Liver Cirrhosis Classification on M-Mode Ultrasound Images by Higher-Order Local Auto-Correlation Features

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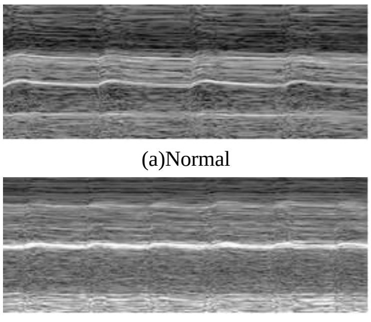
***Abstract*—Ultrasound images are widely used for diagnosis of liver cirrhosis. In liver cirrhosis classification using M-mode ultrasound images, Zhou's method has been shown to be effective. However, in Zhou's approach, the liver cirrhosis classification performance depends on the accuracy of the abdominal aorta wall extraction. Therefore, we examine to classify the liver cirrhosis not using the abdominal aorta wall extraction. In this paper, we propose a liver cirrhosis classification method using higher-order local auto-correlation (HLAC) features. Furthermore, we propose to use image processing techniques of a thresholding technique and a shading technique to effectively extract the HLAC features. We also examine a feature selection method by Fisher ratio to reduce the dimensionality of the HLAC features. Experimental results show the proposed method is promising. The average error rate of the proposed method achieves 12.11(%).**

***Index Terms*—Liver cirrhosis classification, M-mode ultrasound images, HLAC feature vector, Adaptive thresholding, Shading technique, Reduction of the dimensionality**

I. INTRODUCTION

Ultrasound images are widely used for diagnosis of liver cirrhosis. In practice, there are differences in the result of diagnosis among individuals for physician's experiences. Therefore, the objective and quantitative method for diagnosis is required. In liver cirrhosis classification on M-mode images, 2 processes were carried out in general. Firstly, an abdominal aorta wall from the M-mode image is extracted. Secondly, the feature vector generated by based on the extracted abdominal aorta wall is used for liver cirrhosis classification. Fig. 1 shows M-mode ultrasound images. Fig. 1 (a) is normal. On the other hand, (b) is cirrhosis. In liver cirrhosis classification using M-mode ultrasound images, Zhou's method has been shown to be effective [1]. However, the liver cirrhosis classification performance depends on the accuracy of the abdominal aorta wall extraction. Therefore, we examine to classify the liver cirrhosis not using the abdominal aorta wall extraction. In this paper, we propose a liver cirrhosis classification method using higher-order local auto-correlation (HLAC) [2] features. The HLAC features are successfully applied to pattern recognition problems. The advantages of the HLAC features are considered to be simple, robust, and easily implemented. Furthermore, in order to improve the liver cirrhosis classification performance, we propose to apply image processing techniques [3] of a thresholding technique and a shading method. By thresholding the M-mode image, the HLAC features are expected to be obtained effectively. The thresholding techniques are by Otsu [4], Kittler [5], and the adaptive thresholding. The results show that the HLAC feature vector approach with the adaptive thresholding method is effective for liver cirrhosis classification on M-mode ultrasound images. We also propose to use a shading technique to reduce the influence of noises in an ultrasound image. An ultrasound image is known to be a heavily noisy image, in general. Therefore, we investigate the effect of a shading technique. This is expected to reduce the influence of noises in the image. By the combination of an adaptive thresholding and a shading technique, the HLAC feature vector may be effectively extracted. Moreover, we examine a feature selection method by Fisher ratio to reduce the dimensionality of the HLAC feature vector. Experimental results show the effectiveness of the proposed method.



(a)Normal

(b)Cirrhosis.

Figure 1. M-mode ultrasound images.

