VISUALIZATION OF INDONESIAN SIGN LANGUAGE SYSTEM USING IMAGE CLASSIFICATION FOR SPECIAL NEEDS STUDENTS IN SPECIAL SCHOOLS

TUGAS AKHIR

Diajukan Sebagai Salah Satu Syarat
untuk Memperoleh Gelar Sarjana Komputer pada
Program Studi Sistem Informasi

Oleh:

NAUFAL SAFIQ TAMA
12050313382

UIN SUSKA RIAU

FAKULTAS SAINS DAN TEKNOLOGI
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
PEKANBARU
2024

LEMBAR PERSETUJUAN

VISUALIZATION OF INDONESIAN SIGN LANGUAGE SYSTEM USING IMAGE CLASSIFICATION FOR SPECIAL NEEDS STUDENTS IN SPECIAL SCHOOLS

TUGAS AKHIR

Oleh:

NAUFAL SAFIQ TAMA
12050313382

Telah diperiksa dan disetujui sebagai Laporan Tugas Akhir
di Pekanbaru, pada tanggal 3 Juli 2024

Ketua Program Studi	Pembimbing
Eki Saputra, S.Kom., M.Kom.	**Dr. Rice Novita, S.Kom., M.Kom.**
NIP. 198307162011011008	**NIP. 198511272023212032**

LEMBAR PENGESAHAN

VISUALIZATION OF INDONESIAN SIGN LANGUAGE SYSTEM USING IMAGE CLASSIFICATION FOR SPECIAL NEEDS STUDENTS IN SPECIAL SCHOOLS

TUGAS AKHIR

Oleh:

NAUFAL SAFIQ TAMA
12050313382

Telah dipertahankan di depan sidang dewan penguji
sebagai salah satu syarat untuk memperoleh gelar Sarjana Komputer
Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau
di Pekanbaru, pada tanggal 24 Juni 2024

Pekanbaru, 24 Juni 2024
Mengesahkan,

Dekan	**Ketua Program Studi**
Dr. Hartono, M.Pd.	**Eki Saputra, S.Kom., M.Kom.**
NIP. 196403011992031003	**NIP. 198307162011011008**

DEWAN PENGUJI:

Ketua : **Dr. M. Luthfi Hamzah, B.IT., M.Kom.**

Sekretaris : **Dr. Rice Novita, S.Kom., M.Kom.**

Anggota 1 : **Mustakim, ST., M.Kom.**

Anggota 2 : **M. Afdal, ST., M.Kom.**

Lampiran Surat :

Nomor :

Tanggal :

SURAT PERNYATAAN

Saya yang bertandatangan di bawah ini :

Nama : Naufal Safiq Tama

NIM : 12050313382

Tempat/ Tgl. Lahir : Pekanbaru, 20 Juni 2002

Fakultas/Pascasarjana : Sains dan Teknologi

Prodi : Sistem Informasi

Judul ~~Disertasi/Thesis/Skripsi/~~Karya Ilmiah lainnya*:

Visualization Of Indonesian Sign Language System Using Image Classification For Special needs Students In Special School.

Menyatakan dengan sebenar-benarnya bahwa :

1. Penulisan ~~Disertasi/Tesis/Skripsi/~~Karya Ilmiah lainnya* dengan judul sebagaimana tersebut di atas adalah hasil pemikiran dan penelitian saya sendiri.
2. Semua kutipan pada karya tulis saya ini sudah disebutkan sumbernya.
3. Oleh karena itu ~~Disertasi/Tesis/Skripsi/~~Karya Ilmiah lainnya* saya ini, saya nyatakan bebas dari plagiat.
4. Apa bila dikemudian hari terbukti terdapat plagiat dalam penulisan ~~Disertasi/Tesis/Skripsi/~~(Karya Ilmiah lainnya)* saya tersebut, maka saya bersedia menerima sanksi sesuai peraturan peraturan perundang-undangan.

Demikian Surat Pernyataan ini saya buat dengan penuh kesadaran dan tanpa paksaan dari pihak manapun juga.

Pekanbaru, 10 Juli 2024

Yang membuat pernyataan

METERAI TEMPEL 10000 SEPULUH RIBU RUPIAH 2922EALX275051596

Naufal Safiq Tama

NIM : 12050313382

**pilih salah salah satu sesuai jenis karya tulis*

LEMBAR HAK ATAS KEKAYAAN INTELEKTUAL

Tugas Akhir yang tidak diterbitkan ini terdaftar dan tersedia di Perpustakaan Universitas Islam Negeri Sultan Syarif Kasim Riau adalah terbuka untuk umum, dengan ketentuan bahwa hak cipta ada pada peneliti. Referensi kepustakaan diperkenankan dicatat, tetapi pengutipan atau ringkasan hanya dapat dilakukan atas izin peneliti dan harus dilakukan mengikuti kaedah dan kebiasaan ilmiah serta menyebutkan sumbernya.

Penggandaan atau penerbitan sebagian atau seluruh Tugas Akhir ini harus memperoleh izin tertulis dari Dekan Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau. Perpustakaan dapat meminjamkan Tugas Akhir ini untuk anggotanya dengan mengisi nama, tanda peminjaman dan tanggal pinjam pada *form* peminjaman.

LEMBAR PERNYATAAN

Dengan ini saya menyatakan bahwa dalam Tugas Akhir ini tidak terdapat karya yang pernah diajukan untuk memperoleh gelar kesarjanaan di suatu Perguruan Tinggi, dan sepanjang pengetahuan saya juga tidak terdapat karya atau pendapat yang pernah ditulis atau diterbitkan oleh orang lain kecuali yang secara tertulis diacu dalam naskah ini dan disebutkan di dalam daftar pustaka.

