Series: Atlantis Highlights in Engineering

Proceedings of the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023)

PREFACE

Conference name: Proceedings of the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023)
Date: 14-15 September, 2023
Location: Yogyakarta, Indonesia (Hybrid)
Website: https://incite.ubaya.ac.id/

We proudly present the proceedings of the 4th International Conference on Informatics, Technology, and Engineering 2023 (InCITE 2023), published as part of the Atlantis Highlights in Engineering series. The conference was successfully held in a hybrid setting on September 14–15, 2023, in Yogyakarta, Indonesia. InCITE 2023 is organized by the Faculty of Engineering, University of Surabaya (UBAYA). The conference theme, “Adaptive, Resilient & Collaborative Engineering: Towards Faster Recovery & Impactful Solutions,” set the stage for insightful discussions and breakthroughs across four key tracks: engineering design and innovation, manufacturing and engineering processes, power systems and energy management, and IT for innovation enhancement.

During InCITE 2023, we had the privilege of hosting five distinguished keynote speakers who shared their expertise on critical topics. One speaker emphasized

the influential role of strategic design in eliciting specific emotions, showca its potential to drive consumer behavior and inspire positive environmenta actions. Another introduced an innovative framework that combined affect/Kansei-based design principles, design thinking, and sustainability approaches, offering a holistic methodology for product/service improvement. Thailand's adaptive and resilient use of technology during the COVID-19 pandemic was another keynote highlight. This speaker emphasized the role of online education, remote work tools, e-commerce platforms, collaboration software, and information-sharing applications in helping citizens endure and recover from the crisis. Additionally, one keynote explored the versatile applications of pillared interlayered clays (PILCs) as eco-friendly adsorbents and catalysts, emphasizing their alignment with green chemistry principles for sustainable pollutant removal and catalytic reactions. Lastly, a keynote speaker delved into the potential benefits and challenges of implementing 6G-based vehicular ad hoc networks (VANETs) within intelligent transportation systems (ITS), emphasizing improved communication capabilities, enhanced reliability, and the importance of addressing security vulnerabilities.

InCITE 2023 attracted 67 submissions from authors from diverse countries such as Indonesia, Netherlands, Australia, South Korea, Bangladesh, and Vietnam, where 53 papers were selected for presentation, which was divided into nine parallel sessions. These papers reflect the high quality and global relevance of the research shared, underscoring the conference's role as a catalyst for interdisciplinary collaboration and knowledge exchange.

We extend our sincere gratitude to our keynote speakers, diligent reviewers, dedicated organizers, and talented authors for their invaluable contributions to the success of InCITE 2023. The collaborative spirit, innovative ideas, and scholarly excellence showcased at this conference reaffirm our commitment to advancing engineering, technology, and informatics. Finally, we would like to express our sincere appreciation to the Atlantis Press Editorial Board for their valuable contributions and unwavering support throughout the preparation of the proceedings.

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54 articles

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Peer-Review Statements

Markus Hartono, Hudiyo Firmanto, Connie Susilawati

All of the articles in this proceedings volume have been presented at the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023) during 14-15 September 2023 in Yogyakarta, Indonesia, which was held in hybrid mode. These articles have been peer reviewed by the members...

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Warehouse Safety in Order Picking

Donna Kharisma, Markus Hartono

Safety in warehouse becomes one of the important factors in manual order picking process. Workplace accidents can be caused by a variety of things, including the use of incorrect tools, a lack of work processes, inadequate equipment and safety equipment, and pickers' negligence. Picker safety must...

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Designing Smart Contracts on Insurance Claims to Support the Supply Chain Performance

Josephine Permata Sari, Joniarto Parung

Blockchain as a distributed ledger technology that can guarantee transparency and speed in real time is increasingly being used to increase supply chain performance directly or indirectly. Blockchain in the form of smart contracts in the insurance business will speed up insurance claims and increase...

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Measuring E-Service Quality & Webqual 4.0 in ICMS Through Kano Method & Importance-Performance Analysis For Development Strategies

Billy Hartanto, Moses Laksono Singgih

This research focuses on the Palm Oil Company (POC), operating in Indones palm oil industry, and its implementation of the Integrated Calibration Management System (ICMS) application. The study aims to analyze the quality of the ICMS application and propose alternative solutions based on the quality...

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Lean Manufacturing to Reduce Production Time for Pressure Vessel Production

Bintang Timur Lazuardi, Moses Laksono Singgih

In a fiercely competitive business landscape, every company must optimize its resources and minimize wastage in the production process. At the Pressure Vessel Company (PVC), a study revealed various areas of waste, including non-compliant raw materials, delayed engineering documents, extended production...

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The Application of the Box-Jenkins (BJ) Method for Process Identification of the Batch Milk Cooling System

Rudy Agustriyanto, P. Setyopratomo, E. Srihari Mochni

The Box-Jenkins (BJ) method is a well-known system identification method that has been applied in several fields. Engineers use the Box-Jenkins method for quality control and process optimization in manufacturing. It can identify patterns and trends in production data, leading to improvements in product...

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Performance and Kinetic Study of Xylan Hydrolysis by Free and Immobilized *Trichoderma* Xylanase

Lieke Riadi, Yuana Elly Agustin, Lu Ki Ong, Ferrent Auryn Hadiwijaya, Amelia Winoto, Edrea Adelia Gunawan, Jessica Tambatjong, Tjie Kok

Enzyme immobilization is essential for enhancing the stability and reusability of enzymes in various industrial processes. To improve its feasibility, efficient yet simple immobilization techniques were required to be explored with respect to enhance overall catalytic efficiency and/or operational performance....

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Influence of Inulin and Isomalto-oligosaccharides as Thickener on the Stability of Vitamin C Containing $W_1/O/W_2$ Double Emulsion

Lanny Sapei, Emma Savitri, Hillary Emmanuella Darsono, Yenni Anggraeni

Encapsulation with a W1/O/W2 double emulsion (DE) system is a method that could protect vitamin C or other active ingredients from external influences thus increasing their stability and bioavailability. The DEs were prepared using hydrogenated coconut oil (HCNO) and middle chain triglycerides (MCT)...

