

Alphabet Learning Media Using Image Classification for Speech-Impaired Students in Special Education Schools

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Abstract— This research aims to develop an image classification-based learning medium for teaching the alphabet to students with speech impairments in special schools (SLB). The technique used in image classification is Random Forest with a dataset of 5,400 images, including 1 default image and 26 alphabet classes. The software development follows the waterfall model, including requirements analysis, system design, implementation, and testing, with system design utilizing object-oriented analysis and design (OOAD). Evaluation metrics, including accuracy (98.00%), precision (1.00), recall (1.00), and F1 score (1.00), indicate the model's outstanding performance. The system was tested on 10 students with speech impairments, showing an average improvement in ability from 5.9 in the pretest to 12.8 in the posttest, demonstrating consistent gains among participants. This image classification-based learning medium is expected to support the learning process for students with speech impairments in SLB effectively.

Keywords— Learning Media, Image Classification, Waterfall, Speech Impaired

I. INTRODUCTION

Educational technology has provided benefits for both educators and students. However, many educators still lack the knowledge to utilize learning media and create innovations as teaching tools [1]. Education is the primary foundation for improving the standard of living and the quality of a nation's civilization. Education produces educated and competent individuals in their fields of study, equipping them to compete based on their expertise and character at national, regional, and international levels [2]. In education, it is hoped to elevate the dignity of both individuals and the nation in the eyes of other countries, by producing graduates who embody defined character values, possess knowledge, and demonstrate creativity and independence in their fields of expertise.

Special Schools are established to provide dedicated services through Special Education, continually supporting individuals with special needs [3]. One of the benefits of Special Schools (SLB) is to assess the abilities of individuals with special needs to interact in academic and non-academic areas using appropriate methods [4]. Individuals with speech impairments are those who have hearing disorders that affect their ability to communicate, particularly in speaking. Hearing impairments can also impact physical and psychological aspects. Intellectually, they may be weaker, more prone to anger, have limited social interactions with their surroundings, and may struggle with effectively conveying messages and tone in communication [5].

Communicating in a clear and understandable language is very important for human life. According to Dwihartani, humans spend about 75% of their time communicating, from communicating with themselves to communicating with others. For

instance, women communicate using approximately 20,000 words every day [6]. The variety of languages used in daily life varies in different ways. One example is Sign Language, which is used by individuals with special needs to communicate in their daily lives. Sign language is expressed through finger movements, hand gestures, facial expressions, and body movements [7].

In communication, language elements are very important. Sign language is used by individuals with speech impairments, based on the Indonesian Sign Language System (SIBI) [7]. SIBI has been officially recognized by the government as the standard sign language used in special schools. According to the Ministry of Health, approximately 7.87% of Indonesia's population has disabilities, with 19,993 of them being children who are either deaf or speech-impaired. Central Java has the highest number of individuals with hearing or speech impairments in Indonesia [7]. This phenomenon is largely due to a lack of knowledge in understanding sign language, as there are differences and a shortage of media for delivering information [7]. Therefore, a medium such as written text is needed to help understand or enable the use of sign language [8].

Regarding the current method of teaching Sign Language in Special Schools, teachers practice the alphabet using hands and fingers, and utilize YouTube as a medium to review lessons or conduct lessons via video calls. The drawback of these existing media is that students tend to learn at a slower pace, and there is no medium available to help review the material that the teacher has taught [9]. Several applications, such as Hear Me ID, Live Transcribe, Petralex Hearing Aid, I-Chat, and Sibiku, can assist in communication between individuals with speech impairments and those without. These apps help translate words into gestures, convert speech into gestures, and record information. However, the limitation of these media is that they are not suitable for beginner students learning sign language, especially the alphabet. Additionally, there is no feature to detect errors or correctness in performing hand movements during basic sign language learning.

