Field Extraction for Form Documents

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Abstract

Since form documents play a very important role in various applications, form interpretation is always a good topic in image processing. In this paper, a method for extracting field features of a form document is presented. This method is immune to slant forms with skew angle being less than 45 degrees. It can be divided into the following steps: image scanning, connected-component generation, contour tracing, corner extraction, line generation, corner grouping, and line alignment. Experimental results show that this method produces good results in fast running speed.

1. Introduction

Paper documents have been serving as the main media for storing and transmitting information in various applications for a long time, such as business letters, journals, technical manuals, table forms, engineering drawings, etc. Traditional methods for paper documents processing are carried out mainly by human beings. Such schemes cost too much time and money. Therefore, an automatic form-reading system is a very good research topic in image processing. Many techniques[1-10] are proposed on this topic.

Since form documents are used widely in the modern world, recognition of form documents is a very important subject from the viewpoint of practical applications. Several form-processing systems[11-20] have been proposed so far. Traditionally, the processing flow of a form reader is as follows: image scanning, feature extraction, form classification, data extraction, recognition, human validation, and database management.

In fact, a good form reader always needs a powerful mechanism to extract field features from form documents. The proposed method extracts field-features accurately with remarkable running speed even when documents slant very seriously that is a fatal problem for conventional form-reading systems.

This paper is organized as follows. Section two describes the scheme we adopted for extracting field-features in a form document. Section three shows the experimental results. Section four gives a conclusion and the future work.

2. Field extraction

Our method contains the following steps: (1) image scanning, (2) connected-component generation, (3) tables/graphics/text classification, (4) contour tracing, (5) corner detection, (6) deskew, (7) line generation, (8) corner grouping, and (9) line alignment.

2.1 Image scanning

Form documents are scanned and converted to raster-based images. Some pre-processing are provided to obtain better quality of the input images.

2.2 Connected-component generation

In order to extract information from a form document, connected components[21] are generated at first. There are many types of connected components, such as 4-connected, 8-connected, and m-connected[23]. In this paper, 8-connected is adopted.

Let p denotes the current-examining pixel, p_1, p_2, … and p_8 represent the eight neighboring pixels of p as shown in Fig. 1. The scanning sequence, from top to bottom and left to right, ensures that p_4, p_6, p_7, and p_8 must have already been processed before p is reached. The algorithm adopted in this paper is described as follows:

```
if ( $p$ is a background pixel )
    Move to the next scanning position.
else if ( $p$ is a foreground pixel )
{
    if ( none of $p_4$, $p_6$, $p_7$, and $p_8$ is foreground )
        Assign a new label for $p$.
    if ( only one of $p_4$, $p_6$, $p_7$ and $p_8$ is foreground )
        Assign the label of the foreground neighbor to $p$.
    if ( two or more of $p_4$, $p_6$, $p_7$, and $p_8$ are foreground )
    {
        Assign one of the foreground neighbor's label to $p$.
        Make a note that the foreground neighbors have the
        same label.
    }
}
```

This algorithm is implemented with linked list to register the connected components that are determined.

2.3 Tables/graphics/text classification

There are many objects, including text, table, isolated lines, noise, etc., in a form document. The generated connected-components should be classified for further processing. Two predefined thresholds, width-threshold(*WT*) and height-threshold(*HT*), are used for connected-component classification. The algorithm is described in table 1.

To discriminate tables from images, another predefined threshold, black pixel density (*BPD*), is adopted. A connected component is an image if its black pixel density is larger than *BPD*, or it is a table.

2.4 Contour tracing

A table contains an outer frame and several inner frames. In order to obtain the information of a table, contour of each field is traced. Each tracing result corresponds to a field as shown in Fig.2.

The proposed contour-tracing algorithm, which can be divided into 3 procedures: get a starting point for contour tracing (*GetTraceSP*), trace the outer frame (*TraceOuterFrame*), and trace inner frames (*TraceInnerFrame*), is described as follows:

```
SP = A starting point for contour tracing.
While( ( SP = GetTraceSP() != NULL )
{
    If ( SP is the first starting point of current table )
        Call TraceOuterFrame( SP ). //Trace outer frame.
    Else
        Call TraceInnerFrame( SP ).//Trace inner frame.
}
```

Procedure GetTraceSP scan the region of current examining connected-component, represented by *rectangle(Left, Top, Right, Bottom)*, from *bottom* to *top* and *left* to *right*. It returns a pixel as a starting point for tracing if it meets the following conditions.

(1) It is a foreground pixel.

(2) It has not been traversed.

(3) It has at least one 4-connected neighbor which is background.

