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IJNMT (International Journal of New Media Technology) is a scholarly open access, peer-reviewed, and interdisciplinary journal focusing on theories, methods and implementations of new media technology. Topics include, but not limited to digital technology for creative industry, infrastructure technology, computing communication and networking, signal and image processing, intelligent system, control and embedded system, mobile and web based system, and robotics. IJNMT is published regularly twice a year (June and December) by Faculty of Engineering and Informatics, Universitas Multimedia Nusantara in cooperation with UMN Press.

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FOREWORD

Greetings!

IJNMT (International Journal of New Media Technology) is a scholarly open access, peer-reviewed, and interdisciplinary journal focusing on theories, methods and implementations of new media technology. Topics include, but not limited to digital technology for creative industry, infrastructure technology, computing communication and networking, signal and image processing, intelligent system, control and embedded system, mobile and web based system, and robotics. IJNMT is published regularly twice a year (June and December) by Faculty of Engineering and Informatics, Universitas Multimedia Nusantara in cooperation with UMN Press.

In this June 2024 edition, IJNMT enters the 1st Edition of Volume 11 No 1. In this edition there are six scientific papers from researchers, academics and practitioners in the fields covered by IJNMT. Some of the topics raised in this journal are: The Potential of "GENIUS": Deep Learning Integrated Application to Fight Obesity, Comparison of Linear and Non-Linear Machine Learning Algorithms for Predicting the Effectiveness of Plant Extracts as Corrosion Inhibitors, Convolutional Neural Network Implementation in BISINDO Alphabet Sign Language Recognition System, Implementation of Support Vector Machine Method for Twitter Sentiment Analysis Related to Cancellation of U-20 World Cup in Indonesia, Avia Saga: A Gamified Mobile-Based Learning Management System

On this occasion we would also like to invite the participation of our dear readers, researchers, academics, and practitioners, in the field of Engineering and Informatics, to submit quality scientific papers to: International Journal of New Media Technology (IJNMT), Ultimatics : Jurnal Teknik Informatics, Ultima Infosys: Journal of Information Systems and Ultima Computing: Journal of Computer Systems. Information regarding writing guidelines and templates, as well as other related information can be obtained through the email address ultimaijnmt@umn.ac.id and the web page of our Journal here.

Finally, we would like to thank all contributors to this June 2024 Edition of IJNMT. We hope that scientific articles from research in this journal can be useful and contribute to the development of research and science in Indonesia.

June 2024,

Fenina Adline Twince Tobing, S.Kom., M.Kom.
Editor-in-Chief

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The Potential of "GENIUS": Deep Learning Integrated Application to Fight Obesity

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***Abstract*— Lifestyle changes regarding food consumption and sedentary lifestyle has led to increase prevalence of obesity worldwide, including in Indonesia. Obesity as a risk factor for various diseases has become an urgent issue considering that currently available therapies have not shown optimal results in overcoming this problem. The "GENIUS" application is present as a body types analysis system and program recommendations for obesity therapy. The purpose of writing this paper is to find out the potential, construction mechanism, and operating mechanism of the application. The methodology of writing this paper is literature review, based on secondary data from databases such as Google Scholar, PubMed, and ScienceDirect. The construction mechanism of the application includes process of collecting dataset, creating the application and deep learning system, and launching the application. The technology utilized in the application involves image processing deep learning and recurrent neural networks, enabling it to generate outputs suit to each individual's needs and provide appropriate program recommendations. Through the "GENIUS" application, users can also consult with medical professionals, receive recommendations, and record clinical data progress in a single digital application accessible via smartphones. The application also provides an interesting sub-feature in the form of reward points given to users for using the application's features. The implementation of the application involves the quadruple helix model. The benefits of the application encompass the fields of health and knowledge, aiming to prevent obesity in order to foster an intelligent generation and achieve a healthy Indonesia.**

***Keywords*— deep learning; diet; exercise; obesity; personal digital assistant**

I. INTRODUCTION

In recent years, obesity has become a global health issue associated with changes in people's lifestyles, such as changes in eating habits and lack of physical activity [1]. Obesity is a condition in which excess fat accumulates in the body as a result of an imbalance between energy intake and energy expenditure. If left untreated, obesity can lead to various serious health problems, such as diabetes mellitus, hypertension, coronary heart disease, respiratory disorders, musculoskeletal disorders, and others [2].

According to data from the World Health Organization (WHO) in 2016, about 650 million adults worldwide are classified as obese. The global prevalence of obesity reached 13%, with more cases occurring in women (15%) than in men (11%). In addition to adults, WHO data also recorded that about 340 million children and adolescents aged 5-19 years are classified as overweight (overweight) to obese [3].

In Indonesia, the prevalence of obesity is 28.7% in adults aged 18 years and over. Meanwhile, for children aged 5-12 years, about 10.8% of them are obese. Recent data on the obesity problem in Indonesia shows that this problem is not yet well controlled. Based on the results of the 2016 National Health Indicators Survey (SIRKESNAS), the number of obese people with a Body Mass Index (BMI) of 27 or higher was recorded at 20.7%, which is an increase from the results of the 2013 Basic Health Research (RISKESDAS) which showed a percentage of 15.4% [4].

The association between obesity and the risk of life-threatening chronic diseases also increases the urgency of this problem. Data from the 2018 RISKESDAS showed that the prevalence of non-communicable diseases related to metabolic syndrome such as diabetes mellitus and hypertension has continued to increase [5]. A study by Pammer et al. (2021) also proved that individuals with metabolic syndrome have a 1.26 times higher risk of death than those who do not [6].

Therapeutic options available today to address obesity include lifestyle modification, medication, endoscopic procedures, and surgery [7]. However, the available therapies have not shown optimal results in addressing obesity globally. Only less than 5% of individuals have been able to lose weight significantly through a combination of diet and exercise. Studies also show that 90% of individuals who participate in diet modification programs regain weight within two years,

or what is known as "yo-yo dieting" [8]. If repeated, "yo-yo dieting" can pose more serious health risks because it disrupts the body's normal metabolism, makes it more difficult to lose weight in the future, and increases the risk of heart disease [9]. Meanwhile, pharmacological and surgical therapies also have side effects, a higher risk of mortality, and a higher cost.

In the current era of digitalization, technology is advancing rapidly in various aspects of human life. One algorithm that has experienced rapid development is deep learning, which is an algorithm that can learn on its own. This technology can automate various complex problems, including analyzing human body types and providing program recommendations. In this case, the technology that can be applied is image processing, which is a part of deep learning that uses multiple computational layers to generate a specific architecture through the concept of object detection [10]. The concept of object detection is an advanced algorithm of the classification procedure, which works by determining the location of an object in an image, then classifying the selected image location according to the predefined category [11]. Meanwhile, the recurrent neural network (RNN) concept is also used to determine the prediction and recommendation of diet and exercise programs that are suitable for a person. This concept is able to read hidden patterns in data by adding computation between nodes in each hidden layer.

Based on the urgency of the problems that have been outlined, there is a need for innovative preventive efforts to prevent obesity and the diseases that can be triggered by obesity. These efforts can be made by empowering all aspects of society, especially the younger generation, while also utilizing the industrial revolution with digitalization through an application called "GENIUS: Gen Z Innovation to Fight Upon Obesity" which is integrated with deep learning. In an effort to create a smart young generation and achieve a healthy Indonesia, in line with the Sustainable Development Goals (SDGs) 2030, point three, namely healthy and prosperous life, and utilizing the industrial revolution 4.0, the author presents a breakthrough in the idea of a paper entitled “The Potential of “GENIUS”: Deep Learning Integrated Application to Fight Obesity”.

II. METHOD

The method of writing this paper uses literature review method from appropriate sources with key words based on the topics raised. Key words used include "obesity", "deep learning", "personal digital assistant", "exercise", and "diet". The data source used in the preparation of this paper is in the form of secondary data derived from literary sources related to the topic raised. The library sources used come from scientific journals such as Google Scholar, PubMed, and ScienceDirect. Other sources used are articles from health associations and government institutions that accountable for the truth. Data collection is based on the results of research and previous assessments that are valid and relevant to the topics discussed.

The data that has been collected is then analyzed systematically with argumentative descriptive analysis techniques. The author presents a descriptive analysis based on valid and relevant data from the results of research and previous studies that are able to strengthen the arguments presented. Arguments are arranged systematically according to the writing component. Drawing the conclusions of this paper is based on the problem formulations and the purpose of writing, and using synthesis analysis studies. The process of synthesis analysis is carried out to combine the formulation of the problem, the purpose of writing, and the discussion, so that conclusions can be drawn which can summarize the essence of writing this scientific paper. The conclusions drawn represent points of ideas, accompanied by recommendations or suggestions for the development of the author's ideas.

III. RESULT AND DISCUSSION

A. Overview of Obesity

Obesity is defined as a condition where there is an excessive accumulation of fat within the body that can adversely affect health [12]. An individual is considered obese when their body mass index (BMI) is equal to or greater than 30 kg/m^2 [3]. Based on the distribution of fat in the body, obesity can be categorized into two types:

1. Apple-type obesity

Individuals with apple-type obesity resemble the shape of an apple, characterized by excessive fat accumulation in the upper body, around the chest, shoulders, neck, as well as the wall and cavity of the abdomen [13]. This type of obesity is more common in males and is sometimes referred to as android obesity. In individuals with apple-type obesity, the waist circumference increases, leading to a larger weight-to-height ratio (WHR) [14].

2. Pear-type obesity

Individuals with pear-type obesity resemble the shape of a pear, characterized by excessive fat accumulation in the lower body, around the hips and thighs [13]. This type of obesity leads to a wider body shape, hence it's also referred to as peripheral obesity. Pear-type obesity is more common in females and is sometimes referred to as gynoid obesity [14].

Obesity is caused by an imbalance between the amount of energy intake and the amount of energy expenditure [12]. When the amount of energy consumed from food and drink exceeds the energy used for physical activity, excess energy is stored in the form of fat. Obesity can also be caused by genetic

abnormalities, such as Prader-Willi Syndrome, MC4R Syndrome, and Wilson Turner congenital leptin deficiency [2]. The accumulation of fat in adipose tissue plays a role in secreting adipokines and free fatty acids, leading to systemic inflammation that ultimately results in insulin resistance and elevated triglyceride levels. Furthermore, obesity increases the deposition of fatty acids in the cardiac myocardium, leading to left ventricular dysfunction, which contributes to the development of coronary heart disease. Fatty acids can also disrupt the renin-angiotensin system, causing salt retention and increased blood pressure, resulting in hypertension [2].

In general, the management of obesity includes lifestyle modifications, pharmacological therapy, and surgery, as described below:

1. Lifestyle modifications, involve adjustments to dietary habits and physical activity. In Indonesia, the recommended dietary pattern is the "T-plate" model and reducing daily calorie intake by around 500 kcal to achieve a weight loss of approximately 0.5 kg per week [15]. Additionally, physical activity is recommended through moderate-intensity exercise 3-5 times per week. Low-impact aerobic exercises like swimming, brisk walking, or aerobic workouts are advised, with a total duration of 150 minutes per week, then gradually increased according to capabilities [16].
2. Pharmacological therapy, which is indicated for patients with a BMI $\geq$ 30 kg/m^2 or BMI $\geq$ 27 kg/m^2 with associated conditions like hypertension, diabetes mellitus, and others. Some drugs approved by the Food and Drug Administration (FDA) for long-term use to manage obesity include orlistat, liraglutide 3 mg, gelesis100, and setmelanotide [17].
3. Surgery, which is an effective therapeutic option for obesity in patients with a BMI $\geq$ 30 kg/m^2 with comorbidities. Bariatric surgery includes procedures such as BPD (Bilio-pancreatic diversion), SG (sleeve gastrectomy), RYGB (Roux-en-Y gastric bypass), and AGB (adjustable gastric banding) [18].

B. Potency of Body Image Analysis, Program Suggestion System, and Deep Learning Algorithm Technology

The body shape analysis system is a process that can detect human body shape types. This system is inspired by the individuals who follow diet programs, but do not achieve their desired targets due to the lack of precision in the techniques and strategies that they used. A study was done by Muslihah et al (2013) showed that the quality of the diet is related to individual knowledge about nutrition ($p<0.01$) [19]. A good perception and knowledge about body shape are essential so that each individual can adjust programs and methods to lose or maintain a body shape that fits with their respective goals. This is also supported by research from Ismayanti (2020), which indicates that a lack of nutritional knowledge in an individual results in 11-fold higher risk of having poor nutritional status compared to those with good nutritional knowledge [20].

Individuals who experience obesity have higher urgency to acquire a suitable design and monitoring for their diet program. The arrangement of diet programs and exercise patterns needed among individuals can differ based on the clinical parameters that need to be corrected [21]. Therefore, the implementation of a personal digital assistant (PDA) is necessary to overcome this issue. PDA is a digital media in the application form that can organize users' needs. The diet analysis system with PDA has the potential to be well-implemented for individuals with obesity, as it can provide information adjusted to each individual's needs. The use of PDA is also relatively easy and practical since it can be used anytime and anywhere through the user's smartphone [22].

Deep learning as a system that analyses datasets without human assistance allows the system learn and have precise and intelligent decisions autonomously. Through pattern identification in complex datasets, deep learning methods can provide information for disease diagnosis and prediction, which ultimately can be used for the management and prevention of health disorders such as obesity. A study conducted by Forte *et al.* (2023) showed that deep learning neural networks presents a good accuracy (75%) and validity (ROC AUC 66%) in people at risk of obesity [23]. Another study by Bhaskar and Manikandan (2019) successfully classified their samples with an accuracy of 98% [24]. Therefore, application development through deep learning has great potential to provide benefits to individuals with obesity.

In the present scenario, community welfare is paramount, necessitating solutions to health-related challenges through technological advancements in medical research. Previous research utilizing a new personal area sensor network that revolutionizes activity recognition, called RNN, had promising results. This network employs multiple sensor nodes dispersed throughout the body, utilizing recurrent neural networks (RNNs) to analyze local sensor data and classify activities. Aggregating results through a weighted voting process at a central node enhances accuracy and conserves energy, as sensor nodes transmit local results exclusively for recognized activities [25]. Using RNN research conducted by Musa (2022), a respectable accuracy of 95.74% was found. Experimentation involving sensor nodes on various body parts demonstrated superior recognition accuracy across eight activities compared to existing methods. Consequently, optimizing sensor node configuration

enhances activity recognition accuracy while minimizing transmissions from supporting nodes [26].

Visualization of deep learning computation is described in **Figure 1** and **Figure 2**.

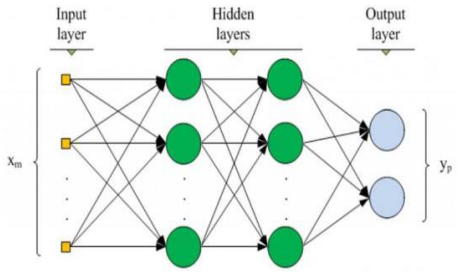

Fig 1. Visualization of Deep Learning Computational Architecture

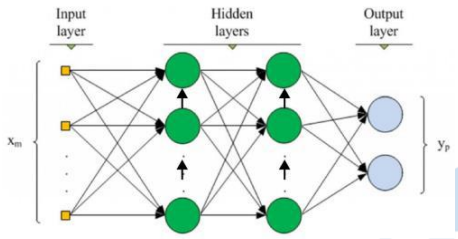

Fig 2. Visualization of Deep Learning Computational Architecture of RNN Type

C. *Mechanism of Construction of "GENIUS" Application*

The construction of the "GENIUS" application consists of three stages, including the process of collecting data sets, creating a PDA application and deep learning system, and the installation of deep learning and launch of the application.

The deep learning applied in the "GENIUS" application is a supervised learning model. This means that the parameters used in this application are input parameters and output parameters in the form of labels. The data collection process consists of two stages, namely data sets related to body image analysis and program suggestion. The data set related to body image analysis is collected by inputting human body sketch images and their interpretations. The data set of body sketch shapes contains data such as the positions of the head, body, and upper and lower extremities as labels for detecting objects and interpreting their body types. Meanwhile, the data set related to program suggestion contains a collection of data and parameters such as food consumed on previous days and the day, exercise performed on previous days and the day, and the user's clinical data history.

The use of two types of data sets in this application requires two deep learning training processes. For the body image analysis data set, the concept used is the pre-trained network EfficientDet, which is then trained in such a way that it can detect the body parts shown in the sketch image and interpret their shapes. As for the program suggestion data set, the concept used is Recurrent Neural Network (RNN), which is then trained in such a way that it can provide diet and exercise program recommendations for users according to their individual needs and conditions. The architecture model is described in **Figure 3** [27].

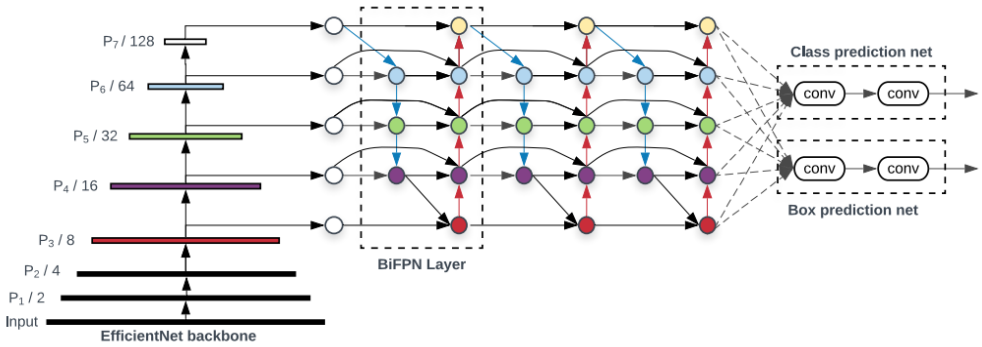

Fig 3. Architecture of the Pre-trained EfficientDet Network

After that, the validation and testing stages will be carried out using a subset of the dataset. If the accuracy score does not reach 80%, the training process will be repeated with changes to the architecture. If the accuracy score reaches 80% or higher, the application will be created and the two deep learning models will be installed on the PDA. The application and its features will also be tested for functionality to ensure that the PDA is able to operate properly.

