
Text extraction from images captured via mobile and digital devices

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Abstract: The paper presents the development of a human-machine interactive software application, specifically useful for text extraction from images, which are captured using mobile and digital devices with cameras. This software is the principal part of a full application, which is being developed to translate the text in such a captured image to another language. The full application will comprise of two stages: a processing stage (which is the part of concern in this paper) and a recognition stage. In the processing stage, an intelligent and adaptive algorithm will yield the essential information from the raw image. This paper will focus mainly on the development of the processing stage. In the recognition stage, the extracted text will be interpreted and translated through an optical character recognition (OCR) engine, which is widely available. The effectiveness of the proposed algorithm in meeting the challenges behind the processing of such images will be highlighted with real images.

Keywords: colour images; greyscale transformation; background analysis; noise elimination; edge detection; labelling; character recognition.

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1 Introduction

Mobile applications are rampantly available nowadays, for a whole variety of purposes. The small and inexpensive wearable devices facilitate new ways through which users can interact with the physical world. Besides the basic communication function for mobile phones, multimedia entertainment functions are fast expanding and reshaping the growth of this promising market for phone developers. Such existing functions including radio, recording, MPEG3 player, camera, map guide, dictionary, language translation and video conferencing.

With functions such as dictionary and language translation fast becoming a standard part of a mobile phone, coupled with the fact that the mobile is now essentially an item which follows its owner throughout the day, the stage is set for the development of mobile interpretation applications. An example of such an application scenario; a Japanese tourist in Singapore needs to navigate his way to a unit in a hospital through the signs available. He will snap an image of the sign using his mobile. The mobile application will preprocess the image and condition it into a form which contains the key text information he needs in a usable form. The processed form of the image can then be used by the optical character recognition (OCR) and language translation engines to yield the exact meaning of the sign in Japanese. The potential of such an application is immensely extensive.

This paper will focus on the development of such a mobile translation application. Apart from use for interpretation by transnational travellers as highlighted earlier, with such a function embedded in mobile device, a written message can be efficiently processed and sent to a target recipient via SMS, as shown in Figure 1. In addition, an adequate text extraction algorithm is a necessary and important component for OCR from camera-based images. The application is also amenable to the development of a seamless interface to the external world by propagating to specific website from a URL captured from an advertisement or a poster on the mobile phone. These set the motivation to develop a complete text extraction algorithm to equip the phone with real-time or near real-time translation function across different languages.

Figure 2 shows some signs taken by mobile phones. There are many challenges with respect to text extraction and recognition from modest images captured via mobile devices.

First, there can be a large variation in both the font size and font type of the text expected in the diverse forms of images captured [see Figures 2(a) and 2(b)]. Therefore, the threshold box for segmentation cannot be fixed at a specific size. Secondly, the resolution of such images will be typically modest. Coupled with an uncontrolled environment, uneven illumination and reflection [see Figure 2(a) where there is an obvious reflection in the image captured], and a possibly odd image capturing angle [see images in Figures 2(c), 2(d)], the target text captured can be blurred, all of these posing difficulties to text extraction. Thirdly, the text extraction and recognition function will inevitably be limited by the nature of the small-screen mobile devices, which will restrict the span of the image which can be captured. It may be difficult to capture a sign with just a homogenous background, and the inevitably unwanted part captured, if it differs from the background, may lead to problems during the processing stage [see images in Figures 2(b), 2(c), 2(d), 2(e) where the unwanted parts outside of the sign boundary were also captured]. Finally, images taken under a poor lighting condition may result in low

entropy [see the image in Figure 2(c)]. Low entropy may also cause problems in processing (entropy will be covered in more details in Section 2.2). In addition, it should be noted that this paper will only focus on text extraction from images containing text in a relatively simple background. Far more intensive computation will be necessary when the text is embedded in a complex background (Takahashi and Nakajima, 2005; Haritaoglu, 2001; Kim et al., 2005; Sun et al., 2003; Yang et al., 2004).

The proposed text extraction algorithm will be based on two assumptions. First, the font size of the text in the captured image should be sufficiently large, otherwise it may be ignored. Secondly, the background should be uniform or at least near uniform, and it should constitute a major part of the whole image. For example, in Figure 2(b), the portion outside of the sign boundary should not be larger than the green background, otherwise it may be treated as the background instead, and the entire entity within and including the boundary will be wrongly regarded as an object.

Figure 1 Efficient way to transmit an SMS (see online version for colours)