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Effect of the Amount of KIO_3, Water, and Stirring Time on Salt Quality in the Iodization Process

Herry Santoso, Febianus F. Setyadi, Maria Lestanur, Kevin C. Wanta, Angel Nadut, Judy R. Witono

Currently, IDD (Iodine Deficiency Disorder) is a problem that still requires attention from the Indonesian government. IDD problems can be overcome by adding iodized salt to daily food. However, the quality of consumption salt produced by small industries in Indonesia is still relatively low in terms...

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Carboxylated Multi-walled Carbon Nanotubes/Calcium Alginate Composite for Methylene Blue Removal

Puguh Setyopratomo, Restu Kartiko Widi, Rudy Agustriyanto, Endang Srihari

In this research work, the adsorption of methylene blue (MB) on carboxylated poly-walled nanotubes carbon (PWNC)/calcium alginate composite was studied. The composite was synthesized by the impregnation method. The study was aimed to observe the impact of carbon nanotube dosage on the ability of the...

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Delignification and Characterization of Fiber from Durian Peel Waste

Emma Savitri, Prayogo Widyastoto Waluyo, Leonardus Edward Layantara, Nathasya Fabiola Rusly

The limited availability of natural fiber sources makes durian peel waste an alternative source of natural fiber. The characteristic of durian peel waste, which is mechanically strength, has the potential to be developed. During the durian season, the amount of durian consumption by the community increases...

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Lean and Green Value Stream Mapping: Case Study of an East Java Furniture Factory

Reyhan Iskandar, Moses Laksono Singgih

Research on lean principles in developing countries remains limited, highlighting the need for exploring alternative methods that have a positive environmental impact. One such approach is the utilization of the Value Stream Mapping (VSM) method to develop a system for waste reduction in production processes....

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The Adoption of the Response Surface Methodology within the DMAIC Process to Achieve Optimal Solutions in Reducing Product Defect

Yenny Sari, Amelia Santoso, Nadia Angelina Putri Pangestu

The high number of defective products can cause the company to receive many complaints. This research aimed to apply the quality improvement approach i.e.,

the DMAIC methodology (Define-Measure-Analysis-Improve-Control), to rec product defect. The object of discussion was the black-color cloth hangers..

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Behavior of Vehicle Platoon with Limited Output Information Based on Constant Time Heading

Agung Prayitno, Veronica Indrawati, Pyae Pyae Phyo

This paper presents synchronization of vehicle platoon with limited-output information based on constant time heading spacing policy. Two control schemes, namely neighborhood controller neighborhood observer and neighborhood controller local observer designed based on constant time heading will be applied...

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The Interaction Effect of $CaCo_3$ Composition, Injection Temperature, and Injection Pressure on the Tensile Strength and Hardness of Recycled HDPE

Hendra Prasetyo, Yon Haryono, The Jaya Suteja

The mechanical properties of recycled High-Density Polyethylene (HDPE) are inferior compared to non-recycled HDPE. To overcome this problem, Calcium Carbonate (CaCO3) is added to improve the material's mechanical properties. The temperature and injection pressure changes can affect the material's mechanical...

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Comparing the Effects of Efficiency and Distortion in Audio Power Amplifiers with and without Tracking Power Supply Circuit Design

Yohanes Gunawan Yusuf, Veronica Indrawati

This research aims to compare the effects of efficiency and distortion in Audio Power Amplifiers with and without Tracking Power Supply (TPS) circuit design. The TPS circuit design is known for enhancing power efficiency while keeping low distortion in the amplifiers. This paper examined the performance...

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Risk Analysis to Mitigate Dominant Risk of Electrical Infrastructure Construction

Salim Afif, Moses Laksono Singgih

Over the past 5 years, the achievement of the Risk Maturity Model (RMM) level value at PT PLN (Persero) UID Bali has not yet reached the target with a gap of 0.47 from the target of 4.19 at the end of 2024. The company's lack of optimization in using the budget period 2018-2023 may be an indicator that...

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Reducing Procurement Waiting Time through Lean Six Sigm

Bagoes Iman Prakoso, Moses Laksono Singgih

A Mass Transportation Manufacturer (MTM) is a pseudonym for the company's name as the subject in this study, faces significant challenges in its procurement process, particularly in acquiring components from foreign suppliers, which often results in prolonged delays. This delay in procurement has a direct...

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A Model for Evaluating the Impact of Priority Rules on Flow Time and Wait Time In A Job Shop Scheduling System: A Single Machine Case

Muhammad Usman Nisar, Andi Cakravastia Arisaputra Raja, Anas Ma'ruf, Abdul Hakim Halim

In the dynamic realm of job shop scheduling (JSS), where decisions regarding the order of job processing have a significant impact on the initial state and performance of the system, addressing the effects of priority changes becomes crucial. To address this challenge, the first part of the study proposes...

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Modeling and Optimization of Location Selection of Fuel Terminal Considering Vessels and Pipeline Operations

F. Qudsi, R. T. Cahyono, N. F. Sa'idah

This study discusses mathematical modeling using the mixed-integer linea programming (MILP) technique for selecting the optimal fuel terminal loca which considers not only aspects of ship and pipeline transportation, but also marine technical aspects. In addition, coverage days are also included...

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Lean Six Sigma and TRIZ to Reduce Non-Value-Added Activities of the Transformer Production Process

Adritho Zaifar, Moses Laksono Singgih

Electronic Transformer Producer (ETP, a nickname) is electronic transformer manufacturing and distribution in Indonesia. The company has encountered challenges in meeting the escalating demands for both quantity and quality from its clientele. Concurrently, the company strives to curtail superfluous...