The final stage in the application construction is launching the application to the general public. At this stage, the application can be accessed by the public and the interaction between the database and the user will be configured. In addition, the application requires regular maintenance and evaluation for the convenience of users and to gather user feedback for the advancement of the application.

D. *Mechanism of Operation of "GENIUS" Application*

The features in the "GENIUS" application are a comprehensive implementation of the concept for treating obesity, as described in **Figure 4**.

1. Feature “Me and My Body”

This feature is a body shape analysis feature and program adjustments that the user will go through. The data that needs to be input by the user is a full body photo with minimal clothing, body weight and height. Body image analysis technology will produce output in the form of an interpretation of body shape and body mass index. Through program suggestion technology, this feature will also provide recommendations for exercise and diet programs that suit the user's comfort preferences and the goals the user wants to achieve. This feature will be very useful because it makes the implementation of programs run by users more focused and targeted according to each individual's conditions.

2. Feature “Hello Doctor”

This feature is a feature that can be used by users to get in touch with medical personnel who are members of the "GENIUS" application partners. With this feature, users can discuss and consult with medical personnel regarding the program they are undergoing, complaints or difficulties that arise during the program, as well as updates regarding their body condition.

3. Feature “Let’s Move”

This feature is a feature that serves as a guide for users to do sports and physical activities according to the program that has been analyzed through the “Me and My Body” feature. Users can record physical activity carried out every day, then this feature will provide information regarding the estimated number of calories expended from recorded physical activity.

4. Feature “Happy Diet”

This feature is a feature that serves as a guide for users to make adjustments to diet patterns according to the program that has been analyzed through the “Me and My Body” feature. Users can record food and drinks consumed each day, then this feature will provide information regarding the estimated number of calories included from recorded consumption.

5. Feature “My Healthy Diary”

This feature is a useful service for users to record a combination of all the information recorded in the four features above. Some of the information that can be input in this feature includes age, anthropometric data such as body weight, height, waist circumference, abdominal circumference, and waist-to-hip ratio, as well as clinical data such as blood pressure, fasting blood sugar, triglyceride levels, and blood sugar levels. HDL-C, LDL-C, and cholesterol. All input data will be synchronized via a cloud-based system with the health service center to facilitate comprehensive user health monitoring.

6. Sub-Features

The features of this application are equipped with the "Share My Journey" sub-feature as a forum for users who want to share their daily lives in carrying out diet and exercise programs. This sub-feature also becomes a platform for building a community between users to motivate each other to live healthy and avoid obesity. Apart from that, this application also has a sub-feature in the form of reward points which will be obtained every time a user opens the application and uses the features in it. These points can later be exchanged for various attractive prizes.

Fig 4. Interface of “GENIUS” Application

After the application is well constructed, relationships and collaboration with related parties must be carried out so that the application target can use this application optimally. Related to this, the model used is quadruple-helix (QH) which involves four parties, namely academics, government, industry and society. Academics play a role is in designing and developing application concepts, preparing resources for implementing applications, as well as executing manufacturing and manufacturing processes according to standard procedures that are designed to be ready for use. The government plays a role as a party that has important authority in providing guarantees for the protection of copyrighted works of applications, as well as regulates and strives for applications and services in it to be accessible to the whole community. The health industry and institutions, play role to facilitate consulting services and carry out quality control of the content and services in the application, so that the information contained in it can be ascertained the truth and validity. The community, especially the younger generation and people with obesity, as users of the application, play a role as a party that can provide feedback and input for the development of applications in a better direction, and can reach people's aspirations and market needs.

IV. CONCLUSION

The "GENIUS" application is potential to be developed as a personal digital assistant that can be used as a preventive tool against obesity through a combination of holistic management. The construction mechanism of this application includes the stages of collecting datasets, creating applications and deep learning systems, as well as installing deep learning and launching applications. The operating mechanism of this application can fulfill individual needs that vary between users through the use of body image analysis technology and recommendation programs with deep learning systems. The implementation of this application involves academics, government, health institutions, and the community. This application is useful in the field of health and knowledge in order to realize a smart generation and a healthy Indonesia. The suggestions that can be given are the need for active participation from various parties to realize this application and the need to test this application to evaluate the features in it so that it can meet user needs.

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Comparison of Linear and Non-Linear Machine Learning Algorithms for Predicting the Effectiveness of Plant Extracts as Corrosion Inhibitors

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***Abstract*— This research aims to develop a Machine Learning (ML) model to accurately predict the corrosion inhibition potential of plant extracts. The ML model development involves data normalization, selecting both linear and non-linear ML algorithms, model training with k-fold cross-validation, and performance evaluation using regression metrics such as MSE, RMSE, MAE, and R^2. Various ML algorithms were compared, with the AdaBoost Regressor (ABR) model achieving the best performance, marked by an R^2 value of 0.993 and a low MSE of 0.002. These results highlight the potential of ML models in predicting effective corrosion inhibitors from plant extracts. Moreover, feature importance analysis reveals that two features, concentration (Conc) and LUMO, significantly influence the ABR model. This research contributes significantly to developing effective prediction methods in the corrosion control industry.**

Keywords— Machine learning; Corrosion; Plant extract; Adaboost regressor, Linear Regression.

I. INTRODUCTION

Corrosion is a process of material degradation or decay caused by a chemical reaction between the metal and the environment where many corrosive substances cause surrounding corrosion [1]. The corrosion process involves the oxidation of metals by oxygen in air or other corrosive substances, which results in corrosion products such as oxides, hydroxides, or metal salts [2]. These corrosion reactions can affect material quality and performance, reduce service life, and cause significant economic losses. Some of the factors that affect the corrosion rate include the type of metal involved, the nature of the corrosive environment such as humidity, pH, temperature, the concentration of corrosive substances, as well as other factors such as mechanical stress or friction [3]. The corrosion process can also be accelerated by the presence of galvanic (contact between two dissimilar metals in an electrolyte), interaction by microorganisms such as bacteria, or stress-induced corrosion [4]. The study of corrosion involves an in-depth understanding of corrosion mechanisms, development of corrosion control methods, and evaluation of material performance in corrosive environments [5]. Controlling corrosion processes is essential in various industries such as the oil and gas industry, chemical industry, automotive industry, and construction to ensure the sustainability and safety of the materials used [6]. Research in the field of corrosion inhibitors continues to grow, especially in the exploration of organic inhibitors. This is due to the negative properties possessed by inorganic inhibitors, such as toxicity, environmental unfriendliness, and high production costs [7]. One type of organic inhibitor that is increasingly in demand is natural plant extract-based corrosion inhibitors, which are often referred to as "green inhibitors" [8]. Green inhibitors are highly valued because they are environmentally friendly, easily degradable, renewable, do not pollute with toxins or pollutants, easy to produce, low cost, and have high anticorrosive efficiency [9]. Natural plant extracts contain natural compounds that play an important role as corrosion inhibitors [10]. The structure of compounds in natural plant extracts often contains heteroatom groups such as Oxygen (O), Nitrogen (N), Sulfur (S), Phosphorus (P), and also aromatic rings. This combination of structures is

considered to be the most efficient as a corrosion inhibitor [7]. Experimentally studying the use of plant extracts as corrosion inhibitors is time-, cost-, and resource-intensive.

To address this gap, machine learning (ML) approaches based on quantitative structure-property relationship (QSPR) models have recently been used in the investigation and exploration of new anti-corrosion materials. Given the relationship between the structure and molecular properties of compounds, QSPR is an effective and reliable method [7]. Lu Li et al. [8] used an ML algorithm, namely a support vector machine (SVM), to investigate benzimidazole compounds as corrosion inhibitors. The results showed that the SVM model had a coefficient of determination (R^2) of 0.96 and a root mean square error (RMSE) of 6.79. In addition, Akrom et al. [9] compared several ML models on a dataset of pyrimidine compounds, and found that the gradient boosting regressor (GBR) model had the best accuracy with an R^2 value of 0.92 and an RMSE of 0.95, compared to the support vector regression (SVR) and k-nearest neighbor (KNN) models.

In this research, the focus is on the use of plant extracts as an alternative corrosion inhibitor. By utilizing the natural compounds contained in plant extracts, it is expected to develop a machine learning (ML) model that can predict corrosion inhibition efficiency with high accuracy [7]. The implementation of data normalization techniques during preprocessing and the use of k-fold cross-validation techniques in the development of ML models are expected to improve the accuracy of predicting corrosion inhibition efficiency [11]. This research makes an important contribution to the development of machine-learning models for designing potential corrosion inhibitor compounds sourced from plant extracts. It can serve as a reference for other researchers in developing more accurate machine learning models to predict corrosion inhibition efficiency by utilizing environmentally friendly natural resources [12].

II. METHOD

Figure 1 illustrates the process of developing the Machine Learning (ML) model in this study. The initial stage is the selection of a plant extract dataset, followed by data normalization to address scale differences and sensitivity to outliers. [9]. After that, ML algorithms, both linear and non-linear, are selected to model the relationship between input and output variables that can accurately predict the corrosion inhibition efficiency of plant extracts [1]. Furthermore, the models are trained using the k-fold cross-validation technique, which helps avoid overfitting and obtain a more generalized model [13]. Model performance evaluation is performed using regression metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Coefficient of Determination (R2) [14]. These stages not only help in the selection of the optimal ML models but also ensure that the model can produce accurate predictions regarding the corrosion inhibition efficiency of the plant extracts in this study [4].

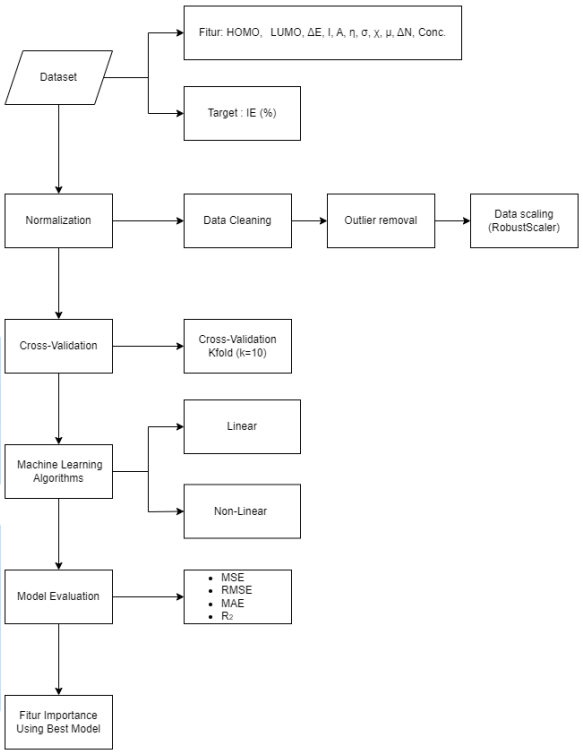

Fig 1. ML model development method

[1] Dataset

The dataset used in this study consists of plant extracts derived from published literature written by Akrom, et al [15]. This dataset includes specific plant extracts that have 12 features, namely HOMO, LUMO, ΔE, I, A, η, σ, χ, μ, ΔN, Conc., and IE (%). These features reflect the molecular properties and physicochemical characteristics of the plant extract [15]. Some of these features are related to the electronic properties, polarity, and corrosion inhibition efficiency (IE (%)) as dependent variables which are the main focus of the analysis and prediction in this study [14].

[2] Normalization

In the course of this research, the researcher adopted a very comprehensive approach to preprocessing the plant extract dataset used. A series of important steps were applied to ensure the quality and reliability of the processed data [16]. First of all, we performed data normalization using the RobustScaler technique. This was done to address the sensitivity to the presence of outliers or extreme data that could affect model performance. Data normalization is a crucial step in

ensuring that the data used has a uniform scale, allowing machine learning models to provide consistent and accurate results [17]. In addition, researchers also remove outliers using the Interquartile Range (IQR) method [18]. Outlier removal is done to rid the dataset of unusual or unrepresentative data that may affect the interpretation of the analysis results. By calculating the IQR, researchers can identify and eliminate extreme data that may negatively affect model performance.

[3] Data Cleaning

In the data cleaning stage, researchers normalize the data using RobustScaler to address sensitivity to outliers or extreme data that can affect model performance [21],[17]. The RobustScaler technique was chosen because it can handle differences in scale in the data and maintain the consistency of the prediction results. In addition, researchers also applied the Interquartile Range (IQR) method to remove outliers [18]. Outlier removal is necessary to rid the dataset of unusual or unrepresentative data that may affect the analysis and prediction results [18], [1]. This data-cleaning process aims to prepare a clean and consistent dataset for further analysis [22].

[4] Scaling Data

After the data cleaning process is complete, the data scaling process is carried out to standardize the range of values on each feature in the dataset. The goal is for all features to have a uniform scale so that the model can provide consistent and accurate results [23]. In this study, researchers used data scaling techniques to improve the performance of Machine Learning models in predicting the corrosion inhibition efficiency of plant extracts. The combination of data normalization and data scaling helps prepare a dataset of optimal quality for use in developing accurate and relevant ML models [24].

[5] Cross-Validation

We applied the k-fold cross-validation method with k = 10 to divide the data into 10 equal subsets. In each iteration, the model is trained on 9 subsets and tested on the remaining one, rotating through all subsets [19]. This process helps identify the model with the smallest error rate, ensuring robustness and reliability. We chose k = 10 to maximize data use and minimize bias and variance [20].

[6] ML Algoritma

These experiments involve a comparison between linear algorithms, which tend to use linear relationships between input and output variables, and non-linear algorithms, which can handle more complex and non-linear relationships between input and output variables [25]. The linear algorithms evaluated, such as multilinear regressor (MLR), ridge, lasso, Elastic-Net (EN), Support Vector Regression (SVR), and Generalized Linear Model (GLM), focus on models that have a linear relationship between input and output variables, while non-linear algorithms, such as random forest (RF), k-nearest neighbors (KNN), nu-support vector regressor (NuSVR), decision tree regressor (DT), gradient boosting regressor (GBR), orthogonal matching pursuit (OMP), kernel ridge (KR), partial least square (PLS), adaboost regressor (ABR), and bagging regressor (BR), can address more complex and non-linear relationships between input and output variables [14], [1], [4]. Through this comparison, the experiment aims to find the most optimal algorithm for predicting the corrosion inhibition efficiency of plant extracts. The results show that the best model for predicting the corrosion inhibition efficiency is the AdaBoost Regressor (ABR). ABR is a boosting algorithm used to improve the accuracy of predictive models. The prediction of the AdaBoost Regressor is based on a combination of multiple weak learners. Each weak learner contributes to the final prediction through a weighted vote, where the weight reflects the accuracy of the weak learner [32]. The final prediction $H(x)$ is computed as shown in the equation.

$$H(x) = \sum_{m=1}^{M} \alpha_m h_m(x)$$

With $H(x)$ being the final prediction of the ensemble model, α_m the weight of the m-th weak learner, $h_m(x)$ the prediction of the m-th weak learner for the input x, and M the total number of weak learners in the ensemble. The weights α_m are calculated based on the accuracy of each weak learner. Where,

H(x) : Final prediction function of the AdaBoost Regressor model

α_m: The coefficient or weight of the m-th base model

$h_m(x)$: Prediction of the m-th base model (weak learner)

m : Iteration index for the base model

M : Total number of base models used in boosting

[7] Model Evaluation

To evaluate the performance of the prediction model, various regression metrics such as mean squared error (MSE), root mean squared error (RMSE), mean absolute error (MAE), and coefficient of determination (R2) are used [26]. The main objective is to select a model that has the minimum possible MSE, RMSE, and MAE value while approaching the ideal R2 value which is close to 1 [27]. This is important because it shows that the models have a high level of accuracy in predicting the corrosion inhibition efficiency of plant extracts [9], [26]. These metrics provide comprehensive information on the model's ability to estimate the potential value of corrosion inhibitors, which is an important step in the development of effective and relevant prediction methods for industrial applications, especially in the context of corrosion control [11].

[8] Important Features

The analysis of important features in this study is a critical step that requires an in-depth understanding of the relationship between the molecular and physicochemical characteristics of plant extracts and their corrosion inhibition efficiency [1], [13]. This method not only helps in identifying the most influential features in the prediction but also provides a deeper insight into the corrosion inhibitor mechanism of action of the plant extracts. Thus, the results of feature importance analysis provide a strong foundation in the selection of the most relevant features to be used in the construction of accurate and effective Machine Learning models [18]. The information obtained from feature importance analysis also has important implications in the context of industrial applications and further research [28]. The discovery of the most significant features in indicating corrosion inhibition effectiveness can be used to direct the development of more efficient and environmentally friendly corrosion inhibitor materials [11]. Furthermore, a deeper understanding of the relationship between the molecular properties of plant extracts and their performance as corrosion inhibitors provides opportunities for further research in the optimization of inhibitor formulations that can be widely applied in the corrosion industry [4]. Thus, the analysis of feature importance is not only an important part of this research but also makes a real contribution to the development of science and technology in the field of corrosion control.

