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Investigation on the Storage Method of Blurred Art Image with Retrieval and Processing

Jingyi bo, Yubin Wang and Yu Xiang Li

College of Math and Information Science & Technology, Hebei Normal University of Science& Technology
Qinhuangdao, Hebei, 066004, China,
E-mail: qhdbjy@126.com,

Abstract

For the Chinese ancient art, stone carving experiences the etching of the natural environment and become blurred. How to process and store their images becomes a quite important problem. In this paper, an image process and storage method have been proposed. In this method, the blurred image will be firstly pretreated. Then, relative images which have high similarity with the blurred image will be retrieved in the database. Thirdly, blurred images are processed with template matching method to improve the clarity. Finally, processed images and the original images are stored in the dataset with classification. A blurred art image is used as the example to verify the validity of the method. The blurred image contains a person and a door. The query method is proposed with higher speed and precision, which is due to the pretreatment and mixed subgraph method. The pretreatment can improve the precision of the query content, while the mixed subgraph method can provide the completeness of the query content. Both the mechanism improves the retrieval precision. The blurred images excavated in the soil are often with pitting and rust, which is corresponding to the noise in the image process. In the image process step, the image is fixed up when the blurry points are big enough. The verification confirms the validity of the method.

Keywords*: blurred art image, image retrieval, template matching, image pretreatment, storage*

1. Introduction

The Chinese ancient art, which has a long history, covers a wide range of content, such as calligraphy [1], painting [2], sculpture [3], *etc.* Due to the exceptional preservation method, the calligraphy and painting can maintain its original definition despite of the color variation. Relatively speaking, stone carving [4-6] will experience the etching of the natural environment and become blurred. Even more, tombs carving will suffer more serious corrosion due to it deeply buried in the soil. At the same time, due to the special nature of the tombs carvings, many images will be captured in the discovery process, and the number of images will be accumulated with time. Various images will be retrieved and processed for different aims, therefore, image retrieval [7-8] and processing method [9-10] with high efficiency will be quite important. High efficient image retrieval and processing methods will play an important role for the image restoration, image retrieval, and image classification.

Image query and image retrieval have essential importance in the art image process. There are many methods proposed for the image retrieval, such as image number and image label and semantic based method. Image number or label retrieves the image according to the number and label, and their query efficiency is quite low and the query results will be inadequate. Semantic methods [11-13] based on the content of the image, and this kinds of methods have high efficiency and high precision. The methods can be

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divided into two steps: semantic query and target image sequencing. Both of the two steps should be processed with high precision.

Image processing methods are widely used in target tracking [14], digital image processing [15], pipeline detection [16-17], and automatic image capturing [18]. In order to get higher efficiency, the processing methods have also been widely developed. The image processing methods can be classified into two types: low level image processing methods and advanced image processing methods. In the low image processing methods, lots of simple processing behavior will be used, including filtering, rotating, sampling, and some related operations [19-20]. Although the low level image processing behavior is quite simple, it is very important to preprocess the images. In fact, each pixel in each image often costs thousands of steps in a process step. The advanced image processing methods often use more advanced algorithms. The typical type methods are image template operations [21-22] which include variable template pipes or sequence [23]. How to execute the effective implementation of universal variable template is an important point to study.

So far, there are lots of Chinese ancient art image stored in the database. However, many more images still have been exploited. In order to conveniently process the images, these images will be classified and stored. Therefore, how to classify and process the images will be quite important. The main work in this paper is to propose a comprehensive method to process the art images, especially the corrosive image exploited from the soil. In this paper, a new image will be classified firstly with template matching method. Secondly, it will be processed to increase its articulation. Thirdly, processed images will be classified and stored. The remainder of the paper is shown as the following: the blurred art image store method is introduced in Section 2; the verification is described in Section 3; and the conclusion is shown in Section 4.

2. The Blurred Art Image Storage Method

The image storage method proposed in this paper can be divided into three steps:

(1) The coarse image template matching. When a new image is captured, it will be firstly matched with the template for preliminary classification;

(2) The image will be processed to several types with the specific methods.

(3) The original image and processed image will be stored into dataset with different classes.

