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A Study on Number Gesture Recognition using Neural Network

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ABSTRACT

A natural way of counting is with the use of hands. As hand gesture recognition is becoming more recognized through its growing applications, this paper focuses on recognizing the number shown by the hand gesture. The code used in this study is developed by Makeshkha. This system uses an extraction feature which extracts the parts of the image of the hand gesture which is to be used by the system, and a neural network. This system has been trained for numerous iterations with the use of different input images. The network is then used in the recognition of hand number gestures. The system works by first prompting the user for an image to be used for input. The next process is the extraction of the features which goes by the reprocessing of the image through the removal or addition of noise in order to extract the required shape and form of the hand. Lastly, the Artificial Neural Network then scans the database for similarities in the image, with regards to the extracted features, from the input image. The experimental results of the study showed that the system has a considerable percentage of accuracy in the recognition of hand number gestures.

Key words: artificial neural network, hand gesture, number gesture recognition, image processing.

1. INTRODUCTION

Science and technology play a huge and important role in the development and advancement of society today. Numerous researches and experiments are done in order to acquire new knowledge that could be beneficial for the society [1]. The researches done before have led to the invention of different computer devices and innovation of robots [2]. These devices have helped society perform different tasks quickly and more efficiently. Although these devices are working or functioning properly, researchers do not stop at simply that. They continue to look for ways on how these computer devices could be improved for even better performances in order to adapt and cater to the ever-changing society. Numerous researches are done, which is dedicated to looking for various ways in order to communicate with these computer devices. Communicating with technology is seen as one of the possible ways on how to improve these devices. Symeonidis (2000) states in their report that the current means of communicating with computers are limited to keyboards, mice, light pen, trackball, keypad, and etc. Using human hand gestures presents as another way of being able to communicate with computers. Ahmed (2012) notes that the use of the current communicating devices may be familiar, but they do not seem natural. As mentioned in the same study, Symeonidis (2000) describes using computer recognition of hand gestures as natural, stating examples of gestures that allow humans to interact with computers like allowing people to point at an object or to rotate an object with their hands. Using gesture recognition provides a more natural-computer interface [3].

There has been numerous research work done focusing on hand gesture recognition. The difference among all these works is the different methods and techniques used by the researchers to approach the topic. Köpüklü, Gunduz, Kose, and Rigoll (2019) state three different methods of practicing hand gesture recognition. These methods are (i) using glove-based wearable devices, (ii) using three-dimensional locations of hand key points, and (iii) using raw visual data. [4].

2. BACKGROUND OF THE STUDY

As stated previously, hand gesture recognition could be practiced using three methods. The first method is a glove-based analysis that involves wearable devices that makes use of the sensors attached to the glove in order to determine the hand gesture. The sensors in the gloves convert the actions done by the hand into electrical signals, which is then used to determine the gesture. The second method is a hand gesture analysis using a three-dimensional hand model. This method involves using the three-dimensional model of the human hand to extract hand-key points to use for the different gestures to be recognized by the program. Lastly, the third method involves image capturing sensors to determine hand gestures [5,6]. These sensors could range from a simple camera to an infrared sensor.

This project is done with the use of artificial neural networks. An artificial neural network is a computational model that is based on the neural networks of humans. It imitates the

structure and the functions of a biological neural network. As stated by Dormehl (2019), artificial neural networks are considered as one of the main tools to be used in machine learning. These artificial neural networks have input and output layers. The information that could flow into the network is able to affect the structure because of the input and output layers of the neural network. In some cases, they could also contain a hidden layer that consists of different elements that are able to transform the input into something that the output could use.

The number of gesture recognition using a neural network is a project that aims to be able to detect the number of gesture done by an individual. Using the MATLAB software, the number gesture done should be detected, regardless of the size of the hand, the color of the skin, and other factors.

3. STATEMENT OF THE PROBLEM

Computers have been a great part of how society lives. It has become an essential part of their everyday lives as it aids people in making tasks more accessible and faster. As a consequence, it has continuously been improving to provide easier use and still be reliable for people. However, there still exists a limit to how a person can interact with a computer. Together with the developments done about the vision-based interface and artificial neural network, this can be a key role in designing and building a more natural way of communication between the human and computer. In this paper, the researchers propose to create an algorithm wherein gestures done by the hand can be detected by the computer. Each hand gesture recognized by the system will have a respective meaning which should be able to be identified, despite the different possible characteristics of the users. This study intends to offer new progress on bridging the human-computer interaction in a more natural way of communication.

