街景導覽之招牌偵測系統

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摘要

在這份論文中，我們提出了一個以選取邊為基礎的方法來偵測招牌邊緣，我們希望能在街景導覽系統中自動的偵測招牌並在招牌上加入超連結至該店的首頁。整個過程將分成兩個步驟：選取平行候選邊及選取垂直候選邊。在第一個部分中，影像中強度較強的平行邊將會被選取出來，接著因招牌內部文字所產生的文字平行邊將會被刪除；在第二個步驟中，垂直候選邊將從每兩條平行候選邊中選取強度較強的垂直邊，然後因單一文字所產生的文字垂直邊將會被刪除。在刪除平行邊的部分，因為招牌內部的文字與文字之間會有間隔，此種現象在直方圖中會顯示出許多山峰與山谷；在刪除垂直邊的部分，由於招牌文字必定在招牌內部，因此由文字所產生的垂直邊必然會小於招牌所產生的垂直邊。上述特徵皆可以直方圖顯現的平滑曲線所分別。由於招牌通常是大且顯而易見的，因此我們在最後以最大面積選擇法來選出最大面積區域來當作我們的招牌結果。根據實驗結果，我們的方法是有效且快速的。

Shop Sign Detection of Route Panorama System

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Abstract

In this thesis, we present an edge-based shop sign detection algorithm for automatic detecting shop signs in route panorama system. The whole processes are divided into two parts: candidate horizontal line selection and candidate vertical line selection. In the first part, the stronger horizontal lines in the image are selected and then the erroneous lines caused by texts on the shop sign are deleted. In the second part, the stronger vertical lines of the region between two selected horizontal lines are selected and then erroneous lines caused by single character on the shop sign are deleted. For horizontal line deletion, the texts on the shop sign have blanks between each character; this feature generates many peaks and valleys in histogram projection profiles. For vertical lines deletion, characters are on the shop sign and therefore the vertical lines caused by single character are shorter than the vertical lines of the shop sign edges. In contrast, the shop sign edges have a smooth curve on projection profile; this difference can be used to separate them. Since shop signs usually are significant and large in the image, we use the maximum area selection to select the largest region as the shop sign. The experimental results show our method is fast and effective.

誌謝

這份論文的完成首先要感謝的是我的指導教授 張明峰教授。這兩年的碩士班生涯，教授不時的叮嚀指導及督促，讓我不只在做研究的態度上有所改進，對於做人處事方面也更加有所成長。另外在研究期間，趙善隆學長時時給我指導以及解惑更是此份論文能完成的重要推手。

除了師長的教誨外，實驗室陪我度過兩年的好朋友們坤揚、冠璋、忠育及學弟們更是不可或缺，每每在被壓力壓得透不過氣時，他們總會適時的給我支持與打氣，使我在研究中不會受到太大的阻礙。

最後我要將此論文獻給我的家人們，謝謝你們在我求學期間對我全心全意的支持，使我能順順利利的完成學業。

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Chapter 1 Introduction

1.1 Introduction

A single photograph of a scene is just a static snapshot with limited field of view captured from a single viewpoint. Many techniques have been proposed to extend the ways in which a scene can be visualized by taking multiple photographs. Multi-perspective panorama (MPP), also called route panorama, is based on side-captured images which are photographed continuously when walking along the street. Then those images are stitching together to show the street view. Users can browse the street view by web browser or other graphical user interface. Combining the route panorama with internet, the user can easily see the street view without going outside.

General route panorama systems can help users to see the street view; however, these systems only show the street view in a static way and lack of interaction with users. In nowadays, people want to have some interactions with shops on the web, like ordering a ticket when seeing a movie theater or having a reservation when seeing a famous restaurant. Route panorama cannot offer these services to people by just stitching those continuous images. Therefore, to solve this problem, route panorama needs to add other system to handle dynamic requests, a system can help people link to those street shops homepage or related discussion on the internet.

In order to help user linking to the homepage of street shop when viewing route panorama, a hyperlink for each street shop sign in route panorama is needed. To add a hyperlink for the shop sign, the shop sign have to be identified first, and then the texts in the shop sign will be recognized; according to these recognized terxts, a hyperlink will be added on it in the end.

To achieve the purpose, a system is designed as follow. First, the sign in the images must be detected. Second, we classify the characters in the sign by optical character recognition (OCR). Finally, we add a hyperlink on the characters to link to the home page or related pages of the shop. Characters in the images are not only in the sign but everywhere, so sign detection have to be done before classify characters in the images. In this paper, we focus on the first step, sign detection.

In general, a sign is a rigid object. A rigid object usually have fixed shape and fixed colors and these characteristics can be used to detect the rigid object from a digital image. In rigid objects researches, vehicle license plate detection and traffic sign detection are two of the most popular researches now. Here are some researches about them.

1.2 Related Work

Vehicle license plate detection (LPD) is widely used for detecting speeding cars, security control in restricted areas, unattended parking zone, traffic law enforcement and electronic toll collection. There are three steps in VLP recognition system, plate location step detects the license plate location in the image, characters segmentation step extracts characters in the license plate, and characters recognition step recognizes characters. Here we focus on the plate location step.

