Developing a Prototype Hand Gesture Recognition System in Interpreting American Sign Language

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Abstract

Hand gestures of sign language is a form of non-verbal communication which have been used by most people in their daily life. Sign language is not only used by people with speaking issues but it is also unconsciously used by normal people during their daily interaction with others. This is because it is a way to express their current feelings or the meaning they wanted to convey to others. On other hand, sign language is an important alternative used by people with hearing impairment or speaking obstacles so they can communicate with others. However, not everyone from all walks of life has learned sign language so there will be problems of interaction between them and people with speaking issues. Thus, this research focuses on developing a hand gesture recognition system for accurately interpreting American Sign Language (ASL) so that it can deliver a message that can be understood by others and enable efficient communication. In our system, it will utilize computer vision techniques to analyze hand postures and movements which will include hand sign recognition, finger tracking, and motion estimation. With the pre-developed libraries like OpenCV and MediaPipe are employed in the system so it can recognize and classify ASL gestures based on extracted features. Extensive datasets of ASL hand gestures are collected and annotated to enhance the system's accuracy and robustness. The developed system aims to improve human-computer interaction, enabling seamless communication between deaf individuals and technology. The potential applications include real-time interpretation of ASL gestures for enhanced accessibility and inclusivity.

Keywords: Human-Computer Interaction, American Sign Language, Hand Gesture Recognition System.

1. Introduction

In this age of technology, there are many IT related tools or systems that provide various benefits to all walks of life which include Hand Gesture Recognition System (HGRs). The Hand Gesture Recognition System is a type of technology that uses computer vision and machine learning to interpret the motion and sign of individuals [1]. Therefore, this technology can contribute a significant transformation to society nowadays by providing a particular group of people huge benefits who are born with hearing impairment or muted. This is because people with hearing impairment or mute usually rely on sign language, and it is an important tool of communication for them. There is a specific meaning from each gesture in sign language which can construct a complex meaning with the combination of various gestures. In American sign language, where each hand sign will represent different alphabets from A to Z which then can form a specific word. As a result, this project purpose is about developing a Hand Gesture Recognition System that can help in reading sign language. With this system, it can help people with hearing impairment or speaking disabilities to communicate with others more efficiently as well as allow non-signers to get know more about what actually a sign language is [7], [8].

Hand gestures are something that are typically used in daily communication including communicating with people having hearing problems. According to the research, hand gestures can be defined as a type of body language that can be expressed through the center of the palm, finger position and the shape constructed by the hand [9]. There are two classifications of hand gestures which will be the static and dynamic. The static

gestures mostly have to do with the shape of the hand whereas the dynamic gestures deal with a variety of hand movements [9]. For instance, we can find static gestures from the American Sign Language (ASL) at the figure (Fig. 1) in which most of its hand gestures are in a particular shape or pattern that represent an alphabet excluding j and z. Dynamic gestures are mostly related to body language or hand gestures that require movement such as waving, shaking other hands, or even showing the J and Z letter in ASL [11]. It is hard to track the dynamic gestures so in our project we will be focusing more on the ASL static gestures and think of future improvement for the dynamic hand gestures recognition system.

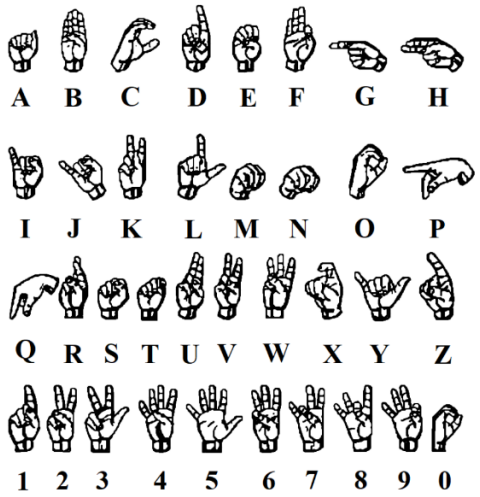

Fig. 1 American Sign Language [10].

