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Face Recognition Using Local Binary Pattern (LBP) and Local Enhancement (LE) Methods At Night Period

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***Abstract*— Face recognition is a technique that is widely used in the field of identification of a person or in the field of security. This technique basically determines the similarity on each face of a person who will be identified with the face already stored in a storage (database). In this paper, the facial recognition technique to be used is an approach technique for the facial features based on the Local Binary Pattern (LBP) method with lighting focused on the night time. In essence LBP method will change the face traits into the form of a binary obtained from the thresholding result with around pixels or commonly called neighbors pixel. The binary result will be arranged in a clockwise direction, resulting in a binary code composition. After applying the binary code, this binary code will be converted into a histogram. Facial recognition in poor conditions or at night time, gives results less than the maximum, so the accuracy is also less than optimal. To improve accuracy, LBP is merged with Local Enhancement process. This merging process will be performed on the face image with less lighting at night period.**

Keywords—face recognition; local binary pattern; local enhancement; night period.

I. INTRODUCTION

Face recognition is a widely used method in biometric recognition commonly used at houses or public places. This technique attempts to analyze physical characteristics to identify a face and find similarities with available face data [2]. Face recognition has factors that can affect accuracy, one of which is the light conditions during the facial recognition [2], [5], [6]. Poor light factors are often encountered during nighttime conditions, especially face recognition done in open space and using a simple camera without night vision and infrared features.

Accuracy of LBP is greatly affected by the condition of when the recognition is done. A previous study [10] shows that face recognition done in the morning gets a fairly high level of accuracy compared with face recognition performed at night.

In this paper, the face recognition will be performed during nighttime conditions using a simple camera without night vision features or infrared features. To get results that match with the night conditions, the facial recognition is done in open space with the help of direct exposure from the moonlight. To improve the accuracy, the facial recognition process is combined with local enhancement processes. In the local enhancement process, the poor light conditions in the image will be enhanced by increasing the level of illumination in the image, the local enhancement will work only by altering the image portion that has a poor light condition, and for stable light conditions in the image, the lighting level will be kept. So, for the process of detection of the face it will be easier, and the system will be easier to distinguish the face on the image. The face recognition technique to be used in this paper is a feature-approximation technique [7] using the Local Binary Pattern (LBP) method. This facial feature approach (LBP) will transform an image into multiple binary shapes, which later in binary form it will be organized into binary bundles and converted to decimal. The use of local enhancement process before LBP can increase the accuracy of LBP algorithm. Our result shows that without using local enhancement the accuracy is 42.18%, and if use the local enhancement the accuracy improves to 58.62%.

II. SYSTEM OVERVIEW

Basically, the face recognition has 2 pieces of process. The first process is the creation of training data or commonly called the process of making facial features on each face. Face images will be processed using the LBP method to get a characteristic of each face. The characteristics of this face are obtained from the extraction process characteristic that will be done on the LBP method, LBP will give the values of histogram of each face image. From these histogram values will be combined and formed into a (face image) to be used for the characteristics of the face. After getting the image, the image will be stored in a storage (database). The second process is the introduction or the process of matching the face image with the image stored in a storage (database). In this matching process two images will be converted to histogram values using the LBP method, the two histogram values will be compared to obtain a match of a face image. The facial resemblance will be obtained if in the face matching process gets the smallest value from the histogram value matching process. The description of the system to be made can be seen in Figure 1.