Regarding basic learning of the alphabet in Special Schools (SLB), it can be optimally implemented by utilizing Information Technology, particularly in the field of machine learning. Machine learning is a branch of AI that focuses on data [10] and can perform pattern recognition [11] and learn a single hypothesis from the training data [12]. The data used can consist of images, which fall under Image Classification. In Image Classification, a technique is applied in the process of analyzing and categorizing data into different classes, as well as labeling pixel groups within an image using a Random Forest Classifier [11] that can predict patterns from the data used [13].

Machine learning uses images as training data, collected in the number of classes required. Each classification of a SIBI alphabet letter will produce different precision and sensitivity values. The model training process utilizes the Python library scikit-learn [14]. In image tracking, images are grouped based on their content categories. The Image Classification method can achieve high accuracy, even when labeled data is limited, which is highly beneficial for rapid learning [15]. Random Forest is used as a solution to address class imbalance issues. The results show that the proposed framework is capable of achieving high accuracy in various applications, including image classification [16]. Random Forest Classifier on SIBI Translator Application is able to get precise results from the SIBI alphabet [14]. In real-time ML-based Sign Language, the recognition system is built using real-time colored images captured with the help of a PC camera [17].

Therefore, this research will develop a web-based learning media for the alphabet for Special Schools (SLB), applying Image Classification with the Random Forest Classifier

technique for visualizing SIBI for the speech-impaired group. The website will be built using the Waterfall development model and Object-Oriented Design. Through this research, it is hoped that it will bring benefits to both teaching and learning processes in Special Schools, optimizing methods for handling students in these schools.

II. METHODOLOGY

The research focuses on learning media for the Indonesian Sign Language System (SIBI) using image classification for the speech-impaired group in special schools. Learning media refers to anything used to assist the learning process, making it more effective and engaging. The types of learning media can vary depending on their usage and form. The training and testing data are processed using the Random Forest technique. The dataset is created by taking photos with a webcam, demonstrating the alphabet shapes of the Indonesian Sign Language System in sequence, which will then be stored in a folder containing over 5000 datasets. Visualization is built using MediaPipe, and the system is web-based. The website is developed using the Waterfall software development model, and the system design follows the Object-Oriented Analysis Design (OOAD) concept. This learning media will be used by both teachers and students.

