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Sign Language Translator Based on Raspberry Pi Camera Using The Haar Cascade Classifier Method

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Abstract−Sign language is the main tool of communication for people with hearing impairments. Communication is very limited and difficult to understand between normal people who do not know sign language, so an interpreter is needed. Where not everyone, even a few normal people, learns sign language, especially the Indonesian Sign Language System (SIBI). Motion Detection is an important subject in the field of computer vision, which is used by many systems. Today's Internet of Things is very helpful and facilitates daily human activities. An internet network allows a device to be controlled from a considerable distance. This study described a sign language translator tool for the deaf and speech impaired using a raspberry-pi camera and displayed it on the other device monitor. This system was built using the Python programming language and the OpenCV Library. The system is using Haar Cascade Classifier algorithm, where there will be data on all hand shapes based on the letters to be translated. This application uses the OpenCV library and Visual Studio Code IDE software connected to the Raspberry Pi Camera. The publisher will send data to other devices using the MQTT Broker to connect and display detection results to other device monitors wirelessly using a local network. The research was conducted at various distances between the hand and the webcam, from 30cm to 150cm. The research results using the Haar Cascade Classifier method to detect sign language obtained an accuracy of 82%.

Keywords: OpenCV; Finger Detection; Speech Deaf; Haar Cascade Algorithm; Raspberry Pi; Python

1. INTRODUCTION

Based on the National Socioeconomic Survey (Susenas) conducted by the Central Bureau of Statistics (BPS) in 2012, 6,008,661 people with disabilities in Indonesia. Around 472,855 people with hearing disabilities: taken from the Ministry of Social website on Services for Persons with Disabilities Using Various Accessibility Facilities [1].

People with hearing impairments to communicate use sign language. Sign Language is not using voice but hand movements because it does nonverbal. Indonesian Sign Language System (SIBI) is one of the sign languages used in Indonesia [2]. Therefore hand/finger detection in this study is compared to sign language for speech-deaf people to communicate.

Image processing is the science of manipulating images, including techniques for improving or reducing image quality, displaying certain parts of an image, creating a new image from several parts of an existing image, and several other techniques. The result can produce an image with low contrast from an image source with low lighting or lighting processes or due to a setting error during image capture. Knowledge and use of digital images are growing rapidly, not only in the fields of medicine, industry, health, agriculture, and others [3]. Based on the concept, the writer wants to develop a sign language translator tool that will be displayed on the monitor screen as a word or sentence.

This research performs the recognition of finger movements by using Raspberry Pi Camera as a detection tool. This finger recognition technique uses a library from OpenCV, a free library developed by Intel developers Corporations. This implementation will use template matching theory owned by the OpenCV platform [4]. After the captured image is taken and processed, the publisher will send the data to another device to display the results using an intermediary MQTT Broker as an IoT (Internet of Things) application. IBM first developed the MQTT protocol in the late 1990s. Initially, MQTT developed this protocol to connect sensors on oil pipelines with satellites. This protocol is used for asynchronous message exchange, in which the sender and receiver are separated by distance and time, i.e., they do not have to communicate synchronously [5].

Previous research has been carried out using the haar cascade classifier method is class presence system using face recognition with the haar cascade classifier. From the results of facial shortening using the haar cascade classifier method, the percentage achieved is 75%. The system makes it easy to monitor student attendance in class accurately, efficiently and saves time and effort [6]. Application of Haar Cascade Method in mask detection application, The results of this study are the application can detect masks from images sourced from photos or videos from internal and external webcams well, with the highest total accuracy of 88.7% and the lowest 44.9% [7]. Four-Wheeler Drowsiness Detection Using the Haar Cascade Classifier and Convolutional Neural Network, the system can detect various types of eyes with a success rate of 100%. The average accuracy for detecting open and closed eyes with a distance of 30-50 cm is 95.4%. The average accuracy for detecting drowsiness is 93.9%. The average computing time of this system is 0.1069 seconds which will speed up the detection of drowsiness[8]. Vehicle Speed Detection System Using the Haar Cascade Method for Driving Safety, the speed calculation method is the distance divided by time. The results showed that the vehicle speed detection system for driving safety has a detection success rate of 70.6%[9]. Helmet Detection Using the haar cascade classifier method, The detection process in this study there are two processes, the first detection process whether human or not, if the result of human detected will continue the process of detection of

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whether to use a helmet or not. Detection system testing is done individually using helmet colors red, blue and yellow. It obtained accuracy rate of 92%, while the testing group obtained the degree of accuracy of 71%[10].