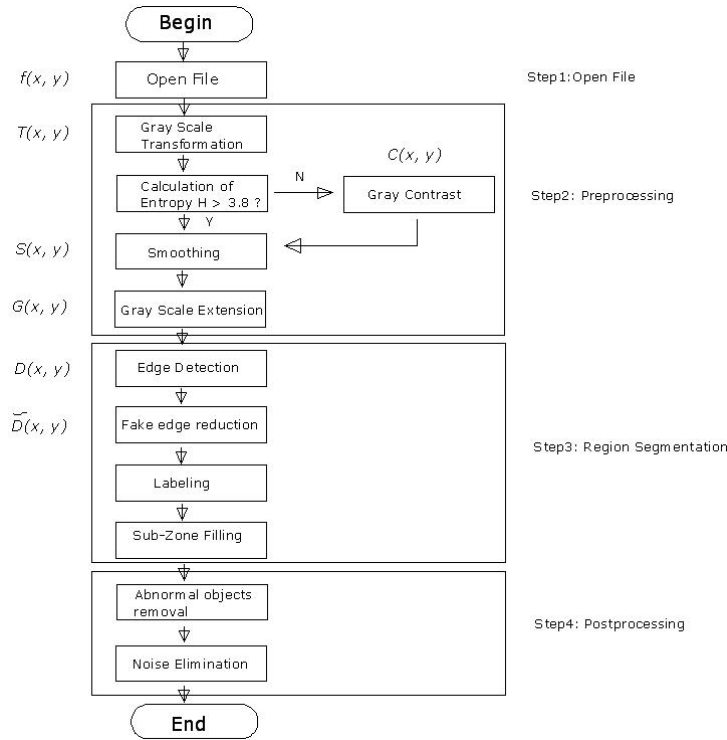
Figure 2 Sample of sign images which are captured with a mobile phone, (a) with reflection (b) with boundary (c) under poor lighting condition (d) with signs (e) with different font size (f) with characters and numbers (see online version for colours)



The full algorithm for the entire application comprises of two main stages; the processing stage and the recognition stage. In the processing stage, the original colour image will first be transformed to an adequate grey image, which is sufficient for the text extraction purpose (Section 2.1). Next, the sharp transition portions of the image (the edges) are detected using a revised Prewitt edge detection algorithm (Prewitt, 1970), which is specifically developed to meet the specific requirements of this application (Section 3.1). The algorithm assumes the edges will be black. After the edges are detected and closed-shapes formed, the image will be segmented into several white regions. The zone

with the largest area will be regarded as the background, and the difference of the colour value of the regions in the original image from the value associated with the background will be used to determine whether it is an object, or it is part of the background (Section 3.4). Following these steps, signs and noise may still exist in the processed image. A decision-making and elimination algorithm will be employed to remove these remaining unwanted parts. This completes the processing stage and at this time, only the desired characters will be left in the image, and they are ready to be sent to an OCR engine for interpretation. OCR software is widely available (Mori et al., 1999), and thus it will not be discussed further in the paper. The flow of the complete text extraction algorithm is shown in Figure 3. The details behind each of the step will be duly highlighted in the ensuing sections.

Figure 3 Flowchart



Note: The alphabets f , T etc., represent the original/transformed images at various stages of the processing, they will be referred to in the ensuing sections.

The rest of the paper is organised as follows. Section 2 will describe the preprocessing stage, which contains four steps in order to transform the original colour image to a grey level image, and increase its contrast when necessary. Section 3 will present the key part of the processing stage, which includes edge detection and region segmentation so as to segregate the region of interest (RoI) from the rest of the image, and to reconfigure the character. Section 4 will present the details of the post-processing algorithm proposed to eliminate the boundary and unwanted parts. Section 5 will show the experiment results when the software is applied to 30 real images captured with a mobile phone. The

accuracy of the recognition results by popular OCR software will be presented as well. Finally, in Section 6, the paper will be concluded with suggestions for future works.

2 Processing

The main objective behind this part of the algorithm is to transform the original colour image to a grey level image and if necessary, to increase the contrast between background and objects, so as to facilitate their separation. It involves five key steps as follows.

Figure 4 Image after greyscale transformation



2.1 Colour to greyscale transformation

The transformation function to transform a colour image to the grey level image is given in (2.1). Let $f(x, y)$ be the colour value of a pixel original image at the (x, y) position. (We will refer to f as the original colour image). Then $f(x, y).R$, $f(x, y).G$ and $f(x, y).B$, denotes the corresponding value of its red (R), green (G) and blue (B) components respectively. $T(x, y)$ represents the greyscale value of that pixel of the transformed image.

$$T(x, y) = 0.114 \times f(x, y).R + 0.587 \times f(x, y).G + 0.299 \times f(x, y).B \quad (2.1)$$

2.2 Entropy computation for contrast enhancement

Entropy, in the context of thermodynamics, is a measure of the disorder or randomness in a closed system. When applied to image processing, entropy represents the amount of information or the level of monotone of an image. Entropy can be computed as follows:

$$H = -\sum p_i \times \log p_i = \sum p_i \times \log \left(\frac{1}{p_i} \right) \quad (2.2)$$

H denotes the entropy of an image, p_i represents the proportion of greyscale values in the range $i \in [0, 255]$ over the entire image. Due to the limited computational ability of mobile devices, when an image is captured under poor lighting condition, the image will appear dark and monotonous compared to another which is taken under good lighting condition [see image in Figure 2(c) which was captured with a mobile phone under a street lamp]. Therefore, entropy can be used as an indication if an increase in the contrast of the image will be necessary. If the entropy calculated of the image is too low, the contrast can be increased, otherwise the detected edges of characters may not form closed shapes. To this end, a threshold for the entropy will be useful. For a visual feel of entropy value, the entropies of the images in Figures 2(a) to 2(f) are computed to be 4.58190, 4.68040, 3.33655, 4.92679, 4.24316 and 4.33515 respectively. From extensive experiments, an empirical value of $H_{thres} = 38$ is recommended to identify images, which needs to be enhanced in terms of the contrast. Under this guideline, the contrast of the image in Figure 1(c) needs to be increased prior to further steps. Figure 5 shows the same image before and after the enhancement of contrast.

