Automatic Extraction of Signatures from Bank Cheques and other Documents

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Abstract: An innovative approach for extracting signatures from bank cheque images and other documents is proposed based on the integration of the crop method with the sliding window technique. The idea is to estimate the approximate area in which the signature lies using the sliding window technique. In this approach, a window of adaptable height and width is moved over the image; one pixel at a time and the density of pixels within the window is calculated. This density is then used to find the entropy, which in turn helps fit the box that can segment the signature. The signatures thus extracted are then fed to a known fuzzy based off-line signature verification and forgery detection system. The proposed method has been applied with almost 100% success on several bank cheques from India, Malaysia and Australia. Signature extraction has also been shown on two typical types of documents which have varied and noisy backgrounds.

Keywords: Bank cheque processing, Signature extraction, Sliding window method, Entropy

1   Introduction

Automatic extraction of user entered components from bank cheques and other document forms has been the prime focus of researchers concerned with document analysis and recognition for the past one decade. Bank cheques and financial documents in paper format are still in enormous demand in spite of the overall rapid emergence of e-commerce and online banking. Fraud committed in cheques is also growing at an equally alarming rate with consequent loss [1]. The American Banker has projected that check fraud will grow by 25 percent annually in coming years. According to the American Bankers Association's (ABA) 1998 Check Fraud Survey, financial institutions alone incurred $512.3 million in check fraud losses. When losses to all businesses were factored in, that figure rose to more than $13 billion, according to a 1997 article in the St. Louis Business Journal. In this paper, we try to address the

problem of cheque fraud by trying to develop a new bank cheque processing system, which can be integrated with our earlier work on signature verification and forgery detection [2].

One of the most important tasks in automatic bank cheque processing is the extraction of handwritten signatures from bank cheques and then feeding them to an off-line signature verification system which tests the signature for authenticity. The extraction and recognition of handwritten information from a bank cheque pose a formidable task [3] which involves several subtasks such as extraction and recognition of signatures, courtesy amount, legal amount, payee and date (see Fig. 1). In one of the most pioneering works in this field, Djeziri et al. [4] tackled the problem of extracting handwritten information by means of an intuitive approach that is close to human visual perception, defining a topological criterion specific to handwritten lines which they termed as *filiformity*. They extracted several signatures from cheques with patterned backgrounds using this *filiformity* criterion.
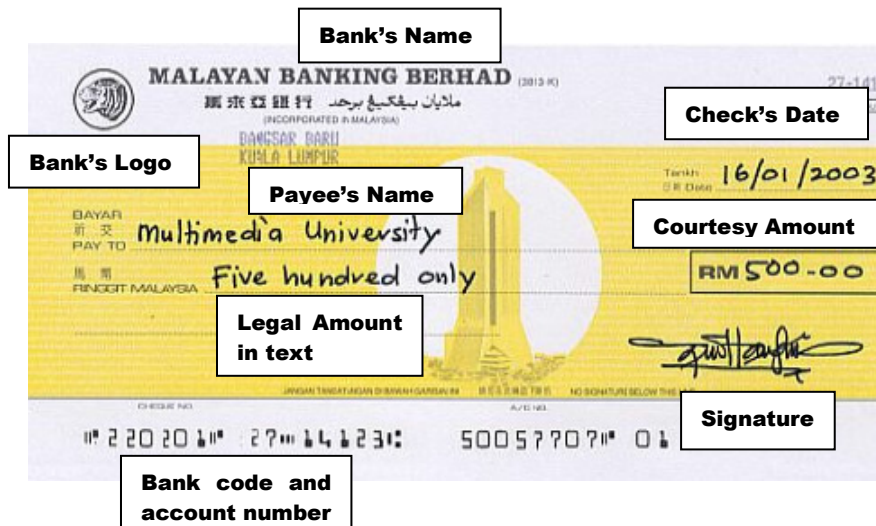

Fig.1. Different fields in a bank Cheque

The nature of bank cheques is varied and complex and this makes the problem of automatic bank cheque processing very difficult [5]. The only way to extract signatures from bank cheques and other forms is to have some sort of prior information about the layout of the document [6,7]. In this paper, we have proposed a similar technique to approximate the area of segmentation before extracting the signatures from the region of interest.