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Driving Growth in Village Industries: Exploring Effective Financing Facilities for Micro and Small Enterprises

Gunawan

The challenge of financing for micro and small manufacturing enterprises is a global issue but needs local solutions, as the industry characteristics and financing facilities are different among countries and even within countries. In the post-pandemic period, recovering micro and small industries in...

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Remarshaling in A Bin-to-Person-based Smart Automated Warehouse

Ivan Kristianto Singgih, Mai-Ha Phan, Indri Hapsari

In a bin-to-person warehouse, robots lift and then transport racks that contain items from the replenishment area to the storage area and from the storage area to the pickup area. In such an automated warehouse, it is necessary to ensure smooth item flows. One of the important decisions is on which racks...

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Comparison of Classification Machine Learning Models for Production Flow Analysis in a Semiconductor Fab

Ivan Kristianto Singgih, Stefanus Soegiharto, Arida Ferti Syafiandini

A semiconductor fab has complex wafer lot movements between machines and workstations. To ensure a smooth flow of the wafer lots, the system must be observed appropriately. Observation of such a complicated system is possible using machine learning. In this study, various machine learning techniques...

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Circular Economy at LNG Bontang Company: Transforming Aluminum Jacketing Waste Into Sacrificial Anode Products

Defi Willy Simanjuntak, Moses Laksono Singgih

In the industrial activities of the company, one of the crucial considerations and management aspects is waste. At PT. Badak NGL, an existing environmental issue pertains to aluminum jacketing waste. This waste emanates from the factory's operational activities, thereby presenting an opportunity for...

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Restructuring Job Design Using Job Analysis to Balance Workload and Enhance Productivity

Revy Maghriza, Moses Laksono Singgih

One logistics company in Indonesia has experienced a drastic increase of 60% in the demand for imported goods from 2018 to 2022. This upward trend is expected to continue. The admin staff, leader, and supervisor of the Export-Import Department feel the direct impact and are experiencing a higher workload...

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Design of Mid Drive Electric Cargo Bike for Urban Area

Sunardi Tjandra, Susila Candra, Albertus Agung Jody Saputra, Yehezkiel D. Faraisc Putra

Some couriers use bicycles for work. However, it is not efficient because relies on their stamina, which can affect the delivery duration and capacity. E-bike can be

a solution to this problem. However, its price is unaffordable for most courie is necessary to modify the couriers' bicycles into...

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The House of Risk with Multi-Actor Approach Aligned with ISO 31000:2018 for Effective Risk Management in Business with Risky Environment

Evy Herowati, Rosita Meitha Surjani, I Made Panca Bayu Tarsa Ragacca

Effective risk management requires a thorough comprehension of risks and the involvement of multiple actors in the process. In conjunction with the internationally recognized ISO 31000 standard, the House of Risk (HOR) framework provides a robust approach to risk management. This article examines the...

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Centralized AGV Control Systems based on OutsealESP32 PLC and ESP-NOW Protocol

Fransiscus Xaverius Florenza, Hendi Wicaksono Agung

In this paper, a centralized wireless AGV control system is presented using the OE32-PLC board. The OutsealESP32 PLC (O32-PLC) is a combination of the Outseal PLC Mega and the ESP32. Wire-less communication is carried out using the ESP-NOW protocol. The system is divided into three sections according...

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Improving Loading and Unloading Performance at Patimban Port Car Terminal with a Lean Strategy

Yanuar Ardiansyah, Moses Laksono Singgih

Patimban Port located in Subang, West Java, has gained recognition as a National Strategic Project. Its operations, which commenced in December 2020, area primarily designed to optimize the Car Terminal's functionality. This terminal facilitates the loading and unloading of Completely Built Up (CBU)...

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The Influence of Noise Factors on Concentration Based on EEG Signal

Rahmaniyah Dwi Astuti, Rahma Sabilah Nurbi, Bambang Suhardi, Pringgo Widyo Laksono, Irwan Iftadi

The noise intensity with different levels can affect human cognitive abilities, performance, and brain activity. Human cognitive performance, especially concentration, is needed when doing work activities. However, there are still few studies related to the effect of continuous noise in the textile industry...

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Indonesia e-Bike Consumer Preference Trough Market Poter Research: A Choice-Based Conjoint Analysis

Andi Ameera Sayaka Cakravastia, Anas Ma'ruf

E-bike is gaining popularity and accelerating the bike industry to speed up new product development. This study aims to identify e-bike preferences desired by consumers through market research. The choice-based conjoint method analyzes consumer preferences, forecasts potential e-bike market share, and...

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Electric Vehicle Charging Allocation Considering Electricity Price Fluctuation

Ivan Kristianto Singgih, Christian Yavin Ibrahim, Stefanus Soegiharto, Olyvia Novawanda

Charging decisions on electric vehicles is an important aspect to consider for ensuring the continuity of the electric vehicle demand satisfaction. An electric vehicle system could not operate well without sufficient resources for charging each vehicle's battery after its use. In this study, we...

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Overview of Ergonomics and Safety Aspects of Human-Cobot Interaction in the Manufacturing Industry

Muhammad Ragil Suryoputro, Tieling Zhang, Senevi Kiridena

The technological advancements accompanied by Industry 4.0 have create more opportunities for collaborative interactions between humans and machines. In work environments where humans work alongside collaborative robots (i.e., cobots), there is a critical need to address ergonomics and occupational...

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Affective-based Human Factors Design: Design Thinking & Sustainability Approach

Markus Hartono

This paper proposes a refined framework of affect/Kansei-based applied to product/service experience considering design thinking and sustainability approaches. Design thinking facilitates more comprehensive step-by-step methodology starting with more human basic needs, followed by the global issues which...