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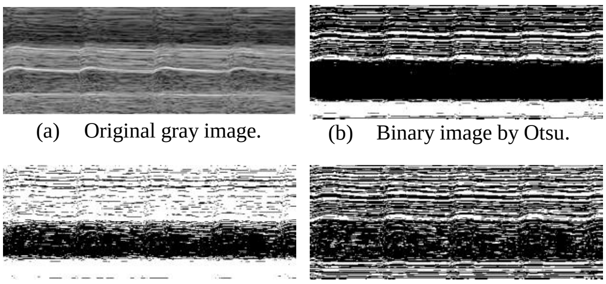
II. Liver Cirrhosis Classification

We propose a method of liver cirrhosis classification on M-mode ultrasound images by HLAC features [2]. The HLAC features are obtained by the use of 25 3 x 3 mask patterns. The dimensionality of HLAC feature vectors is 25. The HLAC feature-based method is expected to be effective for shapes, such as the abdominal aorta wall, to get information of a local direction element.

Firstly, in order effectively to use HLAC features, we also propose to apply image processing techniques [3] of thresholding an M-mode image. In this paper, binarization techniques from a gray image to a binary image are carried out by Otsu [4], Kittler [5], and adaptive thresholding. By thresholding, we expect for the HLAC features more effectively to extract the classification information. The adaptive thresholding technique finds local threshold in each pixel. In the adaptive thresholding technique, we use the mean of the local intensity distribution. If the pixel is larger than the mean, we regard the pixel as the white pixel. Otherwise, the pixel is black. The size of local areas directly influences the liver cirrhosis classification performance. We have to determine the size of local areas to separate desirable foreground objects from the background. In the experiment, we used that sizes of local areas in the adaptive thresholding were 3*x*3, 5*x*5, …, and 19*x*19. Fig. 2 shows differences between an original gray image and binary images for each of thresholding techniques. In Fig. 2 (d), the size of the local areas in the adaptive thresholding is 13x13.



(a) Original gray image. (b) Binary image by Otsu.

(c) Binary image by Kittler. (d) Binary image by adaptive.

Figure 2. Difference between an original gray image and binary images for each of thresholding techniques.

Secondly, we show a shading technique. The shading technique is known to remove the illumination influence in an image. The illumination always affects the result of the image processing. This shading technique is expected to reduce a heavily noise in the image. Fig. 3 shows a shading technique. First, the smoothed image is generated by applying a median filter to the original image. Second, the subtracted image is produced by subtracting the smoothed image to the original image. If the value of the subtracted image is less than zero, we regard the value as zero. This means that these values are ignored. Here, the selection of the median filter size is important. Since, it influences the smoothing degree. In the experiment, we used the median filter sizes: 3x3, 5x5, …, and 19x19. Fig. 4 shows images with a shading technique. In Fig. 4 (b) and (d), both sizes of the median filter and local areas in the adaptive thresholding are the same, 15x15. As we can see the Fig. 2 (d) and the Fig. 4 (d), the difference between them seems to appear a little bit slightly.

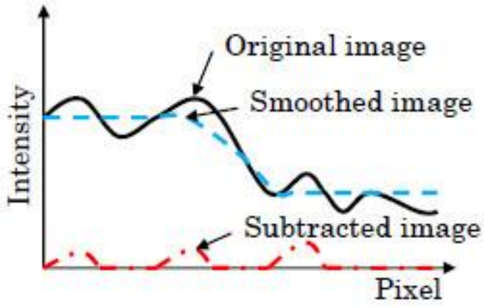
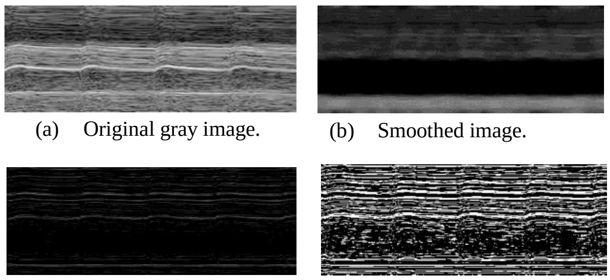


Figure 3. A shading technique.