A computationally efficient way to enhance contrast can be achieved through an exponential transformation:

$$C(x, y) = \frac{255}{1 + \exp\left(\frac{aver_T - T(x, y)}{v}\right)} \quad (2.3)$$

$C(x, y)$ denotes the transformed results. $aver_T$ is the average grey values in the image represented by T . The parameter v can be fixed at $v = 15$. Essentially, through this transformation, the range of grey values will be expanded to a wider range. Otherwise, if the entropy is less than H_{thres} , $C(x, y) = T(x, y)$. For image Figure 5(c), the relationship between C and T is shown in Figure 6.

Figure 5 Effect of contrast enhancement, (a) original image (b) greyscale image (c) after contrast enhancement (see online version for colours)

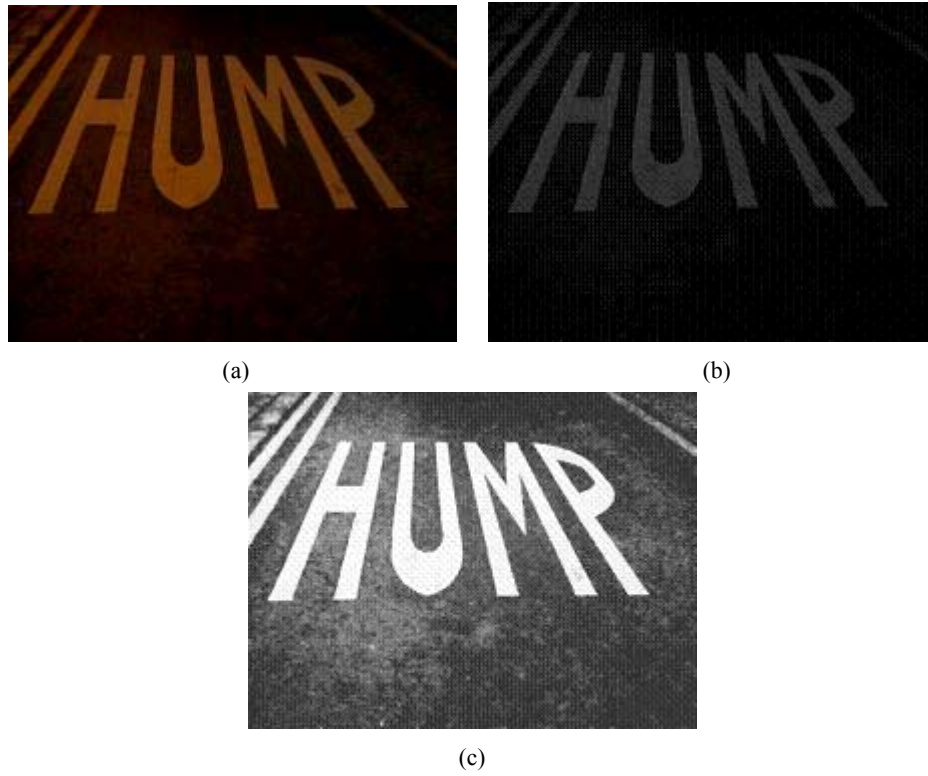
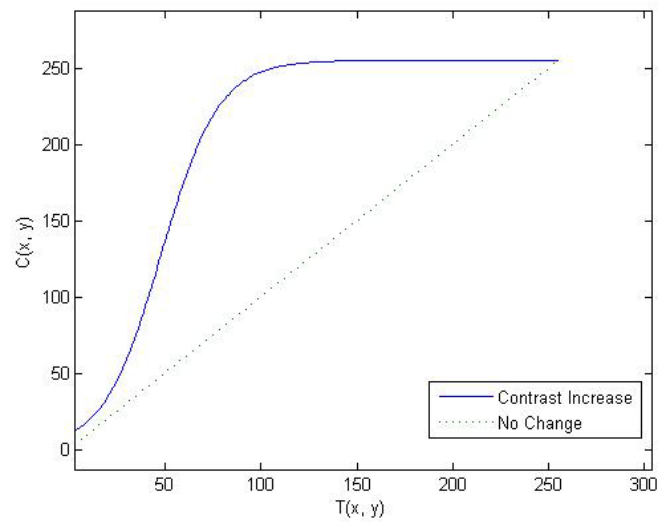


Figure 6 Contrast enhancement via exponential transformation ($aver_T = 48$) (see online version for colours)



2.3 Smoothing

Smoothing is also sometimes termed as blurring (Gonzalez and Woods, 2001). The aim of a smoothing function is to smooth the image prior to edge detection. The edge detection process aims to highlight the sharp transition parts in an image; however, many of these algorithms are quite sensitive to noise (Rakesh et al., 2004). Therefore, a simple smoothing algorithm may help to minimise the effects of these disturbances on the edge detection process. Smoothing is mainly achieved based on a mask which dictates the weightage of the surrounding pixels in influencing the pixel of concern. A possible mask M is shown in Figure 7.