Based on this background, the authors propose research on the design of a sign language interpreter for the deaf and speech impaired to make it easier for someone to understand the language used by people with disabilities speech deaf to communicate. Using the Haar Cascade Classifier where the hand signal will be caught and then carried out several processes so that this system can display letters or words according to the language signaling on devices with a larger monitor size using the MQTT protocol device connection.

2. METHODOLOGICAL RESEARCH

2.1 Stages Study

This research uses the Haar Cascade Classifier method or algorithm to classify images in sign language. Haar Cascade classifier is a method used in object detection. This method is also known as the Viola Jones method. One object detection method that is quite popular is the Viola Jones method, which Paul Viola and Michael Jones proposed in 2001. There are four primary keys in the Viola Jones object detection method. The first is a simple rectangular feature called the Haar feature. Integral image for fast feature detection. AdaBoost Method machine learning (algorithm improvement). Cascade Classifier for efficiently linking and grouping multiple features [11]. The following is the design of the system needed for the case of this research in figure 1.

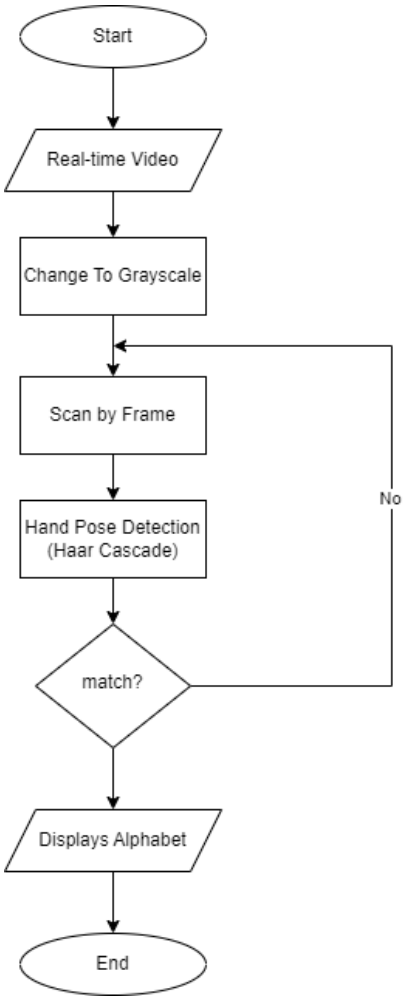

Figure 1. Design Flowcharts System

In the flowchart in Figure 1 above, the system takes pictures in real-time video using the camera as input. Next, the image is converted to grayscale to classify sign language patterns and the system scans per frame. A grayscale image is an image that has the colors black, grey and white. The colour of the resulting image depends on the pixel value that is in that pixel [12]. If the system detects a pattern in the same alphabet, it will display an alphabet output that matches the classified sign language pattern. In general, system modeling is carried out in 2 stages: process designing poses as input. The mechanical design of the propulsion of the tools will be carried out with the Python programming language. In designing poses, first, we determine what pose will be used, then use the Haar Cascade Classifier to train the poses so they can be detected by raspberry cam in real time, assisted by OpenCV. Principle

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Haar-like features are recognized objects based on the score from the feature, but no is score pixels from object images. This method owns excess that is very fast because every score of pixels is not from a picture but only depends on the number of pixels in a rectangle[13].

2.2 Collection and Collection of Datasets

SIBI (Indonesian Sign Language System) is one of the two sign languages in Indonesia. SIBI is a sign language that the government inaugurated in 1994 through the Minister of Education and Culture No. 0161/U/2994 and contained Standardization of SIBI (Indonesian Sign System) [14]. 26 sign languages show 26 letters of the alphabet using one hand, 24 signs language in the form of static, and two signs of movement in the form of dynamic hand Retrieval of data by real-time video method using a webcam or camera on the shape of a hand. For maximum accuracy, we collect multiple sample images, each alphabet A to Z, with 20 to 25 positive pictures of the alphabet.