Finally, we examine a feature selection method to reduce the dimensionality of the HLAC feature vector. Here, we adopted the feature selection methods by Fisher ratio and the variance-based method. The Fisher ratio is a well-known method in the pattern recognition field. The ratio is defined by the square of the difference of the mean values of each for 2-classes to the sum of the variances of each for 2-classes. The larger the value of the ratio is, the more the class separability increases. On the other hand, the variance-based method is a simple approach. The dimensionality of the HLAC feature vector is 25. We want to reduce the dimensionality of the HLAC feature vector as much as possible while keeping the classification performance.



(a) Original gray image. (b) Smoothed image.

(c) Subtracted image. (d) Binary image by adaptive.

Figure 4. Images with a shading technique.

III. Experimental Results

In the experiments, we used 49 available M-mode ultrasound images: 28 cirrhosis images and 21 normal images. This is a two-class problem. The gray level is 8 bits, i.e., 256. In the size of images, height times width equals to about 180 pixels times 250-570 pixels. The effectiveness of the proposed method is examined in terms of the error rate. The error rate is defined as a ratio of the number of test samples misclassified to the number of all test samples. In error rate estimation literature, the holdout method [6] has been successfully used, because it maintains the statistical independence between the training and test samples. In order to evaluate the

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proposed method, the average error rate was obtained by the holdout method. Fig. 5 shows a flow of the error rate estimation. First, we randomly divided 49 available images into 30 training images and 19 test images. 30 training images consist of 15 cirrhosis and 15 normal images. On the other hand, 19 test images are made up of 13 cirrhosis and 6 normal images. Second, we extracted HLAC features from these images. Third, the error rate was computed by using a nearest neighbor classifier [6]. Finally, by 100 repetitions, the average error rate was obtained.

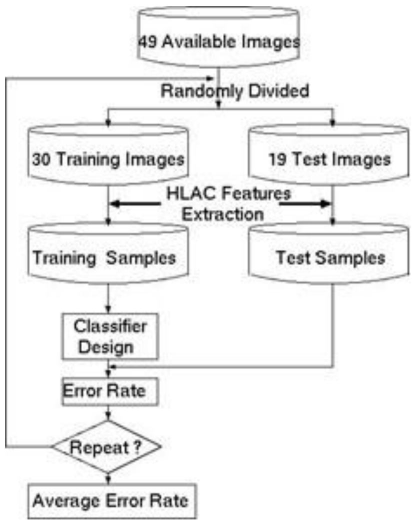

Figure 5. A flow of the error rate estimation.

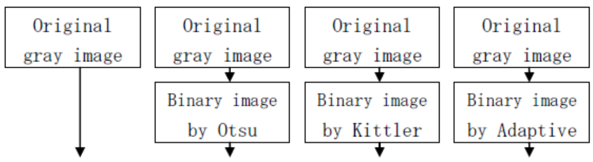

Figure 6. Outline of the experiment 1.

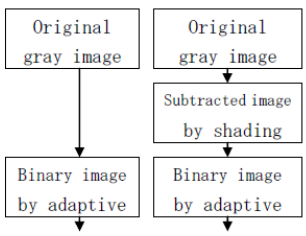

Figure 7. Outline of the experiment 2.

The purpose of the experiment 1 is to investigate the performance of the thresholding techniques by Otsu, Kittler, and adaptive. Fig. 6 illustrates the outline of four types of experiments. The left figure shows that we carry out the HLAC feature vector extraction without thresholding. On the other hand, the others mean that the HLAC feature vector is extracted from each of the binary images. Table I is the result of an original gray image and binary images on the average error rate. The size of local areas in the adaptive thresholding is 13*x*13, which gives the smallest average error rate among sizes of local areas to be examined. The average error rate by the adaptive thresholding method is superior to that of the original gray image. The experimental result shows the effects of the adaptive thresholding method. By adaptive thresholding, the HLAC features seem more effectively to extract the useful classification information. On the other hand, the global thresholding methods, such as Otsu and Kittler, yield a poor result. The following experiment is carried out only by the use of the adaptive thresholding.

