Adaptive Segmentation Method of Currency Image Based on Texture Features

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***Abstract*- In this article, we establish a fast and convenient image retrieval system. The currency image is presented through segmentation– the color image is converted to a gray image and then the image is used to create a Haar Discrete Wavelet Transform (HDWT). The next step is to extract the texture feather, adopt the Principal Component Analysis to determine the most suitable weights of each trait and conduct the binary operation. This is followed by a repair using image processing technology to achieve separation of the currency and the background. Image segmentation was conducted on images from different eras, different shapes, and different colors. A comparison with the established image segmentation methods, such as Otsu's and Level Set, as stated in this article, show that the proposed method can overcome the problems regarding imbalances in image decoration and color as well as irregularities; the segmentation can be successfully achieved even though the color of the image background is similar to that on the edge of currency objects.**

Keywords: digital currency image, HDWT, texture feature, principal component analysis, segmentation

I. INTRODUCTION

In the first phase of the National Digital Archives Program, the National Palace Museum houses 110,758 digital photographs and 74,208 objects in its collection.

Currency, with a long history and culture, is listed among the objects. About 4000 years ago, seashells were the first currency to appear and were used during the Xia Dynasty. In the economic system of the *Spring and Autumn Period*, metallic currency came into use: types of metal currency included: bronze knives, coins, cloth coins, ring coins, and conchoidal ant-nose money. The materials making up the currency consisted of copper, gold, silver, iron, gold, cloth, paper, silver ingots, and lead; the Qin Dynasty unified currency using round copper coins with a square hole in the middle. Words on the currency were developed from the seals and scripts on the coins beginning in the early Qin Dynasty and Han Dynasties. Then, the ancient style of calligraphy in Tan Currency was developed, followed by the running script, the cursive script and the regular script in the Song currency. After this, came the simplified characters from the Taiping Heavenly Kingdom; the characters systematically reflected the change of words and the techniques of ancient and modern calligraphy. Precisely separating objects from the background in an image relies on accurate image segmentation processes [3-15]. Current automatic image segmentation approaches can be divided into three categories according to pixel: discontinuity, similarity, and hybrid techniques. *Discontinuity* refers to dramatic changes in pixel intensity value. *Similarity* refers to aiming at the similarity region based on the preamble principle and segmentation. *Hybrid techniques* are designed to obtain more precision with regard to image segmentation through edge detection and by region.

Segmentation rooted in edge detection does so through the suddenly modified pixel values in different regions, as in Sobel [5], Roberts (edge detection), Canny (canny edge detection) [6,7].

The area-based approach segments several similar areas depending on similarities. Similarities may include traits of the neighboring pixels within a region, for example: gray image, color or texture feather, etc. Commonly used methods include a variety of area-based approaches such as early Mumford and Shah algorithms [8], Level Set [9], (Threshold Method) [10], and the Active Contour Model (ACM) [11-13].

This research uses a motif-strengthening front-end image processing disposition to separate objects from the background by adopting four motif characteristics: roughness, contrast, direction, and degree, as specified by Lin [14]. Following this, we conduct a principal component analysis (PCA), employ the Otsu method [15], and image morphology to complete the filtering. Last, we conduct boundary extraction and watershed segmentation.

II. THE PROPOSED METHOD

A. Image preprocessing

The RGB of the pixel (x, y) was converted into YCbCr for the purposes of this paper. The calculation of texture features are from gray-level value $f(x, y)$, where $f(x, y) = Y(x, y)$. We then focus on the gray image to perform the smoothing treatment using a 5×5 Gaussian filter to eliminate some unnecessary noise signals and to better facilitate the follow-up treatment.

Haar Discrete Wavelet Transform (HDWT): all the pixels of the image treated with the smoothing process were regarded by HDWT as having an individual value. We then performed an add-subtract operation for the coefficient of the image in different bands.

HDWT mode in this article divides the image into four bands, as shown in Fig. 1. Fig. 2 shows data after the conversion of HDWT. Here, LL is used to strengthen the edge of the currency imagine.