2.3 Training Dataset Using Cascade Trainer

Data processing already took pictures of each alphabetically. After that, the change becomes one file with an XML extension that OpenCV can read. The method creates two folders, n and p folders, the n folder for negative objects and the p folder for positive things. Before training is carried out, the data has been collected equated size with the method cut picture Becomes the same section with dimensions 480 x 480. The image has been cut in the same size changed. It becomes grayscale speeds up the training process due to the image cascade training with composition RGB will longer in comparison, grayscale only has two ingredients color that is white and black [15].

2.4 OpenCV installation and configuration

OpenCV is a computer vision library created by Intel Corporation developers that are open source. The most mature programming language in providing the OpenCV library is Python [16]. This library converts video images from color origin RGB to grayscale using the cv2.cvtcolor function provided in the OpenCV library. Videos are later read on a frame-by-frame basis [17].

2.5 Raspberry Pi Configuration and MQTT Broker

Raspberry Pi was developed by the foundation non-profit Raspberry Pi Foundation, which comprises developers (Alan Mycroft, Rob Mullins, Eben Upton, Jack Lang) from Cambridge University in England, from the Laboratory University of Cambridge Computers in 2009 [18]. Raspberry Pi uses the system Raspbian operation. Save media for system operation, and data is microSD Card. There are 4 USB ports, an HDMI connector, Ethernet port. The micro-USB port is power supply power [19]. Following Is an example picture from Raspy.

Figure 2. Raspberry Pi

3. RESULTS AND DISCUSSION

This discussion explains in more detail the results of applying the Haar Cascade Classification Model for Sign Language Detection. This algorithm will extract the resulting image features from the camera using computer vision, consisting of a series of dark and white rectangular windows, each of which has a value that will produce an integral image value. An object or sign language image was taken using a real-time camera device with the existing OpenCV library function. Testing was conducted using two instruments where one becomes Publisher data and the other as Subscriber data using Python as the programming language. The system is designed to be implemented in real-time using a raspberry pi integrated with the camera to take images and connect with other devices using MQTT Broker as intermediary data transmission. Using the MQTT Broker, the system can be easily connected by more than one device without cables to make the hardware more effective.

3.1 Datasets

Deep datasets are testing this using 25 positive images and 24 pictures negative in each alphabet. Images were collected with dimensions 290 x 290 pixels. Taking a picture with several variation positions and with intensity good light to get nice file cascade results for classification. Order system walk well then cascade must own level low

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negative fake, f^x is the overall positive false of the cascade classifier, where the false positive rate per stage in range (0 1) is f, and san s is total stage [20].

Table 1. Alphabetical Dataset

Data	Number /Alphabet	Total
Positive Image	25	600
Negative Image	24	576
Total		1.176

In table 1, each alphabet in sign language has 25 positive images and 24 negative images so that the total images for the dataset in this system are 1176 images.

3.2 Training Data Using Cascade Trainer GUI

To change object data from each alphabet into a cascade file is required an application or system for conducting data training so that you can read by OpenCV. In Thing in, the cascade file is a data set trained from the data collected in negative data and positive data in a file with XML extension. Following is an example appearance from the Cascade Trainer GUI application.

3.2.1 Positive Image

Positive images are the images that the system wants to detect, in this case, the images in each form of sign language are positive images. In the trainer folder, positive images are placed in a folder named "p". An example of a positive sample image in Figure 3.

