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Research Article

Stabilization of Distance Measurement Between Landmarks for Gesture Recognition Using Polynomial Regression

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Abstract: Gesture recognition technology enables computers and digital devices to detect, understand, and interpret human body movements through image processing techniques. This technology has significant potential to facilitate communication between individuals with hearing impairments and those without, thereby improving interaction and mutual understanding. However, the accuracy of gesture recognition systems is often influenced by variations in the distances between hand landmark points, which can introduce instability and reduce recognition performance. To address this issue, this study proposes a polynomial regression-based approach to stabilize distance measurements between hand landmarks in gesture recognition tasks. The proposed method calculates and normalizes landmark distances using polynomial regression to minimize measurement fluctuations and improve recognition accuracy. The system is implemented using the MediaPipe framework for real-time hand detection and tracking, while OpenCV is utilized for video processing and management. Experimental results demonstrate that the proposed approach significantly enhances the stability and accuracy of gesture detection. The developed system successfully recognizes hand gestures representing the letters A through F with an average accuracy exceeding 98.3%. Furthermore, the application of polynomial regression effectively reduces noise in landmark data, contributing to more reliable and accurate gesture recognition performance.

Keywords: Gesture Recognition, Hand Landmark Detection, MediaPipe, Polynomial Regression, Sign Language Recognition.

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1. Introduction

Gesture recognition has become an important research area because it addresses both technological needs and social inclusion. In human-computer interaction, gesture recognition enables users to interact with digital systems through natural hand and finger movements, making it relevant for virtual reality, augmented reality, touchless control, and assistive communication systems [1], [2]. Beyond technical applications, this technology is socially significant because it can support communication access for deaf and hard-of-hearing communities. Sign language remains the primary medium of communication for many deaf individuals; however, people without sign language literacy often face difficulties understanding it [3], [4]. This condition creates communication barriers in education, public services, and daily social interaction. Therefore, developing an accurate and stable sign language recognition system is not only a technological challenge but also a response to a real social problem. Gesture recognition technology offers the potential to bridge communication gaps by translating hand movements into interpretable digital outputs [5], [6].

Previous studies have shown that computer vision-based gesture recognition can be implemented using several approaches, including Single Shot Detection, MediaPipe, OpenCV, machine learning, and deep learning models [7], [8], [9]. MediaPipe has been widely used because it can detect and track hand landmarks in real time, making it suitable for sign language recognition systems [10]. However, several studies still indicate challenges related to detection stability, hand orientation, gesture similarity, lighting conditions, and variations in hand position [11], [12], [13]. These problems may reduce system accuracy, especially when visually similar gestures are detected. The novelty of this study lies in optimizing the measurement of distances between hand landmarks using polynomial regression. Unlike previous studies that mainly focused on detection models or classification algorithms, this research emphasizes landmark distance stabilization as a strategy to improve accuracy, stability, and detection range in gesture recognition.

This study aims to optimize sign language gesture detection by applying distance measurement between hand landmarks and improving the stability of those measurements through polynomial regression. Specifically, the research focuses on hand landmark coordinates, particularly knuckle-related landmark points, as the basis for calculating gesture characteristics. Polynomial regression is used to reduce fluctuations in landmark distance data so that the system can produce more stable and accurate recognition results [14]. Based on this objective, the study addresses three research questions. First, how does the application of optimized hand landmark distance measurement affect the accuracy, stability, and detection range of sign language recognition? Second, to what extent does polynomial regression improve the performance of gesture recognition systems? Third, how can this research contribute to the development of gesture recognition technology and communication accessibility for the deaf community? These questions guide the study toward solving both technical and social problems in sign language recognition.

The main argument of this study is that the stability of hand landmark distance measurement is a crucial factor in improving gesture recognition performance. When landmark distances are unstable due to changes in hand position, tilt, or orientation, the recognition system may produce inaccurate results. Therefore, polynomial regression is proposed as an optimization approach to minimize noise and stabilize the distance patterns between landmarks. This study contributes theoretically by expanding the discussion of gesture recognition from model classification accuracy to landmark distance stability. It also contributes practically by providing an alternative method for improving sign language detection using MediaPipe and OpenCV-based implementation [15], [16]. In a broader social context, the proposed approach may support the development of more reliable assistive technology for deaf individuals. By improving recognition accuracy and system responsiveness, this research is expected to strengthen inclusive communication and reduce interaction barriers between deaf and non-deaf communities.