Pekanbaru, 3 Juli 2024
Yang membuat pernyataan,

NAUFAL SAFIQ TAMA
NIM. 12050313382

LEMBAR PERSEMBAHAN

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

Dengan menyebut nama Allah yang maha pengasih lagi maha penyayang

Alhamdulillah, segala puji bagi Allah *Subhanahu Wa Ta'ala* yang telah melimpahkan rahmat, dan karunia-Nya memberikan kekuatan, kesabaran, dan ilmu pengetahuan dalam menyelesaikan Tugas Akhir ini. Shalawat dan salam senantiasa saya sampaikan kepada Nabi Muhammad *Shallallahu 'Alaihi Wa Salam* dengan mengucapkan *Allahuma Sholli'ala Sayyidina Muhammad Wa'ala 'Ali Sayyidina Muhammad*.

Semoga kita semua selalu senantiasa mendapat syafaat-Nya di dunia maupun di akhirat, *aamiin ya rabbal'aalamiin*. Saya persembahkan hadiah istimewa karya kecil ini sebagai salah satu bentuk bakti, rasa terima kasih, dan hormat kepada Ayah dan Ibu tercinta. Terima kasih yang tidak terhingga karena telah merawat dan membesarkan saya dengan setulus hati dan penuh perjuangan hingga saya bisa mampu pada tahap ini. Berkat doa dan kasih sayangmu, anakmu telah berhasil memperoleh gelar sarjana seperti yang engkau harapkan. Tiada apapun di dunia ini yang dapat membalas semua jasa-jasa dan pengorbananmu. Untuk itu saya anakmu ini selalu mendoakan yang terbaik untuk Ayah dan Ibu agar bahagia dunia dan akhirat serta diberikan tempat istimewa di sisi-Nya kelak. Saya juga berterima kasih yang tidak terhingga kepada saudara kandung tercinta yaitu Adik yang telah memberikan saya pelajaran dan pemahaman mengenai indahnya kehidupan yang damai sebagai saudara. Kepada Bapak dan Ibu Dosen Program Studi Sistem Informasi Universitas Islam Negeri Sultan Syarif Kasim Riau yang telah memberikan ilmu pengetahuan, pengalaman, dan kebaikan selama perkuliahan, saya ucapkan terima kasih banyak dan semoga menjadi amal jariyah. Aamiin. Untuk sahabat terdekat yang tidak bisa saya sebutkan satu persatu dan pastinya juga teman-teman seperjuangan, terima kasih berkat kalian masa perkuliahan menjadi lebih bermakna semoga dimasa mendatang kita bisa bertemu lagi dalam keadaan yang lebih baik.

"Allah-lah yang menundukkan laut untukmu agar kapal-kapal dapat berlayar di atasnya dengan perintah-Nya, dan agar kamu dapat mencari sebagian karunia-Nya dan agar kamu bersyukur" (Q.S Al–Jasiyah: 12).

KATA PENGANTAR

Alhamdulillahi Rabbil 'Alamin, bersyukur kehadirat Allah *Subhanahu Wa Ta'ala* atas segala rahmat dan karunia-Nya sehingga peneliti dapat menyelesaikan Tugas Akhir ini. Shalawat serta salam kita ucapkan kepada Nabi Muhammad *Shallallahu 'Alaihi Wa Sallam* dengan mengucapkan *Allahumma Sholli'Ala Sayyidina Muhammad Wa'Ala Ali Sayyidina Muhammad.* Tugas Akhir ini dibuat sebagai salah satu syarat untuk mendapatkan gelar Sarjana Komputer di Program Studi Sistem Informasi Universitas Islam Negeri Sultan Syarif Kasim Riau.

Pada penulisan Tugas Akhir ini, terdapat beberapa pihak yang sudah berkontribusi dan mendukung peneliti baik berupa materi, moril, dan motivasi. Peneliti ingin mengucapkan banyak terima kasih kepada:

1. Bapak Prof. Dr. Hairunas, M.Ag sebagai Rektor Universitas Islam Negeri Sultan Syarif Kasim Riau.
2. Bapak Dr. Hartono, M.Pd sebagai Dekan Fakultas Sains dan Teknologi.
3. Bapak Eki Saputra, S.Kom., M.Kom sebagai Ketua Program Studi Sistem Informasi.
4. Ibu Siti Monalisa, ST., M.Kom sebagai Sekretaris Program Studi Sistem Informasi.
5. Bapak Tengku Khairil Ahsyar, S.Kom., M.Kom sebagai Kepala Laboratorium Program Studi Sistem Informasi.
6. Ibu Dr. Rice Novita, S.Kom., M.Kom sebagai Dosen Pembimbing Tugas Akhir yang telah berkenan membimbing, mengarahkan, dan meluangkan waktu, tenaga serta pikiran guna membantu peneliti dalam menyelesaikan Tugas Akhir ini.
7. Bapak Dr. Muhammad Luthfi Hamzah, B.IT., M.Kom sebagai Ketua Sidang peneliti yang telah banyak memberi nasihat dan arahan dalam penyelesaian Tugas Akhir serta dalam perkuliahan.
8. Bapak Mustakim, ST., M.Kom sebagai Penguji I peneliti yang telah memberikan banyak arahan, motivasi, dan nasihat dalam penyelesaian Tugas Akhir ini serta dalam perkuliahan.
9. Bapak M. Afdal, ST., M.Kom sebagai Penguji II peneliti yang telah memberikan banyak masukan, nasihat, dan arahan selama penyelesaian Tugas Akhir dan dalam perkuliahan.
10. Seluruh Bapak Ibu Dosen Program Studi Sistem Informasi yang telah banyak memberikan ilmu selama berada di perkuliahan. Semoga dapat peneliti amalkan dan menjadi amal jariyah.

