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A Recognition Method for Skewed Four-state Bar Codes by using Raster-Scanned Binary Images and Connected Components

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Abstract

A method for reading a four-state bar code, using raster-scanned images is described. Documents are pre-bar coded with one-dimensional four-state bar code that has the free location and no more than 5 degrees inclination. Using raster-scanned images captured by optical character recognition (OCR) equipment, the location and orientation of this bar code is detected and decoded to 20 data characters. The location detecting is done by labeling the binary image runs and merging the connected components of a code. The decoding is done by classifying the connected components based on their shape and location in the code line. Experiments demonstrated that the rejection rate, error rate, and processing speed are sufficient for practical application.

1. Introduction

Documents such as forms and mails are pre-bar coded by printing in black or dark blue ink. It is a one-dimensional symbol structure consisting of sequence of four-state-type dark bars. It has a check sum character that provides an additional margin of safety against misdecoding. Since the bar is pre-printed by customers, its location and orientation is free and not pre-defined by any standard[1][2]. The orientation of one is horizontal or vertical and also is not pre-defined. Optical recognition equipment is used to capture a raster-scanned image for both charcter recognition and bar code recognition. The location and orientation of the bar code is detected from raster-scanned binary images and then decoded to sort[3].

This paper proposes a new method of one-dimensional four-state type bar code recognition using a raster-scanned binary image. The method has two steps. The first is locating the bar code line. This step is based on a process of labeling runs[4] and merging the connected components of the bar code line. The candidate lines consisting of connected components are extracted in the first step. In the second step the sequence of four-state bars is decoded by classifying the bar elements; connected components, based on their shape and location in the code line. The first step is a purely bottom-up recognition process, while the second step involves both bottom-up and top-down processes. We measured the recognition rate and processing time of the proposed method by experimenting with binary sample images.

2. Properties of four-state bar code images

2.1. Description of four-state bar code symbols

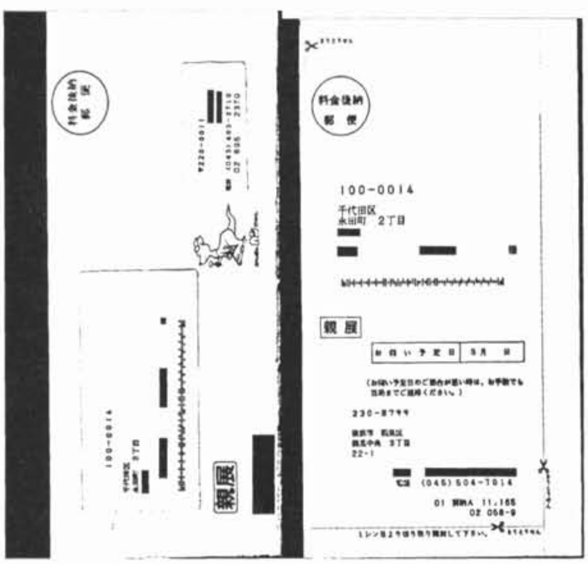
The four-state bar code character set contains alphanumeric, hyphenic and control-code symbols. A sample is shown in Fig. 1. There are four types of dark elements that comprise a code; a long bar, a semi-long bar (upper), a semi-long bar (lower) and a timing bar. The code line symbol structure consists of a start character, 20 data characters, a check character, and a stop character. Each data symbol and the check character contain three elements. There is a quiet zone of at a least 2mm in the surrounding margins. The code line can be oriented either horizontally or vertically at an inclination angle of no more than 5 degrees.

Figure 1. Sample four-state bar code

2.2. Problems in four-state bar code recognition

Four-state bar codes are printed horizontally or vertically as shown in Figs. 2 (a) and 2 (b). The positioning of codes is not standardized, with some images having up to three lines of bar. Some images even have the code printed upside down.

The following problems occur in the process of locating and decoding the four-state bar code.
(1) Arbitary position and inclination of the code line.
The positioning of pre-printed bar codes is free and not defined. Scanned images include stamps, character strings, messages, and illustrations that are obstacles in the search for bars for some images.
(2) Background noises near white margin zones.
The white margin for a code is small and optical noise near the margin zones, such as parts of characters, adhensive edges, or a cellophane window are obstacles to separating the code from the background image.
(3) Low-quality printing and poor image binarization.
Bar code printing on documents is of such low-quality that the bars are distorted. In binary images, defects such as missing bar parts, darked images soiling, and smearing are present. Distortion and defects make it difficult to classify connected components by shape interpretation and location detection.
(4) High-speed bar code recognition.
Whole images must be scanned to locate the bar code. Processing speed is an important measure of performance for a document reader system.



(a) vertical (b) horizontal
Figure 2. Sample images of four-state bar codes

3. Four-state bar code recognition method

Our recognition method for one-dimensional four-state bar code is based on the labeling of runs and the merging of connected components in binary raster-scanned images. The method has two steps. The first step is locating the bar code line on a document, a purely bottom-up process. Binary image runs are tracked and labeled to extract the connected components[4]. The box enclosing the connected component is detected and each component is selected and identified by checking against the allowable height and width of bars, namely dark elements. From identified components, neighboring connected components are merged to extract the bar-code-string line, namely the box enclosing the dark elements. The candidate lines of the bar-code string are also extracted in this step.