4. SIGNIFICANCE OF THE STUDY

An artificial neural network, or simply a neural network, has been used in numerous studies as this has great potential for new developments. In a neural network, the systems used in this computational model is based on the structure, functions, and the processing of a human brain/neural networks [7,8]. With this in mind, it can be said that this could be very advantageous to research that requires more involvement with the human/user. This has also been proven to be effective based from the studies that needed a recognition system Ashmed (2012), had a research about "Real-Time Hand Gesture Recognition System" where the system extracted the complex image of the hand gesture done in real-time, and the system had to recognize the feature of the captured image. With more progress on this topic, hand gesture recognition can have a close to 100% accuracy. Further studies can also show how much more possibilities this design can do, similar to how big the face recognition system is now.

This paper aims to improve more on the studies regarding hand gesture recognition, with more focus on recognizing number gesture. The researchers believe that this can be a good start on expanding the uses on how neural network can be utilized more with the use of computers [9]. They also believe that this could also be helpful in the establishment of a better, and more user-friendly system, which consequently may also be used for providing an accessible system for people with disabilities.

5. DESCRIPTION OF THE SYSTEM

The number gesture recognition system is a program that makes use of artificial neural networks in order to be able to detect any number hand gesture placed into the input. The system of this project has two main parts, the input/output and the software used to create the program. Due to the previous knowledge and experience, the researchers have with the software, they have opted to use MATLAB to implement this program. In any system, the input and output components are essential. The input allows the user to place the data to be analyzed into the system. This input is analyzed in the software portion of the system. The software contains the codes and calculations that are used in order to read and process the hand gesture found in the input. After the information and data are processed, the program will display the output.

6. METHODOLOGY

In this section, the algorithm of the gesture recognition system is elaborated on as much as possible. The processes required in order to be able to create a program or application that will be able to detect the numbers done by simple hand gestures will be elaborated here. A detailed explanation is to be given regarding the processes of the said gesture recognition algorithm that allows the researchers to further learn and understand the topic.

6.1. Algorithm

This study by Mekala, Fan, Lai, and Hsue (2013), the number gesture system could be classified into three major steps [10]. These steps come after obtaining the input from either of the different possible methods like by means of camera, video, or glove-based device. The first step, which is known as preprocessing, makes use of morphological operations and edge detection. This is done in order to divide the image into different sections. The next step is known as features estimation and extraction. Mekala, Fan, Lai, and Hsue (2013) state that feature extraction is a crucial step in the algorithm of gesture recognition. From the divided image, the feature vector could be obtained by using different methods, depending on the application. The sections of the image may be extracted based on skin color, hand shape, the contour of the hand, the position of the fingertips, palm center, and more [11,12]. The last step is the actual recognition of the image.

6.2. Architecture

The system architecture of the number gesture recognition program is simple. Based on the requirements given to this

project, only a software platform is to be discussed in the architecture. In this case, the software platform used for this project in MATLAB. The software implementation is done in the training phase of the network. The system starts off with the preprocessing of the image placed as an input in the program. As discussed in the previous section, the image undergoes the different steps to be able to detect the gesture. This all happens within the program. Once the program has matched the input image to one of that in its database, it will proceed to display the output [13].

6.3. Database

This project aims to be able to detect the number based on the hand gestures presented in the input image. To be able to implement this, the program must have an existing database that shows the number of hand gestures. These images are loaded into MATLAB, in which the software converts them from images into text files. These text files contain the hexadecimal value of the pixels of the images.

7. REVIEW OF RELATED LITERATURE

In the hand gesture recognition system developed by Ahmed Tasnuva, his system involves real-time recognition of hand gestures. This is opposed to the system used in our study which only involves the use of static input images for recognition [14]. The system developed by Tasnuva follows a similar methodology used in this study by getting an input image then reprocessing the captured image and extracting the several required features from the image. This is done in order for the neural network to recognize the hand gesture shown in the input image with the additional use of digital cameras, in which the input image that the system will use to recognize the hand gesture is to be taken from. Tasnuva's developed system relies only on the simple artificial neural network in order to execute the recognition function of the system. With this approach and based on the experimental results, he concluded that he has indeed succeeded in the development of a new method of extracting the required features from the images by making the various variables of the system such as the system rotation, and scaling and translation as independent, as well as creating a system that is both flexible with considerable performance in real-time inputs with a recognition percentage of 88.7% [15].

