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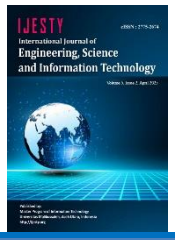

Using Artificial Neural Networks and the Kohonen Method, an Image Pattern Recognition System for Khat Art Types

Rasna[1]*, Adyanata Lubis[2], Dikky Suryadi[3], Alexius Ulan Bani[4], Fifto Nugroho[4]

[1]*Department of Information System, Universitas Yapis Papua, Indonesia*
[2]*Department of Computer Science, Universitas Rokania, Indonesia*
[3]*Department of Computer Science, STMIK Al Muslim, Aceh, Indonesia*
[4]*Department of Computer Systems, Faculty of Computer Science, Universitas Bung Karno, Indonesia*

**Corresponding author Email: razna.anwar@gmail.com*

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Abstract

Arabic letter writing is known as khat art. Khat is classified into many categories and can be identified into three types: Khat Naskhi, Khat Qufi, and Khat Farisi, per the rules established in the art of Khat. Arabic letters, the subjects of khat art, evolved following the region where it first appeared. As a result, the Qufi style, for instance, marked the start of the evolution of Khat in the tenth century. Previously somewhat rigid, Khat became more fluid and beautiful, although it remained angular. Subsequently, the art of Sulus, Naskhi, Raiham, Riqa, and Tauqi evolved and exhibited the form of Khat, cursive (italic)—artificial neural network-based khat art type recognition by selecting the Kohonen.

Keywords: *Khat Art, Khat Naskhi, Khat Qufi, Khat Farisi, Kohonen.*

1. Introduction

Art is one of the universal elements from the cultural products of the community that are often found in daily life. Art is an activity to express feelings or souls through words, behaviours, and deeds, which are then visualized through certain symbols and added to the form created [1]. In this regard, Soedarso, Sp. Art is all activities made by humans that prioritize their inner experience, which, because it is presented uniquely and interestingly, experiences or inner activities also arise for the person who lives it [2].
Islamic civilization began to emerge on the surface when there was a reciprocal relationship between the civilizations of Arabs and non-Arabs. At first, Islam did not need a form of art, but with time, Muslims used art as a medium to express their views on life [3], [4]. They built rich art forms according to the perspective of Islamic value awareness, slowly developed their style, and added to the cultural contribution in the art field. One form of this is the art of calligraphy [1]. Calligraphy, known as Khat, grows and develops in Islamic culture into an attractive alternative expression with a vital unifying element [5], [6]. The existence of calligraphy during the development of Arabic as the language of the Qur'an has had considerable influence on Muslims worldwide.
This is in line with the development and growth of Islam, which has a considerable impact on Muslims themselves. Calligraphy is one of the most important works of Islamic art. Islamic calligraphy that emerged in the Arab world is a development of the art of beautiful writing in Arabic letters called thirsty. This definition is the same as the etymological meaning of the word calligraphy from Greece Calligraphia (beautifully written) [7]. In its development, Arabic letters became the object of art thirst, which developed according to where the place of art originated thirst. Thus, in the 10th century, for example, the Qufi style began the development of thirst. It was previously somewhat stiff and became increasingly flexible and ornamental even though it remained angular. Then, it also developed its form of thirst, cursive (italics), embodied in the art called Sulus, Naskhi, Raiham, Riqa, and Tauqi. In the next phase of the force, Riqa and Tauqi's use is no longer visible. Based on the description above, the author is interested in developing an image-processing

application to introduce the type of Khat based on the art pattern of the kind of Khat so that it can help the community distinguish some of the existing Khat types of art.