Vehicle license plates have two significant characteristics, fixed shape and limited color. All vehicle license plates must be rectangular and have fixed aspect ratio. According to this characteristic, Hough transforms (HT) [1] was proposed for line detection. Sliding concentric windows (SCW) algorithm was also proposed for detecting candidate rectangles [2]. Mathematical morphology method was another effective approach that often used in detecting license plate location [3]. However, when vehicle license plate image was taken in various incline angles or under various lighting, detecting vehicle license plate by edge-based methods mentioned above were not useful. Color-based methods have been proposed to solve these problems. Color collocation in vehicle license plate only has a few kinds of collocation, so in these methods, the system makes use of color information of the plate [4].

Another popular research in detecting rigid object is traffic sign detection. Traffic sign detection also has three stages, detection stage, classification stage and recognition. Detection stage finds the most likely image area that may contain traffic sign. These areas are often called region of interest (ROI). Each ROI will be tested to classify which one is traffic sign and belongs to which traffic sign category, such as warning, prohibition and obligation. In the final stage, recognition stage identify what does the traffic sign represent. Here we also focus on the first stage, detecting region of interest (ROI).

Since traffic signs all have strict shape format (circle, rectangle, octagon, and triangle), many shape-based methods were proposed by this significant characteristic. Hough transforms was proposed for line detection [5]. Cross-correlation based template matching with traffic sign template (strict shape format) [6]. Shape-based methods using in detecting traffic sign still have the same problems that mentioned in detecting vehicle license plate, images were taken in various incline angles or under various lighting. In these situations, color-based methods were proposed to solve these situations.

1.3 Objectives

However, shape-based and color-based methods mentioned above cannot work well in detecting shop sign. Sliding concentric windows algorithm can only detect rectangle with fixed aspect ratio, but shop signs' shape are various. They do not have a fixed aspect ratio. Color-based methods are not suitable in detecting shop sign, either. There are not too many collocations of colors in vehicle license plates and traffic signs, so they can be easily detected by color feature, but shop signs are colorful and have no rules, therefore, colors cannot be a feature in detecting shop signs.

To detect shop sign, Jerod Weinman has proposed a Markov random field based method to detect text regions from photos [7]. In his research, texts only exist in the shop sign and the image background is simple. But images we want to detect are more complicate. Texts in our images are everywhere, not just in the shop sign. Besides, using Markov random field to detect text form an image is time-consuming. For these reasons, a new method must be found to solve these problems.

Out system divides into two stages, first stage detects areas that may possibly include shop sign, and second stage extracts the most possible area to be our shop sign as a result. In the first stage, Sobel edge detection algorithm was used to find all horizontal and vertical edges; histogram projection filtrate shorter lines for those edges. Then we build new rules to cancel impossible lines for the rest of candidate lines. In the second stage, max area matching rule was proposed to classify those regions which were made by candidate lines in the first stage.

1.4 Overview of this thesis

The paper is organized as follows. Chapter 2 introduces our new method. In chapter 3, experimental results and some probable faults of our method will be presented. Chapter 4 gives conclusions and suggestions for future work to our research.

Chapter 2 System Design

2.1 Specific Features of Shop Signs

In a photo, the shape of a shop sign usually forms a rectangle. For different purposes or different shops, the aspect ratios of the shop signs are varied. The attribute of varied aspect ratio is much different to that of vehicle license plates and traffic signs. According to this reason, we want to find all possible rectangles in the image and then find shop sign in those rectangles. The pictures shown in Figure 2-1 are two photos capture in a street. The shapes of the shop signs in the pictures do not have a fixed aspect ratio. The shop sign "市民小站" in Figure 2-1(a) have higher aspect ratio of width to height than the shop sign "50 元比薩 焗烤美食專賣店" in Figure 2-1. Therefore, we cannot use fixed shape as a characteristic. In general, for the purpose of conspicuousness, a shop owner usually makes the shop sign as large as possible. The rectangle of shop sign is usually the biggest one of all the rectangles in a photo, and that means the height and width of a shop sign are longer than other rectangular objects in a photo. Base on this characteristic, we first find longer horizontal and vertical edges in an image. Then several heuristic rules are applied to remove the edges that do not belong to shop sign. The possible rectangles of shop sings are marked by the remainder edges. Finally, we select the biggest rectangle from the possible rectangles as shop sign. The overview of our system shows in Figure 2-2.

Figure 2-1 Sample of input images (a) left, (b) right

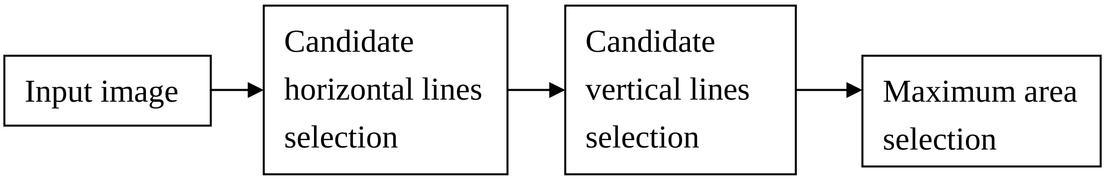


Figure 2-2 Flowchart of sign detection system

2.2 Candidate Horizontal Lines Selection

Most of the shop signs are horizontal rectangles, which means their horizontal edges is longer than vertical edges. To detect longer horizontal edges, we use Sobel horizontal edges detection algorithm to detect edges in the input image, first. Then histogram projection analysis is applied to find the distribution of horizontal edges. The longer edges are detected according to the distribution. Finally, we remove the edges that do not belong to a shop sign by extra horizontal edges deletion process. The flowchart of candidate horizontal lines selection is shown in Figure 2-3.

