Hybrid learning vector quantization (LVQ) algorithm on face recognition using webcam

Parini¹, Herman Mawengkang², Syahril Efendi³
¹Student in Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia
²Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, Indonesia
³Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia
¹parini.royal@yahoo.com, ²hmawengkang@yahoo.com, ³syahril1@usu.ac.id

Abstract. In this research, hybridization of Learning Vector Quantization (LVQ) algorithm with Self Organizing Kohonen for face recognition using webcam. Hybrid technique performed is Kohonen algorithm used for initial weighting and the result of weighting inserted into LVQ algorithm to get result of training in the form of final weight used for face recognition. The data used in this study is the face of a digital image of the acquisition with a digital tool make use of camera that will be used for learning (learning data set) and a set of images for testing (testing data set). The first step of the process the face image (preprocessing) used for prepare the input face image to be input into network. The preprocessing step in this research is divided into four step like Image Readings, Grayscale, Sobel operator edge detection and binaryization. The result of this test is percentage of face recognition success with LVQ algorithm is 57.03%, Kohonen is 52.59% and Hybrid is 68.88%. While the average time of the introduction process is for LVQ of 2.64 seconds, Kohonen of 2.61 seconds and Hybrid 2.59 seconds. From the above results can be concluded that in terms of accuracy Hybrid algorithm slightly superior to the Kohonen is 16.29% and in terms of time Hybrid algorithm faster than LVQ algorithm of 0.05 seconds and Kohonen an average of 0.02 seconds.

1. Introduction
The face is part of the focus of the human body which is the main concern in the social interaction for the marker or recognize a person, therefore the face is used for other things such as for the purposes of population data collection, security system and absent using facial recognition system.

Generally attendance system employees at the office is doing by filling the book absent using the fingerprint machine, in terms of security, this system has a weakness, among others, is the absence of employees always have human error as fingerprint scan is difficult to accept. This can be due to an abnormal finger condition, such as wet, dirty, too dry, fingertips peeling and finally the system cannot accept, then in solving the problem requires a precise method of accurate and precise.

Some researchers have conducted research on Artificial Neural Network (ANN) such as in research [1] with the title of attendance system using facial on artificial neural network with algorithm.

Learning Vector Quantization (LVQ) with maximum epoch research result of 20 and threshold is 50 obtained accurate accuracy of facial pattern recognition as much as 75%
through 20 samples and 15 according to target. Because in the study the author uses learning vector quantization algorithm, the authors suggest should be combined with SOM algorithm Kohonen to get faster and more accurate results in finding face match. Furthermore, the research of Emnita Ginting [2] entitled Combination of artificial neural network algorithm learning vector quantization (LVQ) and self-organizing Kohonen at the speed of introduction of signature pattern with the conclusion of artificial neural network application can accelerate the computing process both during training and during recognition.

Looking at the above research, the authors do a combination of both algorithms by taking advantage of each of the above algorithms.

2. **Base of Theory**
   a. **Pattern Recognition**
      Pattern recognition is a science to classify or describe something based on the quantitative measurement of features (features) or the main nature of an object. The pattern itself is an undefined entity and can be identified and named. Patterns can be a collection of results or monitoring and biases expressed in vector or matrix notation.
   b. **Image**
      Digital Image is an image that can be processed by a computer that has the type and size of the file of the image. Digital image is an image arranged in the form of raster (grid). Each tile formed is called a pixel and has coordinates (x, y). X axis (horizontal): column (column), y-axis (vertical): line (row, line). Each pixel has a value (or number) that indicates the gray intensity of the pixel. The gray degree represents the gray level or color code [10].
   c. **Artificial Neural Network (ANN)**
      Artificial Neural Network (ANN) is a method of learning that is inspired from the network of biological learning systems that occur from neural network (neuron) connected to each other [8].
   d. **Neural Network Learning Vector Quantization (LVQ)**
      LVQ is a neural network with single layer feeder (Single Layer Feedforward) architecture type which consists of input unit and output unit. A competitive layer will automatically learn to classify input vectors. The classes obtained as a result of this competitive layer depend only on the distance between the input vectors. If two input vectors are close together then the competitive layer will place the two input vectors into the same class.
      Algorithm:
      1. Set: Initial Weight (W), Maximum Epoch (MaxEpoch), and Learning rate (α).
      2. Input:
         a. Input: x(m,n); m is the amount of input, n is the amount of data.
         b. Target: T(1,n)
      3. Set First Condition:
         a. Epoch=0;
      4. Do if: (epoch < MaxEpoch)
         a. Epoch = epoch + 1
         b. Do for i=1 until n
            - Fixed J such that || X – Wj || minimum (call as Cj (distance Euclidian)) .