2. Literature Review

Systematic Literature Review

A Systematic Literature Review (SLR) is a structured method used to identify, evaluate, analyze, and interpret previous studies that are relevant to a specific research topic. In this study, SLR is applied to understand the development of gesture recognition technology, especially in relation to sign language detection, hand landmark measurement, MediaPipe implementation, and polynomial regression. Through this approach, previous studies are reviewed systematically to identify research trends, methodological gaps, and potential improvements that can support the development of a more accurate gesture recognition system. The SLR method is important because it helps researchers avoid subjective selection of literature and provides a clear basis for determining the novelty of the study. In the context of this research, SLR is used not only to summarize prior findings but also to formulate the research direction, especially regarding the stabilization of hand landmark distance measurements for sign language recognition systems [17], [18].

Survey Methodology

The survey methodology in this study is organized using the PICOC framework, which consists of Population, Intervention, Comparison, Outcomes, and Context. This framework is used to define the scope of the literature search and ensure that the selected publications are relevant to the research objective. The population includes studies related to sign language recognition, gesture recognition, landmark distance measurement, polynomial regression, MediaPipe, and object detection. The intervention focuses on the problem of reduced gesture recognition performance when hand position, orientation, or tilt changes during detection.

The comparison element is not emphasized because this study focuses on optimizing a proposed method rather than comparing several competing methods. The expected outcomes include improved stability, accuracy, and detection range in gesture recognition systems. The context of this study is the use of Indonesian Sign Language gesture data, particularly references obtained from official SIBI vocabulary sources [19].

Review Survey Protocol

The review survey protocol explains the procedure used to collect, filter, and select scientific publications related to the research topic. In this study, the publication period is limited to studies published between 2019 and 2024 to ensure that the reviewed literature reflects recent developments in computer vision-based gesture recognition. The selected publications consist of journal articles, conference papers, proceedings, and supporting references that are relevant to sign language detection, object recognition, hand gesture recognition, MediaPipe, and measurement distance. The search string includes keywords such as "sign language," "object detection," "object recognition," "hand gesture," and "measurement distance." These keywords help identify studies that discuss both technical and application-oriented aspects of gesture recognition systems. The final selected literature is used as the foundation for identifying research gaps, particularly those related to instability in hand landmark detection and the need for distance measurement optimization [2], [9].

Matrix of Research Problems, Research Questions, and Research Objectives

The matrix of research problems, research questions, and research objectives is used to align the main issues of the study with the expected research outcomes. One of the central problems identified in the literature is the limited public understanding of sign language, which creates communication barriers between deaf individuals and people without hearing impairments. This problem leads to the need for a real-time sign language translator that can convert hand gestures into text using computer vision technology. Another problem is that sensor-based sign language translators are often considered less practical because they may be expensive, uncomfortable, and difficult to use. Therefore, this research focuses on a camera-based approach that does not require additional physical sensors. The research questions are directed toward how gesture recognition can be improved through automatic detection and how landmark distance optimization can support recognition accuracy. The research objective is to develop a more practical, accurate, and accessible sign language recognition system [5], [6].

Definition and Conceptual Foundation

Sign language is a visual communication system that uses hand movements, facial expressions, body posture, and gestures to convey meaning. It plays an essential role in supporting communication among deaf and hard-of-hearing individuals. Unlike spoken language, sign language relies primarily on manual and visual elements rather than sound. In practice, sign language may include finger spelling, symbolic hand movements, and expressive gestures that represent letters, words, or concepts. This makes sign language highly dependent on accurate visual interpretation. In the context of gesture recognition research, sign language becomes an important object of study because each gesture contains specific hand shapes, positions, and movements that must be detected correctly. Failure to distinguish similar gestures can produce incorrect interpretation and reduce communication effectiveness. Therefore, understanding the characteristics of sign language is necessary before developing a recognition system that can translate gestures into digital output accurately and reliably [3], [4].

