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A PROGRESSIVE IMAGE TRANSMISSION METHOD FOR 2D-GE IMAGE BASED ON CONTEXT FEATURE WITH DIFFERENT THRESHOLDS

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Abstract. *Two-Dimensional Gel Electrophoresis (2D-GE) images are one of the tools for protein research. The research method with images containing protein spots is called proteomics. Currently, there are many image databases on-line and biologists can use them through the internet. In order to transmit this type of data quickly, one of the methods for image transfer is called the Progressive Image Transmission (PIT) method. Biologists are interested in spots, which might have important proteins residing inside the spots and it is important to transmit these important parts of the image data first. The Tsai et al. method provides a technique to transmit the more important parts of the images from the first several phases. However, the Tsai et al. method used only one (1) threshold to find these parts, which is not considered sufficient. This is due to the less important parts in different regions of the image data having different levels. If only one (1) threshold is used; there will be some loss of the more important parts of the image. For this reason, a losses compression progressive image transmission method was designed in this research that uses more than one (1) threshold to detect the more important parts of an image. In the experimental results, the most important parts were detected better than the Tsai et al. method. And, this method allows the quick viewing of the location, size and color of the most important parts through the first several phases.*
Keywords: 2D-GE image, Two-dimensional gel electrophoresis, Progressive image transmission

1. **Introduction.** With the advancements in biotechnology, more research is being done to understand the causes of diseases. One area of research by biotechnique methods is the proteomics. It is known that the body consists of proteins and when some of them turn abnormal, the body becomes sick and diseased. If the different proteins' attributes between the patients and healthy people can be found, new drugs might be created to cure the patient's disease. One of the tools developed for this purpose is the Two-Dimensional Gel Electrophoresis (2D-GE) in proteome research.

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2D-GE is a method that can separate proteins in a mixture. It uses the Isoelectric point (pI) in the Iso-Electric Focusing (IEF), which is the horizontal dimensional and Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE), which is the vertical dimensional to separate the proteins on the gel and from which each protein is dispersed. When a scanner is used to scan the 2D-GE, a 2D-GE image is created.

In a 2D-GE image, researchers are paying attention to protein spots. Research is being done with these protein spots to define the differences between normal people and diseased patients in the 2D-GE images. The focus is on the protein spots size, quantity and location. The 2D-GE images are compared and if there is a difference between the healthy persons and the patients, then it must be determined whether the protein is the cause of the disease. After confirming the protein is the real cause of the disease, a new drug will be created to treat the disease of the patients.

There are many organizations that have established image databases with 2D-GE images and these databases can provide researchers with images downloaded from the internet. When researchers download the images, they must wait for a time, due to the large image size and the network bandwidth restrictions. In traditional image processing methods, there are many methods which will help to quickly transmit the image. The Progressive Image Transmission (PIT) method [1, 6, 8, 4] is often used to transmit theses images. One of the simple PIT methods is the Bit-Plane Method (BPM) [8].

The BPM [8] is divided into eight (8) phases to transmit these large images and each phase transmits a bit plane. It is known that a gray pixel value in an image needs eight bits to represent it. As an example, a gray pixel value is 255 and can be represented by 11111111. This method transmits each phase from the Most Significant Bit (MSB) of a pixel value to the Least Significant Bit (LSB).

In general images, the traditional detecting method [9, 3] would offer good performance. However, the 2D-GE images are extremely different than the general images. The 2D-GE images have two obvious characteristics in the image: one is the most important data such as the protein spots and the other is the less important data such as the background. Therefore, this study will be used to discover a better and quicker method of image transmission for the 2D-GE images. In order to resolve this problem, Tsai et al. [7] proposed a new method with the PIT to quicken the image transmission speed.

Tsai et al. [7] analyzed the images characteristics and used the threshold to find the most important parts in the 2D-GE images. The important parts are transmitted first and other parts are transmitted progressively using the BPM. The purpose for this is to quickly show the location of the most important parts so that researchers can recognize what they want. The researcher will notice the rough location and can then decide whether or not to download the full image.

However, there are some queries in this method. Tsai et al. used a threshold to decide the differences between the more important parts and the background. Nevertheless, because the image's background may not be the same pixel value, if a threshold is used, some parts may be lost which might have important data in the image.