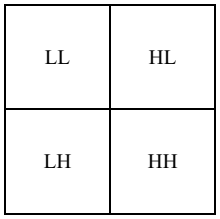


Fig 1: HDWT Diagram

Fig 2: HDWT Image

B. *Texture Feature*

The motif on the currency shown in Fig. 3 not only expresses the characteristics and local customs from each dynasty but clearly distinguishes the objects and background regions. In this article, the motif on the currency is used as a feature for image segmentation. The feature extraction method used in this study not only takes into account the gradient features of object's edge but also incorporates a method proposed to describe texture features as described by Lin et al. [14].

Fig. 3: Currency image

1) Gradient: Sobel edge detection is employed to detect the gradient features, as shown in Fig. 4.

2) Coarseness: this refers to the degree of coarseness of the image. The coarseness of (x, y) is defined as $k^p(x, y) = 5$, results are shown in Fig. 5.

Fig. 4: Gradient image

Fig. 5: The coarseness image

3) Contrast: refers to the level of contrast between the image's colors. The contrast image can be described using 0~255 gray levels, as shown in Fig. 6.

4) Directionality: generally describes the degree of directional variation of a certain color. A larger value of directionality indicates a higher degree of directional variation of the color. The directionality can be described using gray levels 0~255 in an image, as shown in Fig. 7.

Fig.6: Contrast image

Fig.7: Directionality image

C. *Morphological Processing*

Morphological processing involves the use of an object extraction tool which uses mathematical characteristics that can process the unique shapes of the porcelain objects [14].

1) Feature Extraction: Principal Component Analysis (PCA) is used to project data in a high-dimensional space onto a low-dimensional space and to find the optimal projection method. The coarseness, contrast, directionality, and gradient are transferred to the first principal component dimension through a PCA, as shown in Fig. 8.

2) Binary Processing: Otsu's method [15] is used to binarize the image in this study. The boundary between the object and the background is noticeably more definitive, as shown in Fig. 9.

Fig. 8: Image projected by PCA

Fig. 9: Image treated by binarization

3) Object Filter: the closing operation in morphology in this article is used to remove noise signals and acquire complete information. The closing operation expands the region of the object through a dilation of the binary image, and then through a reduction of the region using an erosion treatment. This produces a tally of the size of the original image object. This allows for a more complete object contour and edge. Fig. 10 shows the binary image in Fig. 9 after dilation. Fig.11 shows the binary image in Fig.9 after erosion.

Fig. 10: The porcelain image after dilation

Fig. 11: The porcelain image after erosion

D. *Segmentation*

Currency segmentation, an operation similar to Watershed Segmentation, extracts objects from the background (Lin et al. [14]) using a boundary extraction treatment after the object has been subjected to the object filter.

1) Boundary Extraction: in order to achieve precise segmentation, this research uses an 8-way cold chain to

determine the contour of the object in order to perform the object segmentation. A closed object boundary can be extracted, as shown in Fig. 12.

2) Watershed Segmentation: In order to improve the feature extraction of objects and for retrieval comparison purposes, this study aimed to separate money from the background images using methods similar to watershed segmentation for achieving the 0 and 1 that represent the segmentation of background and object, respectively. After processing by the watershed segmentation method, the money object can be separated from the background image, as shown in Fig. 13, and the image of the object can be obtained.

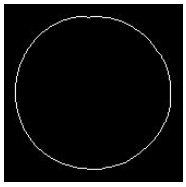


Fig. 12: Result of boundary extraction

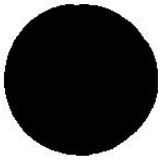


Fig. 13: Object image after watershed segmentation

III. Experimental Results

In this paper, trials using 600 currency images were conducted separately; the images were obtained from Resources Retrieval System of the National Museum of History [16] and the Taiwan Currency Website [17]. These images consist of different dates, colors, and shapes, such as: shellfish, Bo class, cutter, hole side type, coins and bills. In this study, the experimental results of image segmentation were compared and analyzed using Otsu's [15] and Level Set [9] methods, respectively. In order to verify the resistance of image segmentation methods in this study, the image segmentation experiments were conducted after noise signals were added into the original image.

A. Comparison and Analysis of Currency Image Segmentation

In this study, currency images were divided into three categories in accordance with the degree of difficulty according to human visual identification between the currency and background; the first category is the simple type, the second is medium type, and the third category is the complicated type, as shown in Fig. 14.