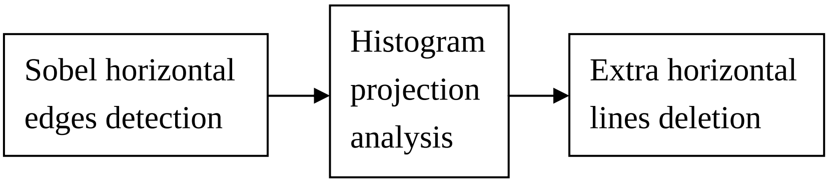


Figure 2-3 Flowchart of candidate horizontal lines selection

2.2.1 Sobel Horizontal Edge Detection

An image can be filter in spatial domain, spatial filter also called mask $h(i, j)$, we can get image $g(x, y)$ after original image $f(x, y)$ operates by spatial filter as following equation:

$$g(i, j) = h(i, j) \Theta f(i, j)$$

This operation is called convolution, it moves filter h from left to right, top to down, multiple with the original image region covered by filter mask and then add all product to get one mapping pixel value on filter image. Suppose the size of spatial filter is $M \times M$, the equation is show as following and Figure 2-4 shows the operation.

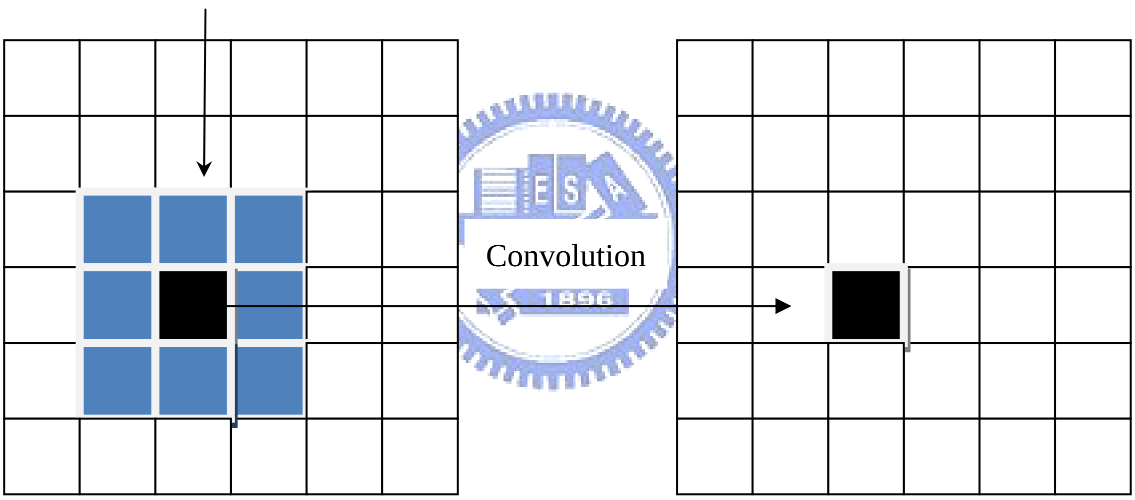
$$g(i, j) = \sum_{m=-\frac{M}{2}}^{\frac{M}{2}} \sum_{n=-\frac{M}{2}}^{\frac{M}{2}} h(m, n) f(i-m, j-n)$$

Edges usually exist in two closing parts of image which have different color or strong intensity. If there are abrupt changes in such local characteristics of the image are observed, it may possible be edges. Sobel edge detection use first derivative of spatial domain to strengthen the high frequency of spatial signal.

$$\nabla f = \frac{\partial f}{\partial x} + \frac{\partial f}{\partial y},\ Gx = \frac{\partial f}{\partial x},\ Gy = \frac{\partial f}{\partial y}$$

There are two masks in Sobel edge detection algorithm, horizontal mask and vertical mask Gx and Gy can be presented in discrete filter as show in Figure 2-5.In this process we want to detect horizontal edges, and therefore the horizontal mask is used. Figure 2-6 (a) and (c) shows the horizontal edge detection results of the images in Figure 2-1. The image shows the intensity of horizontal edges is called *horizontal edge maps*.

Spatial filter $h(i, j)$



Original image $f(x, y)$ Filter image $g(x, y)$

Figure 2-4 Convolution

-1	-2	-1
0	0	0
1	2	1

(a)Horizontal mask

-1	0	1
-2	0	2
-1	0	1

(b) Vertical mask

Figure 2-5 Sobel masks

2.2.2 Histogram Projection Analysis

In digit image processing, we usually use histogram projection for estimating intensity distribution of an image. In the horizontal edge map, the longer horizontal edges form continuous points with strongest intensity. Horizontal projection is used for finding the location of the strongest intensity edge. Figure 2-6 (b) and (d) shows the horizontal projection profile of Figure 2-6 (a) and (c). Figure 2-6 (b) and (d) have two axes; vertical axis is the rows of horizontal edge map, and horizontal axis shows the number of white pixels in each row. To find which edges have stronger intensity and where they locate we only need to find the row that have the largest white pixels

Figure 2-6 (b) and (d) two horizontal projection profile clearly show the horizontal edges' intensity and distribution. Longer edge has stronger intensity in diagram. By the horizontal projection profile analysis, the longer edges will be selected from the image. The selection algorithm is described below.