2.1. The Coarse Image Matching

In coarse image matching step, semantic retrieval method is used. In order to reduce the time cost in this step, the results filtration and semantic retrieval is combined for the image matching.

Define the image set as:

$$T = \{I_1, I_2, ... I_n\} \tag{1}$$

Extract the visual word bag based Dense SIFT local feature points in each image:

$$V^i = \{p^{(i)}(v_1), p^{(i)}(v_2), ..., p^{(i)}(v_k)\} \tag{2}$$

If the semantic attributes distribution can be got according to the image attribute, then the V^i can be expressed as:

$$V^i = \{p^{(i)}(a_1), p^{(i)}(a_2), ..., p^{(i)}(a_m)\} \tag{3}$$

Where, v_j is the semantic attribute and a_j is visual word. The relation of them can be marked as $p(v_j | a_k)$, which means the transfer probability between visual word and semantic attribute.

Introduce the sigmoid function:

$$f(x) = \frac{1}{e^{-x} + 1} \tag{4}$$

This function is used to express the semantic attribute of the image. Use A' as the unmapped semantic attribute, the semantic attribute distribution can be expressed as:

$$A = f(A') \tag{5}$$

Here, f is a sigmoid function.

According to the Bayesian total probability formula, the probability can be described as:

$$p(v_j) = \sum_i p(v_i \mid a_i) * p(a_i) \tag{6}$$

The objective function of reconstruct learning can be described as:

$$\begin{aligned} &\min_D \frac{1}{2} \left\| B_{d\times k} - D_{d\times n} A_{n\times k} \right\|_2 \\ &s.t. \sum_i D_{i,j}^2 \le 1, \forall 1,2,...,n \end{aligned} \tag{7}$$

Here, B represents the visual word distribution matrix;

D represent the visual semantic mapping dictionary;

A is semantic attribute probability distribution matrix.

Inverted index method is used to retrieve the images as the template in the database. The key step in this method is to find a sphere radius which is suitable to distinguish the feature points inside or outside it. When the results are generated, the reorder process will be realized as the following:

(1) Give the inverted index structure $L = \{l_1, l_2, ..., l_k\}$, and the corresponding cluster centers $C = \{c_1, c_2, ..., c_k\}$.

(2) Calculate Euclidean distance of all clustering centers $d = \{d_1, d_2, ..., d_k\}$.

(3) Get the relative smaller distance in $\{d_{q,1}, d_{q,2}, ..., d_{q,w}\}$. Then, calculate the query results $RS_q = \{y_1, y_2, ..., y_m\}$ of feature points in invert list.

(4) Define a sphere with center Q. If set Rq as the radius of the sphere, the Rq can be calculated by:

$$Rq = \lambda \times \frac{1}{w} \sum_{i=1}^{w} d_{q,i} \tag{8}$$

Where, $d_{q,i}$ is the distance; λ is the ratio coefficient to adjust the sphere radius.

(5) Calculate the distance $d(q, y_i)$ between query characteristics q and RS_q characteristics. The calculation results will be retained by the condition of :

$$d(q, y_i) = \left\| q - y_i \right\| \le R_q \qquad i = 1,2,...,m \tag{9}$$

(6) Select the feature points with the minimum distance will be selected as the final results.

The flowchart of the image retrieval process is shown in Figure. 1. In the flowchart, the image pretreatment is the extraction of the key characteristics.

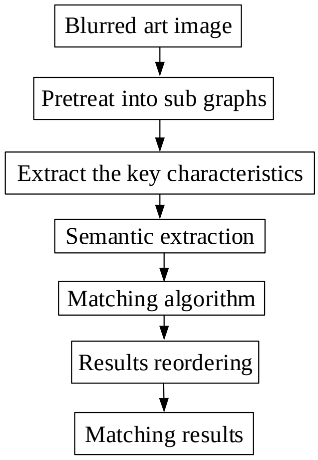

Figure 1. The Flow Chart of the Coarse Image Retrieval

2.2. The Blurred Image Process

In this step, the template match method is used to process the image. Firstly, the target image is set as the template $T(m, n)$, and it can be translated into some search graphs $S(M, N)$. Secondly, the searched graph covered by the template is defined as sub graph S^{ij} . Therefore, the range of (i, j) should meet the demand of $1 < i < M - m + 1$, $1 < j < N - n + 1$.