2. Methodology

2.1 Comparison Of Different Methodology in Hand Gestures Recognition System

A comparison of methodology is shown in the table below (Table 1).

Table 1 Comparison Table of methodology in Hand Gesture Recognition System

Sr. No	Paper Name	Year of Public	Techniques	Advantages
1	Hand Gesture Recognition via Lightweight VGG16 and Ensemble Classifier [4]	2022	1.CNN 2.Random Forest Classifier	• Random forest is great in handling large input variables. • Having the highest classification rate.
2	Indian Sign Language Recognition Using Random Forest Classifier [2]	2021	1.Random Forest Classifier	• High accuracy even on complex datasets. • Robust to missing data as users may not always perform gestures perfectly.
3	A Vision-based System for Recognition of Words used in Indian Sign Language Using MediaPipe [6]	2022	1.Random Forest Classifier 2.MediaPipe	• Able to learn complex relationships between the features of the sign language gestures. • Achieving high accuracy in 97.4%.
4	Communicating with the Deaf and Hard of Hearing through Automatic Arabic Sign Language Translator [5]	2021	1.Feature Extraction 2.Random Forest Classifier	• Achieving best recognition accuracy out of all other classification algorithms.
5	Smart Communication System Using Sign Language Interpretation [3]	2022	1.MediaPipe 2.Light Weight Random Forest Classifier	• Achieving good accuracy on recognition about 94.69% • Ability in adapting to different sign language datasets by using different feature extraction techniques and hyperparameter tuning

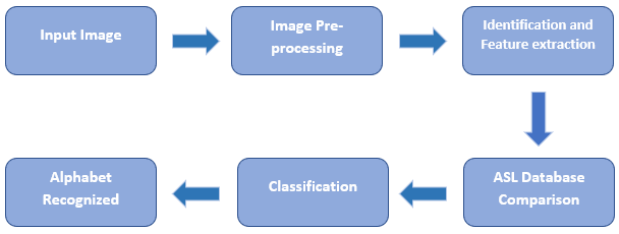

Fig. 2 Proposed concept of Hand Gesture Recognition System

2.2 Analysis

We will be revealing the outcomes and analyzing the information about the Hand Gesture Recognition System in interpreting ASL from the survey organized that was distributed on the network through emailing and messaging (Fig. 2). Based on the outcomes of the survey, we will know about whatever this project can provide a system in interpreting ASL for

communication between normal people and deaf or people with hearing problems.

2.3 Methodology

In this report, we have employed a quantitative method to gather information regarding the Hand Gesture Recognition System in interpreting ASL. The chosen approach for data collection was a survey form created using Google Forms. The survey form consisted of 2 parts, the first part is about the demographics of the respondents and the second part is about the system inquiries. There are a total of 16 questions that focus on which the 12 questions from the total are mostly asking about the Hand Gesture Recognition System and ASL. The questions included in the survey form were carefully selected to extract essential information required for our research. We aimed to understand more about the Hand Gesture Recognition system so that we can successfully develop the system in interpreting ASL.

The survey form consisted of multiple-choice questions that allowed respondents to select multiple answers from a given list of options. This format enabled us to capture a range of basic understanding of the respondents in the Hand Gesture Recognition System. In addition to multiple-choice questions, we also included rating questions in the survey form. These questions employed a scaling approach to measure respondents' agreement or disagreement with specific statements related to the Hand Gesture Recognition System. This format allowed us to assess the level of agreement towards certain measures or opinions about the Hand Gesture Recognition System in interpreting ASL.

By utilizing the survey form with these question formats and employing various distribution methods, we intended to gather comprehensive insights into the Hand Gesture Recognition System. For reference, the appendix of this report contains 15 survey questions pertaining to the Hand Gesture Recognition System in interpreting ASL.

3. Results and Discussion

In this section, it will be discovering all the validation and testing that are done after the development of the Hand Gesture Recognition system. This chapter is a very significant part that needs to be taken in the entire process of the project development as it will be the sources to know what are the weaknesses and limitations of the current system and the improvement that it needs to enhance in the future. The results are shown in Table 2 and Table 3.