Gesture recognition refers to a computer-based system that enables machines to interpret human movements as input commands or meaningful information. In computer vision, gestures are usually captured through cameras and processed using image processing or machine learning techniques. Hand gesture recognition is widely applied in human-computer interaction, assistive technology, virtual environments, and sign language recognition. The main challenge in gesture recognition is ensuring that the system can detect hand movements accurately despite variations in lighting, hand orientation, distance from the camera, and gesture similarity. In sign language recognition, this challenge becomes more complex because small differences in finger position or hand shape can represent different meanings. MediaPipe is one of the frameworks commonly used to address this challenge because it provides real-time hand tracking and landmark detection. By detecting 21 hand landmark points, MediaPipe allows researchers to calculate hand structure and movement patterns more precisely [10], [16].

Polynomial regression, OpenCV, Python, and Euclidean distance are important technical components in the development of the proposed gesture recognition system. Polynomial regression is used to model nonlinear relationships between variables, making it suitable for stabilizing fluctuating landmark distance data. In this study, it is applied to optimize the distance measurement between hand landmark points so that gesture recognition becomes more stable and accurate. Euclidean distance is used to calculate the distance between two landmark points in coordinate space, which provides a numerical representation of hand shape and movement. OpenCV supports video processing, image capture, and computer vision operations, while Python is used as the main programming language for dataset processing, model implementation, and system development. These components work together to support real-time sign language detection. By combining MediaPipe landmark detection, Euclidean distance calculation, and polynomial regression optimization, the system is expected to reduce noise and improve gesture recognition performance [14], [15].

3. Materials and Method

Research Data

The data used in this study consist of hand gesture data collected directly through a camera using the MediaPipe and OpenCV libraries. The acquisition process was performed in real time through video streaming, where the system detected and tracked hand landmarks to identify gesture patterns. The dataset was specifically designed for gesture recognition tasks and contains classification data representing six alphabet gestures (A, B, C, D, E, and F) as well as five sign language vocabularies, namely Hello, What?, Who?, When?, and How?. Each gesture was recorded under controlled conditions and processed through the MediaPipe Hand Landmark Detection framework to extract hand landmark coordinates. These coordinates were subsequently used to calculate the distances between relevant landmark points, providing quantitative features that represent the geometric characteristics of each gesture. Because the data were collected specifically for this research, the dataset is considered private and was not obtained from any public repository.

The dataset is characterized by several important attributes that support the development and evaluation of the proposed gesture recognition system. First, the data source consists of real-time camera captures, enabling the collection of dynamic hand movements under practical usage conditions. Second, the dataset belongs to the classification category, where each sample is assigned to a predefined gesture class. The primary features used in this study are the distances between hand landmarks, initially measured in pixels and subsequently converted into centimeters to provide more consistent spatial measurements. Data collection was conducted using MediaPipe for hand landmark detection and OpenCV for video acquisition and processing. The collected dataset was then utilized for both training and testing purposes to evaluate the effectiveness of polynomial regression in stabilizing landmark distance measurements. The performance of the gesture recognition system was analyzed by comparing recognition accuracy and detection stability before and after the implementation of polynomial regression optimization.

Research Methodology

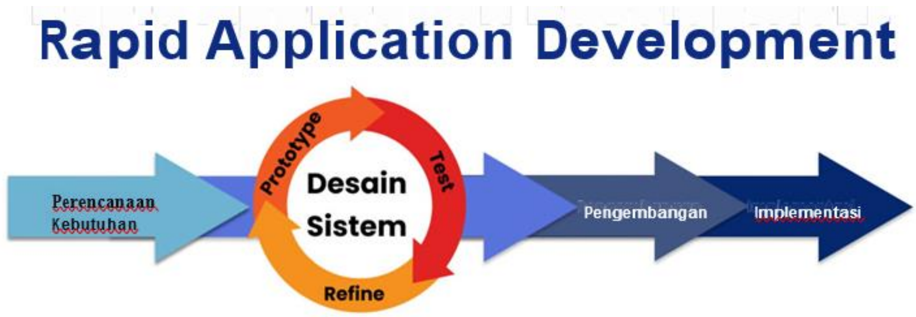

Figure 1. Rapid Application Development

This study adopts the Rapid Application Development (RAD) methodology as the primary framework for developing the proposed gesture recognition system. RAD is a software development approach that emphasizes rapid prototyping, iterative development, and continuous refinement, making it suitable for projects with limited development time and evolving requirements. The methodology was selected because it enables the efficient development and evaluation of a real-time hand gesture recognition system while maintaining flexibility during implementation. Several mathematical models are incorporated into the system, including Euclidean Distance, pixel-to-centimeter conversion, and Polynomial Regression. Euclidean Distance is used to calculate the spatial distance between two hand landmark coordinates detected by MediaPipe. The measured distance in pixels is then converted into centimeters using a predefined reference distance between landmark points 0 and 9, which was selected due to its stability under various hand orientations and movements. These measurements provide quantitative features that represent hand gestures and serve as the basis for the recognition process.