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Performance Evaluation of Roof Tile Solar PV under Tropical Climate of Surabaya, Indonesia

Elieser Tarigan, Fitri Dwi Kartikasari, Fenny Irawati, Rafina Destiarti Ainul, Pradiksa Pratyahara Kirana

This paper discusses the applications of roof tiles type of PV modules. Published researches on this topic were reviewed. In addition, performance evaluation of a

roof tile type of PV modules was conducted under the tropical climate of Surabaya, Indonesia. The objectives of present study are to review...

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Pillared Interlayered Clays (PILCs): Harnessing Their Potential as Adsorbents and Catalysts - A Mini Review

Restu Kartiko Widi

The Pillared Interlayered Clays (PILCs) have attracted significant attention in recent years due to their versatile applications as adsorbents and catalysts in various environmental and industrial processes. This mini review presents a comprehensive overview of the recent researches conducted on PILCs...

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Implementation of K-Means and K-Nearest Neighbor Methods for Laptop Recommendation Websites

Vincentius Riandaru Prasetyo, Mohammad Farid Naufal, Budiarjo

Along with technology development, laptops are becoming increasingly popular and are handy tools in everyday life. However, with so many brands and laptops available, people often find it difficult and need help choosing the laptop that best suits their needs and desires. A website-based system has been...

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Implementation of Recency, Frequency, and Monetary Patterns in Adaptive Blockchain-Based Transactions

Daniel Soesanto, Igi Ardiyanto, Teguh Bharata Adji

The development of cryptocurrency cannot be separated from the development of blockchain technology. However, problems arise related to the scalability of the blockchain itself. The long duration of the consensus process means that the scalability of the blockchain cannot increase. Various methods have...

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Electronic Election for Small Medium Non-Profit Organizations in Indonesian Cities

Felix Handani

Elections in Indonesia often include direct voting, enabling every community member to immediately contribute to the election process and support their chosen leader. The digital divide, the security of data and systems, verification and transparency, and the legal and social-cultural acceptance of online...

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Online Claim and Guarantee Mechanism for Electronics Peripheral in Urban Country

Liliana, Felix Handani, Daniel Soesanto, Maya Hilda Lestari Louk

According to consumer protection law, business actors must provide good services, including post-transaction services. Most of the current warranty claim process is still done conventionally, where consumers must come to the store to bring their documents and goods and ask the officer for the repair...

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Perceived Usability Evaluation of IRiS: an Integrated Recommendation Collection System

Jimmy, Kristian Tanuwijaya

This study evaluates the perceived usability of IRiS, which was developed to collect recommendations from senators related to the election of principals in the University of Surabaya (UBAYA). The primary question of this study was “Will IRiS be usable for all senators to use as intended?”. The answer...

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Incorporating Interactive Elements into Children’s Storybook to Improve Children’s Motivation to Learn Bible: Case Study on the Parable of the Sower

Ng Melissa Angga, Tyrza Adelia, Jiechella Davidson

Christian children frequently show low enthusiasm in learning the Bible due to difficulties in understanding the language and unappealing content for their taste. Moreover, their motivation towards Bible studies getting even lower by the exposure to more captivating multimedia products available in this...

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Development of Artificial Immune System in Multi-Objective Vehicle Routing Problem with Time Windows

Iris Martin, Eric Wibisono

Setting logistics routes and product distribution in everyday problems, such as delivery of fresh products, requires an algorithm that can produce decisions in a short time. This type of problem belongs to a methodology popularly known as the vehicle routing problem (VRP). VRP is NP-Hard, and its complexity...

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Has Website Design using Website Builder Fulfilled Usability Aspects? A Study Case of Three Website Builders

Argo Hadi Kusumo

The significance of e-commerce is particularly crucial for businesses. The enhancement of sales can be achieved through the contribution of e-commerce. In the current era of digitalization, it is unnecessary for SMEs to develop e-commerce platforms from scratch. Instead, they can opt for affordable website...

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Design of Employee Bus Routes for Madiun City Government Based on Home Locations and Presence Location History

Daniel Hary Prasetyo, Arizia Aulia Aziiza, Endang Sulistiyani

Madiun City is strategically positioned as the center of regional activities in the western part of East Java Province. Based on the data presented for the City of Madiun in Figures for 2022, the number of residents and private vehicle units is almost the same. Hence, road congestion is likely to occur....

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Arabic Letter Classification Using Convolutional Neural Networks for Learning to Write Quran

Mohammad Farid Naufal, Muhammad Zain Fawwaz Nuruddin Siswantoro, Andre

Learning to write the Arabic language, particularly the Arabic letters used in the Quran, is essential for individuals who aim to understand and recite the holy book accurately. In this research, we propose a classification method utilizing Convolutional Neural Networks (CNNs) with MobileNet architecture...

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Alveolar Bone Quality Classification from Dental Cone Beam Computed Tomography Images using YOLOv4-tiny

Monica Widiasri, Nanik Suciati, Chastine Fatichah, Eha Renwi Astuti, Ramadhan Hardani Putra, Agus Zainal Arifin

Bone quality is essential in dental implant planning for successful implant placement. Bone quality can be determined based on bone density observed from Beam Computed Tomography (CBCT) images which are commonly used in dental implant planning. The most accepted classification of alveolar bone quality...

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Exploring the Impact of Mobile-Based 3D Simulation on Student's Achievement and Satisfaction in Physics Education

Lisana Lisana, Edwin Pramana

The purpose of this study is to investigate the efficacy of utilizing a mobile-based 3D simulation to support students in the 11th grade in their learning of physics. The precise subject matter that was selected for this piece of research was the equilibrium of rigid bodies. There were 91 students from...

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An Encrypted QR Code Using Layered Numeral Calculation for Low Powered Devices

Rafina Destiarti Ainul, Susilo Wibowo, Irzal Zaini

Providing security system for every electronic data exchange through internet as the unsecured medium has become an essential regulation. Conventional Caesar Cipher had less computation complexity than other security method that really appropriate with low powered device requirement. However, it is susceptible...

