Segmentation of Brazilian Bank Check Logos
Without a Priori Knowledge

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Abstract

This paper presents a method to locate and extract Brazilian bank check logos automatically by employing mathematical morphology. The objective is to minimize the number of heuristic parameters to obtain the most precise possible segmentation in every situation, thereby allowing this approach to be reused in other applications. Trials and results are presented.

Keywords: segmentation, Brazilian bank checks, logo, granulometries, mathematical morphology.

1. Introduction

Image segmentation is a process that typically partitions the spatial domain of an image into mutually excluding subsets, called regions. Each region is uniform and homogeneous with regards to some properties such as hue or texture, and the values of those properties vary in some aspects and meanings from the properties of the each neighboring region.

One of the major challenges in image processing might be image segmentation of significant data. The major problem lies in the absence of a priori knowledge of the number and type of structures the image will present. Such structures are identified on the basis of their geometry, shape, topology, texture, color or brilliance, those characteristics allowing better identification being chosen.

In the literature very little is said about automatic logo segmentation. Suda [1], Soffer [2] and Cesarini [3] focused their efforts on the recognition phase, but the location and segmentation of logos was performed manually. Doermann [4] employed the page segmentation algorithm in the logo segmentation phase of his work, but the complete and precise segmentation was not possible in all situations because in some cases the logos generated showed parts missing, corrupted regions, or the presence of components that were extraneous to them.

In segmentation many heuristics are generally used for the size and position of the components to be extracted. Logos (typically confined to a compact and isolated part of the document, and not linked to the text structure as other graphs) are frequently separated from the other graphic components by their position in the page and by using the previous knowledge of the type of document (memorandum, letter, etc.). The use of many heuristics ends up by limiting segmentation for a given type of application.

The approach presented here employs mathematical morphology to automatically locate and extract logos from the image of Brazilian bank checks. The objective is to minimize the number of heuristic parameters in order to obtain the most precise possible segmentation in every situation, thereby allowing this approach to be reused in other applications.

This paper is organized as follows: In Section 2 an explanation about the basic morphological tools used in our approach will be presented. Section 3 will describe the assumptions underlying the approach presented here. Section 4 will describe the phases of Brazilian bank checks segmentation. Section 5 will present trials and results.
2. Técnicas Morfológicas

2.1 Operadores básicos

The two basic morphological operators are erosion $\varepsilon$ and dilation $\delta$. Other morphological operators can be defined from erosion and dilation, for instance, the opening $\Phi$ and closing used in this work. Their definitions using the Minkowski’s formalism [5][6] are:

- The erosion $\varepsilon$ of a set $X$ from the structuring element $B$ is:

$$\varepsilon^B(X) = \bigcap_{b \in B} X_b$$

- The dilation $\delta$ of a set $X$ from the structuring element $B$ is:

$$\delta^B(X) = \bigcup_{b \in B} X_b$$

- The opening $\Phi$ of a set $X$ from the structuring element $B$ is:

$$\Phi^B(X) = \delta^{-B}(\varepsilon^{B}(X))$$

- The closing $\gamma$ of a set $X$ from the structuring element $B$ is:

$$\gamma^B(X) = \varepsilon^{\tilde{B}}(\delta^{-B}(X))$$

where $\tilde{B}$ represents the symmetrical of $B$, $\Theta$ and $\oplus$ respectively represent the Minkowski’s subtraction and addition.

2.2 Reconstrução Binária $\rho_S(z)$

The binary reconstruction $\rho_S(z)$ of a mask image (finite set) $g$ from a marker image $Z (Z \subseteq S)$ using the structuring element $B$ is [5]:

$$\rho_S(z) = \lim_{n \to \infty} \delta^B_{cS}(\ldots \delta^B_{cS}(Z))$$

where $\delta^B_{cS}(Z)$ represents the conditional dilation of $Z$ from $S$.

