

應用於文件分析的彩色表格二元量化技術  
Binary Quantization of Color Table Images for Document Analysis

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摘要

表格處理是屬於文件分析技術的一部份。早期的研究全都專注於黑底白字形態的表格，在本論文中我們提出了一個有效的方法將彩色表格轉換成黑底白字形態的表格，以便後續處理。

關鍵字: 文件分析, 表格處理, 彩色影像處理

Abstract

Table processing is a subdomain of document analysis technology. Earlier researches are all based on the assumption that data is presented in the white-background/black-text (WB/BT) binary type. In this paper we propose a method for transforming color tables into binary format to facilitate subsequent processing.

Keywords: document analysis, table processing, color image processing

1. Introduction

Many works concerning document image processing have been reported during the latest decade. This research field has involved a great number of studies because there is more and more urgent requisite to transform volumes of paper-based documents into a digitized format. A digitized document has many advantages over a paper-based one. For example, a digitized document needs much less space to store than a paper-based document; a digitized document can also be retrieved and reproduced in a more efficient and economical way. A more significant strength of digitized documents is that they can be conveyed by networks and this fact makes them gain more special appreciation in the modern applications. However, to give computers an ability to recognize paper-based documents is a challenging task. A number of prototype systems dedicated to some specific domain have been explored in recent years. A category of them concentrated on dealing with table of form images [1-10]. To simplify the task, all the

型號	分辨率/英寸	重量/克	厚度/英寸	價格/美元
1001	1000x1000	100g	0.1	100
1002	1000x1000	100g	0.1	100
1003	1000x1000	100g	0.1	100
1004	1000x1000	100g	0.1	100
1005	1000x1000	100g	0.1	100
1006	1000x1000	100g	0.1	100
1007	1000x1000	100g	0.1	100
1008	1000x1000	100g	0.1	100
1009	1000x1000	100g	0.1	100
1010	1000x1000	100g	0.1	100
1011	1000x1000	100g	0.1	100
1012	1000x1000	100g	0.1	100
1013	1000x1000	100g	0.1	100
1014	1000x1000	100g	0.1	100
1015	1000x1000	100g	0.1	100
1016	1000x1000	100g	0.1	100
1017	1000x1000	100g	0.1	100
1018	1000x1000	100g	0.1	100
1019	1000x1000	100g	0.1	100
1020	1000x1000	100g	0.1	100

(a)

	造型設計	車廂內部	功能作用	登車入座
一	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
手	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
單	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
訊	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
消	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
費	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
評	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
比	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手
表	車頭造型 車身顏色 車窗玻璃	通風設備 照明設備 地毯	防盜設備 防暴設備 防劫設備	登車門 登車梯 登車扶手

(b)

Fig. 1. Color tables presented in Chinese magazines.

車型	研研等位L/KE1	尖玉星GL/TKS	霹靂馬GL/GTA	Essior GLi/GLx
排氣量	1997cc	1991cc	1998cc	1998cc
引擎設計	直列四缸SOHC 16V	直列四缸DOHC 16V	直列四缸DOHC 16V	直列四缸DOHC 16V
最大馬力	133hp/5700rpm	116hp/5500rpm	142hp/6000rpm	133hp/5800rpm
最大扭力	18.5kgm/5000rpm	17.3kgm/4500rpm	18.2kgm/4600rpm	18.8/4600rpm
變速裝置	5MT/4AT/4AT	4AT/5MT/4AT	5MT/4AT/4AT	5MT/4AT/4AT
車長	4475mm	4470mm	4400mm	4420mm
車高	1400mm	1390mm	1395mm	1410mm
車重	1290kg/1300kg	1217kg	1274kg	1210/1260kg
軸距尺寸	195/65R15	195/65R14	185/65R15	185/65R14
安全裝置	...	...	...	...
AES	...	...	...	...
安全氣囊	...	...	...	...
組合音響	...	...	...	...