The purpose of horizontal lines selection method is ensuring that the top and bottom horizontal edges of a shop sign will be selected. To achieve this purpose, a fixed number of longer horizontal lines are selected first, and then a further check will be performed to remove most of the misclassified edges in the process of extra horizontal lines deletion.

Horizontal lines selection algorithm

Data: row_point[Image_Height] : Horizontal projection values of the edge map from top to bottom

Step1: select row_point[0 to 2/3 Image_Height]

Step2: sorting the row_point[] array (from high to low)

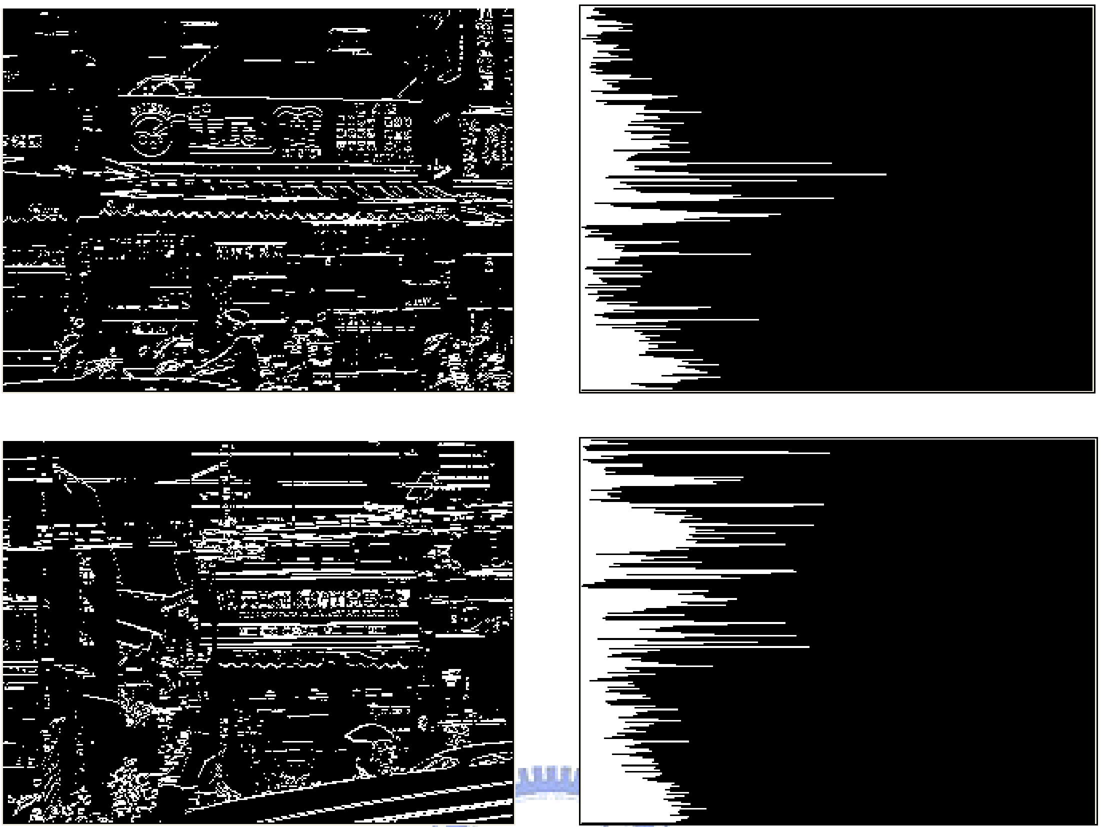
Step3: mark the *k* rows that have highest values

Step4: if distance of each two marked rows are smaller than *d*, unmark the shorter one

Step5: the horizontal edges located on the corresponding positions of remainder *n* rows are selected as candidate edges.

Note that the variables *k*, *d* and *n* are manually set depending on the size of input image.

Shop sign usually locates in the middle position of the image, so in step 1 we only detect horizontal edges in upper part image, from top to $\frac{2}{3}$ image height, to reduce execution time. In a sign, the text of shop name and several related information is drawn in the region between top and bottom edges. Therefore, the distance between top and bottom edges must be large enough to include the text. If two horizontal edge lines are too close, they should not belong to the same sign. In step 4 we reduce some impossible lines by deleting lines that are too closed. Step 5 we select the final *n* lines that are the longest edges in the image and each of them are separated in *d* pixels, variable *n* will not be a fixed number, it is judged by the image information. Figure 2-7 shows the result of selection method.



(a) Sobel horizontal edge result (b) histogram projection of (a)

Figure 2-6 Histogram projection results.

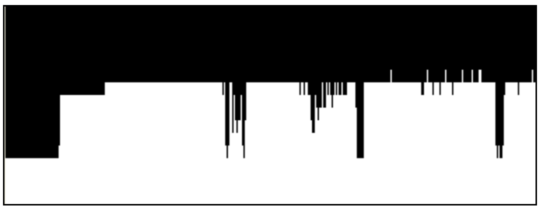
Figure 2-7 Horizontal lines selection results

2.2.3 Extra Horizontal Lines Deletion

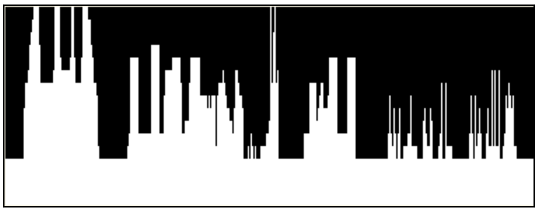
As shown in Figure 2-7, the horizontal lines selection step has successfully select shop sign's two horizontal edges. But there are still a few extra lines in the image. These lines were caused by three situations, text in the shop sign; edge lines of incomplete shop signs, and the extra edges of buildings. In our horizontal lines deletion, we focus on the first situation.