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Spices Identification in Essential Oil Producers using Comparasion of KNN and Naïve Bayes Classifier

Fifin Ayu Mufarroha, Achmad Zain Nur, Mohammad Rizal Rahabillah, Achmad Jauhari, Devie Rosa Anamisa, Mulaab

Indonesia is a spice-growing country, providing a variety of spices with numerous health advantages. Aside from being a producer, Indonesia is the world's largest supplier of spices. Spices have a wide range of usage, including food ingredients, herbal medicines, and essential oils. Essential oils are...

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Long Short-Term Memory Method Based on Normalization Data For Forecasting Analysis of Madura Ginger Selling Price

Devie Rosa Anamisa, Fifin Ayu Mufarroha, Achmad Jauhari, Muhammad Yusuf, Bain Khusnul Khotimah, Ahmad Farisul Haq

Forecasting is a method for estimating a future value using past data. The selling price of Madura ginger needs a forecasting analysis to predict future prices because, until now, the selling price has increased significantly. This analysis aims to increase trade business competition and maintain sales...

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Analyzing the Probability Density Distribution of Sustained Phoneme Voice Features in the PC-GITA Dataset for Parkinson's Disease Identification

Nemuel Daniel Pah, Veronica Indrawati, Dinesh K. Kumar, Mohammod A. Motin

One of the possibilities for developing computerized diagnostic tools for Parkinson's disease (PD) is to utilize the voice change known as Parkinsonian dysarthria. Voice features extracted from sustained phonemes have been statistically investigated as parameters for this purpose. However, the commonly...

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Drowsiness Eye Detection using Convolutional Neural Network

Heru Arwoko, Susana Limanto, Endah Asmawati

Eye fatigue while driving can cause drivers to be drowsy and less alert, which can potentially increase the risk of an accident. Existing data shows that the number of accidents in the world is increasing from year to year. One of the most common causes of accidents is fatigue and the leading cause of...

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Drowsiness Eye Detection using Convolutional Neural Network

Heru Arwoko[1], Susana Limanto[1*], Endah Asmawati[1]

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Abstract. Eye fatigue while driving can cause drivers to be drowsy and less alert, which can potentially increase the risk of an accident. Existing data shows that the number of accidents in the world is increasing from year to year. One of the most common causes of accidents is fatigue and the leading cause of death is car accidents. Therefore, efforts are needed to reduce accidents due to fatigue. To overcome this, in this study, a system was developed to detect driver eye fatigue using the Convolutional Neural Network method with varying image sizes as input. The dataset consists of 1289 facial images that contain the eyes and is divided into 614 drowsiness eyes and 675 non-drowsiness eyes. In dealing with variations in image size, scaling was carried out using five interpolation methods, namely nearest-neighbor, bilinear, bicubic, inter-area, and lanczos4. The performance of the sleepy eye detection model will be evaluated based on accuracy and processing time. The results show that the image size of 64×64 with bilinear interpolation and 96×96 with inter-area interpolation gives the highest accuracy of 99%. Based on processing time, resizing the image to 8×8 size by using bilinear, bicubic, inter-area, and lanczos4 interpolation, results in the fastest processing time and high accuracy of 94% - 95%. The difference in accuracy with other image sizes is only 5%, with processing time for other size images up to 200 times longer than processing time for 8×8 image sizes.

Keywords: Drowsiness, Eye Fatigue Detection, Convolutional Neural Network, Interpolation.

1. Introduction

The eye is one of the five senses that helps humans in carrying out daily activities. Without the help of the eyes, some activities cannot be carried out, such as driving a vehicle. However, as one of the organs of the body, the eyes can experience fatigue, so they need rest. Eyes that are tired if forced to move will cause decreased concentration and can even interfere with eye health.

Someone who drives a vehicle needs the help of the eyes to know the situation of the road being traversed so that they can move properly. However, driving for too long, hot weather, or the situation on the road being traversed can cause the eyes to

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become tired so that the driver becomes drowsy. This condition causes the driver to be less concentrated and alert so prone to accidents [1], [2]. Accidents can result in motorists or other people experiencing injuries, material losses, being unable to return to normal activities, and can even cause death [3]. Existing data shows that the number of accidents in the world is increasing from year to year [4], [5], Indonesia is no exception [6]. In 2020, the number of traffic accidents in Indonesia reached 100,028 and in 2021 it increased to 103,645 [7]. One of the most common causes of accidents is fatigue [4] and the leading cause of death is car accidents [5]. Therefore, efforts are needed to reduce accidents due to fatigue. According to data statistics, nearly 1.3 million people have road traffic accidents every year, one of which is due to drowsiness [3], and Traffic Safety Foundation of the American Automobile Association report that 16-21% of traffic accidents are caused by driver fatigue [8].

Various studies have been developed to detect driver sleepiness based on changes in driver behavior, such as eye movements, mouth, head, and facial expressions with the help of cameras and image or video processing techniques [6]. Sleep detection based on whether the eyes are open or closed was developed by [5]. The determination of open or closed eyes is done using the Eye Aspect Ratio (EAR), which calculates the ratio of the distance between horizontal and vertical eye landmarks. The detection results will be used to sound an alarm. If the driver is still detected with eyes closed after 50 alarms, the system will send an SMS and email to the driver's family members containing a photo, the driver's location, and a message that the driver is sleepy. The same research was conducted by [3] by using the Convolutional Neural Network (CNN) and [9] by using Deep CNN. Reference [10] also doing research to detect open or closed eyes but considering different resolution variations and lighting conditions. The research was conducted using images that have been scaled to a size of 224×224 pixels using a deep residual convolutional neural network.

Drowsiness, defined as a state when a person needs rest to sleep, can cause major accident hazards while on task, delayed response time, lack of awareness, or microsleeps [2]. A drowsiness detection system based on the geometric features of the eyes and mouth was developed by [4]. Eye-based drowsiness detection is done using EAR. While yawning detection is done by calculating the distance between the lower lip and upper lip and then compared with a predetermined threshold value. The level of drowsiness obtained is used to sound the alarm. Research yields close to 100% accuracy when the image is in the right position and not wearing anything.