2   System Overview

The overall block diagram of our system is given in Figure 2. The first step is to scan the cheque or the form from which signature is to extracted and apply some pre-processing steps to remove the noise. The system then uses *a priori* knowledge about the document to determine the approximate area of interest. This is followed by the application of the sliding window technique in order to extract the signature or other user entered components. The following sections describe the individual stages of the system in more detail for the complete understanding of the system.

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                        ┌─────────────────┐
                        │  Scanned Image  │
                        └─────────────────┘
                                │
                                ▼
                    ┌─────────────────────────┐
                    │ Pre-processing Techniques│
                    └─────────────────────────┘
                                │
                                ▼
                    ┌─────────────────────────┐
                    │  Layout Analysis (Area  │
                    │     Approximation)      │
                    └─────────────────────────┘
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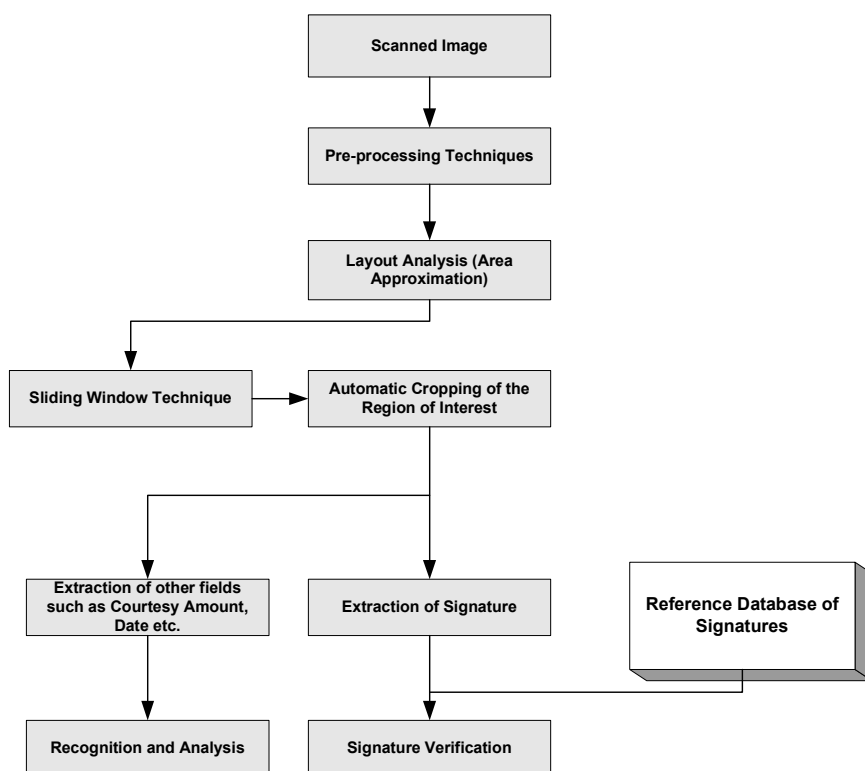
Fig.2. Block Diagram

3   Pre-processing

Binarization is an important step in bank cheque processing. This involves removing the background and extracting useful information. For this task, we have used a B-Spline filter which employs a threshold value to segregate the background from the printed and handwritten information.

The guidelines on which the user has to fill in are present all over the cheque. The guideline or base line removal is the next important pre-processing step. Since we are interested in specific fields on the cheque, by segmenting these fields we can do away with the guidelines. Thus we do not resort to any processing for their removal. There are other pre-processing steps as slant removal of the document and enhancement of noisy images which are applied to specific examples in case the need arises.

