based Applications	Mr. Steven Martin Wijaya; Mr. Atar Fuady Babgei; Dr. Achmad Arifin
IS-5	1570849414	Identification of Conflicts in User Story Requirements Using the Clustering Algorithm	Ms. Ms Sarwosri; Mrs. Umi Laili Yuhana; Dr. Siti Rochimah
IS-6	1570847499	Acceptability of Internal and External Users Toward Industry 4.0 at Surabaya City Office for Population Administration and Civil Registration (COPACR)	Mr. Agus Imam Sonhaji; Dr. Maria Anityasari; Dr. Mahendrawathi ER

SESSION 2 – Track: Power System

PWR-1 2022 – 11 – 23 Virtual Room 3

13:00 – 16:30

Code	Paper ID	Title	Authors
PWR-1-1	1570831004	Charging Station Controller Design using Particle Swarm Optimization Algorithms for Electric Vehicles with NiMH Battery	Mrs. Nuh Enola; Mr. Eka Iskandar; Mr. Ali Fatoni; Dr. Ari Santoso
PWR-1-2	1570848124	Frequency Stability Analysis On Optimization Of Virtual Inertia Control (VIC) Capacitor Energy Storage (CES) Controller Settings Using Particle Swarm Optimization	Mrs. Alief Nur Aisyi Maulidhia; Dr. Dimas Anton Asfani; Dr. Ardyono Priyadi; Dr. Herlambang Setiadi
PWR-1-3	1570848303	Frequency Stability Analysis on Optimization of Virtual Inertia Controller Settings Based on Retired Electric Vehicles Battery Using Firefly Algorithm	Ms. Baity Nuris Syifa; Dr. Dimas Anton Asfani; Dr. Ardyono Priyadi; Dr. Herlambang Setiadi
PWR-1-4	1570852995	Optimal Setting of Overcurrent Relay on Industrial Power System Using Particle Swarm Optimization	Ms. Miftakhul Fauzia Hakim; Mr. Margo Pujiantara; Dr. Vita Lystianingrum
PWR-1-5	1570839630	Control of Temperature in Biodiesel Water Removal System	Mr. Hafizh Ghazidin; Mr. Kristianto Adi Widiatmoko; Mr. Fairuz Milkiy Kuswa; Mr. Romelan Romelan; Mrs. Maharani Dewi Solikhah
PWR-1-6	1570840519	A Novel Ranked Emission-Factor Retrieval for Emission Calculation	Mr. Sathees Paskaran; Mrs. Anjalie Gamage; Ms. Sanjeevi Sashikala Chandrasiri
PWR-1-7	1570848414	Convolution Neural Network (CNN) Architectures Analysis for Photovoltaic (PV) Module Defect Images Classification	Dr. Shahrani Shahbudin; Dr. Murizah Kassim; Ms. Kama Azura Othman