Research conducted by [2] detects driver fatigue from a series of images with a duration of 60 seconds. Before use, the resulting image is scaled so that it has a size of 64×64 pixels. After being scaled, the images are processed using two methods, namely: CNN and a combination of AI and CNN. The second method [2] uses a combination of linear SVM and histogram of oriented gradients (HOG) to detect the location of the driver's face. The accuracy of the research results from the two methods did not differ, namely: around 65% for training data and more than 60% for test data. However, the second method has advantages, namely it can work continuously without disturbing the driver when he is not sleepy because the system only sounds an alarm incorrectly once out of 60 videos.

In this study, the detection of drowsiness eyes will be carried out using the CNN method. This method was chosen because the classification ability of this method in image recognition is very good [10]. The model will be developed using various image sizes. Image size scaling will be performed using five different interpolation methods to reduce the possibility of loss of information. The use of interpolation for image scaling is an advantage of this study. The performance of the sleepy eye detection model will be evaluated based on accuracy and processing time. This research is part of a larger study that focuses on developing methods to detect generally sleepy eyes based on real-time data captured by the camera. What is meant by "in general" is not limited to vehicle drivers, but can also be used for other activities, such as detecting drowsiness in people at a meeting.

2. Materials and Methodology

The research methodology consists of five stages, namely: dataset collection, preprocessing, classification model, training and testing, and performance evaluation. Fig. 1 shows the flow of the research methodology used in this study.

2.1 Workflow

Eye fatigue detection is important for rider safety. For this reason, it is necessary to develop an intelligent system that can detect drowsiness accurately and quickly. In this research, eye fatigue was detected using the Convolutional Neural Network (CNN). Accuracy and convergence of CNN process results are determined by the setting hyperparameters, including the number of epochs, momentum, and learning rate are the most common hyperparameters [11]. In this study, the CNN accuracy performance in detecting drowsiness was increased from different points of view. The CNN process requires a uniform input image [12]. The existing input images are not always uniform and vary widely. So, it is necessary to transform the image into a fixed size for the CNN process. To resize an image from a large size to a smaller size raises the significant loss of image pixel information. The image needed for the smoothing process through the interpolation method [13], as shown on the process of flow diagram in Fig. 1.

In this research, the optimization of the CNN process was used by changing the size of the image. In the first step, dataset collection is carried out. This dataset has image sizes that vary from 206×162 to 255×200. In this study, the size was made uniform to 8×8, 16×16, 32×32, 64×64, 96×96, 128×128, 160×160, and 192×192. Meanwhile, the interpolation process uses five methods, including nearest-neighbor, bilinear, bicubic, inter-area, and lanczos4 interpolation. Then measure the image quality using the Peak Signal-to-Noise Ratio (PSNR), which is an expression for the ratio between the maximum intensity value of the image and the noise strength that affects its representation.

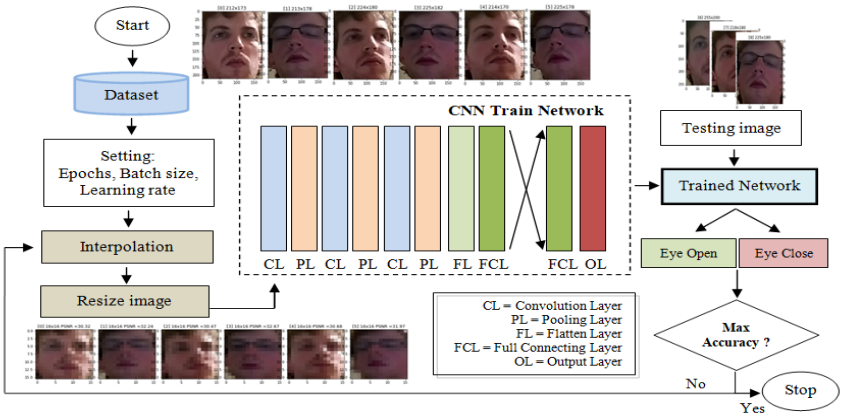


Fig. 1. Flow Diagram of Drowsiness Detection.

2.2 Dataset

Sleepy and not sleepy face images are collected from the public dataset available repositories from http://vlm1.uta.edu/ and were used in this work. The dataset consists of a total of 1289 facial images, which were divided into 614 sleepy faces and 675 not-sleepy faces. Image sizes vary from 206-255 pixels in height, 162-200 pixels in width. The average shape image is $231 \times 181 \times 3$. Next, the image must be set to the same resolution for CNN processing.

2.3 Image Interpolation

Interpolation is a method of generating new data points within a range of discrete sets. The most widely used interpolation techniques for vision computers are nearest-neighbor, bilinear, bicubic, inter-area, and lanczos4. In general, to enlarge an image, it is better to use bilinear or bicubic interpolation, otherwise for shrinking the image, it is better to use inter-area interpolation.

Nearest-neighbor interpolation is a simple method because it replaces the new pixel value with the nearest neighbor. In addition, the method nearest-neighbor does not have calculations. This pixel replication will replace the existing pixel value which repeats the predetermined pixel value according to the desired magnification size.

Bilinear interpolation, new pixel values based on the weighted average of the 4 pixels nearest neighbors $2x2$ pixels in the image original [13]. Bilinear interpolation determines a new pixel value based on the average weight of 4 pixels at the level of 2×2 neighbors in the original image.

Bicubic interpolation is an interpolation method that uses 16 pixels in the nearest neighboring 4×4 pixels in the original image. Using this bicubic interpolation method can make the edges of the resulting image smoother [14].

Inter-area interpolation is like the Nearest neighbor method when downsampling the image. Inter-area does better at thinning the image and avoids spurious inference patterns in the image.

Lanczos4 interpolation over an 8×8 pixel neighborhood. It performs the same task as the bicubic interpolation method, which is slow and resource intensive.