Figure 7 Smoothing mask

1	1	1
1	2	1
1	1	1

Let $C(x, y)$ and $S(x, y)$ denote the greyscale value at position (x, y) of the image before and after the transformation. M represents the mask of Figure 7,

$$S(x, y) = \frac{1}{10} (C(x, y) \otimes M) \quad (2.4)$$

Figure 8 shows the images after smoothing is done.

Figure 8 Effects of smoothing, (a) with reflection (b) with boundary (c) under poor lighting conditions (d) with signs (e) different font size (f) characters with numbers

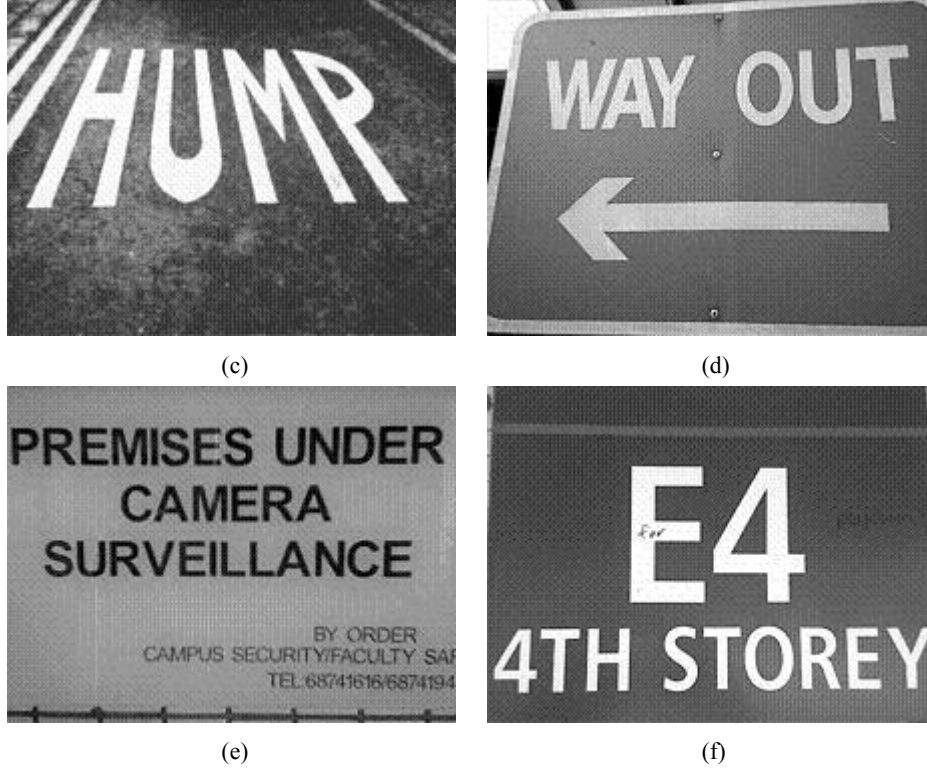


(a)



(b)

Figure 8 Effects of smoothing, (a) with reflection (b) with boundary (c) under poor lighting conditions (d) with signs (e) different font size (f) characters with numbers (continued)



2.4 Greyscale extension

Histogram analysis is an important tool in image processing. After the colour image has been transformed to the greyscale equivalent and conditioned to image S according to (2.4), the maximum $\max S$ and minimum $\min S$ greyscale values can be computed. If $\max S$ and $\min S$ are close to each other, e.g., $\max S - \min S < 80$, the greyscale image will be monotonous with a low contrast. Greyscale extension will increase contrast via exploiting the full range $\max S - \min S = 255$. If the original $\max S$ and $\min S$ are already 255 and 0 respectively, then the image will remain unchanged following the transformation (Klette and Zamperoni, 1996). Figure 9 depicts the extension result. Suppose the dimension of the image is $M \times N$.

$$\min_S = \min \{S(x, y) : 1 \leq x \leq M \wedge 1 \leq y \leq N\} \text{ and}$$

$$\max_S = \max \{S(x, y) : 1 \leq x \leq M \wedge 1 \leq y \leq N\}$$

Let $\alpha = -\min_S$ and $\beta = \frac{255}{\max_S - \min_S}$. Then the transformation equation is given by:

$$G(x, y) = (S(x, y) + \alpha) \times \beta \quad (2.5)$$

Where S is the greyscale image after the smoothing transformation in (2.4) and G represents the image following extension.

Figure 9 Effects of greyscale extension



More elaborate methods can be used to improve contrast (Shapiro and Veleva, 1992; (Ye et al., 2001). However, it should be noted that an adequate edge detection algorithm will be quite effective and efficient to detect transitional parts without exceptional contrast. This also means that an elaborate contrast enhancement algorithm is usually not necessary for this application. Edge detection is a keenly researched topic in image

pattern recognition (Canny, 1995). In this paper, an efficient edge detection algorithm based on a revision of an existing algorithm will be described in the next section.

3 Region segmentation

The main objective behind region segmentation is to segregate the grey image into several regions, so as to be able to separate the background from the objects (Gonzalez and Woods, 2001). It involves four key steps which will be explained in the ensuing subsections.

