

# PROCEEDING

**The 2022**  
**IC3INA**  
**The 9<sup>th</sup> INTERNATIONAL CONFERENCE ON COMPUTER, CONTROL,**  
**INFORMATICS AND ITS APPLICATIONS**  
**Digital Transformation Towards Sustainable Society**  
**For Post Covid-19 Recovery**

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# **The 2022 9th International Conference on Computer, Control, Informatics and Its Applications (IC3INA 2022)**

## **Table of Contents**

<b>Preface</b>	xiii
<b>Conference Committees</b>	xv
 <b>Chapter 1 – Computer and Networking</b>	
FPGA-Based Acceleration of Stereo Matching Using OpenCL <i>Iman Firmansyah; Ryo Nakagawa; Yoshiki Yamaguchi</i>	1
Preliminary Assessment of Using Spanning Tree Open Protocols in INA-CBT Communication System <i>Mohammad Hamdani; Dedy Irawan; A. A. N. Ananda Kusuma; Tahar Agastani; Muhammad Iqbal</i>	6
Genetic Algorithm Improvement: A Case Study of Capacitated Vehicle Routing Problem <i>Himma Firdaus; Tri Widiarti</i>	11
Automatic Data Acquisition of Electric Power Usage in Phnom Penh City <i>Seven, Siren; Rothna, Pec; Vannak, Ros; Sithirith, Kum; Sokoeun, Un; Sros, Nhek</i>	17
QoS Analysis of Site-to-Site VPN and Its Integration Potential for Securing Communication on Electric Vehicles <i>Arief Indriarto Haris; Rd. Angga Ferianda; Akbari Indra Basuki</i>	25

Designing Earthquake Monitoring System Using Earthquake Catcher Network	29
<i>Ridwan Suhud; Muhammad Hanif; Christoporus Deo Putratama; Kevin Shidqi Prakoso; Bramantio Yuwono; Ary Setijadi Prihatmanto</i>	
Initial Study and Performance Analysis of Vertical LoRa Using Drone in Forest Areas	35
<i>Dimas Biwas Putra; Bondan Suwandi; Riski Fitriani; Fito Wigunanto Herminawan; Yoga Prastiya Wibawa; Moh. Alma Samudro</i>	
The Effect of Fiber Bragg Grating (FBG) Sensors on Data Channel of Fiber Optic Communication (FOC) System	40
<i>Muhammad Yusha Firdaus; Dena Karunianto Wibowo; Maratul Hamidah; Ryan Prasetya Utama; Mustika Fitriana Dewi; Mohammad Hamdani; Lesti Setianingrum; Sasono Rahardjo; Michael Andreas Purwoadi; Edhi Purnomo</i>	
Realtime Video Latency Reduction for Autonomous Vehicle Teleoperation Using RTMP Over UDP Protocols	44
<i>Ana Heryana; Dikdik Krisnandi; Hilman F. Pardede; Galih Nugraha Nurkahfi; Mochamad Mardi Marta Dinata; Andri Fachrur Rozie; Rendra Dwi Firmansyah</i>	
The Consideration of Attenuation and Chromatic Dispersion Parameters to Long-Haul Optical Communication	50
<i>Maristya Rahmadiansyah; Sakinah Puspa Anggraeni; Muhammad Yusha Firdaus; Mustika Fitriana Dewi; Sasono Rahardjo; Muhammad Putra Rasuanta; Maratul Hamidah; Lesti Setianingrum; Agus Muhamad Hatta</i>	
<b>Chapter 2 – Control</b>	
Advanced Control for Hammerstein-Bilinear HVAC System	55
<i>Iput Kasiyanto</i>	
Modeling and Analysis of a Dual-Mode Electric Power Steering for Manual and Autonomous Driving	60
<i>Muhammad Hafil Nugraha; Oka Mahendra; Estiko Rijanto</i>	
Cooperative Formation Control Study for Agricultural Robot Simulation in Square Farmland Areas	65
<i>Jalu A. Prakosa; Azwirman Gusrialdi; Mohamad Syahadi; Edi Kurniawan; Harry Septanto; Chifayah Astuti</i>	