SESSION 2 – Track: Computer and Communication Networks

NET-1 2022 – 11 – 23 Virtual Room 4

13:00 – 16:30

Code	Paper ID	Title	Authors
NET-1-1	1570839999	Simulation-Based Evaluation of THz and VLC Access Links in Tropical Rain Regions	Mr. Muhammad Idris Romadly; Prof. Gamantyo Hendrantoro; Dr. Achmad Mauludiyanto
NET-1-2	1570840020	Modification of CPW Antenna Using Various Slot Shapes for Wireless Communication System	Mr. Nurul Fahmi Arief Hakim; Mrs. Silmi ath thahirah al Azhima; Mrs. Mariya Al Qibtiya; Ms. Hafizha Silmi Nur Rahkmi
NET-1-3	1570840218	Analyzing The Effect of Network Traffic Segmentation on The Accuracy of Botnet Activity Detection	Mr. Muhammad Aidiel Rachman Putra; Mrs. Umi Laili Yuhana; Prof. Tohari Ahmad; Dr. Dandy Pramana Hostiadi
NET-1-4	1570840241	Correlation-Based Feature Selection on Botnet Activity Detection Using Kendall Correlation	Dr. Dandy Pramana Hostiadi; Mr. Yohanes Priyo Atmojo; Dr. Roy Rudolf Huizen; Mr. I Made Darma Susila; Mr. Gede Angga Pradipta; Mr. Made Liandana
NET-1-5	1570847719	C-Band Horn Antenna Fed by Rectangular Microstrip Patch	Mr. B. Pratiknyo Adi Mahatmanto; Mr. Dedi Irawadi; Ms. Anita Pascawati; Dr. Catur Apriono
NET-1-6	1570850263	Integration of Personal Health Record Using Database System and Blockchain Access Control Based on Smartphone	Mr. Muhammad Akbar Maulana; Dr. Achmad Arifin; Prof. Mohammad Nuh
NET-1-7	1570843204	A Study to Improve Image Steganography Using Linear Feedback Shift Register	Mrs. Majd Shunnar; Mrs. Amaal Othman; Dr. Ahmed Awad
NET-1-8	1570848476	Feature Representation For Network Intrusion Detection System Through Embedding Neural Network	Mr. Vian Handika; Mr. Satriawan Rasyid Purnama; Mr. Syafiqur Rochman; Prof. Jazi Eko Istiyanto; Dr. Ahmad Ashari; Dr. Andi Dharmawan

Correlation-Based Feature Selection on Botnet Activity Detection Using Kendall Correlation

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***Abstract*— Botnets are a dangerous threat to computer networks that uses malicious code to infect computer networks. Thus, the right system security model is needed to detect botnet attack activities accurately. Several previous studies have introduced a botnet detection model using mining-based, but it requires the correct approach to obtain the optimal performance. This paper proposes a botnet detection model by improving feature selection using correlation-based analysis. The aim is to improve accuracy detection by analyzing features with solid correlations that can be used for machine learning classification models. The proposed model consists of 4 main parts: data splitting pre-processing, classification process, and evaluation. The experiment used public datasets, namely CTU-13 datasets containing botnet activity. The experiment shows that the model can detect botnet activity with a detection accuracy of 99.7218%, precision of 99.1691%, and recall of 96.6533%. The proposed model can improve the existing botnet detection system model.**

Keywords—Botnet, Bot activity, Bot Detection, Network Security.

I. INTRODUCTION

System security requires serious attention in the cyber era [1]. An intrusion Detection System (IDS) is known as a security system that is currently widely used as an attack handling [2], [3]. Along with the development of technology, attacks develop into dangerous forms of activity such as involving illegal software called malware [4], [5].

The threat of malware in the cyber era is overgrowing [6]. Malware tends to use computers that have been infected to carry out malicious activities, which are called botnets [7], [8]. A botnet consists of a collection of computers that have been infected and form a communication network. The botnet consists of a master bot and a client bot [9]. The master bot controls each bot client to attack the target computer. Some of the dangerous activities of botnets include Spam activity, click ad fraud, identity theft, spreading malicious code programming, Denial of Service attacks (DDoS), phishing, and adware illegal installation [10], [11].

In its development, botnets have several characteristic behavioral patterns, such as centralized, distributed, and spreading [12]. Thus, it takes the right detection technique to detect bot activity accurately. Several detection techniques that can be used include DNS-based [13], [14], mining-based [6], [10], [15], anomaly-based [8], [16] and signature-based [17], [18]. However, it must be optimized through proper feature selection techniques.

Feature selection is part of the pre-processing stage used in modeling to reduce feature dimensions [2], [11], [14]. In addition, feature selection can be used to increase detection accuracy [2], [19], [20]. In previous studies, botnet detection has resulted in high detection accuracy with feature selection techniques such as the use of Principal Component Analysis (PCA) methods [21], [22], lightweight Logistic Regression model [23] and manuals based on model requirements [9], [11], [15], [24]. However, it has not shown a correlation between each feature and feature priority to improve detection accuracy in the botnet activity detection model. Correlation analysis between each feature is needed to find a strong relationship between one feature and another to improve the accuracy of the detection model performance.