4   Extraction procedure

This is the most important module in the entire system. To perform this procedure, the text image should have been pre-processing as explained in the earlier section. Only then, signature segmentation can be achieved as all the noise and other extraneous features have been phased out.
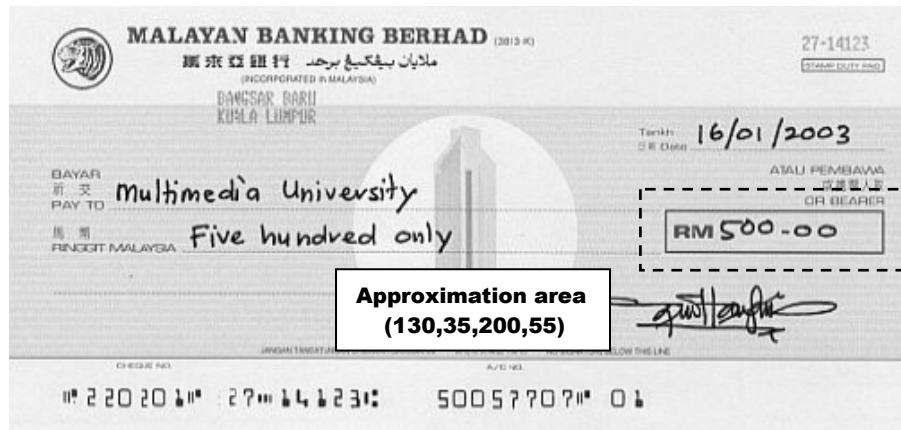

Fig.3. Approximation area

This method can be used to locate a box in cheques. In this, a sliding window is created to move horizontally from left to right on the approximation area (refer Fig.4). The width of the window is fixed to a certain number of pixels and the height of the pixel will be set according to the height of the approximation area. As the sliding window moves by one pixel at a time, the density of the pixels within the current window is calculated. This density is used to calculate the entropy as follows:

$$E = -\sum P(a_j) \log P(a_j) \tag{1}$$

where $P(a_j)$ is the pixel density

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The entropy is a better choice than density because it introduces larger range of values leading to easier and more accurate segmentation. The left and right borders of a box are determined by the two maximum values of pixel entropy. To get the top and bottom borders of the box, we run the sliding window vertically from top to bottom of the approximation area of the box by repeating the process of horizontal sliding as shown in Fig. 4.
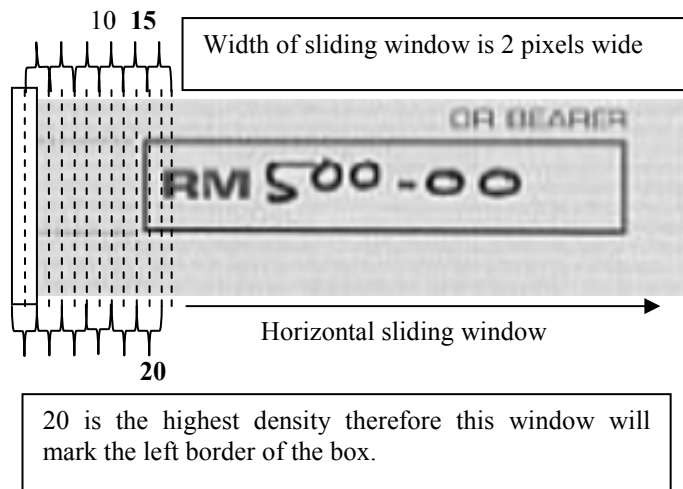

Fig.4. Sliding Window Concept

4.1 Crop Method

The crop method as shown in figure 5 is applied on the defined approximation area in a cheque. Its objective is to locate a rectangular box around an object of interest and remove other objects outside this area. If the signature is the object of interest in the cheque, this could be easily done. The crop method works by moving four vectors from four different directions (namely up, right, bottom and left) towards the object of interest. This procedure is illustrated as below:
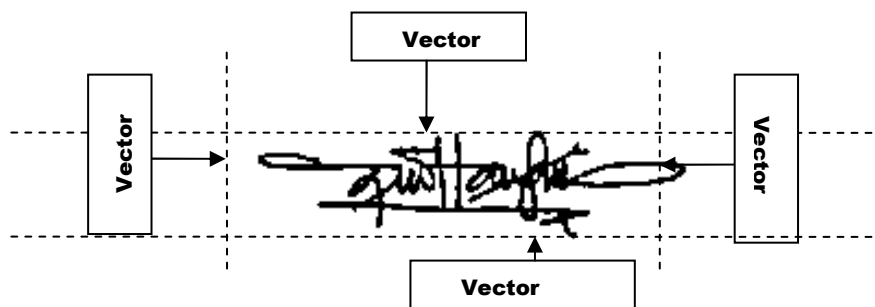