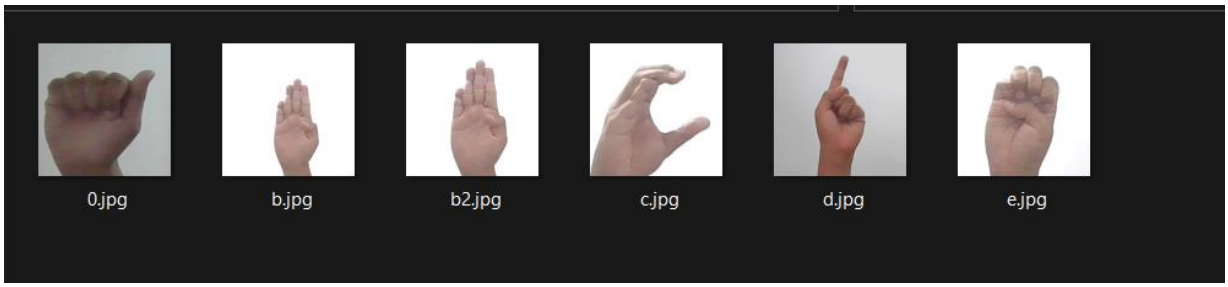

Figure 3. Positive Images

3.2.2 Negative Image

Negative image is an image that does not want to be detected by the system. In this case, background, other objects, and body parts that are not part of the hand are negative images or objects. negative images are stored in the "n" folder in the trainer folder. Example like Figure 4.

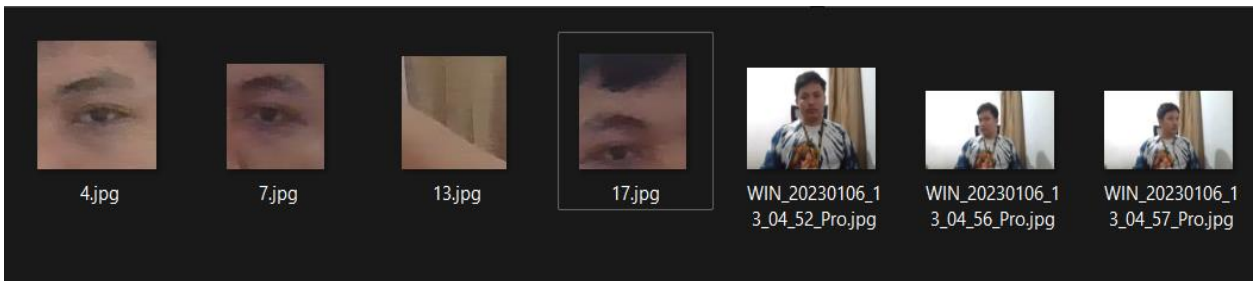

Figure 4. Negative Image

3.3 Implementation

In this test, we carried out a test of the results of data training using Cascade Trainer. Because the J and Z are sign languages with movement or gesture, we created a system to detect differences in shape and changes in movement.. The trainer is data resulting from training. The image classification is using the Haar Cascade Classifier method. The detector used is a webcam camera. Data processing is done with the method change picture becomes black white or grayscale using a feature from OpenCV as shown in Figure 4 below.

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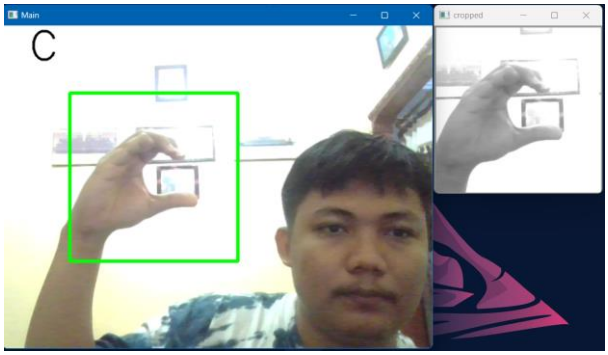

Figure 5. Detection object

3.3.1 Testing Based on Distance

Testing the system in detecting hands based on the distance between the hands and the camera, aims to determine the accuracy and how far the system can recognize objects.

Table 2. Testing result based on Distance

Distance (cm)	Accuracy
30 cm	100%
60 cm	100%
100 cm	100%
150 cm	0%

Based on the calculation results in Table 2 above, a distance of 30 cm to 100 cm facing the camera is the best distance for the system to detect sign language correctly. Example in Figure 6 below.