Strategic Policy Model of Wind Turbine Power Quality Control System Using Lookup Table in Remote Area	70
<i>Soedibyo; Dedet Candra Riawan; Mochamad Ashari; Avian Lukman Setya Budi</i>	
A Control Strategy for Balancing and Tracking Position of Unicycle Robot Based on State Feedback LQR Control	75
<i>Yusie Rizal; Trihastuti Agustinah; Rudy Dikairono</i>	
The Design of 1/10 Scale Model for Autonomous Electric Vehicle Dynamic Testing	80
<i>Mochamad Adityo Rahmadi; Galuh Prihantoro; Tsani Hendro Nugroho; Dito Eka Cahya; Heru Taufiqurrohman; Zaid Cahya</i>	
<b>Chapter 3 – Informatics and Data Processing</b>	
Classification of Customer Orders in the Internal Section of Supply Chain Management Using Machine Learning	85
<i>Wawa Wikusna; Mustafid Mustafid; Budi Wasito; Adi Wibowo</i>	
CNN Model with Parameter Optimisation for Fine-Grained Banana Ripening Stage Classification	90
<i>Zaid Cahya; Dito Eka Cahya; Tsani Hendro Nugroho; Ardani Caesario Zuhri; Waqif Agusta</i>	
Active-to-Passive Arabic Word Conversion and MSD Identification Using RNN	95
<i>Khalisyahdini; Moch Arif Bijaksana; Kemas Muslim Lhaksmana</i>	
Deep Learning for Robust Speech Command Recognition Using Convolutional Neural Networks (CNN)	101
<i>Zahra Cantiabela; Hilman F. Pardede; Vicky Zilvan; Winita Sulandari; R. Sandra Yuwana; Ahmad Afif Supianto; Dikdik Krisnandi</i>	
A Hybrid CNN-LSTM for Battery Remaining Useful Life Prediction with Charging Profiles Data	106
<i>Huzaiifi Hafizhahullah; Asri Rizki Yuliani; Hilman Ferdinandus Pardede; Ade Ramdan; Vicky Zilvan; Dikdik Krisnandi; Jimmy Abdel Kadar</i>	

Image Segmentation for Aspergillus, Cladosporium, and Trichoderma Fungus	111
<i>M. Wibowo; B. R. Maulana; G. M. Putra; J. G. Pinem; U. Chasanah; R. P. Pramesti; M. R. Supriyadi; D. N. Hidayati; Kristiningrum; A. H. Subekti; M. Alfin; D. H. Budiarti; J. Muliadi; A. S. Nugroho</i>	
Performance Comparison of Topic Modeling Algorithms on Indonesian Short Texts	117
<i>Nuraisa Novia Hidayati; Anne Parlina</i>	
Comparison of Optimizer on Convolutional Neural Network and Color Representation on Data for Face Presentation Attack Detection	121
<i>Nur Aisyah Nadiyah; Anto Satriyo Nugroho</i>	
Evaluation of Machine Learning Models for Detecting Disambiguation on Medical Abbreviations	125
<i>Ruth Andini; Raden Sandra Yuwana; Hilman F. Pardede; Winita Sulandari; Ahmad Afif Supianto; Endang Suryawati; Candra Nur Ihsan</i>	
Sarcasm Detection in Indonesian Tweets Using Hyperbole Features	130
<i>Novitasari Arlim; Siti Kania Kushadiani; Slamet Riyanto; Rodiah Rodiah; Rini Arianty; Maukar Maukar; Shidiq Al Hakim; Al Hafiz Akbar Maulana Siagian</i>	
Detection of Driver Drowsiness Based on Eye and Mouth Movements Using Convolutional Neural Networks	135
<i>Siwi Azizah Oktaviana; R. Budiarianto Suryo Kusumo; Winita Sulandari; Ana Heryana; R. Sandra Yuwana; Endang Suryawati; Asri R. Yuliani</i>	
Parallel Programming in Finite Difference Method to Solve Turing's Model of Spot Pattern	141
<i>Theodoret Putra Agatho; Pranowo</i>	
Dialogue System Based on Reinforcement Learning in Smart Home Application	146
<i>Hanif Fakhurroja; Ahmad Musnansyah; Muhammad Dewan Satriakamal; Bima Kusuma Wardana; Rizal Kusuma Putra; Dita Pramesti</i>	
SESS: Utilization of SPIN for Ethnomedicine Semantic Search	153
<i>Dewi Wardani; Mauluah Susmawati</i>	

Impact of Air Pollution to Solar Radiation in Megacity Jakarta	158
<i>Inna Syafarina; Arnida Lailatul Latifah; Intan Nuni Wahyuni; Rido Dwi Ismanto; Ariani Indrawati; Mohammad Rosyidi; Windy Iriana; Sheila Dewi Ayu Kusumaningtyas; Ahmad Daudsyah Imami; Erma Yulihastin</i>	
Effects of Land Cover, Topography, and Wind on Fire Spread in Kalimantan Using Cellular Automata	163
<i>Intan Nuni Wahyuni; Arnida L. Latifah; Rido Dwi Ismanto, Ariani Indrawati; Usnida U. Zahra; Agus Yodi Gunawan</i>	
Virtual Screening of HMG-CoA Reductase Inhibitors of West Bali National Park Natural Compounds Database Using Machine Learning	168
<i>Elpri E. Permadi; Susi Kusumaningrum; Donny Ramadhan; Sjaikhurrizal E. Muttaqien; Agus Supriyono</i>	
Air Pollution Index (API) Analysis at Jakarta in 2019-2020 Using Fuzzy C-Means and Gaussian Mixture Model	174
<i>Melva H. S. Situmorang; Bahrul I. Nasution; Muhammad E. Aminanto; Yudhistira Nugraha; Juan I. Kanggrawan</i>	
Identification of Hoya Plant Using Convolutional Neural Network (CNN) and Transfer Learning	179
<i>Gibtha Fitri Laxmi; Siti Kania Kushadiani; Sri Rahayu; Budi Nugroho; Toto Haryanto</i>	
A Knowledge Graph Exploration Method with No Prior Knowledge	184
<i>Ariani Indrawati; Zaenal Akbar; Dwi S. Rini; Aris Yaman; Yulia A. Kartika; Dadan R. Saleh</i>	
Short-Term Road Traffic Flow Prediction Model on Damaged Road Characteristics (Type of Distress Raveling)	189
<i>M Rosyidi; Winarno; Nurhadi P; Nofriyadi; Tri Widodo; Sahid Bismantoko</i>	
Modelling the Climate Factors Affecting Forest Fire in Sumatra Using Random Forest and Artificial Neural Network	194
<i>Ayu Shabrina; Irma Palupi; Bambang Ari Wahyudi; Intan Nuni Wahyuni; Mulya Diana Murti; Arnida L. Latifah</i>	