TraceOuterFrame() and *TraceInnerFrame()* are conventional contour-tracing algorithms which can be found in [22]. The obtained contour points are recorded by linked lists to generate corners of a field. If the number of contour points of a field is less than a predefined threshold (for example, 40 pixels), that tracing result will be considered as a noise and then removed.

2.5 Corner generation

Four corners will be generated for each field by using the list of its contour points. The proposed corner-detection algorithm is described as follows:

(1) For each pair of pixels (p_i, p_j) in the list, calculate the distance of (p_i, p_j).

(2) Find a pair (p_k, p_m) with the largest distance. Set p_k and p_m as the two diagonal corners of current examining field.

(3) For any pixel p in the list, $p \neq p_k$ and $p \neq p_m$, calculate the projective distance from p to the diagonal (p_k,p_m). For each side of the diagonal (p_k,p_m), find a pixel with the largest projective distance. The found two pixels, p_s and p_t , are the other two corners in this field. An example is shown in Fig. 3.

The algorithm described above is imperfect for the computational complexity being too large. In order to find (p_k, p_m), calculating the distance of each possible pairs (p_i, p_j) in a field is ineluctable which makes the computational complexity be $O(n^2)$. For a rectangle with 5,000 contour pixels, which can be easily achieved by a high resolution image-scanner, needs 25,000,000 computations to find p_k and p_m.

To solve this problem, we propose the idea of finding corner-candidates in a field before applying the corner-detection algorithm. Since only the contour points with their curvature close to 90 degrees are possible to be the corners of a field. We select the contour points with their curvature close to 90 degrees as corner candidates. Now, the corner-detection algorithm take the corner candidates as input instead of all contour pixels. Because the number of input data is much smaller, the computational complexity is greatly reduced.

2.6 Deskew

After corners are generated for each field, line information is available as shown in Fig. 4. In order to get the skew angle and deskew, the following procedures are applied.

(1) Find the longest field line, L_m. Assume the starting and ending points of L_m are (x_1, y_1) and (x_2, y_2).
(2) Skew angle of this document is then easily obtianed by $tan^{-1}(y_2-y_1/x_2-x_1)$.
(3) Deskew all corners found in the previous section.

If the skew angle of a form document is larger than 45 degrees, for example, 55 degrees as shown in Fig. 5. It is impossible to know the accurate skew angle of a form document. Such ambiguity can not be solved without the help from a OCR system. Therefore, in this paper, the skew angle of a form document must be restricted to no more than 45 degrees.

2.7 Line generation

For each field, the following three steps are applied:
(1) Generate four field-lines by the deskewed corners
(2) Calculate the width of each field-line. Width of a field line can be easily obtained by calculating the distance between two lines as shown in Fig. 6.
(3) Correct the starting and ending points of each line by line-width information as shown in Fig. 7.

2.8 Corner grouping

Neighboring corners should be grouped into one because they are actually the same point. An example is shown in Fig. 8. The grouping algorithm contains two steps:
(1) Define a threshold T.
(2) Two corners, p_i and p_j in a table, will be grouped into a single pixel if $distance(p_i, p_j) < T$.

2.9 Line alignment

Near-colinear lines of different fields will be aligned into colinear as shown in Fig 9. This algorithm contains two steps:

(1) Define a threshold F.
(2) Two field lines, L_1 and L_2, will be aligned into colinear if $distance(L_1, L_2) < F$.

3. Experimental results

Some experimental results are given in this section. The platform of our system is IBM compatible PC, Pentium-120 CPU, running on Microsoft Windows-95. For two testing samples(Fig. 10 and Fig. 12), with resolutions being 2,352 × 1,480 and 2,925 × 2,490, it takes 6.3 and 10.5 seconds to generate all the connected components and field-features as shown in Fig. 11 and Fig. 13.

4. Conclusion and future work

In this paper, a simple but efficient algorithm for extracting field-features of form documents is presented. It contains nine steps: (1) image scanning, (2) connected-component generation, (3) tables/graphics/text classification, (4) contour tracing, (5) corner generation, (6) deskew, (7) line generation, (8) corner grouping, and (9) line alignment. Steps (4) and (5) are rotation invariant. Therefore, the proposed method is immune to a slant document with the skew angle being less than 45 degrees. Also the running speed is remarkable.

The other form-processing procedures, such as text block generation, character grouping, writing direction detection, and character recognition, segmentation of touching characters ...etc, are still under developing in our team.

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Table 1. *CCW*: Width of a connected component.
CCH: Height of a connected component.