The similarity between $T(m, n)$ and S^{ij} can be used to describe the match degree $D(i, j)$ as following:

$$\begin{aligned} D(i, j) &= \sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n) - T(m, n)\right]^2 \\ &= \sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n)\right]^2 - 2\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n)\right] \times T(m, n) + \sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m, n)\right]^2 \end{aligned} \tag{10}$$

Where, $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n)\right]^2$ represents the energy of the sub graph of the template, which is not sensitive to the position of (i, j);

$\sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m, n)\right]^2$ is constant, which represent the energy of the template;

$\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n)\right] \times T(m, n)$ reflects the relationship between sub graph and the templates. When the sub graph and the template are coincidence, the value of $\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n)\right] \times T(m, n)$ will be the maximum. Process the parameter with normalization method:

$$R(i, j) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[S^{ij}(m, n) - T(m, n)\right]}{\sqrt{\sum\sum\left[S^{ij}(m, n)\right]^2} \bullet \sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[T(m, n)\right]^2}} \tag{11}$$

With the same meaning, when the sub graph is incoinsidence of the template, the value of $R(i, j)$ will be 1.

Define ε as:

$$\varepsilon = x_{u,v} - y \tag{12}$$

Here, ε is the difference of vectors of y and $x_{u,v}$. If y and $x_{u,v}$ are two vectors, ε will be the distance of $x_{u,v}$ and y.

There are usually four kinds of measurement algorithm of distance:

(1) The absolute difference

$$D(u,v) = \|\varepsilon\|_1 = \|x_{u,v} - y\|_1 \text{ or } D(u,v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left|x_{i+u,j+v} - y_{ij}\right| \tag{13}$$

(2) Mean absolute difference

$$D(u,v) = \frac{1}{n \times n}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left|x_{i+u,j+v} - y_{ij}\right| \tag{14}$$

(3) Square difference

$$D(u,v) = \|\varepsilon\|_2^2 = \|x_{u,v} - y\|_2^2 \text{ or } D(u,v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(x_{i+u,j+v} - y_{ij})^2 \tag{15}$$

(4) Mean square difference

$$D(u,v) = \frac{1}{n \times n}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(x_{i+u,j+v} - y_{ij})^2 \tag{16}$$

Here, $D(u,v)$: value of test position (u,v);

$x_{i+u,j+v}$: gray value of element (i, j) in test position (u,v), that is gray value of element $(u+i, v+j)$ in template;

y_{ij}: gray value of element (i, j) in the image to be processed. It can be easily found that $D(u,v)$ has minimum value at condition of $D(u,v) \geq 0$.

When the two vectors are the same, the distance ε will be 0. Therefore, matching work can be realized by this property. The product correlation can be expressed as:

$$R(u,v) = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1} x_{i+u,j+v}\, y_{ij} \tag{17}$$

And the other form is:

$$R(u,v) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} x_{i+u,j+v}\, y_{i,j}}{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} x^2_{i+u,j+v}\right)^{1/2}\left(\sum_{i=1}^{n}\sum_{j=1}^{n} y^2_{i,j}\right)^{1/2}} \tag{18}$$

Then, $R(u,v)$ is the normalized correlation coefficient. For $R(u,v)$, there are two conditions:

$$\mathrm{R}(u,v) = \begin{cases} <1 & if \quad \theta \neq 0^\circ \\ =1 & if \quad \theta = 0^\circ \end{cases} \tag{19}$$

The normalized form can be simplified as follows:

$$R(u,v) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} x_{i+u,j+v} y_{i,j}}{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} x^{2}_{i+u,j+v}\right)^{1/2}} \tag{20}$$

In the template matching image process, the mixed subgraph technology has been used. Mixed subgraphs means that each template image is divided into subgraphs and all the subgraphs are included in the template matching images set. The flowchart of the template matching image process is shown in Figure. 2.