In the hand gesture recognition system developed by Köpüklü, O., Gunduz, A., Kose, N., & Rigoll, G., they used a somewhat different approach on the topic. They used CNNs, which stand for convolutional neural networks. CNN is a sub-group of neural network that have been used in the growing trend in the field of computer vision due to its success in object detection and classification of tasks [16] Convolutional neural networks have had phenomenal performances with regards to two-dimensional (2D) static images, which is why its uses have been extended to video action and activity recognition [17] This study shows that there have been numerous approaches in the application of convolutional neural networks in video action. One of the approaches used was by treating the video frames in videos as multi-channel inputs which divides the video input into several segments, allowing the use of the conventional method of extracting the features of a 2D image to be applied. Convolutional neural networks are different from the regular artificial neural network in a way that convolutional neural networks are easier to train and have the capability of reducing the complexity of the model image [18]. The convolutional neural network also functions better in regards to capturing local information such as neighboring pixels in an image compared to its regular counterpart [19].

Another design with another approach on the topic of hand gesture recognition is the one developed by Alsheakhali, M., Skaik, A., Aldahdouh, M. and Alhelou, M. The hand gesture recognition system they have developed utilizes hand detection and real-time hand tracking in order to determine the trajectory and variations before finally recognizing the gesture being made by the detected hand [20]. The system developed by the four researchers can be divided into four parts. The first part is the camera which displays and records the gestures in real-time. The second part is the hand center detection which is the one responsible for detecting where the hand is as well as the center of the hand which will be used for the next part of the system. The next part of the system is the center region tracking. The center region tracking is the one responsible for tracking the center of the detected hand, keeping a note of the changes in its position. Lastly, the Hand Gesture recognition part which is the one responsible for determining the gesture being done by the detected hand [21]. In the Hand detection part of the system, the four researchers used a combination of skin tone and motion detection which means that the detection of the required features on the input video are detected differently allowing the two processes to be executed simultaneously allowing a real-time detection to be made possible [22]. Then the center of the hand is then determined. The Hand Tracking system used by the researchers tracks the determined center hand and stores 10 frames of the input video [23]. Lastly, the Hand gesture recognition system developed by the four researchers matches the dynamic processes of the whole system which takes into account the number of hands detected in the input video as well as the overall calculated trajectory of the detected hand/s based on the stored data from the tracking process as well as its distance and angle [24,25].

8. THEORETICAL CONSIDERATIONS

Image Recognition is the term used for identifying objects, places, things and even people on images or videos. The tasks involved in Image Recognition are the labeling of images with tags and searching images or videos for specific content [26]. Normally Image Recognition can only be done by humans and can be a very difficult task for technology to do since Image Recognition involves a large number of variables which is why Image Recognition uses an Artificial intelligence technology called Artificial Neural Network in which it somewhat copies the model of the neural network present in the brains of people and functions the same way as the neurons in the brains of humans work. This allows this type of artificial intelligence to learn and be trained to allow

the capability to determine the required data and content on images and videos [27].

A sub-group variant of the Artificial Neural Network is the Convolutional Neural Network. This type of Artificial Neural Network is the most favored with regards to Image processing since this type of Artificial Neural Network takes less time to train and can take in multiple inputs, for example, can gather data from neighbor pixels [28,29].

9. DATA AND RESULTS

To test the system, the user would need to do different hand gestures that represent the number that the system is trying to recognize. The following figures 1- 10 showed if the system was able to recognize the number, and shows the features extracted from the photo.

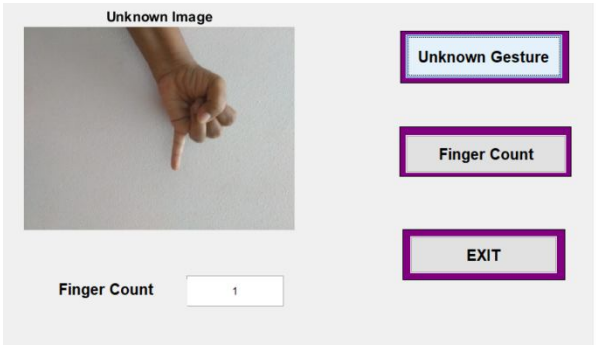

Figure 1: Number Hand Recognition (1)