2. Literature Review

An image is a two-dimensional image produced from a continuous two-dimensional analogue image into a discrete image through a sampling process. Analog images are divided into N rows and M columns to become discrete images. The intersection between a particular line and column is called a pixel. An example is a discrete image/point in row n; column m is called a pixel [8].
An analogue image is a continuous image. Such as images on television monitors, X-ray photos, photos printed on photo paper, paintings, natural landscapes, CT results scans, images recorded on cassette tapes, etc. Analog images cannot be presented on a computer, so they cannot be processed directly [9]. Meanwhile, the digital image is a discipline that studies things related to improving image quality (increasing contrast, colour transformation, image restoration), image transformation (rotation, translation, scale, geometric transformation), selecting feature images (feature image) that are optimal for analysis, performing the process of retrieving information or object description or recognizing objects contained in the image, performing data compression or reduction for data storage, data transmission, and data processing time [10].
Analogue images must be converted into digital images for the computer to process them. The process of converting analogue photos into digital images is called image digitization. Two things are done in the image digitization process: spatial digitization, also known as sampling (erosion), and intensity digitization, often called quantity. There are two types of image digitization processes, namely spatial digitization (x,y) and f(x,y) intensity digitization [11].
The .bmp format is a standard, uncompressed storage format commonly used for storing binary images to colour images. This format consists of several types, each determined by the number of bits used to store a pixel value. All image files used have a .bmp extension. This type is selected only to simplify the code used to process the image [12].
The word calligraphy comes from Latin and consists of two syllables: kalios (calios), beautiful, and graf (Graph), which means image or writing. For the United Kingdom, it is known as calligraphy, which means beautiful writing and art. In general, thirst is the writing of Arabic letters, either standing alone or composed with others, well and beautifully and following the principles and rules set by experts in the arts thirst. Calligraphy (thirst), also called Tahsinul Khat (improving writing), is a category of writing that not only emphasizes the appearance or posture of letters in forming words or sentences but touches on aesthetic aspects (Al-Jamal) [13].
Khat is divided into several categories. According to the standard provisions in pure Arabic writing (Khat), it can be recognized in several ways. In the book Uthul at-Tadris al-'Arabiyah, Abdul Fatah mentioned that thirst consists of 8 categories, namely Khat Qufi, Khat Sulus, rahyani, diwani, farisi, riq'ah, diwani jaly and Naskhi [14], [15].
Compared to other Islamic arts, calligraphy gained the highest position and is an expression of the spirit of Islam, which is very distinctive. Therefore, calligraphy is often called "the art of Islamic art." This qualification is appropriate because calligraphy reflects the depth of artistic meaning, the essence of which comes from the values and concepts of faith. Therefore, calligraphy has a significant influence on other forms of creative expression or, in other words, on cultural expression in general [16].
The speciality of calligraphy in Islamic art can be seen mainly because it is a form of "embodiment" of the holy word of Allah SWT. In addition, calligraphy is the only Islamic art produced purely by Muslims, unlike other Islamic art types (such as architecture, painting, and ornamental), which are heavily influenced by non-Muslim art and artists. It is unsurprising that throughout history, Muslims have appreciated calligraphy much more than other types of art [17].
Artificial neural network or Artificial Neural Network, which is often abbreviated as ANN, is a network model That imitates the working principle of Neurons in the human brain (biological neurons) [18], [19]. ANNs first appeared after McCulloch and Pitts introduced a simple model of neuron artificial in 1943. The simple model is created based on the biological neurons, which are the basis of the signalling unit of the nervous system.
Artificial neural networks have some abilities like the human brain [20] that is:

1. Ability to learn from experience.
2. The ability to make parables to new inputs from his expertise.
3. Ability to separate important characteristics from inputs that contain non-essential data.

Coonen learning is carried out competitively based on the proximity of the distance between the weight vector of each class and the selected input vector. Distance can be calculated by:

$$Dj = \sum(Wij - Xi) \quad \ldots\ldots(1)$$

The class that wins the competition is the class that has the smallest distance. The weight values in the winning class will be adjusted or corrected by:

$$Wik = Wik + \alpha[Xi - Wik] \quad \ldots\ldots(2)$$

Weight factor initialization can be done by assigning arbitrary values or by the following formula:

$$Wij = \frac{Max\,(Xi)+Min\,(Xi)}{2} \quad \ldots\ldots(3)$$

3. Method

3.1. Research Workflow Diagram

The workflow diagram that will be carried out in this study is illustrated in Figure 1 below.