In this study, it is considered that the background of the image may have some changes. The background's pixel values might be similar in the same region. However, in different locations in the image, there will be some different values. These values could influence the protein spots pixel values. Therefore, a method is provided using these different values to decide the differences between the more important parts and the background in different regions. Plus, the progressive transmission is used to transmit the important data first then progressively transmit the other data with the images. From this, the receiver will get a lossless image.

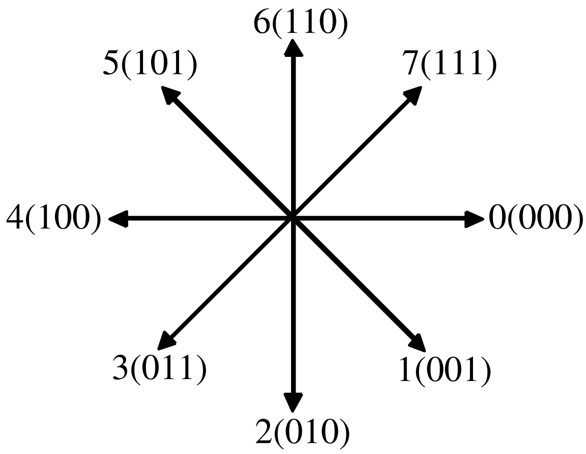

FIGURE 1. Chain code method's eight directions

2. **Review of Tsai et al. Method.** This method can be divided into three (3) steps: 1) detect the more important parts in the 2D-GE image, 2) the transmit process and 3) the image reconstruction. These steps are mentioned as follows.

2.1. **Detect the more important parts in the 2D-GE images.** A 2D-GE image can be separated into the more important and the less important parts. This method tries to find the most important parts.

Step 1: Use the following equation to calculate the average pixel value of the whole image:

$$b = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} pixel}{M \times N}.$$

where M is the height and N is the width of the image.

Step 2: Calculate the average pixel value as threshold B with the sum of the pixel values being larger than the value b.

Step 3: Use the chain code [2] to find the edges of the most important parts. Figure 1 shows the chain code's eight (8) directions. In Figure 1, 0(000) represents the right direction, 1(001) represents right down direction, and so on.

1. Check each pixel p_{ij} to find the first protein's edge's start pixel S_{ij} with the whole image using the following equation:

$$S_{ij} = p_{ij} \text{ if } |p_{ij} - B| < t.$$

2. Use chain code's idea to find the edge's other pixels with the following equation:

$$S_{ij} = p_{ij} \text{ if } |S_{ij} - p_{ij}| < t_1. \tag{1}$$

After finding all pixels as one protein's edge, it calculates the locations by edges and gets center (O_x, O_y), top-left (L_x, L_y) and bottom-right (R_x, R_y) three coordinates.

3. Repeat 1, 2 till all the more important parts could be detected and obtained the coordinates.

2.2. **The transmission process.** The main concept of the transmission process is based on the BPM. It is divided into nineteen (19) phases.

Step 1: The sender transmits the more important parts locations including the (O_x, O_y), (L_x, L_y), (R_x, R_y) and threshold B expresses the less important parts information to the receiver. This data is compressed with a run-length encoding [5]. When the receiver receives this data and decompresses, the image can be restored to its original values.

Step 2: In the second to tenth phase, the sender transmits one bit which contains the differences between the more important parts, the rudimentary image and original image with the BPM to fix the rudimentary image. This data is also compressed with a run-length encoding.

Step 3: The sender transmits the less important parts difference using the same method as in Step 2.

2.3. **Image reconstruction.** The receiver receives the data step by step and restores the image. When the first phase data is received, it can restore the rudimentary image. After the second to tenth phase data is received, the BPM can be used to fix the rudimentary image progressively and the more important parts in the image can be seen. Finally, when the last phase is received, the image can be restored to match the original image.

When the receiver collects numerous preceding data, parts that interest the receiver can be quickly seen. However, it is known that the degree and distribution of the gray color in the image is not very uniform and using a threshold to detect the more important parts may cause some loss of important parts in the region of the image. This is due to the gray level in the region of the image being similar to the threshold value B. From this problem, this study proposes a new method that modifies the Tsai et al. method to solve this dilemma.