3.1 Edge detection

Several edge detection algorithms have been developed (Peli, 2002; Canny, 1995; Prewitt, 1970; Roberts, 1965). Among them, Canny's (1995) algorithm is arguably among the most popular and widely used. Compared to geological images, the features of characters are easier to be captured. The key issue is to ensure that the detected edges form a closed shape. Otherwise, two components will be labelled as one through the following step. This problem will compound when it comes to the subsequent filling process. In this section, we will present a new detection algorithm based on the revision of an existing one, to guarantee a closed shape for such images.

The eight kernels to be used in this algorithm are listed in Figure 10. In the literature, kernels can also be referred to as operators, detectors or masks.

Figure 10 Edge detection kernels

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & 1 \\ -1 & -1 & -1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 1 & -2 & -1 \\ 1 & -1 & -1 \end{bmatrix} \begin{bmatrix} 1 & 1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 1 & -1 & -1 \\ 1 & -2 & -1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -1 & -1 & -1 \\ 1 & -2 & 1 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} -1 & -1 & 1 \\ -1 & -2 & 1 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} -1 & 1 & 1 \\ -1 & -2 & 1 \\ -1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ -1 & -2 & 1 \\ -1 & -1 & 1 \end{bmatrix}$$

First, through the convolution operations, $D(x, y)$ can be obtained by the following convolution computation:

$$D(x, y) = \max(F_i \otimes G(x, y)). \quad (3.1)$$

$D(x, y)$ denotes the results following edge detection at (x, y) , and F_i is the i th kernel listed above. $D(x, y)$ is determined by the maximum value of $(F_i \otimes G(x, y))$. In the proposed algorithm, we will use a hard-limiter to differentiate an edge from the background and connected parts. The following decision making process is proposed for this purpose:

- 1 After computing $D(x, y)$ over the whole image, calculate the average edge value:

$$aver_E = \frac{\sum_{x=1}^M \sum_{y=1}^N D(x, y)}{M \times N}. \quad (3.2)$$

- 2 Compare $D(x, y)$ to $\gamma \times aver_E$, if $D(x, y) > \gamma \times aver_E$, then the pixel at (x, y) will be turned to black, which means we regard this point as part of the edge. Otherwise, it will be kept as white. Through experiments, an empirical value $\gamma = 2.4$ is recommended. Figure 11 shows the results after edge detection is performed on the images.