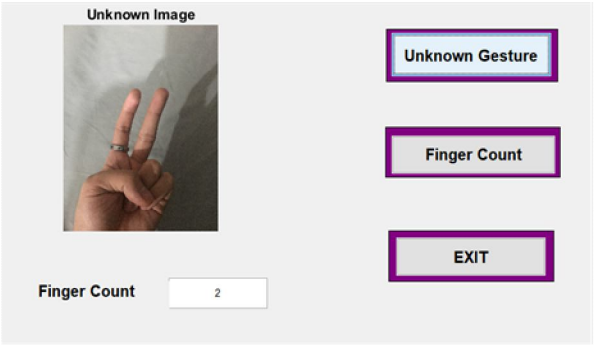

Figure 2: Number Hand Recognition (2)

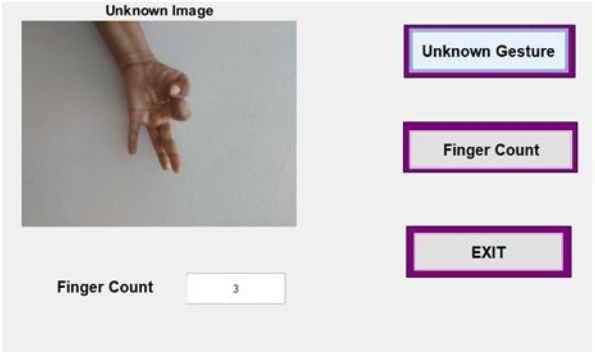

Figure 3: Number Hand Recognition (3)

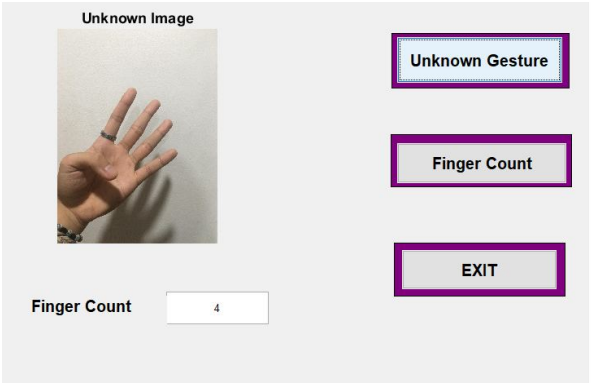

Figure 4: Number Hand Recognition (4)

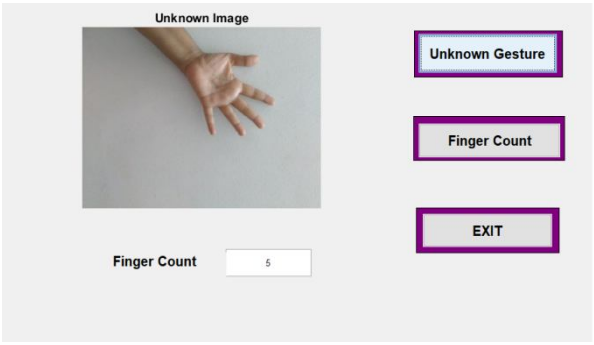

Figure 5: Number Hand Recognition (5)

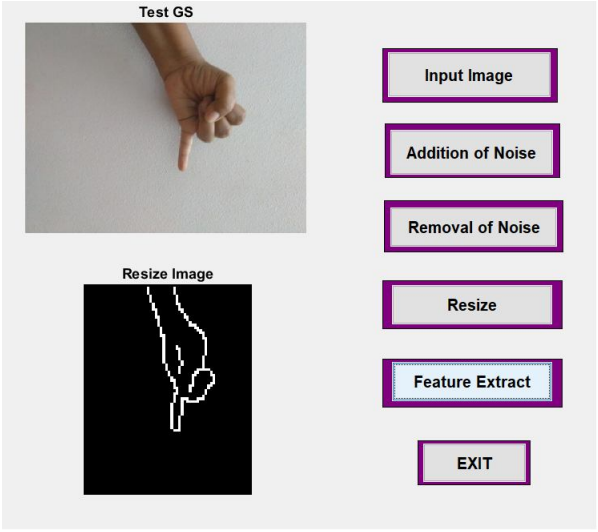

Figure 6: Number Hand Feature Extraction (1)