Texts in shop sign always have blanks between to each other; those blanks in vertical histogram projection have lower intensity. Figure 2-8 (b) and (c) are two kinds of edges diagram: edge on the shop sign and edge on the shop sign texts. As show in Figure 2-8 (b), there are just a few valley in the diagram, and that may caused by the light in the image, but in Figure 2-8 (c), mountains and valley are intersected. Base on this feature, we perform vertical histogram projection around the region of each candidate horizontal line, and then delete the line which has this kind of feature. Our deletion algorithm is showing below.

(a) Image of horizontal line selection



(b) Histogram projection of shop sign edge



(c) Histogram projection of texts edge

Figure 2-8 Vertical histogram projection to text in shop sign

Extra horizontal lines deletion method

Step1: Extend *n* pixels up and down for each candidate horizontal line, and then each line becomes a frame with height is $2n+1$.

Step2: Use Sobel vertical edges detection to detect all vertical edges in each frame.

Step3: Vertical histogram projection

Step4: For each frame, count average height of white points for each *k* columns (*area height*), compare with the average height of white points for whole frame (*frame height*), if *area height* is bigger than *frame height*, define *high area count* as a counter, increase *high area count*.

Step5: calculate the *average high area count* for all frame, delete the line which *high area count* is larger than *average high area count*.

Note that *n* and *k* two variables are changed depending the original image size.

In our deletion method, step4 calculates high area count by calculating area height and frame height. A mountain in the diagram usually takes a few columns, so to find the height of the mountain we cannot calculate only one column. Area height was defined and calculated by this reason to reduce possible error situation. The relation between area width and error rate will be discussed in next chapter. Figure

2-9 shows the results of our deletion method.

Figure 2-9 Extra horizontal lines deletion method result

2.3 Candidate Vertical Lines Selection

In section 2.2, we successfully select candidate horizontal lines. In this section, we want to select candidate vertical lines. Since the candidate horizontal edge lines of shop sign are selected, to reduce the process time and avoid confusion of other objects, we just find vertical lines inside the region between each pair of consecutive candidate horizontal lines. The flowchart of candidate vertical lines selection is shown in Figure 2-10.

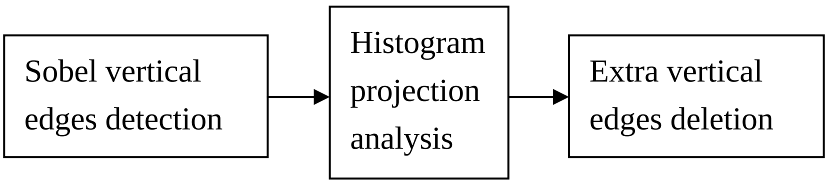


Figure 2-10 Flowchart of candidate vertical lines selection

2.3.1 Sobel Vertical Edge Detection and Vertical Histogram Projection

Similar to candidate horizontal line selection, we apply Sobel vertical edges detection to calculate the intensity of vertical edges to form vertical edge map. Then we find stronger vertical edges by projection analysis. Finally, extra vertical edges deletion is used to delete extra vertical edges.

To detect vertical edges of image in the region of two candidate horizontal lines, we use Sobel vertical mask (Figure 2-4(b)). Then vertical projection analysis is applied to detect vertical edge which has stronger intensity. Figure 2-11(a) (c) shows the result of Sobel vertical edge maps. Figure 2-11(b) (d) shows the result of vertical projection profile process.

From Figure 2-11 (b) and (d), we can see that most of the error edges are caused by texts in shop sign and buildings' edges. To correctly detect the shop sign, edges caused by texts in shop sign will decrease detection rate, they will separate a shop sign in many parts; therefore, to increase our detection rate, texts edges must be deleted.

Figure 2-11 Sobel vertical edges maps and first vertical edges selection

2.3.2 Extra Vertical Edges Deletion

As shown in Figure 2-11, extra vertical edges usually belong to two types of objects: characters and buildings. This section still focuses on the first situation. The different between deleting extra horizontal edge and deleting extra vertical edge is that extra horizontal edge is generated by several characters, but extra vertical edge is generated only by a single character. Therefore, blanks between characters this feature cannot be used in deleting extra vertical edge. To delete the vertical edge caused by single character but cannot using the feature of characters, we have to find the difference between the edge of shop sign and the edge of the character in shop sign.

There is no doubt that the character in shop sign must inside the shop sign, so the edges of character must be shorter than the edges of shop sign; base on this difference, the purpose of extra vertical edges deletion is comparing the length between the edges of shop sign and the edges of the character in shop sign, and then delete the shorter one. Extra vertical edges deletion algorithm is showing below.

Extra vertical edges deletion algorithm

Input: v_line[3][height]; //height: height between two candidate horizontal lines

3: Red, Green and Blue format.

