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The Extraction of Characters from Scene Image Using Mathematical morphology

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Abstract

In understanding an image, the extraction of charcters existing in the image is considered to be important. Scene images are differ from document images, which are composed of characters and complicated background (i.e.photo, picture, or painting etc.) instead of white one, this make it difficult to be dealt with. In this paper, we introduce a new method to extract characters from scene images using mathematical morphology.

1 Introduction

In this paper, a new approach to extract characters from scene image is proposed. For a scene image, there are many complicated information on it. The information carried through characters is considered to be most important among them. therefore, the extraction of characters from scene image in order to recognize them become increasingly concerned.[1]–[3]

The characters on the scene images are difficult to be extracted, because they are intricate with complicated background, and show various size, shape, direction and situation. Although the importance of this field have led a number of researchers to pay attentions to it and there have been several studies in the character extraction, they are proposed to be optimal ideas for extraction characters, but are limited to simpler background or other restrictive conditions.

In this paper, a new method using mathematical morphology is proposed. Mathematical morphology provides us the theory and the tools to analyze shapes, while the decomposition of shapes plays an important role in the implementation of morphological operation. This effect has been noticed by many researchers in the shape based processing and several optimal algorithms [4]–[8] have been proposed.

Characters in scene images may be characterized by word, "they float on the background or sink under it with a flat surface". This characteristic underlines the basic idea of our new method. The process includes two distinct stages:

- Primary processing (shape decomposition filter)
- Extraction processing
  - feature emphasis
  - character extraction
  - noise reduction

In the first stage, a new shape decomposition filter based on morphological recursive opening and closing is implemented. This filter decomposes a gray scale input image into a series of subimages according to the size of characters. In the second stage, we first employ a new morphological filter to emphasize characters' features in the subimages and remove most noises out of them, and then, the characters are extracted directly from the grey scale subimages by the histogram method. Lastly, a morphological image cleaning algorithm based on morphological conditional dilation is introduced to make the extracted character region distinct from noise. The resulting subimages are composed togather to produce the final result in binary.

The remainder of this paper is organized as follows: In section 2, terminologies and notations are defined; section 3 gives a detailed look into morphological algorithm of primary processing; section 4 describes morphological algorithm and implementation of character extraction; experimental results are presented in section 5; and the concluding remarks in section 6.

2 Conception and Notation

2.1 Morphological Operation

Mathematical morphology includes four basic operations: dilation, erosion, opening and closing. We make use of them throughout this work besides conditional dilation which is composed with morphological operation and connectivity. The main operations are also distincted into binary operations and gray scale operations. They are denoted as follows dependently in our studying.

Dilation($\oplus, \oplus_g$), Erosion($\ominus, \ominus_g$), Opening($\circ, \circ_g$) and Closing($\bullet, \bullet_g$).

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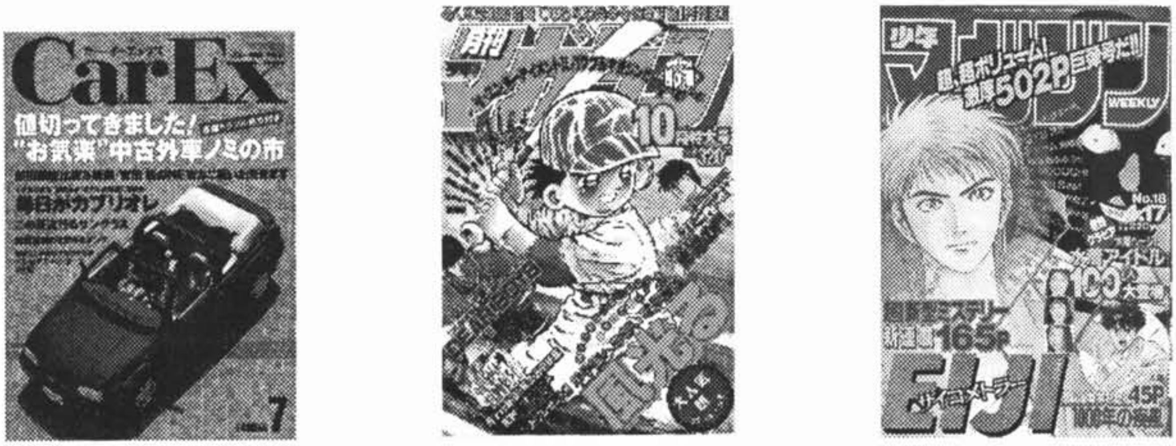