	CCW>WT	*CCW* ≦ *WT*
CCH>HT	tables or images	isolated horizontal lines
CCW ≦ *HT*	isolated vertical lines	text

p_6	p_7	p_8
p_4	p	p_5
p_1	p_2	p_3

Fig. 1. *p* and its eight neighbors.

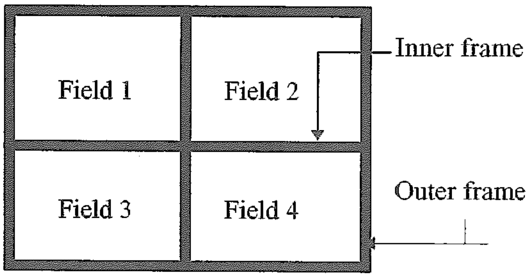

Fig. 2. The outer frame and inner frames in a table.

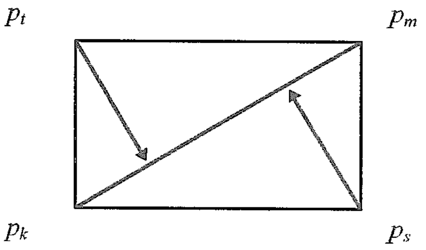

Fig. 3. A field with 4 corners: p_k, p_m, p_s, and p_t.

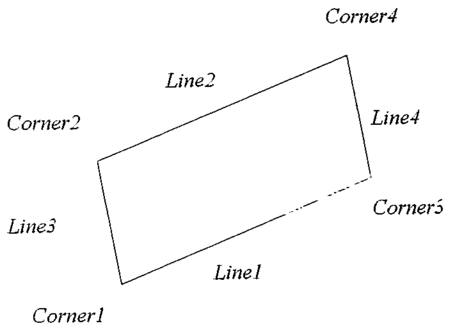

Fig. 4. Lines and corners in a field.

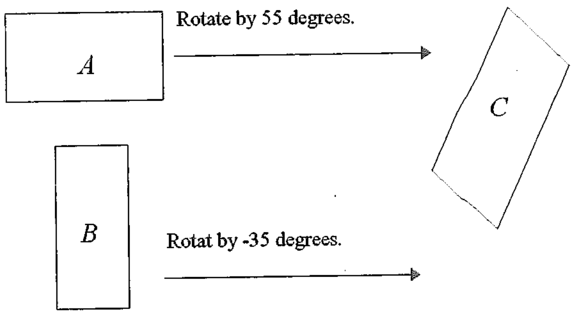

Fig. 5. It is impossible to identify *C* is rotated from *A* or *B*.

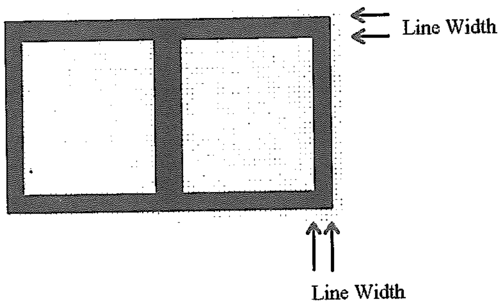

Fig. 6. Line width calculation.

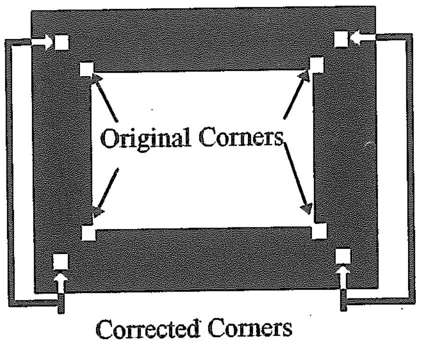

Fig. 7. Correct corners by line width.

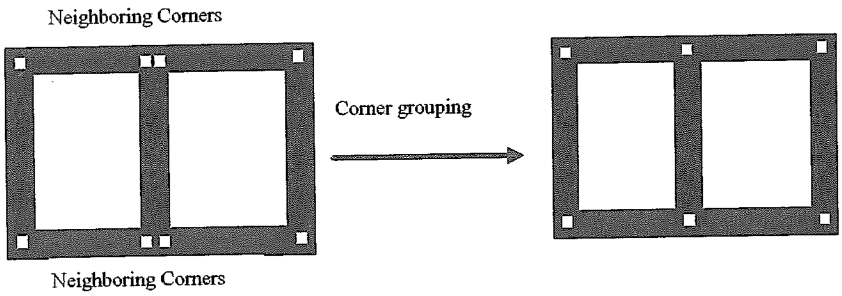

Fig. 8. An example of corner grouping.