In the second step the sequence of the four-state bars is decoded. The method is based on the classification of the dark elements (candidate bars) by identifying their type using shape and location in the code line. This step involves both bottom-up and top-down processes. The bar codes have four types of dark elements; long bar, semi-long bar (upper), semi-long bar (lower) and timing bar, as described above. First the bar; the connected component involved in the code line, is detected and it is classified into the three types (including long bar, semi-long bar , or timing bar). Next, the center-line of the bar-code string, that is shown in Fig. 3 as the equation; y=ax+b, is detected. And the top and bottom position of each (i-th) bar element, that is shown in Fig. 3 as (xt(i),yt(i)) and (xb(i),yb(i)), is detected. And the relative position of each connected component from the center line, that is shown in Fig. 3 as (xl(i),yl(i)), is detected. By checking its relative position on the center line, a semi-long bar is classified as upper or lower.

Some defects in binary images, such as missing bar part, darkness, soiling and smearing are present. When a box of detected connected component has a size ratio larger than the normal, the connected component is cut and the sequence of the four-state type bars is reconstructed and decoded. A check character is used in the above bottom up and top down decoding process.

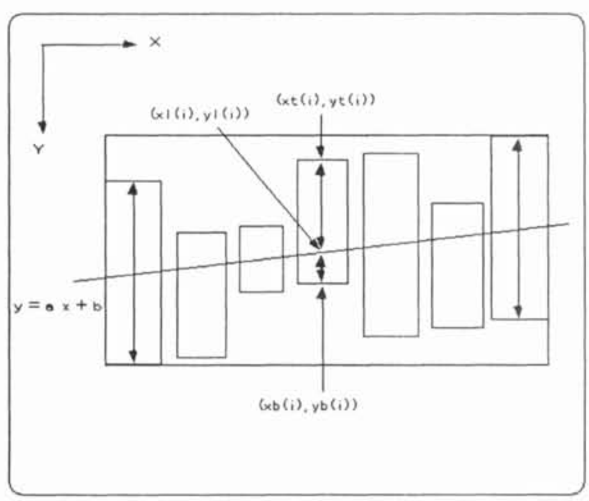


Figure 3. Representation of bar location

4. Experiments

Our experimental system was a personal computer (PC, FLORA SB-1, 200 MHz) and magnetic storage devices. The resolution of the test images was 200 dpi. Their red components were binarized and input for the bar-code recognition process. The bar code recognition software was written in C language and had 6.4k lines.

An example of an input skewed image is shown in Fig.4. The result of an extraction of the connected components in the four-state bar code line is shown in Fig.5. The result of one classification of bar elements, indicated as numerals (1: long bar, 2: semi-long bar (upper), 3: semi-long bar (lower), 4: timing bar), is shown in Fig. 6.

The result for a bar-code-recognition performance test using approximately 2300 test images has an average processing time of 26 msec. This result is fast enough for practical application. There were no errors reading the bar code of the test images, though one image was rejected because of soiling.

5. Conclusion

A method of one-dimensional four-state bar code recognition using raster-scanned binary images was described. This method is based on the labeling of runs and the merging of connected components on a bar code line. The decoding method is based on the classification of the connected components by their shape and location. It has been determined by experiment that the error rate and processing speed are sufficient for practical application.

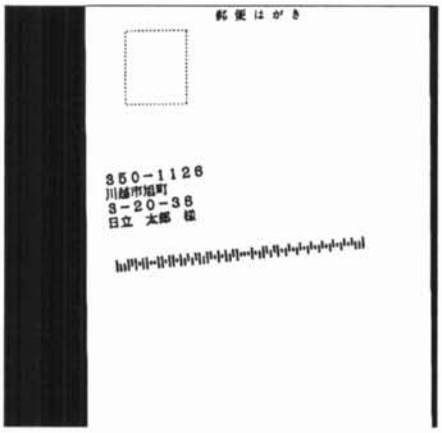


Figure 4. Sample input skewed image

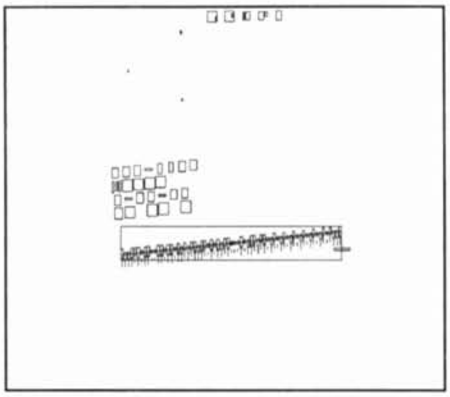


Figure 5. Sample bar code line extraction result

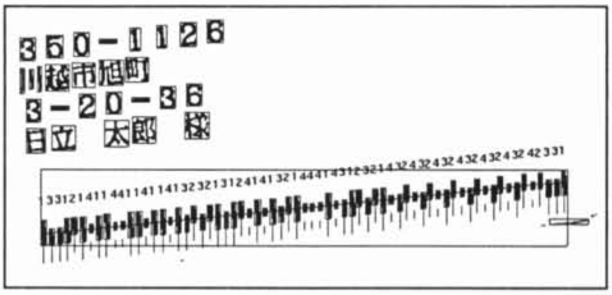


Figure 6. Sample bar code recognition result

6. References

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