AUTOMATIC SYSTEM FOR THE RECOGNITION OF AMOUNTS IN HANDWRITTEN CHEQUES

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Abstract: Until the rise of electronic means for direct debit, bank cheques have been used as the best form of payment, balancing security and ease of use. Its acceptance and generalized use are result of international agreements that define rules for filling and using it. The fast processing of payments and transactions through safer electronic methods has created the need to reduce its usage over the last years. But despite this progressive reduction, bank cheques still are and will continue to be used; therefore, there is the need to optimize processing mechanisms. The existing automatic cheque processing systems are proprietary and not adapted to the Portuguese language, which is crucial for the cheque analysis and recognition. A prototype of an automatic system for the recognition of the amount in Portuguese bank cheques has been implemented and is being used as a test platform for improved intelligent character recognition algorithms.

1 INTRODUCTION

Bank cheques are probably the most widespread type of documents, with nearly one hundred billion cheques circulating all over the world every year. Retail banks need to assure a prompt answer to these payment requests, which amount to a significant number each day. Most of them are still processed manually by human operators, with document amount reading and validation being the most common and labour-consuming operations.

The Basel II Agreement demanded better security procedures and fraud detection mechanisms in order to improve bank cheque processing. Currently, cheque recognition and validation use a significant part of human resources, due to the multiplicity of handwriting styles that, although easily recognized by the human brain, are too difficult for electronic systems. The processing and manual verification of bank cheques currently require a large investment in human resources by financial institutions. Its automation may achieve substantial gains of performance and allow the reallocation of human resources to other tasks.

The performance of state of the art Optical Character Recognition (OCR) and Intelligent Character Recognition (ICR) algorithms (Arica and Yarman-Vural, 2001) allows the development of systems capable of recognizing handwritten text in cheques, specifically the courtesy and legal amount fields for comparison and validation. In fact, there are currently various solutions on this area. However, most of these systems are proprietary, managed by financial institutions or dedicated companies, which spent years on its development and fine-tuning to specific countries (Gorski et al., 1999; Kaufmann and Bunke, 2000; Palacios and Gupta, 2002; Guillevic and Suen, 1998). As such, there is no open source system on this area adapted to the Portuguese language and handwriting.

This paper describes a complete system for the automated reading of amounts extracted from Portuguese bank cheques. We present the specification and implementation of a system integrating all the required features. It uniquely combines ICR technology in the system, easing the conversion of Portuguese cheques to a structured, flexible, XML-based format. The automatic processing of bank cheques is made tractable only by the contextual constraints offered by this application.

At the system level, we present the specification of the system architecture and the implementation of a prototype taking the proposed architecture as a basis. At the recognition level, we detail the preprocessing operations necessary for the successful extraction of the legal and courtesy amounts. A comparative study was conducted on the recognition of the courtesy amount, assessing the strength of different features and learning algorithms. Finally, we present

a critical study of specific techniques to the recognition of the legal amount, outlining the current line of investigation.

2 SYSTEM ARCHITECTURE AND IMPLEMENTATION

In this section, we present the adopted architecture and technologies used for the system development, as well as the research made for the amount recognition.

2.1 General Architecture

The system proposed in this paper comprises the creation of a database of Portuguese cheques and a web-based application mainly featuring the addition of Portuguese cheques to the system, performing their recognition and conversion to a structured format as XML in an integrated manner, allowing the user to confirm and correct the conversion results at the last stage of this process.
The architecture of the proposed system is based on three main entities, as shown in Figure 1.

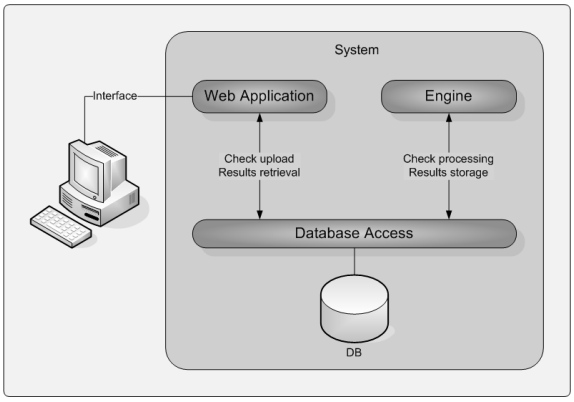


Figure 1: Generic system architecture.