The RAD implementation consists of four main phases: requirements planning, system design, development and testing, and implementation. During the requirements planning phase, the functional and technical requirements of the gesture recognition system were identified, including real-time hand tracking, landmark extraction, and distance stabilization. The system design phase focused on creating modules for image acquisition, landmark detection, distance calculation, and gesture classification. In the development phase, OpenCV was utilized for video processing, while MediaPipe was employed for hand landmark detection. Polynomial Regression was integrated to reduce measurement noise and stabilize landmark distance values, thereby improving recognition accuracy and detection consistency. Each module was tested independently before being integrated into the complete system. Finally, the implementation phase involved deploying the system in a real-time environment and evaluating its performance by comparing gesture recognition accuracy, detection range, and measurement stability before and after the application of Polynomial Regression optimization.

Testing Design

The testing design in this study is intended to evaluate whether the proposed gesture recognition system, enhanced through polynomial regression optimization, can effectively address the identified research problems and achieve the established research objectives. The evaluation focuses on several key performance indicators, including recognition accuracy, measurement stability, system reliability, and real-time responsiveness. Specifically, the testing process aims to verify that the landmark distance-based detection approach can accurately recognize and classify hand gestures while maintaining consistent performance under varying hand positions and orientations. In addition, the experiments assess the effectiveness of Polynomial Regression in stabilizing the distances between hand landmarks by reducing fluctuations and measurement noise that may negatively affect recognition performance. Another important objective is to ensure that the system operates efficiently in real-time environments, allowing it to respond quickly to dynamic changes in hand gestures without significant delays. Through a series of controlled experiments, the proposed sign language detection system is evaluated to determine whether the optimized landmark distance measurements can provide more accurate, stable, and reliable gesture recognition results compared to measurements obtained without polynomial regression optimization.

Here are some steps that can be used to design a sign language detection system test:

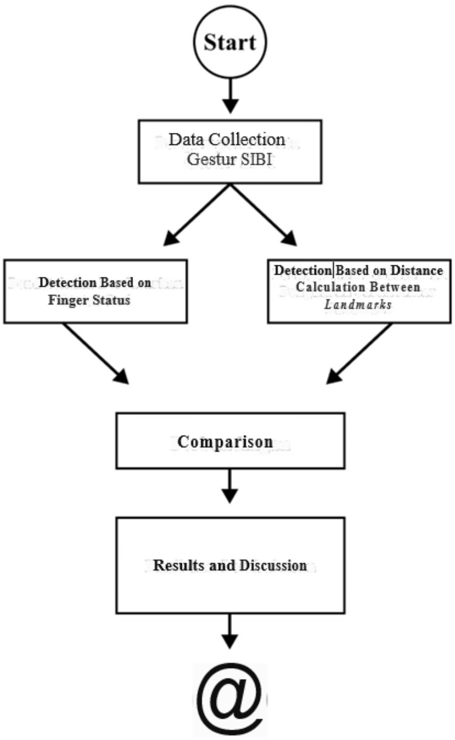

Figure 2. Testing Plan.

The testing procedure begins with the preparation of the SIBI sign language gesture dataset, which includes hand gestures representing the letters A–F and basic vocabulary such as Hello, What?, Who?, When?, and How?. The collected data are evaluated using two different detection approaches. The first approach recognizes gestures based on finger status, specifically whether individual fingers are open or closed. The second approach performs recognition using hand landmark distance measurements optimized through Polynomial Regression. The performance of both approaches is then compared in terms of recognition accuracy, detection stability, and detection range. Testing is conducted under three hand orientations: normal, tilted to the left, and tilted to the right. Finally, the results are analyzed and presented systematically to evaluate the effectiveness of the proposed method and its potential contribution to improving sign language recognition performance.

4. Results and Discussion

Research Instruments

Table 1. Hardware Specifications.

