3rd International Conference on Computer Networks and Information Technology on 8th - 9th July 2017, in Pattaya,Thailand ISBN: 9780998900018

AUTOMATIC LIBRARY SHELF READING FROM BOOK-SPINE IMAGE RECOGNITION

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Abstract—This paper has proposed the automatic library shelf reading from book spine image recognition. Program classified books into 10 categories by analyzing the average color of color tag on book's spine. The system has three main steps. The first step is preprocessing. It consists of removing noise from the RGB image by Median filter and adjusting the contrast by gray-level transformation. The second step is the color tag edge detection using Difference of Gaussians technique. The third step is book categories considering from the color average of each color tag on book's spine. The average accuracy is 97.40%.

Keywords—book-spine image, Difference of Gaussian, library.

I. Introduction

Nowadays, technology has become an important thing in our day life. Also the library, it has to transform from old manual system to become a smart library. A library shelf reading is time consuming and costly task [1]. Librarian has to manually shelf reading, classifying book, and reshelving a misplace book. These repetitive tasks need an expert librarian. The automatic shelf reading could make library innovative and efficient. The repetitive tasks could be replaced with the computer system.

In literature review, radio frequency identification (RFID) tag are popular method for wireless communication to locate a book positioning in library. Wing W.Y. NG et al. [2] proposed Radial Basis Function Neural Network (RBFNN) and image matching to locate a RFID tagged books. Yuanzhong Shu et al. [3] used LANDMARC algorithm based on RFID technology to locate a book. But the RFID tag is a high investment both in time and money.

The color information is also used to identify objects [4]-[6]. Spencer G. Fower, Dah-Jye Lee and Guangming Xiong [7]-[8] proposed Color Difference of Gaussians Scale Invariant Feature Transform algorithm for improving the library inventory process. The RGB images are converted to YC_bC_r. The color information then matched to the database. The algorithm is still have a problem with low contrast image.

At Burapha university, Chanthaburi campus, a color dot paper is used to labeling book category. It was placed at the bottom of book spine. Each book spine color information represent book categories. They are ten book categories according to the Dewey Decimal classification. Every day, librarian have to spent lot of

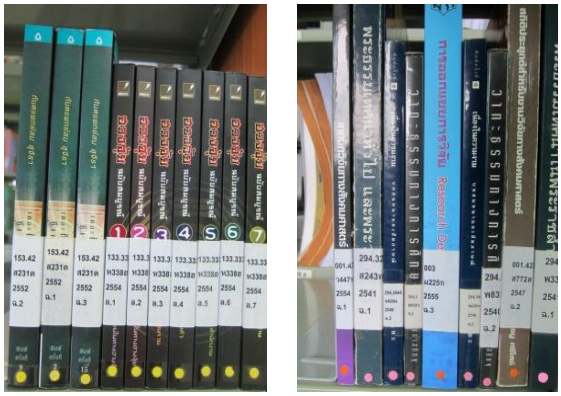
time on shelf management. Misplaced books are always found.

This paper present an automatic shelf reading using image processing from color tag on book spine. The proposed method could be easily merged into an existed library system. Only image capturing device such as smart phone is needed. The images of book spine are captured and then send to match the color information in shelf data set. It's low cost and simple process but very efficiency. With the large number of book, an automatic shelf reading could increase task performance and save a librarian time.

II. Proposed method

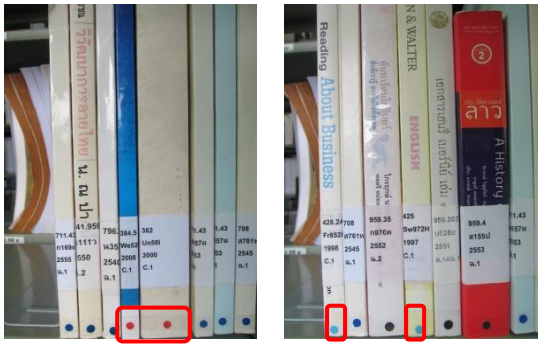
A. Image Aquisition

The book shelf images are taken from the Burapha university, Chanthaburi campus library with smart phone. They are RGB images with 512x685 pixels size. The book contains ten categories (ID 000- ID 900). Totally 200 images are used. They are divided in ten categories equally. Book shelf images and color of book spine are shown in Fig. 1, Fig. 2 and Table 1.



(a) (b)

Fig. 1. Example of correct book shelf images (a) Philosophy shelf, and (b) Religion shelf



(a) (b)

Fig. 2. Example of misplace book shelf images (a) Generality book is misplaced in Arts and Recreation shelf, and (b) Language and Literature books are misplaced in Technology shelf.