(a).carex (grey scale) (b).mangagin a (grey scale) (c).mangagin b (color)

Figure 1: Examples of source images

2.2 Structure Element

Tow standard shaped structure element DISK and SQUARE are selected in our method, they are described as following:

- A DISK structure element with its origin at the center and radius i is denoted by $r_i D_{disk}$.
- A SQUARE structure element with length of 2i is denoted by $r_i D_{square}$

In this processing stage, the original grey scale image is decomposed into a series of subimages with different size of characters.Scene image involves numbers of components besides characters, it is difficult to be dealt in a general view, thus we compose it into simpler ones in our first processing stage.

The decomposition will be implemented by the morphological algorithm, and a set of particular structure elements which are derived from 3×3 region of support in a recursive manner will also be used. For a given simplest structure element B, which may be a disk, a square, a triangle (in the Euclidean space R^2), a sphere, or a cube (in the Euclidean space R^3), etc., a set of structure element X_i is defined by

$$X_i = r_i B \quad (1)$$

When r_i is an integer, (1) is equivalent to the following relation, if B is bounded and convex:

$$X_i = B \oplus B \oplus \cdots \oplus B \quad (r_i \ times) \quad (2)$$

This had been proven by I.Pitas and A.N. Venetsanpoulos.[5]

For our apporach, the structure element $r_i B_{square}$ and $r_i B_{disk}$ will be obtained according to the equation (1)(2). $r_i B_{square}$ can be directly produced in recurrence due to its simplity,

$$r_i B_{square} = r_1 B_{square} \oplus r_1 B_{square} \oplus \cdots \oplus r_1 B_{square} \quad (r_i \ times) \quad (3)$$

and $r_i B_{disk}$ has to be dealt by $r_1 B_{square}$ and $r_1 B_{rhombus}$, because it is not a simple structure element just derived from a 3×3 element, it is denoted as

$$r_i B_{disk} = r_1 B_{rhombus} \oplus r_1 B_{square} \oplus \cdots \oplus r_1 B_{square} \quad (r_i \ times) \quad (4)$$
$$(i = 2n : r_1 B_{square}; i = 2n-1 : r_1 B_{rhombus}, n = 1, 2, 3, \cdots)$$

2.3 Morphological Notations

$$X_i = |X_0 - X_0 \circ r_i D_{disk}|_B$$

This equation implies that the original gray scale image X_0 is to be opened by a disk structure element with radius of i and a subtraction will be implemented between original image and opened image, then the result is going to be thresholded by a fixed value to produce a binary image X_i.

3 Primary Processing

The decomposition procedure is implemented by following morphological algorithm, which is applied to grey scale image and binary images are produced.

$$X_i = |(X_0 - X_0 \circ_g r_i B_{disk}) - (X_0 - X_0 \circ_g r_{i-1} B_{disk})|_B - X'_{i-1} \quad (5)$$
$$X'_j = \bigcup_{0<j\leq i} X_i, \ X'_1 = \emptyset$$

or

$$X_i = |(X_0 \bullet_g r_i B_{disk} - X_0) - (X_0 \bullet_g r_{i-1} B_{disk} - X_0)|_B - X'_{i-1} \quad (6)$$
$$X'_j = \bigcup_{0<j\leq i} X_i, \ X'_1 = \emptyset$$

Where, X_0 is the original image with a grey scale, X'_i is the decomposed binary image, and "$| \ \ |_B$"

(a).$i = 4$ (b).$i = 10$ (c).$i = 30$

Figure 2: Examples of discomposed subimages

denotes a threshold operation in a defined value. Equation (5) is used to decompose the images where characters are brighter than the background; if the characters are darker than background, equation (6) will be applied.

The procedure of this processing is start with $r_1 B_{disk}(r_1 B_{rhombus})$, a series of subimages X_i' are produced in a recursive manner. The processing will be stoped when the image $X_0 \circ r_i B_{disk}$ or $X_0 \bullet r_i B_{disk}$ have no characters remained.

4 Extraction Processing

4.1 Feature Emphasis

The decomposed subimages are processed by a morphological filter to release noises and emphasize character region.

$$E_i = \begin{cases} (((X_i' \circ r_{i-1} B_{disk}) \\ \quad \oplus r_{i+1} B_{disk}) \\ \quad \circ r_{2i} B_{disk}) \times X_0 & (i \leq 10) \\ (X_i' - X_{10}') \times X_0 & (i > 10) \end{cases} \quad (7)$$

4.2 Character Extraction

Since character regions are the main component in E_i, they hold the peak values in the histogram. The peak values which are bigger than the average of all peak values are searched and E_i is thresholded by the selected peak values to extract characters from it. The extracted characters are in H_i.

4.3 Refinement

The extracted characters are broken in H_i and there remain several noises. A morphological filter derived from conditional dilation is implimented to refine them perfected.

$$R_{i0} = H_i \circ r_{i-1} B_{square}$$

$$R_{in} = (R_{i(n-1)} \oplus r_5 B_{disk}) \bigcap |X_0|_B \quad (8)$$

$$if \quad R_{ik} = R_{i(k-1)} \; then \; stop$$

In the last, subimages R_{ik} are united to obtain the entire result image X_r, denoted by

$$X_r = \bigcup_{1 \leq i \leq j} R_{ik} \quad (9)$$

5 Experiment and Result

Grey scale and color cover pages of magazines are used in our experiment to demonstrate the efficiency of our method. They are scaned in 100dpi, 1170 × 848 and computed by SUN SPARC STATION 20. We focused on covers of various magazines because they have many variations thought to be a typical representative of scene image. The 3 examples of them are shown in Fig.1.

In the experiments, primary processing is conducted using equation (5) and (6), the stop condition is prefered to $j \leq 40$, because the size of characters in scene image is no more than this value. The subimages of $i = 4, 10, 30$ derived from Fig.1(a) is shown in Fig.2.

A color image is transformed to RGB images and the three greyscale images are implemented by the presented approach. Although the approach also appropriate to color image, an improvement of extraction processing is made to satisfy color characteristic. Next filter is introduced instead of equation (7).

$$E_{ki} = \begin{cases} (((X_{ki}' \circ r_{i-1} B_{disk}) \\ \quad \oplus r_{i+1} B_{disk}) \\ \quad \circ r_{2i} B_{disk}) & (i \leq 10) \\ (X_{ki}' - X_{k10}') & (i > 10) \end{cases} \quad (10)$$

$$H_{ki} = \bigcap_{m \in c \cap k^c} |E_{ki} \times X_{m0}|_B$$

(a).carex (b).mangagin a (c).mangagin b

Figure 3: Examples of result images

$$X_0 \Rightarrow X_{c0} = \{X_{R0}, X_{G0}, X_{B0}\}$$

$$c = R, G, B, \quad k \in c$$

- X_{c0}: R,G,B source images;
- k^c: complement of set k;
- $|\ |_B$: threshold transmit by character' greyscale value.

The three resultant examples shown in Fig.3 appear encouraging. In grey scale image "Carex", 180 characters extracted from total 230 characters, show a 78% extraction rate(ER), when "magagin a"(M-a)'s extracted characters(EC) are 314 from total 389 characters, effected by poor contrast, a 80% ER is gotten. Color image "magagin b"(M-b) gets a 90% ER. The results are shown in table 1. There has a same problem in the experiment, the extra smallest characters(ES) can't be extracted so far, if the source images were scaned in high resolution, they could be extracted. and a 99% ER could be gotten.

6 Conclusition

A new method of character extraction from scene image is proposed. It is based on mathematical morphology and can deal with various cases of scene images. The experimental results appear encouraging to demonstrate the efficiency of mathematical morphology for shape analyzing and detecting. We intended to proceed with our studing on character extraction from scene image to improve its accuracy and apply it to other variation not just for cover image. Finally a character recognition system on scene image using mathematical morphology is suggested to be constructed.

Table 1: The results of characters extraction

source	sort	totals	ES	EC	ER
carex	grey	230	50	180	78%
M-a	grey	389	33	314	80%
M-b	color	303	29	274	90%

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