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- Repair Wj with the conditions:
  i. If \( T = C_j \) so \( W_j(\text{baru}) = W_j(\text{lama}) + \alpha (X - W_j(\text{lama})) \)
  ii. If \( T \neq C_j \) so \( W_j(\text{baru}) = W_j(\text{lama}) - \alpha (X - W_j(\text{lama})) \)
  c. Subtract the value \( \alpha \)

5. Done[3] Image 2.10 explains the LVQ network architecture. Where \( X_1, X_i, ..., X_n \) as input, \( W_{11}, W_{ij}, ..., W_{rm} \) as weight and \( Y_1, Y_j, ..., Y_m \) as output.

e. **Self-Organizing Kannel Neural Network**

In this unsupervised learning method does not require the target output. In this method, it cannot be determined what kind of results are expected during the learning process. During the learning process, the weighting value is arranged in a given suaturange depending on the value of the given input. The purpose of this study is to group similar units within a certain area [7].

The Self Organizing Koh networking grouping algorithm [9] is as follows:

1. **Step 0** Initialization initial
   Weight of wij (random)
   The value of learning rate parameter (\( \alpha \)) and its decreasing factor
   The shape and radius (R) of the surrounding topology

2. **Step 1** During the termination condition is incorrect, perform steps 2-7

3. **Step 2** For each input vector \( x, (i = 1, 2, ..., n) \) do steps 3-5

4. **Step 3** Compute D(j) for all j (j = 1, 2, ..., m)

5. **Step 4** Find index J such that D(j) is minimum

6. **Step 5** For each unit j around J, modify the weights

\[
W_{ij}(baru) = W_{ij}(lama) + \alpha [x_i - W_{ij}(lama)]
\]

7. **Step 6** Modify the learning rate parameter

\[
\alpha_{t+1} = 0.5 \cdot \alpha_t
\]

The termination condition of the iteration is the difference between the current wij and the wij on the previous iteration. If all the wij only changes slightly, it means that the iteration has reached convergence so that it can be stopped.

3. **Research Methods**

In this research, the analysis of facial recognition speed improvement and face identification in attendance process by hybridization of Learning Vector Quantizatin (LVQ) and Self OrganizingMaps (SOM) or Kohonen algorithm. Hybrid technique performed is Kohonen algorithm used for initial weighting and the result of weighting is inserted into LVQ algorithm to get result of training in the form of final weight used for face recognition.

The working principle of the Kohonen algorithm is the reduction of neighboring nodes, so that in the end there is only one output node selected (winner node). The first thing to do is to initialize the weights for each node with a random value. After the random weight is given, the network is inputed by a number of dimensions of the input node / neuron. Once the input
is received by the network, the network begins to calculate the vector distance obtained by summing the difference between the input vector and the weighted vector.

In the LVQ algorithm the facial recognition process begins with the training process for faces to get the final weight. In the test process, the final weight is used to calculate the distance between the final weight and the weight of the inputted face, where the closest distance is the face of the introduction.