An Empirical Analysis of Knowledge Overlapping from Big Vocabulary in Biodiversity Domain	199
<i>Yulia A. Kartika; Dadan R. Saleh; Zaenal Akbar; Widya Fatriasari</i>	
Sentiment Analysis of Indonesian New Capitol (IKN) Tweets by Stacked Generalization of Deep Learning	204
<i>Josua Geovani Pinem; Aulia Haritsuddin Karisma Muhammad Subekti; Gembong Satrio Wibowanto; Siti Shaleha; Muhammad Reza Alfin; Agung Septiadi; Elvira Nurfadhilah; Dian Isnaeni Nurul Afra; Jemie Muliadi; Agung Santosa; M. Teduh Uliniansyah; Asril Jarin; Andi Djalal Latief; Gunarso; Hammam Riza</i>	
The Prototype of Orbital Database System for Satellite Tracking Information	211
<i>Yoga Andrian; La Ode Muhammad Musafar Kilowasid; Siti Kurniawati Fatimah</i>	
Performance Face Image Quality Assessment under the Difference of Illumination Directions in Face Recognition System Using FaceQnet, SDD-FIQA, and SER-FIQ	219
<i>Auliati Nisa; Radhiyatul Fajri; Erwin Nashrullah; Fandy Rizqi Azhari Harahap; Junanto Prihantoro; Gembong Satrio Wibowanto; Jemie Muliadi; Anto Satriyo Nugroho</i>	
Toward a New Standard for DEM Generation Based on Radar Remote Sensing Technology	224
<i>Winhard Tampubolon; Wolfgang Reinhardt; Fahmi Amhar</i>	
Developing Semantic Annotation Representation of Social Media Sentiments and Metadata as Resource Description Framework; A Study of Indonesian New Capital Related Tweets Written in Bahasa	229
<i>Josua G. Pinem; Agung Septiadi; Siti Shaleha; Muhammad R. Alfin; Aulia H.K.M. Subekti; Jemie Muliadi; Gembong S. Wibowanto; Agung Santosa; M.T. Uliniansyah; Asril Jarin; Andi D. Latief; Gunarso; Hammam Riza</i>	
Application of Bayes' Theorem in an Expert System for Diagnosing Mangosteen Diseases and Pests	235
<i>Foni A. Setiawan; Freza Riana; Siti Aisyah</i>	



Implementation of Road Segmentation Using U-Net Model on Single Board Computer	240
<i>Dary Zhafran; Esa Prakasa; Dwi Astharini</i>	
Extended Reality Technologies for Sustainable Development of Learning and Education in Indonesia	245
<i>Wecka, I., Yudhistyra; A'liyatur, Rosyidah; Chalita, Srinuan; Singha, Chaveesuk</i>	
The Recommendation Augmented Reality: For Maritime Navigation Applications in Indonesia	251
<i>Muhammad Yudhi Rezaldi; Hendrik Marantino Napitupulu; Emir Husni; Esa Prakasa</i>	
Hand Skeleton Graph Feature for Indonesian Sign Language (BISINDO) Recognition Based on Computer Vision	256
<i>Edy Maryadi; Syahrul; Dea Maulidya; Risnandar; Esa Prakasa; Dian Andriana</i>	
Effects of Aromatherapy and Music on Napping-Time Quality in Young Adults: EEG Sleep Study	261
<i>Dwi Esti Kusumandari, DEK, Kusumandari; Rizka Adriani, RA, Adriani; M Faizal Amri, MFA, Amri; Auditya P Sutarto, APS, Sutarto; Artha Ivonita Simbolon, AIS, Simbolon; Muhammad Ilham Rizqyawan, MIR, Rizqyawan</i>	
UAV-Photogrammetry Specification for Generating 3D-Orthomosaic in Case of 3D Animation Modeling	267
<i>Abdurrahman Prasetyadi; Muhammad Yudhi Rezaldi; Ambar Yoganingrum; Nuraini Rahma Hanifa; Widjo Kongko</i>	
Open Science Progress: A Literature Assessment of Open Access Articles	271
<i>A. A. Waskita; Z. Akbar; D. R. Saleh; Y. A. Kartika; A. Indrawati</i>	
Identification of Conflict Opinion in Aspect-Based Sentiment Analysis Using BERT-Based Method	276
<i>Nuryani; Ayu Purwarianti; Dwi Hendratmo Widyantoro</i>	
D-ViShaDeRec: Double Intensity of Video Shadow Detection, Removal, and Re-coloring in Autonomous Vehicle	281
<i>Deeva Nabila; Risnandar</i>	