TABLE I. RESULT OF AN ORIGINAL GRAY IMAGE AND BINARY IMAGES ON THE AVERAGE ERROR RATE

	Error rate(%)
(a) Original gray image	38.16
(b) Binary image by Otsu	42.26
(c) Binary image by Kittler	50.73
(d) Binary image by adaptive	29.24

TABLE II. EFFECTS OF A SHADING METHOD ON THE AVERAGE ERROR RATE

	Error rate(%)
(a) Binary image without shading	29.24
(b) Binary image with shading	17.05

TABLE III. EFFECTS OF A FEATURE SELECTION METHODS BY FISHER RATIO AND THE VARIANCE BASED METHOD ON THE AVERAGE ERROR RATE

	Dimensionality	Error rate(%)
(a) HLAC	25	17.05
(b) HLAC with Fisher	23	12.11
(c) HLAC with variance	22	15.89

The purpose of the experiment 2 is to investigate the effectiveness of a shading technique. In Fig. 7, we show 2 types of experiments. For a binary image generated by the adaptive thresholding, the HLAC feature vector is extracted. The left figure shows that the HLAC feature vector is extracted from the binary image by the adaptive thresholding. On the other hand, the right figure means that the HLAC feature vector is extracted through a shading technique. Table II shows the effects of a shading method on the average error rate. For the result without shading, the size of local areas in the adaptive thresholding is 13*x*13, which gives a minimum average error rate. On the other hand, for the result with shading, the average error rate when both sizes of the median filter and local areas in the adaptive thresholding are the same, 15x15, shows a minimum. From the result, the use of a shading technique shows a high performance. By the use of a shading approach, noises in the ultrasound image seem to reduce.

The purpose of the experiment 3 is to investigate feature selection methods by Fisher ratio and the variance-based approach. Table III shows the effects of feature selection methods by Fisher ratio and the variance based method on the average error rate. From the experimental results, the average error rate gives a peaking phenomenon. When the dimensionality is 23, the average error rate of Fisher ratio shows the minimum, 12.11(%). This shows a positive effect of the feature

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selection method by Fisher ratio. As the dimensionality goes down, the average error rate improves dramatically. On the other hand, when the dimensionality is 22, the average error rate of the variance based method is 15.89(%). To reduce the dimensionality of the HLAC feature vector and to further improve the classification performance of the HLAC feature vector, the feature selection method by Fisher ratio should be used.

IV. CONCLUSION

In this paper, we have proposed a liver cirrhosis classification method using HLAC features. Furthermore, in order to effectively extract the HLAC feature vector, we have proposed to use the image processing techniques of a shading technique and a thresholding technique. The combination of a shading technique and an adaptive thresholding shows a positive effect. We have also showed the effectiveness of a feature selection method by Fisher ratio. From the result, the proposed method is promising. In the future study, in order to further improvement of the liver cirrhosis classification performance, other types of thresholding techniques, shading techniques, and feature selection methods must be investigated.

ACKNOWLEDGMENT

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REFERENCES

[1] G. Zhou, Y. Wang, W. Wang, Y. Sun, and Y. Chen, "Decision of cirrhosis using liver's ultrasonic images," in *Proceedings 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference*, Shanghai, 2005, pp. 3351-3354.

[2] N. Otsu and T. Kurita, "A new scheme for practical flexible and intelligent vision systems," in *Proceedings IAPR Workshop on Computer Vision, Special Hardware and Industrial Applications*, 1988, pp. 431-435.

[3] J. C. Russ, *The Image Processing Handbook*, Third Edition, CRC Press, 1999.

[4] N. Otsu, "A threshold selection method from gray level histograms," *IEEE Trans., Syst. Man Cybern.*, vol. 9, no. 1, pp. 62-66, 1979.

[5] J. Kittler and J. Illingworth, "Minimum error thresholding," *Pattern Recognition*, vol. 19, no. 1, pp. 41-47, 1986.

[6] K. Fukunaga, *Introduction to Statistical Pattern Recognition*, Second Edition, Academic Press, 1990.

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