Figure 11 Effects of edge detection

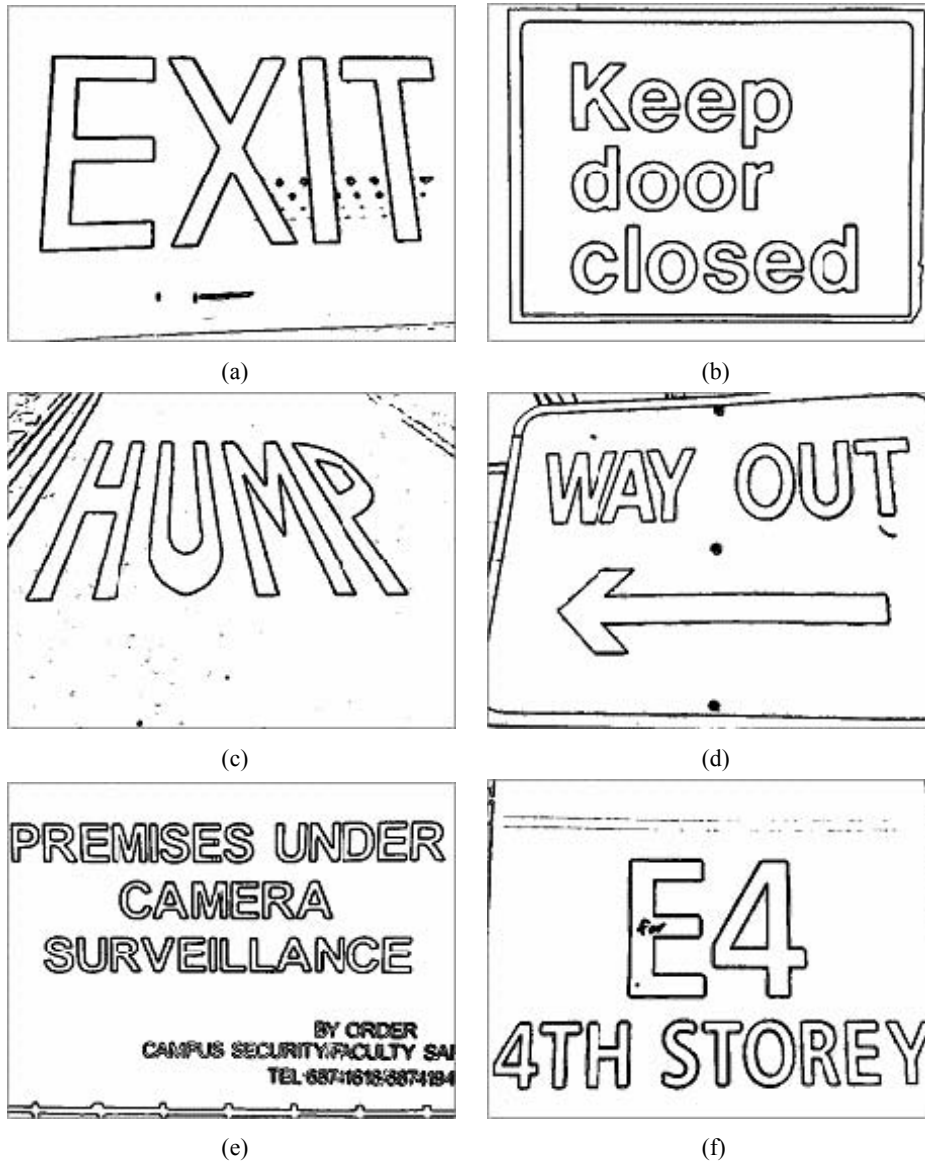
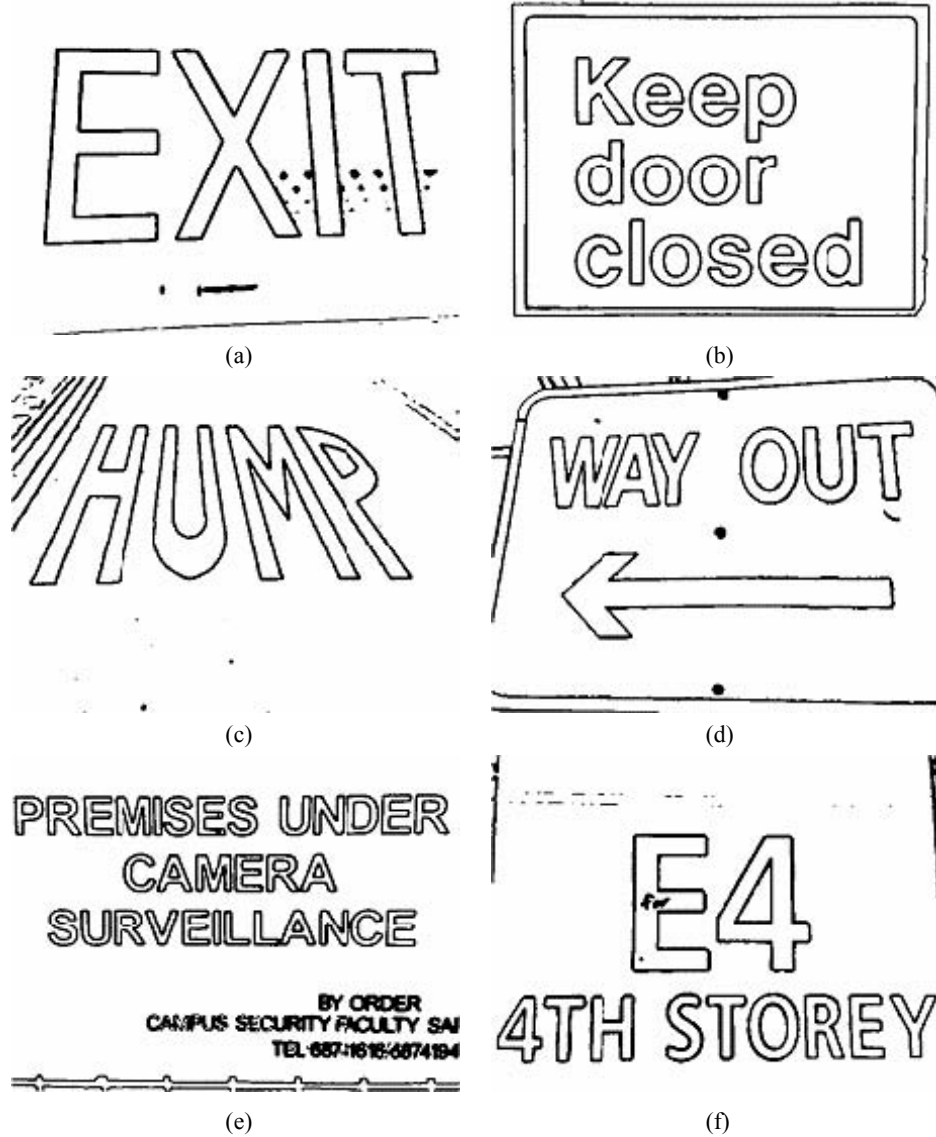


Figure 12 Fake edge reduction results

3.2 Fake edge reduction

Through edge detection, sharp transition parts are turned to black and the rest will remain as white. However, many fake edges may exist in the image due to the non-uniform texture in the original image (see Figure 11). A reduction function is needed to remove these fake edges. Let $\text{aver } D(x, y)$ denotes the average value of the eight-neighbours of the pixel of the image D located at (x, y) , and $D(x, y)$ denotes the value of the pixel. Then, the following operations can be done to realise the reduction function. $\tilde{D}(x, y)$ denotes the output.

$$\begin{aligned} &\text{if } |\text{aver_}D(x, y) - D(x, y)| > 127.5 \quad \tilde{D}(x, y) = 255 - D(x, y) \\ &\text{Otherwise} \quad \tilde{D}(x, y) = D(x, y). \end{aligned} \quad (3.3)$$

After this step, some isolated fake edges will be removed (see Figure 12). Although this step may not completely eliminate all fake edges, it helps to reduce the computation intensity needed in subsequent steps.