Trading Simulation Using Python and Visualization on Streamlit with Machine Learning Decision Tree	286
<i>Imelda Uli Vistalina Simanjuntak; Heriyanto; Yosy Rahmawati; Ketty Siti Salamah; Agus Dendi Rochendi; Sulistiyono</i>	
Comparison of Machine Learning and Deep Learning Model for Medical Subject Headings Indexation	292
<i>Lukman, lh, Heryawan; Arif Farhan, Afb, Bukhori</i>	
Housing Price Prediction Using a Hybrid Genetic Algorithm with Extreme Gradient Boosting	296
<i>Maria Ulfah Siregar; Pahlevi Wahyu Hardjita; Farhan Armawan Asdin; Dewi Wardani; Ardhi Wijayanto; Yessi Yunitasari; Muhammad Anshari</i>	
A Scientific Expertise Classification Model Based on Experts' Self-Claims Using the Semantic and the TF-IDF Approac	301
<i>Andre Sihombing; Aris Yaman; Ariani Indrawati; Cahyo Trianggoro; Lindung P. Manik; Zaenal Akbar</i>	
Deep Learning and Machine Learning Model Comparison for Diagnosis Detection from Medical Records	306
<i>Lukman, LH, Heryawan; Fitra, FF, Febriansyah; Arif Farhan, AFB, Bukhori</i>	
Accelerating Encrypted Watermarking Using Wavelet Transform and CKKS Homomorphic Encryption	311
<i>Akbari Indra Basuki; Iwan Setiawan; Didi Rosiyadi; Taufik Iqbal Ramdhani; Heru Susanto</i>	
Leak Detection Using Non-Intrusive Ultrasonic Water Flowmeter Sensor in Water Distribution Networks	316
<i>Ary Mazharuddin Shiddiqi; M. Akmal Fakhri Baihaqi; Atar Fuady Babgei</i>	
Engagement Analysis on Local Small-Medium Enterprises: Case Study in Bandung	321
<i>Purnomo Husnul Khotimah; Andria Arisal; Dwi Alfianti; Nabila Eka Putri; Ekasari Nugraheni; Dianadewi Riswantini</i>	

On Generating SHACL Shapes from Collective Collection of Plant Trait Data	326
<i>Dadan Ridwan Saleh; Yulia Aris Kartika; Zaenal Akbar; Adila Alfa Krisnadhi; Widya Fatriasari</i>	
Location Extraction from Traffic Event-Related Text	331
<i>Andri Fachrur Rozie; Purnomo Husnul Khotimah; Lia Sadita; Muh. Hafizh Izzaturrahim; Andria Arisal</i>	
Onthel: Online Delivery App to Induce Green Lifestyle Awareness	336
<i>Andre, Andre; Marcellinus F Suciadi</i>	
Analysis of H-Component of Geomagnetic Variation in Indonesian Region	341
<i>Nia Syafitri; Angga Yolanda Putra; Erlansyah; Muzirwan; Hadi Rasidi; Singgih Anggi Purnama; Helmi Suryaputra; La Ode Muhammad Musafar Kilowasid; Kuncoro Wisnu; Iskandar Bakri; Lambang Nurdiansah; Fitri Nuraeni; Cahyo Purnomo; Syamsurijal Rasimeng</i>	
Auto Code Comment Assessment for Online Judge Using Word Embedding and Word Mover's Distance	345
<i>Rosa Ariani Sukamto; Muhammad Nabillah Fihira Rischa; Erna Piantari; Yudi Wibisono; Rani Megasari</i>	
<b>Chapter 4 – Information Communication Technologies (ICTs) Applications</b>	
Household Electricity Profile as Alternative Data for Credit Appraisal	350
<i>Wahyu Haris Kusuma Atmaja; Mohammad Isa; Muhammad Aidil Fahmy</i>	
Android-Based Forest Fire Danger Rating Information System for Early Prevention of Forest/Land Fires	356
<i>Anwar Annas; Silvan A.B.S.P; Taufik Hidayat; Aby Al Khudri</i>	
Anomaly Detection of Hallux Valgus using Plantar Pressure Data	361
<i>Latif Rozaqi; Yukhi Mustaqim Kusuma Sya'bana; Asep Nugroho; Nugrahaning Sani Dewi; Kadek Heri Sanjaya</i>	
Geographic Information System Continuance Adoption and Use to Determine Bidikmisi Scholarship Recipients Distribution	366
<i>Nurdin, Nurdin; Muh. Ridha Agam; Adawiyah Pettalongi</i>	