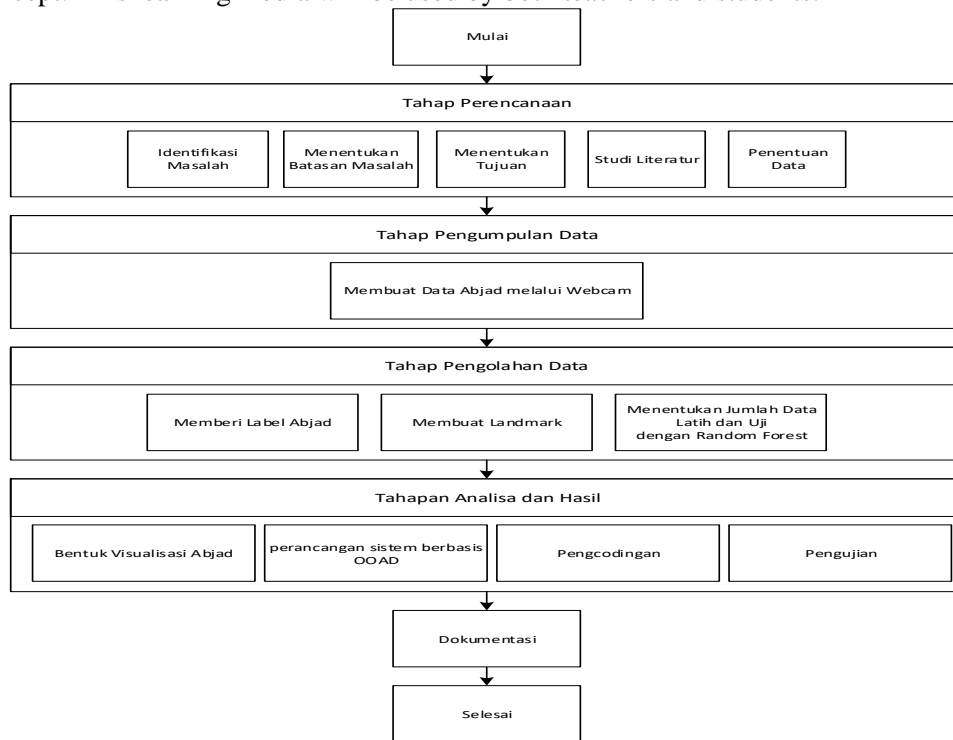


Figure 1: Research methodology

In the development of knowledge management systems, technology and machine learning can be leveraged to recognize patterns and trends within data [3]. By using machine learning, we can develop models that train themselves through recorded input data and the features contained within it [4]. Image classification always centers on feature extraction from images, which forms the basis of image classification. Traditional image feature extraction algorithms focus more on the manual configuration of specific image features [5].

Random Forest (RF) is an advancement of the Decision Tree method that uses multiple Decision Trees, where each tree is trained using individual samples, and each attribute is split within the tree based on a randomly chosen subset of attributes. The advantages of Random Forest include improved accuracy in the presence of missing data, robustness

against extreme data, and efficiency in data storage. Additionally, Random Forest involves a feature selection process that can extract the best features to enhance the classification model's performance [7].

The method to calculate the Gini Index value is as follows:

$$Gini(S_i) = 1 - \sum_{i=0}^{c-1} p_i^2$$

In this context, the relative frequency of class C_i in a set is compared to the relative frequency of class C for $i = 1, \dots, c-1$, where c is the predetermined number of classes. The quality of the split on feature k ditentukan is determined by how the frequency of samples belonging to class C_i compares to the total frequency of samples belonging to all classes, and it is then measured using the Gini Index calculation for the resulting subsets. The formula to calculate this is as follows:

$$Gini_{split} = \sum_{i=0}^{k-1} \left(\frac{n_i}{n}\right) Gini(S_i)$$

n_i is the number of samples in subset S_i after the split, and n is the total number of samples in the given node [18].

III. RESULTS AND DISCUSSION

A. Data Collection

In this study, data was collected through interviews at the Pelita Hati Special School (SLB) in Pekanbaru, as well as by independently creating a dataset using a laptop webcam. The process of creating the dataset was done using the Python programming language, resulting in 5,400 images consisting of 1 default class and 26 alphabet classes, which will be used for further analysis and research.

Creating Alphabetical Labels

1) Re-scaling Dataset

Re-scaling the dataset involves changing the dimensions of the dataset images to a specified size. This study utilizes image classification, so the dataset consisting of 5,400 images will be grouped into 27 categories: 'Default' and all the letters of the alphabet, with each category containing 200 images. The dataset will undergo three stages of processing to meet the requirements for classification, assisted by Python programming syntax. Below, the dataset that has been divided into classes will be resized to 640x480 pixels. The syntax and results of the resized dataset are attached :

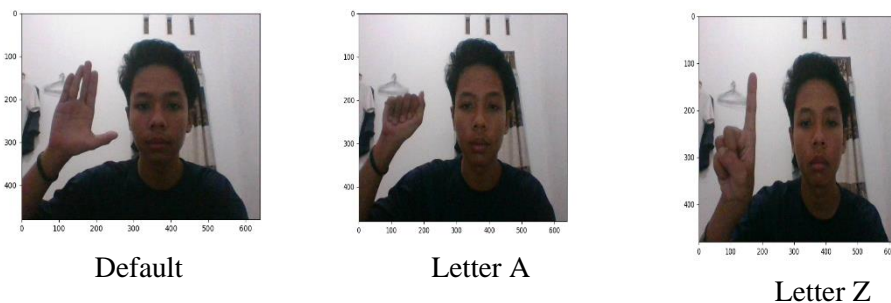


Figure 2. Re-Scaling the Dataset

2) *Landmark pada Dataset*

After labeling the dataset, the next step is to draw landmarks using MediaPipe. Landmarks are key points used to represent the position and shape of an object, in this case, parts of the human body. MediaPipe is a framework for image and video processing that enables accurate landmark extraction. By drawing these landmarks, the researcher can visualize and analyze in more detail how the objects in the dataset are shaped, which is also assisted by Python programming. Below is the visualization of the dataset with the landmarks drawn :