III. Result and Discussion

The first step in this research was to test the plant extract dataset using the linear algorithm available in the scikit-learn library using Python. The performance of each model was measured using R2 and RMSE values as evaluation metrics. Table 1 and Table 2 below show the performance results of the linear and non-linear models respectively. These tables serve as the basis for evaluating the performance and prediction accuracy of each model.

Based on the analysis results in Table 1, it can be concluded that among the linear models evaluated, the Linear Regression (MLR) model shows superior prediction performance compared to the Ridge Regression, Support Vector Regression (SVR), and Generalized Linear Model (GLM) models. This is supported by the highest R-squared (R2) value obtained by MLR of 0.626, as well as the lowest Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE) values (0.236, 0.486, and 0.330 respectively). Figures 2 to 5 are data distributions in linear models that show that the predicted points from MLR are closer to the predicted line than other linear models. This indicates that the MLR model is the best model of similar models.

TABLE 1. Linear Model Performance

Model	Linear Model Evaluation			
	MSE	***RMSE***	***MAE***	***R_2***
Ridge	0.265	0.515	0.363	0.580
MLR	0.236	0.486	0.330	0.626
SVR	0.283	0.532	0.343	0.552
GLM	0.246	0.476	0.331	0.624

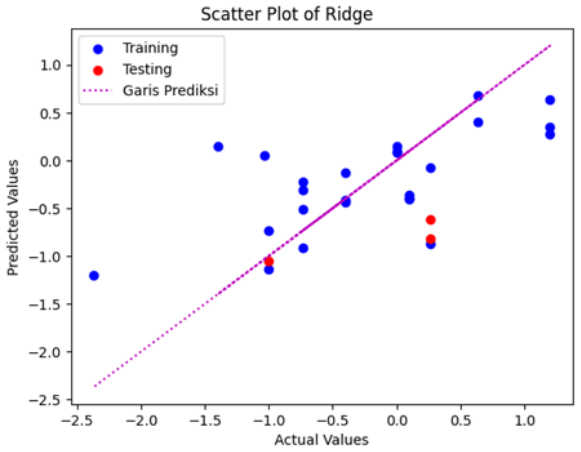

Fig. 2. Scatter Plot of Ridge

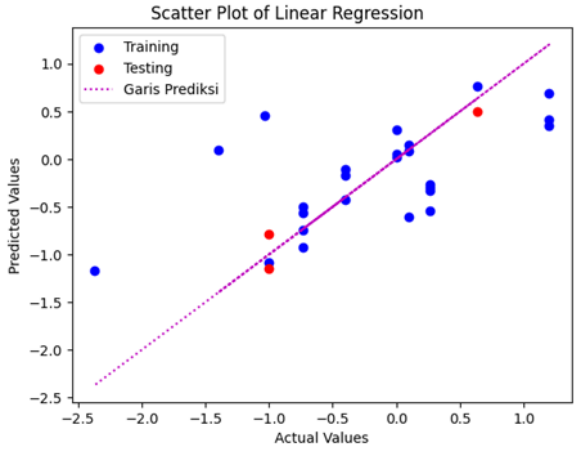

Fig. 3. Scatter Plot of MLR

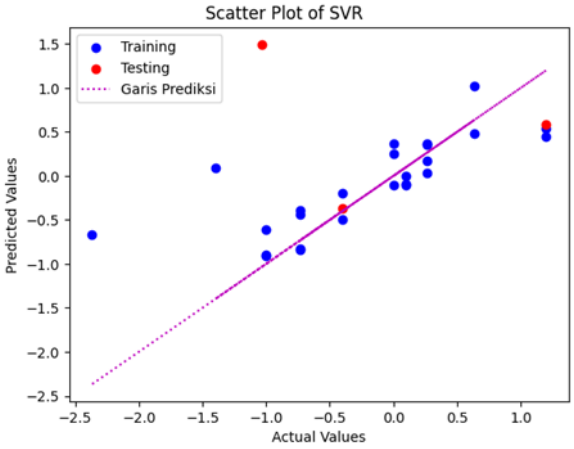

Fig. 4. Scatter Plot of SVR

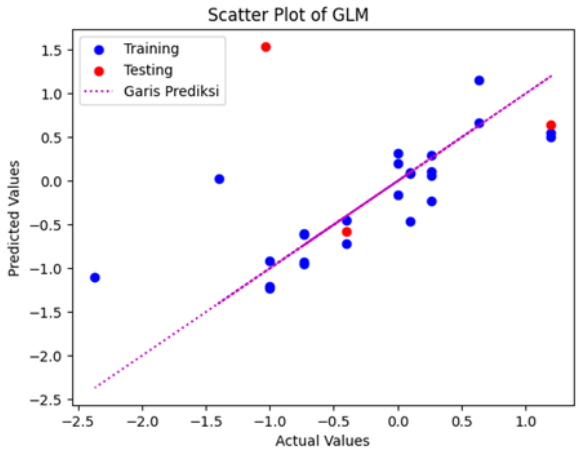

Fig. 5. Scatter Plot of GLM

For non-linear models, Table 2 presents model performances. The Adaboost Regressor (ABR) showed superior prediction performance when compared to the Random Forest (RF), Bagging Regressor (BR), and Gradient Boosting Regressor (GBR) based on the evaluation metrics used (R2 = 0.993, MSE = 0.002, RMSE = 0.053, and MAE = 0.034). The distribution of data points from the ABR model also showed a better fit to the prediction line. Thus, it can be concluded that overall, the Adaboost Regressor (ABR) model is the best choice in predicting the corrosion inhibitor potential values of plant extracts based on CIE values. Figures 6 to 9 are data distributions in non-linear models that show that the predicted points from ABR are closer to the predicted line than other linear models. This indicates that the ABR model is the best model of similar models.

TABLE 2. NON-LINEAR MODEL PERFORMANCE

Model	Non-Linear Model Evaluation			
	MSE	***RMSE***	***MAE***	***R₂***
RFR	0.030	0.173	0.114	0.934
GBR	0.041	0.203	0.129	0.934
ABR	0.002	0.053	0.034	0.993
BR	0.054	0.233	0.130	0.921

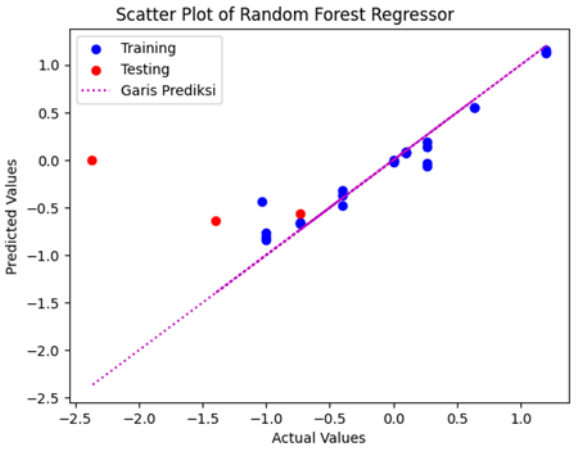

Fig. 6. Scatter Plot of RFR

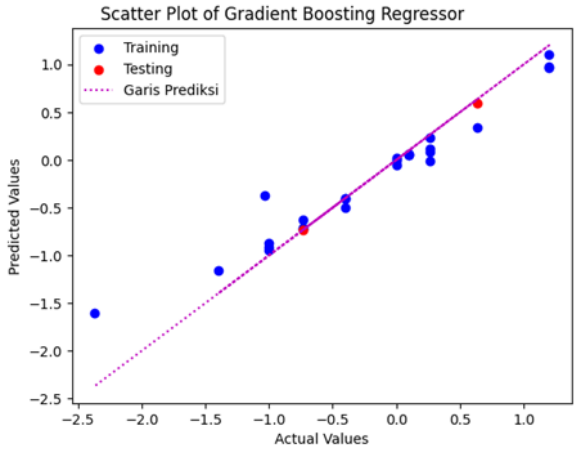

Fig. 7. Scatter Plot of GBR

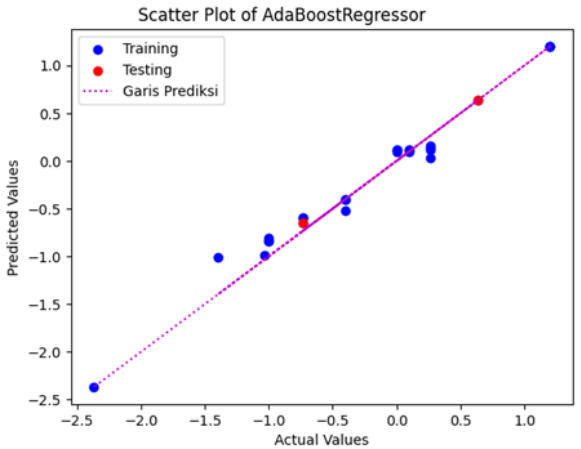

Fig. 8. Scatter Plot of ABR

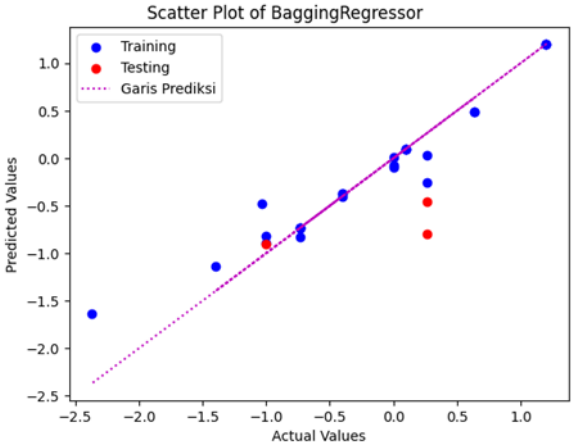

Fig. 9. Scatter Plot of BR

Figure 10 provides a clear picture of the performance comparison between Model Linear Regression (MLR) and AdaBoost Regressor (ABR) based on their R2 scores. From the results shown, it can be seen that the ABR model consistently achieves R2 scores close to 0.99 across all folds evaluated, demonstrating its ability to explain about 95% of the variability in the data consistently. On the other hand, the MLR model showed greater variation in R2 scores, with values ranging between 0.58 and 0.63. This analysis indicates that the ABR model has higher accuracy and better consistency in predicting plant extract efficiency than the MLR model. The ability of the ABR model to consistently approach R2 values close to 1 indicates that the model can describe the relationship between input and output variables with a high degree of accuracy. Therefore, based on this evaluation, it can be concluded that the ABR model is a better choice in this context to predict the corrosion inhibition efficiency of plant extracts. This is supported by the ABR model's ability to provide accurate and consistent predictions in explaining variations in the evaluation data used.

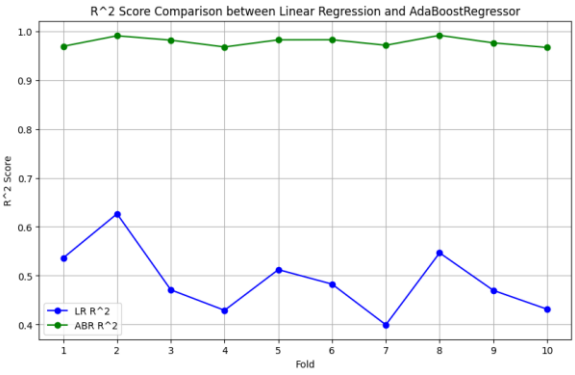

Fig. 10. Comparison of the best linear and best nonlinear algorithms for 10 experiments

From the residual analysis in Figure 11, it can be seen that most of the residual points from the ABR model are close to the zero line, indicating that the model has a low prediction error rate and can provide accurate estimates. In contrast, the residual error plot of the MLR model shows a larger spread and is not centered around the zero line, indicating that the MLR model has a higher error rate than the ABR model. Thus, based on this residual analysis, it can be concluded that the ABR model performs better in making predictions with a low error rate, compared to the MLR model. This corroborates the previous conclusion that the ABR model is a better choice for predicting the corrosion inhibition efficiency of plant extracts.

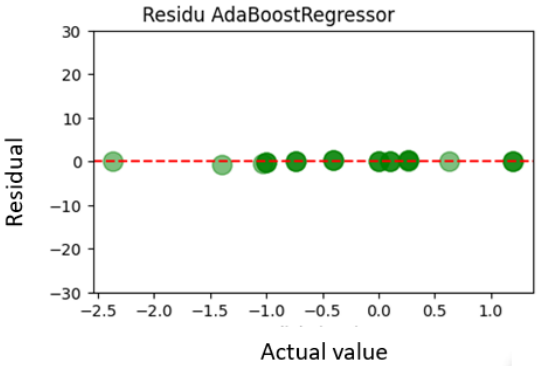

Fig. 11. Residual Error on ABR model

The selection of ABR as the superior model is also supported by feature importance analysis, which measures the extent to which a feature affects the algorithm's performance. Feature importance aims to reduce errors and eliminate noise in the dataset, thus providing more generalized and relevant results. In developing a predictive model, it is important to select input features that have a significant impact on the target variable. From the results of the critical feature analysis in Figure 12, it can be seen that two features have a significant impact on the ABR model, namely Conc and LUMO. This indicates that these features have a strong role in influencing the predictions of the model. The ABR model is strengthened by its ability to recognize complex patterns in the data, which may not be handled by the MLR model. Therefore, the nonlinear best model (ABR) is a better choice for predicting the corrosion inhibitor efficiency of plant extracts compared to the linear best model (MLR).

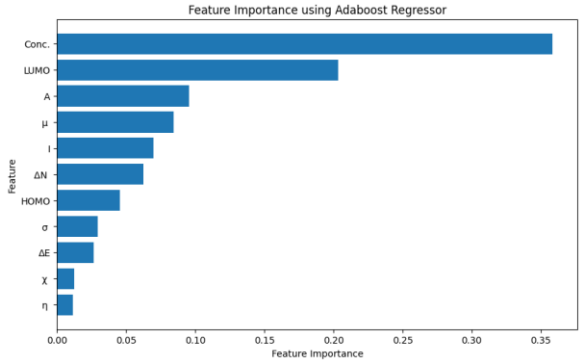

Fig. 12. Importance features of the Adaboost Regressor model

Based on Table 3 evaluation of linear (MLR) and non-linear (ABR) models, the ABR model shows better performance with lower MSE, RMSE, and MAE values and higher R^2 values. This indicates that the ABR model is more accurate and effective in predicting the data compared to the MLR model.

TABLE 3. EVALUATION OF THE BEST LINEAR AND NON-LINEAR MODELS

Evaluation	Best Linear and Non-Linear Models	
	MLR	***ABR***
MSE	0.236	0.002
RMSE	0.486	0.053
MAE	0.330	0.034
R2	0.626	0.992

IV. CONCLUSION

This study explores the best models for predicting the corrosion inhibitor potential of plant extracts using a Machine Learning (ML) approach by comparing the performance of linear and nonlinear models. The results showed that the nonlinear Adaboost Regressor (ABR) model was the most accurate, outperforming four linear models and three other nonlinear models. The ABR model achieved the highest R-squared (R^2) value of 0.992, indicating very high prediction accuracy. Additionally, the low Mean Squared Error (MSE) of 0.002, Root Mean Square Error (RMSE) of 0.053, and Mean Absolute Error (MAE) of 0.034 indicate minimal prediction error. These findings provide valuable insights for developing efficient material exploration methods in the corrosion control industry and can serve as a basis for designing more effective and environmentally friendly corrosion inhibitor materials.

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Convolutional Neural Network Implementation in BISINDO Alphabet Sign Language Recognition System Using Flask

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***Abstract*—This research develops a system for recognizing finger spelling gestures in Indonesian Sign Language (BISINDO) using Convolutional Neural Network (CNN). The objective of this research is to apply the Convolutional Neural Network (CNN) method to the BISINDO finger spelling gesture recognition system to improve its accuracy. The method employed is Convolutional Neural Network (CNN), an effective method for processing image data for pattern recognition. Based on the test results, the system demonstrates that the developed CNN model is capable of recognizing BISINDO finger spelling gestures with an accuracy of 97.5%. This indicates that the BISINDO finger spelling gesture recognition system performs well in pattern recognition. The implementation of the system for real-time prediction via a web interface using Flask also enhances its accessibility. However, there is still room for improvement, particularly in recognizing one of the 26 letters that has not been predicted accurately. For further development, it is recommended to consider collecting a larger dataset and incorporating more complex gesture variations to improve recognition accuracy.**

Keywords*— *Accuracy; Dataset; Flask; Convolutional Neural Network; Gesture Recognition; Indonesian Sign Language

I. INTRODUCTION

Sign language is a method of communication used by individuals who were deaf and mute [1]. It involves bodily or physical movements to convey messages [2]. For these individuals, sign language has become the primary means of communication in their daily lives [3]. According to data from the Disability Management Information System of the Ministry of Health of the Republic of Indonesia in March 2022, there were 212,240 individuals with disabilities in Indonesia. Of these, approximately 9.14% or 19,392 individuals were deaf-mute [4]. In this particular setting, sign language holds dual significance: it serves not only as a means of communication for those with hearing impairments but also as a vital component of their cultural heritage and identity.

Indonesian Sign Language (BISINDO) is one of the two sign languages used in Indonesia, along with the Indonesian Sign System (SIBI), which was officially recognized at the sixth National Congress of Gerkatin in Bali in 2002 to preserve the authenticity of natural sign language [4]. Despite the existence of both sign languages, the disabled community in Indonesia more frequently uses BISINDO. This preference is due to the fact that BISINDO is derived from the Indonesian language, which is their native language and is used daily [3].

