Hijaiyah Letters Sign Language Recognition for Deaf and Hearing Impaired Children Based on Principal Component Analysis Method

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Abstract. Knowing and learning hijaiyah letters is a very important basis in reading Qur’an from an early age. For some normal people knowing and learning hijaiyah letters is relatively easy but unlike the children who have special needs like deaf and hearing impaired children. They can only communicate using sign language both in the form of hand gesture, body gesture, and facial expression. From these problems, the author is motivated to make a system for implementing the hijaiyah letters cues for deaf and hearing impaired children using PCA (Principal Component Analysis) method which was installed on desktop computer. The process of hand gesture recognition consists of several steps: camera initialization, preprocessing, feature extraction using PCA to find eigen value and eigen vector, and hand classification using euclidean distance. The output of hand gesture recognition is hijaiyah letters identification from alif to ya’ in the form of text and sounds.

Keywords: hijaiyah letters, deaf and hearing impaired children, principal component analysis, Euclidean distance

1. Introduction

Special needs children means the children that has abnormalities. This children has different characteristics from one to another. For example special needs children is deaf and hearing impaired children[4]. They tend to use sign language for example hand gesture, body gesture, and facial expression as communication media.

In the special needs’ children education, deaf and speech impaired children need special and extra attention from their teacher because they are different from normal children. Islamic education is is very important for a toddler and a compulsory for Islamic people to learn hijaiyah letters. At least, every Islamic people can read Arabic letters in order to read Qur’an[7][8].

The development of science and technology in the field of education, business, and health can make teaching process of hijaiyah letter sign language much easier. Based on this reason, author is motivated to build a system “Hijaiyah Letters Sign Language Recognition For Deaf and Hearing Impaired Children Based on Principal Component Analysis Method”.

The process of hand gesture recognition consists of several steps: camera initialization, preprocessing, feature extraction using PCA to find eigen value and eigen vector, and hand classification using Euclidean distance. The output of hand gesture recognition is hijaiyah letters identification from alif to ya’ in the form of text and sounds. The purpose of this system is to help deaf and hearing-impaired children to communicate with normal people[9][10][11][12].
2. Methods

There are some steps in this hijaiyah letter recognition research method for deaf and hearing-impaired children. The steps are at following figure:

![System Diagram](image)

**Figure 1. System Diagram**

This design system is intended for deaf and impaired hearing children, we use Principal Component Analysis method for recognition. There are several sub processes: preprocessing (RGB image, Grayscale, Binary, and Masking), PCA feature extraction, and Euclidean distance is used to find the similarity of the testing and training data and then the output is in form of sounds and text.

2.1 Preprocessing

In this process, the input RGB image is converted into binary image then masked with grayscale image. The image feature then extracted.

![Image Preprocessing](image)

**Figure 2 Image preprocessing process**

2.2 Feature Extraction Using PCA

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables (entities each of which takes on various numerical values) into a set of values of linearly uncorrelated variables called principal components.

Principal component analysis (PCA) is linear technique to project high dimensional vector data to smaller one [2][3][5][6]. PCA process calculation can be done with the following steps:

- Calculate the mean pixel data of all the image
- Calculate zero mean
- Calculate covariance
- Calculate eigenvalue and eigenvector
- Calculate M number of eigenvectors from covariance matrix
- Normalize u
- Collect K number of eigenvectors

2.3 Euclidean Distance for Matching
Euclidean distance refers to the distance between two points. These points can be in different dimensional space and are represented by different forms of coordinates. In one-dimensional space, the points are just on a straight number line. In two-dimensional space, the coordinates are given as points on the x- and y-axes, and in three-dimensional space, x-, y- and z-axes are used. Finding the Euclidean distance between points depends on the particular dimensional space in which they are found.

2.4 Output In Form of Text and Sound
The output of hijaiyah letter recognition is in form of text and voice of hijaiyah letter.

2.5 Image Database System Design
Training images are captured to make training image for this system. Training images consists of three images for one hijaiyah letter. The training images are saved in .bmp format and the result of feature extraction is saved in .txt format at Visual Studio program.