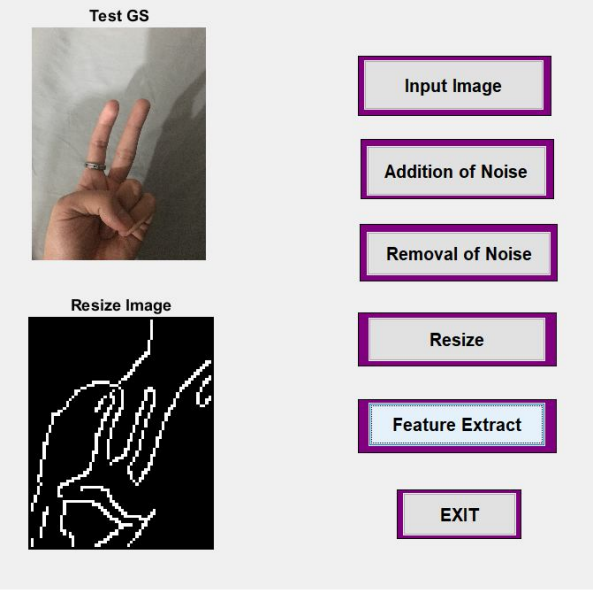

Figure 7: Number Hand Feature Extraction (2)

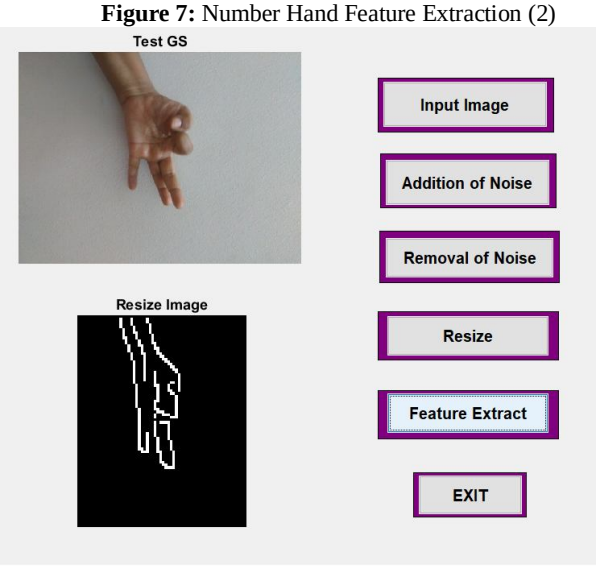

Figure 8: Number Hand Feature Extraction (3)

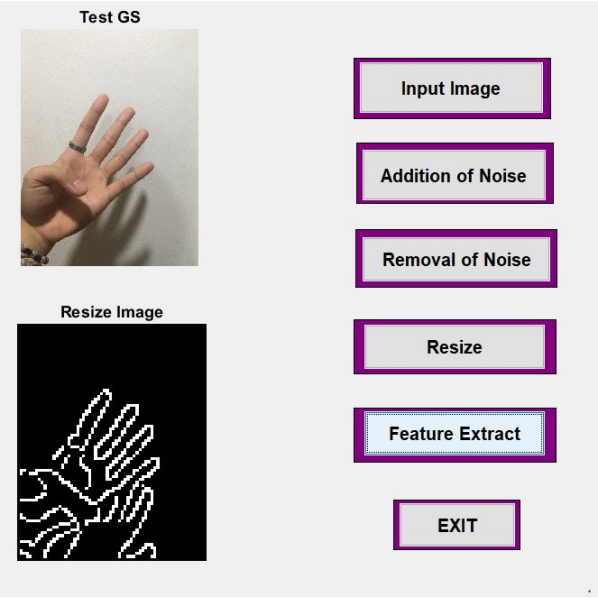

Figure 9: Number Hand Feature Extraction (4)

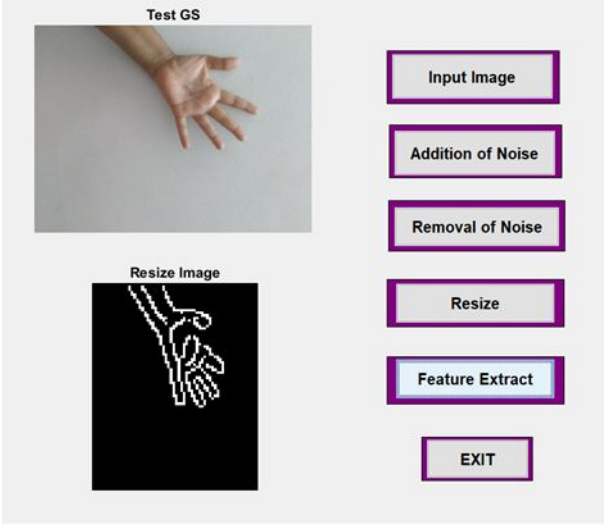

Figure 10: Number Hand Feature Extraction (5)