No	Jenis *Hardware*	Spesifikasi
1	Laptop	Lenovo Ideapad 330-15ICH, Prosesor: Intel(R) Core(TM) i5-8300H CPU @ 2.30Ghz(8 CPUs), -2,3GHz, RAM: 8GB, GPU: NYDIA GeForce GTX 1050 Kamera: Resolusi: HD 720p, Frame Rate: 60 FPS, Sistem Operasi: Windows 11 Home Single Language 64-bit (10.0, build 22631).

The development and evaluation of the proposed gesture recognition system were supported by both hardware and software components specifically selected to ensure reliable real-time processing and accurate hand landmark detection. The hardware platform consisted of a Lenovo IdeaPad 330-15ICH laptop equipped with an Intel® Core™ i5-8300H processor running at 2.30 GHz, 8 GB of RAM, an NVIDIA GeForce GTX 1050 graphics processing unit, and an integrated HD 720p camera capable of capturing video at up to 60 frames per second. The system operated on Windows 11 Home Single Language 64-bit, providing a stable environment for software development and testing. On the software side, Python 3.12 was used as the primary programming language due to its flexibility and extensive support for machine learning and computer vision applications. OpenCV was utilized for image acquisition and video processing, while MediaPipe was employed for real-time hand landmark detection and tracking. NumPy and Pandas were used for numerical computation and data analysis, respectively, whereas Scikit-learn provided the implementation of Polynomial Regression. The entire development process was conducted using PyCharm Community Edition 2024.1.1 as the integrated development environment (IDE).

Implementation and testing

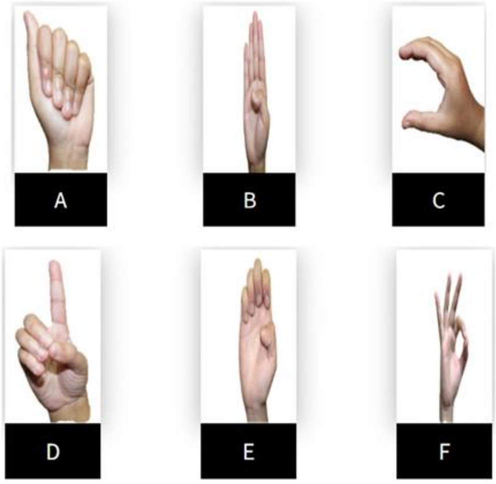

Figure 3. SIBI Sign Language.

Figure 4. SIBI Sign Language Vocabulary.

The system implementation began with the initialization of MediaPipe Hands and the configuration of the camera to capture real-time video input. MediaPipe Hands was used to detect hand landmarks, while OpenCV was applied to capture, flip, convert, and display video frames. Each detected hand landmark was stored as coordinate data and then processed to calculate Euclidean distances between selected landmark pairs. Several important landmark pairs, such as 5–17, 5–8, 9–12, 13–16, 17–20, 4–1, and 8–4, were used as the basis for gesture classification. Polynomial regression was applied to the collected landmark distance data to model nonlinear distance patterns and predict more stable landmark values. In addition, exponential smoothing was used to reduce fluctuations in the predicted values. After smoothing, the landmark distances were normalized using a reference distance, particularly between landmark points 0 and 9, and then converted into centimeters for more consistent measurement and interpretation.

The testing phase was conducted to evaluate the performance of the gesture recognition system after optimizing landmark distance measurement using polynomial regression. The evaluation compared two models: the first model used finger status classification, such as open or closed fingers, while the second model used optimized landmark distance measurement. Testing was carried out under consistent environmental conditions with stable lighting and minimal external disturbance to reduce uncontrolled variables. The system was tested using SIBI sign language gestures consisting of six alphabet gestures, namely A, B, C, D, E, and F, as well as five vocabulary gestures: hello, what?, who?, when?, and how?. Each gesture was identified based on predefined distance thresholds between landmark pairs, such as thumb, index finger, middle finger, ring finger, little finger, and palm-related landmarks. The comparison aimed to determine whether polynomial regression optimization improved detection accuracy, stability, and distance measurement reliability in real-time sign language recognition.

Final Testing Results

Table 2. Comparison Results of Sign Language Detection Methods.