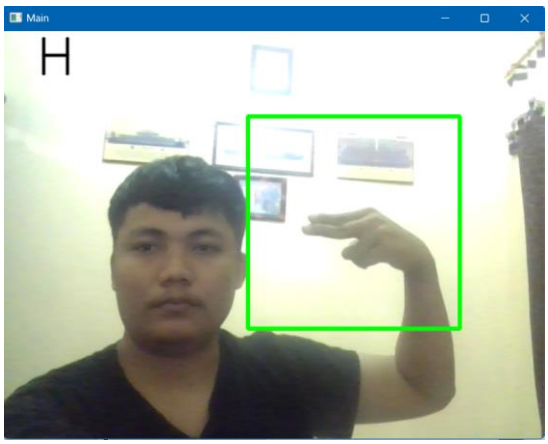

Figure 6. Detection object detection at a distance of 60cm

3.4 Discussion

Based on results testing functionality from all alphabets, there are two letters, J and Z used because he signaled by the finger's movement/gestures. The result is in Table 3 below.

Table 3. Detection Results object

Alphabet	Attempts	Scale Factor, Min Neighbors	Accuracy
A	15	2.0,10	100%
B	15	1.5,10	86,6%
C	15	2.0,10	73,3%
D	15	1.5,10	53,3%
E	15	1.5,10	86,6%
F	15	1.5,10	73,3%
G	15	1.5,10	100%
H	15	1.5,10	100%
I	15	1.1,10	86,6%
J	15	1.1,10	73,3%
K	15	2.0,10	73,3%
L	15	1.5,10	100%

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M	15	1.5,10	73,3%
N	15	1.5,10	73,3%
O	15	1.5,10	100%
P	15	1.5,10	100%
Q	15	1.5,10	86,6%
R	15	2.0,10	73,3%
S	15	1.5,10	53,3%
T	15	1.5,10	86,6%
U	15	1.1,10	100%
V	15	1.5,10	100%
W	15	2.0,10	100%
X	15	1.5,10	86,6%
Y	15	1.5,10	100%
Z	15	1.5,10	53,3%
Average Total			82%

The table results from testing using Method Haar Cascade Classifier to recognize the form of Sign Language based on SIBI on real-time video can detect shape sign language with Haar Cascade Scale Factor values 1.1 to 2.0 and Minimum Neighbors 1 to 10. The scale factor is a parameter that determines the big-size picture lowered value for each scaled image. Minimum Neighbors are the minimum number of squares around which will form something object. Accuracy rate results in the detection sign language obtained from detected alphabetical comparisons with the all-over image used in the data. After testing 15 times, the system's accuracy can detect sign language with an average of 82%. In sign language, the letter S has the same pattern as A and E, so the system has difficulty distinguishing the pattern of the letter S. The letters D and Z have a pattern like U, so the system has difficulty distinguishing the pattern from the letters D and Z. This is obtained from the average accuracy of each detected alphabet. Data accuracy is calculated using formula 1.

$$Accuracy = \frac{amount\ correct\ detection}{\text{attempts}}\ X\ 100\% \quad (1)$$

Amount detection correct = the number of detected sign language
attempts = total attempts

4. CONCLUSION

Based on the testing and result above, the process from system detection is changing real-time images to become grayscale first formerly for simplifying the classification process. The system uses the K-Nearest Neighbors algorithm or normal abbreviated KNN. Haar cascade classifier method in sign language work with good supported normal lighting as well high, as well stable local network connection that makes sending data from publisher to subscriber not has a long delay. This research gets quite satisfactory results with an accuracy rate of 82%. On the system, classification object shape hands-on sign language capable of detecting with a distance of 20 cm to 100 cm. There are other difficulties in the system. This is an introduction shape owning hand almost form similar could produce an error, like alphabetic code A and E, where both own very similar shapes, only distinguishing the position of the thumb. Using MQTT Broker as intermediary data transmission is effective and easy to implement so that not too much script code is made. We hope for a future, necessary enhancement feature system on the OpenCV library, which is where to detect not only something picture or object but can also detect movement of something object. And also upgrades the system in condition light with low-intensity lighting to support conditions in a dark place or at night day. Suggestions for further research using a larger dataset to get better accuracy and to be able to overcome a problem in dynamic objects, such as in the case of the letters J and Z. And make better hand gesture detection techniques so that they can distinguish the letters D, U, Z, A, E, and S.

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