11. Seluruh Pegawai dan Staff Fakultas Sains dan Teknologi yang telah ikut serta pada proses administrasi selama perkuliahan ini.
12. Terutama pada kedua orangtua saya yaitu Ayah Edi Sudrajad dan Ibu Fitri Wahyuni tercinta yang selalu memberikan segala sesuatunya kepada peneliti berupa doa, nasihat, dan motivasi agar dapat menyelesaikan Strata 1 (S1) ini.
13. Kepada Adik peneliti yaitu Retno Azzahra Puspita. Terima kasih telah memberikan semangat, motivasi, dan doa kepada peneliti.
14. Kepada orang terdekat peneliti Nilam Wahdiaz Azani. Terima kasih telah menemani segala proses peneliti selama perkuliahan baik berupa semangat, waktu, dan doa.
15. Terima kasih kepada seluruh rekan saya yaitu Dedi Purnomo, Umar Dani, Rizki Aulia Putra, Rizki Riyanto, Ahmad Ilham Sitio, Rian Irawan, Reren Hidayat, dan Rahmad Supirman yang telah banyak membantu peneliti selama perkuliahan.
16. Serta semua pihak yang namanya tidak dapat disebutkan satu persatu yang telah banyak membantu dalam penyusunan Tugas Akhir ini. Semoga kebaikan yang telah diberikan kepada peneliti mendapat balasan dan diterima oleh Allah *Subhanahu Wa Ta'ala, Amiin*.

Pengerjaan laporan ini terdapat banyak kesalahan dan kekurangan. Oleh karenanya, kritik dan saran yang membangun sangat diharapkan untuk kesempurnaan Laporan Tugas Akhir ini. Dapat menghubungi peneliti melalui email di 12050313382@students.uin-suska.ac.id. Semoga laporan ini dapat memberikan sesuatu yang bermanfaat bagi siapa saja yang membacanya. *Aamiin*.

Pekanbaru, 3 Juli 2024
Peneliti,

NAUFAL SAFIQ TAMA
NIM. 12050313382

National Association for Applied Scientific Research Morocco

ICSC
International Conference on Circuit, Systems and Communication

NAASRM - National Association for Applied Scientific Research-MOROCCO

Date: May 21, 2024

Acceptance Letter

Dear Naufal Safiq Tama,

Thank you for submitting your contribution ID-[229] for presentation at ICCSC2024 virtual conference "2024 International Conference on Circuit, Systems and Communication " to be held (virtual) June 28-29, 2024 in FSDM, SMBA University, Fez, Morocco.

Congratulations, your contribution meets acceptance requirements set forth by the Program Committee:

Event : 2024 International Conference on Circuit, Systems and Communication
Paper ID : 229
Paper title : Visualization of Indonesian Sign Language System using Image Classification for Special Needs Students in Special Schools.

Confirmation of your presentation on the final program is contingent upon receipt of the presenting author's registration and the payment of fees before 24 May 2024. Please indicate the ID of your paper in a payment order on the bank desk and after fill the registration form on this page : https://iccsc.info/reg.html

You must attend and present your work at the conference to be included in the final proceeding.

Thank you for your interest, and we look forward to working with you on a successful conference.

Best regards,

From the Organizing committee

CHAIRMAN OF : International Conference on Circuit, Systems and Communication
ICSC
Prof. El Ghzaoui Mohammed

PRESIDENT OF NAASRM

الجمعية الوطنية للبحث العلمي التطبيقي
National Association for Applied Scientific Research

NAASRM - National Association for Applied Scientific Research-MOROCCO
Residence Amelia, Office N° 2 RUE OUED MAKHAZINE, Kenitra.
Tel.: +212 5 30 777 555, E-mail: contact@naasrm.org - Web: https://www.naasrm.org

Visualization of Indonesian Sign Language System using Image Classification for Special Needs Students in Special Schools

Naufal Safiq Tama
Department of Information System
Faculty of Science and Technology
Universitas Islam Negeri Sultan Syarif Kasim Riau
Pekanbaru, Indonesia
12050313382@students.uin-suska.ac.id

Rice Novita
Department of Information System
Faculty of Science and Technology
Universitas Islam Negeri Sultan Syarif Kasim Riau
Pekanbaru, Indonesia
rice.novita@uin-suska.ac.id

***Abstract*— Language is a vital means of communication for human life, from communicating with oneself to interacting with others. Within communication, the role of language is paramount. In Indonesia, sign language is commonly utilized by deaf individuals, guided by the Indonesian Sign Language System (SIBI). Sign language refers to gestures or movements involving fingers, hands, arms, facial expressions, head, and body**

In this research, we propose utilizing Image Classification, which is the process of categorizing images based on specific rules and employing machine learning algorithms. The machine learning aspect aims to recognize hand shapes in the web camera video. The interpretation of these hand shapes is trained using the Random Forest algorithm, enabling real-time video display showcasing identified hand movements. Ultimately, the displayed alphabet will be converted into a graphical format with assistance from mediapipe.

Keywords—Indonesian Sign Language System (SIBI), Real-time Video Processing, Machine Learning, Random Forest Classifier,Media Pipe, Sign Language Recognition.