Fig.5. The crop method

For each vector, it will stop moving when it finds a point (black pixel) in its direction. Each vector will mark the border of each side of the rectangular box (i.e. Vector top marks the top border of the rectangle, vector right marks the right border, vector bottom marks the bottom border and vector left marks the left border.)

4.1.1 Implementation on the signature

The original cheque image can be in colour or grayscale. The scanned image must be converted to binary format with the help of any thinning algorithm. We have used the modified SPTA as outlined in [2]. One the approximation area of the signature for a particular check is defined, the crop method is then applied to the approximation area. The cropped image contains only the signature ready to be fed to an offline signature verification system.

4.1.2 Implementation on the courtesy amount box

In this case, the approximation area of the courtesy amount box is calculated from a virgin model of the cheque and this information is pre-defined to the system. The width of sliding window is set to two or three pixels depending on the thickness of the box. For a thicker box, we will use a size of three. Sliding window is applied to the approximation area. Then we will remove two pixels from each border of the box to remove the box lines to get only the content of the box, i.e., the courtesy amount itself.
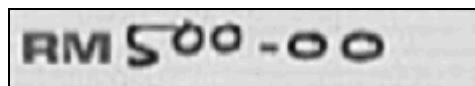

Fig.6. The extracted courtesy amount box

We will then apply the sliding window method again to the resulting image (with box removed). But this time we do the segmentation based on the minimum entropy of the window, because this value represents the gap between characters / digits. The segmented characters will be fed to the fuzzy system for recognition and verification.

5   Experimental Results

The present system for extracting signatures from bank cheques and other different kinds of forms has been implemented on a Pentium III personal computer under the Windows environment. The entire code has been written in Visual Basic. The images were scanned using a HP Scanjet with 600 dpi resolution. It took less than a minute to extract a signature from a bank cheque, once the area approximation has been done on the first model of the cheque.

Our system has achieved a total accurate extraction rate of 99.26% on a database of 211 images. The extraction rates of signatures from different types of documents are

summarized in Table 1. The system failed to completely extract only one signature from a bank cheque. This was due to the fact that the person who had signed the cheque had not done so in the stipulated area and hence the system could not correctly approximate the area to be segmented.

Table 1. Overall results

Type of Document	Number	Correct Extraction (%)	Partial/No Extraction (%)
Bank Cheques	45	97.78	2.22
Tutor Forms	130	100	0
Donation Receipts	36	100	0

In the following sections, we describe in detail two typical types of extraction problems to which we have successfully applied sliding window technique. These experiments have been conducted in order to show the easy adaptability and robustness of our system. The first involved extraction of signatures of a tutor from student assessment forms collected over a period of three months. The second example, which we describe in more detail, has used fuzzy enhancement technique in its pre-processing stage as the document was highly corrupted in nature. Our method can also be applied to several different forms to extract not only signatures but other user entered components provided the approximate area of interest is pre-specified.