One of the critical elements in sign language used by the deaf-mute community is finger spelling or manual alphabet, which serves to spell out words in spoken language by showing each letter individually using hand fingers [5]. Consequently, finger spelling forms the foundation of communication in sign language. This also makes finger spelling a key element in building an effective communication system for the deaf-mute. However, as known, not all individuals can understand sign language [1]. Based on research conducted by Suryati in 2019, a survey was carried out involving deaf individuals, with responses from two deaf participants, assisted by their closest companions, and ten members of the general public who had interacted with the deaf in Bogor Regency. The results concluded that both groups of respondents agreed there were difficulties in communication between the deaf and the general public [6]. This highlights the importance of developing a hand gesture recognition system to aid in understanding and interpreting sign language.

Several systems have been developed to assist in translating sign language into alphabetical text. One

such example is the research conducted by Dimas Permana and Joko Sutopo in 2023, where they developed an alphabet recognition application for the Indonesian Sign System (SIBI) using the YOLOv5 algorithm, achieving an accuracy of 77% [7]. Although an accuracy of 77% is considered adequate, there were still some shortcomings that need to be addressed. Firstly, an accuracy rate of 77% is not yet optimal for daily use, particularly in communication contexts that require a high level of accuracy. Secondly, there were still some letters that the system fails to recognize accurately, indicating that there is room for improvement in sign recognition. These findings suggest that while advancements in sign language recognition technology have been made, further research is needed to enhance letter recognition accuracy. To improve accuracy in image recognition systems, it is important to consider the use of Convolutional Neural Networks (CNN), a method effective in processing image data for pattern recognition [8].

Convolutional Neural Network (CNN) or ConvNet is a notable algorithm in deep learning [9]. Deep Learning itself is a branch of machine learning, derived from Artificial Neural Networks (ANN), or it can be considered an evolution of ANN [10]. Deep Learning employs deeper network architectures (with many layers) compared to conventional ANN, enabling more complex modeling of larger and more intricate data. CNNs were specifically used for classification tasks [11]. Since 2012, CNNs have become a crucial model in object recognition [12]. CNNs have become one of the most dominant methods in image data processing and pattern recognition, particularly due to their ability to handle complex problems such as object recognition in images and face recognition. CNNs have proven to be effective and were widely used with satisfactory results [13].

The excellent performance of CNN can be observed from related research conducted by Fauzan Akbar, Aris Triwiyanto, and Achmad Hidayanto, titled "Design of Hand Gesture Recognition Program using Convolutional Neural Network (CNN)," which achieved an accuracy of 92% [10]. This result confirms that CNN is an effective method for hand gesture recognition, with a high level of accuracy. Both studies demonstrate that CNN has great potential in hand gesture recognition, particularly in the context of Indonesian Sign Language. This success provides hope that the development of hand gesture recognition systems using CNN can be continuously improved to make a more significant contribution to the field of technology.

Flask, as a minimalist and easy-to-understand web framework, has advantages in developing web applications that require integration with webcams, including in the context of hand gesture recognition. Flask's advantage lies in its flexibility to facilitate developers in integrating webcam features into the web application they were developing.

From the outlined issues, there is a need to develop a hand gesture recognition system for the Indonesian Sign Language (BISINDO) alphabet that can recognize hand gestures with a high level of accuracy in real-time. Therefore, in this research, the Convolutional Neural Network (CNN) method is chosen for its excellence in image and object recognition. The development of this system will be integrated with the Flask framework to allow access through the web. Flask will be used to create a user interface that allows users to perform real-time hand gesture recognition using a webcam. After the hand gesture is identified via the webcam, Flask will send it to the CNN model for processing. The model will identify the hand gesture in real-time images and return the result to Flask. Flask will then display the identification result to the user through the user interface.

By using Flask, developers can build a BISINDO hand gesture recognition system that is easily accessible and usable via the web with real-time recognition, without the need to re-run the model, which would require more time when the system is to be used. This also allows more people to access and utilize it, as well as integration with various other platforms and applications for further development.

II. Literature Review

1. Sign Language

Sign language is a communication system that utilizes hand movements, facial expressions, and body postures to create symbols representing letters or words [7]. It is employed by individuals with hearing and speech impairments to communicate [14]. Communication in sign language is a form of non-verbal communication that does not involve any auditory components [15]. Instead, it involves the use of hand gestures, body movements, and eye contact [16]. Sign language is considered unique as it varies from country to country [17]. In Indonesia, two main types of sign language were commonly used: the Indonesian Sign System (SIBI) and Indonesian Sign Language (BISINDO) [18]. Based on the aforementioned theory, it can be concluded that sign language is a non-verbal communication system that relies on hand movements, facial expressions, and body postures to form symbols representing letters or words. Sign language is primarily used by individuals with hearing or speech impairments to communicate. In Indonesia, sign language is divided into two types: the Indonesian Sign System (SIBI) and Indonesian Sign Language (BISINDO). According to the European Union of the Deaf, as explained on their

website, there is no universal use of sign language in the world [19]. Each country has its own unique and distinct form of sign language. Communication in sign language does not involve sound elements but rather uses hand gestures, body movements, and eye contact symbols.

2. Indonesian Sign Language (BISINDO)

Indonesian Sign Language (BISINDO) is the sign language used by deaf individuals based on their understanding of their surroundings [17]. BISINDO is often used by the deaf community from childhood and can be considered their mother tongue, as it is easily understood and used in daily life [20]. BISINDO is one of the two sign languages used in Indonesia, alongside the Indonesian Sign System (SIBI) [17]. BISINDO is a type of sign language used by deaf individuals and is considered older than SIBI [4]. The alphabet in BISINDO consists of 26 characters, from A to Z. These letters can be formed with one hand, such as C, E, I, J, L, O, R, U, V, and Z, as well as letters that can be formed with two hands, such as A, B, D, F, G, H, K, M, N, P, Q, S, T, W, X, and Y [4]. This can be seen in Figure 8.

3. Deep Learning

Deep learning is a learning method that employs artificial neural networks with multiple layers [11]. It uses metadata as input [9] and consists of hidden layers that train a set of metadata based on the output from previous neurons [9]. With deep learning, computers can directly learn to classify images or sounds [21]. The deep learning approach can automatically extract features from input images without manual intervention [2]. This machine learning technique mimics the way human neurons work, which were fundamental components of the brain [8]. Deep learning has achieved remarkable results, largely due to more powerful computation, larger datasets, and better neural network training techniques [22]. Deep learning is a subset of machine learning that uses Artificial Neural Networks (ANN) as its foundation or can be considered an evolution of ANN [10]. By utilizing multi-layered neural networks, deep learning enables computers to learn complex patterns from raw data, such as images or sounds, without the need for manual feature extraction.

4. Convolutional Neural Network (CNN)

Convolutional Neural Network (CNN) or ConvNet is a method commonly used for image analysis [23]. CNN utilizes convolutional features to extract features from images [24]. CNN is a form of Multilayer Perceptron (MLP) that works on two-dimensional data and resembles the human neural network [25]. The main advantage of CNN is its ability to effectively extract important features from images and classify them with high accuracy [8]. This method can independently learn to recognize objects, extract object features, classify, and can be used on images [23]. Broadly speaking, CNN has two layers in the pattern recognition model, namely the feature extraction layer and the classification layer [8]. CNN also has two methods, namely classification using feedforward and learning stages using backpropagation [26]. CNN can be used to process input images with complex backgrounds and various hand gesture postures [2]. CNN has a significant impact on image recognition because it mimics the human visual cortex's image recognition system, thus able to process image information effectively [22]. Although CNN achieves the best results on large datasets, it requires a lot of data and computational resources to train [27]. The architecture of Convolutional Neural Network (CNN) can be seen in Figure 7.

1) Convolutional Layer

The Convolutional Layer is the first layer in the architecture of a Convolutional Neural Network (CNN) [1]. It is responsible for calculating the output of neurons connected to a local region of the input image. Each neuron in this layer uses a filter that is repeatedly shifted to multiply a small region connected to the input image, perform convolution operations, and produce the output of the layer. The filters in the convolutional layer were used to capture specific patterns from the image, such as edges, corners, and textures [11]. This process helps in extracting important features from the image [1]. Initially, the input image is enlarged by adding zero pixels around it. Each shift of the filter produces a 2-dimensional matrix as the output of the convolution process [9].

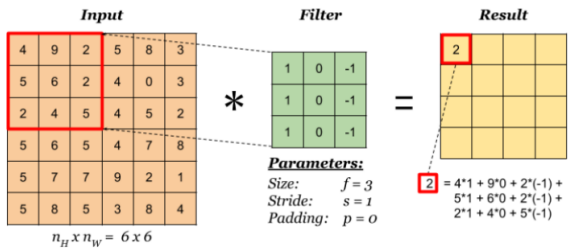

Fig. 1. Illustration of the Convolution Calculation Matrix [9]

2) Pooling Layer

Pooling or subsampling is the process of reducing the size of a matrix. The pooling layer in Convolutional Neural Network (CNN) aims to reduce the dimensions of an image to make it easier to process by the next convolutional layer. There were two commonly used pooling techniques, which were average pooling and max pooling [1]. Max Pooling is a technique to represent an area by using the largest value within that area. On the other hand, Average Pooling is a technique that uses the average value within an area to represent that area [18].

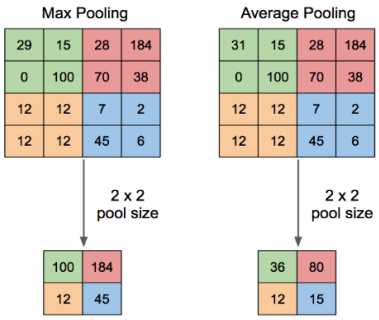

Fig. 2. Illustration of the Max Pooling and Average Pooling Processes [18]

3) Flatten Layer

Flatten is the stage in which the matrix produced from feature learning (through convolution and pooling) is transformed into a vector. This vector is then used as input for classification with a fully connected layer structure [13]. It converts the 2-dimensional matrix resulting from feature learning into a 1-dimensional vector [9].

Fig. 3. Ilustation of the Flatten Layer [9]

4) Dropout

Dropout is used to randomly remove neurons temporarily, which were considered as noise, aiming to prevent overfitting [9].

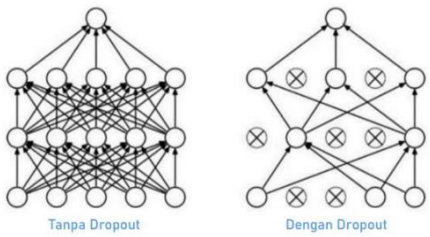

Fig. 4. Illustration of Without Dropout and With Dropout [9]

5) Full Connected Layer

Fully Connected layer is a crucial component in a neural network consisting of a number of nodes that were fully connected to the previous layer. Its main function is to combine the features that have been previously extracted into the corresponding classes. The process begins with the random initialization of weights and biases, which were then used to multiply with the input. If the result is still far from expected, the weights and biases were updated using the appropriate learning algorithm, and this process is repeated until the optimal weights and biases were obtained [11]. The Fully Connected layer is the result of the convolution process that receives input from the previous layers and is responsible for extracting the features that were most correlated with a particular class. Each activation neuron from the previous layer is connected to every neuron in the Fully Connected layer, allowing for comprehensive information processing. This layer typically consists of multiple hidden layers, activation functions, output layers, and loss functions used for classification [1]. The process of combining all neurons into one-dimensional data that has gone through the feature learning process is generally done with flatten, transforming it into a vector [9].

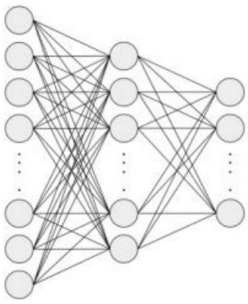

Fig. 5. Illustrates the Fully Connected layer [9]

5. Flask

Flask is a web framework that provides you with tools, libraries, and technologies to build web applications. These web applications can range from web pages, blogs, and wikis to web-based calendar applications or commercial websites. Flask is a lightweight web application framework written in Python and based on the WSGI toolkit and Jinja2 template engine. Flask falls into the category of microframeworks, which typically have few or no dependencies on external libraries [28].

6. Python

Python is an interpreted programming language designed for general purposes, with a focus on code clarity. It aims to be a language that combines functionality and capability with very clear syntax. Additionally, Python comes with a comprehensive standard library of functions [21]. Python supports various programming paradigms, including object-oriented, imperative, and functional programming. Python is also known as a dynamic programming language with automatic memory management. Although often used as a scripting language, Python can be used for various software development needs

and can run on various operating system platforms [18].

III. METHODOLOGY

In this study, Convolutional Neural Network (CNN) is selected as the primary method. The methodology includes data preparation, CNN model construction, and model training. The workflow of the CNN method used in this research is illustrated in Figure 6.

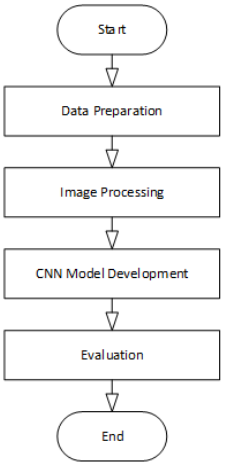

Fig. 6. Research Flow of Method

Convolutional Neural Network (CNN) or ConvNet is a method commonly used for image analysis [23]. The CNN method can extract features in an unsupervised manner [11]. CNN has been proven to have excellent accuracy and can handle large volumes of data. In 2012, CNN achieved image recognition accuracy levels that rival human performance on certain datasets [13]. Overall, Convolutional Neural Network (CNN) or ConvNet is a highly effective method in image analysis. CNN can extract important features from images with high accuracy, similar to the way the human neural network operates. With its ability to recognize objects, extract features, and classify images, CNN has had a significant impact in image recognition and is one of the important algorithms in deep learning.

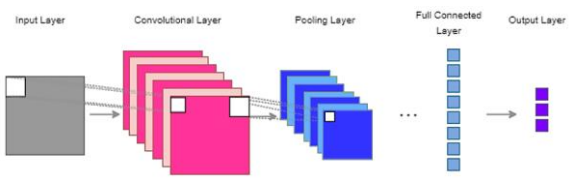

Fig. 7. Convolutional Neural Network Architecture

1. *Data*

The data used in this study is a dataset consisting of images of Indonesian Sign Language (BISINDO) alphabet hand signs, downloaded from Kaggle OpenDataset. This dataset was collected by a Kaggle user named Agung Ma'ruf from various sources for the purpose of analysis and development of the BISINDO alphabet hand sign recognition model [29]. The dataset consists of a number of images showing hand signs for each letter of the BISINDO alphabet, from the letter A to Z. The dataset can be visualized as follows:

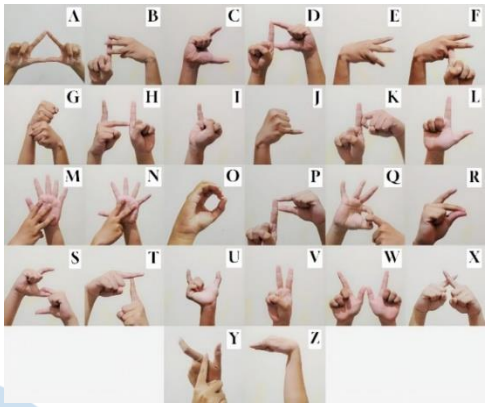

Fig. 8. Indonesian Sign Language (BISINDO) Alphabet Hand Sign Dataset [29]

This dataset consists of a number of photos taken to represent each BISINDO alphabet hand sign. Each photo is labeled according to the letter it represents, which will be used to train and test the BISINDO alphabet hand sign recognition model.

2. *Data Preparation*

Data preparation in the development of the Indonesian Sign Language (BISINDO) alphabet hand sign recognition system using Convolutional Neural Network (CNN) is an important stage. This stage includes collecting hand sign data, preprocessing data, encoding labels, data augmentation, and data splitting. The process in this stage is as follows:

1) Data Collection

The Indonesian Sign Language (BISINDO) alphabet hand sign data was collected from Kaggle's OpenDataset, with hand sign images that have been properly labeled. This dataset includes hand sign images for each letter of the BISINDO alphabet, with variations in position, angle, and lighting. Data collection was done by ensuring a balanced representation of each hand sign class, so that the model can learn well from the variations present in the dataset. After the data was collected, a validation process was conducted to ensure the accuracy and reliability of the data before using it in model training. This dataset consists of 7131 images with a white background, has 26 classes, and a total dataset size of 876 MB. An example of the hand sign image for the letter "A" can be seen in Figure 9.

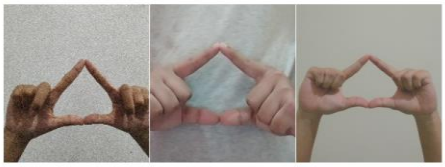

Fig. 9. Sample of BISINDO Alphabet Hand Sign "A" [29]

2) Data Preprocessing

During the data preprocessing phase, the dataset consisting of 7131 images categorized into 26 classes was uploaded to Google Colab for conversion into pixel representations. After reading the BISINDO alphabet hand sign images, these images were converted into pixel matrices. Each image, originally represented as a 2D matrix, was resized into a 28x28 pixel matrix. This step was taken to transform the visual representation of the images into a numerical representation that can be processed by the Convolutional Neural Network (CNN) model. For example, the hand sign image of the letter 'A' would be converted into a 28x28 pixel matrix, where each matrix element represents the color intensity value at one pixel. After that, the separation between features (pixel matrices) and labels (alphabet letter classes) was performed. Once the pixel matrices were formed from the images, the next step was to separate the features (pixel matrices) and labels (alphabet letter classes) from the dataset. The 'label' column containing information about the alphabet letter in each image was removed from the feature dataset. For instance, if there was a hand sign image of the letter 'A' with the label '0', that image was removed from the feature dataset, and the label '0' was stored separately for use in model training. The data preprocessing flowchart can be seen in Figure

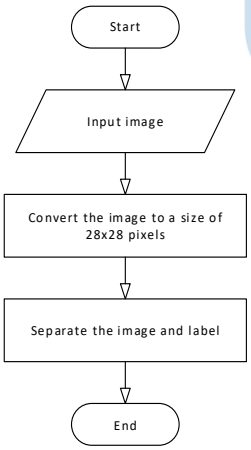

Fig. 10 Data Collection Flowchart

This separation is important so that the CNN model can correctly learn the relationship between the images (features) and the labels. By separating the features and labels, the model can learn to recognize patterns in the images that correspond to the correct labels.