TABLE I: COLOR OF BOOK SPINE

Category	Color	Name
000	(orange)	Generalities
100	(yellow)	Philosophy
200	(pink)	Religion
300	(red)	Social Sciences
400	(light blue)	Language
500	(dark green)	Science
600	(purple)	Technology
700	(dark blue)	Arts and Recreation
800	(light green)	Literature
900	(black)	History and geography

B. Image Enhancement

Noise removal with median filtering is used. A median filtering method is an effective method to reduce noise by sliding window on the original image and replace a center pixel with median value like a smoothing technique. And to improve the quality of the images, a gray level transformations is applied. A transformation function is used. A output image will be have clearer brightness and more contrast. The

equation of gray level transformation is shown in Eq. (1).

$s = T(r)$ (1)

where r is input image and s is output image

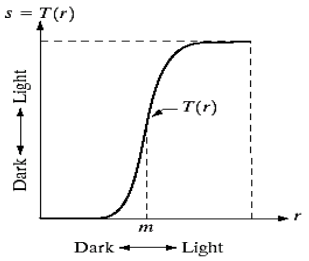


Fig. 3. Gray level transformation function (http://bme.med.upatras.gr/improc/image_negatives.htm)

C. Edge Detection

To identify the category of each book, the circle color tag has to be detected. Difference of Gaussians (DoG) [9]-[10] technique is used to detect the edge of circle color tag. The main idea is about the subtraction of one blurred image of an original image from another. The image is blurred by convolution with Gaussian filter of certain width σ_1. The Gaussian filter is shown in Eq.(2) and (3). The DoG is shown in Eq. (4)

$$G_{\sigma_1}(x,y) = \frac{1}{\sqrt{2\pi\sigma_1^2}} exp\left(-\frac{x^2+y^2}{2\sigma_1^2}\right) \quad (2)$$

to get

$$g_1(x,y) = G_{\sigma_1}(x,y) * f(x,y) \quad (3)$$

$DoG = g_2(x,y) - g_1(x,y)$ (4)

where σ is standard deviation $G_{\sigma 1}(x,y)$ is coefficient of Gaussian function

$g_1(x,y)$ and $g_2(x,y)$ are Gaussian filter with σ_1 and σ_2

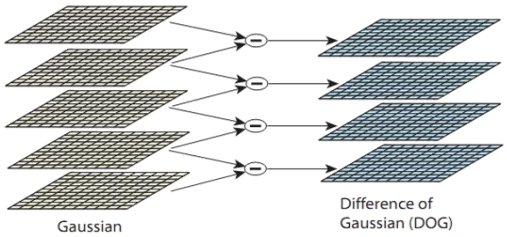


Fig. 4. Difference of Gaussian (DoG) (http://aishack.in/tutorials/sift-scale-invariant-feature-transform-log-approximation)

D. Interested Area Selection

From the previous step, all clear edge object are detected. We have to select only circle color tag by divide the area of book spine into small part equally and remove all object over the part which contain the circle color tag. A slightly unwanted objects are remains. A non-circle objects are then removed at the final. The result are shown in Fig. 5.

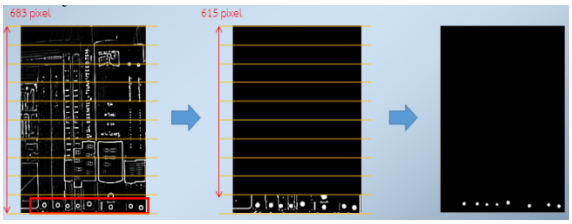


Fig. 5. Interested area selection.

E. Feature Matching

Due to the invariant to scale, inconstant color shade, the average value of each color tag from RGB images are considered. Each detected color tag will be compared with the average valued to identify its category. Table II. shown the average RGB value of each book category.

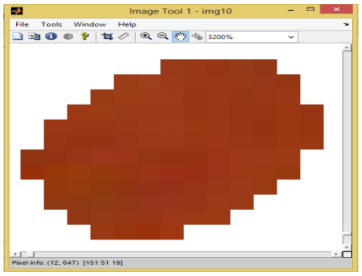


Fig. 6. Average color values calculation.