Automatic Migration from Imperfect Relational Database to Resource Description Framework	371
<i>Dewi Wardani; Maulia Harjono</i>	
SSTI: Semantic Similarity to Detect Novelty of Thesis Ideas	376
<i>Dewi Wardani; Chairul Achmad</i>	
An Indonesian Adaption of Visual Aesthetics of Website Inventory (VisAWI) Questionnaire for Evaluating Video Game User Interface	382
<i>Lia Sadita; Harry Budi Santoso; Luqman Iffan Windrawan; Purnomo Husnul Khotimah</i>	
The Effect of Information Quality on Product Reviews in the Short Video Platform for Viewers Purchase Intention	387
<i>Jovanka Jeremy Wijaya; Marvin Setyo; Kevin William; Yakob Utama Chandra</i>	
Implementation of Workflow Engine on BRIN HPC Infrastructure	393
<i>Ihsan Nugaraha; Imam Civi Cartealy; Inna Syafarina; Maulida Mazaya; Anis Kamilah Hayati; Syam Budi Iryanto</i>	

## Preface

On behalf of the IC3INA 2022 organizing committee, I am honored and delighted to welcome you to the ninth of 2022 International Conference on Computer, Control, Informatics, and its Applications (IC3INA 2021) with the theme: “Digital Transformation Towards Sustainable Society For Post Covid-19 Recovery”. The theme is perfectly in line with these two important reasons. First, the acceleration of digital transformation caused by change of lifestyle due to Covid-19 pandemic. This momentum is perfect to forge partnerships and cooperation, and to share research progress between research institutions, campuses, and small to large scale industries in order to optimize the management and the use of the available resources into multi-disciplinary science, to attain sustainable development. And second, with the world recession is around the corner, the theme never becomes more important than today for us to exchange ideas on how digital transformation could also tackle future challenges and ensure that everyone has the best (access) to participate and benefit from the digital transformation of our economy.

Our technical program is rich and varied with 5 keynote speakers and 76 technical papers split between 15 parallel oral sessions in two days' virtual conference. From 112 reviewed papers, we have accepted 76 papers, which means 67.9% of acceptance rate and 32.1% rejection rate. Both accepted paper number and rejection rate increase compared to IC3INA 2021 (45 accepted papers, 10% of rejection rate). IC3INA is committed to maintain and improve the quality of accepted papers. The accepted papers are separated into Computer and Networking (10 papers), Control (6 papers), Informatics and Data Processing (51 papers), and Information Communication Technologies (ICTs) Applications (9papers). The IC3INA 2022 has been approved and sponsored by the Association for Computing Machinery (ACM) as the global proceeding which is indexed by the Scopus.

Regarding the conference, this is the second year that we are holding the IC3INA annual event in a virtual format, with no audience physically in the

room. Following our previous success in 2021, this year we use a conference management system (Indico) to ensure that we all could optimally engage and present the latest innovations and developments, and to exchange ideas and various aspects of advances in computer technology, control, informatics and their applications.

As a conference chair of IC3INA 2022, I know that the success of the conference depends ultimately on the many people and the committees who have worked with us in planning and organizing both the technical program and the supporting team arrangements. We thank the steering committees for their wise advice and brilliant suggestions from the organizing committee. The technical program committee (TPC) for their thorough and timely reviewing of the papers, and our ad-hoc teams who have helped us to keep down the costs of IC3INA2021 for all participants. Recognition should go to the organizing committee members who have all worked extremely hard both individually and team efforts for the details of important aspects of this virtual conference program and the other related activities. Last but not least, thank you very much for your participation and support of our International Conference on Computer, Control, Informatics, and Its Applications (IC3INA 2022).

General Chair of IC3INA 2022,

Dr. Purnomo Husnul Khotimah M.T.

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(IC3INA 2022)

“Digital Transformation Towards Sustainable Society For  
Post Covid-19 Recovery”

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# Housing Price Prediction Using a Hybrid Genetic Algorithm with Extreme Gradient Boosting

Maria Ulfah Siregar\*  
Pahlevi Wahyu Hardjita†  
Farhan Armawan Asdin‡  
maria.siregar@uin-suka.ac.id  
UIN Sunan Kalijaga  
Sleman, Daerah Istimewa Yogyakarta, Indonesia

Yessi Yunitasari  
Universitas PGRI  
Madiun, Indonesia  
yessi@unipma.ac.id

Dewi Wardani§  
Ardhi Wijayanto¶  
dww\_ok@uns.ac.id  
ardhi.wijayanto@staff.uns.ac.id  
Universitas Negeri Sebelas Maret  
Surakarta, Indonesia

Muhammad Anshari  
Universiti Brunei Darussalam  
Brunei, Brunei Darussalam  
anshari.ali@ubd.edu.bn

## ABSTRACT

Predicting property prices provides a better service for customers to evaluate and estimate price movement before their purchases. Some features including OverallQual and GrLivArea, which were selected when applying GA, become important features that can influence property prices. This research proposes a hybrid Genetic algorithm combined with the Extreme Gradient Boosting algorithm to predict real estate housing prices. The proposed scheme is evaluated by Root Mean Square Error, processing time, and the number of deleted features. The proposed scheme has been compared with the sole Extreme Gradient Boosting. The experimental results show that the proposed scheme produces the smallest root mean square error value of 0.129 compared to 0.133 of the sole Extreme Gradient Boosting. Furthermore, the predicted time of the proposed scheme is much better than the sole method.

