Ethnomathematics elements in Batik Bali using backpropagation method

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Abstract. Batik is one of traditional arts that has been established by the UNESCO as Indonesia’s cultural heritage. Batik has varieties and motifs, and each motifs has its own uniqueness but seems similar, that makes it difficult to identify. This study aims to develop an application that can identify typical batik Bali with etnomatematics elements on it. Etnomateamatics is a study that shows relation between culture and mathematics concepts. Etnomatematics in Batik Bali is more to geometrical concept in line of strong Balinese culture element. The identification process is use backpropagation method. Steps of backpropagation methods are image processing (including scalling and tresholding image process). Next step is insert the processed image to an artificial neural network. This study resulted an accuracy of identification of batik Bali that has Etnomatematics elements on it.

1. Introduction

Indonesia has varied cultural diversity; one of them is Batik which known as an icon of Indonesia. Almost every region in Indonesia has Batik culture and they have unique characteristics that vary in each region. As a form of International appreciation of Batik, UNESCO (United Nations Educational, Scientific and Cultural Organization) officially crowned Indonesian Batik as World Culture Heritage on October 2nd 2009 in France. World culture heritage is only specializing on Batik Tulis which became an authentic characteristic of Indonesian Batik and not printed Batik. Is mentioned more than 181 batik motifs. The amount does not include a variety of local batik motif continues to grow [1]. Batik is a cultural heritage not because of the batik itself but because of the art in making the batik [2].

Marvin and Wahyuni et.al. said that culture is defined as a whole aspects of human life in society, acquired by way of learning, include thoughts and behavior [3]. Wahyuni et.al., states that culture is something that will affect the level of knowledge including the system of ideas or ideas contained in human mind, so that in everyday life, the culture is abstract.

Meanwhile the embodiment of culture is the objects created by human as cultured creatures, such as behaviour and objects that are real, for example; patterns of behaviour, language, life tools, social organization, religion, art, and et cetera, which intended to help human in social life.
From the understanding above, it can be concluded, culture is as a manifestation of habits, objects and tradition which is in heritage from generation to generation which still used by the inheritors. Batik is a traditional fabric that became one of the nation's cultural richness of Indonesia[1]. Batik has a long history, which began before the era of Raden Wijaya (1294 -1309), the first King of Majapahit. During its development, style, motif, and colour of batik is also influenced by the culture from outside, such as Hinduism, Islam, Netherlands, China, and Japan. In the book "Spirits of Batik Indonesia" is mentioned more than 181 batik motifs. Ethnomathematics research is suitable to do in Indonesia which has a lot of culture. Despite the progress of the times happening, many ethnic in Indonesia who survived by clinging to the doctrine of his ancestors[4].

Batik is pictorial fabric (patterned or fermented) which is made in certain way; first written and scratched with candles, followed by colouring with tarum and soga. Bali is a province in Indonesia[5]. Capital district in Bali is Denpasar. Bali is also the name of the island in this area. Wastika states in Balinese cultural which most population is Hinduism, has their cultural character built since in the fetus until death[6]. Their lives are fulfilling with religious and traditional ceremonies to be done. From the understanding above it can be conclude that Balinese batik is tangible artworks or fabric that have special motif which is influence by Hindu doctrine which exist in Bali.

Ethno-mathematics is a study about math that calculate cultural considerations where math arise by understanding the system of the math that they use[3]. Ethno-mathematics is math which is grow and evolve in a certain culture[7]. Ethnomathematics is a concept, knowledge, study, or approaches that associate mathematics with culture [8], The presence of math that have cultural nuances will give big contribution for school mathematics, because school is social institution which is different with others, it increase the possibilities of some cultural socialization[9]. Ethno-mathematics defined as cultural anthropology of mathematics and mathematics education. From the understanding above, it can be concluded that ethno-mathematics is one of math-elements which is exist inside of the surrounding society. Consciously or not, that cultural have mathematical elements which applied on daily life. The ethnomathematician mediator plays a major role in this approach. It is his or her reflections on the things that has been said and done, and the perceptual shifts that he or she undergoes during the investigation, that keep the dialogue going[10].