2.3 Dual Grayscale Reconstruction $\rho^*_g(f)$ and Fillhole $FILL(f)$

The dual reconstruction $\rho^*_g(f)$ (or also reconstruction by erosion) of a mask image $g$ from a marker image $f (f \geq g)$ is defined [7] as the geodesic erosion $\varepsilon^B_g(f)$ of $f$ with respect to $g$ until idempotence is reached. In practice,

$$\rho^*_g(f) = \varepsilon^i_g(f),$$

where $i$ is such that:

$$\varepsilon^i_g(f) = \varepsilon^{i+1}_g(f).$$

The holes of binary image are defined as the set of its regional minima not connected to the image border. This definition applies directly to grayscale images. Hence, the holes of an image can be removed or filled using a minima imposition technique called Fillhole. The marker image $f_m$ used in the dual morphological reconstruction is set to the maximum image value $t_{max}$ except along its border where the values of original image are kept [7]:

$$FILL(f) = \rho^*_f(f)$$

where

$$f_m(x) = \begin{cases} f(x) & \text{if } p \text{ lies on the border of } f, \\ t_{max} & \text{otherwise.} \end{cases}$$

2.4 Morphological Granulometries

Granulometries, concept introduced by G. Matheron [8], constitute one of the most useful and versatile sets of morphological image analysis tools. They can be applied to a wide range of tasks, from features extraction, to texture characterization, to size estimation, to imagem segmentation, etc... The granulometric analysis of an image $X$ with a family of openings $\phi^{nB}_{n \geq 0}$ is often compared to a sifting process: $X$ is sifted though a series of sieves with increasing mesh size. Each opening (corresponding to one mesh size) removes more than the previous one, until the empty set is finally reached. The rate at which $X$ is sifted is characteristic of this set and
provides a “signature” of $X$ with respect to the granulometry used.

3. Logo Segmentation Assumption

Segmenting without previous knowledge and employing just a few heuristics is a challenge. In the case of Brazilian bank checks, despite the complexity of images, just the single assumption that the logo is bigger than any other information present in the check will be employed.

4. Segmentation Phases

Segmenting without previous knowledge and employing just a few heuristics is a challenge. In the case of Brazilian bank checks, despite the complexity of images, just the single assumption that the logo is bigger than any other information present in the check will be employed.

Because of the blending of relevant logo aspects with the artistic background, the extraction of information from colored images of Brazilian bank checks is a complex task. Acknowledging that fact, the transformation of originally colored images into grayscale images was chosen.

The initial steps of automatic logo segmentation consist in:

- Removing the artistic background from the grayscale image of Brazilian bank checks using the Fillhole process;
- Thresholding the grayscale image;
- Removing the noise from the binary image;
- Filtering in a heuristic way, by binary closing (cross structuring element and 1 iteration), the disconnected and/or distorted parts of the check components;
- Filling in by the Fillhole process all the connected components of the previous image so as to reinforce the logo as the largest component.

Because of the wide variety of logos in bank checks, their location and extraction by eliminating irrelevant information and reconstructing the logos is extremely heuristic.

The automatic logo extraction is supported by a single assumption: the logo is the largest component found in a bank check. On the basis of this assumption, one can think of sieving the image until its largest component is found. By using the size criteria in the absence of heuristic parameters, binary granulometry was once more employed.

Theoretically, the last class generated in the granulometric process must contain the whole logo. In practice, however, because of wear sustained during the thresholding process and because of the fact that the size of the logo component is irregular, this not always happens, and just a portion of the logo is obtained as a result.

The logo location and extraction process is carried out as follows (Figure 1):

- Extracting the largest part of the logo contained in the last class by granulometric sieving;
- Performing the heuristic horizontal dilation of the binary image of the check with 15 iterations so as to connect all the symbols and letters that make up the logo;
- Extracting a dilated version of the logo by means of binary reconstruction, having the part of the logo contained in the last class as marker, and the dilated image as mask;
- Extracting the logo in its original shape by intersecting the filtered binary image and the image containing the dilated logo version.

The phases of the Brazilian bank check logo location and extraction methodology are described and justified below.

4.1 Removal of the artistic background by the Fillhole system

Since the logo blends with the artistic background, up-front removal of the check background becomes necessary. The direct background removal was rejected because it affects the logo. The inverse approach, maintaining the background, was chosen. The Fillhole morphological operator was deemed the best tool because it is automatic and not heuristic, and allows the maintenance of most background components. The removal is performed by subtraction between the bank check grayscale image and the image resulting from the Fillhole morphological operator.
4.2 Thresholding phase

The thresholding process consisting in transforming grayscale images into binary images not always provides good quality black-and-white images. The assessment of that quality is always a challenge.