This paper proposes a botnet detection model by optimizing the feature selection process using correlation analysis. The aim is to improve detection accuracy through correlation analysis between features using the Kendal Correlation algorithm. In correlation analysis, a threshold value is used to determine the strong correlation between features. The selected features are used in the k -NN classification machine learning model. The k-NN method is used because it does not require complex parameters, is easy to implement, and can obtain optimal accuracy detection [25].

The paper is organized into several sections. Previous studies related to feature selection techniques in botnet detection models are described in Section II. Section 3 introduces the process stages of the proposed model. The trials and results of the research are presented in Section IV. Finally, section V presents the conclusions of the research.

II. RELATED WORK

The botnet activity detection model using a mining-based approach is popular to use. Generally, to improve detection performance, optimization of feature selection is carried out. Feature selection techniques have been developed in many botnet detection models [2], [8], [11], [14], [22], [23].

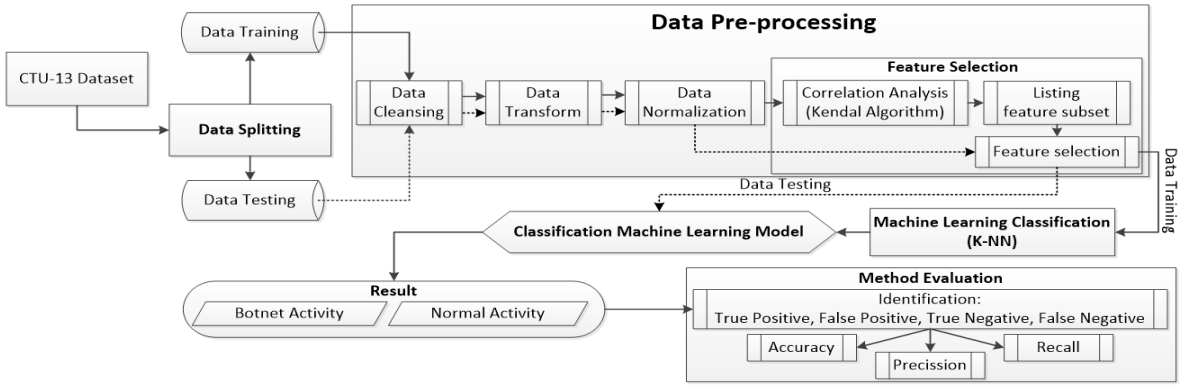

Fig. 1. Proposed Methodolgy

Alieyan et al. [26] proposed a botnet attack detection model based on DNS features. In the feature selection process, two algorithms are used: Information Gain Ratio (IGR) and Principal Component Analysis (PCA) algorithm, and 9 out of 19 features were selected based on the intersection of measurements of the two feature selection methods. The nine selected features are time, source IP address, destination IP address, QNAME, QR, RCODE, domain length, packet length, and TTL (domain response). This study has a high level of rationality to increase detection accuracy in the botnet activity detection model. However, the proposal for using the feature selection method has not been implemented.

Hostiadi, Wibisono and Ahmad [27] developed a botnet detection model by manually selecting 8 out of 13 features in the CTU-13 dataset [28]. The eight features in question are duration, protocol, source port, destination port, source IP, destination IP, total packets, and total bytes. The result of botnet activity detection accuracy obtained is 89.16%. In addition, the detection model named B-corr model can detect attack behavior as a bot group activity. However, the research has not analyzed how strong the relationship between the features represented in the form of a correlation relationship is.

The IoT Botnet detection model was introduced using several feature selection techniques, including mutual information (MI), PCA, and ANOVA F-test in [29]. Of the three feature selection methods, MI is the best feature selection technique capable of producing detection accuracy in the classification process. The highest detection accuracy in the MI feature selection technique is 99.903% in the k-NN classification method. However, the feature selection results have not shown a strong correlation between features.