(a)

一手車訊消費評比表	車廂內部	功能作用
	選購材料第一級效果	控制排氣管溫度
	...	...
	...	...

(b)

Fig. 2. Table images obtained by scanning the color tables shown in Fig. 1 using the binary mode.

proposed techniques have made a prior assumption that the input table or form images are in the white-background/black-text (WB/BT) binary format. Although this condition is commonly held for monochrome tables, it is not always true for the color tables appearing frequently in today's magazines and newspapers (see Fig. 1 for example). Hence, if we want to employ these existing techniques to process color tables, the color table must be quantized into the WB/BT type first. A simple method of doing that is to directly scan the color table using the binary format.

The table images shown in Fig. 2 are obtained in this way. It can be seen that the results are not satisfying because some text has been smeared seriously in these images and therefore a considerable piece of information has been lost. To avoid this problem, a more sophisticated method is required to achieve this task. We present in this paper an approach toward this end.

## 2. Proposed approach for binarizing color table images

In a color table, table cells can be of any color and so can the characters in the table cells. Hence, we can not make any *a priori* assumption on the colors of characters and the table cells. However, if we want to directly detect the colors of characters or table cells on the color image, the computational complexity will be relatively high because there can be 16 million colors in a true-color image (this is the image format used in our study). In this paper, we propose an efficient method for solving such a problem. We first use a color edge detection technique to find out edges in the color table image. For each pixel with coordinates (i, j), its gradients on the R, G, and B color bands are computed, respectively, using the Sobel operators [11]. For instance, the gradient at pixel p(i, j) on the R color band is computed by the following formula

$$\nabla f_R = \begin{bmatrix} G_{R_v} \\ G_{R_h} \end{bmatrix}$$

where

$$G_{R_v} = p_R(i+1, j-1) + 2p_R(i+1, j) + p_R(i+1, j+1) - p_R(i-1, j-1) - 2p_R(i-1, j) - p_R(i-1, j+1)$$

$$G_{R_h} = p_R(i+1, j+1) + 2p_R(i, j+1) + p_R(i-1, j+1) - p_R(i+1, j-1) - 2p_R(i, j-1) - p_R(i-1, j-1)$$

The gradients at pixel p(i, j) on G and B color bands (i.e.,  $\nabla f_G$  and  $\nabla f_B$ ) can also be computed in a similar manner. Since edges in color images appear at the points where R, G, and B color values have abrupt transitions, the edge strength of each pixel can be evaluated by

$$\text{edge strength} = |\nabla f_R| + |\nabla f_G| + |\nabla f_B|$$

Then, the pixels with high edge strength will be regarded as the edge points. During processing, the result is written into a new binary image: edge points are represented by 1 (as white) and non-edge points are represented by 0 (as black). Fig. 3 shows the binary edge image of the table image shown in Fig. 1(a).

項目	新華中 XL1/XR1	大正風 GL1/TS	廣龍角 GL1/G1/G1A	RealDoc GL1/G1/G1
顯示器	1997cc	1991cc	1998cc	1998cc
引擎設計	直列四缸 DOHC 16V	直列四缸 DOHC 16V	直列四缸 DOHC 16V	直列四缸 DOHC 16V
壓縮比	9.0:1	9.1:1	9.3:1	9.8:1
最大馬力	155hp/5700rpm	118hp/5500rpm	142hp/5400rpm	133hp/5800rpm
最大扭力	18.5kgm/3000rpm	17.3kgm/4500rpm	18.2kgm/4800rpm	18.4/4600rpm
排氣系統	雙邊雙出口/四吸	雙邊雙出口/四吸	四吸雙出口	四吸雙出口
變速系統	5MT/4AT/6AT	4AT/5MT/6AT	5MT/4AT/6AT	5MT/4AT/6AT
車長	4675mm	4670mm	4600mm	4620mm
車寬	1780mm	1770mm	1790mm	1695mm
車高	1400mm	1390mm	1395mm	1420mm
車重	1280kg/1300kg	1217kg	1274kg	1210/1240kg
軸距	2715mm	2610mm	2550mm	2580mm
軸距尺寸	185/65R15	185/65R14	185/65R15	185/65R14
安全配置	ABS		ABS	ABS
安全氣袋	前排	前排	前排	前排
安全氣袋	前排	前排	前排	前排
售價(萬)	40.8/43.8/46.8	43.5/46.7/49.8	46.5/49.8/53.8	40.5/43.5/46.5

Fig. 3. Binary edge image of Fig. 1(a).

