A New Efficient Methods for Contour Extraction and Compression

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Abstract—This paper presents a two algorithms of contour extraction from grey level image. The first proposed algorithm is applied in spectral domain using single-level wavelet transform (WT). Single step parallel contour extraction (SSPCE) method is used for the binary image after inverse wavelet transform is applied to the details images. Then the contours are compressed using either ramer, or triangle methods in spatial domain. The second proposed algorithm is applied in spectral domain using discrete cosine transform (DCT). The algorithm of contour extraction and image compression using low-pass filter (LPF) and high-pass filter (HPF) is presented and compared with the traditional zonal sampling algorithm of low-pass and high-pass filters in this paper. Effectiveness of the contour extraction and compression for test image is evaluated. In the paper the main idea of the analyzed procedures for both contour extraction and image compression are performed. To compare the results, the mean square error, signal-to-noise ratio criterions, and compression ratio (or bit per pixel) were used. The simplicity to obtain compressed image and extracted contours with accepted level of the reconstruction is the main advantage of the proposed algorithms.

Keywords—Wavelet transform, discrete cosine transform, image compression, contour extraction, low-pass & high-pass filters

I. INTRODUCTION

Contour representation and compression are required in many applications e.g. computer vision, topographic or weather maps preparation, medical images and moreover in image compression. The transform coding method compresses image data by representing the original signal with a small number of transform coefficients. It exploits the fact that for typical images a large amount of signal energy is concentrated in a small number of coefficients. The goal of transform coding is to minimize the number of retained transform coefficients while keeping distortion at an acceptable level. Transform coding is an integral part of one of the most widely known standards for lossy image compression, the JPEG (Joint Photographic Experts Group) standard. Contour extraction and image compression can be obtained using transforms such as fourier [1], walsh [8], dct [3], wavelet [6] & [7] and periodic haar piecewise-linear (PHL) which is based on the integration of haar functions [4]. & [5]. In this paper the discrete wavelet transform and discrete cosine transform will be used for two proposed algorithms respectively. In the first proposed algorithm, the compressed image and binary image are obtained using inverse wavelet transform to the approximation coefficients image and details coefficients images respectively. The contours are extracted from binary image using single step parallel contour extraction (SSPCE) method [2]. Flowchart of the algorithm for image compression and contour extraction is depicted in Fig. 1. In the second proposed algorithm, by using low and high-pass filters after the zonal procedure the two spectral sub-images are obtained. The threshold is done for the obtained image by HPF to get the extracted contour. The compressed image and extracted contour are obtained by using the inverse transform for each of the two sub-images respectively. These two sub-images are combined together to reconstruct the original grey-level image. Flowchart of the algorithm for image compression and contour extraction is depicted in Fig. 2.

II. DISCRETE WAVELET TRANSFORM (DWT)

The wavelet analysis is an exciting new method for solving difficult problems in mathematics, physics, and engineering, with modern applications as diverse as wave propagation, data compression, signal processing, image processing, pattern recognition, computer graphics, the detection of aircraft and submarines and other medical image technology [6] & [7]. Wavelets allow complex information such as music, speech, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision. Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting.

The contour uses chain coding schemes of contour representations to determine all possible connections for both 8-connectivity and 4-connectivity schemes such as Cartesian representation, or polar representation, or generalized [6].

III. DISCRETE COSINE TRANSFORM (DCT)

The Discrete Cosine Transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image’s visual quality). The DCT is similar to the Discrete Fourier Transform (DFT):
transforms a signal or image from the spatial domain to the frequency domain. DCT is approximate lines well with fewer coefficients. The 2-D DCT block calculates the two-dimensional discrete cosine transform of the input signal. It is computationally easier to implement and more efficient to regard the DCT as a set of basis functions which given a known input array size (8 x 8) can be pre-computed and stored. This involves simply computing values for a convolution mask (8 x 8 window) that get applied (sum values x pixel the window overlap with image apply window across all rows/columns of image). To obtain the output array of DCT coefficients, apply 1D DCT (vertically) columns and apply 1D DCT (horizontally) to resultant vertical DCT above or alternately horizontal to vertical.

IV. APPLIED MEASURES

The proposed image compression and contour extraction method is related to the data compression and extraction problems. To evaluate its compression ability, the following compression ratio (or bit per pixel) was introduced if each pixel is implemented by eight bits, and is defined by equations (1) and (2) respectively.

$$ CR = \frac{NOZ}{(n \times m)} \times 100\% $$  \hspace{1cm} (1)

where: NOZ is number of zero coefficients in the spectral domain; n \times m is size of the image

$$ bpp = \frac{ZS \times 8}{(n \times m)} $$  \hspace{1cm} (2)

where: ZS is coefficients number in the desired zonal

The mean square error (MSE) and peak signal-to-noise ratio (PSNR) criterions were used to evaluate the distortion introduced during the image compression and contour extraction procedures, and is defined by equations (3) and (4) respectively.

$$ MSE(I, \tilde{I}) = \frac{1}{(n \times m)} \sum_{i=0}^{n} \sum_{j=0}^{m} (I(i,j) - \tilde{I}(i,j))^2 $$  \hspace{1cm} (3)

$$ PSNR(I, \tilde{I}) = 10 \log_{10} \left( \frac{(L-1)^2}{MSE(I, \tilde{I})} \right) $$  \hspace{1cm} (4)

where \( I \) is the original image, \( \tilde{I} \) is the reconstructed image, and \( L \) is the grey-level number.