3. **A New Detection Method.** This study divides the proposed method into three (3) steps: 1) detection of the more important parts, 2) the transmission process and 3) image reconstruction. The three (3) steps are similar to the Chen et al. method. However, there are some differences. The proposed method uses a greater than one (1) threshold to separate the more important and less important parts. This is due to most regions of the 2D-GE image looking the same in the gray color. However, the degrees of gray are different in different regions of an image. Due to these differences, if only one (1) threshold is used to separate the more important parts, some important parts may be lost. Therefore, this method uses a greater than one threshold. The proposed method is shown in the following sub-sections.

3.1. **Detecting the important parts in 2D-GE images.** The image is separated into $m \times n$ blocks and each block's threshold is calculated by using the Tsai et al. method. The more important parts in each block were then detected with its own threshold. As an example, if Figure 2 is a 512×512 2D-GE image and the image is set using m=2 and n=2 to separate the image into 2×2 blocks, the threshold can be calculated with each block and the four (4) threshold values become $B1$, $B2$, $B3$ and $B4$.

When these thresholds are acquired, the next step is to find the edges of the more important parts in each block. The following equation is used to find the start edge and chain code to detect all edges of the important parts with Equation (1).

$$S_{ij} = p_{ij} \text{ if } |p_{ij} - B_k| < t, k = 0, 1, \cdots, n. \tag{2}$$

The thresholds t and $t1$ are set to find the edges. If the edges of one part is found, the center, top-left and right down coordinates are calculated as the transmission data. This action is repeated to detect each block until all parts are detected in the 2D-GE image.

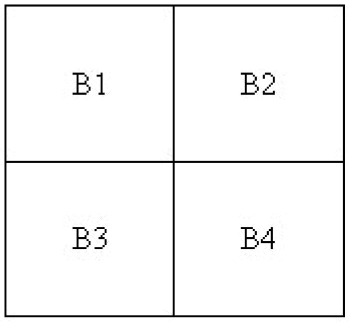

FIGURE 2. A 512×512 2D-GE image

3.2. **The transmission process.** This study method also has nineteen (19) phases to transmit a 2D-GE image. In the first phase, the more important parts transmission data are in the center, top-left and right down coordinates. And the less important parts transmission data are the thresholds of blocks that were separated. In order to transmit quickly, a run-length encoding is used to compress the data. This data can help the receiver restore the rudimentary image. Then the differences between the rudimentary image and the original image are calculated as the second to nineteenth phases of the transmission data. Like the Tsai et al. method, the more important parts difference is transmitted first with the BPM from the second to tenth phase. The second phase is the sign bit of 0 or 1 for the difference that is either positive or negative. The third to tenth phase is the one bit of difference from the MSB to the LSB.

The less important parts difference are then transmitted from the eleventh to nineteenth phase. The eleventh phase is the sign bit of 0 or 1 for the difference that is either positive or negative. The twelfth phase to the nineteenth phase is the one bit of difference from the MSB to the LSB.

3.3. **Image reconstruction.** First, the receiver restores the image from the decompressed data of the first phase. The coordinates are used to restore the more important parts and the thresholds are used to restore each block's less important parts. Next, the receiver can fix the more important parts from the decompressed data of the second to tenth phases. Finally, the other parts can be fixed in the train of data. When all the data of transmission is received, an image can be obtained that is the same as the original image.

As an example, the 2D-GE image is separated into 2×2 blocks and has one (1) more important part. When the receiver receives the four (4) thresholds $B1$, $B2$, $B3$ and $B4$ and the three (3) coordinates (2, 2), (0, 0) and (4, 4) in the first phase, it is shown that the more important parts center coordinates are (2, 2). It is also shown that the top-left coordinates are (0, 0) and the right-down coordinates are (4, 4). The parts circled from outer to inner can be restored and the pixel value from the threshold of the block reduces progressively by a value of k until the parts are finished being restored. The thresholds of each block can be used to restore the parts which are not important.

The image quality with the difference can then be fixed. If the first bit of the difference is 1, it is certain that the difference is negative. If the second bit of the difference is 1, it is known that the difference is -192.

4. **Experimental Results and Discussions.** In this study, the three (3) 2D-GE experimental images used are 512×512 blocks. Figure 3 shows the 2D1, 2D2 and 2D3 five original 2D-GE images. First, the images were separated into 1×2, 2×2 and 4×2 blocks.