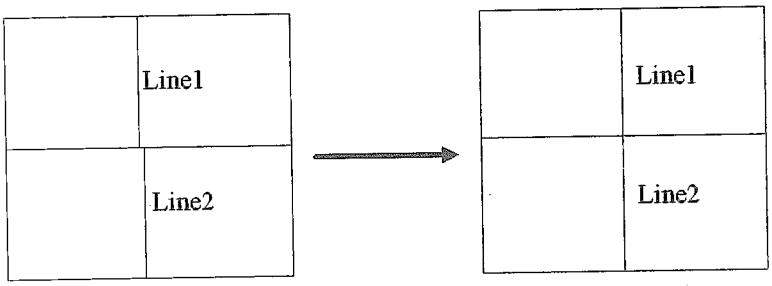

Fig. 9. Alignment for near-colinear field lines.

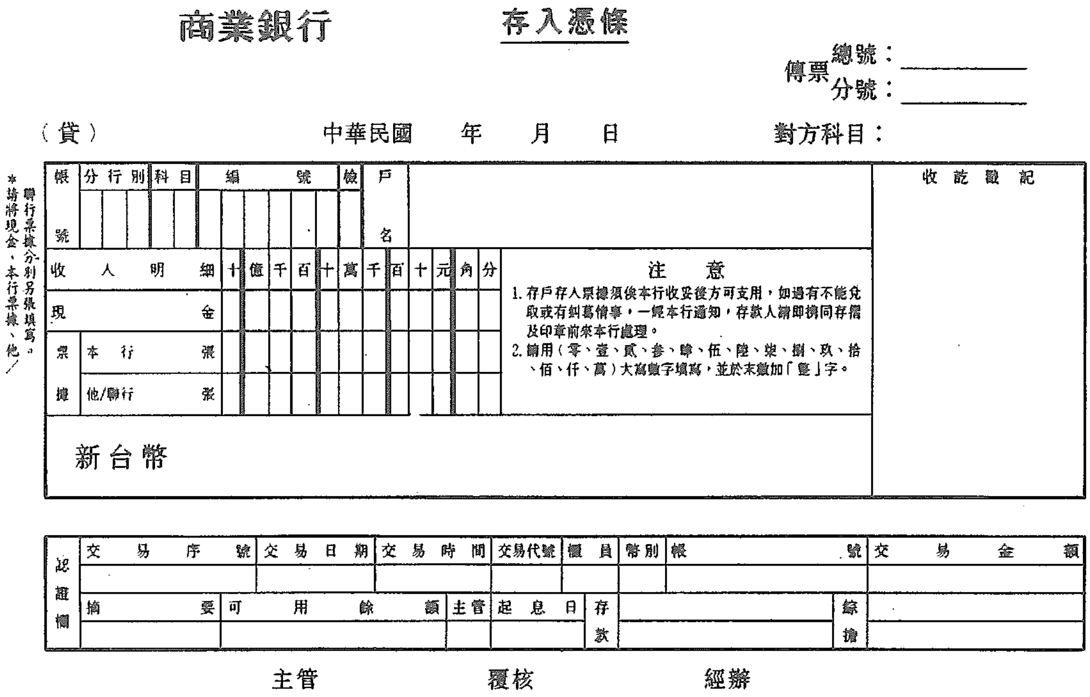

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Fig. 10. A testing example.

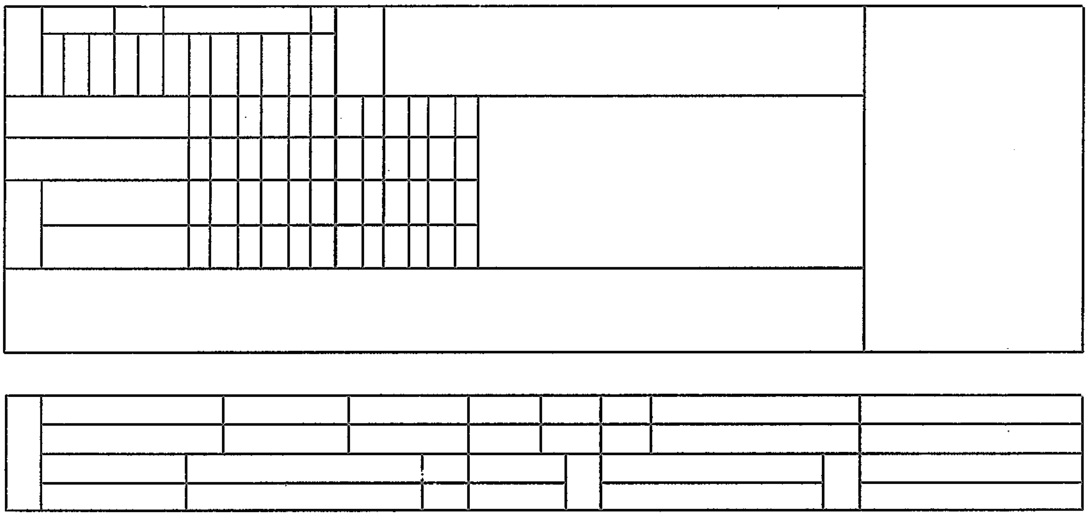

Fig. 11. The obtained result.