Velasco-Mata et al. [25] introduced a botnet activity detection model using two filter techniques for feature selection. The two techniques in question are Gini Importance (GI) and Information Gain (IG). There are five best features selected from the feature selection stage. The results of the two feature selection methods produce model performance through an F1 score of 94%, with the best classification method being the Decision Tree. The results of the F1 score are highly but have not analyzed the relationship between features that strongly affect the accuracy of botnet activity detection.

III. Methodology

This paper proposes a feature selection technique using Kendal correlation in the botnet detection model. The purpose of correlation analysis is to obtain an analysis of the effect of correlated feature pairs on the performance of the botnet detection model. In this paper, the research methodology is shown in Fig. 1.

A. Problem Definition and Notation

The feature number and dimensions on a dataset can be reduced by feature selection [30]–[32]. The feature selection algorithm's advantage is that it can improve the detection performance of attack detection models in computer networks [33]–[35]. Besides, the use of appropriate feature selection techniques can reduce computational time [31], [32], [36], [37]. Based on this, this paper analyzes correlation-based feature selection techniques using the Kendall correlation algorithm. The aim is to see the effect of the detection performance of the detection model, measured from detection accuracy, recall, and precision.

The feature selection process in this paper adopts correlation analysis using the Kendall Rank Correlation Coefficient. Kendall correlation is one of the algorithms for measuring the correlation between two sets of ratings given to the same set of objects [38]. The strength of similarity as a correlation between two feature sets is measured and ranked to obtain correlated features. Furthermore, the correlation results are used in the classification process using k-NN. In this paper, notation is used to describe the proposed model.

- Record (ϑ). The dataset has a collection of data records (φ). Thus it is written as $\varphi \in \vartheta, \vartheta = \{\varphi_0, \varphi_1, \dots, \varphi_j\}$.
- Feature (Φ). Φ is consists of feature sets (ϕ). If feature (ϕ) is an element of φ, denoted as Φ, written as $\Phi = \{\phi_0, \phi_1, \dots, \phi_j\}$, then $\Phi \in \varphi, \varphi = \{\phi_0, \phi_1, \dots, \phi_j\}$.
- Correlation (τ). The correlation between f_i and f_j is calculated using the Kendall correlation equation (1).

$$\tau = \frac{2\,(C-D)}{\sqrt{n(n-1)-T_x}\sqrt{n(n-1)-T_y}} \quad (1)$$

where τ is the correlation coefficient, C is the number of pairs that are in the same direction, D is the number of pairs that are in the opposite direction, n is the number of pairs of x and y, T_x is the ranking correction factor for x and T_y is the ranking correction factor for y.

B. CTU-13 Dataset

The Czech Technical University owns CTU Public dataset through a lab project called the Stratosphere IPS Laboratory.

This dataset contains network traffic at the Czech Technical University containing malware activity. The CTU and malware capture dataset consist of a pure dataset of Botnet malware activity, normal traffic, and a combination of network traffic contaminated with Botnet malware activity or normal activity on the Czech Technical University network. Several different botnets were built and recorded at CTU University in 2011 and are known as the CTU-13 Dataset [28].

C. Data Splitting

At this stage, the dataset is divided into two parts: training data and testing data. We use 70% as training data and 30% as testing data. Then the two data are continued in the data pre-processing process.

D. Data Pre-processing

The pre-processing stage consists of four stages, beginning with the data cleansing process. The data cleansing process standardizes each feature's values and deletes data records. Some values in the feature do not have standardized writing, such as a writer from the SrcAddr feature in IPv6 form, thus requiring a written change to IPv4. In addition, there is an empty feature value (null), and the data record is deleted.

The second stage is data transformation, changing categorical data into numeric data. In this paper, the data transformation used one hot encoding, the same technique as in [12]. The third process is the data normalization process. Each feature value is numeric data that has various value ranges. So normalization data is needed to uniform the range of values in each feature. In this study, normalization was carried out using a value pool of 0 to 1, where 0 was the lowest value limit and 1 was the highest value limit. Then after normalizing the data, the fourth process is carried out, namely the selection feature on the training data. In contrast, the testing data is prepared as a classification process after the machine learning model is formed.