Mattana [9] studied the efficacy of several thresholding algorithms on Brazilian bank check images. The Otsu algorithm was chosen because it presents the best results in a short time.

4.3 Noise Removal Phase

The means chosen to remove noise originating from background residues and the Otsu algorithm is the morphological erosion operator. The binary granulometric approach was employed to carry out that removal objectively, and not heuristically.

Granulometry was applied to check images by varying the type of structuring elements, and the results were analyzed. It was concluded that the most adequate solution is 2 erosion iterations with the cross structuring element, because it eliminates undesirable information without affecting relevant information.

4.4 Binary Closing Filtering Phase

After removing the noise by the binary granulometric approach, part of the check components and mainly the logo can become disconnected and/or distorted. Heuristic filtering by binary closing (with the cross structuring element and 1 iteration) is carried out to minimize such disconnection and distortions.

4.5 Filling in connected components by the Fillhole process

To reinforce the logo as the largest component, the Fillhole process is again employed to fill in indiscriminately all the connected components of the closed binary image.

4.6 Logo Location and Extraction

The logo location and extraction process is illustrated in Figure 1.
Figure 1: (a) Original grayscale image; (b) Components filled in by the Fillhole process; (c) Portion of a logo extracted by granulometry; (d) Dilated image (e) Segmented logo.

5. Trials

Logos are complex patterns, consisting in several text and image patterns that can be divided into four types [10]:
- word-in-mark, containing only the characters or words in the mark;
- device-mark, containing only graphic or figurative elements;
- composite-mark, consisting in characters or words and graphic elements;
- complex-mark, containing a complex image.

As a rule, works found in the literature process just one type of logo, such as the one by Y.S.Kim & W.Y.Kim [10].

In this study a database of Brazilian bank check images mixing word-in-mark and composite-mark logos was processed. The database contains 418 grayscale bank checks filled in by hand, typewritten and blank, from seventeen banking institutions.

The main problems found were:
(i) Unsatisfactory thresholding of bank check images generating degradation and reducing the size of some logos, that consequently are not sieved in the last class;
(ii) Improper filling in by the Fillhole process of some handwritten components such signatures, rendering them bigger than the logo, and placing them in the last class by the granulometry process sieving;
(iii) Extraction of other check components besides the logo because of overlapping handwritten strokes. This overlap leads to the linkage of those elements, blending them into a sole, larger component that is therefore placed in the last class by the granulometry process sieving.

Table 1 groups the statistical results obtained by the proposed approach of automatic Brazilian bank check logo segmentation. In 27% of the cases the logo was not segmented. In 5% of the cases, other elements besides the logo were segmented. The rate of full logo segmentation was 68%.

<table>
<thead>
<tr>
<th>Status</th>
<th>Nº of checks</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem (i)</td>
<td>46</td>
<td>11</td>
</tr>
<tr>
<td>Problem (ii)</td>
<td>65</td>
<td>16</td>
</tr>
<tr>
<td>Problem (iii)</td>
<td>22</td>
<td>05</td>
</tr>
<tr>
<td>Exact Segmentation</td>
<td>285</td>
<td>68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>418</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 1: Results obtained with the proposed automatic Brazilian bank check logo segmentation technique.

6. Conclusion

This paper presents a method to locate and extract Brazilian bank check logos automatically by employing mathematical morphology in order to minimize heuristic parameters.

The feasibility of the granulometric approach to reduce the number of heuristic parameters in automatic logo location and extraction was evidenced in a database of 418 Brazilian bank checks.

This approach was also shown to allow the extraction of different types of logos, in our case word-in-mark and composite-mark logos.

To reduce the influence of overlapping handwritten strokes and consequently the impairment of the efficacy of the method, future work may involve the extraction of handwritten or pre-printed strokes (by applying the Hough transform, for instance) and/or a process of handwritten or pre-printed patterns recognition.
7. References