I. Introduction

Language is a vital means of communication crucial to human life. It is estimated that humans spend 75% of their time engaged in communication [1]. This ranges from internal dialogue to interaction with others. Among the diverse array of languages worldwide, Sign Language stands out. It refers to any form of communication utilizing gestures or movements involving fingers, hands, arms, facial expressions, head, and body movements [2]. Sign language serves as the primary mode of communication for individuals who are deaf [3]. Communication through sign language predominantly relies on hand movements. There exist 26 handshapes, each corresponding to the 26 letters of the alphabet, with each shape representing a distinct letter [4].

In communication, the element of language is very important. In Indonesia, proficiency in vocabulary is indispensable for individuals utilizing language, serving not only as a conduit for conveying ideas but also as a means to streamline oral and written communication. A comprehensive lexicon not only facilitates the transmission of information but also enhances comprehension, thus playing a crucial role in effective communication [5]. Sign language is generally used by deaf individuals who are guided by the Indonesian Sign Language System (SIBI). SIBI has been formalized by the government as the official sign language used in special schools. Deaf individuals encounter challenges when interacting with hearing individuals in their everyday experiences. One contributing factor to this difficulty is the limited understanding among many hearing individuals [6].

Hearing loss also affects individuals physically and psychologically, leading to obstacles such as needing to bend down when communicating. Intellectually, they may appear weaker, be easily provoked to anger, have difficulties socializing with their surroundings, and struggle with message delivery and tone of speech [7].

Likewise, the lack of accessibility of sign language-related information is also a major obstacle to the communication integration of people with disabilities in society. Therefore, collaborative efforts are needed to improve understanding and provide media that facilitate the learning and use of sign language. Through a holistic and sustainable approach, it is hoped that the community can better understand the importance of sign language and facilitate the inclusion of individuals with disabilities in various aspects of life. For example, research by Hendyanto and Hendra Suryawan confirms the urgency of visualizing the Indonesian sign system (SIBI) as a strategy that focuses on a more personal and holistic interaction between students and learning media. This step is expected to intensify the understanding of the subject matter among students [8].

The current method of learning sign language in special schools involves practicing the alphabet with hands and fingers. Learning is done through media such as YouTube or video calls, but students may take longer to understand, which is the reason this research was conducted. A possible strategy is to optimize learning by using machine learning to improve communication and learning between educators and students in special schools [9].

The focus of image classification research has always been image feature extraction, which is fundamental to the classification process. This approach will utilize the Image Classification method, widely recognized for its effectiveness in various image-related tasks. Image Classification involves categorizing images based on predefined criteria, a process facilitated by machine learning algorithms [10]. These methods can be generally divided into traditional machine learning-based image classification and deep learning-based image classification [11]. Among these algorithms, the Random Forest Classifier stands out as a robust method, known for its ability to handle complex data structures and produce reliable results. Random Forest also offers easy insight into the variables that matter [12]. By employing the Random Forest algorithm, the project aims to enhance its capability in accurately classifying diverse images. Through rigorous data training procedures, the algorithm will learn to discern patterns and features inherent

979-8-3503-6530-6/24/$31.00 ©2024 IEEE

in the dataset, enabling informed decisions during classification tasks. This approach underscores the commitment to leveraging cutting-edge techniques to achieve optimal performance and accuracy [13].

This approach significantly contributes to the creation of alphabet learning resources for special schools. With its innovative methodology, this solution offers a fresh approach that enhances the effectiveness and engagement of alphabet learning for students.

II. LITERATURE SURVEY

In creating knowledge management solutions, technology and machine learning can aid in identifying patterns and trends within data [14]. This approach to image classification has always centered on image feature extraction, which is the basis of image classification. Traditional image feature extraction algorithms focus more on manually setting specific features in the image. Image classification will not require as much data as previously needed, now relying on hundreds or thousands of data points rather than millions [15].

In recent years, Deep Learning techniques have become the main focus in image classification research, as discussed in an article on the development of medical image classification algorithms using CNN. This research shows that CNN can be used for medical image classification with high accuracy but requires large computational resources and a lot of training data, making real-time implementation challenging [16].

This study utilizes Random Forest (RF), an extension of the Decision Tree method that uses multiple Decision Trees, where each Decision Tree is trained using individual samples, and each attribute is split based on the random selection of subset attributes. The advantages of Random Forest include increased accuracy in the presence of missing data, robustness to extreme data, and efficiency in data storage [17]. Machine learning also uses ensemble techniques that combine multiple hypotheses to solve problems, aiming to learn a single hypothesis from training data [18].

MediaPipe is a platform used to create workflows and process video data with the help of machine learning (ML) [19]. MediaPipe is a framework designed to implement ready-to-use machine learning technologies. The framework is used to build workflows that can perform inference on various types of sensor data, has published source code that supports research, and also develops technology prototypes. In MediaPipe, the modular components used are derived from sensor data processing workflows as well as inference model functions, media processing models, and data transformations [20].

Previous research by Ikhsanico Hendapratama, which applied the Random Forest Classifier to the SIBI Translator Application, successfully obtained accurate results for the SIBI alphabet using this algorithm. However, this research had shortcomings in the stability of the confusion matrix in data distributions of 70:30 and 60:40, affecting the model's consistency in some sign forms [21]. Research conducted by P. Rishi Sanmitra et al. on real-time Machine Learning-based Sign Language Recognition built this recognition system using real-colored images taken with the help of a PC camera [22].

The structure of this paper is as follows. Section III discusses the architecture, followed by a description of the preprocessing and classification stages. Section IV covers the development environment and experimental setup. Section V presents the classification results and statistical analysis of our work. Finally, the concluding section offers conclusions and an outlook on future research directions.