Table 2. Results of Unit Testing

Procedure Description	**Expected Result**	**Actual Result**	**Test Result**
Click Start Camera Button	The camera is started after button was clicked	Worked as expected	Pass
Click Stop Camera Button	The camera frame is stopped after the button was clicked	Worked as expected	Pass
Recognizing the ASL hand gesture	All the static ASL hand gesture is recognized successfully on both right and left hand	Worked as expected	Pass
Click Exit Button	Close the entire program	Worked as expected	Pass
Click Save Character Button	Able to save the recognized ASL hand gesture to text file	Worked as expected	Pass
Click Clear Texts Button	Able to clear the textbox with the recognized ASL hand gesture	Worked as expected	Pass
Enable to save message as history	Click the Save Messages button to store it as history at history message page	Worked as expected	Pass
Click History Message Button	Open up a new frame that redirect to the History Message page	Worked as expected	Pass
Click ASL Display Button	Allow users to view on the ASL gestures information on new frame	Worked as expected	Pass
Click Testing Page Button	Open up a new frame that redirect to the testing page	Worked as expected	Pass
On History Message page, double click on message	Allow long message to be view in full on the label of “Full Message:”	Worked as expected	Pass
On History Message page, click clear button	Able to clear the full shown messages on the below the label of “Full Message:”	Worked as expected	Pass
On History Message page, click clear history button	All the history on the page will be able to clear	Worked as expected	Pass
Click Text to Speech	Able to hear the voice of messages to speech	Worked as expected	Pass
Inside message box of History Message page	Information of saved message will be recorded such as Date, Time and Message contents	Worked as expected	Pass
On testing page, click start camera button	It will activate the camera frame for hand gesture recognition process	Worked as expected	Pass
On testing page, click stop camera button	It will stop the operation of camera frame	Worked as expected	Pass
On testing page, information box display	After camera operated, it will show different information such as recognized alphabets, hands, interpretation and FPS	Worked as expected	Pass

Table 3. Results of System Testing

Procedure Description	Expected Result	Actual Result	Test Result
Recognizing ASL hand gestures through webcam	To ensure the users were able to recognize the ASL hand gesture through the start camera.	Worked as expected	Pass
Saving the ASL hand gestures	To ensure that the users are able to save the recognized ASL alphabets to the textbox.	Worked as expected	Pass
ASL information display	To ensure that the users are able to view types of ASL hand gestures at the page.	Worked as expected	Pass
Saving the text in Message History	To ensure that the users are able to save and view back the history of text.	Worked as expected	Pass
Testing feature for users	To ensure that the users are able to familiarize themselves with the ASL hand gesture system before directly using it.	Worked as expected	Pass
Converting Text to Speech	To ensure the messages from the deaf or people with hearing problem can be heard by the others	Worked as expected	Pass
Stop the system operation	To ensure that the users are able to quit the system by clicking the exit button.	Worked as expected	Pass

4. Conclusion

In conclusion, the project is researched and analyzed comprehensively in order to ensure that the objectives and aims that have been decided at the proposal phase are accomplished. After the development and analysis of the hand gesture recognition system, it can be stated and concluded that all objectives that were planned in the proposal phase have all been accomplished. Since the hand gesture recognition system is specially created for people with hearing problems to have an interaction with others through the gesturing and recording characters of ASL which form a text to bring the meaning they are expressing. At the same time, it may also serve as an educational tool to help people who might be interested in American Sign Language and want to learn it by using the system. This is how the research project's key goals will be accomplished. However, there are no perfect system exist in the world which include our hand gesture recognition system. For instance, one of the limitations of our hand gesture recognition system are unable to recognize in dark environment or classify dynamic gestures. Therefore, there will be future works to be accomplish in order to conquer these limitations stated in this project. Nevertheless, our hand gesture recognition system has already attained the objectives and solve some of the problems stated in the project.

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