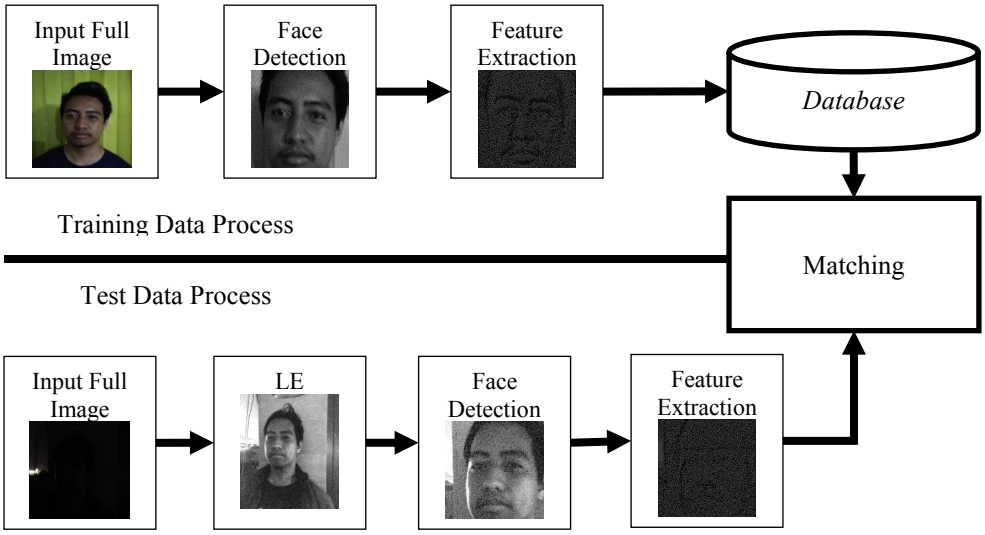

Fig. 1 Training Data and Test Data Process [6]

III. LOCAL ENHANCEMENT (LE)

In an image state that has a low level of lighting or during the night, it will be difficult to recognize a person's face image. Therefore, the local enhancement will create an image with poor lighting conditions (darkness) to be better and flat in terms of lighting levels. This method will change the value of a pixel if the value on the pixel meets the requirements, and for pixel values that do not meet the requirements will be skipped. This method uses local techniques where the image will be divided into sub-images, and from this sub-image will be processed by the method of Local Enhancement. This method requires two aspects of a pixel, the first step is to find the value of the global average and global variance of an image contrast value. The second step looks for the local average and local variance values of sub image contrast values. After that, both aspects will be compared with a condition if the pixel value to be upgraded meets a requirement. Here is the function that will be used in the Local Enhancement method as follows [8].

$$g(x,y) = \begin{cases} E.f(x,y), \ If \ \ m_{s_{xy}} \leq \ k_0 M_G \\ \qquad AND \\ \qquad k_1 D_G \leq \sigma_{s_{xy}} \leq k_2 D_G \\ f(x,y), \qquad otherwise \end{cases} \tag{1}$$

With M_G as Global Mean, D_G as Global Standard Deviation, m_{sxy} as Local Mean, σ_{sxy} as Local Standard Deviation, E is 4.0, k_1 is 0.02, k_0 and k_2 is 0.4. Sub image that will be processed in advance will be search a value of mean and standard deviation. After obtaining both values, the image will be processed by two conditions where the first condition of the mean value in the sub image is less than or equal with the value of k_0 that is multiplied by the global mean value and the second condition is by comparing the value $k_1 D_G \leq \sigma_{s_{xy}} \leq k_2 D_G$. After both conditions are met then the pixels in the middle of the sub image will be multiplied by the constant value E [8].

IV. LOCAL BINARY PATTERN (LBP)

Local Binary Pattern is a technique widely used to describe the texture and sharpness of the image [7]. LBP works by comparing the pixel value to be processed by its neighbor pixel value or commonly called thresholding, for example if the LBP operation is performed in 3x3 region then the center pixel will compare with its neighbor. If the neighbor's value is greater than the center pixel, the pixel value of the neighbor will be changed to 1 or otherwise the value becomes 0. After thresholding the neighbor from the center pixel, the number will assign a binary number (1 or 0), binary number This will be arranged in a clockwise direction.

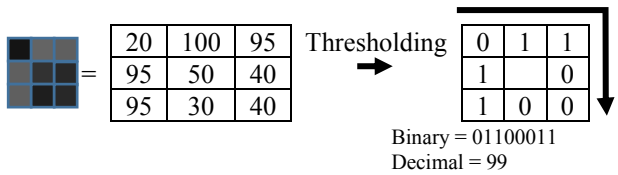

Fig. 2 Thresholding Process at center pixel [9]

Operators to get the value of the LBP method can be expressed in the following equations.

$$\mathrm{LBP}_{\mathrm{P,R}}(\mathrm{xc},\mathrm{yc}) = \sum_{\mathrm{p=0}}^{\mathrm{P=X-1}} \mathrm{s}(\mathrm{gp}-\mathrm{gc})2^{\mathrm{p}} \tag{2}$$

Assuming as follows.

$$S(X) = \begin{cases} 1, \ x \geq 0 \\ 0, \ x < 0 \end{cases} \tag{3}$$

With the operator results stored on $LBP_{P,R}$, with P as the number of neighbors, R as the number of radius. So, the operator will be as much as the sum of P-1. To obtain a different result, the operator will assign a value to the neighbor pixel if the value on the neighbor pixel is greater than the pixel in the middle, it will be assigned a value of 1, otherwise it will be given a value of 0. For example, the result of the LBP method can be seen in Figure 3.