Based on those things, need a deeper identification in order to increase the devotion of batik culture especially for Indonesia itself and worldwide. In this case for some region which hasn’t exposed yet from the batik culture is Bali. Worldwide only knew that Bali is a place for tourist destination for domestic or international tourist. Besides, there are thing stored well and maintained; Balinese Batik which had vary variety and motif that is different with others regions especially Java. Balinese batik have pattern that used ethno-mathematic, that unconsciously use mathematical elements.

Subjects that matter on ethno-mathematic are:

a. Emblems, concepts, principals, and mathematical skills which exist on national group, tribe, or other communities.

b. The differences and similarity on mathematically things between each group and also factors behind every differences and similarity.

c. Interesting or specific thing between one group and several groups, for example: the way to think, behave, speak, and et cetera that related with math.

d. Every aspect on social life is related with mathematic, for example: financial literacy and economic awareness, social justice, cultural awareness, and political awareness.

There are many people who doesn’t know mathematical elements on batik’s motif therefore it needs deeper study about those elements. In addition to overcome the ignorance of the Balinese people in particular about the motive and variety of batik in Bali it is important to have a method that can be used to identify the motive of Balinese Batik. This is what underlies the use of back propagation algorithms in recognizing Balinese motives.

Back-propagation algorithm itself is one of the most common methods from artificial neural networks for the pattern identification and had high accuracy. Back-propagation trainee the networks to balance between network capability to identify the pattern used and also the capability to give the
accurate response for similar pattern (but different) with pattern that use on training period[11]. On training period of back-propagation algorithm there are three phases: forward propagation, backward propagation and weight changes. First, propagate the input signal to the hidden screen with activation functions which determined. Second, back-propagation phase, every output unit which already done on the feed forward phase will receive pattern that targeted that related with input pattern to calculate the mistakes numbers. Third, weight modifications in order to decrease the numbers of mistake.

2. Methods
This research is use qualitative methods with explorative approach to reveal ethno-mathematical elements in Batik’s motif. Research development of the application maker of Batik motif identifies and contains ethno-mathematic elements. Sample which used in this research is five motifs that contain ethno-mathematics element inside.

3. Result and Discussion
Balinese batik had unique characteristics; vary of the motifs, colours and also fabrics. The name of the Balinese batik also gained because of the varies of the motifs, for instance; Balinese batik buketan, merak abyorhokokai, singabarong, ulamsari mas, jagatan pisang, et cetera. Each motif drawn in order to accentuate a characteristic that reminds us to Balinese culture which is really sacred, mythology, tradition, culture, and the artworks. In Bali the use of Balinese Batik still preserve by still use Batik in every traditional and religious ceremonies.

Figure 1. Motif Abyorhokokai

On abyorhokokai motif seen only on the rectangular frame that surrounds the image of the peacock. There is only a reflective element, however it’s created with different colour between each flowers. The most predominate on this motif is there are two peacock which is face-to-face. The meaning is where the destination of human soul afterlife. From this illustration can be concluded that death is only body damage, meanwhile the soul still alive run into the creator (God).

Figure 2. Motif Buketan

Buketan mean a bunch of flowers, and this name adopted by French language. The motif of this Balinese batik is flowers pattern or small plants arranged along the fabric with an additional decoration such as butterfly, hong, stork, and also vines that increase the values of the art from this batik. Ethno-mathematic elements from this batik can be seen from the reflection of the geometry element; black fabric and gold coloured flowers.
Some people called this motif as Balinese banana, this motif describes Balinese banana which has been distilled. There are called as Balinese banana which mean “back again/retro”. This batik usually given from someone to their loves one who will travel far away in order to make the loves one will return. Based from the picture above, there are mathematical elements; curved lines with variety arch and every arch are connected. Besides, there are many reflection elements and relatable between each motifs.

Barong lion motifs has a very few ethno-mathematical elements, because this batik is the two-pieces image of Barong which different and also facing each other. The meaning and philosophy of this batik is one of mythological or magical animals, because in Balinese or Javanese culture, “barong” means “magical”. The miracle of it is being can be seen by the existence of these elements: integration between lion and tiger (body, foot, and eye), elephants (trunk), garuda (wings), dragon (grinning mouth with tongue sticking out). The embodied animals in Barong lion not just because of it is physical strengthen, but also because of the spiritual symbols.