In the hybridization algorithm, the weights generated with the Kohonen algorithm are used as the initial weights of the training process using the LVQ algorithm. And at the final weights testing stage obtained will be used for face identification process, whether the system has been able to find the target. Tests are performed until the lowest or nearest error is obtained. Weight and all the variables used during the test will be used. If the percentage of accuracy at a high testing stage then the accuracy of the results will also be high.

4. Results and Discussion
4.1. Process Analysis

In the network architecture LVQ and Kohonen Hybrid algorithms that are designed consist of input layer (input layer), hidden layer and output layer. Where the parent architecture is taken from the LVQ network, while the characteristics taken from Kohonen are hidden layer and random weighting (-1 to +1).

In this research the face image to be in-training is done preprocessing which aims to process the image to be more clear and read the image pixel as the input vector into the network. The initial process is Resize the image 100 x 100 pixels to create an input image size with size 100 x 100 pixels. The next process is grayscale is to change the pixel values of three color components (R, G, B) into one color component. The next process is noise reduction to clean the image from noise with Median filter algorithm. Next done edge detection with Sobel operator that serve to reinforce the edge of the face image that separates the face against the background. The next is a binary process that serves to convert the face image into binary which will be used as data input on the network.

In the input layer the inclusion of pixel value of the training face image is extracted from the pre-processing of the face image of the binary value (0 or 1). Next randomization is done for the formation of initial weight. In the hidden layer consists of two neurons where in the first neuron performed random weight calculation with the input vector in accordance with the class in the form of pixel image value of the face that produces the final weight and stored in the database. Next weigh the final weights also on the second neuron of the hidden layer where the stored weight is the average.

In the process of recognizing the calculation of the weight of the image pixel value of testing and then done the calculation of the distance data, where the closest distance is the class or face image.

4.2. Result Analysis

The initial process is the inclusion of training data in the form of JPG formatted face files into the database. The results of the implementation of the program for pattern recognition are as follows:

4.2.1. Input Data Training

To do the training of the face then, the files of faces that will be recognized later must be filled first into the database as in figure 1.
4.2.2. Hybrid Algorithm Training Module
Hybrid Algorithm Training Module is a module that implements the training process or facial pattern learning by using Hybrid algorithm between Kohonen and LVQ. Hybrid algorithm training process can be seen as in figure 2.

4.2.3. Hybrid Algorithm Recognition Module
Module Recognition Hybrid Algorithm is a module that implements facial recognition process using Hybrid algorithm. Hybrid Recognition Process algorithm can be seen as in figure 3.
4.3. Discussion
Testing is done by using five different size digital images where each image will be training by network. The network parameters used are maximum error, learning rate and epoch number as can be seen in Table 1.

Table 1. Network parameters testing algorithm

| Parameter jaringan       | Nilai           |
|-------------------------|-----------------|
| Epoch                   | 10, 50, 100     |
| Learning rate           | 0.1, 0.5, 1     |
| Minimum Error           | 0.1, 0.01, 0.001|

The test results are done by using parameters in Table 1 with the number of tests 10 faces each face is tested 10 times for all parameters can be seen as in Table 2.