## CCS CONCEPTS

• Computing methodologies → Machine learning algorithms.

## KEYWORDS

feature selection, RMSE, crossover, mutation

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\*All authors contributed equally to this research.

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## 1 INTRODUCTION

The real estate and property sector could be categorized as quite profitable but with a high risk because sales are pegged to market prices with high and low buyers' interest. Real estate and property businesses consist of land, buildings, and everything attached to the land [1].

During the Covid-19 pandemic, many companies were downsizing their firms due to economic uncertainties and business turmoil. These facts have encouraged people to seek alternative jobs. Real estates and housing businesses promise high returns for business and primary needs for almost everyone [2].

On the other hand, this pandemic is also blamed for the slow increase or even decrease in house prices. Bank Indonesia (BI)/ Indonesian Bank recorded that the prices of real properties, especially residential ones, relatively stagnate in the fourth quartile of 2020 [3]. This slowdown is predicted to stay until the first quartile of 2021.

By knowing the interest of the market, the company could predict these prices. There exist algorithms and tools performing prediction. However, it is always a necessity to get accurate results. Therefore, this paper examined the combination of the eXtreme Gradient Boosting (XGBoost) algorithm and the Genetic Algorithm (GA) and compared both algorithms independently. By doing so, it is expected to find the better accuracy of those algorithms for this prediction. We aim to get a house that suits the wishes of the buyer based on price and other criteria.

The GA is a prediction method which has advantages such as dealing with non-stationary data [4]. Another advantage is a modelled phenomenon which is not necessary to define since this model will be enhanced gradually during the process. This method is a kind of adaptive heuristic algorithm that can be integrated to select the best features for prediction, rather than spend much time searching for the ideal features using the greedy algorithm [5]. It is because GA can be used for global optimization, which determines the optimal features [6]. GA is a search technique used in computer science to find approximate solutions for optimization and search problems which were created to mimic some of the processes observed in natural evolution [7]. Furthermore, GA is

a strong stochastic algorithm that is quite successful in machine learning relating to those problems.

XGBoost is one of the methods in machine learning, which uses the ensemble method for a regression and classification algorithm. This method is a variant of the algorithm of the Tree Boosting System, a scalable end-to-end of this algorithm [8]. Tree boosting is a greatly effective and broadly used machine learning method.

XGBoost has been implemented or reviewed in many research. For example, XGBoost has been a winner of challenges hosted by Kaggle, 17 out of 29 solutions which eight these solutions were obtained from the implementation XGBoost alone [8].

Another application of XGBoost is on medical problems such as in [9]. In their research, this algorithm is used to classify the fMRI (functional MRI) in epileptic patients and healthy subjects. The research also aims at determining the best combinations of features that show the most predictive power. Features here are region, hemisphere, and task which focused on filter and wrapper methods. The finding of this research is a special mix of features, the SEM\_LH BA\_47-21 was the most compelling to identify patients. XGBoost is also applied to predict gene expression value [10]. The profiling of these values is used to reflect the health of the body, diagnose genetic diseases, and others. By using the XGBoost method, the cost to profile genome-wide expression could be reduced. The performance of XGBoost was compared to the D-GEX algorithm, linear regression, and KNN methods. The result is that the XGBoost model has a lower overall error than the three models.

XGBoost has also been applied to predict environmental resources. One of these applications is the prediction of the levels of groundwater in Selangor, Malaysia [11]. There, XGBoost, ANN, and Support Vector Regression have been tested and evaluated in order to obtain accurate groundwater level prediction. The precise input variables are critical for the model's achievement; thus cross-correlation is used to find the match between the target variable and the delayed values of inputs. The results of this research are XGBoost has the highest mean absolute error (MAE) and root mean square error (RMSE). Another application is the prediction of PM2.5 concentration every hour in Tianjin, China [12]. This prediction was modelled using data-driven models. The application of XGBoost was compared with other established data-mining models, such as the Random Forest, Multiple Linear Regression, Decision Tree Regression, and Support Vector Machine for Regression. The result is the RMSE and MAE of XGBoost which is better than the four compared models. It is claimed that the XGBoost is more efficient to predict the hourly PM2.5 concentration.

Although much research has been conducted using XGBoost, we have never found any of these that combined with GA and relate to house price prediction. Thus, in this paper, we present our research on applying a combination of XGBoost and GA to this problem. Algorithm implementation will be processed in the Python programming language. Following this, our contribution is to identify the better features of the problem of house pricing prediction by implementing the combination of GA and XGBoost using the Kaggle dataset and machine. Features in our study are factors regarding the House Price Index (HPI), which is commonly used to estimate changes in house prices. Based on this index, house prices are highly correlated with other factors such as location, area, population, and other information.

**Table 1: The XGBoost's Parameter**

Parameter	Value
n_estimators	500
learning_rate	0.05
subsample	0.5
colsample_bytree	0.5
max_depth	3
objective	reg:linear
gamma	0
alpha	0
lambda	2

## 2 MATERIAL AND METHOD

There are several stages of our research. A brief description is given as follows.