10. ANALYSIS OF DATA

The program used to simulate the experimental results shows the process where the images undergo, in order to achieve an output expected, which is the proper number hand gesture recognition. The processes involved in this hand gesture recognition program is first, the acquisition of the image in which the users are prompted to pick an image to serve as input. Second, the extraction of features from the image, this involves reprocessing the image by removing or adding noise from the original image in order to make it easier to extract the shape of the image to be used on the next part of the process. Third, the system now uses the Artificial Neural Network to access its database in order to search for similarities between the features extracted from the input image with that in the database. Fourth, this process is finally the display of results showing what the Artificial Neural Network has found based on the data stored in its database.

The simulations were only up to the number five in the hand gesture recognition system since the numbers one to five were the only ones stored in the database of the artificial neural network along with five of each of the gesture classes meaning there are five different types of gestures stored in the database that will result in the corresponding number hand gesture. The system sports a considerable 75% similarity rate with input images not found in the existing database which results from the lack of “training” for the Artificial Neural Network and may be also due to flaws in the coding or parts of it that may be up for improvement especially in the feature extraction process. This was also the reason why numerous errors were seen in which 1 finger raised up in an image displayed a number 4 on the results. For sending the data channel impulse can be used via channel line emulator [30,31,32,33].

11. CONCLUSION

This paper presents an approach towards the topic of hand gesture recognition which is limited only to number hand gestures from one to five and can only be used on 2D static images. The proposed approach executes the primary and fundamental features that a gesture recognition system should have, although this system only displays satisfactory performance and results. The whole backbone of the system is in its feature extraction since this is what the Artificial Neural Network will greatly rely on, the feature extraction works by the elimination or addition of noise in the input image and by simply marking the detected surfaces of the hand in color white and then removing all the other features of the images leaving the image of only the detected surfaces of the hand. The success rate of correct recognition of the system does not only rely on the data available for the Artificial Neural Network in its database but also on the position and angle of the hand as well as the complexity and illumination of the background which was experienced by the researchers as the system had a hard time in extracting the required features from the input image and there were instances in which with a picture with a considerably high percentage of illumination, the system extraction feature also extracted the shadow emitted by the hand in the input image.

The performance of the system can still be greatly improved by extending its application beyond 2D static images and onto being able to do image processing on videos and by using Convolutional Neural Networks, which will greatly improve the resulting data gathered as well as the speed and time required to gather the required data making it fit for real-time gesture recognition as well. This is so because the Convolutional Neural Network displays a clear advantage over other types of Artificial Neural Network with regards to its great performance in data gathering and the Convolutional Neural Network takes less time and iterations in the training for data to be stored in its database and overall, increasing the capabilities of the system.

12. RECOMMENDATIONS

The researchers recommend a more improved code or system that can gather a more accurate answer from the visual image gathered. The system in this study which is a code developed by maheskha achieved a considerable 75% similarity rate, so it is advised to analyze and locate which parts of the code can still be improved or changed in order to obtain a more accurate result. Enhancing the database can also be done so that it can also recognize values from two hands. In this research, the simulations done were only from number one to five. For counting the numbers six to ten, it would need two hands, which was not executed in this system due to the researchers not being fully well-versed with this topic yet. It is also likely that using a different software than MATLAB may allow the other researchers to experiment more on neural network and on hand gesture recognition.

The system used in the study is limited to only 2D static images, which is why the researchers also recommend adding a feature where it can also catch motions. It is suggested to look into studies done motion recognition, whether it is hand gestures or body motion, as there could be idea used before which can be applied on more improved systems. If done successfully, this study can also be used for computer system which can gather data through sign language. This can be tricky as the movements are critical in understanding the meaning of the gesture done. Similar to what was mentioned earlier, this would also require the system to be able to recognize two hands doing gestures. This idea is highly suggested by the researchers as this was what they had in mind when they decided for this topic. Persons with disabilities can encounter problems when using a computer as most of them cannot maximize the features of it, which is why the researchers think that this idea can be beneficial for them.

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