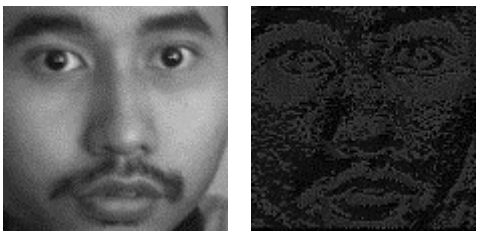

Fig. 3 Result LBP Process

A. Step LBP Method

Here is a process from the feature extraction of LBP method, LBP method is divided into 4 stages, the stage of making region, the stage of the region division, the stage of feature extraction (thresholding) and the image reconstruction (image merging). These four stages will produce an image that can be seen in Figure 3, in which is where the image is the result of the thresholding process of feature extraction by LBP method. The process of LBP method can be seen in the picture below.

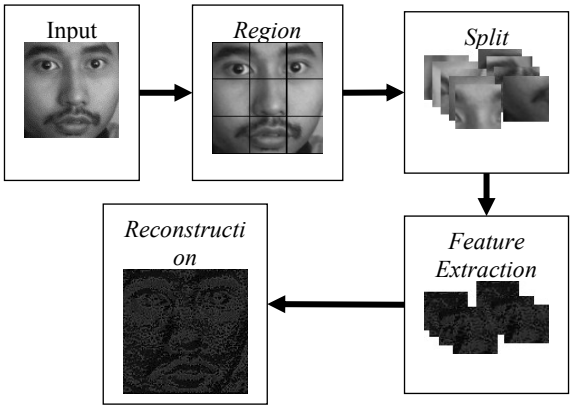

Fig. 4 Diagram flow of LBP process

The first step is to input the image, in which where the image to be used is the image that has changed the shape of the color into grayscale.

Step Two is Region. In this step, the face image will be divided into several regions by using K^2, where the value of K is to determine the number of region [5]. The process of forming the region is carried out to obtain the most important information values such as the eye region, the protected area, and the region that has characteristics for each person, therefore each region has an important role in describing a feature (texture) on the face [9].

The Third Step is the Solution. In the process of splitting the image that has been divided into several regions, it will then be split down in accordance with the number of regions that have been determined.

Step Four is the feature extraction process (Thresholding). In the feature extraction process the center pixel value will be compared with the neighbor pixel value using equation 3, which if the value of neighbor pixel is greater than the center pixel value then the neighbor value will be changed to the value 1, while the center pixel value is greater than the neighbor value the neighbor value will be changed to a value of 0. After doing the thresholding of each the neighbor, the next process is to convert the binary values into decimal values. Changing the binary value can be expressed by equation of number 2 which can be seen in Figure 5.

g^0	g^1	g^2
g^7	g^c	g^3
g^6	g^5	g^4

⇔

2^0	2^1	2^2
2^7		2^3
2^6	2^5	2^4

Fig. 5 Template binary value

After changing the decimal value of each neighbor pixel, the next step sums up the neighbor values which will be the sum, the value obtained will replace the value in the center pixel.

Step Five is the image reconstruction process of the pixel value that has been obtained. So once the value in the center pixel is replaced by the pixel value of the threshold result then the values will be compiled and put together again resulting in an image of the threshold result. The image of feature extraction can be seen in the picture below.