From the viewpoint of a reader, no matter how a color table is organized, the table background and data cells are both meaning just background parts in contrast to the foreground characters and line structures. Thus, if we can identify these background areas in the table image, then a WB/BT version of the table image can be obtained by resetting all the pixels belonging to the background areas to white and other pixels to black. Examining carefully the binary edge image shown in Fig. 3, we can see that the black regions in the image are just the background areas in addition to some small fragments within characters. To pick out the desired background areas, we first use a connected component labeling algorithm to locate all the black regions in the binary edge image. During the labeling procedure, the location, color, and pixel count of each black region are memorized. The location of a black region is represented by a bounding rectangle that encloses it. The color of a black region is represented by the color of the corresponding region in the original table image. The pixel count of a black region is the total number of pixels belonging to the region.

After the black regions on the binary edge image are extracted, we then make a pixel count histogram of them, as illustrated in Fig. 4. It can be seen that these black regions clustered distinctly into two groups in the pixel count histogram. Those regions with pixel count fewer than 1000 gathered as class one while the regions with pixel count more than 15000 gathered as class two. By tracing the locations of the black regions of class one, we found that they are just the small fragments within characters; on the other hand, the black regions of class two are the background areas. This is not just a special situation in this illustrative case. In fact, after examining over twenty different table images, we realized that the

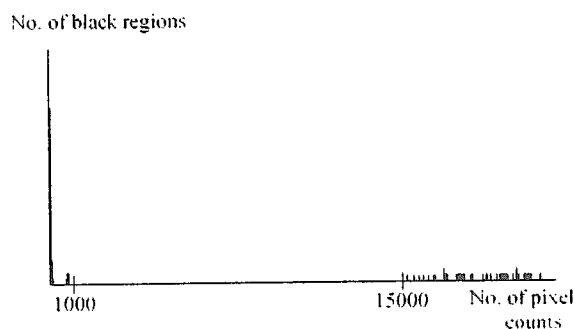


Fig. 4. Pixel count histogram of the black regions extracted from Fig. 3.

pixel counts of the small fragments within characters are always much fewer than the pixel counts of the background regions in a table image. According to this practice, the background areas can be distinguished from all the extracted regions by using only a filter for the pixel count. To determine a proper threshold value for filtering off the spurious fragments within characters, we initially scan the pixel count histogram within the range of 0 to 10000 to find the longest valley in this range. Suppose that the located valley starts from  $s$  and ends at  $t$ . Then the threshold value is chosen to be  $(s+t)/2$ . Once the background areas are identified, a WB/BT format of the color table image can be obtained by converting all the pixels belonging to the background areas to white and other pixels to black. As all the extracted background regions have been specified by respective bounding rectangles and their colors are also recognized, this pixel type conversion can be conveniently achieved by sequentially examining each pixel within the bounding rectangles to see if its color is close to the background color. Those pixels with nearly background color are considered as background parts and hence are reset to white while other pixels are reset to black as foreground components. When this conversion finishes, the resulting image is just the desired result.