3) Label Encoding

The next step is to encode the labels in the dataset. Encoding is done so that the labels can be processed more efficiently by the model. In the case of BISINDO alphabet hand sign recognition, the labels were generally represented in the form of numbers, for example, from 0 to 25 (for letters A to Z). The label encoding flowchart can be seen in Figure 11.

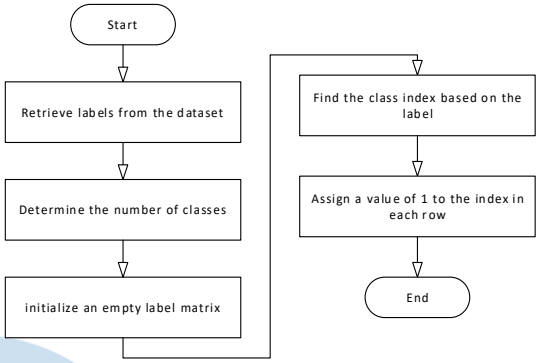

Fig. 11. Label Encoding Flowchart

One of the encoding techniques that can be used is one-hot encoding, where each label is represented as a binary vector with a length equal to the number of classes. For example, if there were 26 classes (A to Z), then each label will be represented as a vector of length 26, where only the index corresponding to the label class has a value of 1, while the other indices have a value of 0.

4) Data Augmentation

In this stage, data augmentation is performed on the dataset of BISINDO alphabet hand sign images. Data augmentation is a technique used to create variations in the training dataset by manipulating the original images. Data augmentation aims to decrease overfitting and enhance the model's capacity to generalize to unseen data. The data augmentation process is carried out using the ImageDataGenerator object from TensorFlow. The data augmentation is performed with the following parameters:

- rotation_range = 10,
- width_shift_range=0.1,
- height_shift_range=0.1,
- shear_range=0.1,
- zoom_range=0.1,
- horizontal_flip=True,
- fill_mode='nearest'

After configuring the data augmentation, the augmentation process is applied to the training data (`x_train`) using the `fit` method of the ImageDataGenerator object.

5) Data Splitting

Following the completion of the data augmentation stage, the next step involves splitting the dataset into two portions: the training data and the test data. The purpose is to test the model's performance on data it

has never seen before, providing a better indication of how well the model can generalize. The data is split using the parameter test_size=0.2, which means that out of the total 7131 data points, the test data will consist of 20% of the total data, which is 1426 test data points, while the training data will consist of 80% of the total data, which is 5704 training data points. The splitting is done randomly using the parameter random_state=101 to ensure consistent results each time the code is executed. After the data splitting is completed, four sets of data will be formed: x_train (training feature data), y_train (training label data), x_test (test feature data), and y_test (test label data). The training data will be utilized to train the model, while the test data will be employed to assess the model's performance post-training.

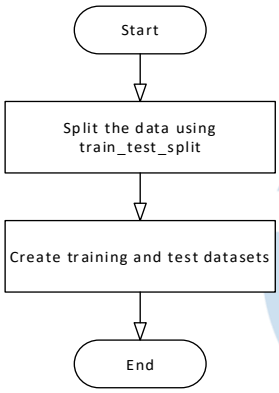

Fig. 12. Data Splitting Flowchart

3. *CNN Model Development*

To develop the Convolutional Neural Network (CNN) model for recognizing BISINDO alphabet hand signs, the Python programming language is used along with the TensorFlow/Keras library. The CNN model flowchart can be seen in Figure 13.

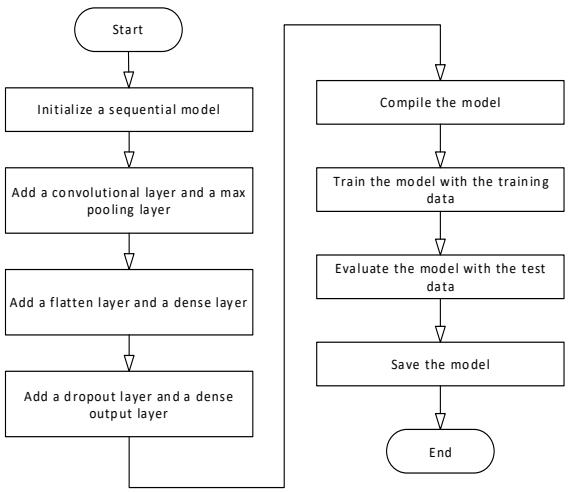

Fig. 13. CNN Model Development Flowchart

The sequential model used can be seen in Figure 14.

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d (MaxPooling2D)	(None, 13, 13, 64)	0
conv2d_1 (Conv2D)	(None, 11, 11, 128)	73,856
max_pooling2d_1 (MaxPooling2D)	(None, 5, 5, 128)	0
conv2d_2 (Conv2D)	(None, 3, 3, 256)	295,168
max_pooling2d_2 (MaxPooling2D)	(None, 1, 1, 256)	0
flatten (Flatten)	(None, 256)	0
dense (Dense)	(None, 512)	131,584
dropout (Dropout)	(None, 512)	0
dense_1 (Dense)	(None, 26)	13,338

Total params: 514,586 (1.96 MB)

Trainable params: 514,586 (1.96 MB)

Non-trainable params: 0 (0.00 B)

Fig. 14. Sequential Model

After training is completed, the model is evaluated using the test data to measure the accuracy and loss of the model. Finally, the model is saved for use in predicting hand signs.

4. *Training*

In training the Convolutional Neural Network (CNN) model for Indonesian Sign Language (BISINDO) alphabet hand sign recognition, the `fit` method is used on the model object. The training process utilizes the training data (x_train, y_train) as input, with a batch size of 128 and 30 epochs. The verbose=1 parameter is used to monitor the training progress at each epoch, while the evaluation metric employed is accuracy to gauge the model's performance in correctly classifying data. The iteration process runs for 30 iterations, where each iteration experiences fluctuations in accuracy on the validation data, showing both increases and decreases. This can be observed in Figure 15:

```
Epoch 1/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 49s 708ms/step - accuracy: 0.0466 - loss: 3.2529 - val_accuracy: 0.1781 - val_loss: 3.0227
Epoch 2/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 34s 595ms/step - accuracy: 0.2848 - loss: 2.5026 - val_accuracy: 0.7980 - val_loss: 0.9708
Epoch 3/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 40s 562ms/step - accuracy: 0.7024 - loss: 1.0082 - val_accuracy: 0.9011 - val_loss: 0.4885
Epoch 4/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 46s 666ms/step - accuracy: 0.8471 - loss: 0.5791 - val_accuracy: 0.9264 - val_loss: 0.3123
Epoch 5/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 40s 629ms/step - accuracy: 0.9098 - loss: 0.3556 - val_accuracy: 0.9306 - val_loss: 0.2842
Epoch 6/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 55s 945ms/step - accuracy: 0.9127 - loss: 0.3346 - val_accuracy: 0.9397 - val_loss: 0.2056
Epoch 7/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 68s 615ms/step - accuracy: 0.9389 - loss: 0.2285 - val_accuracy: 0.9453 - val_loss: 0.2028
Epoch 8/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 42s 625ms/step - accuracy: 0.9390 - loss: 0.2225 - val_accuracy: 0.9481 - val_loss: 0.1582
Epoch 9/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 39s 583ms/step - accuracy: 0.9455 - loss: 0.1891 - val_accuracy: 0.9439 - val_loss: 0.1586
Epoch 10/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 48s 738ms/step - accuracy: 0.9531 - loss: 0.1636 - val_accuracy: 0.9558 - val_loss: 0.1405
Epoch 11/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 37s 640ms/step - accuracy: 0.9613 - loss: 0.1435 - val_accuracy: 0.9593 - val_loss: 0.1183
Epoch 12/30
45/45 ━━━━━━━━━━━━━━━━━━━━ 41s 632ms/step - accuracy: 0.9655 - loss: 0.1207 - val_accuracy: 0.9572 - val_loss: 0.1241
Epoch 13/30
```

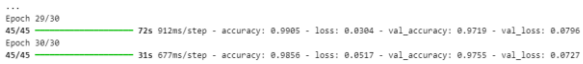

Fig. 15. Iteration Process

The training results, including accuracy and loss on the training and validation data, will be stored in a variable named `history` for further analysis. Visualization of training metrics, such as accuracy and loss graphs, will be used to understand the model's performance during the training process.

5. Training

In the evaluation stage, the Convolutional Neural Network (CNN) model is evaluated using separate test data (x_test, y_test) to measure the model's performance on unseen data. Evaluation is done using the evaluate method on the model object, which provides the loss and accuracy values on the test data. Additionally, the sklearn.metrics library is used to calculate the accuracy score of the model on the test data. The accuracy score provides information about how well the model can classify BISINDO alphabet hand signs on unseen data. This testing process is important to validate the model's performance before it is used in real-world applications. Finally, the training results of the model were visualized to understand the performance trends of the model during the training process.

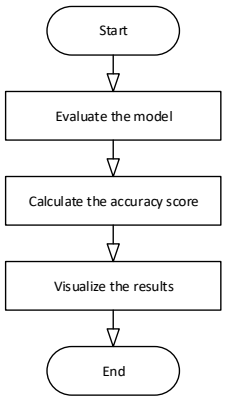

Fig. 16. Testing Flowchart

This process helps evaluate whether the model experiences overfitting or underfitting and determines if adjustments were needed in the architecture or parameters of the model. The results of this testing serve as the primary evaluation basis to determine how well the CNN model that has been built can be used in the BISINDO alphabet hand sign recognition application.

IV. Result and Discussion

In this section, the results of testing the BISINDO alphabet hand sign recognition system using Convolutional Neural Network (CNN) were presented to evaluate the system's performance in recognizing hand signs in the prepared dataset. The following were the detailed test results obtained:

1. Evaluation Metrics

Evaluation metrics were used to measure the performance of the Convolutional Neural Network (CNN) model that has been built. Evaluation is done using four main metrics, namely accuracy, recall, F1 score, and precision. The details of each metric were as follows:

TABLE I
Evaluation Metrics

Accuracy	Recall	F1 Score	Precision
97,5%	97,5%	97,5%	97,6%

2. Training and Validation Data

In the training stage of the Convolutional Neural Network (CNN) model for BISINDO alphabet hand sign recognition, the data is divided into two main parts: training data and validation data, which were taken from the test data. The training data is used to train the model, while the validation data is used to measure the model's performance during the training process.

1) Training and Validation Data Accuracy

In the final epoch, the model training is stopped after the 30th iteration, as specified by the batch size of 128. At this point, the evaluation accuracy reaches 97.5%. The model also achieves an accuracy of 97.5% for the training dataset, demonstrating the model's ability to recognize hand signs with a high level of accuracy. The accuracy graph can be seen in Figure 17.

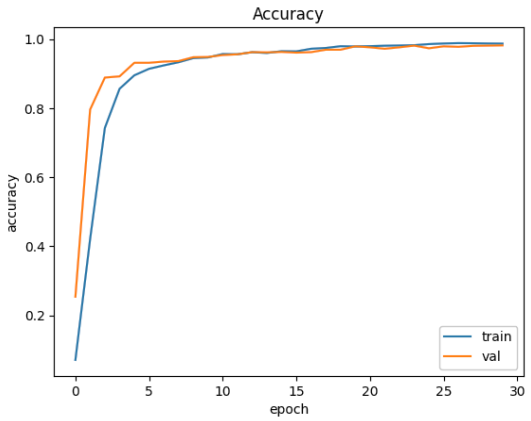

Fig. 17. Graph od Training and Validation Data Accuracy

2) Training and Validation Data Loss

In the final epoch, the model training is stopped after the 30th iteration, as specified by the batch size of 128. At this point, the evaluation loss reaches 0.076, indicating that the model has a low error rate in making predictions. The detailed loss for the training dataset

also reaches 0.076, indicating that the model can recognize hand signs with a high level of accuracy. The loss graph can be seen in Figure 18.

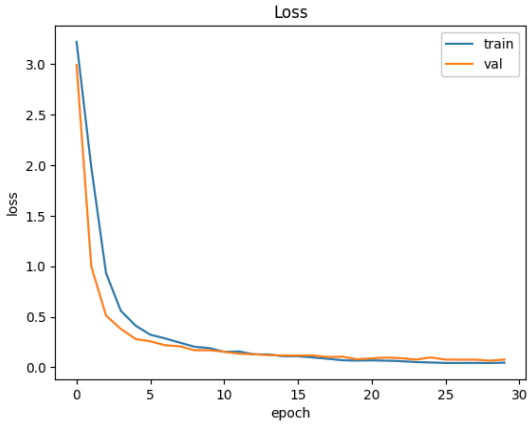

Fig. 18. Graph of Training and Validation Data Loss

Previous training was conducted until a satisfactory accuracy value was achieved, resulting in an optimal model. Here is a comparison of the Training Accuracy, Training Loss, Validation Accuracy, and Validation Loss values in Table 2.

TABLE II
COMPARISON OF ACCURACY AND LOSS VALUES PER EPOCH

Epoch	Train Accuracy	Train Loss	Val Accuracy	Val Loss
5	0.9098	0.3556	0.9306	0.2842
10	0.9531	0.1636	0.9558	0.1405
15	0.9728	0.0903	0.9621	0.1111
20	0.9858	0.0533	0.9712	0.0913
25	0.9925	0.0331	0.9804	0.0599
30	0.9856	0.0517	0.9755	0.0727

3. *Prediction Test*

The prediction test is conducted to evaluate the performance of the Indonesian Sign Language (BISINDO) alphabet hand sign recognition system that has been developed. Prediction is done using Flask to run the previously designed CNN model. The prediction test is conducted on a prediction dashboard via a web interface that displays a webcam prediction feature to predict alphabet hand signs in real-time. Below were sample prediction results that can be seen in the images below:

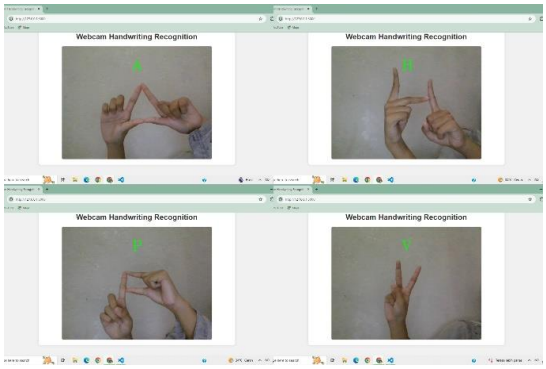

Fig. 19. Sample Prediction Result

After the prediction process, a prediction table is created to present the results of predicting the letters of the alphabet hand sign. The table contains correctly and incorrectly predicted letters based on the test data used in the evaluation. An example of a prediction table can be seen in Table 3 below:

TABLE III
PREDICTED LETTER RESULT

No.	Letter	Prediction Result
1.	A	Correct
2.	B	Correct
3.	C	Correct
4.	D	Correct
5.	E	Correct
6.	F	Correct
7.	G	Incorrect
8.	H	Correct
9.	I	Correct
10.	J	Correct
11.	K	Correct
12.	L	Correct
13.	M	Correct
14.	N	Correct
15.	O	Correct
16.	P	Correct
17.	Q	Correct
18.	R	Correct
19.	S	Correct
20.	T	Correct
21.	U	Correct
22.	V	Correct
23.	W	Correct
24.	X	Correct
25.	Y	Correct
26.	Z	Correct

4. *Comparison with Previous Research*

In this study, input images of size 28x28 pixels were used, and training was conducted for 30 epochs. The results show that the proposed algorithm achieved an accuracy of 97.54%. The comparison of the accuracy of this research with previous research can be seen in Table 4:

TABLE IV
COMPARISON OF ACCURACY WITH PREVIOUS RESEARCH

No.	Method	Data	Input Size	Accuracy (%)
1.	*Convolutional Long Short Term Memory* (LTSM) [3]	Alphabet Sign Language BISINDO	100 x 100	68%
2.	*Local Directional Pattern* & Klasifikasi *K-Nearest Neighbour* (KNN) [14]	*Turkey Ankara Ayrancı Anadolu High School's Sign Language Digits*	100 x 100	88,45%
3.	*Convolutional Neural Network* (CNN) [9]	Alphabet Sign Language SIBI	200 x 200	90,05%
4.	*Convolutional Neural Network* (CNN)	Alphabet Sign Language BISINDO	28 x 28	97,54%

From the table above, it can be seen that the developed method has achieved a higher level of accuracy compared to previous research. This difference indicates significant progress in the development of a better model.

5. Prediction Test

In testing the Indonesian Sign Language (BISINDO) alphabet sign recognition system using Convolutional Neural Network (CNN), evaluation metrics such as accuracy, recall, precision, and F1 score provided satisfactory results. An accuracy of 97.5% indicates a high level of accuracy in recognizing sign language. The same recall value indicates that the model is able to recognize most of the sign language that should be positive, while a precision of 97.6% indicates that most of the sign language classified as positive by the model is indeed positive. An F1 score of 97.5% indicates that the model has a good balance between precision and recall, making it reliable in recognizing BISINDO alphabet sign language.