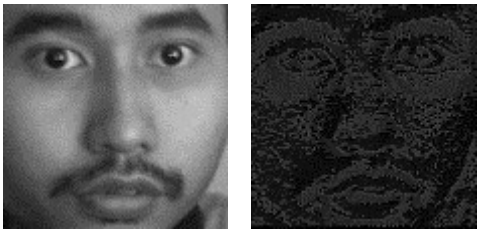

Fig. 6 Result thresholding process

V. CHI SQUARE

Chi Square is one of the classifiers in the feature approach techniques. This classifier will test a face image of the test image with the trained image. The work of this chi square classifier is by finding the average value of a face image to be tested with the training facial image. This average retrieval will take the minimum value of the classifier results from each test. The chi square equation can be formed as follows.

$$X^2(S,M) = \sum_{j=1}^{k^2}\left(\sum_{i=1}^{P(P-1)+3}\frac{(S_{i,j}-M_{i,j})^2}{S_{i,j}+M_{i,j}}\right) \quad (4)$$

With S as sample (training data) and M as Model (data to be matched), this process will repeat as much as k2 and in each region (j) will continue to repeat as much as the image (bin) in each region. From the results obtained it will look for the smallest value of any clarification process (matching) [5].

VI. EXPERIMENTAL RESULT

This experiment will be divided into 3 pieces of scenario where the scenario will be differentiated based on the time of image taking. Details of scenarios to be used can be seen in table 1 as follows.

Table 1 Details of Time Scenario

Scenario	Time Scenario	Moon phase
Scenario 1	18.00 WIB	Waning Gibbous
Scenario 2	19.00-24.00 WIB	Waning Gibbous
Scenario 3	01.00-03.00 WIB	Waning Gibbous

Here is the image that will be used in this research process which will be divided into 4 pieces. The first section will be used for data training. The second section will be used for scenario 1, the third section will be used for scenario 2, and part 4 will be used for scenario 3.

Fig. 7 First section for training data

The second part, the third and fourth images that will be used for the LE process in the form of a full image. For more details, it can be seen in the Figure 8, 9, 10.

Fig. 8 Full image at scenario 1

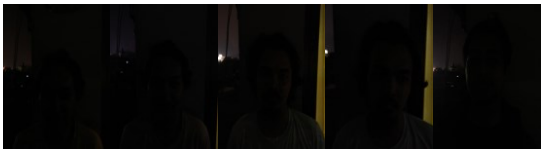

Fig. 9 Full image at scenario 2

Fig. 10 Full image at scenario 3

From the whole image, it will be processed by using the local enhancement (LE). LE process is done before detecting face, this is done to get the appropriate face image, here is the result of the LE process on the whole image in each scenario.

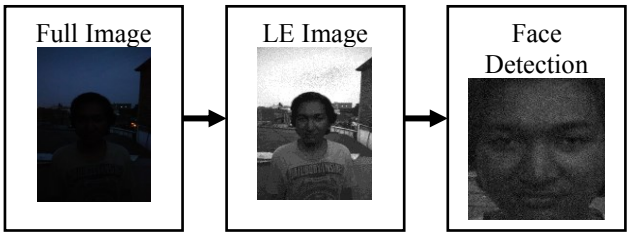

Fig. 11 Result LE process at scenario 1

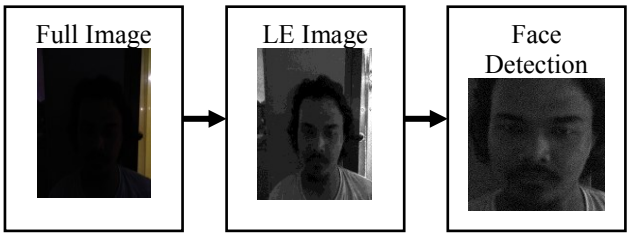

Fig. 12 Result LE process at scenario 2

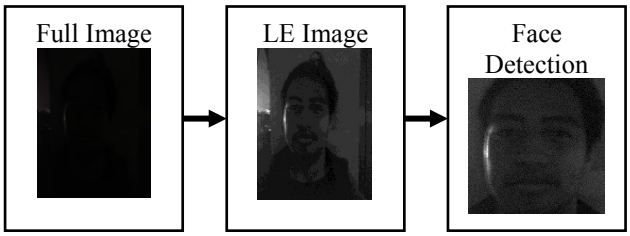

Fig. 13 Result LE process at scenario 3

After getting the face image of each scenario with the resolution used for the face image is 130 x 150, the next step is the process of matching the face image of the LE process with the face image stored in the database. This matching is done as many as the number of facial image successfully obtained in the LE process, the details of the number of images to be used are as follows.