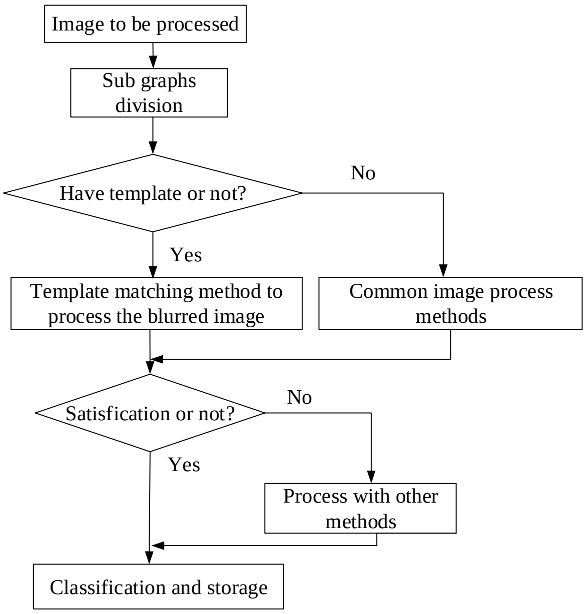

Figure 2. The Flowchart of the Template Matching Image Process

3. Verification

In order to verify the blurred art image process method, an experiment has been proposed. Here, a blurred art image is firstly given, as shown in Figure. 3. As it can be seen that there are a person and a door in the picture. In various datasets, there is not so much images like this kind, and it is difficult to find a proper template under actual condition. It is also can be seen that the picture is quite blurred. It should be processed to make the image clear and stored in the database. Clear image is helpful to identify and store the image excavated.

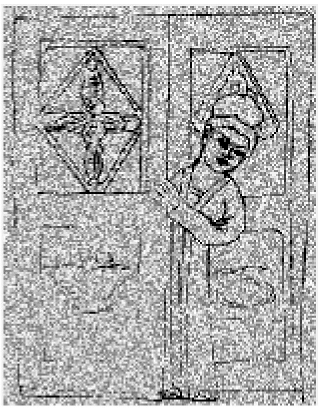

Figure 3. A Blurred Art Image to be Processed

3.1. The Template Retrieval

Template retrival is the first step to process the image. Due to the existing open database can't meet the demand in the paper, some similar images (about 1000 pieces) have been stored in the open SIFT feature dataset [24], which is selected to evaluate the method proposed in this paper. Specific information of the data set is shown in Table 1 and the results are compared with that in reference [25]. Besides, the query improvement is compared with the existing method. All the tests are executed on a computer with Intel Xeon E5-2690 v2 with the frequency of 3.0 GHz and 16G memory. The software is matlab R2010b.

Table 1. Information in the Test Dataset SIFT

Dataset	sift
Feature dimension	128
Training set	100100
Dataset	1001000
Query set	1000

Query precision calculated by both the reference method and new method is shown in Figure.4 to 6 when the parameter k is 64, 256 and 1024. And Figure.7 to 9 give the comparison of query time when the both methods are adopted. In the figures, *R* represents the query results number and the value of which is 100; *k* is the inverted list number of the index structure; *w* is the number of inverted permutation table. In experiments, query precision and the query time will be tested. The higher query precision and query time can help to classify the images and reduce the waiting time, which is quite important to the art image process and improve the process efficiency.