2.4 Peak Signal-to-Noise Ratio

The quality of the resized image compared to the original image using Peak Signal to Noise Ratio (*PSNR*). The calculation of *PNSR* requires Mean Square Error (*MSE*). Let image A(x, y) is the intensity function of the original image and image B(x, y) is the intensity of the transformed image, both the same size as $M \times N$. Where x and y are spatial domains of the image. Then, *MSE* is calculated using (1). *MSE* is calculated calculated pixel by pixel by adding up the squared differences of all pixels and is divided by the total number of pixels $M \times N$.

$$MSE = \frac{1}{MN} \sum \sum [A(x,y) - B(x,y)]^2 \quad (1)$$

If H is the range of the pixel values, then *PSNR* is calculated using (1). The higher of the *PSNR* value, the higher the image quality.

$$PSNR = 10\ Log\ 10\ [H^2/MSE] \quad (2)$$

2.5 The Architecture of Proposed CNN

The proposed CNN model contains three convolution blocks followed by a fully connected layer and an output layer (see Fig. 2). The CNN architecture consists of an input layer, convolution layer: conv-1, conv-2, conv-3, and each at the end with a max pooling layer. At the end of the network section is a full-connecting layer and output layers. The convolution layer of CNN is responsible for extracting features from input images using some convolutional filters. Convolution layer contains the weights that must be optimized using gradient descent training. The features extracted from convolution layer are mapped into feature space using the nonlinear Rectified Linear Units (ReLU).

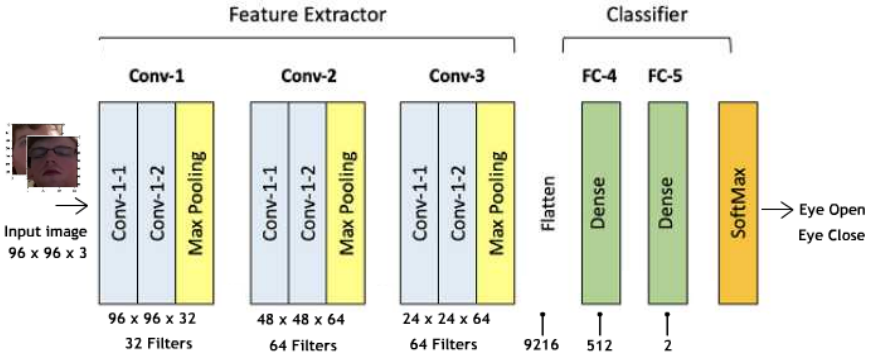


Fig. 2. Architecture of Proposed CNN.

This input image is convoluted with 32 filters of 3×3 size, so the shape of the image becomes $96 \times 96 \times 32$. Then the end of the first convolution is given max pooling with a size of 2×2 so every image size is reduced to 48×48. In the second convolution the shape of the image becomes $48 \times 48 \times 64$ and followed by a 2×2 max pooling so that the image size becomes $24 \times 24 \times 64$ in the third stage of convolution. In the last convolution process after max pooling, the image shape is $12 \times 12 \times 64$, so during the flattening process, $12 \times 12 \times 64 = 9216$ extraction features are obtained. The next step is the multi-layer perceptron (MLP) process by providing 512 hidden neurons in layers FC-4 and 2 neurons FC-5 as the final network target. One characteristic of a drowsy driver is the driver's eyes close for a few moments. So, in this research, the output to be used are eyes open and eyes closed.

3. Result and Discussion

The main objective of this study is designed to get high accuracy in the detection of drowsiness and the required process quickly. So, it is necessary to do experiment to get the optimal input image size for the optimal CNN model. The CNN model in Fig. 1 is implemented through a series of experiments using the hardware specification, Intel(R) Core(TM) i7-7700HQ CPU model, 2.80 GHz main frequency, 8G memory, and GTX1050 GPU.

In our experiment, the TensorFlow Keras platform was used to build a convolutional neural network. The initial values for the CNN training parameters were 20 epochs, 30 batch sizes, 1 stride, same padding, 0.3 validation split, and 0.001 for learning rate. There were 1289 images in the dataset divided into 90% for training and 10% for testing. So for the training data with shape (1160, height, width, 3) and the remaining for the testing data with shape (129, height, width, 3). The height and width of image size vary from 8×8, 16×16, 32×32, 64×64, 96×96, 128×128, 160×160, 192×192. Model performance was measured based on accuracy and time required for the training and testing process.

Table 1 shows the accuracy of the test results with the CNN method for 8 image sizes and five interpolations. The test results for image sizes of 16×16 and above with various interpolation methods yield an accuracy of between 95% - 99%. The best test results were obtained for images measuring 96×96 with an average accuracy of 98.2%. While the best interpolation method is obtained when bicubic interpolation is used with an average accuracy of 96.8%. The highest accuracy, 99%, is obtained when using 64×64 images with bilinear interpolation and 96x96 images with interpolation between areas.

Table 2 shows the time required to obtain classification results using the CNN method with a variety of image sizes and interpolation methods. Based on the average use of processing time, it appears that the larger the image size, the more processing time is required. The average accuracy of all image sizes is above 88%. Although each 8×8 image interpolation method produces the smallest accuracy compared to the others, the processing time is much faster. For 96×96 image size which is the

best size, processing time is 49 times longer than the processing time of 8 × 8 image size.

Based on the accuracy results in Table 1 and the processing time in Table 2, for each interpolation method, resizing the image to an 8 × 8 size using an interpolation other than the nearest produces the fastest processing time with a high level of accuracy. The difference in accuracy with other image sizes is only 5%, whereas the processing time for other sizes can be up to 200 times the processing time of 8 × 8 images. Table 3 shows the resized image in several sizes. Even though the results of resizing to size 8 × 8 are not very clear, the accuracy results are good.

Table 1. Accuracy model for image size - interpolation methods.