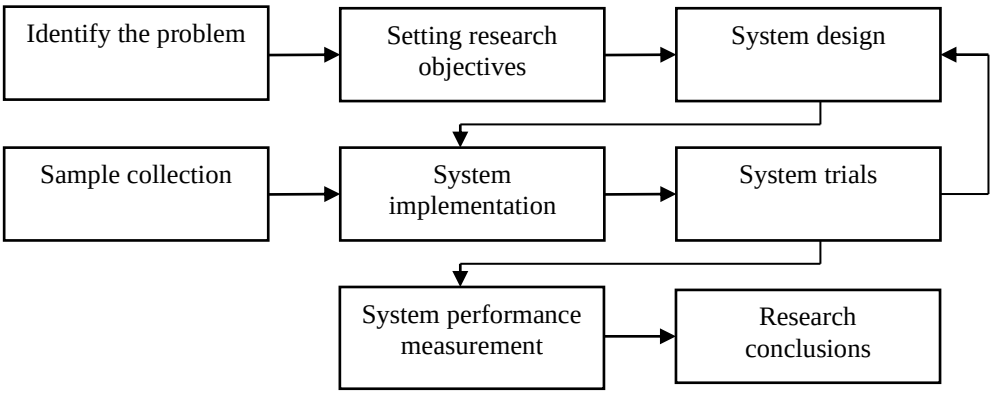


Fig 1. General Research Workflow

3.2. Data Collection

After planning the research, the first step is to collect references about artificial neural networks, image processing, and the data needed to make the system. The data used in the research is in the form of data on the type of khat art. The data or sample is khat art from the scanner, limited to a 24-bit image with a bitmap extension.

Literature studies aim to collect data and information in the form of theories, journals, methods, or approaches that have developed and have been documented in the form of books, magazines, manuscripts, and so on. Conduct a literature study on various references related to the research conducted, such as reading and studying books on image processing, as well as learning about the application of the methods used to complete this research.

3.3. Program Input Needs Analysis

The implementation in building this system uses a scanner image of the .bmp file type as a file input in the program. The data collection process (sample) is carried out with the following steps:

1. Taking one type of khat art at random is done to make it easier and faster to detect the type of khat art.
2. Each pattern of khat art will be planted first for testing.

3.4. System Schematics

The system scheme in this study consists of a resizing scheme, a grayscale scheme, a convolution scheme, and a content scheme. The following is the overall scheme illustrated in Figure 2.