Step1: skew line correction. // v_line[3][height] -> sv_line[3][height];

Step2: turn each pixel of the line after step1 from RGB format to YCbCr format.

// sv_line[R, G, B] [height] -> sv_line[Y, Cb, Cr] [height]

Step3: sort sv_line[Cb] [height], sv_line[Cr] [height] from low to high

define q_{Cb1} = sv_line[Cb][$\frac{height}{4}$], q_{Cb2} = sv_line[Cb][$\frac{3\times height}{4}$]

q_{Cr1} = sv_line[Cr][$\frac{height}{4}$], q_{Cr2} = sv_line[Cr][$\frac{3\times height}{4}$]

Step4: $\overline{q_{Cb}} = \frac{q_{Cb1}+q_{Cb2}}{2}$, $\overline{q_{Cr}} = \frac{q_{Cr1}+q_{Cr2}}{2}$

for (int i= 0 to height)

if (sv_line[Cb][i] $- \overline{q_{Cb}} \le p$ && sv_line[Cb][i] $- \overline{q_{Cr}} \le p$)

Matching pixel increase

Step5: define matching pixel rate $q = \frac{Matching\ pixel}{height}$, calculate the match pixel rate for each candidate vertical line; delete the line which match pixel rate is lower than q.

It usually has some angle error when taking pictures and that makes the vertical edge selected by our first selection will not vertical in the picture. To get the real length of shop sign edge, skew line correction is used for simply correct those skew line. In step1, skew line correction moves basic line n pixels to left and right, as shown in Figure 2-12, to get template lines, and then match these template lines to vertical edge map for calculating the mapping white points; select the template line which has the largest mapping white points as final line. Various lights are another problem when taking a picture and that will make color layered in the image. To handle this problem, step2 turns color format from RGB value to YCbCr value. Y is luminance; step3 separates Y value to reduce the effect of layered color. The transform formula of RGB to YCbCr is shown below. Step4 calculates the average of Cb and Cr' first quartile and third quartile in a statistic way to get the count of matching points with the final line, and step5 delete the line which has lower matching points. Figure 2-13 shows the result of extra vertical edges deletion.

$$\begin{aligned} Y &= 0.299R + 0.587G + 0.114B \\ Cb &= -0.1687R - 0.3313G + 0.5B + 128 \\ Cr &= 0.5R - 0.4187G - 0.0813B + 128 \end{aligned} \quad (1)$$

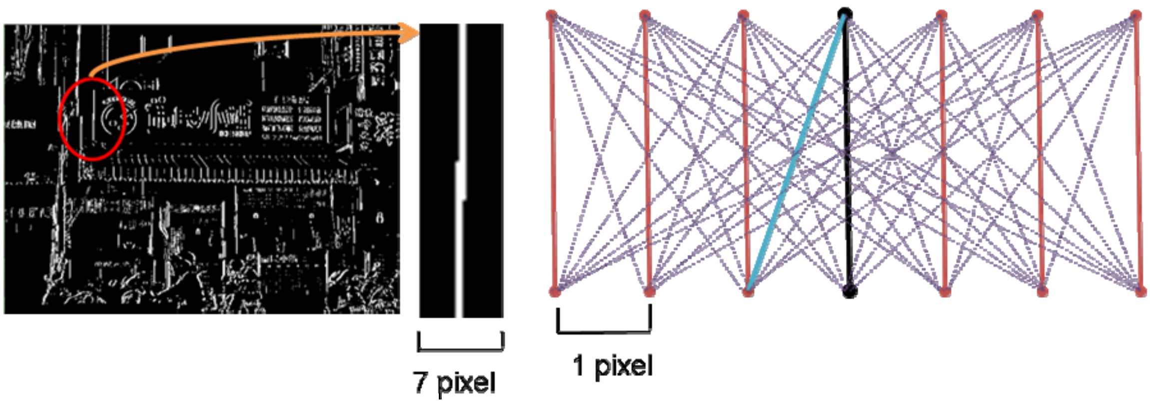


Figure 2-12 The black line is basic line, red lines are template lines, and blue line is the final line which has the largest matching points

Figure 2-13 Extra vertical edges deletion results

2.4 Maximum Area Selection

Figure 2-14 Maximum area selection result

As shown in Figure 2-13, after horizontal and vertical edges selection and deletion; the rectangle of shop sign is already detected, but there are still a few rectangles that do not belong to shop sign. This section is going to use maximum area selection to find the rectangle of shop sign.

As mentioned in section 2.1, the rectangle of shop sign is usually the biggest one of all the other rectangles in a photo, so max area mapping rule is going to find the area of all rectangles in the photo and then select the rectangle which has the biggest area. In Figure 2-14, rectangle of shop sign is shown with color image and other rectangles are shown with grayscale image.

Chapter 3 Performance Analysis

To analysis the performance of our proposed method, we test the shop sign detection algorithm on 102 pictures, which are 640*480 JPEG formatted color images. These pictures are taken from night market of National Tsing Hua University. In addition to the analysis of shop sign detection rate, we also further analyze the results of horizontal and vertical sign edges selection. This chapter is organized as follow, section 3.1 analyses the correct rate with our shop sign detection; section 3.2 analyses the correct rate and missing rate for our horizontal and vertical edges selection, and in section 3.3, we are going to analysis some special case of shop sign.