The feature selection begins with determining the number of feature pairs. The featured pair is formed by using the combination in (2).

$$comb = \frac{\phi!}{(\phi-e)!e!}, \quad (2)$$

where $comb$ is the number of features, which are 14 features, and e is the number of selected features, which are eight features. Then the four features are calculated using the Kendall correlation by adopting (1), so that it becomes (3).

$$\tau(\phi_i, \phi_j) = \frac{2\,(C-D)}{\sqrt{n(n-1)-T_{\phi i}}\sqrt{n(n-1)-T_{\phi j}}} \quad (3)$$

where $\tau(\phi_i, \phi_j)$ is the correlation coefficient between the first feature ϕ_i and the second ϕ_j, C is the number of pairs of features ϕ that are in the same direction, and D is the number of pairs of features ϕ in the opposite direction. n is the number of pairs of ϕ_i and ϕ_j, $T_{\phi i}$ is the ranking correction factor ϕ_i and $T_{\phi j}$ is the ranking correction factor ϕ_j.

The correlation strength between ϕ_i and ϕ_j is determined using the correlation threshold value (4).

$$threshold_\tau = \frac{min_\tau + max_\tau}{2}, \quad (4)$$

threshold τ is the correlation threshold between ϕ_i and ϕ_j, min_τ is the minimum correlation value, and max_τ is the maximum correlation value. Each feature with a strong correlation is based on the correlation threshold value, followed by an analysis of its occurrence in each feature pair set. The result is a sequence of features that appear the most and become the selected features for the machine learning model.

E. Machine Learning Classification Model

In the pre-processing stage, two data are used: training data and testing data at the step of forming a classification model using training data. The formation of the machine learning model in this paper uses the k-NN classification method. The value of k uses 5, calculated using (5).

$$\delta(a, b) = \sqrt{\sum_{k=1}^{d}(X_k - Y_k)^2}, \quad (5)$$

where $\delta(a, b)$ is the proximity between two feature vectors, d is the number of vectors, k is the length of the vector, X is the first vector data, and Y is the second vector data. After the machine learning classification model is formed, then the classification of the test data is carried out. The result of the classification is the detection of attack activity contained in the dataset. Then the performance of classification results is evaluated in the evaluation process.

F. Performane Evaluation

Measurement of model detection performance uses a confusion matrix, where true positive (TP), false positive (FP), false negative (FN), and true negative (TN) values are traced from the detection results of the k-NN machine learning model. TP is the number of botnet activities detected as a botnet attack. FP is the amount of normal activity data detected as a botnet attack. FN is the amount of data on botnet activity that is not detected, and TN is the number of normal activities detected as normal. The TP, FP, FN, and TN values are summarized in the confusion matrix table in Table 1.

TABLE I. CONFUSION MATRIX EVALUATION

Predicted Value \ Actual	**True**	**False**
True	TP	FP
False	FN	TN

From the search for confusion matrix values, accuracy, precision, and recall are calculated in equations (6), (7), and (8).

$$Accuracy = \frac{TP + TN}{TP+FP+FN+TN} \quad (6)$$

$$Precision = \frac{TP}{TP+FP} \quad (7)$$

$$Recall = \frac{TP}{TP+FN} \quad (8)$$

IV. EXPERIMENT AND RESULT

In this study, it has a hardware environment with a core i5-7200U processor, 8 GB RAM, and 500 GB storage. The model is built with three programming languages supported by several libraries such as NumPy, pandas, and sci-kit-learn. The test in this study uses the CTU-13 dataset by selecting scenario 9. Description of the dataset is shown in Table 2.