Table 2. Face recognition testing results

| No | A   | B     | C     | LVQ  | Kohonen | Hybrid |
|----|-----|-------|-------|------|---------|--------|
|    |     |       |       | D    | E       | T      |
| 1  | 10  | 0.1   | 0.1   | 6    | 4       | 2:44   |
| 2  | 10  | 0.1   | 0.01  | 8    | 2       | 2:33   |
| 3  | 10  | 0.1   | 0.001 | 7    | 3       | 2:20   |
| 4  | 10  | 0.5   | 0.1   | 0    | 10      | 2:52   |
| 5  | 10  | 0.5   | 0.01  | 3    | 7       | 3:03   |
| 6  | 10  | 0.5   | 0.001 | 4    | 6       | 3:01   |
| 7  | 10  | 1     | 0.1   | 3    | 7       | 2:55   |
| 8  | 10  | 1     | 0.01  | 7    | 3       | 2:52   |
| 9  | 10  | 1     | 0.001 | 7    | 3       | 3:13   |
| 10 | 50  | 0.1   | 0.1   | 3    | 7       | 3:52   |
| 11 | 50  | 0.1   | 0.01  | 4    | 6       | 3:48   |
| 12 | 50  | 0.1   | 0.001 | 3    | 7       | 3:49   |
| 13 | 50  | 0.5   | 0.1   | 5    | 5       | 3:50   |
| 14 | 50  | 0.5   | 0.01  | 6    | 4       | 3:43   |
| 15 | 50  | 0.5   | 0.001 | 5    | 5       | 3:42   |
| 16 | 50  | 1     | 0.1   | 6    | 4       | 3:43   |
| 17 | 50  | 1     | 0.01  | 8    | 2       | 3:47   |
| 18 | 50  | 1     | 0.001 | 9    | 1       | 3:51   |
| 19 | 100 | 0.1   | 0.1   | 5    | 5       | 4:13   |
| 20 | 100 | 0.1   | 0.01  | 8    | 2       | 4:12   |
| 21 | 100 | 0.1   | 0.001 | 5    | 5       | 5:02   |
| 22 | 100 | 0.5   | 0.1   | 5    | 5       | 4:18   |
| 23 | 100 | 0.5   | 0.01  | 6    | 4       | 4:22   |
| 24 | 100 | 0.5   | 0.001 | 5    | 5       | 4:28   |
| 25 | 100 | 1     | 0.1   | 8    | 2       | 4:30   |
| 26 | 100 | 1     | 0.01  | 8    | 2       | 4:54   |
| 27 | 100 | 1     | 0.001 | 10   | 0       | 4:27   |

Explanation:
A = Maximum Recurrence (Epoch)  C = Minimum Error  E = Not recognized
B = Learning Ratio (Learning rate)  D = Recognized  T = Average time

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Percentage of facial recognition success with algorithm:

a. LVQ = $\frac{154}{270} = 57.03\%$

b. Kohonen = $\frac{142}{270} = 52.59\%$

c. Hybrid = $\frac{186}{270} = 68.88\%$

While the average length of the acquisition process obtained for LVQ of 2.64 seconds, Kohonen of 2.61 seconds and Hybrid 2.59 seconds. From the above results can be concluded that in terms of accuracy Hybrid algorithm slightly superior to the Kohonen is $68.88\% - 52.59\% = 16.29\%$ and in terms of time Hybrid algorithm faster than LVQ algorithm of 0.05 seconds and Kohonen an average of 0.02 seconds.

5. Conclusions
The conclusions that can be drawn from this research are as follows:

1. Artificial neural network algorithms Learning Vector Quantization and Kohonen can be hybridized for face recognition.

2. Percentage of facial recognition success with LVQ algorithm is $7.03\%$, Kohonen $52.59\%$ and Hybrid $68.88\%$.

3. While the average length of recognition process obtained for LVQ of 2.64 seconds, Kohonen of 2.61 seconds and Hybrid 2.59 seconds. From the above results can be concluded that in terms of accuracy Hybrid algorithm slightly superior to the Kohonen is $68.88\% - 52.59\% = 16.29\%$ and in terms of time Hybrid algorithm faster than LVQ algorithm of 0.05 seconds and Kohonen an average of 0.02 seconds.

4. The recognition match rate depends on the combination of parameter values used in the learning process where from the test results, the best combination of Learning Vector Quantization is obtained, the maximum is 50 loops, the learning ratio is 0.1 and the minimum error is 0.001. While the best parameters of Backpropagation is 100 repetitive maximum, the ratio of learning 1 and minimal error 0.001, while for the Combination algorithm is 100 repetitive maximum, the ratio of learning 0.1 and minimal error 0.01.

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