3.3 Labelling

Following edge detection, labelling is a usual method to identify the connected components. When labelling is carried out adequately, each of the identified characters is associated with a sequential number. Thus, through this method, we can label the connected white zones in the image. The white background may be marked as 0 for convenience. Meanwhile, we should note that some characters such as 'P', 'A', 'R', 'D' have two connected white areas since they have a 'hole' as part of the characters.

3.4 Sub-zone filling

Following the previous steps, the RoI are now available. The next step would be to fill the character so as to derive black characters on a white background. This is the crucial step in the whole algorithm, and it can be accomplished by a fusion of colour and edge information. To fulfil this task, we will need to compare the reference template, the original images Figure 2 and the constructed contour in Figure 12. Consider Figure 1(a) as an example, with the original colour image and constructed contour shown below in Figure 13.

Figure 13 Analysis of sub-zone filling, (a) colour information (b) edge information (see online version for colours)



The filling step essentially involves a binary decision-making process, based on a comparison between the average colour values of each sub-zone in the original colour image to the average colour value of the background. First, in Figure 13(b) the largest sub-zone is regarded as the background. Thus, it is kept as white as in Figure 13(b). Meanwhile, we trace the corresponding location of the background in the original image [i.e., the green portion of Figure 13(a)], and compute the average colour value of the background. Let $\text{aver}R_{bg}$, $\text{aver}G_{bg}$ and $\text{aver}B_{bg}$ denotes the average value of red, green

and blue component of background respectively. Secondly, we find the location of the i th sub-zone in the original image and compute the $averR_i$, $averG_i$ and $averB_i$ with the same method. Let $dis[i]$ denotes the colour distance between the background and the i th sub-zone. The colour distance essentially refers to the difference in the colour values. Thus, the calculation of the colour distance is presented below:

$$dis[i] = \frac{|averR_i - averR_{bg}|}{averR_{bg}} + \frac{|averG_i - averG_{bg}|}{averG_{bg}} + \frac{|averB_i - averB_{bg}|}{averB_{bg}} \quad (3.4)$$

The colour distance reflects the contrast between the sub-zone and the background. Now the problem is how to determine whether it is an object or the background based on the colour distance obtained. Let max_dis , min_dis and $thres$ denotes the maximum, minimum colour distance and threshold respectively. Through experiment, we recommend that $thres = 0.45 * (max_dis + min_dis)$ would be a proper threshold to use. Essentially, this means that if the colour distance between the zone and the background is larger than the threshold $thres$, the zone will be regarded as an object, and thus it is drawn black as in Figure 13(b).

The pseudo code for filling is given as follows:

```

BEGIN
compute  $averR_{bg}$ ,  $averG_{bg}$  and  $averB_{bg}$ 
 $i = 1$ 
compute  $averR_i$ ,  $averG_i$  and  $averB_i$ 
compute
 $dis[i] = \frac{|averR_i - averR_{bg}|}{averR_{bg}} + \frac{|averG_i - averG_{bg}|}{averG_{bg}} + \frac{|averB_i - averB_{bg}|}{averB_{bg}}$ 
 $i++$ 
compute  $max\_dis$  and  $min\_dis$ 
compute  $thres = 0.45 * (max\_dis + min\_dis)$ 
 $i = 1$ 
if  $dis[i] > thres$  draw the  $i$ th sub-zone black
 $i++$ 
END

```

The filling results are shown in Figure 14.

At this stage, after filling, the results are already adequate for future recognition. However, in sign boards, there can be directional signs on it which cannot be eliminated through the aforementioned steps. In other cases, the results may be still premature for recognition, due to the presence of noise and bubbles inside the characters, all of which will affect recognition. In these cases, a post-processing step for elimination of these elements will be needed.

Figure 14 Effects of sub-zone filling



4 Post-processing

In post-processing, the focus will be on the elimination of signs and noises.

4.1 Abnormal objects removal

Abnormal objects include boundary, signs, rifts, etc. Usually, these objects have such features in common as a wide span and a large length to width ratio or a large width to length ratio (Takahashi and Nakajima, 2005). Therefore, we can locate and remove them based on these features. The following six criterions are used to identify and eliminate these abnormal objects.

- vertical span $> 0.8 * \text{width of the image}$
- horizontal span $> 0.4 * \text{length of the image}$
- vertical span/horizontal span > 16
- horizontal span/vertical span > 4
- area $> 5 * \text{average area}$
- area $< 0.2 * \text{average area}$.

4.2 Noise elimination

At this stage, only characters and noise will remain. The remaining task on hand is to remove the noise portion. The second important function of labelling lies in the calculation of area so as to identify the noise. Denote as max_Area and min_Area , the largest and smallest area of the connected components. The component with max_Area should be classified as an object, thus max_Area can be used as a reference value to differentiate between objects and noise. Considering the area of the characters in one image should typically not vary considerably from each other, e.g., $\text{max_Area} < 6 \times \text{min_Area}$. As a result, if the area of the i th component satisfies a certain condition, say $\text{Area}_i < \frac{\text{max_Area}}{\varsigma}$, the area can be treated as noise or an

unwanted part. In this application, we use an empirical value of $\varsigma = 10$. The processed results after filling and elimination are shown below in Figure 15.