3. Results and Discussion
3.1 Designing Hijaiyah Letter Recognition
Hijaiyah letters recognition implementation:
In the training data screen menu, hand images are captured then processed into its features. There are several buttons that used to process or insert the captured training hand images:
1. Training Data Capture Process Window
2. Start Button
3. Stop Button
4. Exit Button
5. Original Image
6. Grayscale Image
7. Binary Image
8. Masking Image
9. Capture Button
10. Resize Mask Window
11. Save Button
12. Load and Train Button
13. PCA Image Window
14. Save Train and All PCA Value Button

![Testing Data Screen](image)

Figure 6. Testing Data Screen

In the testing data screen menu, hand images are captured and there are several button that used to process:
1. Testing Capture Process Window
2. Start Button
3. Capture Button
4. Clear Button
5. Preprocessing Window
6. Testing Image Window
7. Identification Process Result Button
8. Euclidean Distance
9. Identification Result
10. Hijaiyah Letter Transliteration Window
11. Audio Picture

3.2 Software Testing
The software system test step consists of several process: Preprocessing process, Feature Extraction PCA, and Matching using Euclidean distance. Before we execute feature extraction process, all of the image will be processed into preprocessing step. Initiated RGB to Grayscale image conversion, grayscale to binary image, and binary to masking image. The purpose of RGB to Grayscale image conversion is to minimize the image channel into one channel (8 bit). Then Grayscale image is converted into binary image to differentiate object image (human skin) and background
image. After we get object image then masking process is executed. Masking image is obtained from grayscale and binary image. The white region supposed as object/human skin image while black image is supposed as background image. After we proceed the masking, we will get the skin image and background.

Feature extraction is used to get the feature in a form of eigen vector and eigen value and then these two eigen are saved into .txt file formats reference of testing image.

Matching process using Euclidean distance is aimed to calculate the matching distance between training data and testing data.

System testing step is intended to know the level of hijaiyah letter recognition. This testing is conducted by variation of the camera distance and lighting. The result can be seen at the table.
Table 1. Hijaiyah letter sign image sample based on the distance and camera type
Logitech C270 (at the lighting of 20W Philips)

| Letter | Camera Distance 50 cm | Camera Distance 75 cm | Camera Distance 100 cm |
|--------|------------------------|------------------------|------------------------|
|        | Yes | No | Yes | No | Yes | No |
| Alif   | -   | -  | -   | -  | -   | -  |
| Ba     | -   | -  | -   | -  | -   | -  |
| Ta     | √   | -  | √   | -  | -   | -  |
| Tsa    | -   | -  | -   | -  | -   | -  |
| Jim    | -   | -  | -   | -  | √   | -  |
| Kha    | -   | -  | -   | -  | -   | -  |
| Kho    | -   | -  | -   | -  | -   | √  |
| Dal    | -   | -  | √   | -  | -   | -  |
| Dzal   | -   | -  | -   | -  | -   | -  |
| Ra     | -   | -  | -   | -  | -   | √  |
| Za     | -   | -  | -   | -  | -   | -  |
| Sin    | -   | √  | -   | -  | -   | -  |
| Syin   | -   | -  | -   | -  | -   | -  |
| Shod   | -   | -  | -   | -  | -   | -  |
| Dhod   | -   | -  | -   | -  | -   | √  |
| Tho    | -   | -  | -   | -  | -   | -  |
| Dhlo   | -   | -  | -   | -  | -   | -  |
| Ain    | -   | -  | -   | -  | -   | -  |
| Ghoin  | -   | -  | -   | -  | √   | -  |
| Fa     | -   | √  | -   | -  | -   | -  |
| Qof    | -   | -  | -   | -  | -   | -  |
| Kaf    | -   | -  | -   | -  | √   | -  |
| Lam    | -   | -  | -   | -  | -   | -  |
| Mim    | -   | -  | -   | -  | -   | -  |
| Nun    | -   | -  | -   | -  | -   | -  |
| Wawu   | -   | -  | -   | -  | -   | -  |
| Lam    | -   | -  | -   | -  | -   | -  |
| Alif   | -   | -  | -   | -  | -   | -  |
| Ya     | -   | -  | -   | -  | -   | -  |