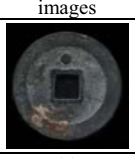
The first category of images	The second category of images	The third category of images
		
(a)	(c)	(e)
		
(b)	(d)	(f)

Fig. 14: Experimental images

1) Simple type images: simple type refer to images where the background can be clearly distinguished from the currency, as shown in Fig.14 (a) (b). The experimental results of currency segmentation of the first category of images are shown in Fig.15. Significantly, the results of the Level Set [9] method proved difficult insofar as separating the currency from the background and resulted in the splitting phenomenon; Otsu's [15] method resulted in the loss of currency information could not cut out the entire images of the currency; the method designed for this study can cut out the currency image more accurately and completely.

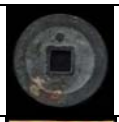
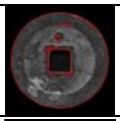
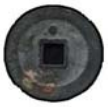
	original image	Level set [8]	Otsu's [15]	The method of this study
(a)				
(b)				

Fig. 15: Cutting results of the first category of images

2) Medium type images: the shadow images that are generated from different lighting angles when the images were taken belong to the Medium type category, as shown in Figs.14 (c) and (d). The experimental results of the second type of images are shown in Fig. 16. It was found from the results that the Level Set method [9] is vulnerable to influence from shadowing; Otsu's method [15]; although a small portion of image was influenced by the shadow, the image of the currency cannot be entirely separated. Notably, the method used by this study has not been affected by the shadow, and can completely cut out the money.

	original image	Level set[9]	Otsu's[15]	The proposed method
(c)				
(d)				

Fig. 16: Comparison of the cutting results of the second category images

3) Complicated images: the colors of currency and background are very similar, as shown in Figs. 14 (e) and (f). The experimental results of the third type of image are shown in Fig. 17. The results indicate that the Level Set method [9] and Otsu's [15] method are severely affected by similar colors in the currency's image as well as the background and shadowing and cannot complete cut out the images of the currency. Our method can overcome these problems.

Fig. 17: The comparison of the cutting results of the third category images

B. Comparison and analysis of the resistance

To verify the resistance of the segmentation method, the Speckle noises were added into the image in this study. Experimental results are shown in Fig. 18. The results from the Level set [9] are vulnerable to disturbance, which cannot successful complete currency segmentation; Otsu's method [15] cannot cut out the image of the currency; the proposed method can accurately cut out the currency.

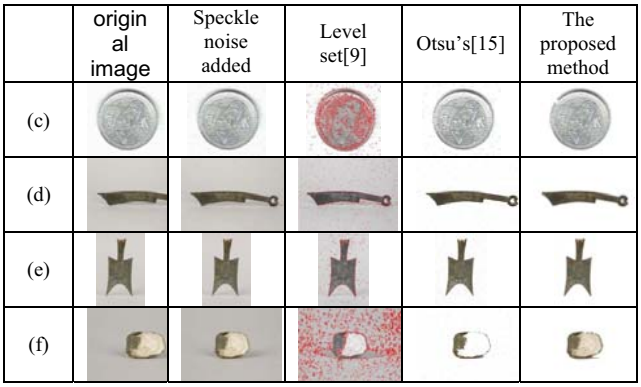


Fig. 18: Comparison of the cutting results from the Speckle noise.

C. Performance Evaluation

In order to more accurately and concretely verify the cutting results, the criteria of Modified Hausdorff Distance (MHD) [18] were used to evaluate the performance in this study. Then, an artificial enhancement of the outline of the money, referred to as the reference image, was further analyzed and compared with the experimental results of this study. MHD is the scope pixel value of distance that measures the reference image and the experimental image of the money contours; MHD can be defined as follows:

$$MHD(F_O, F_T) = \max(d_{MHD}(F_O, F_T), d_{MHD}(F_T, F_O)), \quad (1)$$

in the above equation,

$$d_{MHD}(F_O, F_T) = \frac{1}{|F_o|} \sum_{f_O \in F_O} \min_{f_T \in F_T} \| f_O - f_T \|, \quad (2)$$

and $\| f_O - f_T \|$ indicates the Euclidean distance between two pixels in the foreground of the reference and experimental images. The smaller the MHD values, the more comparable an object is to the reference image. In this study, when the MHD <0.5, it signifies the success of currency segmentation. Therefore, the *success sheets number* of these results is 536, as shown in Table I.