TABLE II: AVERAGE VALUE OF COLOR OF BOOK SPINE

Category	RED	GREEN	BLUE
000	214.94 – 220.49	74.34 – 79.99	32.91 – 39.28
100	194.06 – 199.64	196.39 – 203.05	20.82 – 26.32
200	220.27 – 226.95	116.42 – 122.95	185.94 – 192.99
300	193.23 – 200.73	41.12 – 46.80	42.45 – 47.69
400	68.65 – 74.98	170.83 – 177.66	192.64 – 198.89
500	42.09 – 50.00	114.06 – 121.33	64.09 – 71.78
600	86.14 – 94.13	50.45 – 56.97	132.93 – 140.91
700	18.62 – 24.83	66.67 – 72.85	133.70 – 140.80
800	80.08 – 89.11	167.55 – 178.03	62.12 – 71.88
900	33.78 – 38.72	33.90 – 39.03	31.27 – 37.99

F. Performance Evaluation

The image-based evaluation is performed. The accuracy, sensitivity and specificity are used to evaluate classifier performance. Accuracy measures the degree of veracity of a diagnostic test on a condition. The sensitivity measures the true condition that is correctly detected over total number of subjects with given condition. The specificity measures how condition is correctly detected over total number of subjects without given condition. The equation of each values are given below

$$Accuracy\,(\%) = \frac{Total\ number\ of\ correct\ prediction}{Total\ number\ of\ instances\ prediction\ in\ test} \quad (3)$$

$$Sensitivity(\%) = \frac{True\ Positive\ (TP)}{True\ Positive\ (TP) + False\ Negative\ (FN)} * 100 \quad (4)$$

$$Specificity\,(\%) = \frac{True\ Negative\ (TN)}{True\ Negative\ (TN) + False\ Positive\ (FP)} * 100 \quad (5)$$

where TP is the number of classes correctly classified as positive, TN is the number of classes correctly classified as negative, FP is the number of test instances that is falsely classified as positive and FN is the number of test instances that is falsely classified as negative.

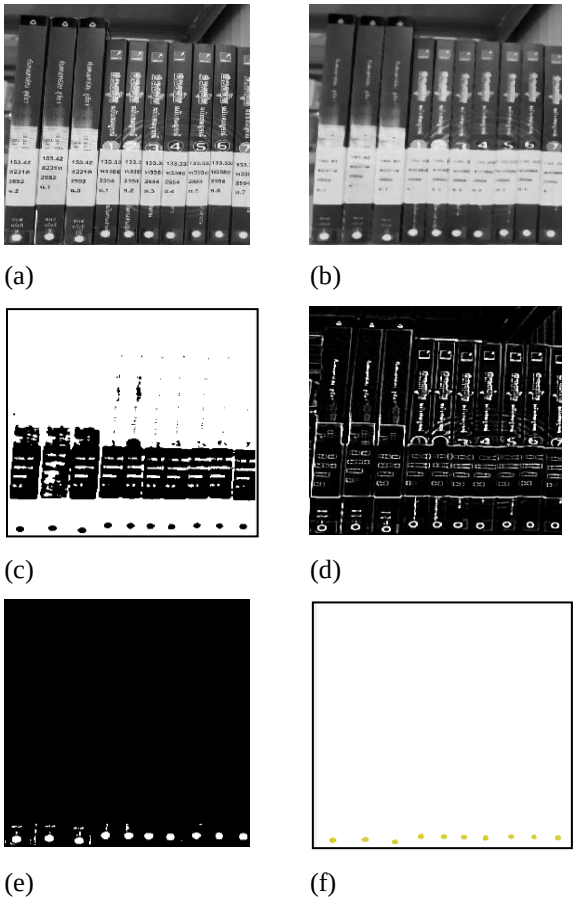


Fig. 7. Result of book spine detection (a) red band (from RGB) image, (b) noise removal image, (c) enhanced image, (d) edge detected image, (e) interested area selected image, and (f) circle color tag detected image.

III. RESULT AND DISCUSSION

To test the performance, a dataset images are taken from bookshelves in th Burapha university, Chanthaburi campus. From 10 book categories, 20 images from each categories are tested. The detected circle color tag are compared with the average color value in database. The sensitivity, specificity and accuracy of overall system are 99.92%, 91.95% and 97.40% respectively. Low light situation is one of the cause of misclassify. Another causes are from the difference size of book, uncertain area of circle tag and damaged tag.

IV. CONCLUSION

In this paper we present the automatic library shelf reading from book spine using image processing techniques. The color feature is used. The experimental results has a significant accuracy at 97.40%. The system could help the librarian to manage the bookshelves more easily and more accurately. In future work, the performance can be increased with more images data and better edge detection.

ACKNOWLEDGMENT

This research is funded by Faculty of Humanities and Social Sciences, Burapha University.

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