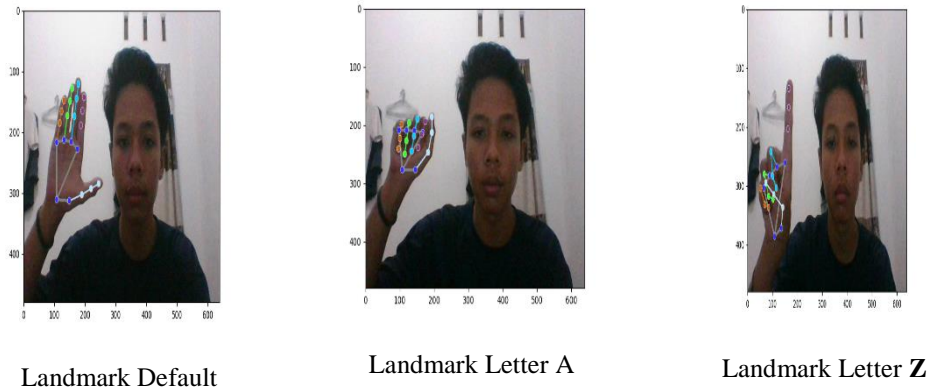


Figure 3. Landmark on the dataset

3) *Saving the Dataset*

After the landmarks are created on the dataset, the next step is to serialize the dataset into Pickle data. Serialization refers to the process of converting the dataset into a format that can be stored or transmitted, and later restored back to its original state or format.

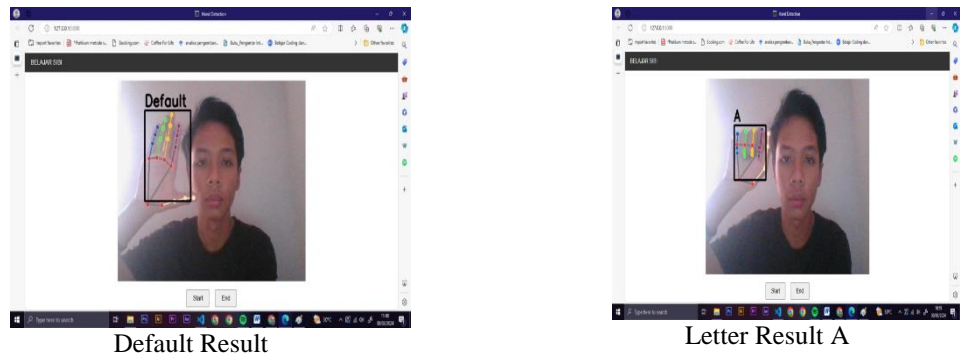


Figure 4. saving dataset

4) *Performance Evaluation*

- a) **Evaluation Metrics:** The evaluation results show that the model excels in data classification. Model accuracy represents the proportion of accurate predictions among the entire dataset, while precision assesses the accuracy of the model in recognizing positive examples. Recall measures the effectiveness of the model in identifying all correct positive examples. In addition, the F1 value combines precision and recall, which offers an overall picture of the model's ability to handle unbalanced classes. With the evaluation results achieving maximum values in all metrics, it can be concluded that the model has demonstrated outstanding performance in the classification task at hand

TABEL 1 PERFORMANCE

| No. | Evaluation Metrics | | | |
|-----|--------------------|--------|----------|-----------|
| | Accuracy | Recall | F1 Score | Precision |
| 1 | 98 % | 1.00 | 1.00 | 1.00 |

The evaluation metrics, including 98.00% accuracy, 1.00 precision, 1.00 recall, and 1.00 F1 score, indicate the model's exceptional performance with three tests. These high values confirm its ability to make accurate predictions, identify relevant data patterns, and handle unbalanced classes effectively. The attainment of maximum values across all evaluation metrics highlights the model's proficiency in making accurate predictions, recognizing relevant data patterns, and effectively managing unbalanced datasets. These results substantiate the model's reliability and suitability for realworld applications. Furthermore. Overall, our findings underscore the significance and potential impact of our research in the field of sign language recognition and classification. applications. Figure 5 visually represents its effectiveness and reliability in various classification scenarios.