TABLE I
Experimental statistics the number of sheets

	The total sheets number	The success sheets number	Success rate
Shellfish	12	8	**66.67%**
Bo Dollar	31	31	**100.0%**
Knife	15	15	**100.0%**
Square Hole	478	419	**87.66%**
Coin type	38	37	**97.36%**
Banknotes category	26	26	**100.0%**
Total amount	600	536	**89.33%**

IV. CONCLUSIONS

With a massive number of currency images, in order to help users quickly search, this paper proposes an image preprocessing method designed to first enhance the textures and then, use texture feature extraction methods proposed by Lin [14]. Then, we combine this process with image cutting technology to allow for image background and currency separation. In this study, we defined three categories of difficulty with which human visual recognition perceives the objects and background. We compared our study with results from Otsu's Method and Level set methods to verification. For more accurate and more concrete verification of the effectiveness of this proposed method, in addition to completing currency image segmentation, this study also adds Speckle noise to the experimental images and further compares with the Otsu's and Level set methods. We also use the criteria of MHD Performance Evaluation to evaluate the effectiveness of the image cutting methods proposed. This research clearly shows that our proposed method can be faster and more accurate, and can achieve the currency image segmentation.

REFERENCES

[1] National Palace museum – archives of information retrieval，http://www.npm.gov.tw/digitization/implementation/archives.htm。
[2] Shenzhen Museum，http://www.szhwtcg.com/Products.asp。
[3] J. Haddon, and J. Boyce, "Image segmentation by unifying region and boundary information," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 12, Issue 10, pp. 929-948, October, 1990.
[4] M. Kass, A. Witkin, and D. Terzopoulos, "Snakes: active contour models," International Journal of Computer Vision, vol. 1, pp. 321-331, 1998..
[5] R. C. Gonzalez, and R. E. Woods, "Digital image processing," Prentice-Hall, 2002.
[6] J. F. Canny, "A computational approach to edge detection," IEEE Transaction on Pattern Analysis and Machine Intelligence, vol. 8, No. 6, pp. 679-698, 1986.
[7] L. Ding, and A. Goshtasby, "On the Canny Edge Detector," Pattern Recognition, vol. 34, pp.721-725, 2001.
[8] D. Mumford, and J. Shah, "Optimal approximations by piecewise smooth function and associated variational problems," Communications on Pure and Applied Mathematics, Vol. 42, pp.577-685, 1898.

[9] T. F. Chan, Member, IEEE, and L. A. Vese, ”Active contours without edges”, IEEE Transactions on Image Processing, vol. 10, No. 2, pp. 266-277, 2001.
[10] Z. Hou, Q. Hu, W. L. Nowinski, “On minimum variance thresholding,” Pattern Recognition Letters, vol. 27, pp. 1732-1743, 2006.
[11] C. Xu, and J. L. Prince, “Snakes, Shapes, and Gradient Vector Flow,” IEEE Transactions on Image Processing, vol. 7, No. 3, pp. 359-369, 1998.
[12] M. Kass, A. Witkin, and D. Terzopoulos, “Snakes: Active Contour Models,” International Journal of Computer Vision, vol. 1, pp. 321-331, 1998.
[13] A. Davatzikos, J.L. Prince, “An active contour model for mapping the cortex,” IEEE Transactions on Medical Imaging, vol.14, pp. 65–80, 1995.
[14] C. H. Lin, and Y. J. Syu, “Fast segmentation of porcelain images based on texture features,” Journal of Visual Communication and Image Representation, May, 2010.
[15] N. Otsu, “A threshold selection method from gray-level histograms,” IEEE Transactions of Systems, Man, and Cybernetics , vol. 9, 62-66, 1979.
[16] National Museum of History- Search Library Resources ， http://collection.nmh.gov.tw/zh-tw/Home.htm。
[17] 台灣貨幣，http://member.giga.net.tw/taiwannote/index.htm。
[18] M. Sezgin, and B. Sankur, “Survey over image thresholding techniques and quantitative performance evaluation”, Journal of Electronic Imaging , vol.13, Issue 1, pp.146-165, 2004.