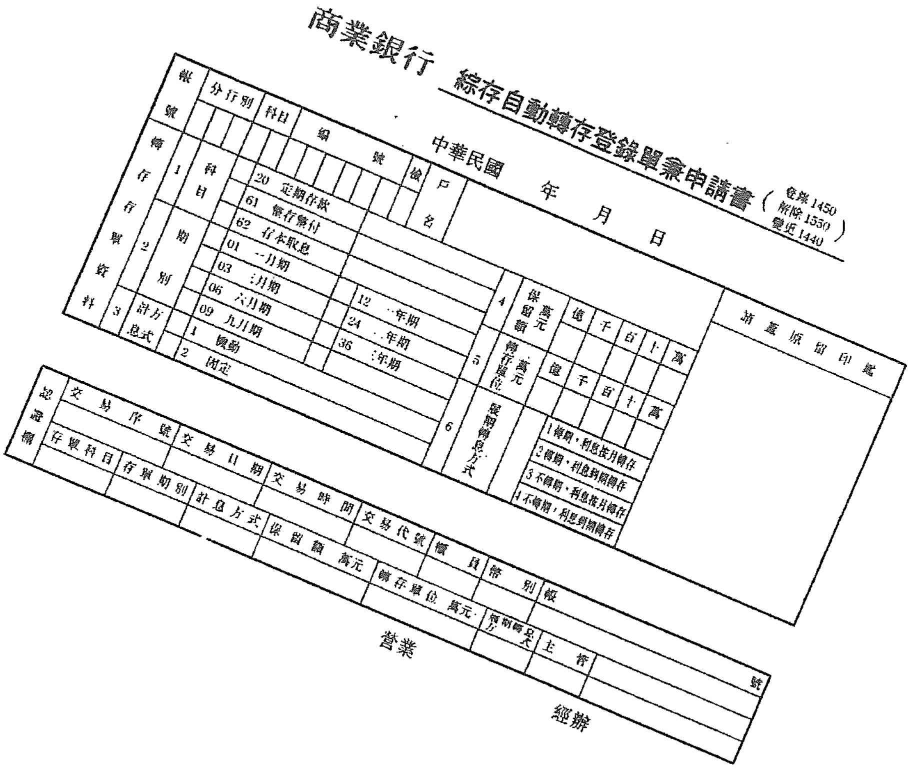

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Fig. 12. Another testing example.

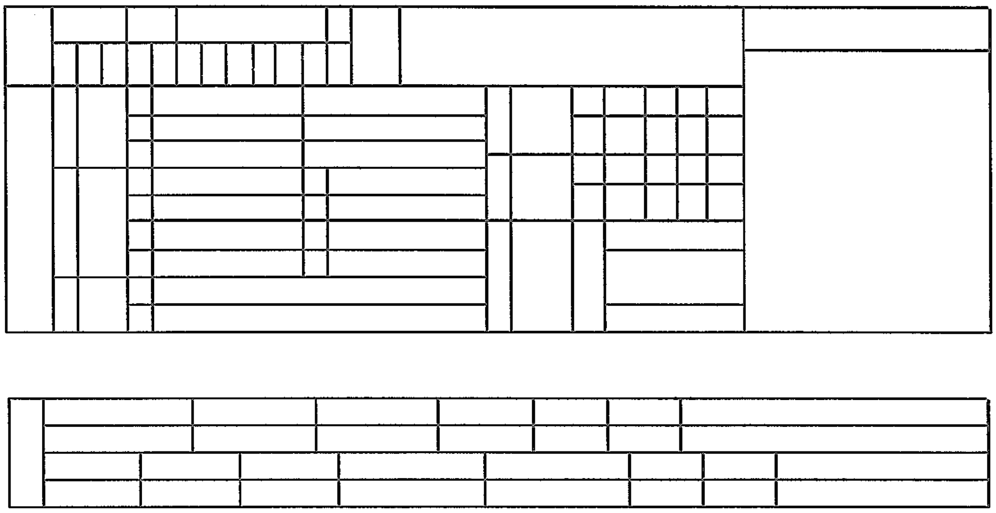

Fig. 13. The obtained result.