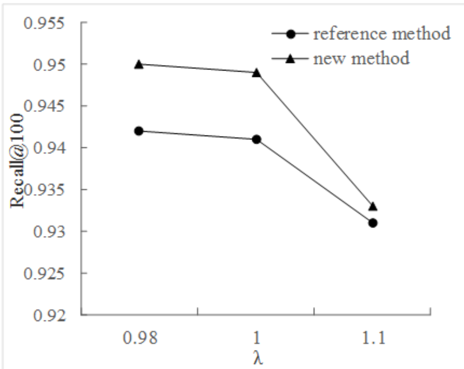

Figure 4. The Query Precision with Λ when K=64/W=8

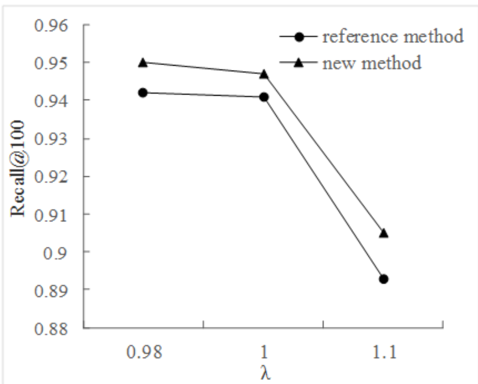

Figure 5. The Query Precision with Λ when K=256/W=16

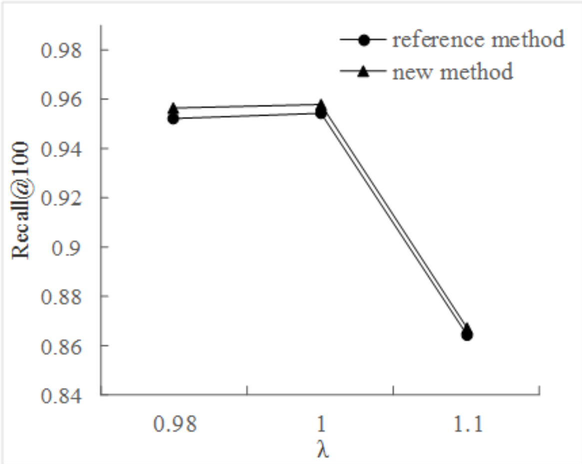

Figure 6. The Query Precision with Λ when K=1024/W=32

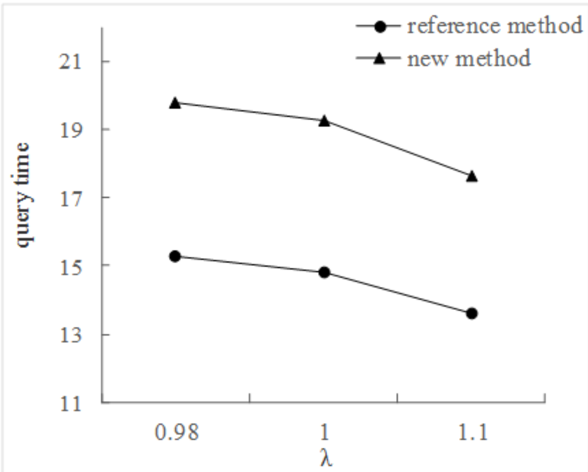

Figure 7. The Query Time with Λ when K=64/W=8

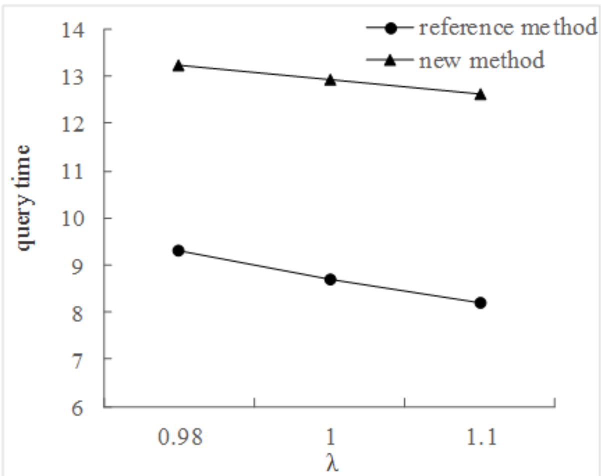

Figure 8. The Query Time with Λ when K=256/W=16

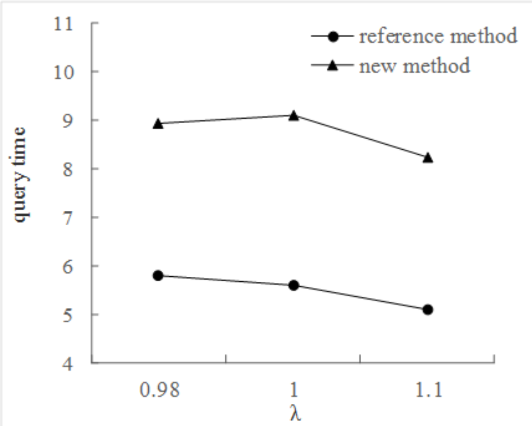

Figure 9. The Query Time with Λ when K=1024/W=32

From the query precision figure, it can be seen that the new method have higher performance on the query precision. This is due to the pretreatment and mixed subgraph method. The pretreatment can improve the precision of the query content, while the mixed subgraph method can provide the completeness of the query content. Both the mechanism improves the retrieval precision. In addition, the number of the query results is also increased according to enlarge the distance value which reduces the omissive target images. Therefore, the query precision has been increased.