To visualize the experimental results a test grey level image were selected. Selected image is shown in Fig. 3.
V. FIRST PROPOSED ALGORITHM

The first analyzed algorithm is decomposed of Tools image using first level of DWT as shown in Fig. 4. This algorithm in this work is referred as algorithm I.

The compressed Tools image can be obtained using approximation coefficients only as shown in Fig. 5 (related results are shown in the Table 1).

![Fig. 4. Tools image decomposition using first level of DWT](image)

<table>
<thead>
<tr>
<th>MSE</th>
<th>PSNR [dB]</th>
<th>Bit Per Pixel (bpp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>24.61</td>
<td>34.22</td>
</tr>
<tr>
<td></td>
<td>b)</td>
<td>2</td>
</tr>
</tbody>
</table>

![Fig. 5. Tools image reconstruction using approximation coefficients: a) Original image, and b) Compressed image](image)

The extracted contours using SSPCE method for contour extraction of Tools image are obtained using horizontal, vertical, and diagonal coefficients as shown in Fig. 6.

![Fig. 6. Tools image: (a) Binary image from details coefficients, and (b) Contours extraction using SSPCE method](image)

The first proposed algorithm is compared with binary image which is obtained using suitable threshold criteria as shown in Fig. 7 (this compared algorithm in this work is referred as algorithm II).

![Fig. 7. Tools image by algorithm II: (a) Binary image using threshold, and (b) Contours extraction using SSPCE method](image)

The next step now is contour compression using Ramer or Triangle algorithms in spatial domain.

A. Ramer algorithm

Ramer presented an iterative method which starts with an initial segmentation and splits the segment at the point which has the farthest distance from the corresponding segment unless the approximation error is no more than the pre-specified tolerance [10].

B. Triangle algorithm

The idea of this method consists in segmentation of the contour points to get triangle shape (SP, B, and EP points) [11].

The ratio between height of the triangle h and length of the base of the triangle b is compared with the given threshold value by the equation (2).

\[
\frac{h}{b} < th
\]  \hspace{1cm} (2)

If the ratio value is smaller than the threshold, the EP of the triangle is stored and SP is shifted to the EP, then a new segment is drawn. Otherwise the second point (B) is stored and the SP is shifted to the B point of the triangle. Then a new segment is drawn. The stored points determine the vertices of an edge of the approximating polygon.
The compressed contours for Tools image are obtained using ramer or triangle algorithms as shown in Fig. 8 (related results are shown in the Table II).

TABLE II

<table>
<thead>
<tr>
<th>Measures (Compression)</th>
<th>MSE</th>
<th>PSNR [db]</th>
<th>CR</th>
<th>Elapsed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Ramer</td>
<td>0.0175</td>
<td>17.58</td>
<td>69.46</td>
<td>10.65</td>
</tr>
<tr>
<td>b) Triangle</td>
<td>0.0172</td>
<td>17.65</td>
<td>68.43</td>
<td>9.13</td>
</tr>
</tbody>
</table>

(a)                                               (b)

Fig. 8. Tools image contour compression using: (a) ramer algorithm, and (b) triangle algorithm

The proposed algorithm is compared with binary image which is obtained using suitable threshold criteria (related results are shown in Fig. 9 and in Table III).

TABLE III

<table>
<thead>
<tr>
<th>Measures (Compression)</th>
<th>MSE</th>
<th>PSNR [db]</th>
<th>CR</th>
<th>Elapsed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Ramer</td>
<td>0.0183</td>
<td>17.38</td>
<td>69.47</td>
<td>9.89</td>
</tr>
<tr>
<td>c) Triangle</td>
<td>0.0184</td>
<td>17.36</td>
<td>69.88</td>
<td>9.44</td>
</tr>
</tbody>
</table>

(a)                                               (b)

Fig. 9. Tools image contour compression (by threshold) using: (a) ramer algorithm, and (b) triangle algorithm

The results presented show that the analyzed algorithm I has good extraction property and contour compression abilities with accepted quality compared with the binary image using threshold value (algorithm II). It is seen that ramer algorithm takes more time than the triangle in the analyzed method for tested image. The results show that SNR is improved by the proposed algorithm I compared to binary image using suitable threshold value by about 0.2 decibels for some images.