5.1 Example I: Signature extraction from a practical exam form

In this experiment, around 130 practical assessment forms were collected from the students of an Electrical Engineering lab course over a period of 13 weeks (duration of a normal academic semester) at the University of Queensland. The aim was to automatically extract the tutor signature from the form and check for its authenticity. The form is a complicated document with a number of boxes and fields marked for entering data. The region of interest, in this case, the box containing the tutor signature was approximated and the information so obtained was used for extracting the signatures. The complete process is as show in the following figure.
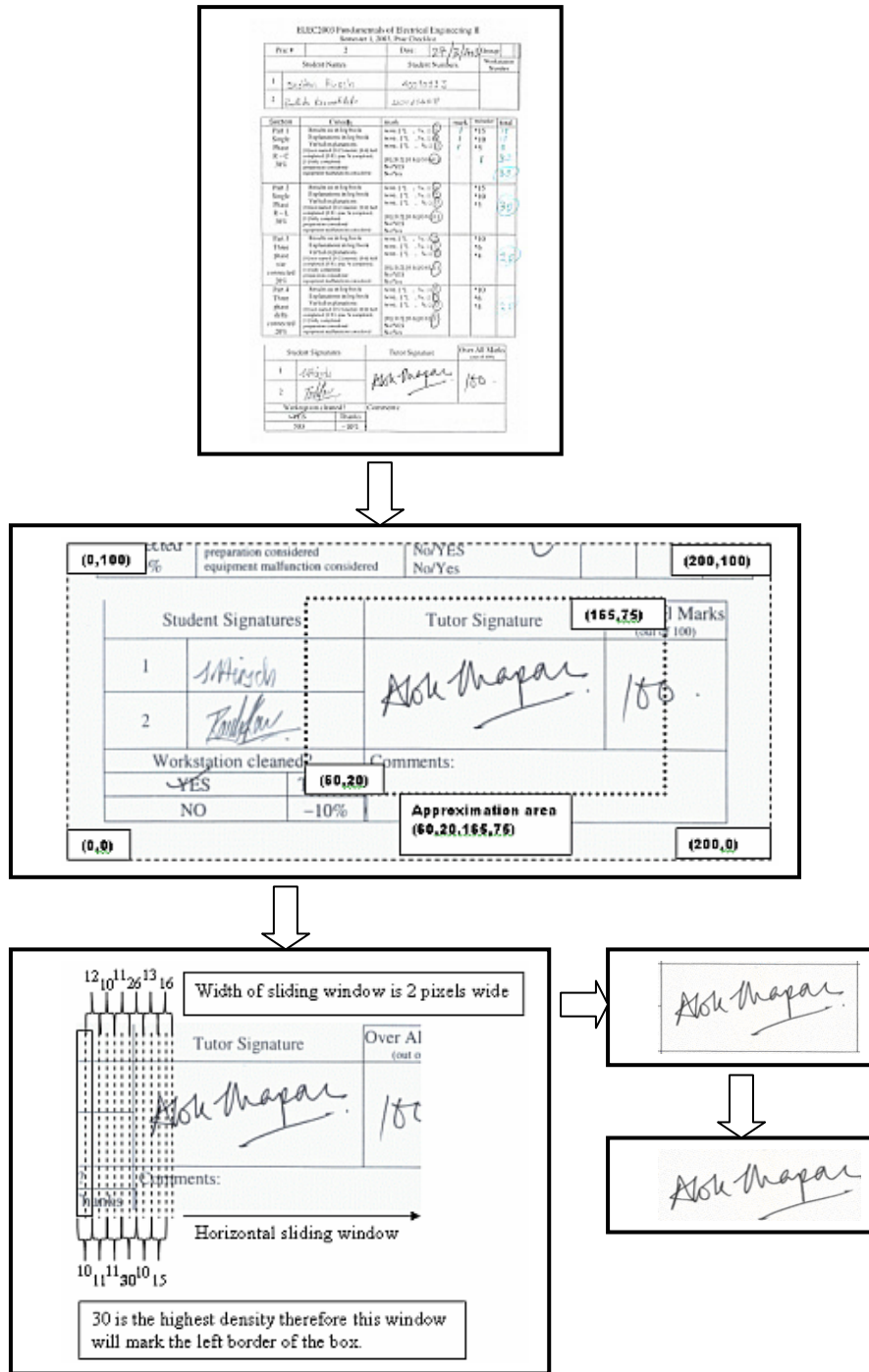
Fig.7. Procedure showing the extraction of tutor signatures