During the training and validation stages, the model successfully achieved a high level of accuracy on their respective datasets. This indicates that the model did not experience overfitting and was able to generalize hand sign patterns well on new, unseen data. Thus, the developed Convolutional Neural Network (CNN) model has a strong capability in recognizing Indonesian Sign Language (BISINDO) alphabet signs.

The results of the prediction test demonstrate the model's ability to recognize sign language in real-time with high accuracy. By using Flask to run the previously designed CNN model, the model can provide predictions for BISINDO alphabet sign language directly through a web interface. The webcam prediction feature allows for direct sign language prediction through the webcam.

During the testing process, the system successfully predicted 25 out of 26 alphabet letters as predicted by the sign language recognition system. However, the prediction results indicate that there is still room for improvement in detecting one letter that was not predicted well out of the total of 26 Indonesian Sign Language (BISINDO) alphabet letters. With further evaluation and necessary adjustments, it is hoped that the system can improve its ability to recognize all alphabet letters with high accuracy.

V. CONCLUSION

Based on the research findings, analysis, method implementation, and discussion, this study successfully developed a hand gesture recognition system for the Indonesian Sign Language alphabet (BISINDO) using Convolutional Neural Networks (CNN). With an accuracy rate of 97.5% and a good balance between recall, precision, and F1 score, this system demonstrates excellent performance in recognizing hand gesture patterns/images of the BISINDO alphabet. The implementation of the system for real-time prediction through a web interface using Flask also enhances its accessibility. However, there is room for improvement, particularly in recognizing a specific letter that has not been predicted accurately. Therefore, the continuous development of this system is necessary to further enhance accuracy and proficiency in recognizing hand gestures more comprehensively.

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Implementation of Support Vector Machine Method for Twitter Sentiment Analysis Related to Cancellation of u-20 World Cup in Indonesia

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***Abstract*-The cancellation of the U-20 world cup in Indonesia in 2023 has become a hot debate among the Indonesian people because the reasons for the cancellation are still unclear. The number of pro and con opinions uploaded by the Indonesian people on twitter social media makes these opinions can be used as data to assess opinions which are divided into three categories, namely positive, negative and neutral. After being divided into three categories, sentiment analysis will then be carried out using the SVM method and comparing linear, polynomial and rbf kernels to get the best performance of existing kernels in the support vector machine method. By using confusion matrix to measure the performance of the classification, accuracy, precision, recall and f1-score can be assessed. It was found that the 80:20 data ratio had the highest accuracy of the linear, polynomial, rbf kernel and the rbf kernel had better results than the linear and polynomial kernels, namely Accuracy 78.15%, F1-Score, 76.30%, Precision 77.37% and Recall 75.58%. In addition, the data obtained also succeeded in analyzing Indonesian texts that were input externally and categorized into positive, neutral and negative. From the results that have been obtained, the support vector machine method has been successfully implemented in sentiment analysis of the U-20 world cup cancellation in Indonesia in 2023 on twitter social media.**

Keywords-Sentiment Analysis, confusion matrix, U-20 World Cup, Support Vector Machine, Twitter

I. INTRODUCTION

The U-20 world cup is a world soccer event established by FIFA (Federation Internationale de Football Association) and followed by countries from all parts of the world by conducting qualifying rounds and players under the age of 20 years. The U-20 world cup is held every 2 years. The U-20 world cup was first held in 1977 in Tunisia [1]. In 2019 at the FIFA board meeting in Shanghai, China it was determined that Indonesia would host the U-20 world cup beating other candidates such as Peru and Brazil. The U-20 world cup in Indonesia was supposed to be held in 2021, but the event was canceled due to the unfinished Covid-19 pandemic. Furthermore, the U-20 world cup in Indonesia was determined to have a new match schedule on May 20, 2023 - June 11, 2023 [2].

When the time of the U-20 World Cup in Indonesia was approaching, the Governor of Bali and the Governor of Central Java gave a statement rejecting the presence of the Israeli national team [2]. Reporting from CNBC Indonesia, the rejection was because Israel did not have diplomatic relations and colonized the Palestinian people [3]. Then on March 26, 2023, PSSI (Indonesian Football Association) confirmed that the U-20 world cup phase match drawing schedule was canceled and the drawing was planned to be held on March 31, 2023 in Bali. Reporting from the official FIFA website on March 29, 2023 it was announced that the U-20 world cup in Indonesia was canceled [4]. Of course, this decision raises a variety of pro and con opinions regarding the cancellation of the U-20 world cup to be held in Indonesia which have sprung up to social media. One of the social media used for opinion is Twitter.

Twitter is a microblog social media that allows users to interact with each other and various topics of discussion [5]. Reporting from Data report, the total active twitter users in Indonesia reached 24 million by 2023 [6]. Reporting from We Are Social Twitter is the sixth most social media of total social media users in Indonesia. This number shows that twitter is a social media that has become one of the media in Indonesian society to get information and have opinions in the public sphere [7]. With the many opinions conveyed on twitter social media, these opinions can be used as an assessment material to determine public sentiment regarding the cancellation of the U-20 world cup in Indonesia.

Sentiment analysis is the process of understanding, extracting and processing textual data automatically to find out sentiment information contained in a word [8]. Therefore, from the many opinions conveyed by the public, this sentiment analysis can be useful for assessing and knowing the sentiments held by the public on twitter social media related to the cancellation of the U-20 world cup in Indonesia. Then, the data obtained will be classified into three opinion categories, namely positive, neutral and negative opinions.

Similar research has been conducted by [9] from the study found that the SVM algorithm gets an accuracy of 88.76% and the K-NN algorithm gets an accuracy of 88.1% from these results the SVM algorithm gets better results than K-NN. Similar research has also been conducted by [10] for sentiment analysis using the Naive Bayes, SVM and K-NN algorithms from the results of this study the SVM algorithm has a higher accuracy than the Naive Bayes and K-NN algorithms.

Based on the background of the problems that have been found, sentiment analysis research on twitter social media related to the cancellation of the U-20 world cup to be held in Indonesia aims to find out what sentiments are contained in opinions expressed by the public through twitter social media and the selection of the Support Vector Machine algorithm because from previous research this algorithm can provide better accuracy than other algorithms such as K-NN and Naive Bayes. SVM (Support Vector Machine) algorithm used to classify data in machine learning which aims to find a dividing line or hyperplane with the largest margin, which serves to classify data sets optimally [11].

II. THEORETICAL FOUNDATION

A. U-20 World Cup

The U-20 World Cup is an international soccer event formed by FIFA (Federation Internationale de Football Association) this event is intended for players under the age of 20 years and is held every 2 years. The U-20 World Cup procurement was first held in 1977 and the tournament was held in Tunisia [12]. The first time this sporting event was held was known as the FIFA Junior Cup and was attended by sixteen U-20 national teams from around the world. in 1985 FIFA changed the name of this sporting event to the FIFA World Championship for young players and added a player age limit to 20 years and under [12].

B. Sentiment Analysis

Sentiment analysis is the process of understanding, extracting, and processing textual data to reveal sentiment information contained in a sentence [8]. Sentiment analysis is part of Text mining which means sentiment analysis performs computational research based on sentiment, emoticons, comments and every expression through text. Sentiment analysis is divided into two classifications, namely the classification of opinion or fact documents and the classification of documents into negative, positive and neutral groups. [13].

C. TF-IDF

TF-IDF method is a method to give weight value to words in a document or sentence. The TF-IDF method combines two concepts in its calculation, namely term frequency and inverse document frequency. Term Frequency is the frequency of occurrence of a word in a particular document or opinion while inversed document frequency is the frequency of documents that have that word. The frequency of occurrence of a word is given to show how important the word is in a document. The frequency of documents containing a word can show how common the word is. This causes the relationship between a word and a document to be high if the frequency of the word is high in a document or sentence and the frequency of all documents containing the word is low in the document collection [14]. To calculate TF-IDF, you can use the following:

1) TF calculation formula.

$$tf_{(t,d)} = tf / max(tf)$$

2) IDF calculation formula

$$Idf_{(t)} = log(D / df_t)$$

3) TF-IDF calculation formula

$$W_{t,d} = t\,f_{(t,d)} \times idf_t$$

Description:
$tf_{(t,d)}$ = Term frequency (TF).
$max(tf)$ = Total of all words in a document.
tf = Term occurrence in the document.
D = Total of all documents.
$idf(t)$ = the occurrence weight of term t across documents.
$W_{t,d}$ = the weight of a word in a document
df_t = number of documents that have term t

D. Support Vector Machine

Support vector machine is an algorithm that uses hypothesis space as a learning system. The Support Vector Machine algorithm is part of data classification that can classify multi-class data. support vector machine algorithm classification uses a hyperplane line as a dividing line if the dividing line is straight called linear and if the dividing line is not straight it is called non-linear [15].

In the classification of models using support vector machines, there are several parameters that are useful for improving the performance of modeling, namely gamma, cost (C) and kernel. The gamma parameter is a parameter that serves to determine how far the influence of the sample dataset is trained and in the

gamma parameter low values mean far while high values mean close, the cost (C) parameter is a parameter used as an optimization of the SVM method to avoid errors in classification on the trained data [16] and the use of kernels in the support vector machine algorithm is useful for transforming data into high-dimensional space [16]. There are several choices of kernel functions that can be used in the classification of the Support Vector Machine method, namely:

1) Linear Kernel

Linear kernel is a simple function in SVM modeling. Linear kernels are useful for analyzing linearly separated data [17]. Equation 2.4 is a linear equation and Figure 1 is an example of using a linear kernel.

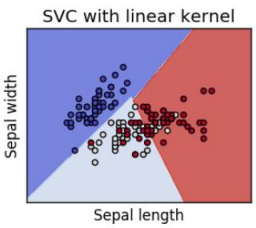

Fig 1. Linear Kernel
Source: [18]

$$K(x, xi) = \text{sum}(x * xi) \quad (2.4)$$

In the kernel equation formula, xi is the training data and x is the Support Vector Machine test data.

2) Polynomial Kernel

Polynomial kernels are used when the dividing line is not linear. Polynomial kernels are used to solve the classification problem of training datasets that have been normalized [17]. Formula 2.5 is a polynomial equation and Figure 2 is an example of using a polynomial kernel.

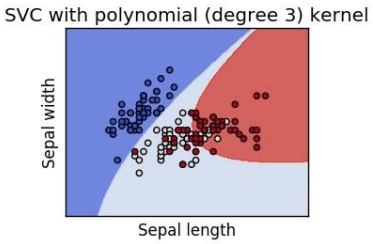

Fig 2.Polynomial kernel
Source: [18]

$$K(x, xi) = 1+\text{sum}(x * xi)^{d} \quad (2.5)$$

The polynomial kernel has a degree parameter (d) the function of this parameter is to find the optimal value of the dataset and the greater the degree used, the less stable the resulting performance.

3) Kernel Rbf

Rbf kernel is used when the data used is non-linear. The rbf kernel produces a smaller error value than other kernels [17] Equation 2.6 is the rbf equation and Figure 3 is an example of using the rbf kernel.

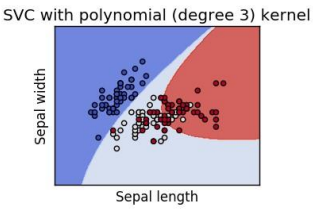

Fig 3.Rbf kernel
Source: [18]

$$K(x, xi) = exp(-\gamma * sum((x - xi^2)) \quad (2.6)$$

RBF kernel has a gamma parameter that serves to determine how far the influence of a sample dataset is trained.

E. Confusion Matrix

Confusion Matrix is used to measure performance in machine learning modeling. Confusion Matrix can consist of two or more classes [19]. Confusion Matrix has a table of four different combinations as seen in Figure 4.

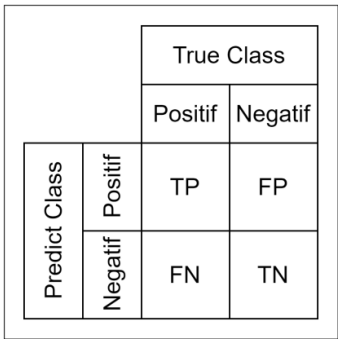

Fig 4. *Confusion Matrix*

Description:

- TP: The prediction result is positive and correct.
- TN : The prediction result is negative and correct.
- FP: The prediction result is positive and false.
- FN : The prediction result is negative and false.

Confusion Matrix has several formulas in its calculations which are used to calculate accuracy, precision, recall and F1-score.

1) *Accuracy*

Accuracy in Confusion Matrix is a calculation to describe how accurate the classification model that has been made correctly. The following is the formula for calculating Accuracy:

$$Accuracy = (TP+TN) / (TP+TN+FP+FN)$$

2) *Precision*

Precision is a formula to describe the accuracy between data and classification results with the model. The following is the formula for calculating precision:

$$Precision = TP / (TP+FP)$$

3) *Recall*

Recall is a depiction of the success of the model applied in retrieving information. The following is the formula for calculating recall:

$$Recall = TP / TP+FN$$

4) *F1-Score*

F1-score is the average comparison of precision and recal results that have been weighted. The following is the formula for calculating F1-score:

$$F1-Score = 2 \times ((precision \times recall) / (precision+recall)) \quad (2.10)$$

III. METHODOLOGY

In this section, we will describe the flowchart of the system that has been created. The flowchart includes a flowchart of the design overview, Pre-Processing flowchart, Apply TF-IDF flowchart and Apply Support Vector Machine flowchart.

A. Overview of the Design

Overview of the Design is the steps of the design which are organized and described using Flowchart diagrams from the beginning to the end of the design. Seen in Figure 5 the flow of this design starts from crawling data, labeling, Text pre-processing, Train-Test split data, Apply TF-IDF, Apply SVM, Evaluation.

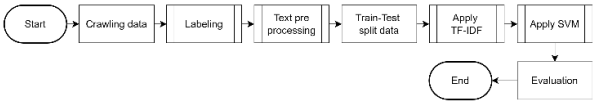

Fig 5. *Flowchart of the* Design Overview

B. Crawling Data

Data Crawling is a method for retrieving information on a website [20]. In this study, data crawling was carried out using the snscrape library to get the tweets of a number of users with the research topic. In this research, crawling data uses the keyword "U20 World Cup" and the data retrieved is only in Indonesian starting from March 30, 2023 to April 05, 2023. The date was chosen since FIFA announced the cancellation of the u-20 world cup which will be in Indonesia in 2023 and from the results of data collection obtained as much as 14807 tweet data.

C. Data Labeling

Data labeling is used to give sentiment to tweets that have been obtained from the data crawling process. At the labeling stage will use the Valence Aware Dictionary and Sentiment Reasoner (VADER). VADER is a tool in sentiment analysis based on rules specifically tailored to the sentiment being expressed. VADER consists of a sentiment dictionary of words that are generally labeled with positive, negative and neutral words [21].

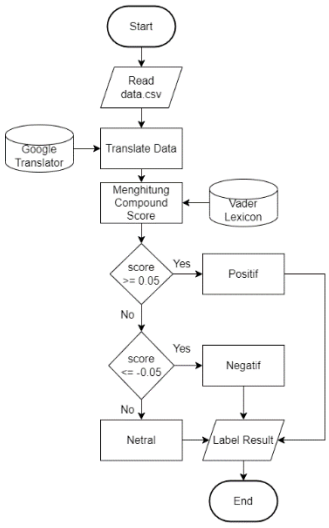

Fig 6. Data Labeling *Flowchart*

Figure 6 is a flowchart in performing the labeling process. Starting from reading the data that has been obtained from the crawling results then translated data. Translated data is done because VADER cannot read data that uses languages other than English. In the Translated Data process using the Google Translator library. After the data has been successfully translated, the next process is to calculate the compound score using VADER. If the score >= 0.05 then the sentiment is positive, if the score <= -0.05 the sentiment is negative and if the score is > -0.05 and < 0.05 then the sentiment given is neutral.

D. Text Preprocessing

Text preprocessing stage is a process to select text data so that it becomes structured. In the research conducted by [22] found that the best stage of doing text preprocessing is to do the normalization process first before doing the stopword and stemming stages. Figure 7 is the stage of text preprocessing.

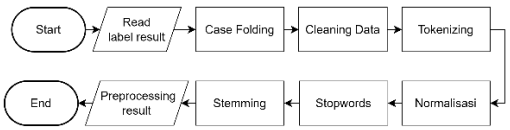

Fig 7. *Text Preprocessing Flowchart*

1) Case Folding

Case Folding is a process that generalizes the text in the data to lower case.

2) Cleaning Data

This stage performs selection by cleaning the text from usernames, hastags, symbols, emoticons, links, single char, numbers, whites pace and punctuation.

3) Tokenizing

Tokenizing stage will separate the sentence into a list of words. This is done for the next stage, namely the Normalization, Stopwords and Stemming stages.

4) Normlasasi

Normalization aims to correct words that are wrong in writing. Examples of the use of normalization such as the word "sdg" becomes the word "sedang".

5) Stopwords

The stopwords stage serves to eliminate words that have no meaning in sentences such as conjunctions.

6) Stemming

Stemming is the stage of extracting the basic word form by removing affix words.

E. Train-Test Split Data

Train-Test split data is a technique in machine learning to split data into training and testing data. This process is done to assess modeling performance in machine learning. Train-Test Split Data is done before weighting because it is to see the data that is divided still into text so that it can read sentences and compare the labels given before and after modeling with the support vector machine algorithm.