### 2.1 Data Collection

The data is from Kaggle.com in the form of a dataset of Ames Housing compiled by Dean De Cock. The following is the data source link <https://www.kaggle.com/c/house-prices-advanced-regression-techniques> [13]. This dataset consists of 4377 entries for houses in Ames, Iowa. A number of 2917 data is for training, and 1460 data is for testing. There are 23 nominal, 23 ordinal, 13 discrete, and 20 continuous variables for each property.

### 2.2 Conducting Pre-processing

The next step is the implementation of pre-processing over the data. This stage includes the implementation of replacing the missing values data and cleansing the data.

### 2.3 Performing Feature Selection using GA

The feature selection stage is carried out to reduce complexity and avoid unused/ irrelevant features so as to achieve a better accuracy rate of the result [14]. In the feature selection phase, the method which is used is the GA. Combining GA and XGBoost differs our research considerably from the implementation of the sole XGBoost algorithm.

### 2.4 Algorithm Implementation

The next stage is to process data from the XGBoost algorithm and GA. Parameters are depicted in Table 1.

For the XGBoost model, we used XGBRegressor so the training model and testing data could use all the features or some of the features as the result of applying GA. Thus, we fed the selected features obtained by GA to the XGBoost. After training the data model, the sale price is predicted over the testing data. These sale prices are then sent to Kaggle to obtain scores of RMSE.

Our research could be categorized as research which describes technical results. Among the four types of technical results, the fitting type is a system construct. In this case, we set a research method by feeding the XGBoost algorithm on the results of GA.

## 2.5 Evaluation of Results

After implementation, the accuracy testing phase of the prediction results using RMSE is conducted. In this case, better accuracy will be found for the prediction of the price of each house.

## 3 RESULTS AND DISCUSSION

This section displays the results obtained after carrying out the steps described in the method section. Through the data collection stages, the training model data is on 81 columns and the testing data is on 80 columns.

We applied three methods of replacing missing values. We replaced the missing values from data that do not number/integers using their modus. Meanwhile, for the number/ integer data values, we replaced the missing values with their mean or median. Furthermore, values of “NaN” will be replaced with “0” or “None”.

The next process is data cleansing. There were as many as 78 training model data features and 78 data testing features within 329 columns. These 329 columns were obtained after pre-processing the data using One-hot Encoding method in which every categorical data will be changed into several columns based on their categorical values. We used this method to ease us in the selection phase. In the cleansing step, we deleted columns with many “NaN” values or columns with only one cluster since it indicates the less important or we could say that they are outliers. First, we plotted data using a Scatter plot, then we delete the outliers. Figure 1 shows a correlation among features. Based on Fig. 1, the two features that influence the price of houses most are OverallQual and GrLivArea. Previous research has found that by performing clustering, outliers could be detected and removed [15][16]. In this research, we found that there are two outliers.

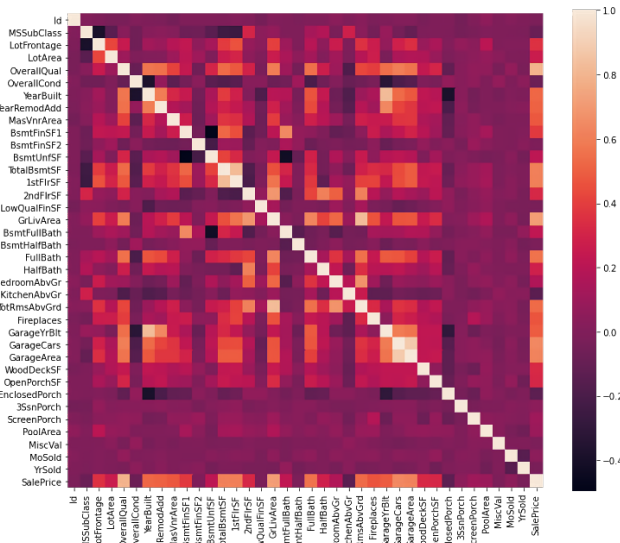


Figure 1: A heat map correlation among columns

The correlation that is shown in Fig. 1 is to correlate the features of the numerical types to other types of features. It ranges from -0.5 to 1, from darker colour to brighter colour, respectively. The brighter

colour represents the strong correlation between the feature in the X ordinate and to feature in the Y ordinate. For example, the correlation between SalePrice and OverallQual is a bright colour tile. It means that both have a strong correlation with each other.

The next process is the feature selection using GA, which is a single-point crossover and flip mutation to reduce columns in the data and speed up the training model process. The mutation rate is defined as 30%. Our GA accepts input: all columns from the training model data except the target column (the column that contains phenotypes/ features of the house), targets (SalePrice), number of populations, and number of generations. A chromosome will represent an individual binary string whose length of this chromosome suits the number of features. Each chromosome represents a feature. Fitness values are obtained from the RMSE values of each population. Thus, the one with the smallest value of RMSE will be the optimum solution for the problem. After several iterations and this number reach the maximum number of iterations, the global optimum is reached [17][18]. For training the data, we used all the training datasets, then, we split the training dataset using the 80:20 method; 80% of the data will be for training, and 20% of it will be for validation.