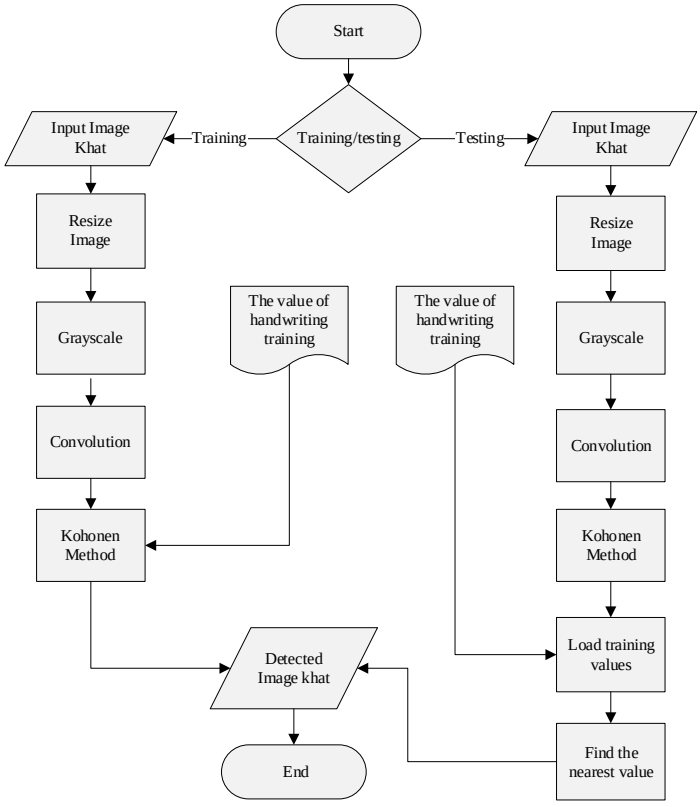


Fig 2. Overall System Schematic

4. Results and Discussion

4.1. System Analysis

System analysis aims to identify problems in the system where the application is built, including the operating environment, users, and related elements.

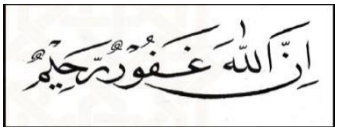
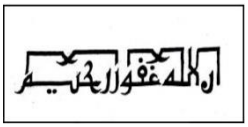
The results discussed include the selection of khat art image training samples, which will be inputted from a computer stored in the system. The system training process includes calculating the original image's matrix value, then the grayscale process, and then entering the edge detection process using the convolution process with a kernel, namely the Sobel operator. Then, the matrix results from the edge detection process are calculated using Kohonen to get energy from the image object of the khat art.

In the testing process, the energy of the test image will be compared with the image energy in the training process that has been previously stored. The approach or similarity of energy values is the reference for introducing the type of khat art.

4.2. Sample Khat Art Type Training

The khat art training samples used in this study are three types of Khat: Khat Naskhi, khat qufi, and khat farisi, representing the vector characteristics of different kinds of khat art.

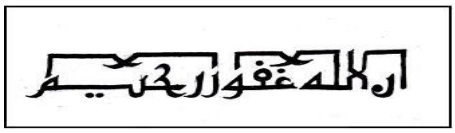
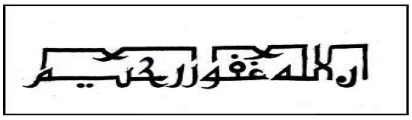
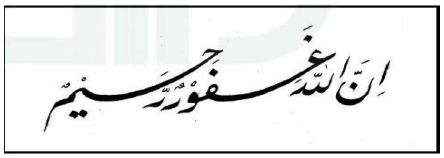
Table 1. Khat Training Sample

Training Samples		
Khat Naskhi	Khat Qufi	Khat Farisi
		

4.3. Sample Testing of Khat Art Types

In this study, the sample of testing the type of khat art used is six image samples. Table 2 shows the khat samples used as tests.

Table 2. Sample of Khat Art Testing

Sample of Khat Art Testing	
1. Khat Naskhi	2. Khat Naskhi
	
3. Khat Qufi	4. Khat Qufi
	
5. Khat Farisi	6. Khat Farisi
	

4.4. Manual Calculation

a. Grayscale

This process is a process of converting a colour image consisting of three channels, namely, R (red), G (green), and B (blue), which are found in a 24-bit image. Before 24-bit RGB imagery is manipulated with certain operations, imagery is first converted to grayscale imagery. This conversion aims to make the image more efficient without requiring the same calculation to occur repeatedly on each image channel.

Table 3. Manual RGB to Grayscale Conversion

(x,y)	0	1	2	3	4
0	(5, 8, 11)	(33, 35,36)	(39,39,39)	(40,38,39)	(33,35,36)
1	(0.1,1)	(248,248,248)	(247,248,248)	(248,247,247)	(242,244,245)
2	(6,246,246)	(246,246,246)	(246,246,246)	(246,246,246)	(246,246,246)

3	(0,0,1)	(255,255,255)	(255,255,255)	(255,255,255)	(252,254,255)
4	(5,255,255)	(255,255,255)	(255,255,255)	(255,255,255)	(255,255,255)

The calculation process uses the formula:

……(4)

$$s = \frac{r+g+b}{3}$$

The calculation is done for each coordinate so that the matrix of the converted image is as follows:

Table 4. Grayscale Conversion Manual Calculation Results

(x,y)	0	1	2	3	4
0	8	35	39	39	35
1	0.7	248	248	247	244
2	166	246	246	246	246
3	0.3	255	255	255	254
4	172	255	255	255	255

b. Convolution

After the grayscale image value is determined, a convolution process will be carried out for edge detection using a Sobel operator. This edge detection operation is used to determine the location of the points on the image object's edges. Here is the matrix of the Sobel operators:

Horizontal sobel operator: =

$$S_v \quad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Vertical sobel operator: =

$$S_v \quad \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

The Sobel operator is the magnitude of the gradient:

$$M = \sqrt{S_x^2 + S_y^2}$$

One example of horizontal and vertical calculations using the Sobel operator is as follows:

Sx = (8)(-1) + (0.7)(-2) + (166)(-1) + (39)(1) + (248)(2) + (246)(1) = 605

Sy = (8)(1) + (35)(2) + (39)(1) + (166)(-1) + (246)(-2) + (246)(-1) = -787

= 993

$$M = \sqrt{S_x^2 + S_y^2}$$

Table 5. Pixel Value Normalization Results

(x,y)	0	1	2	3	4
0	*	*	*	*	*
1	*	993	832	832	*
2	*	662	29	33	*
3	*	673	36	36.05	*
4	*	*	*	*	*

Pixel value normalization: If M > = 0 then M=1, If M<=0 then M=0

Table 6. Binary Value Normalization Table

(x,y)	0	1	2	3	4
0	*	*	*	*	*
1	*	1	1	1	*
2	*	1	1	1	*
3	*	1	1	1	*
4	*	*	*	*	*

c. Kohonen

The following is an example of grouping with a content network of 2 data. The data will be grouped into two classes.

$P_1 = [1\ 0\ 0\ 1]$

$P_2 = [0\ 0\ 1\ 1]$

$P_3 = [0\ 1\ 1\ 1]$

Initial initialization:

$w_1 = [0.04\ \ 0.37\ \ 0.15\ \ 0.91]$

$w_2 = [0.06\ \ 0.1\ \ \ 0.14\ \ \ 0.98]$

$\alpha = 0.5$

Completion: 1st iteration

$P_1 = [1\ 0\ 0\ 1]$

$d_1 = \sum(W_{..} P_{..})^2 = (0.04 - 1)^2 + (0.37 - 0)^2 + (0.15 - 0)^2 + (0.91 - 1)^2$
$= 1.0891$

$d_2 = \sum(W_{..} P_{..})^2 = (0.06 - 1)^2 + (0.1 - 0)^2 + (0.14 - 0)^2 + (0.98 - 1)^2$
$= 0.9136$

Because <, then:

$d_1 d_2$

W_1 baru = W_1 lama

$= [0.04\ \ 0.37\ \ 0.15\ \ 0.91]$

W_2 baru = W_2 lama + $\alpha (P_1 - W_2$ lama)

$= +0.5\ (-)\ [0.04\ \ 0.37\ \ 0.15\ \ 0.91][1\ 0\ 0\ 1][0.04\ \ 0.37\ \ 0.15\ \ 0.91]$

$= [0.53\ \ 0.05\ \ 0.07\ \ 0.99]$

2nd iteration

$P_2 = [0\ 0\ 1\ 1]$

W_1 baru = $[0.02\ \ 0.185\ \ 0.58\ \ 0.96]$

W_2 baru = $[0.53\ \ 0.05\ \ 0.07\ \ 0.99]$

3rd iteration

$P_3 = [0\ 1\ 1\ 1]$

w_1 baru = $[0.52\ \ 0.458\ \ 0.28\ \ 1.01]$

w_2 baru = $[0.53\ \ 0.05\ \ 0.07\ \ 0.99]$

Because all the data has been processed, the one epoch process has been completed, and the following is a test of the weights obtained in the one epoch process above.