5.2   Example II: Signature extraction from the carbon copies of receipts

In addition to extracting signatures from bank cheques and tutor forms, we have attempted a more challenging task of extracting signatures from the scanned images of carbon copies of donation receipts of Heritage Building Society. The receipts were signed over a period of more than three years and the carbon copies of these documents were hazy and not clear in content. In order to remove the high noise content posed by the damaged documents and also to improve the appearance of the signatures to be extracted before applying the sliding window technique, we have applied a fuzzy enhancement method [8] which enhances the overall quality of the documents. The signatures which are extracted using this technique are perfectly suitable for supplying to any off-line signature verification system. Figure 8 shows the original noisy document before enhancement is done and the enhanced signature which is then extracted.
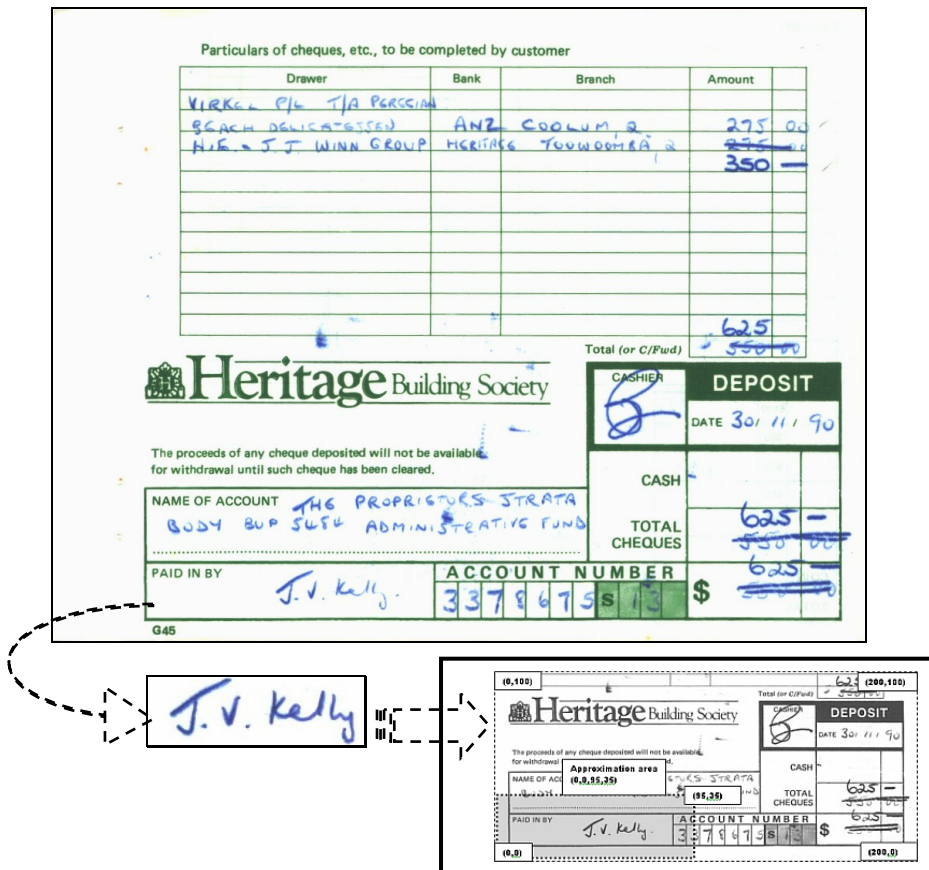

Fig.8. Fuzzy enhancement of signatures before approximation is done

5   Conclusions

The first and foremost step towards developing a complete bank cheque and form processing system is to automatically extract the handwritten signatures and other user entered information from the document. Although, this sounds simple but is quite difficult due to the problem posed by varied backgrounds and the intermixing of machine printed and handwritten information. The only way to tackle this problem is to seek some *priori* information about the location of the signature and other important fields of interest.

This paper is a step in that direction as it presents an automatic signature extraction system based on *a priori* information of the layout of the document. The proposed sliding window is able to extract signatures from any type of documents, as was shown on two examples. In further work, we plan to integrate this system with signature verification so that the whole process of bank cheque authentication is automated.

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