F. Apply TF-IDF

Before classifying the model with the support vector machine algorithm, TF-IDF weighting will be carried out which functions to provide weight values to the data. In Figure 8 after the data has gone through the Train-Test Split Data stage, the next word weighting will be carried out using TF-IDF and produce Train (TF-IDF) and Test (TF-IDF).

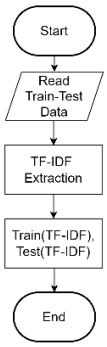

Fig 8. *Flowchart of Apply TF-IDF*

G. Apply SVM

After the text data has been weighted using TF-IDF, the next step is to implement the support vector machine method to classify the data.

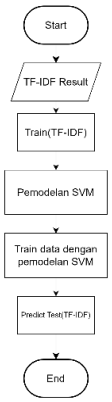

Fig 9. *SVM Apply Flowchart*

Figure 9 the Train(TF-IDF) data goes through a modeling process so that the results of the modeling are used to predict the Test(TF-IDF) data.

H. Evaluation

The evaluation stage will use Confusion Matrix to measure the performance in classifying the data that has been done by the Support Vector Machine algorithm using a table consisting of positive, neutral and negative. The table has a True value which means the true label and predict label predict.

IV. Result

A. Implementation

Data collection related to this research will use the snscrape library and pandas library which is useful for storing the data into csv file dataframes.

	Datetime	Username	Text
0	2023-04-05 23:57:19+00:00	halintarbungkam	@ch_chotimah2 @Dennysiregar7 @erickthohir @jok...
1	2023-04-05 23:54:25+00:00	kirarachelsea	Gagalnya perhelatan piala dunia U-20 di Indone...
2	2023-04-05 23:29:31+00:00	teodorikgultom	@tatakujiyati Tapi @aniesbaswedan kan sering m...
3	2023-04-05 23:22:27+00:00	03__nakula	Dicoret sebagai tuan rumah piala dunia U-20, b...
4	2023-04-05 23:18:25+00:00	Aprilia_wiji	Ketua umum Erick Thohir mengungkapkan alasan F...
...	...	...	...
14802	2023-03-30 00:01:26+00:00	PRFMnews	Piala Dunia U-20 Batal Digelar di Indonesia ht...
14803	2023-03-30 00:00:41+00:00	CNNIndonesia	4 Tahun Perjuangan Indonesia Jadi Tuan Rumah P...
14804	2023-03-30 00:00:08+00:00	Eka12Febby	@Metro_TV 3043 guru PI PPPK se-Indonesia dan T...
14805	2023-03-30 00:00:01+00:00	Bolanet	Pemain Timnas Indonesia U-20 ramai-ramai tumpa...
14806	2023-03-30 00:00:00+00:00	voidotid	Politikus PDIP Budiman Sudjatmiko mengatakan, ...

14807 rows × 3 columns

Fig 10. Data Crawling Results

Figure 10 is the result of crawling data that has been done and obtained as many as 14807 tweets. It can be seen that the data frame contains three columns that store dates, usernames and tweets from the results of crawling twitter. After successfully collecting data, the next step is to label the data that has been collected.

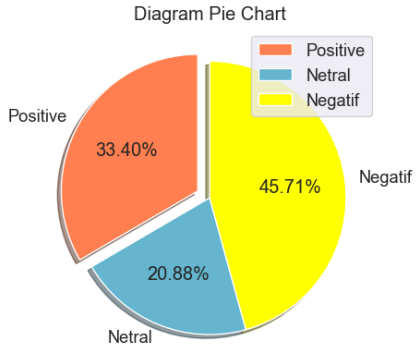

Fig 11. *Labeling Results with VADER*

Figure 11 is the result of labeling using VADER from 14807 data that has been collected. The data shows that 33.40% or 4946 data has positive sentiment, 45.71% or 6769 data has negative sentiment and 20.88% or 3092 has neutral sentiment. After successfully labeling the next step is to do Text Preprocessing. This stage is a process for selecting text data so that it becomes structured. Because the text to be analyzed for sentiment is in Indonesian, the columns that will be stored in the data are Indonesian text and labels. Stages in performing Text Pre-processing are case folding, data cleaning, tokenizing, normalization, stopwords and stemming. Table I is an example of the results of data that has been done a series of text preprocessing.

TABLE I. Example of text preprocessing results

Teks	Text Preprocessing
Intinya dalam salah satu pasal persyaratan ikut FIFA itu bahwa sepakbola ini hanya murni sebatas olahraga jangan ada Intervensi dari pihak pemerintah. ajang piala dunia U-20 sebagai pemersatu anak dari pelbagai bangsa yang hanya mau bermain bola tanpa pedulikan agama atau politik	inti salah pasal syarat fifa sepakbola murni batas olahraga intervensi perintah ajang piala dunia satu anak bangsa main bola peduli agama politik

After the text preprocessing stage has been carried out, the next step is to divide the training data and testing data to measure the performance of the modeling, then weight the data that has been collected using TF-IDF. TF-IDF serves to convert text into numeric data so that the support vector machine algorithm can understand the input text and after the weighting stage is carried out, then classify the data using the SVM method.

B. Testing

The test phase will be carried out with test scenarios and each scenario will be evaluated so that it can be seen which one can provide the best performance. The sentiment analysis test scenario of this research is to compare linear, polynomial and rbf kernels in the Support Vector Machine method and also compare training and testing data as much as 60 to 40, 70 to 30 and 80 to 20. This test is conducted to find which kernel can produce better performance behavior and how influential the comparison of training and testing data is in sentiment analysis. After testing kernels that produce better performance, modeling will be made for training all data that has been collected to test the SVM method in analyzing Indonesian text that is entered or inputted externally.

TABLE II is the result of kernel comparison and division of 14807 data that has been collected as 60% training data and 40% testing data.

TABLE II. 60:40 Dataset Comparison

Matrix %	60:40		
	Linear	Polynomial	Rbf
Accuracy	74.52%	69.42%	76.12%
F1-Score	72.87%	66.11%	74.33%
Precision	73.13%	74.40%	75.51%
Recall	72.63%	63.82%	73.54%

TABLE III is the result of kernel comparison and division of 14807 data that has been collected as 70% training data and 30% testing data.

TABLE III. 70:30 Dataset Comparison

Matrix %	70:30		
	Linear	Polynomial	Rbf
Accuracy	75.39%	70.08%	76.68%
F1-Score	73.87%	66.93%	74.91%
Precision	74.11%	74.72%	76.06%
Recall	73.64%	64.58%	74.12%

TABLE IV is the result of kernel comparison and division of 14807 data that has been collected as 80% training data and 20% testing data.

TABLE IV. 80:20 Dataset Comparison

Matrix %	80:20		
	Linear	Polynomial	Rbf
Accuracy	76.02%	71.47%	78.15%
F1-Score	74.40%	68.65%	76.30%
Precision	74.59%	76.06%	77.37%
Recall	74.23%	66.36%	75.58%

From TABLE II, TABLE III, TABLE IV after the testing process by comparing and dividing the training data and testing data, the results show that the linear, polynomial and rbf kernels get the best assessment of the 80:20 dataset division and the rbf kernel gets better results than the linear and polynomial kernels by getting the results of Accuracy 78.15%, F1-Score 76.30%, Precision 77.37% and Recall 75.58%. From the results of these trials, it can also be seen that the more training data used, the better the performance of the modeling results.

After testing, the rbf kernel obtained better results than the polynomial and linear kernels. The next step is to model sentiment analysis using the rbf kernel and train the model with a total of 14807 data.

	Text	Label-SVM
0	gagalnya piala dunia membuat kita kecewa	negatif
1	tetap semangat buat kedepannya	positif
2	piala dunia membuat masyarakat kecewa	negatif
3	dengan batalnya piala dunia dapat membuat kita...	positif
4	ada apa dengan piala dunia di indonesia ?	netral

Fig 12. Indonesian text testing results

Figure 12, the model can analyze the sentiment contained in Indonesian text and classify it into positive, negative or neutral classes.

V. CONCLUTION

Based on the results of the trials that have been carried out in Twitter Sentiment Analysis Related to the Cancellation of the U-20 World Cup in Indonesia, several conclusions and suggestions can be drawn as follows:

1) Twitter sentiment analysis research related to the cancellation of the U-20 World Cup in Indonesia using the Support Vector Machine method has been successfully carried out and can be used for sentiment analysis related to Indonesian language discussion topics. Of the 14807 data that has been collected, labeling is done using VADER, the results of the labeling are 33.40% or 4946 positive sentiment data, 45.71% or 6769 negative sentiment data and 20.88% or 3092 neutral sentiment.

2) The results of kernel comparison and data comparison measurements that have been carried out using confusion matrix show that the rbf kernel gets better performance than the linear kernel and polynomial kernel by showing the results of Accuracy 78.15%, F1-Score 76.30%, Precision 77.37% and Recall 75.58%. The division of training data and testing data in the test scenario shows that the more data that is trained in modeling, the better the accuracy results will be.

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Avia Saga: A Gamified Mobile-Based Learning Management System

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***Abstract*—The usage of Learning Management Systems (LMS) has increased since the Covid-19 pandemic. LMS has drawbacks despite the advantages they provide. To fully support the advantages it provides, students must be motivated and involved. Adding gamification to the LMS is one way to potentially solve this issue. The MDA framework and Octalysis are combined in this research's gamification approach. The application, named Avia Saga, was designed and built using Flutter and Spring Boot as a mobile application. A trial of the application was conducted with 38 students majoring in Informatics. The evaluation of the application was done using the Hedonic-Motivation System Adoption Model (HMSAM) with a Likert scale. The research results revealed a 7% increase in the behavioral intention to use category, suggesting a greater inclination for reusing the application, and an 11.7% increase in the immersion category, indicating elevated sentiments of users being carried away by the ambiance while using the application.**

Keywords—Avia Saga; Gamification; Learning Management System; MDA; Octalysis

I. INTRODUCTION

The use of Learning Management Systems (LMS) represents the embodiment of technological advancements in the educational sector, which have become increasingly prevalent since the onset of the COVID-19 pandemic [1–3]. LMS enables users to interact with learning content as well as with educators [4]. Studies have shown that the utilization of LMS has a positive impact on academic performance [5–7]. However, the use of LMS is not without its drawbacks.

The success of LMS depends on the motivation of its users [8]. The benefits and positive impacts provided by LMS can only be fully realized if users have the motivation and drive to participate. There is a high tendency for academic failure among students who lack learning motivation [9]. This is also aligned with another drawback of LMS, which is the lack of student engagement or passivity. A decline in student motivation and engagement also diminishes the users' learning experience. Students' motivation in learning tends to decrease [10, 11]. Research indicates that the current use of LMS is largely reduced to being a repository/storage space [8]. One highly potential solution to address this issue is the implementation of gamification in LMS [12].

Gamification is a method of designing a system to provide experiences and motivation similar to those of a game [13]. Gamification has been widely applied in various fields, including business [14], finance [15], health [16], and education [17]. The application of gamification in education has a positive impact on the learning experience, motivation, and academic performance of students [18, 19]. There are several well-known frameworks for designing effective gamification experiences, including the Octalysis and MDA Frameworks [20].

The Octalysis framework is a gamification framework focused on enhancing user motivation and engagement with a system [21]. Octalysis analyzes eight core drives within an individual to determine the gamification components to be implemented in the system. Meanwhile, the MDA Framework is a framework that focuses on the fundamental components and elements when designing a game [22]. MDA is used to design and analyze a game by dividing the gaming experience into mechanics, dynamics, and aesthetics. This framework aims to bridge the gap between game design and development, game criticism, and technical game research [23].

Similar research has been conducted previously using various gamification methods and evaluations [24–26]. There is a study that employed the Octalysis framework [27]. Using the Technique for User Experience Evaluation in e-Learning (TUXEL) method, the system received positive scores in the User Experience Evaluation for practicality, creativity, motivation, and enjoyment, and an average score (0.77) for ease of use. However, various issues were also identified. Thirteen issues were found related to Usability Inspection and eight issues were related to

Pedagogical Usability. It is recommended that the use of Octalysis and TUXEL be continued in future research, but with improvements in application design.

There is also a study that introduced a Multi-Layer Gamification Framework called the NEWTON-Enhanced Gamification Model (N-EGM) [20]. N-EGM was developed by combining aspects from the MDA framework, Design Six, and Octalysis, and adding a socialization element. This study implemented the N-EGM Model in a STEM learning system. The results showed that this gamification approach increased engagement among 78% of the student respondents. There was an improvement in the assimilation of material/knowledge among the students, verified with a confidence level of 95%.

Designing an LMS with the Octalysis framework has yielded positive results in several aspects, but it also has issues, particularly with usability, indicating the need for design improvements. The MDA framework provides an understanding of how game components can affect user experience. This insight from MDA can be used as "fuel" to create a new design [22].

Behavioral Intention to Use (BIU) refers to a person's willingness to reuse a system, while immersion is the degree of engagement and involvement in using the system [28]. BIU is an important factor for assessing the acceptance of a system [29]. Immersion is a key factor for evaluating user engagement with the system [30]. The Hedonic-Motivation System Adoption Model (HMSAM) focuses on testing systems designed to meet users' intrinsic motivations and evaluating both behavioral intention to use and immersion [28]. Studies show that HMSAM is a promising and effective model for assessing students' acceptance of gamified learning [31].

Mobile-based technology has a positive effect on students' academic performance [32]. Research indicates that students desire more learning activities to be conducted on mobile applications [33]. Therefore, there is a need for a mobile-based Learning Management System designed using gamification methods with the MDA and Octalysis frameworks. The method used to evaluate the implementation of gamification in the LMS is the Hedonic-Motivation System Adoption Model (HMSAM).

II. Literature Review

A. MDA Framework

The Mechanics-Dynamics-Aesthetics (MDA) Framework is a tool to analyze a game [23]. Fig. 1 shows a diagram of the division of a game into three elements in the MDA Framework, namely Mechanics, Dynamics, and Aesthetics. Each element affects the formation of the next part. Mechanics creates dynamics, which trigger aesthetics.

Mechanics describes the components that are identical to the game. Anything that can explicitly trigger dynamics can be referred to as a mechanic [22]. Game mechanics consist of points, levels, leaderboards, badges, challenges/quests, onboarding, and social engagement loops.

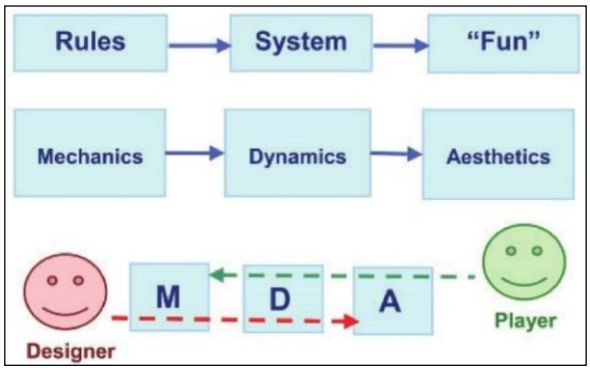


Fig. 1. MDA framework order of influence [23]

Dynamics describes the driving behavior of mechanics that occurs based on player actions and reactions to those actions. Dynamics acts as a bridge between game designers and players. When well defined, dynamics will support the design process and improve the efficiency of game development [23]. Dynamics keeps the user motivated towards the mechanics. It comprises rewards, status, achievement, self-expression, competition, and altruism.

Fun has a complicated definition. It is difficult to define what makes a game fun. Intrinsic and extrinsic motivations motivate people to play games, but intrinsic motivation is the main motivation. A good game should use extrinsic rewards to motivate players and help them reach a mental state of flow. To maintain this state, the game must balance the challenge provided with the user's ability. This can be achieved by utilizing various categories to account for pleasure and aesthetics: sensation, fantasy, narrative, challenge, friendship, discovery, expression, and submission [23].

B. Octalysis

The Octalysis gamification framework consists of eight gamification core drives as follows [21].

1. Epic Meaning & Calling

It is a core drive when a player believes that what the player is doing is bigger than themselves or that the player is chosen to do something. This is reflected when the player dedicates a lot of time to other things related to the game. Another element of this core drive is the luck effect. This effect makes the player believe that the player has a special talent to get something good when just starting the game. Examples of the implementation of this core drive are the use of narrative, beginner's luck, and exclusivity.

2. Development & Accomplishment

It is a core drive that is internally generated. It triggers the drive to take on challenges and make new achievements. This core drive is the easiest to implement. An example of implementing this core drive is the use of leaderboards, badges, and quests that come with challenges.

3. Empowerment of Creativity & Feedback

It is a core drive that occurs when players are required to do something repetitively to find out something. A player needs a way to express their creativity and also see the results of that creativity. An example of implementing this core drive is the use of combinations and instant feedback.

4. Ownership & Possession

It is a core drive that occurs when players feel motivated by a sense of ownership. A sense of ownership makes players want to continue to develop what they have to be better. An example of this core drive implementation is the use of avatars and redeemable points or rewards.

5. Social Influence & Relatedness

It is a core drive related to social elements. Many companies are now focusing on developing social features online. When a player sees another player achieving a certain milestone, it will be a push for that player to be able to achieve the same thing. Examples of the implementation of this core drive are friendship features, gifting between players, and working on challenges together.

6. Scarcity & Impatience

It is a core drive that creates a condition where something cannot be obtained even though it is highly desired. An example of the implementation of this core drive is the waiting period. The waiting period makes the player impatient and makes the player keep thinking about the desired thing until it can be obtained.