Batik ulam sari mas motif is a very simple batik motif if viewed from the ethno-mathematical element which exists on the batik. In this batik the patterns mostly fulfil with reflection of fish and shrimp contradict each other when played. Ulamsari mas are symbol from the society who is livelihood as a fisherman; fish also represented prosperity from people who live in coastal areas.

Data of the batik motif that has been analysed by ethno-mathematical elements will be process with image processing; scaling, grayscale and tresholding stages. Those stages are done to obtain input with binary image followed with learning artificial neural network back-propagation.
3.1. Scaling
Image of Abyorhokokai batik motif measure 350 x 225 pixel, minimize into 50 x 50 pixel

![Figure 6](image)

**Figure 6. Minimize Batik Abyorhokokai Motif Image**

After the pixel size changes, then find the value of RGB every pixel. On the following table will showed RGB value of Abyorhokokai batik motif only to the size 5 x 5 pixel.

| Pixel | 1         | 2         | 3         | 4         | 5         |
|-------|-----------|-----------|-----------|-----------|-----------|
| 1     | 252,255,255 | 252,255,255 | 250,252,249 | 254,255,251 | 254,254,255 |
| 2     | 245,253,248 | 255,255,246 | 255,255,241 | 252,251,233 | 255,255,243 |
| 3     | 255,255,230 | 145,136,105 | 156,147,108 | 165,156,113 | 148,136,96  |
| 4     | 255,255,233 | 157,145,107 | 157,145,97  | 155,142,89  | 253,137,85  |
| 5     | 255,255,228 | 147,138,105 | 85,74,29    | 116,104,54  | 170,154,105 |

3.2. Grayscale
After scaling, image will perform grayscale stage, in this stage image will turn into gray.

![Figure 7](image)

**Figure 7. Citra Grayscale**

Thereafter find the grayscale value of each pixel with formulation: $Grayscale = (R + G + B) / 3$

With the result that obtains grayscale value up to size 5 x 5 pixel as follows:

| Pixel | 1     | 2     | 3     | 4     | 5     |
|-------|-------|-------|-------|-------|-------|
| 1     | 254   | 254   | 250,3 | 253,3 | 254,3 |
| 2     | 248,7 | 252   | 250,3 | 245,3 | 251   |
| 3     | 246,7 | 128,7 | 137   | 144,7 | 126,7 |
| 4     | 247,7 | 136,3 | 133   | 128,7 | 158,3 |
| 5     | 246   | 130   | 62,7  | 91,3  | 143   |
3.3. Thresholding

Thresholding is a process that converts an image into a black and white or binary image.

![Thresholding](image)

**Figure 8. Thresholding**

Calculation into binary form with this following rule:

a. value of threshold range between 0-255 limit $T = 128$.
b. if the value of the pixel more or same with 128, then changes into 1, meanwhile if the value of the pixel is less than 128, then changes into 0.

| Pixel | 1 | 2 | 3 | 4 | 5 |
|-------|---|---|---|---|---|
| 1     | 1 | 1 | 1 | 1 | 1 |
| 2     | 1 | 1 | 1 | 1 | 1 |
| 3     | 1 | 1 | 1 | 1 | 1 |
| 4     | 1 | 1 | 1 | 1 | 1 |
| 5     | 1 | 1 | 0 | 0 | 1 |

The output as shown in table 3 will be used as input in the learning of algorithm back-propagation.

3.4. Training

Input on training process is the result of thresholding process of batik abyorhokokai. Then, the motif transformed into 1 dimension array.

Stages of learning process are:

a. Set the value of epoch, rate of understanding, minimum error. For example: in this calculation limit that used are: epoch = 10 rate of understanding = 0.2, range 0-1, in this case used value 0.2 as learning ratio with minimum error = 0

b. Initialize the initial weights with random values with intervals -0.5 – 0.5

c. Loop is performed as long as loop value is less than the maximum of the iteration and the square of error is greater than the minimum error value. Each data is looped counting step 4 and 5.

d. Feed-forward
   - First loop
   - First data

e. Back-propagation

On the second data do the same operation using the final result from the first data. This process repeated until the maximum iteration.