VI. SECOND PROPOSED ALGORITHM

The zonal sampling methods that was described in [9], shows that the best scheme for compression and contour extraction is as illustrated in Fig. 10.

Fit criterion of the algorithm consists in selecting one of the squared block of the spectral images (e.g. shadow region) as LPF filter for image compression and the other coefficients will be taken into account in the contour reconstruction stage as shown in the Fig. 10. This algorithm in this work is referred as algorithm III.

Figure 10. LPF & HPF filters zonal method for the spectral image using the algorithm III

Fit criterion of the second analyzed algorithm consists in selecting one block of the spectral images (i.e. shadow region) as LPF for image compression and the other coefficients will be taken into account in the contour reconstruction stage. The proposed algorithm is referred as algorithm IV and are shown in Fig. 11.

Fig. 11. LPF & HPF filters zonal method for the spectral image using the first proposed method which is referred as algorithm IV

The proposed algorithm IV is compared with binary image which is obtained using suitable threshold criteria.

The related results of tools image compression and contour extraction are shown in the Fig. 12 (Table IV) & Fig. 13 respectively.
The results presented in the Fig. 12 & Fig. 13 show that the proposed algorithm IV has the best extraction property and better quality compared with the traditional algorithm (algorithm III). The results show that SNR is improved by this algorithm by about 0.2 decibels for tools image and 1.9 decibels for other images (Fig. 12 and Table IV).

VII. CONCLUSIONS

The good quality of contour extraction and compression are the main advantage of the proposed algorithms. The proposed algorithm I uses single level of discrete wavelet transform to obtained the two sub-images (compressed image and extracted contour). The results presented show that the analyzed algorithm I has good extraction property and contour compression abilities with accepted quality compared with the binary image using threshold value (algorithm II).

The second proposed algorithm which is referred to as algorithm IV uses discrete cosine transform and zonal sampling method is compared with the traditional algorithm (algorithm III). The compression ratio obtained by this method can be less than 2 bpp using LPF filter without significant visible distortion and also has good contour extraction using HPF filter. The reconstruction quality improvement of the grey level image can be obtained by combine these two sub-images by about 0.2 decibels for tools image and 1.9 decibels for other images. The simplicity of implementation both in terms of memory requirement and fit criterion complication.

REFERENCES

Abstract—This paper is to optimize the shaft production line by applying the theory of constraints and method of simulation. The simulation model of shaft production’s logistics system was established by the simulation software of Witness. The bottle-neck of the system was found as well after studying and analyzing the model. Finally, the theory of constraints was adopted to continuously improve the model and figure out the method to eliminate the system bottle-neck. Meanwhile, certain practical management suggestions were proposed.

Keywords—Logistics Balance, System Simulation, Theory of Constraints.

I. INTRODUCTION

With the increasingly fierce market competition, customers’ requirements on products are becoming more and more diversified and accelerated [1]. In order to occupy a place and win opportunities in the market, enterprises should promote their production efficiency by limited resources [2]. Enterprise logistics is a significant and tough problem especially on the matter of seeking enterprise potential [3]. It is a tradition to divide enterprise logistics into procurement logistics, production logistics – the core part, sales logistics and reverse logistics [4]. Being the main composition of production system, production logistics influence its efficiency and quality all the time [5]. Therefore, to balance production logistics has become a significant topic of production management research [6]. Based on the production line of a factory in South China, this paper applied IE method and simulation technology to analyze the production system. It found out the bottle-neck process, optimized the process using the theory of constraints. Finally, “One Flow” in the production line was achieved so as to improve the efficiency.

II. LOGISTICS BALANCE OPTIMIZATION OF SHAFT PRODUCTION LINE

A. Production System Description

Company A is an enterprise in South China which produces transportation facilities. The company has good profits and abundant orders. However, the diversity of the orders causes the insufficient productivity of some processes which, therefore, leads to material accumulation, requiring corporations from other processes or teams. The layout of the shaft production line and its main facilities are shown in Fig. 1. The shaft machining processes have the following characteristics: the material flow is unidirectional and forward; the frequency of material feeding is about once every 15 minutes, the quantity being 100 each time; the production line is half automatic.

Fig. 1 Layout of shaft production line

There are two main problems in the logistics process of shaft production line: (1) The number, type and ordering quantity of orders vary frequently, resulting in constant changing production plans, unbalanced production capacity usage and unbalanced production facility load. (2) The number of work-in-process in bottle-neck process is too large that operators from other idle processes are often allocated for assistance, which brings problems to production management.

B. Establishment of the System Model

1) Description of the System Parameters

Suppose that the raw material reaches buffer area actively at the speed of 100 pieces once. The buffer area capacity of each process is determined by the number of turnover containers for work-in-process in the workshop. For simulation convenience, we suppose that all the buffer areas have an equal capacity of 80 pieces. The length of conveying chain is 5m, with the delivering speed of 1m/s. After observation and determination on the production spot, the production process of shaft and the work time of each progress can be obtained as TABLE I: