Robust Extraction of Characters from Color Scene Image Using Mathematical morphology

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Abstract

Current character extraction systems for scene images are not robust for most real-world applications. In contrast, the system present here achieves robust performance by using morphological segmentation. This paper describes a new morphological segmentation algorithm – Differential Top-hats (DTT). In addition, a complete system for extraction of characters from color scene images is presented. The system was verified through experiments on sequences of outdoor color images with varying external conditions. A high average extraction rate of 95% *is obtained.*

1. Introduction

There are many complicated information existing in scene images. The information carried by characters is considered to be the most important which is regarded as the key information for robotic navigation and other computer vision applications. Therefore, the extraction of characters from a scene image for recognition becomes increasingly concerned. There is an abundance of studies in the character extraction[1]–[2], which are optimized for extraction of characters, but are limited to simpler backgrounds or other restrictive conditions. Most of them are also not adapt to changing environment.

Extraction of characters in scene images is more difficult than that in printed document or cover images. The main difficulties of such extraction work can be characterized as follows.

1. Characters in scene images are effected by changing environmental conditions which are significantly different from uniform format of characters in documents or cover images. Since the sun shine changes the lighting on characters from morning to night, the gray levels of characters are varying hourly. The surface of characters are unevenly effected by various lighting and shadows from neighboring objects. Furthermore the weather affect scenes.
2. There are variations due to camera's position. A three dimensional effect is occurring in scene images due to the relationship between characters and camera's position. If characters are seen in a very slanted angle, some characters are tilted. They become difficult to be detected.
3. There exist more objects in scene images which are similar to characters with simple lines. (e.g., window frames, fences, railing of stair)

The above problems can be adequately addressed by our approach.

2. Differential Top-hats

For some complicated images, especially those in which the target objects are combined in the uneven background, it's difficult to segment particles of interest satisfactorily. Clues for detecting features were discovered when we concentrated on the Top-hats transformation (TT) with different sizes of disk structure elements. The difference between $T_i^{(i)}$ and $T_{i-1}^{(i-1)}$ includes our interested objects, and that image can be easily thresholded to make features stand out. This new morphological segmentation algorithm is named "Differential Top-hats"(DTT).

$$\begin{aligned} S_i &= |T_i^{(i)} - T_{i-1}^{(i-1)}|_Z - X_{i-1} \\ X_i &= \bigcup_{1\le j\le i} S_j, \;\; X_1 = \emptyset \qquad (1) \\ T_i &= X_0 - X_0 \circ_g r_i B; \;\; T^{(i)} = X_0 \bullet_g r_i B - X_0, \end{aligned}$$

where X_0, X_i respectively denotes an original image and segmented sub-images holding different sizes of objects. After the T_i operation and the T^i operation have been processed simultaneously, they are unified together to be thresholded by a gray level $Z = 20$ which is determined by experiment.The differences of the neighboring TT results up to i are united together in X_i with certain size of features.

3. Extraction of characters from color scene images

To extraction characters from scene image, there exist many difficulties which we had mentioned in the introduction. Especially, characters under changing environmental conditions are difficult to deal with. In this section, we present a complete system to achieve robust performance by using DTT.

3.1 Preprocessing

The original color image is transformed to R,G,B gray images. Since the G image is less effected by various lighting among the three gray images, we employ G as the main processing image and the others serve as auxiliary which will be utilized in character extraction processing.

3.2 Segmentation

The source image is difficult to be dealt with in a general view. Thus we decompose it into simpler ones in this processing stage [3]. The input image X_G is decomposed into series of sub-images(X_{Gi}) with different sizes of objects by DTT. The segmentation procedure begin with $r_1 B_{disk}$ and end by $r_8 B_{disk}$ because the widest line of characters in scene image is smaller than 17 (diameter of the disk $r_8 B_{disk}$) pixel by statistical investigation.

3.3 Feature Extraction

Many objects which hold the similar features with characters exist in the scene image. In this paper, we introduce a new morphological algorithm – directional filter to detect character regions and suppress noises.

The character regions hold many features. One attractive feature is that they are composed by simple lines (or curves) with many points of contact and arranged together compactly. Paying attention to this feature, we employ sequences of line structure elements to detect simple lines in different directions and catch the points of contact. Most noises are removed by the detection scheme except those which are similar to characters composed by simple lines (e.g., frames of windows). But such noises are not compact. We utilize dilation and opening operation to delete them out from the candidate character sub-images. The processing is described as following.

$$\begin{aligned} D_{Gi} &= ((X_{Gi} \circ L^{0}_{i\times 4i}) \cap (X_{Gi} \circ L^{\pi/2}_{i\times 4i})) \\ &\quad \cup((X_{Gi} \circ L^{\pi/4}_{i\times 4i}) \cap (X_{Gi} \circ L^{3\pi/4}_{i\times 4i})) \qquad (2) \\ E_{Gi} &= (D_{Gi} \oplus r_5 B_{disk}) \circ r_{10} B_{disk} \qquad (3) \end{aligned}$$

3.4 Character Extraction

Since character regions are the main component in E_{Gi}, they hold the peak values in the histogram[3]. The peak values which are larger than the average of all the peak values are searched and $E_{Gi} \times X_m$ is thresholded by the selected peak values Z to extract characters standing out.

$$H_i = \bigcap_{m\in R,B} |E_{Gi} \times X_m|_Z, \qquad (4)$$

where, " $\times$ " denotes an arithmetic multiplication between two identical size images for transforming a binary image to gray-scale. The noise region attaching with the character candidate region may not hold the same gray level in other two gray images. This characteristics provides us with a method to distinguish between them.

3.5 Reconstruction

Since the extracted characters are broken in H_i, a morphological filter derived from conditional dilation is implemented here for reconstruction.

$$\begin{aligned} R_{i0} &= H_i \qquad (5) \\ R_{in} &= (R_{i(n-1)} \oplus r_5 B_{disk}) \cap |X_0|_Z \\ & if \quad R_{in} = R_{i(n-1)} \; then \; stop \end{aligned}$$

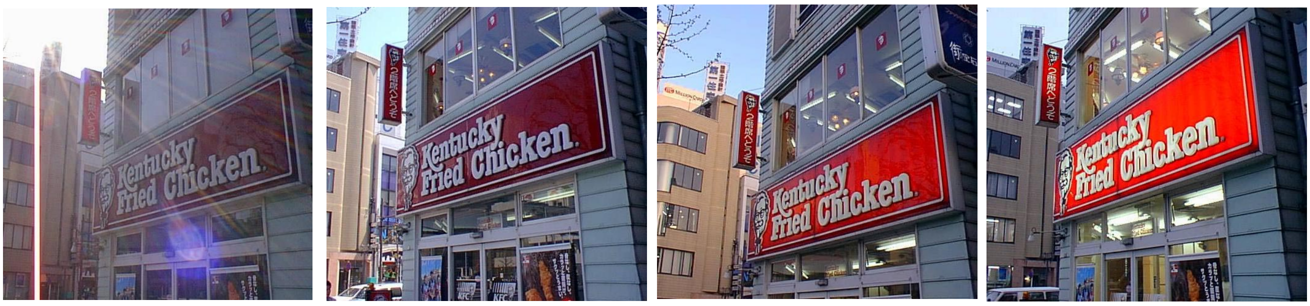
Where, the thresholded source image $|X_0|_Z$ is utilized as the mask.

To obtain the correct result, we feed the sub-image R_{in} back to feature extraction processing ($X_{Gi} = R_{in}$) until the new R_{in} is not change with the old one.

Lastly, all the sub-images R_{in} are united together obtaining the entire result image.

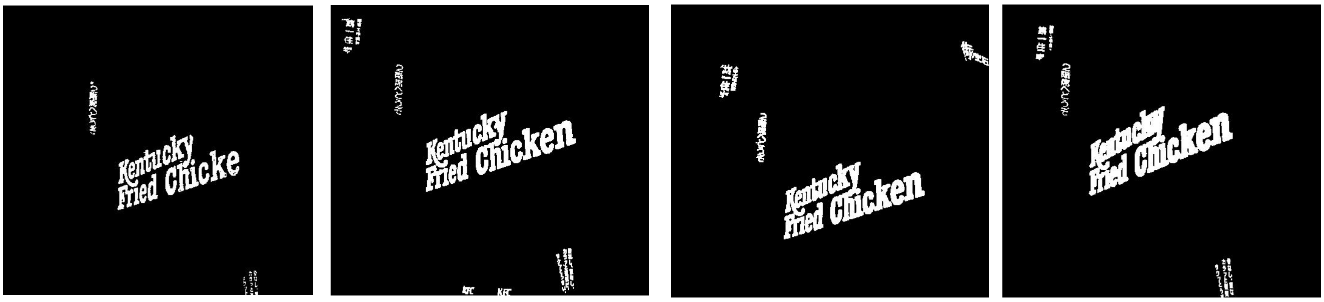
4 Experimental Results

This section describes experimental results evaluating the performance of our system on sequences of



(a) morning (b) noon (c) afternoon (d) evening

Figure 1: Four images of the same scene on different times.



(a) morning (b) noon (c) afternoon (c) evening

Figure 2: Results of images on different times

outdoor color images with varying external conditions. They are computed by SUN SPARC STATION 10. The four images shown in Fig.1 which are collected in the morning, noon, afternoon and evening respectively exhibit various sun shine. The dazzling sunlight in the morning (Fig.1(a)) make the characters in the scene hard to be seen even by our eyes. As the result shown in Fig.2(a), 10 characters which lost almost all contrast could not be extracted while the remaining 41 characters (80%) under very bad condition were extracted correctly. Counter light in the noon (Fig.1(b)) put parts of the characters into bright background with uneven aspects which were resulted in 100% extraction rate (Fig.2(b)). In the afternoon scene (Fig.1(c)), although sunlight becomes weaker and weaker where characters are getting dim, almost all the characters are extracted successfully(Fig.2(c)). Street light changed the lighting pattern in the evening scene(Fig.1(d)) where simple bright lines of lamps make the extraction work more difficult. The result of this scene image shown in Fig.2(d) is that 100% characters were extracted. It is found that a high average extraction rate of 95% was obtained.

5 Conclusion

In this paper, a new approach for character extraction from scene image using mathematical morphology was presented. We described a robust and adaptive system to extract characters from scene images. The new method can deal with more difficult segmentation problems than other known algorithms, especially with the objects existing in a complicated background with irregular sizes and directions which are effected by varying external conditions. The proposed approach for detecting characters in scene images was found to be robust in our experiment.

References

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