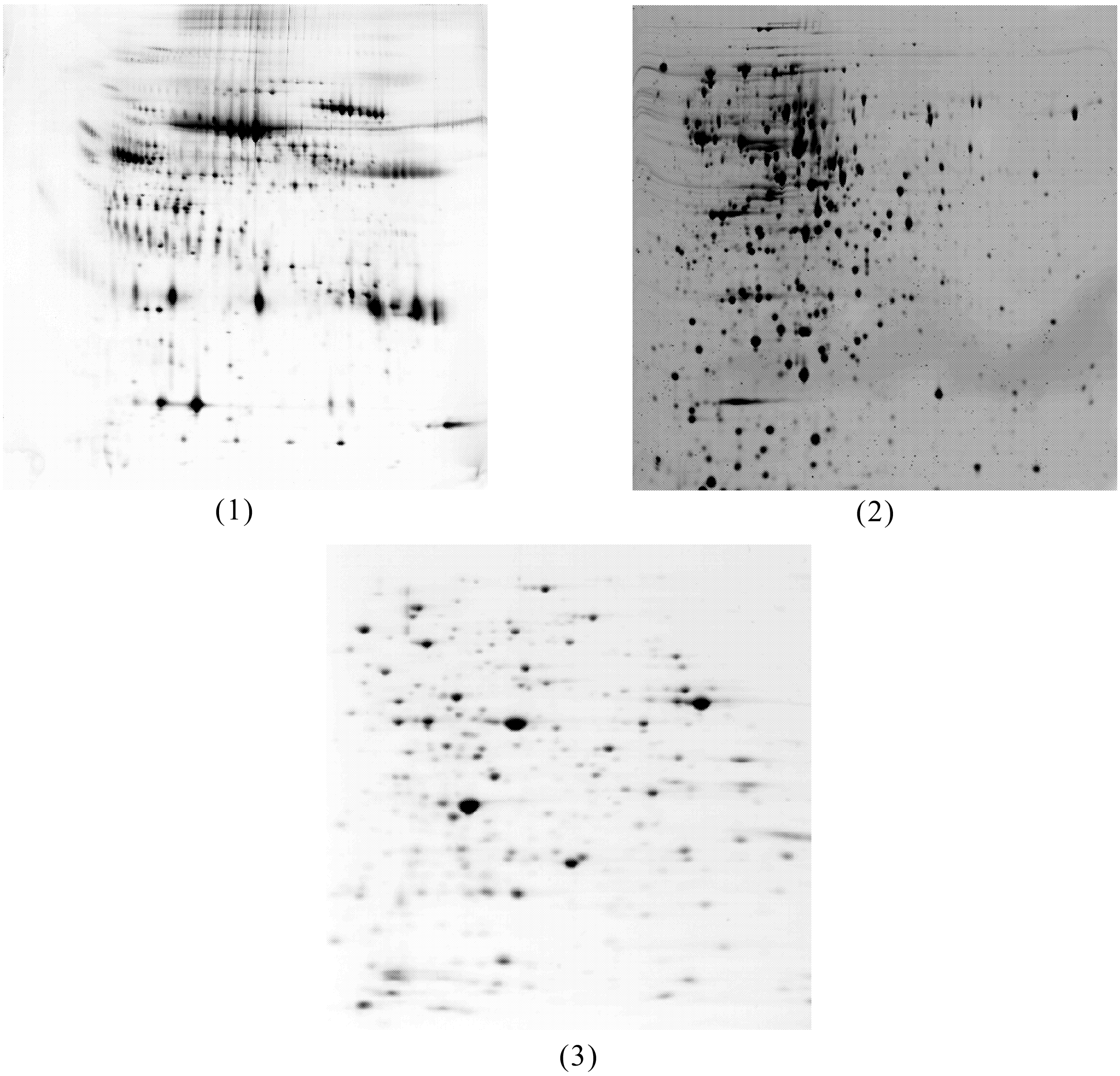

FIGURE 3. (1), (2), and (3) and are 2D1, 2D2 and 2D3 original image

Then the thresholds were calculated with 1×2, 2×2 and 4×2 blocks of the images. In the experiments, the t and $t1$ were set to be 7 and 17 and the more important parts started to show with the chain code, using Equations (1) and (2). After all images were detected, the total number of important parts of the image is shown in Figure 4. We compare with the Tsai et al.'s method In Figure 4. In 2D1, the Tsai et al.'s method can detect 404 parts, but our method can detect 477, 483, and 553 parts in 2D1 separated into 1×2, 2×2 and 4×2 blocks. In 2D2 and 2D3, we also detect more parts than Tsai et al.'s method. It is shown that the proposed method can detect more parts than the Tsai et al. method.