Letter	Program Type	0°	Right Tilt 45°	Right Tilt 90°	Left Tilt 45°	Left Tilt 90°
A	Landmark Distance Measurement	A	A	A	A	A
A	Finger Status	A	E	E	A	A
B	Landmark Distance Measurement	B	B	B	B	B
B	Finger Status	B	B	O	B	F
C	Landmark Distance Measurement	C	C	C	C	C
C	Finger Status	C	C	C	A	A
D	Landmark Distance Measurement	F	F	O	F	F
D	Finger Status	D	D	F	D	O
E	Landmark Distance Measurement	E	E	E	E	E
E	Finger Status	E	O	O	E	A
F	Landmark Distance Measurement	F	F	F	F	F
F	Finger Status	F	B	B	O	A

The final testing results present a comparison between two sign language detection methods: the finger-status method and the landmark distance measurement method optimized using polynomial regression. The test was conducted on six SIBI alphabet gestures, namely A, B, C, D, E, and F, under five hand-position conditions: normal position, 45° right tilt, 90° right tilt, 45° left tilt, and 90° left tilt. The results show that the optimized landmark distance method achieved significantly better accuracy and stability than the finger-status method. Out of 60 tested gestures, the landmark distance-based method correctly detected 59 gestures, with only one error occurring when the letter D was tilted 90° to the right and detected as null. In contrast, the finger-status method performed well only in the normal hand position but experienced a significant performance decrease when the hand was tilted, correctly detecting only 15 out of 60 gestures.

The results also indicate that polynomial regression improved the system's ability to maintain stable detection across different hand orientations and distances from the camera. The finger-status method became less reliable when the hand was tilted or placed farther from the camera, causing frequent misclassification and unstable detection. Conversely, the landmark distance-based method remained more consistent because it used normalized landmark distances and specific gesture conditions for both close and distant hand positions. Although detection precision slightly decreased as the distance between the hand and camera increased, the optimized method still showed better performance than the finger-status approach. These findings confirm that landmark distance measurement optimized with polynomial regression can improve the accuracy, stability, and reliability of SIBI sign language recognition, particularly when hand gestures are performed under non-normal positions or varying detection distances.

5. Conclusion

This study proposed a gesture recognition system that combines hand landmark distance measurement with Polynomial Regression and Exponential Smoothing to improve the accuracy, stability, and detection range of sign language recognition. The experimental results demonstrate that the proposed approach significantly enhances system performance compared to the conventional finger-state method. The developed system successfully recognized sign language gestures representing the letters A–F and selected vocabulary gestures with an average accuracy of 98.3%, whereas the baseline approach achieved only 25% accuracy. The integration of Polynomial Regression effectively reduced fluctuations in landmark measurements and minimized noise, resulting in more stable gesture detection. Furthermore, the system maintained consistent recognition performance when the hand was tilted or positioned at varying distances from the camera, indicating that landmark distance stabilization plays a critical role in improving recognition reliability.

The findings confirm that optimizing hand landmark distance measurements is an effective strategy for enhancing gesture recognition performance in real-time applications. The proposed method provides more consistent and accurate distance estimation, particularly in scenarios involving changes in hand orientation and detection range. Beyond its technical contributions, the system has practical potential for supporting communication accessibility for deaf and hard-of-hearing individuals, enabling more natural human–computer interaction, and facilitating touchless control applications. Future research should focus on expanding the gesture dataset to include the complete sign language alphabet and additional vocabulary, exploring advanced machine learning and deep learning techniques, and evaluating the system across different hardware platforms and real-world environments. Such developments may further improve recognition accuracy, scalability, and usability in practical sign language translation systems.

References

[1] P. Srinil and P. Thongnim, “Deep Learning Enhanced Hand Gesture Recognition for Efficient Drone Use in Agriculture,” *Int. J. Adv. Comput. Sci. Appl.*, vol. 15, no. 5, 2024, doi: 10.14569/IJACSA.2024.01505127.

[2] M. Oudah, A. Al-Naji, and J. Chahl, “Hand Gesture Recognition Based on Computer Vision: A Review of Techniques,” *J. Imaging*, vol. 6, no. 8, p. 73, 2020, doi: 10.3390/jimaging6080073.

[3] N. P. A. Perdana, N. D. Kirana, N. C. Iroth, A. Salsabila, and R. A. F. B., “Fenomena Penggunaan Bahasa Isyarat Bagi Penyandang Tuna Rungu di Sekolah Inklusi,” *Hasanuddin J. Sociol.*, vol. 4, no. 2, pp. 120–134, 2022.