III. SYSTEM ARCHITECTURE

The initial stage of the process involves preprocessing, primarily focusing on image processing techniques. Here, hand shapes and other distinguishable features are carefully extracted from the images. This involves utilizing various methods such as image resizing and landmark delineation using tools like Mediapipe, with the results stored in a pickle file. This approach was also employed by previous researchers in a study titled "MediaPipe: A Framework for Perceiving and Processing Reality," which states that this framework enables efficient resource management, synchronization of time series data such as audio and video frames, and measurement of performance and resource consumption. With MediaPipe, developers can concentrate on developing algorithms or models while using MediaPipe as an environment to iteratively improve their applications, with reproducible results across multiple devices and platforms. This procedure is applied comprehensively across the dataset to ensure robust feature extraction and preparation for further analysis [23].

The second stage involves classifying the images into different possible cues using the Random Forest Classifier, which is trained on a given training set containing various cue samples.

A. *Preprocessing Phase*

This phase involves extracting frames from the dataset and performing image processing steps to extract features from the image by resizing the image and can be seen in Figure 1, drawing landmarks, saving them in a pickle file, which is done on the entire Indonesian Sign Language alphabet system dataset.

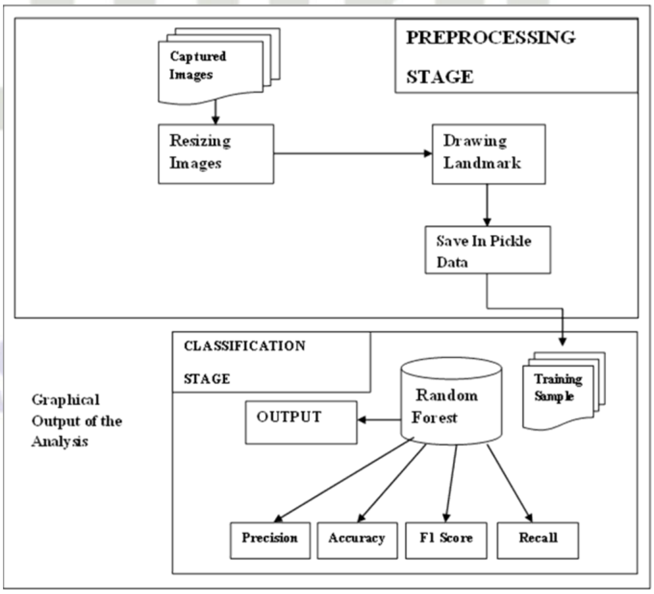


Fig. 1. Sign Language Visualization Architecture

1) Resizing Images: Dataset Resizing is the resizing of dataset images to a specified size. This research utilizes image classification, so the dataset of 5,400 images will be grouped into 27 categories, namely Default and all letters of the alphabet, with each category containing 200 images.

Fig.2. Resize the image of a camera-captured image

2) Drawing Landmarks: Drawing landmarks using Mediapipe. Landmarks are key points used to represent the position and shape of objects, in this context, possibly parts of the human body. Mediapipe is an image and video processing framework that enables accurate landmark extraction.

Fig. 3. Draw landmarks using MediaPipe

3) Saving In Pickle File: Serialize the dataset into Pickle data. The meaning of serialization is the process of converting a dataset into a format that can be stored or transmitted, and then being able to restore the dataset to its original state or return to the format it was in to begin with.

B. Classification Phase

1) Training Dataset: These training image samples were taken from different distances. The training dataset consists of a database of all alphabetic forms of the Indonesian Sign Language System that have been stored in the data pickle. The ratio between the training and testing datasets is 80:20. The sample training dataset will display the results of accuracy, f1 value, recall, and precision. In the context of training with the Random Forest algorithm, the features in the dataset are used to split the data into smaller subsets. At the subdivision stage in each decision tree, the quality of the subdivision is evaluated by comparing the relative frequencies of the classes. One of the metrics used to evaluate the division is the Gini Index, which measures the degree of homogeneity or inhomogeneity of the data in the subsets generated by the division. This process aims to select the most informative divisions, i.e. those that are able to increase the homogeneity of the data subset and thus, improve the predictive ability of the Random Forest model. Here is the formula:

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

```python
import pickle

from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import numpy as np

data_dict = pickle.load(open('./data.pickle', 'rb'))

data = np.asarray(data_dict['data'])
labels = np.asarray(data_dict['labels'])

x_train, x_test, y_train, y_test = train_test_split(data, labels, test_size=0.2, shuffle=True, stratify=labels)

model = RandomForestClassifier()
model.fit(x_train, y_train)

y_predict = model.predict(x_test)

accuracy = accuracy_score(y_predict, y_test)
precision = precision_score(y_test, y_predict, average='weighted')
recall = recall_score(y_test, y_predict, average='weighted')
f1 = f1_score(y_test, y_predict, average='weighted')

print('Accuracy: {:.2f}%'.format(accuracy * 100))
print('Precision: {:.2f}'.format(precision))
print('Recall: {:.2f}'.format(recall))
print('F1 Score: {:.2f}'.format(f1))

f = open('model.p', 'wb')
pickle.dump({'model': model}, f)
f.close()
```

Fig. 4. Coding syntax of training dataset with Random Forest

IV. DEVELOPMENT ENVIRONMENT

To ensure the successful implementation and testing of real-time Indonesian sign language recognition using a random forest classifier algorithm, choosing the right development environment is crucial. This section will detail the research process, from image capture to resizing, landmark delineation, and real-time visualization, supporting the development and evaluation. The selection of these components aims to efficiently process video data, optimize machine learning algorithms, and ensure quick and accurate real-time performance.