The data cleansing process reduced the number of records by 2,4103%, or as many as 66,376 records in the normal

TABLE II. NSL-KDD DATASET DESCRIPTION

Dataset	Records	Normal	Botnet	Number of Features
Data Description (CTU-13 Scenario 9)	2,753,884	2,574,004	179,880	14
Data Training (70%)	1,927,719	1,801,803	125,916	
Data Testing (30%)	826,165	772,201	53,964	

TABLE III. FEATURE FREQUENCY

Parameter	Rank Feature										
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Feature	TotPkts	SrcBytes	TotBytes	Dport	State	DstAddr	SrcAddr	sTos	dTos	Proto	Sport
Frequency	27	22	21	16	12	11	6	6	6	6	4

TABLE IV. PRE-PROCESSING RESULT

Dataset (CTU-13 Scenario 9)	Before Pre-processing				After Pre-processing				Reduce percentage (%)			
	Records	*Normal*	*Attack*	*Number of Feature*	*Records*	*Normal*	*Attack*	*Number of Feature*	*Records*	*Normal*	*Attack*	*Features*
Data Description	2,753,884	2,574,004	179,880	14	2,687,508	2,507,628	179,880	11	2.4103	2.5787	0	21.4286
Data Training (70%)	1,927,719	1,801,803	125,916		1,881,256	1,755,340	125,916		2.4103	2.5787	0	
Data Testing (30%)	826,165	772,201	53,964		806,252	752,288	53,964		2.4102	2.5787	0	

activity class label. This reduction affects the composition of the amount of training data and the amount of testing data. In addition, one feature is removed or ignored at the data cleansing stage, namely the Starttime feature. The reason is that this model does not take into account the analysis of activity time. Then proceed to the data transformation process. Three features are changed from categorical data to numerical data, namely Proto, Dir, and State.

The data transformation results from the value in each feature into a numerical basis with various value ranges. In this study, the normalized data changed the range of values in each feature on a scale of 0 to 1. The 0 value indicates the smallest value range, and 1 is the highest range of values. Then the results of the normalized data feature selection.

The correlation measurements using Kendall Correlation obtained the lowest correlation value of 0.0018, which is taken from features Dir, State, Dur, and dTos. Besides, the highest value of 0.3029 is taken from TotPkts, SrcBytes, TotBytes, and Dport. Thus, to determine the strong correlation between feature sets is 0.1523. Based on the correlation threshold, there are 104 combinations of feature sets, with the number of each set being eight features. Then an analysis of the occurrence of the same feature is carried out in pairs of different feature sets. As a result, 11 features strongly correlate, namely the TotPkts, SrcBytes, TotBytes, Dport, State, DstAddr, SrcAddr, sTos, dTos, Proto, and Sport features. The results of the feature occurrence analysis are shown in Table 3.

Feature selection is the last stage in pre-processing. The pre-processing results can reduce the data records and the number of features. Details of the percentage reduction in pre-processing are shown in Table 4.

The eleven features selected in the feature selection process are used in the classification process using the k-NN model. The classification results produce a confusion matrix value shown in Table 5.

TABLE V. CONFUSION MATRX VALUE

Predicted Value \ Actual value	True	False
True	52,158	437
False	1,806	751,851

The detection results show that the classification model can detect botnet activity with a detection accuracy of 99.7218%, precision of 99.1691%, and recall of 96.6533%. These results indicate that the detection model has an accurate detection performance influenced by the feature selection process. The features used in the classification process use k-NN machine learning using 11, which has a strong correlation and has a high frequency of occurrence in feature combinations. The measurement results are shown in Table 6.

TABLE VI. MODEL EVALUATION

TP	FP	FN	TN	Acc.	Prec.	Rec.
96.6533	0.0581	3.3467	99.9419	99.7218	99.1691	96.6533

In addition to testing the detection performance, in this paper, processing analysis is carried out to see the time it takes to get the detection results. The results of the time measurement are shown in Fig. 2.