Hijaiyah letter sign language sample testing based on camera type Logitech C270. From the hijaiyah letter sign sample testing based on the distance and Logitech camera C270 (at the lighting of 20W Philips). The accuracy of parameters can be calculated as follow:

\[
T = D = A = \frac{\sum T \cdot d}{h \cdot h} \times 100\%
\]

Table 2. The result of Hijaiyah letter sign image sample based on the distance and camera type
Logitech C270 (at the lighting of 20W Philips)

| Image capture distance | Accuracy |
|------------------------|----------|
| 50 cm                  | 6%       |
| 75 cm                  | 24%      |
| 100cm                  | 0%       |
Table 3. Hijaiyah letter sign language sample testing based on the camera type Logitech C922 Pro Philips

| Sampel uji Huruf | Jarak 50 cm | Jarak 75 cm | Jarak 100 cm |
|------------------|-------------|-------------|--------------|
|                  | Yes | No | Yes | No | Yes | No |
| Alif             | √   | -  | -   | -  | -   | -  |
| Ba               | √   | -  | -   | -  | -   | -  |
| Ta               | √   | -  | -   | -  | -   | -  |
| Tsa              | √   | -  | -   | -  | -   | -  |
| Jim              | -   | -  | -   | -  | -   | -  |
| Kha              | √   | -  | -   | -  | -   | -  |
| Kho              | √   | -  | -   | -  | -   | -  |
| Dal              | √   | -  | -   | -  | -   | -  |
| Dzal             | √   | -  | -   | -  | -   | -  |
| Ra               | √   | -  | -   | -  | -   | -  |
| Za               | -   | -  | -   | -  | -   | -  |
| Sin              | √   | -  | -   | -  | -   | -  |
| Syin             | -   | -  | -   | -  | -   | -  |
| Shod             | √   | -  | -   | -  | -   | -  |
| Dhod             | -   | -  | -   | -  | -   | -  |
| Tho              | -   | -  | -   | -  | -   | -  |
| Dholo            | √   | -  | -   | -  | -   | -  |
| Ain              | -   | -  | -   | -  | -   | -  |
| Ghoin            | -   | -  | -   | -  | -   | -  |
| Fa               | -   | -  | -   | -  | -   | -  |
| Qof              | -   | -  | -   | -  | -   | -  |
| Kaf              | -   | -  | -   | -  | -   | -  |
| Lam              | √   | -  | -   | -  | -   | -  |
| Mim              | √   | -  | -   | -  | -   | -  |
| Nun              | √   | -  | -   | -  | -   | -  |
| Wawu             | -   | -  | -   | -  | -   | -  |
| Ha               | √   | -  | -   | -  | -   | -  |
| Lam              | -   | -  | -   | -  | -   | -  |
| Alif             | -   | -  | -   | -  | -   | -  |
| Ya               | -   | -  | -   | -  | -   | -  |

Table 4. The result of Hijaiyah letter sign language sample testing based on the camera type Logitech C922 Pro Philips

| Image capture distance | Accuracy |
|------------------------|----------|
| 50 cm                  | 55%      |
| 75 cm                  | 6%       |
| 100cm                  | 0%       |

Table 5. Hijaiyah letter sign language sample testing based on the light intensity and distance (50cm)

| Sampel uji Huruf | Redup (6 watt) | Normal (20 watt) | Terang (27 watt) |
|------------------|----------------|------------------|------------------|
|                  | Yes | No | Yes | No | Yes | No |
| Alif             | -   | -  | √   | -  | √   | -  |
| Ba               | -   | -  | √   | -  | -   | -  |
| Ta               | -   | -  | √   | -  | -   | -  |
Table 5. The result of Hijaiyah letter sign language sample testing based on the light intensity and distance (50cm)

| Light Intensity | Accuracy |
|-----------------|----------|
| Low (6 watt)    | 0%       |
| Medium (20 watt)| 55%      |
| High (27 watt)  | 13%      |

4. Conclusion
Based on the system result of hijaiyah letter recognition, we can conclude:
1. Our hijaiyah letter recognition runs on realtime
2. In our testing, the closer the better the result of preprocessing and vice versa
3. In our system testing, the highest accuracy is obtained at 50cm with normal lighting 20W and Logitech camera C922 Pro.

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