For the search time, pretreatment of the art image can help to simplify the semantic information of the blurred art image. In the pretreatment, the semantic information of the blurred art image will be filtered, and the key and important information will be retained. Then, the query speed will be improved and the query time will be reduced. Meanwhile, mixed subgraph technology has been used, which can reduce the data quantity in the matching process. Therefore, the query time will be reduced and the query efficiency will be improved.

3.2. The Image Process

When the relative images in the dataset have been retrieved, the blurred art image will be processed. Here, relative images with higher similarity will be used as the template. The blurred art images will be processed into different types and stored into different sets.

The blurred images will be firstly processed into gray type. The gray type images process can reduce the time consumption. Meanwhile, the gray type image can keep the key characteristics of the original image. As it was described before, the original blurred art image will be processed with the template matching method described in Section 2.

Figure 9. The Image Process with Template Matching Method

In Figure 9, the image has been processed. In fact, blurred images excavated in the soil are often with pitting and rusty, and these kinds of damage often make the images with blurry with lots of points. The blurry in the images is corresponding to the noise in the image process. When the blurry point area is big enough, the image needs a template to fix up. The image shown in Figure. 9 has little noise, and it is much clearer. Then, the key characteristics can be easily extracted and stored.

4. Conclusion

Chinese ancient art covers a wide range of content. In the ancient art, stone carving experiences the etching of the natural environment and become blurred. At the same time, many images will be captured in the discovery process, and the number becomes bigger and bigger. How to process and store them becomes a quite important problem.

In this paper, an image process and store methods have been proposed. In the method, the blurred image will be firstly pretreated. Then, relative images which have high similarity with the blurred image will be retrieved in the database. Thirdly, blurred images are processed with template matching method to improve the clarity. Finally, processed images and the original images are stored in the dataset with classification.

A blurred art image is used as the example. The image, which is quite blurred, contains a person and a door. The query method is proposed with higher speed and precision. This is due to the pretreatment and mixed subgraph method. The pretreatment can improve the precision of the query content, while the mixed subgraph method can provide the completeness of the query content. Both the mechanism improves the retrieval precision. In addition, the number of the query results is also increased according to enlarge the distance value which reduces the omissive target images. Therefore, the query precision has been increased. Meanwhile, pretreatment of the art image can help to simplify the semantic information of the blurred art image. Semantic information of the blurred art image is filtered, and the key and important information is retained. Then, the query speed is high. Mixed subgraph technology can reduce the data quantity in the matching process. The blurred images excavated in the soil are often with pitting and rust, which is corresponding to the noise in the image process. When the blurry point area is big enough, the image needs a template to fix up. Therefore, combination of the retrieval methods and image process technology is effective for the classification and storage of the blurred images.

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Authors

Jingyi Bo, She received her bachelor's degree of engineering in Hebei Normal University, Shijiazhuang, Hebei. (2002) and master's degree of engineering in Yanshan University (2008) , Now she is a lecturer in Hebei Normal University of Science & Technology, Qinhuangdao, Hebei. His major fields of study are computer network technology.

Yubin Wang, He received his bachelor's degree of engineering in Yanshan University, Qinhuangdao, Hebei. (2000) and master's degree of engineering in Yanshan University (2009) , Now he is a lecturer in Hebei Normal University of Science & Technology, Qinhuangdao, Hebei. His major fields of study are computer network technology.

YuXiang Li, She received his bachelor's degree of science in Dalian University Of Technology, Dalian. (1987), and master's degree of engineering in Beijing University of Technology, Beijing. (2010). Now she is a professor in Hebei Normal University of Science & Technology, Qinhuangdao, Hebei. Her major fields of study are software engineering, database and computer application.