A. Visualization

This sign language visualization utilizes real-time video captured via a web camera as input. Frames from the video are processed using various image processing techniques. The extracted images undergo further processing with additional techniques. The results are then fed to the Random Forest Classifier for classification, producing a segmented output. Hardware requirements include a low-resolution web camera or an integrated camera on a mobile phone or laptop. The application is accessible online through a web browser platform.

The simulation is shown in Figure 5, which shows the identification process of alphabet A gestures generated by the user. This display can change in real time as the hand gesture changes to another letter, in accordance with the Indonesian Language Sign System.

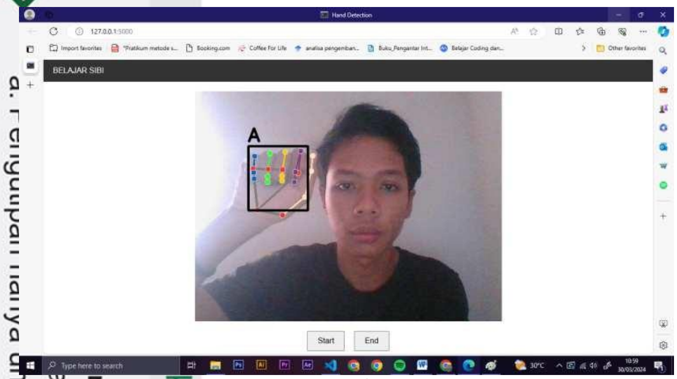


Fig. 5. Realtime visualization of the letter A sign language

B. Performance Evaluation

1) 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.

TABLE I. PERFORMANCE

No.	Evaluation Metrics			
	Accuracy	*Recall*	*F1 Score*	*Precision*
1	100%	1.00	1.00	1.00

The evaluation metrics, including 100.00% accuracy, 1.00 precision, 1.00 recall, and 1.00 F1 score, indicate the model's exceptional performance. These high values confirm its ability to make accurate predictions, identify relevant data patterns, and handle unbalanced classes effectively. The model demonstrates reliability and suitability for real-world applications. Figure 6 visually represents its effectiveness and reliability in various classification scenarios.

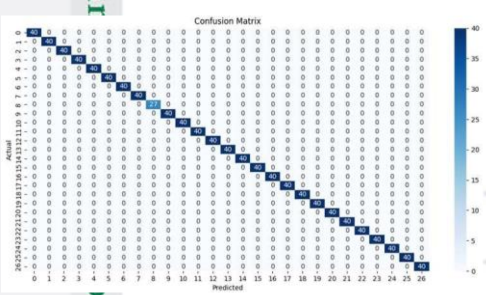


Fig. 6. Confusion Matrix

CONCLUSION

In conclusion, the simulation presented in Figure 5 illustrates the real-time identification process of alphabet A gestures based on the Indonesian Language Sign System. Through rigorous evaluation, our model has demonstrated exceptional performance in data classification, as evidenced by its exemplary accuracy, precision, recall, and F1 score. 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 real-world applications. Furthermore, Figure 6 provides a visual representation of the model's effectiveness and reliability across various classification scenarios. Overall, our findings underscore the significance and potential impact of our research in the field of sign language recognition and classification.

ACKNOWLEDGMENT

The authors would like to thank Dr. Rice Novita, S.Kom, M.Kom, the supervisor in this research, for her meaningful direction, guidance, and support during the research process. Also, thanks to SLB Pelita Hati for being the research site. Thanks also to all the resource persons who have been willing to participate, as well as to family and friends who provided moral support and motivation during the research process. Without their contributions and support, this research would not have been realized.

REFERENCES

[1] P. Rahayu, “Pengaruh Perhatian Orang Tua dan Komunikasi Interpersonal Guru-Siswa terhadap Kedisiplinan Siswa pada Peraturan Tata Tertib Sekolah di SMK Muhammadiyah 1 Wates,” *Angew. Chemie Int. Ed. 6(11), 951–952.*, no. Mi, pp. 5–24, 2019.

[2] R. Fatmawati, R. Asmara, Y. R. Prayogi, and R. Y. Hakkun, “Aplikasi Pembelajaran Sistem Isyarat Bahasa Indonesia (SIBI) Berbasis Voice Menggunakan OpenSIBI,” *Technomedia J.*, vol. 7, no. 1, pp. 22–39, 2022, doi: 10.33050/tmj.v7i1.1690.

[3] Ariadi Retno Tri Hayati Ririd, Yoppy Yunhasnawa, and Y. G. Buata, “Sistem Pengenalan Huruf Bahasa Isyarat Menggunakan Adaptive Learning Vector Quantization,” *J. Inform. Polinema*, vol. 4, no. 2, p. 145, 2018, doi: 10.33795/jip.v4i2.163.

[4] D. Indra, Purnawansyah, S. Madenda, and E. P. Wibowo, “Indonesian sign language recognition based on shape of hand gesture,” *Procedia Comput. Sci.*, vol. 161, pp. 74–81, 2019, doi: 10.1016/j.procs.2019.11.101.

[5] Hajrah, A. Azis, and Ilma Rahim, “Analisis Penggunaan Bahasa Isyarat Indonesia (BISINDO) pada Siswa SLB,” *J. Onoma Pendidikan, Bahasa, dan Sastra*, vol. 9, no. 2, pp. 1396–1402, 2023, doi: 10.30605/onoma.v9i2.2717.

[6] Y. Obi, K. S. Claudio, V. M. Budiman, S. Achmad, and A. Kurniawan, “Sign language recognition system for communicating to people with disabilities,” *Procedia Comput. Sci.*, vol. 216, no. 2022, pp. 13–20, 2022, doi: 10.1016/j.procs.2022.12.106.