3.1 Shop Sign Detection Analysis

We use the following equation to analyses our shop sign detection rate:

Area coverage rate = interaction of A and B / union of A and B

A: Our final selected rectangle area; B: real shop sign area.

Table 3.1 Area coverage rate record

Area mapping rate	Counts of mapping images
>50%	92
>70%	85
>90%	71

(a) Area coverage rate is about 82%

(b) Area mapping rate is about 64%

Figure 3-1 Two examples of different area coverage rates

We test our data in three different area coverage rate, as show in table 3.1, when area coverage rate is larger than 50%, our detection rate is about 93%; when area coverage rate raises to 70%, the detection rate decrease to 83%, and when area coverage rate raises to 90%, the detection rate decrease to 73%. Figures 3-1 (a) and (b) shows the detection results of the area coverage rates larger than 70% and larger than 50%, respectively. They are caused by misclassify one or two horizontal and vertical edge lines or incompletely selection of horizontal and vertical edge lines, so correctly selection of horizontal and vertical edge lines is important in increasing area coverage rate. Horizontal and vertical edge lines selection correct rate are analysis in next section.

The cost time of shop sign detection for each image is about 0.3 second. The speed is very fast for shop sign detection, since we use only the histogram project to select possible edges and the features in possible edges to delete texts edges. These calculations do not need too much time to execute.

3.2 Horizontal and Vertical Edges Selection Analysis

In our proposed algorithm, the rectangle with maximum area is selected as the shop sign. Therefore, we need to remove the detected edge lines that cross the shop sign and keep the edge lines that belong to the boundary of a shop sign. The edge lines that cross the shop sign are usually belonging to the text of the shop sign. To further analysis the failure cases of shop sign detection, we also analysis the numbers of the shop edge lines kept by our algorithm and the text lines removed by our algorithm.

3.2.1 Horizontal Edges Selection and Deletion

In our proposed algorithm for horizontal edges selection, we focus on two parts: ensure to select the horizontal edges of shop sign and delete the horizontal edges caused by texts in shop sign. In order to have a precise performance analysis of our algorithm, this section is going to analysis the correct rate of horizontal edges of shop sign selection, and then discusses the missing rate of our horizontal edges deletion algorithm. The result of horizontal edges of shop sign selection is shown in Table 3.2.

Table 3.2 Horizontal edges of shop sign selection

The kind of horizontal edges of shop sign	Numbers
Total horizontal edges of shop sign	170
Selected horizontal edges of shop sign	151
Missed horizontal edges of shop sign	19

For our testing data, we use 85 shop signs selected by area coverage rate is larger than 70%. In Table 3.2, about 89% horizontal edges of shop sign can be kept by our algorithm. Among the total 19 failure edges, 5 edges are unpaired and 14 edges are paired; that means there are 5 shop signs miss one of the horizontal edges and 7 shop signs miss both two of the horizontal edges. The reason of failure edges can be classified into three major categories.

(a)Horizontal lines selection

(b) Horizontal lines deletion

Figure 3-2 Error case caused by another shop sign

In Figure 3-2 (a), two of the horizontal edges of shop sign have been already selected and there are two horizontal edges of texts in shop sign. Figure 3-2 (b) shows that two of the horizontal edges are deleted but one of the horizontal edges of texts in shop sign still remained. The failure reason caused by the incomplete shop sign in the right of the picture, we can see that the upper edge of shop sign is deleted because the edge line cross the texts in another shop sign; the lower edge of shop sign is deleted because the edge line cross the edge of a canopy in the right of the picture. So, texts in another shop sign and some other objects edges will reduce the correct rate of our algorithm.

(a)Horizontal lines selection (b) Horizontal lines deletion

Figure 3-3 Error case caused by geometric problem

(a)Horizontal lines selection (b) Horizontal lines deletion

Figure 3-4 error case caused by special form of shop sign

In Figure 3-3 (a) and Figure 3-4 (a), our selection method has successfully select the two horizontal edges of shop sign, but two of them both missing the two horizontal edges of shop sign in our deletion method. In Figure 3-3 (b), we can clearly see that the shop sign is too skewed that make the edge line do not cross the edge of shop sign completely. In Figure 3-4 (b), two horizontal edges of shop sign is deleted because the texts of shop sign are across the region of shop sign, therefore, our deletion algorithm judges the two horizontal edges of shop sign as edges caused by texts and then deletes them.

Now we analysis the missing rate of horizontal edges deletion algorithm, the purpose of our deletion algorithm is deleting the edges caused by texts in shop sign. Table 3.3 shows the results of our deletion algorithm. About 8% missing rate with our deletion algorithm. Among the 8% missing edges caused by texts in shop sign, the main reason is shown in Figure 3-5.

Table 3.3 Horizontal edges of texts in shop sign deletion

The kind of horizontal edges of texts in shop sign	Numbers
Total horizontal edges of texts in shop sign	178
Selected horizontal edges of texts in shop sign	164
Missed horizontal edges of texts in shop sign	14

(a)Horizontal lines selection (b) Horizontal lines deletion

Figure 3-5 Error case caused by another shop sign

There are two errors in Figure 3-5 (b), first, the upper horizontal edge of shop sign is deleted, and second, one of the edges caused by texts in shop sign is not deleted. Both of the two errors are caused by the incomplete shop sign in the right of the image; the edge line crosses the edge of shop sign also crosses the texts in another shop sign, the edge line crosses the texts in shop sign also crossed the edge of another shop sign. In this situation, our deletion algorithm will delete the line which has longer texts.