Image size	Accuracy					
	Nearest-neighbor	Bilinear	Bicubic	Inter-area	Lanczos4	Average
8 × 8	0.88	0.94	0.93	0.94	0.93	0.924
16 × 16	0.95	0.96	0.96	0.95	0.96	0.956
32 × 32	**0.98**	0.96	**0.98**	0.98	**0.98**	0.976
64 × 64	0.97	**0.99**	**0.98**	0.98	**0.98**	0.98
96 × 96	**0.98**	0.98	**0.98**	**0.99**	**0.98**	**0.982**
128 × 128	**0.98**	0.96	0.96	0.96	0.95	0.962
160 × 160	0.95	0.97	**0.98**	0.97	0.97	0.968
192 × 192	0.96	0.97	0.97	0.95	0.97	0.964
Average	0.956	0.966	0.968	0.965	0.965	

Table 2. Time processing (s) for image size - interpolation methods.

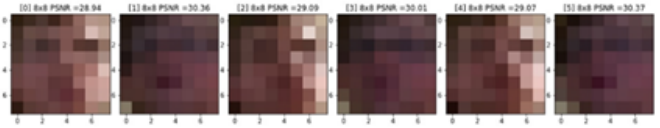
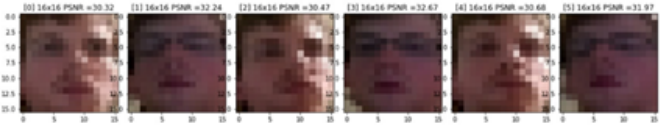
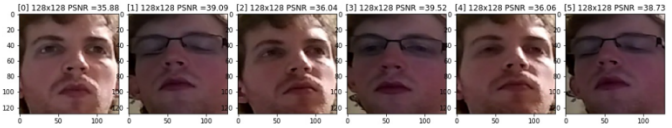
Image size	Time process (s)					
	Nearest-neighbor	Bilinear	Bicubic	Inter-area	Lanczos4	Average
8 × 8	8	9	10	9	9	9
16 × 16	18	20	19	19	19	19
32 × 32	56	58	56	57	58	57
64 × 64	191	183	189	190	194	189.4
96 × 96	437	446	453	443	439	443.6
128 × 128	749	751	761	761	759	756.2
160 × 160	1152	1156	1164	1181	1178	1166.2
192 × 192	1599	1607	1615	1654	1648	1624.6

For image sizes that are too small, the result is lower accuracy. It can be understood that for a small image size the noise value is high, and a lot of lost important information. Mean Squared Error (*MSE*) is a risk function that determines the average squared difference between the pixel value of the original image with the resized image. This can be seen in Fig. 3, that for a smaller image size, the *PSNR* value will

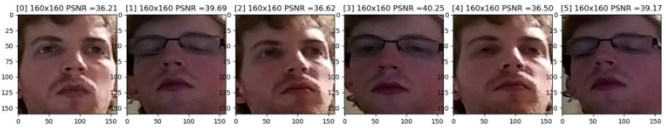
decrease, and the *MSE* value will increase. Mean Squared Error is used to compare the pixel value of the original image to the degraded image. This means that the smaller the image size causes a decrease in image quality.

For image sizes that are too large, the accuracy results are stable. It is understood that for large image sizes, the important information from pixels can be retained. However, it can be seen in Fig. 4 that for large image sizes the processing time is much longer, this is not efficient for the safety purpose of detecting drowsiness in drivers in real-time.

Table 3. Image resizing results in various sizes.

Image size	Image
Original image	
8 × 8	
16 × 16	
32 × 32	
64 × 64	
96 × 96	
128 × 128	

160 × 160



192 × 192

Fig. 3. PSNR and MSE for various image sizes.

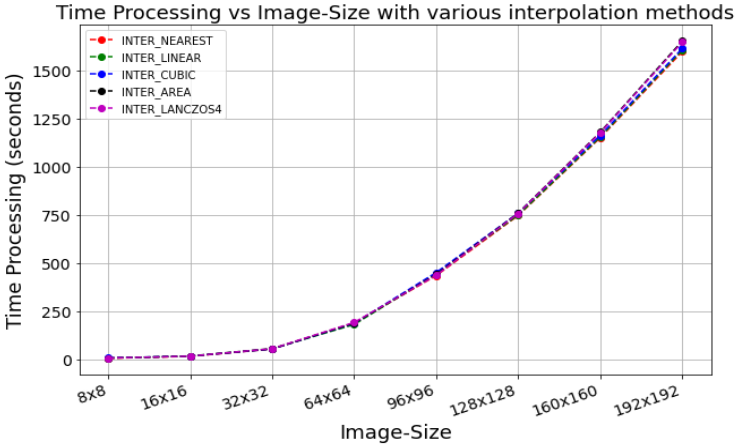


Fig. 4. Time processing for various image sizes.

4. Conclusion

In this study, a performance comparison of various image sizes and interpolation methods was carried out in detecting drowsiness eyes using the CNN method. Based on the results of a comparison of the four interpolation methods at 8 different image sizes, it was found that the optimal image size (highest accuracy) for sleep detection using CNN occurs at an image size of 64×64 for bilinear interpolation and an image size of 96×96 for inter-area interpolation. The interpolation that produces stable accuracy for all image sizes is the bicubic interpolation method. The larger the size of the image, the more time is used to process it, and increase significantly. For detecting drowsiness in drivers, it is necessary to pay attention to work points that require a relatively fast processing time. Resizing to an 8×8 image size produces the fastest processing time with an accuracy rate of 93% - 94% using the bilinear, bicubic, inter-area, and lanczos4 interpolation methods.

In future studies, the best model for detecting drowsiness eyes will be carried out using real-time data taken from the camera. The data used is not only for vehicle driving but also for other conditions. In future research, the performance of the CNN model will also be compared with the performance of other methods such as transfer learning (VGG16, Mobilnet, Resnet50, and others).

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