3.5. Identification

Identification is a process to recognize the testing image identification. For example, there are image of Abyorhokokai batik motif scale 50 x 50 pixels which have been pre-processed and transformed from matrix into one array.
Identification steps are:

a. Do the learning process with feed-propagation and back-propagation. The learning process has been done and obtained the weight of learning outcomes and the value of Y.

b. After the obtained the weight of the learning outcomes, do the identification process with feed-forward-propagation, it will get the value of Y from the output of identification process.

c. After obtained the value of Y from the identification, the value of Y from identification compared with value of Y which on the learning target, then the data will be obtained. Y from identification is Y from calculation using the most optimal weight of W and V that obtained from the learning process that is done repeatedly until the epoch is met, therefore Y from identification will approach Y from learning process, so that the value of this Y is the matching data of learning and training.

3.6. Testing

Testing are aims to know the accuracy of the image recognition of Balinese batik motif from the back-propagation methods which applied on the simulation to identify the batik motif.

The performance testing plan that will run on this simulator is a test using various combinations of learning parameters; it is shown in table 4.

| Table 4. Testing Parameter |
|---------------------------|
| Parameter | Value |
| --- | --- |
| Epoch | 10 | 50 |
| Understanding rate | 0.1 | 0.2 |
| Error Minimum | 0.01 |

| Table 5. Parameter combination |
|------------------------------|
| No | Epoch | Learning rate | Minimum Error |
| --- | --- | --- | --- |
| 1 | 10 | 0.1 | 0.01 |
| 2 | 10 | 0.2 | 0.01 |
| 3 | 50 | 0.1 | 0.01 |
| 4 | 50 | 0.2 | 0.01 |

| Table 6. Testing Result of Parameter 1 |
|--------------------------------------|
| Motives name | Target | Result | Label |
| Abyorhokokai | 1,0000 | 1,0028 | Identified |
| Buketan | 2,0000 | 2,0031 | Identified |
| Jagatan | 3,0000 | 3,0011 | Identified |
| Pisang | Singa Barong | 4,0000 | 4,0003 | Identified |
| Ulam Sari | 5,0000 | 4,3501 | Identified |
| Mas | | | |
| Akurasi=4/5*100%=80% |

| Table 7. Testing Result of Parameter 2 |
|--------------------------------------|
| Motives name | Target | Result | Label |
| Abyorhokokai | 1,0000 | 1,0028 | Identified |
| Buketan | 2,0000 | 2,0031 | Identified |
| Jagatan | 3,0000 | 3,0011 | Identified |
| Pisang | Singa Barong | 4,0000 | 4,0003 | Identified |
| Ulam Sari | 5,0000 | 4,3501 | Identified |
| Mas | | | |
| Akurasi=4/5*100%=80% |

| Table 8. Testing Result of Parameter 3 |
|--------------------------------------|
| Motives name | Target | Result | Label |
| Abyorhokokai | 1,0000 | 1,3596 | Identified |
| Buketan | 2,0000 | 2,2063 | Identified |
| Jagatan | 3,0000 | 2,3949 | Identified |
| Pisang | Singa Barong | 4,0000 | 4,0024 | Identified |
| Ulam Sari | 5,0000 | 4,9951 | Identified |
| Mas | | | |
| Akurasi=4/5*100%=80% |

| Table 9. Testing Result Parameter 4 |
|--------------------------------------|
| Motives name | Target | Result | Label |
| Abyorhokokai | 1,0000 | 2,6637 | Un Identified |
| Buketan | 2,0000 | 2,0144 | Identified |
| Jagatan | 3,0000 | 3,0773 | Identified |
| Pisang | Singa Barong | 4,0000 | 3,9109 | Identified |
| Ulam Sari | 5,0000 | 5,0780 | Identified |
| Mas | | | |
| Akurasi=3/5*100%=60% |
Accuracy Rate

| Testing | 1st | 2nd | 3rd | 4th |
|---------|-----|-----|-----|-----|
| Accuracy| 80% | 80% | 80% | 80% |
| Accuracy rates = (80%+80%+80%+80%)/4 = 80% |

Application Design

4. Conclusion and Suggestion

4.1 Conclusion
Based on the result that obtained from the research and adjusted with the purpose, then obtained the conclusion, average accuracy rate is 80%, which mean the accuracy rate to identify the batik motif that contained ethno-mathematical elements are really good.

4.2 Suggestion
a. in order to increase the performance of this system, the sampling of the batik images need to be multiplied for the trainee of neural network system, to increase the accuracy of this system.
b. For the future work it is suggested to built an application to Identify batik’s motif that has ethnomathematical element.

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