As a result, there are three factors affect our performance with horizontal line selection process. First, incomplete shop sign in the picture, it will not only reduce the correct rate of edges of shop sign selection but also increase the missing rate of edges of texts in shop sign deletion. Second, geometric will reduce the correct rate of edges of shop sign selection, too. Finally, special form of shop sign will be a special case in our deletion algorithm; those special shop sign detection will be another thesis in our research in the future.

3.2.2 Vertical Edges Selection and Deletion

This section is going to analysis the correct rate of vertical edges of shop sign and the missing rate of vertical edges of character of shop sign. Our vertical edges of shop sign selection performance analysis is base on the correct results of horizontal edges of shop sign selection. If the results of horizontal edges of shop sign selection are not correct, two horizontal edges of shop sign will not be marked, and then our vertical edges of shop sign selection will not work. The results of vertical edges of shop sign selection is shown in Table 3.4, and the results of vertical edges of character in shop sign deletion is shown in Table 3.5.

Table 3.4 Vertical edges of shop sign selection

The kind of vertical edges of shop sign	Numbers
Total vertical edges of shop sign	170
Selected vertical edges of shop sign	139
Missed vertical edges of shop sign	31

Table 3.5 Vertical edges of character in shop sign deletion

The kind of vertical edges of character in shop sign	Numbers
Total vertical edges of character in shop sign	195
Selected vertical edges of character in shop sign	176
Missed vertical edges of character in shop sign	19

We test 24 correct results of horizontal edges of shop sign selection, 48 vertical edges of shop sign have to be detected. In table 3.4, we can see that about 82% correct rate with vertical edges of shop sign selection, and in table 3.5, about 9% missing rate with vertical edges of character in shop sign deletion.

Among the 19 failure edges, some edges are missed because the geometric problem and some edges are missed because the step 4 in our vertical edges of shop sign deletion algorithm. Step 4 calculates the matching points with the skew line, and the matching points is calculated by the error rate *p*; if error rate p is too high, some of the edges of character in shop sign will not be deleted, and if error rate *p* is too low, some of the vertical edges of shop sign will be deleted.

The error rate *p* is various in different situations, how to dynamic change the error rate *p* is our next research subject.

3.3 Special Case Discussions

There are still a few special cases of shop signs that our method cannot work well on them. In Figure 3-6 (a), the shop sign of 7-11 have two horizontal edges in the shop sign; the two edges are longer and only cross a character in the shop sign. In our horizontal edges of shop sign deletion, the edge line must cross at least two characters and blanks between them; this shop sign do not follow the rule so that our deletion method cannot work well on it.

(a) Strong horizontal lines in shop sing

(b) Small shop sign

(c) Result of (b)

Figure 3-6 Special cases of shop sign

Figure 3-5 (b) shows the result of horizontal edges of shop sign selection, and Figure 3-5 (c) shows the result of vertical edges of shop sign selection. We can see that the shop sign in the middle of the picture is relatively small; it even smaller than the incomplete shop signs in the right of the picture. So when doing horizontal edge of shop sign selection, our algorithm cannot detect the upper edge of the shop sign in the middle because the edge is shorter than the lower edge of the incomplete shop sign in the right. In vertical edges of shop sign selection, we miss both two of the right and left edges of shop sign because two of them are shorter than the height of two candidate horizontal edges.

For these special cases of shop sign, they can be seen as a shop sign have specific feature. To solve these cases, building specific rules for each of them will be more efficient than fixing our method. It doesn’t have only one rule that can solve all the case of shop sign after all.

Chapter 4 Conclusions and Future Work

In this research, we propose a shop sign detection method using edge-based algorithm. In the horizontal edges of shop sign selection, Sobel horizontal mask and horizontal histogram projection is used for detecting stronger horizontal edges. Since the horizontal edges of texts may also form peaks in projection profile, we further remove these edge by checking whether the candidate edge line is fragmental. In the vertical edges of shop sign selection, just like horizontal edges of shop sign selection process, we use Sobel vertical mask and vertical histogram projection to find stronger vertical edges, too. Similar to horizontal edge lines, the vertical candidate edge lines may also affected by the characters in the shop sign, but vertical candidate edge lines were affected only by a single character. Since the colors of edge lines of shop sign is usually uniform, we check the color uniformity of the vertical lines to remove the vertical edge lines caused by characters. The experimental results show that our proposed methods can successful detect the edges of shop sign and can remove the edges caused by the texts.

We proposed a method with histogram projection to detect edge lines of shop sign rapidly and then delete text edge lines in shop sign by some rules. Different from others researches have only detect the texts in the images, our method can be also used in detecting shop sign with only Figure in the shop sign. Besides, our method has successfully minimized the possible regions of shop sign and that will help our next process: optical character recognition, just have to recognize texts in shop sign without whole image. Further, not only shop signs, our edge-based method can be also used in detecting unfixed aspect ratio rectangles.

In our research, the selection of the parameters used in the deletion of text edge lines is a problem, especially in vertical edge lines. The experimental results show that the parameters are related to the stroke width of the characters. Maybe we can adjust the parameters dynamic by estimating the stroke width of the characters. The dynamic adjustment of parameters is left for future research.

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