Table 2 Details of image matching

Scenario	Number of Image
Scenario 1	534
Scenario 2	616
Scenario 3	488

At the time, the facial detection process does not use the LE, the face is not in accordance with the characteristics of the face, as if detected the results for face recognition is very small. Here is a figure of detected and undetected facial image.

Fig. 14 Face detection at scenario 1 without using LE

Fig. 15 Face detection at scenario 2 without using LE

Fig. 16 Face detection at scenario 3 without using LE

Figure 17 shows that by performing the LE process first, the accuracy rate can increase significantly from the previous one using LE. By doing the LE process on scenario 1,2 and 3 can improve the accuracy level on the facial recognition. And in Figure 18 the comparison of LBP is done by using Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CL).

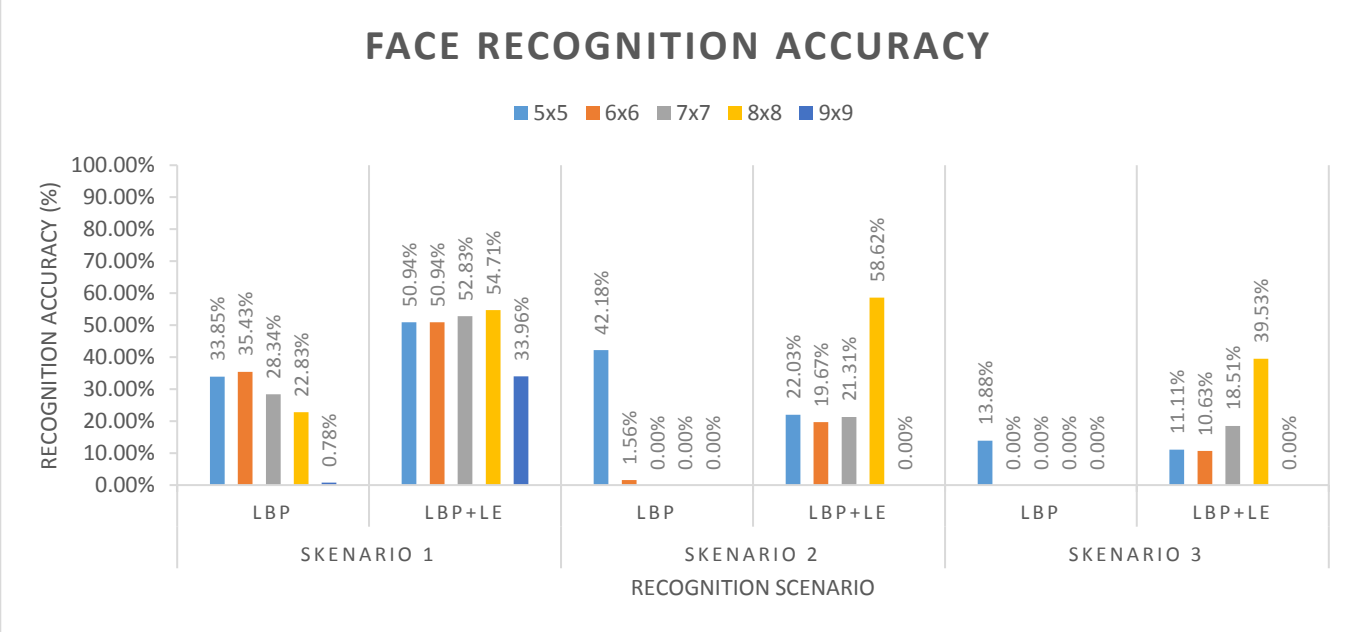

Fig. 17 Comparison of accuracy between LBP and LBP+LE on each scenario

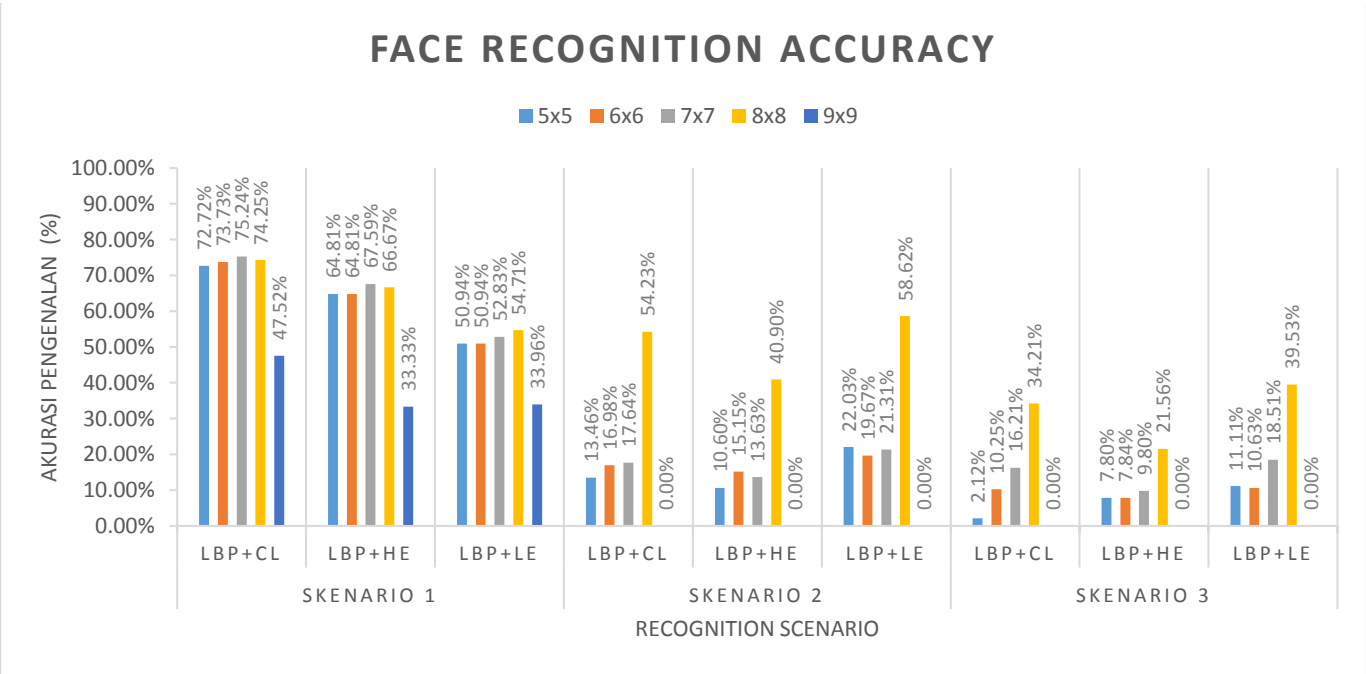

Fig. 18 Comparison of accuracy with other image enhancement methods

VII. CONCLUSION

From the results of the experiments, it can be concluded that the face recognition at night by adding the local enhancement method can increase the level of accuracy obtained from the time before adding the local enhancement method. The use of local enhancement method can increase the accuracy of 16.44% from the time before using the local enhancement method in scenario 2, and in scenario 3 can increase the accuracy of 25.65% from the time before using the local enhancement method. From these results, the local enhancement can provide a very high accuracy, when compared with face recognition before using the local enhancement method. In the further experimental results, the facial recognition by adding the local enhancement methods can provide high accuracy when compared to the face recognition added by the contrast limited adaptive histogram equalization method and histogram equalization method, this improvement is obtained from experiments in scenario 2 and scenario 3 in which this scenario is very dark lighting conditions and lighting is only aided by the moonlight. The face recognition using the local binary pattern method had better use region 8x8, because at the use of region 8x8 this information from facial traits that get better and stable from other region usage, this is based on the face recognition in scenario 1, scenario 2 and scenario 3, where the results indicate the use of 8x8 region that can provide a higher level of accuracy when compared to other regions.

The facial recognition at night by adding an image enhancement method prior to the face recognition process, can increase the level of accuracy obtained. But in the image enhancement process, the image obtained has little damage, it is based on if the use of the region is getting larger or exceeds 8x8, the result of accuracy obtained will be close to 0%. The results are not comparable with the use of the local binary pattern in normal lighting, which is the greater the value of the region used, the greater the value of accuracy obtained. It is therefore desirable in the subsequent research, to provide another image enhancement process in order to correct the damage, so that the image to be used for face recognition has a wealth of characteristic information from the face and has less damage to the image.

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