[4] R. P. Adi, “Fungsi Bahasa Isyarat terhadap Kemudahan Akses Informasi Bagi Siswa Tunarungu di Perpustakaan SLB N 1 Bantul,” Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia, 2019.

[5] A. Sonawane, A. Bhoskar, M. Azam, S. Belhim, and N. Zaman, “Sign Language Detection Without Sensors,” *J. Basic Sci.*, vol. 22, no. 11, pp. 278–284, 2022.

[6] J. Li *et al.*, “Sign Language Recognition and Translation: A Multi-Modal Approach Using Computer Vision and Natural Language Processing,” in *Proceedings of the International Conference Recent Advances in Natural Language Processing*, Varna, Bulgaria, 2023. doi: 10.26615/978-954-452-092-2_071.

[7] D. I. Mulyana, M. B. Yel, and A. Sitohang, “Detection of the Deaf Signal Language Using the Single Shot Detection (SSD) Method,” *J. Appl. Eng. Technol. Sci.*, vol. 4, no. 1, pp. 215–222, 2022, doi: 10.37385/jaets.v4i1.966.

[8] M. H. Abidi, M. K. Muhammad, and H. Alkhalefah, “Deteksi Bahasa Sinyal Tuli Menggunakan Metode Single Shot Detection (SSD),” *J. Tek. Terap. dan Ilmu Teknol.*, vol. 4, no. 1, pp. 215–222, 2022.

[9] A. Tayade and A. Halder, “Real-Time Vernacular Sign Language Recognition Using MediaPipe and Machine Learning,” *Int. J. Res. Publ. Rev.*, vol. 2, no. 5, pp. 9–17, 2021, doi: 10.13140/RG.2.2.32364.03203.

[10] P. B. Utomo, R. A. Ramadhani, and H. Kurniawan, "Deteksi Gerak Tangan sebagai Pengenal Bahasa Isyarat Menggunakan MediaPipe dan Long Short-Term Memory," *J. Simetris*, vol. 15, no. 1, pp. 1–8, 2024.

[11] J. Medellu, A. Sambul, and A. S. M. Lum, "Hand Gesture Detection Application in Sign Language," *J. Tek. Inform.*, vol. 17, no. 4, pp. 285–296, 2022.

[12] A. Sani and S. Rahmadinni, "Deteksi Gestur Tangan Berbasis Pengolahan Citra," *J. Rekayasa Elektr.*, vol. 18, no. 2, pp. 115–124, 2022.

[13] H. Budiati and A. R. Himamunanto, "Metode Subtraksi Citra Sebagai Upaya Deteksi Gerakan Tangan," *Pros. SAINTEK Sains dan Teknol.*, vol. 1, no. 1, 2022.

[14] Abhigyan, "Understanding Polynomial Regression," 2020, *Medium*. [Online]. Available: https://medium.com/analytics-vidhya/understanding-polynomial-regression-5ac25b970e18

[15] T. C. A. Zulkhaidi, E. Maria, and Y. Yulianto, "Pengenalan Pola Bentuk Wajah dengan OpenCV," *J. Rekayasa Teknol. Inf.*, vol. 3, no. 2, pp. 181–185, 2019.

[16] A. H. Nur'azizan, A. R. Ardiansyah, and R. Fernandis, "Implementasi Deteksi Bahasa Isyarat Tangan Menggunakan OpenCV dan MediaPipe," in *Prosiding Seminar Nasional Teknologi dan Sains*, 2024.

[17] R. Soebiartika and I. Rindaningsi, "Systematic Literature Review (SLR): Implementasi Sistem Kompensasi dan Penghargaan Terhadap Kinerja Guru SD Muhammadiyah Sidoarjo," *J. Manaj.*, vol. 2, no. 1, pp. 171–185, 2023.

[18] I. W. Ningsi and others, "Metode Systematic Literature Review untuk Identifikasi Metode Pengembangan Sistem Informasi di Indonesia," *J. Sist. Inf. dan Manaj.*, vol. 10, no. 3, pp. 204–209, 2022.

[19] K. Widiarsa, "Kajian Pustaka (Literature Review) sebagai Layanan Intim Pustakawan Berdasarkan Kepakaran dan Minat Pemustaka," *Media Inf.*, vol. 28, no. 1, pp. 111–124, 2019.