[7] Rian Nanda, “Perancangan Aplikasi Tuna Wicara Dan Tuna Rungu Dengan Metode Waterfall Berbasis Android,” *JEKIN - J. Tek. Inform.*, vol. 3, no. 1, pp. 20–30, 2023, doi: 10.58794/jekin.v3i1.189.

[8] H. Suryawan, “Video Edukasi 2 Dimensi Mengenai Sistem Isyarat Bahasa Indonesia (SIBI) pada Anak-Anak,” *J. Digit. Ecosyst. Nat. …*, vol. 1, no. 2, pp. 2019–2022, 2021, [Online].

Available: http://journal.uvers2.ac.id/index.php/jodens/article/view/44

[9] S. S. Sindarto, D. E. Ratnawati, and I. Arwani, “Klasifikasi Citra Sistem Isyarat Bahasa Indonesia (SIBI) dengan Metode Convolutional Neural Network pada Perangkat Lunak berbasis Android,” *urnal Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 6, no. 5, pp. 2129–2138, 2022, [Online]. Available: http://j-ptiik.ub.ac.id

[10] L. Chen, S. Li, Q. Bai, J. Yang, S. Jiang, and Y. Miao, “Review of image classification algorithms based on convolutional neural networks,” *Remote Sens.*, vol. 13, no. 22, pp. 1–51, 2021, doi: 10.3390/rs13224712.

[11] F. An, X. Li, and X. Ma, “Medical Image Classification Algorithm Based on Visual Attention Mechanism-MCNN,” *Oxid. Med. Cell. Longev.*, vol. 2021, 2021, doi: 10.1155/2021/6280690.

[12] D. Liberda, K. Kosowska, P. Koziol, and T. P. Wrobel, “Spatial sampling effect on data structure and random forest classification of tissue types in High Definition and Standard Definition FT-IR imaging,” *Chemom. Intell. Lab. Syst.*, vol. 217, no. April, pp. 0–6, 2021, doi: 10.1016/j.chemolab.2021.104407.

[13] I. Suyudi, S. Sudadio, and S. Suherman, “Pengenalan Bahasa Isyarat Indonesia menggunakan Mediapipe dengan Model Random Forest dan Multinomial Logistic Regression (Introduction to Indonesian Sign Language Using Mediapipe With Random Forest Models and Multinomial Logistic Regression),” vol. 1, no. 1, pp. 65–80, 2022.

[14] P. Adriansyah, “Pengembangan Sistem Manajemen Pengetahuan dengan Teknologi Data Mining dan Machine Learning untuk Pengambilan Keputusan Organisasi,” *Cyberarea.Id*, vol. 3, no. 5, pp. 1–17, 2023, [Online]. Available: http://www.edukasimu.org/index.php/cyberarea/article/view/391 %0Ahttp://www.edukasimu.org/index.php/cyberarea/article/download/391/379

[15] N. O’Mahony *et al.*, “Deep Learning vs. Traditional Computer Vision,” *Adv. Intell. Syst. Comput.*, vol. 943, no. Cv, pp. 128–144, 2020, doi: 10.1007/978-3-030-17795-9_10.

[16] K. MingRu, Q. Zheng, S. Kui Yan, and N. Arunkumar, “Medical image classification algorithm based on principal component feature dimensionality reduction,” *Futur. Gener. Comput. Syst.*, vol. 98, pp. 627–634, 2019, doi: 10.1016/j.future.2018.11.056.

[17] R. Supriyadi, W. Gata, N. Maulidah, and A. Fauzi, “Penerapan Algoritma Random Forest Untuk Menentukan Kualitas Anggur Merah,” *E-Bisnis J. Ilm. Ekon. dan Bisnis*, vol. 13, no. 2, pp. 67–75, 2020, doi: 10.51903/e-bisnis.v13i2.247.

[18] Y. Zhang, J. Liu, and W. Shen, “A Review of Ensemble Learning Algorithms Used in Remote Sensing Applications,” *Appl. Sci.*, vol. 12, no. 17, 2022, doi: 10.3390/app12178654.

[19] J. W. Kim, J. Y. Choi, E. J. Ha, and J. H. Choi, “Human Pose Estimation Using MediaPipe Pose and Optimization Method Based on a Humanoid Model,” *Appl. Sci.*, vol. 13, no. 4, 2023, doi: 10.3390/app13042700.

[20] Indriani, M. Harris, and A. S. Agoes, “Applying Hand Gesture Recognition for User Guide Application Using MediaPipe,” *Proc. 2nd Int. Semin. Sci. Appl. Technol. (ISSAT 2021)*, vol. 207, no. Issat, pp. 101–108, 2021, doi: 10.2991/aer.k.211106.017.