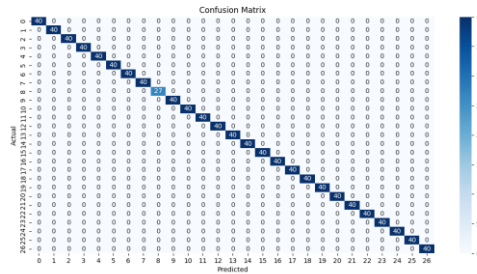


Figure 5. Confution Matrik

B. System Design

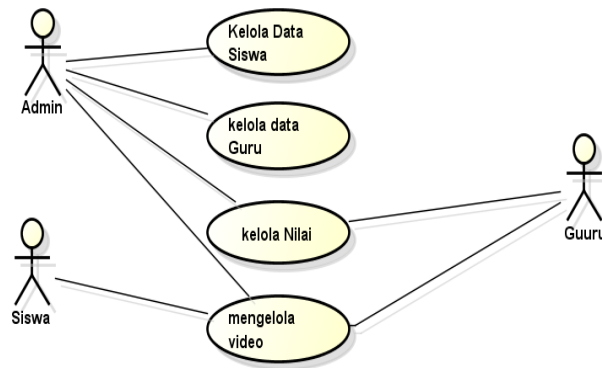


Figure 6. Usecase Diagram

Figure 6 is the use case diagram of the alphabet learning media, which consists of three actors and four use cases. The admin can perform all processes in the system, while the teacher can manage grades and videos. The students can only process grades.

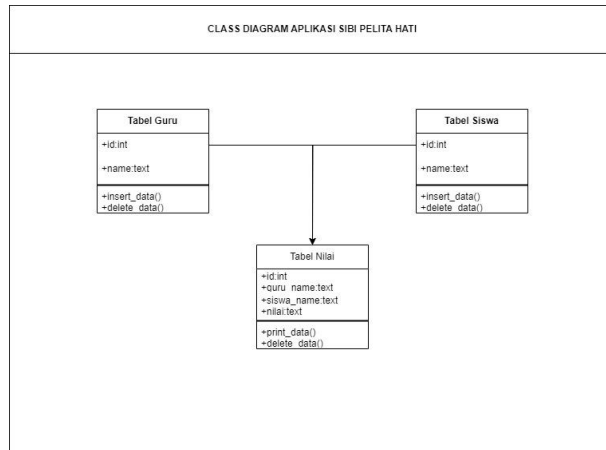


Figure 7. Class Diagram

Class diagram describes the relationship between classes in the system. In this system there are three classes

C. Implementation

1) Menu Home

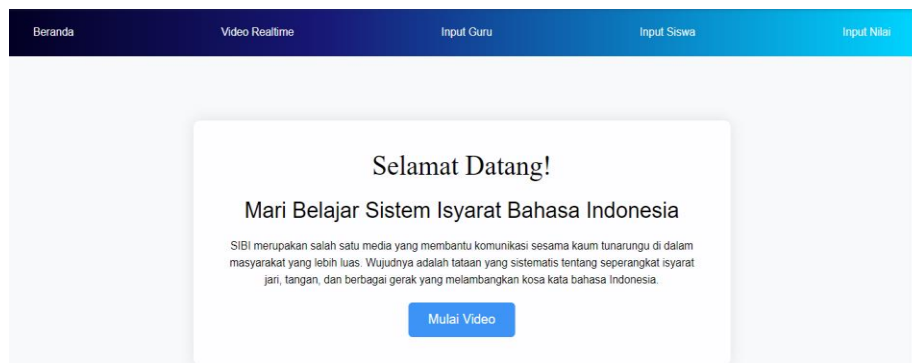


Figure 8. Main Menu

The main menu displays all the accessible features in the system. This menu will be used as needed.