7. Unpredictability & Curiosity

It is a core drive that makes players want to know what happens next. The human brain tends to keep thinking about what will happen, just like when reading a book or watching a movie. An example of implementing this core drive is by giving easter eggs and gifts out of the blue.

8. Loss & Avoidance

It is a core drive that prevents something negative from happening. An example of implementing this core drive is creating temporary events. The player will be afraid to lose the opportunity for the event if the player does not do it right away.

III. METHODOLOGY

A. *Gamification Design*

The Gamification design is conducted by combining two frameworks: Octalysis and MDA. MDA is used to determine the mechanics, dynamics, and aesthetics that will trigger the eight core drives in Octalysis. The elements used in the application are summarized in Table I according to each core drive that aims to be achieved.

TABLE I. GAMIFICATION ELEMENT

Core Drive	Mechanics	Dynamics	Aesthetics
Epic Meaning & Calling	Theme	Rewards Progression	Narrative
Core Development & Accomplishment	Leader-board Progress Bar Badge Points Quest Boss Fights	Rewards Compe-tition	Challenge
Empowerment of Creativity & Feedback	Milestone - Unlocks	Achieve-ment	Discovery
Ownership & Possession	Character	Persona-lization	Expression
Social Influence & Relatedness	Trophy Shelf	Achieve-ment	Challenge
Scarcity & Impatience	Waiting Time	Urgency	Submission
Unpredictability & Curiosity	Mystery Gif	Random-ness	Penalty Status
Loss & Avoidance	Penalty	Penalty Status	Submission

B. *Application Development*

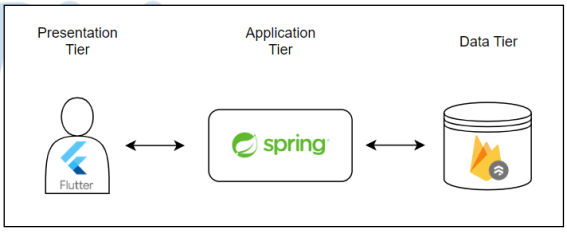


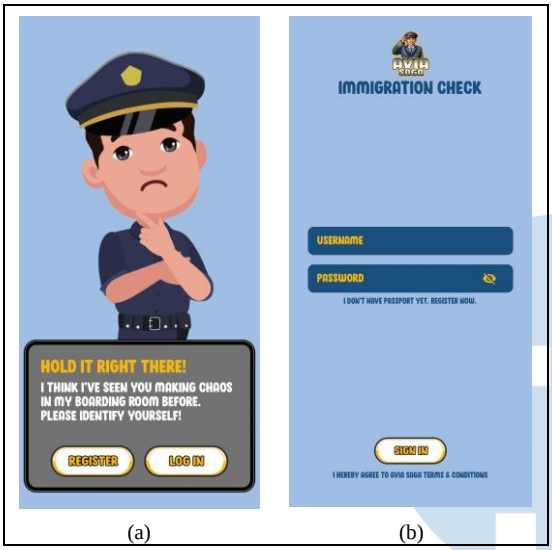
Fig. 2. System architecture

Fig. 2 shows the system architecture used in the application development, which is the 3-Tier Architecture. This architecture consists of the Presentation Tier, Application Tier, and Data Tier. The Application Tier/API will serve as the bridge connecting CRUD operations between the Presentation Tier and the Data Tier. The Presentation Tier is developed using the Dart programming language with the Flutter framework, the Application Tier is implemented using the Java programming language with the Spring Boot framework, and the Data Tier or data storage will use Cloud Firestore provided by Firebase.

IV. IMPLEMENTATION

A. Onboarding and Login

Fig. 3(a) displays the onboarding page that presents users with options to either register or log in by clicking the available buttons. If the user clicks the register button, they will be directed to the registration page. There are three pieces of information requested from the user on the registration process. The questions asked are the username, full name, and password. On the registration process, Conversely, if the user clicks the login button, they will be directed to the login page. The login page is shown in Fig. 3(b).



(a) (b)

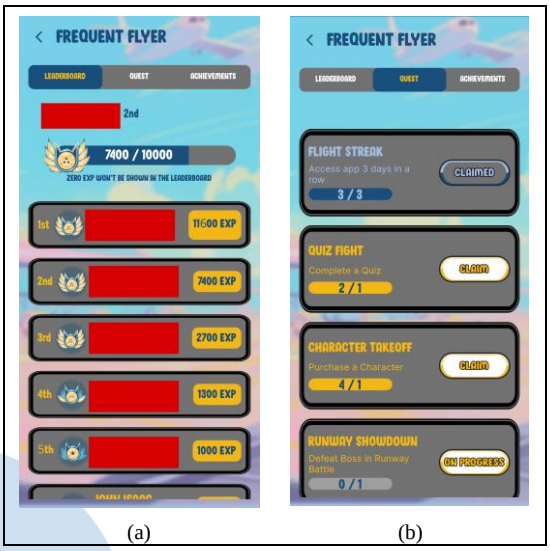
Fig. 3. (a) Onboarding page (b) Login page

B. Home

Fig. 4. Home page

Fig. 4 displays the home page. On the home page, there are user badges and points, miles owned, the currently active character, and a menu list. When the badge is pressed, the user will be directed to the frequent flyer page. An animation is applied to the character to give a flying effect to the character image. There are four menus that users can choose from, namely flights, passport, duty-free, and runway. Users will be directed to the feature page selected in the menu.

C. Frequent Flyer



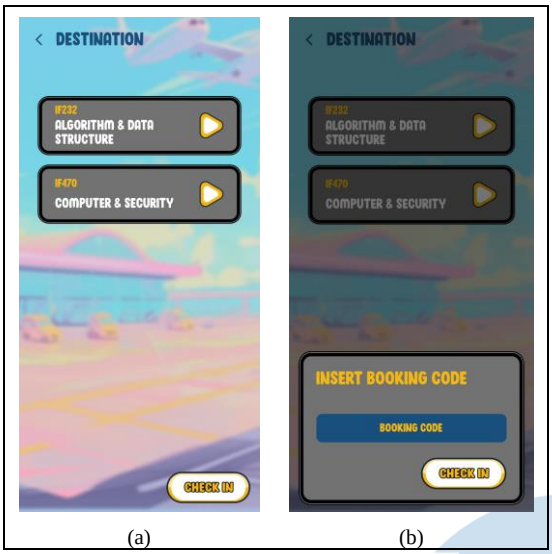
(a) (b)

Fig. 5. (a) Leaderboard tab (b) Quest tab

Fig. 5 displays the frequent flyer page. This page has three menus shown in a tabbed layout: leaderboard, quest, and achievement. The leaderboard tab shows the user's name, rank, and points, along with the ranking data of other users, as shown in Fig. 5(a). The quest in Fig. 5(b) shows a list of quests that users can undertake. Each quest displays a title, description, progress, and an action button. Progress is shown with a progress bar. When the progress is complete, the action button, which was previously "on progress," changes to "claim." By pressing the claim button, the user will receive a mystery gift and be directed to the mystery gift page. The achievement tab displays a collection of cards owned by the user. The card collection consists of bosses defeated in the runway feature. Cards will be colored when unlocked and black-and-white when locked. The achievement tab is shown in Fig. 6.

Fig. 6. Achievement tab

D. Flights



(a) (b)

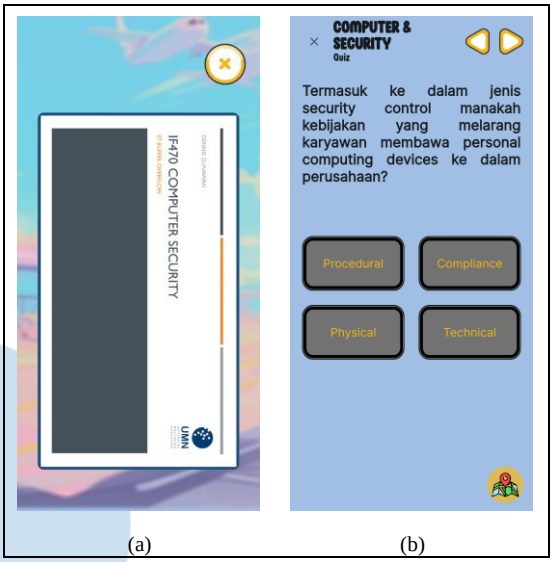
Fig. 7. (a) Flight destination (b) Check-in pop-up

Fig. 7(a) displays the flights page. This page will show a list of destinations (courses) currently being taken by the user. Users can add courses using the check-in button, which is displayed as a floating action button. Fig. 7(b) shows a pop-up when the user presses the check-in button. The user will be asked to enter a booking code. If the code is valid, the course associated with that code will be added to the list of destinations. Users will be directed to the course page when pressing the arrow button on each destination.

Fig. 8. Course page

Fig. 8 displays the course page, which contains a list of content for each lecture session. To access the content, users can press buttons labeled with numbers corresponding to the lecture sessions. When a button is pressed, a pop-up will appear showing the meeting topic along with the content and quiz menu. The quiz menu will only be displayed if the session includes a quiz. Fig. 9(a) shows the content material page.

Fig. 9(b) shows the quiz page. The quiz is displayed in a multiple-choice format. Users can press the map button to display the list of questions or press the arrow button to go to the previous/next question. If users want to exit the quiz page, they can press the close button.



(a) (b)

Fig. 9. (a) Content material page (b) Quiz page

E. Duty-free

Fig. 10. Duty-free page

Fig. 10 displays the duty-free page. This page contains characters owned by or available for purchase by the user. Users can view the list of characters by swiping. Each character will display its name, power, and health. If the user already owns the character, the text "owned" and a button for activation will be displayed. If the user does not own the character, the price of the character and a button for purchase will be

shown. Purchased characters will be automatically activated and become active characters.

F. Runway

Fig. 11. Runway page

Fig. 11 displays the page when the user accesses the runway feature. The runway will show the user's and boss's characters and life, the available maneuvers to choose from, the time to select a maneuver, and a button to perform the maneuver. In each round, the user has 10 seconds to choose a desired maneuver and press the maneuver button to confirm. If no maneuver is selected within 10 seconds, a maneuver will be chosen automatically.

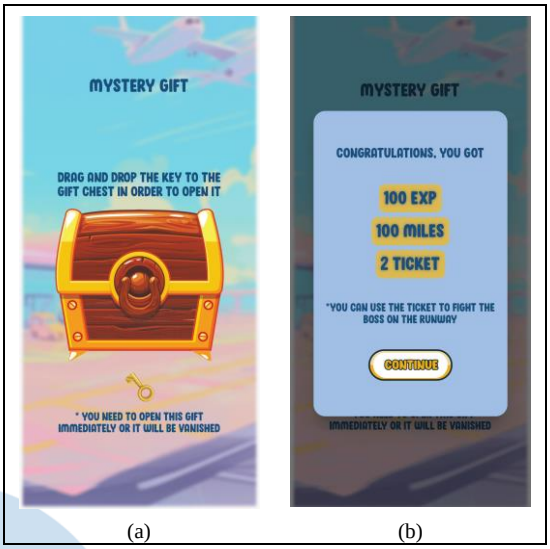
After the user selects a maneuver, the boss will randomly choose a maneuver. The boss's maneuver will be compared with the user's maneuver based on the following rules:

- Roll defeats Climb.
- Climb defeats Dive.
- Dive defeats Roll.
- A tie if the maneuvers are the same.

If the user wins the round, a pop-up will be displayed, and the boss will receive a reduction in life according to the power of the user's character. If the user loses the round, a pop-up will be displayed, and the user will receive a reduction in life according to the power of the boss's character. There is no life reduction if the result is a tie. A new round will start if both the user and the boss still have life remaining. After one player (user or boss) runs out of life, the game will end and display a pop-up indicating whether the user won the game.

G. Mystery Gift

Fig. 12(a) displays the mystery gift page. Users are directed to this page when they receive a mystery gift. To open the mystery gift, users can drag and drop a key onto a chest. Once this is done, an opening animation will play, and a notification will appear showing the number of points, miles, and tickets received. The results of the mystery gift contain points, miles, and tickets obtained by the user, as shown in Fig. 12(b).



(a) (b)

Fig. 12. (a) Mystery gift (b) Rewards details

V. Results and Discussions

The application was evaluated using the Hedonic-Motivation System Adoption Model (HMSAM). Thirty-eight students majoring in Informatics voluntarily tried and evaluated the application by answering the given questions. The questions given to the respondents were divided into two parts, namely questions for the Moodle-based LMS and Avia Saga. Each part consists of 36 questions across seven categories: perceived ease-of-use, perceived usefulness, curiosity, control, joy, behavioral intention to use, and immersion.

The questions were given and answered using the Likert Scale. The responses to each question were tallied according to each scale. Subsequently, the aggregate numbers were calculated to derive the score percentage for each system. Table II shows the score percentage comparison of Moodle-based LMS and Avia Saga.

TABLE II. Score Percentage Comparison

Category	Moodle-Based LMS	Avia Saga	Increase
Perceived Ease-of-Use	81,58%	79,67%	-1,9%
Perceived Usefulness	66,63%	79,79%	13,2%
Curiosity	65,96%	84,56%	18,6%
Control	66,67%	72,63%	6,0%
Joy	67,37%	76,49%	9,1%
Behavioral Intention to Use	71,05%	78,07%	7,0%
Focused Immersion	61,26%	72,95%	11,7%

All categories exhibited enhancements, despite a slight decrease of 1.9% in the perceived ease-of-use category. The assessment of perceived usefulness increased by 13.2%. Curiosity ratings saw a notable rise of 18.6%. Control ratings increased by 6%. Joy ratings experienced an uplift of 9.1%. Behavioral intention to use ratings escalated by 7%. Meanwhile, focused immersion ratings showed an increase of 11.7%.

Based on respondents' comments on the questionnaire, the decrease in the perceived ease of use may be caused by the absence of confirmation to leave the application, the lack of information on running out of tickets, and the absence of boss statistics on the runway feature. According to the user feedback, some improvements have been made and the solution has been released.

VI. Conclusions and Future Works

A gamified mobile-based Learning Management System, named Avia Saga has been successfully designed and developed implementing Octalysis and MDA Framework. The application implements gamification elements for each core drive of the Octalysis Framework and is enhanced with the MDA Framework. Flutter and Spring Boot Framework were used in the application development.

The application was evaluated by 38 respondents using the Hedonic Motivation System Adoption Model. The results revealed a 7% increase in the behavioral intention to use category, suggesting a greater inclination for reusing the application, and an 11.7% increase in the immersion category, indicating elevated sentiments of users being carried away by the ambiance while using the application.

Future studies could investigate the association between the choices of application theme with user motivation to use the Learning Management System. In addition, future attempts could add several elements such as group quest and background music/sound effect. These implementations could add fellowship and sensation to aesthetics.

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AUTHOR GUIDELINES

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- The similarity score from plagiarism checker software such as Turnitin is 20% maximum.

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- Article been typed with 1 line spacing on an A4 paper size (21 cm x 29,7 cm), top-left margin are 3 cm and bottom-right margin are 2 cm, and Times New Roman's font type.
- Article should be prepared according to the following author guidelines in this template. Article contain of minimum 3500 words.
- References contain of minimum 15 references (primary references) from reputable journals/conferences

3. Organization of submitted article

The organization of the submitted article consists of Title, Abstract, Index Terms, Introduction, Method, Result and Discussion, Conclusion, Appendix (if any), Acknowledgment (if any), and References.

- Title
  The maximum words count on the title is 12 words (including the subtitle if available)
- Abstract
  Abstract consists of 150-250 words. The abstract should contain logical argumentation of the research taken, problem-solving methodology, research results, and a brief conclusion.
- Index terms
  A list in alphabetical order in between 4 to 6 words or short phrases separated by a semicolon (;), excluding words used in the title and chosen carefully to reflect the precise content of the paper.
- Introduction
  Introduction commonly contains the background, purpose of the research, problem identification, research methodology, and state of the art conducted by the authors which describe implicitly.
- Method
  Include sufficient details for the work to be repeated. Where specific equipment and materials are named, the manufacturer's details (name, city and country) should be given so that readers can trace specifications by contacting the manufacturer. Where commercially available software has been used, details of the supplier should be given in brackets or the reference given in full in the reference list.
- Results and Discussion
  State the results of experimental or modeling work, drawing attention to important details in tables and figures, and discuss them intensively by comparing and/or citing other references.
- Conclusion
  Explicitly describes the research's results been taken. Future works or suggestion could be explained after it
- Appendix and acknowledgment, if available, could be placed after Conclusion.
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$$\int_0^{r_2} F(r,\phi)\, dr\, d\phi = [\sigma r_2 / (2\mu_0)] \qquad (1)$$

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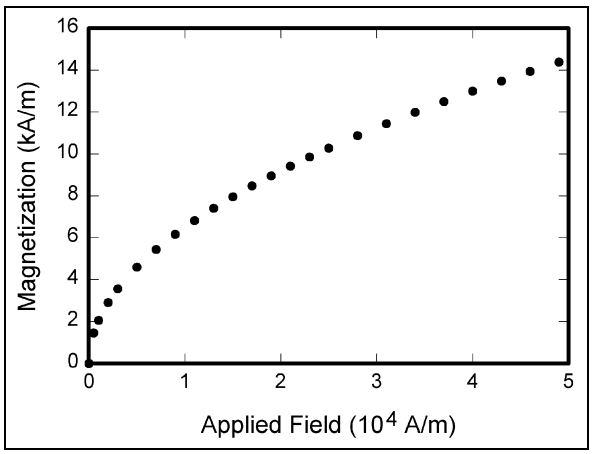

Fig. 1. Example of a figure caption

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Appendix

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[1] G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[3] I.S. Jacobs and C.P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

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