The value predictive between XGBoost and GA is obtained after processing the trained data model and followed by the tested data. We used also all the test datasets. Here we used the RMSE value, processing time, and the number of eliminated features as the benchmark to find the best algorithm of the two algorithms. The RMSE value is obtained by first inputting the predicted results of the data test for each model into Kaggle’s machine. The number of eliminated features and GA’s processing Time are gained from the training process in the GA, whereas the Predicted Time is from the test process.

We conducted 26 experiments with several combinations of numbers of population and generation, in which one of the experiments is the model of XGBoost solely. The comparison is given in Table 2. GA\_P25G25 means that the GA parameters used in the experiment are: 25 for the number of populations and 25 for the number of generations.

Based on our experiments, both XGBoost and GA\_P20G15, and XGBoost and GA\_P25G25 have a better result of RMSE than the other algorithms after being examined by using the Kaggle machine. The best predicted time is obtained on the XGBoost and GA\_P15G25 algorithm. The best GA processing time is on XGBoost + GA\_P5G5. The last evaluation is the number of eliminated features. The algorithm that has many deleted features is the one that has the smallest predicted time.

Based on research [19] it was found that the quality of the house, house\_area, median\_house\_neigh, and the house age were the feature importance components in predicting urban residential housing prices. It is found also that the weighted generated model had the best error value of RMSE which is 25,000. As compared to our research, our RMSE is better, and the number of the important features is different.

From previous research regarding house prediction in [20], this research found the smallest errors which are 16208.5 for MAE, 0.878 for  $R^2$  (coefficient of determination), 10135.9 for MedAE (median absolute error), and 754362031.6 for MSE. Those values were obtained using Random Forest algorithm with values of hyperparameters

**Table 2: Comparison Between XGBoost and Genetic Algorithm**

Algorithm	Population	Iteration	Number of Eliminated Features	GA's Pro- cessing Time (sec- ond)	Predicted Time (sec- ond)	RMSE
XGBoost	-	-	-	-	6.825	0.133
XGBoost+GA_P5G5	5	5	172	49.607	3.569	0.152
XGBoost+GA_P5G10	5	10	165	85.021	2.362	0.142
XGBoost+GA_P5G15	5	15	148	123.204	2.068	0.142
XGBoost+GA_P5G20	5	20	164	161.126	1.930	0.138
XGBoost+GA_P5G25	5	25	175	199.863	1.818	0.136
XGBoost+GA_P10G5	10	5	163	92.574	1.935	0.133
XGBoost+GA_P10G10	10	10	174	168.733	1.803	0.140
XGBoost+GA_P10G15	10	15	155	246.618	2.027	0.136
XGBoost+GA_P10G20	10	20	174	322.058	1.857	0.144
XGBoost+GA_P10G25	10	25	176	396.661	1.832	0.133
XGBoost+GA_P15G5	15	5	159	137.853	1.989	0.141
XGBoost+GA_P15G10	15	10	165	251.729	1.978	0.139
XGBoost+GA_P15G15	15	15	174	368.672	1.808	0.135
XGBoost+GA_P15G20	15	20	166	484.766	1.896	0.137
XGBoost+GA_P15G25	15	25	181	642.557	1.750	0.130
XGBoost+GA_P20G5	20	5	165	185.300	1.931	0.143
XGBoost+GA_P20G10	20	10	169	338.597	1.899	0.134
XGBoost+GA_P20G15	20	15	172	487.316	1.855	0.129
XGBoost+GA_P20G20	20	20	159	646.379	1.997	0.138
XGBoost+GA_P20G25	20	25	154	800.272	2.033	0.133
XGBoost+GA_P25G5	25	5	153	232.330	2.030	0.137
XGBoost+GA_P25G10	25	10	151	421.556	2.070	0.132
XGBoost+GA_P25G15	25	15	150	615.438	2.075	0.138
XGBoost+GA_P25G20	25	20	160	804.718	1.984	0.143
XGBoost+GA_P25G25	25	25	163	987.446	1.939	0.129

are 41 for the number of estimators, 63 for maximum features, and criterion is mse. These values are bigger than the value of the best RMSE of our research.

Another research found 8.31% for MDAPE (median absolute percent error), 14 minutes of CPU-time training, 7.3 minutes of CPU-time predicting using the cluster aggregation model in the lazy learning model of kNN and 5000 objects strong Uppsala municipality sample [21]. This research obtained a better error value rather than ours. However, for the predicted times and processing time, our research is better than this research.

## 4 CONCLUSION

Our research found that the hybrid GA with XGBoost resulted in the best RMSE, processing times, and predicted times compared to the sole XGBoost. It is also found that there are two features that most contributed to housing price prediction: OverallQual, which represents the overall material and finish quality of the house, and GrLivArea, which represents above-grade (ground) living area square feet of the house. Based on the comparison to three previous research, our research could perform better error values than two of those research. Thus, the hybrid method could be developed for housing price prediction.

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# CERTIFICATE

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