2) Video Page

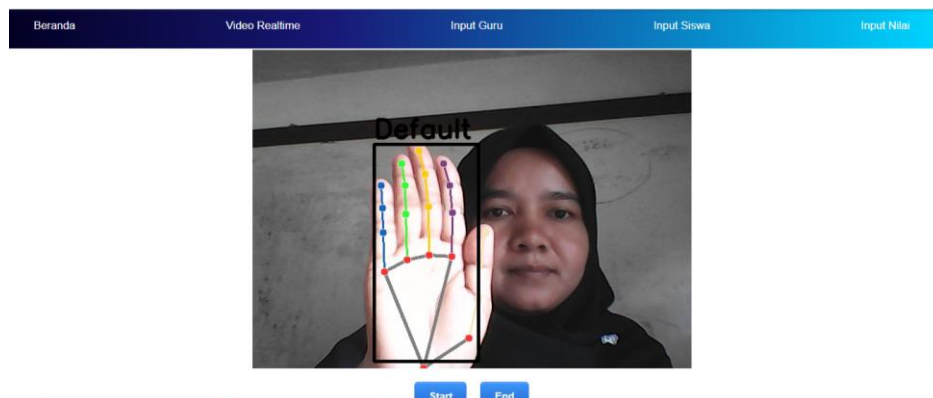


Figure 9. Video Page

The video page menu is a place for practicing alphabet letters. By moving the hand in front of the camera, the system will detect and display the letter being formed

3) *Manage Grades page*



Figure 10. Manage Grades

The score page menu allows teachers to input scores for each student's learning session.

D. Testing

The Pre-Test and Post-Test are conducted visually. The children are asked to demonstrate the requested letters. This testing will assess how many adjustments are made in the application. Fifteen questions are given for the trial to 10 children. On average, the children's ability improved from 5.9 in the Pre-Test to 12.8 in the Post-Test, with an average increase of 6.9 letters. The data distribution is quite consistent with a relatively small standard deviation (Pre-Test: 2.23, Post-Test: 2.39, Improvement: 1.66), indicating a uniform improvement among the children.

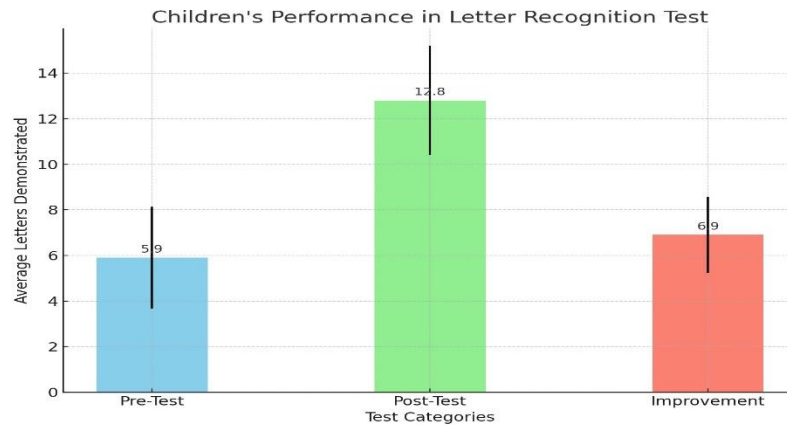


Figure 11. The Pre-Test and Post-Test

IV. CONCLUSION

The alphabet learning media developed makes it easier for homeless children to learn the basics of the alphabet and assists teachers in delivering the alphabet learning process to students. This media has introduced and provided a new method for teaching the alphabet in Special Schools by visualizing the Image Classification using the Random Forest Classifier algorithm.

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