Final Weight:

$W_1 = [0.52\ \ 0.458\ \ 0.28\ \ 1.01]$

$W_2 = [0.53\ \ 0.05\ \ 0.07\ \ 0.99]$

for the first input,

$P_1 = [1\ 0\ 0\ 1]$

$d_1 = \sum(W_{..} P_{..})^2 = (0.52 - 1)^2 + (0.458 - 0)^2 + (0.28 - 0)^2 + (1.01 - 1)^2$
$= + + +$

$d_2 = \sum(w_{..} p_{..})^2 = (0.53 - 1)^2 + (0.05 - 0)^2 + (0.07 - 0)^2 + (0.99 - 1)^2$
$= 0.221$

Because <, this input is a class to [1

$$d_2 d_1]$$

for the second input,

$$p_2 = [0\ 0\ 1\ 1]$$

Because <, this input is the second class [2.

$$d_2 d_1]$$

4.5. User Interface

Here is the khat detection process running on the system:

a. After the program is executed or executed, the next stage is to conduct the training process by inputting a sample of khat images in bitmap format (.bmp).
b. After inputting the khat image sample, the resizing, grayscale, and convolution processes occur.
c. Next, the user searches for the khat pattern that will be planted into the program by directing the coordinates on the khat pattern. Next, the user presses the pattern button corresponding to the image's Khat. The khat pattern that has been planted will be stored as bit.txt.
d. At the testing stage, the khat recognition process can be done by inputting khat images in .bmp format. At this stage, the value of the KHAT pattern and the test image will be compared with the values instilled in each type of KHAT in the previous training process. The results with the closest value to the training value showed the recognition of the khat pattern in the test khat image.

The following implementation of the interface can be seen in Figure 3.

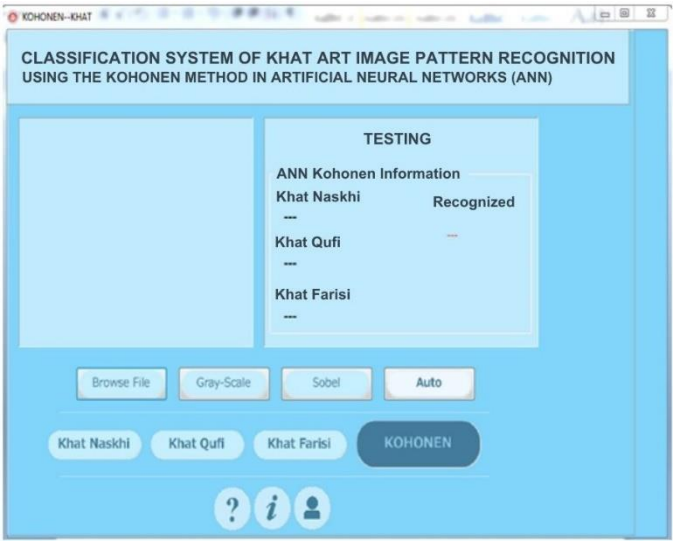


Fig 3. User Interface Display

4.6. System Testing Process

This stage serves as the output of the entire process. After obtaining each khat pattern's value, the khat pattern's value and the test image will be compared with the value instilled in each type of khat pattern in the previous training process. The results with the closest score to the training value show the recognized khat pattern.

5. Conclusion

The results of this study provide several conclusions that will be described as follows:

1. The khat art pattern recognition system using the Coonen method will be easily detected if the image of the scanner results is not broken and is visible.
2. This khat art pattern recognition system has a detection rate ranging from 60% to 90%.
3. The percentage of detection rate shows that the Coonen method can be used as one of the approaches for pattern recognition in khat art imagery.
4. The number of samples trained affects the accuracy of the system.
5. The sample of khat image patterns used as training significantly impacts the high percentage of success in khat recognition.
6. The pattern recognition system using the Coonen method has a high false positive rate or an error rate of around 50%.

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