Through the transmission process, the PSNR value is calculated as shown in Figure 5. This proposed method shows a better PSNR than the Tsai et al. method. The PSNR value is shown in the following equation:

$$PSNR = 10 \log_{10} \frac{255^2}{MSE} db.$$

Method / Image	Chen and Wu et al.'s method	Our method 1×2 blocks	Our method 2×2 blocks	Our method 4×2 blocks
2D1	404	477	483	553
2D2	801	915	1016	968
2D3	451	632	453	472

FIGURE 4. The total number of most important parts of the image

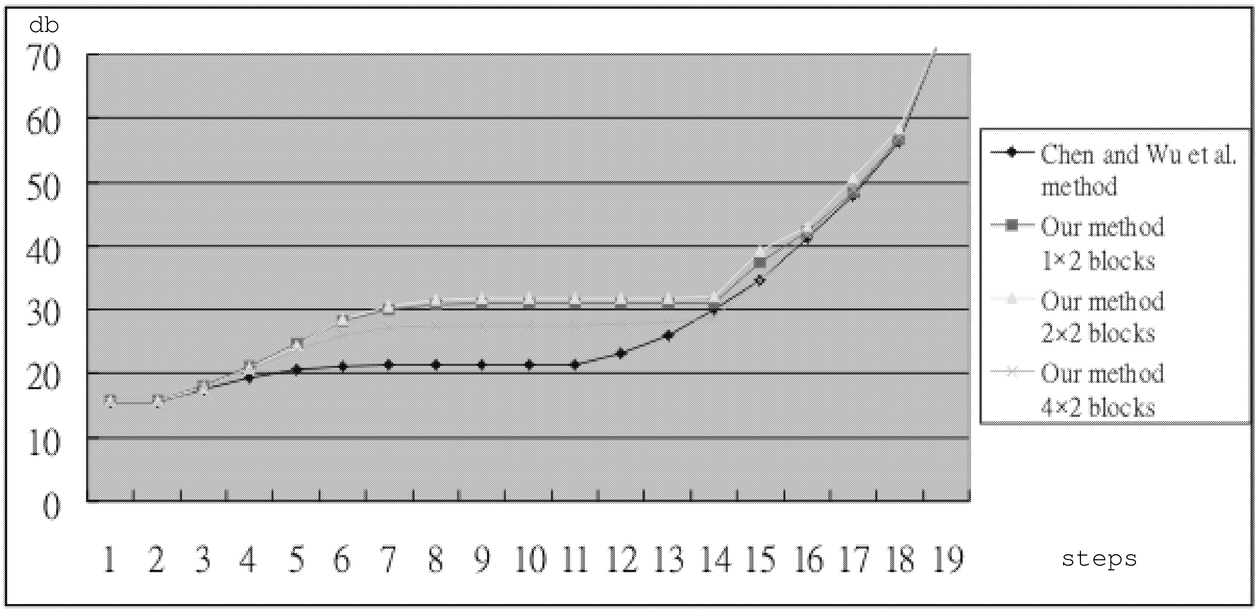

FIGURE 5. The psnr of the 2D1 through nineteen phases

Generally, if the PSNR value is greater than 30db, then the image has better quality. In the Tsai et al. method, the PSNR value is greater than 30db until the transmitting to the fourteenth phase. However, in this proposed method, the 1×2, 2×2 blocks of the image have a PSNR that is greater than 30db through the seventh phase.

5. **Conclusions.** In this study, more than 1 threshold was used to detect the important parts. The Tsai et al [7]. method was compared and a new progressive transmission method was designed for 2D-GE images. This method is a loss and compression method. First, the images were separated into $m \times n$ blocks and the thresholds were calculated with each block. Then, the more important parts were detected and transmitted through the first several phases. The less important parts were transmitted after that. Finally, the difference between the original image and the approximately restored with the first phase were transmitted. The receiver could reconstruct the image progressively with these transmission data. After the experiments, the most important parts could be detected better than the Tsai et al. method. And, a better PSNR value can be obtained with this proposed method through the first several phases than with the Tsai et al. method.

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