The computational time measurement results show a high processing time consumption in the feature selection and classification process. This is because, at the time of selection, the process of forming a combination of feature sets and measuring correlations is carried out. Besides, the classification process requires processing time to classify testing data using the k-NN classification model. In this paper, the proposed model's detection results are compared with those in previous studies. Table 7 shows that the model has

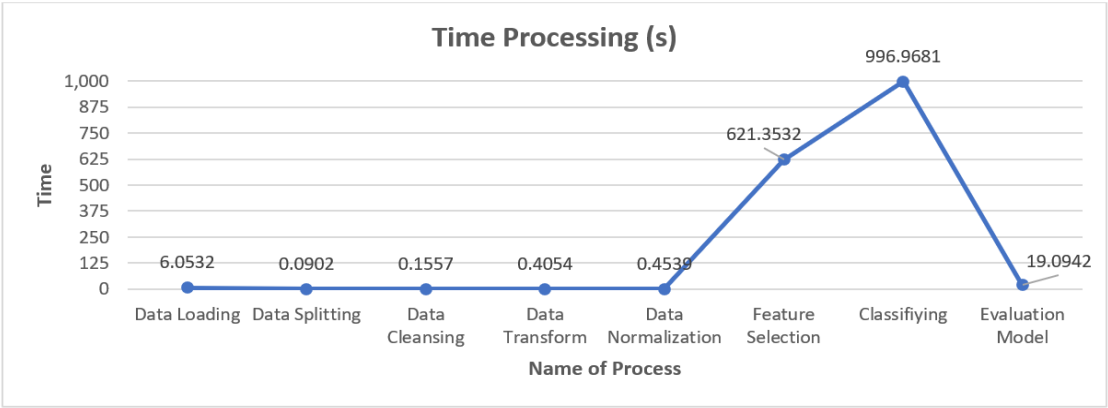

Fig. 2. Computation Time

TABLE VII. COMPARATION RESULT

Model	Acc.	Prec.	Rec.	Dataset	Correlation analysis	Time Analysis
Hostiadi and Ahmad [1]	99.18%	42.29%	91.55%	CTU-Dataset	√	-
Dollah et al. [39] • Decission Tree • *k*-NN • Naïve Bayes • Random Forest	 92.20 75.16 69.34 73.83	 99.93 73.18 62.28 49.99	 84.47 51.52 99.45 47.67	CTU-Dataset	-	-
Eslah, Abidin and Naseri [40] • C4.5 • Random Forest • Naïve Bayes • Support Vector Machine • Feedfprward Neural Network (F-NN)	 98.20 98.20 97.00 98.40 98.50	 98.20 98.20 97.00 98.50 98.50	 98.20 98.20 97.00 98.50 98.50	CTU-Dataset	-	√
Proposed Model	**99.7218**	**99.1691**	**96.6533**	**CTU-Dataset**	**√**	**√**

higher accuracy than research [1],[39],[40]. In terms of precision, the proposed model has a higher value than the research in [1],[39],[40]. But has a lower classification model than the Decision Tree [39]. Recall measurement has the lowest value in the study. In contrast to previous studies, in this paper, the proposed model has the advantage of performing feature selection based on correlation analysis using the Kendall correlation and measuring the computational time that has never been done in previous studies. So, the proposed model can be used to develop a special system security model to detect botnet attacks.

V. CONCLUSION

This paper proposes a new approach to feature selection using correlation analysis to increase detection accuracy in the botnet attack detection model. The proposed model consists of 4 main processes: data splitting, pre-processing, classification and evaluation. The feature selection process successfully reduced the feature dimensional from 11 out of 14 features in pre-processing stages, which have a strong correlation. Besides, it has a high frequency of occurrence in feature set pairs and affects the detection accuracy results. The experiment used the threshold values to determine the set feature with values of 0.1523 to indicate the strong and weak correlation between each selected feature. The detection results show that the classification model has the highest accuracy compared to previous studies, 99.7218%. Compared to previous research, the model has a novelty regarding feature analysis which has a strong correlation with each other and has computational time analysis.

In the future, the proposed model can be developed by examining the use of the classification model. The classification model can maximize precision and recall performance by following the feature selection method.

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