Sometimes, bubbles may exist inside the extracted characters due to scratches, reflection or nails on the sign board. In these situations, a bubble filling algorithm can be used to fill the bubbles. Therefore, the filling algorithm can be used based on both labelling and area calculation. However, the labelling algorithm will pose additional computational burden with no considerable effect on recognition. Thus, this step has not been adopted, in this paper, in order to reduce the processing time.

Figure 15 Results after filling and elimination

EXIT

(a)

Keep
door
closed

(b)

HUMP

(c)

WAY OUT

(d)

PREMISES UNDER
CAMERA
SURVEILLANCE

(e)

E4
4TH STOREY

(f)

5 Experiment results

In this section, we will demonstrate the effectiveness of the application developed. The popular OCR software ABBYY FineReader 8.0 and Adobe Acrobat Professional 7.0 are used to interpret the extracted characters. Thirty images captured via the mobile phone were used for the experiment, giving a total of 408 characters. Table 1 lists the recognition result. For ABBYY, there are eight recognition errors, thus accuracy is 98.04%. Acrobat achieves only 88.97% accuracy. Experiments show that ABBYY faces difficulty when recognising images captured with an odd angle, and characters with a comparatively large size (see images 1, 2, 22). Therefore, users are encouraged to capture sign image with a minimum offset angle.

Table 1 Recognition results (see online version for colours)









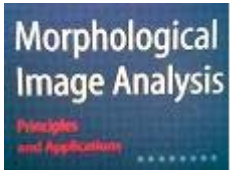
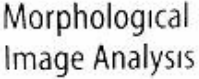



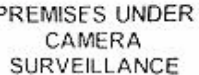
	<i>Original image</i>	<i>Extracted results</i>	<i>ABBYY</i>
			<i>Acrobat</i>
1			EXIT EXIT
2			MK N/A
3			FIRE HOSEREE FIRE HOSEREE
4			Color Image Processing and Applications Color Image Processing and Appl~cat~ons
5			Morphological Image Analysis Morphological Image Analys~
6			EXECUTIVE SEMINAR ROOM EXECUTIVE SEMINAR ROOM
7			PREMISES CAMERA SUVEILLANCE PREMISES CAMERA SUVEILLANCE

Table 1 Recognition results (continued) (see online version for colours)

	<i>Original image</i>	<i>Extracted results</i>	<i>ABBY</i>
			<i>Acrobat</i>
8		Court 1 to 4 Counter 18 Room 19 to 27	Court 1 to 4 Counter 18 Room 19 to 27 Co~1r 1 tto 4 Counter 18 Room 19 to 27
9		MINISTRY OF MANPOWER	MINISTRY OF MANPOWEK MINISTRY OF MANPOWEN
10		Meeting @MOM	Meeting @ MOM N/A
11		FULLY PAID	FULLY PAID FULLY PAID
12		E4 4TH STOREY	E4 4TH STOREY E4 4TH STOREY
13		E4 1ST STOREY	E4 1ST STOREY 7ST STOREY
14		Keep door closed	Keep door closed Keep door closed

Table 1 Recognition results (continued) (see online version for colours)

	<i>Original image</i>	<i>Extracted results</i>	<i>ABBY</i>
			<i>Acrobat</i>
15		FIRE	FIRE FIRE
16		E4A 7TH STOREY	E4A 7 TH STOREY 7 TH STOREY
17		Kent Vale Car Park	Kent Vale Car Park Kent Vale Car Park
18		WAY OUT	WAY OUT WAY OUT
19		Please Use Underpass	Please use Underpass Please use Onde:pass
20		PEDESTRIAN THIS WAY	PEDESTRIAN THIS WAY PEDESTE:.N r w rr r n ~ THIS Ina
21		KENT VALE CARPARK 3	KENT VALE CARPARK 3 KENT VALE CARPARK 3

Table 1 Recognition results (continued) (see online version for colours)

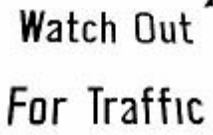




	<i>Original image</i>	<i>Extracted results</i>	<i>ABBY</i>
			<i>Acrobat</i>
22			SUM SLOW
23			Watch Out For Traffic Watch Out For Traffic
24			BLOCKS C D N/A
25			BEWARE OF LOW CEILIN BEWARE OF LOW CEILIN
26			ONE WAV ONE WAY
27			Keep out Keep out
28			RESERVED RESERVED

Table 1 Recognition results (continued) (see online version for colours)

	Original image	Extracted results	ABBY
			Acrobat
29			LOADING AND UNLOADING LOADING AND UNLOADING
30			NUS NUS

6 Conclusions and future work

In this paper, we have presented an approach for text extraction from images captured from sign boards with mobile phones. The approach is also viable as an alternative way to send SMS from images captured and to extract URL text from a complex background and directly link the user to the website via his mobile device. The approach is based on a fusion of colour and edge information. The strategy for text extraction is designed to strike a delicate balance between computational efficiency and identification accuracy. The results of experiments on 30 real images were duly presented in the paper to demonstrate the viability of the proposed approach for this purpose. Using of entropy to calculate the information amount, the method to enhance contrast and approaches for colour and edge fusion are the innovative methods forthcoming from the paper to effectively differentiate objects and background.

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