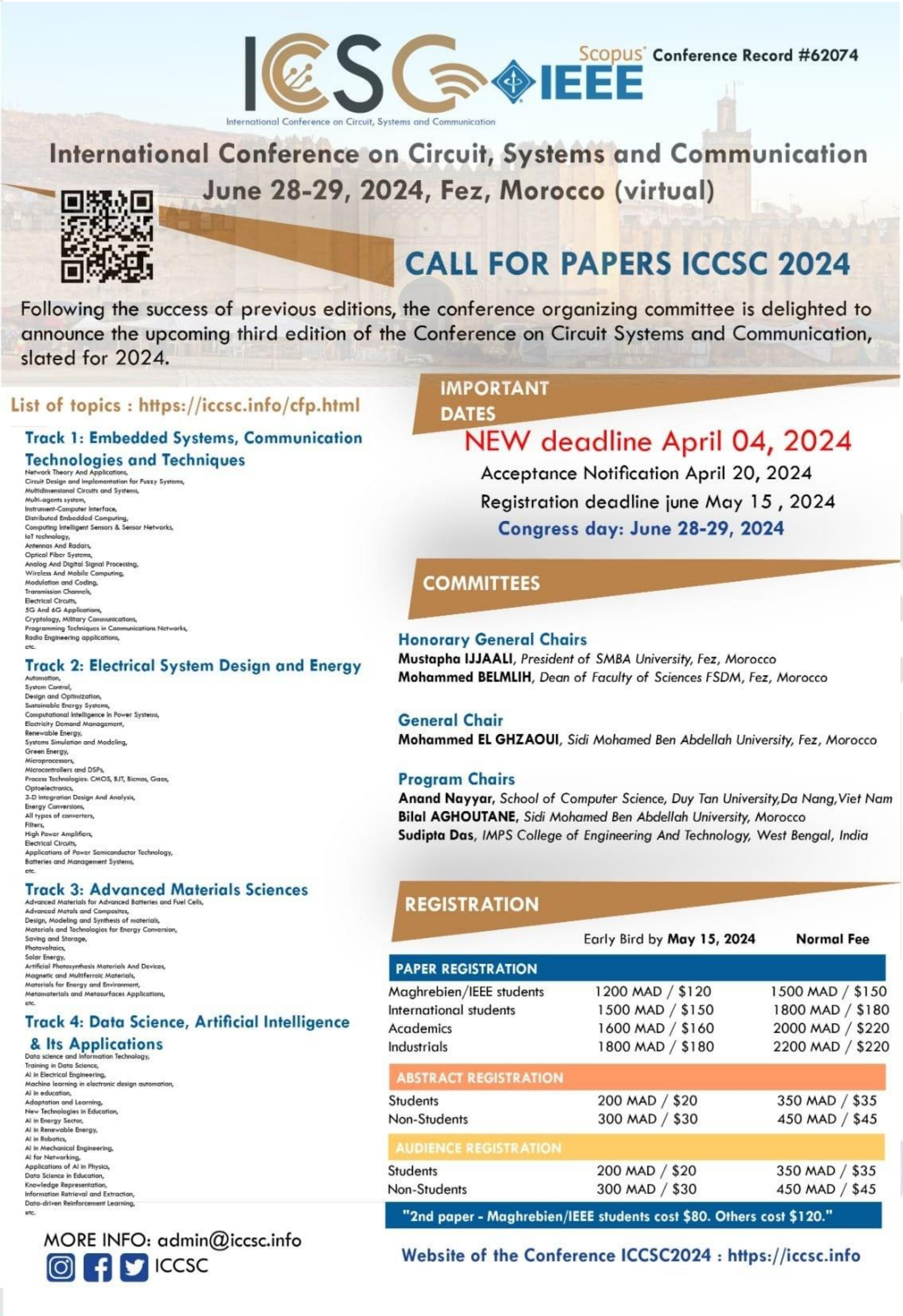
[21] I. Hendapratama, I. W. Hamzah, and S. Astuti, “Rancang Bangun Aplikasi Penerjemah SIBI (Sistem Isyarat Bahasa Indonesia) Menggunakan Algoritma Random Forest Classifier,” *e-Proceeding Eng.*, vol. 8, no. 6, pp. 3850–3855, 2022.

[22] P. R. Sanmitra, V. V. S. Sowmya, and K. Lalithanjana, “Ijresm_V4_I6_33,” vol. 4, no. 6, pp. 137–141, 2021.

[23] C. Lugaresi *et al.*, “MediaPipe: A Framework for Perceiving and Processing Reality,” *Google Res.*, pp. 1–4, 2019, [Online]. Available: https://github.com/google/mediapipe.

LAMPIRAN A

POSTER KEGIATAN



DAFTAR RIWAYAT HIDUP

Saya Naufal Safiq Tama lahir di Kota Pekanbaru, pada tanggal 20 Juni 2002. Peneliti merupakan anak pertama dari dua orang bersaudara dari pasangan Bapak Edi Sudrajad dan Ibu Fitri Wahyuni. Pada Tahun 2007 peniliti memulai pendidikan dengan masuk TK Bunayya di Kota Pekanbaru dan lulus pada tahun 2008. Lalu melanjutkan pendidikan Sekolah Dasar di Madrasah Ibtidaiyah Negeri 3 Pekanbaru. Peneliti menyelesaikan pendidikan Sekolah Dasar pada tahun 2014. Setelah menyelesaikan pendidikan Sekolah Dasar peneliti melanjutkan pendidikan tingkat SLTP di Madrasah Tsanawiyah Negeri 3 Pekanbaru yang selesai pada tahun 2016. Peneliti melanjutkan pendidikan tingkat SLTA di Sekolah Menengah Kejuruan Negeri 6 Pekanbaru. Setelah menyelesaikan pendidikan di Sekolah Menengah Kejuruan Negeri 6 Pekanbaru pada tahun 2020, peneliti pun melanjutkan pendidikan dengan menjadi mahasiswa Program Studi Sistem Informasi Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau. Selama berada di perkuliahan peneliti aktif dalam kegiatan internal dan eksternal kampus dan tergabung dalam organisasi Dewan Eksekutif Mahasiswa Fakultas Sains dan Teknologi, serta menjadi Ketua Pelaksana Kongres Mahasiswa Sistem Informasi Ke- X dan peneliti menyelesaikan kuliah Strata satu (S1) tersebut pada tahun 2024 dengan judul penelitian ”*Visualization of Indonesian Sign Language System using Image Classification for Special Needs Students in Special Schools*”.