### 3. Experimental results and discussion

The proposed approach was implemented and tested on a Pentium/200 PC. Fig. 5 illustrates the processing results of the table images shown in Fig. 1. As can be seen, these table images are successfully converted into the WB/BT binary format. The quality of the resulting images are also far better than those obtained through directly scanning the tables using the binary mode, as shown in Fig. 2. Fig. 6 is a table image scanned in a skew type, together with its processing result. This case demonstrates that our approach still work well even if the table image is severely skewed. To sum up, since the proposed approach does not

項目	新華牌XHL/XEL	大生型GL/TXS	森高型GL/ST/STA	德律風GL/GDX2
耗電量	120W	120W	120W	120W
引擎規格	直列四缸SOMC 16V	直列四缸D9MC 16V	直列四缸D9MC 16V	直列四缸D9MC 16V
壓縮比	9.5:1	9.5:1	9.5:1	9.5:1
最大馬力	125hp/5700rpm	125hp/5500rpm	142hp/6400rpm	123hp/5600rpm
最大扭力	18.5kgm/3000rpm	17.3kgm/4200rpm	19.7kgm/4800rpm	16.8kgm/4000rpm
煞車系統	前碟後鼓/四碟	前碟後鼓/四碟	四輪碟式	四輪碟式
變速裝置	5D/4.45/4.0	4.07/3.97/3.63	5D/4.45/4.0	5D/4.45/4.0
車長	4175mm	4175mm	4420mm	4175mm
車寬	1755mm	1775mm	1790mm	1745mm
車高	1420mm	1392mm	1392mm	1415mm
車重	1295kg/1320kg	1217kg	1274kg	1210/1245kg
軸距	2715mm	2415mm	2415mm	2530mm
輪胎尺寸	175/65SR16	195/65SR16	195/65SR16	185/65SR16
加速裝置	.....	.....	.....	.....
安全裝置	.....	.....	.....	.....
安全裝置	.....	.....	.....	.....
售價(萬)	47.8/43.6/44.8	43.1/44.7/45.8	51.9/42.0/44.0	42.1/43.5/42.8

(a)

引擎型式	Acura NSX	Toyota Supra	Honda CRX	Mitsubishi 3000GT	Nissan 300ZX
引擎型式	2.7 D9MC VTEC	2.8 D9MC VTEC	1.8 D9MC	3.0 D9MC	3.0 D9MC
壓縮比	9.5	9.5	9.5	9.5	9.5
最大馬力 hp/rpm	208/5300	208/5300	142/5500	142/5500	142/5500
最大扭力 kgm/rpm	30.0/3500	30.0/3500	19.7/4000	19.7/4000	19.7/4000
軸距	2415	2415	2415	2415	2415
車長	4175	4175	4175	4175	4175
車寬	1755	1755	1755	1755	1755
車高	1420	1420	1420	1420	1420
車重	1210	1210	1210	1210	1210
售價	42.1	43.5	42.8	42.1	43.5

(a)

一	手	車	訊	消	費	評	比	表	說明			
									造型設計	車廂內部	功能作用	登車入座
										<p>在引後時... 造型設計</p> <p>依圓空... 車廂內部</p> <p>明位... 功能作用</p> <p>保... 登車入座</p>		

(b)

Fig. 5. Processing results of the table images shown in Fig. 1.

make any prior assumption on the color style and layout of the table images, it can be used to transform a wide fashion of color tables into the WB/BT binary format for further table recognition, and its practicability has been proved by test on over twenty different color table images.

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引擎型式	Acura NSX	Toyota Supra	Honda CRX	Mitsubishi 3000GT	Nissan 300ZX
引擎型式	2.7 D9MC VTEC	2.8 D9MC VTEC	1.8 D9MC	3.0 D9MC	3.0 D9MC
壓縮比	9.5	9.5	9.5	9.5	9.5
最大馬力 hp/rpm	208/5300	208/5300	142/5500	142/5500	142/5500
最大扭力 kgm/rpm	30.0/3500	30.0/3500	19.7/4000	19.7/4000	19.7/4000
軸距	2415	2415	2415	2415	2415
車長	4175	4175	4175	4175	4175
車寬	1755	1755	1755	1755	1755
車高	1420	1420	1420	1420	1420
車重	1210	1210	1210	1210	1210
售價	42.1	43.5	42.8	42.1	43.5

(b)

Fig. 6. (a) skewed table image; (b) processing result.

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