The user interacts with the system using the web application, which allows the complete management of the cheques and associated metadata, as well as carrying out the system administration. The web application allows the upload of scanned cheques images and the examples to design the recognition algorithms (or improve the performance when deployed). It also allows the verification and correction of the recognition result for each uploaded cheque. Moreover, additional metadata can be inserted and linked to the cheque.

The processing engine (Figure 2) executes all the cheque analysis operations, specifically the pre-processing, required fields extraction and amount recognition, as can be seen in Figure 2.

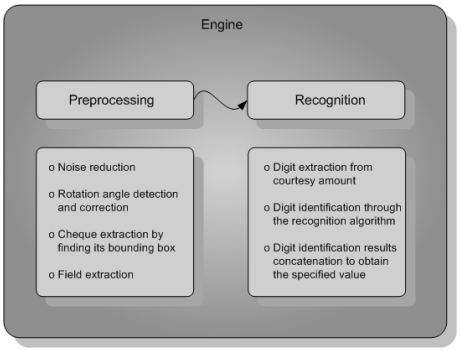


Figure 2: Processing engine.

The database stores the scanned cheques and the digital counterpart in XML, as well as all the descriptive metadata inserted by the user and examples used in the design of the recognition algorithms.

2.2 Prototype Implementation

We developed a prototype taking the system architecture shown in Figure 1 as a basis. The prototype was developed on the Microsoft .NET 2.0 platform. The web application was developed using ASP.NET, and the processing engine is a C♯ application running in background. Both modules use ADO.NET to access the SQL Express 2005 database. The pre-processing was implemented with AForge.NET 1.62. AForge.NET[1] is an open source platform for the development of digital image processing applications on the .NET platform.

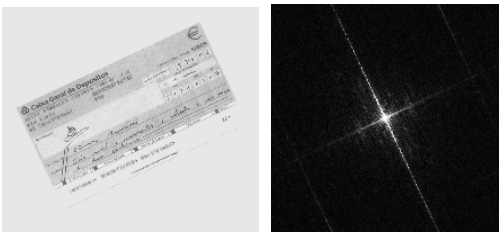
The recognition of the courtesy amount was done with the Weka[2] platform, which offers a collection of machine learning algorithms for solving data mining problems implemented in Java and open sourced under the GPL. The integration of the Weka platform in the developed prototype was done using the IKVM Virtual Machine, which allows Java code conversion to C♯ libraries. By making the Weka library directly available to the system, it was possible to use its implementation of machine learning algorithms.

2.3 Processing Engine

The processing of a cheque combines first a set of operations to facilitate the main recognition stage; the later accounts to the recognition of the courtesy and legal amounts. The pre-processing involves:

[1] http://code.google.com/p/aforge/
[2] http://www.cs.waikato.ac.nz/ml/weka/

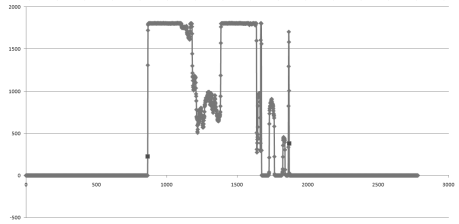
- Noise reduction/elimination:
  - median filtering - achieves both noise removal and edge preservation, by using a 3×3 window and assigning to each pixel the median of the ordered values;
  - contrast stretching - improves the contrast in the image by 'stretching' the range of intensity values it contains to span the full range of pixel values. This facilitates the use of a fixed threshold value in the next step;
  - binarization - turns the image black and white, enhancing the cheque limits and orientation for angle detection.
- Rotation angle detection and correction:
  - Principal Components Analysis (PCA) over the Fourier Transform (FT) of the image (Figure 3) - the rotation angles results as the slope of the first principal direction of the set of points;
  - Rotation with bilinear interpolation - undoes the rotation angle present in the original image, aligning the cheque boundaries horizontally and vertically.
- Cheque extraction by finding its bounding box through horizontal and vertical images projections (Figure 4).
- Field extraction: Portuguese cheques emitted by financial institutions have their layout completely standardized, which allows us to find and retrieve its fields using known coordinates and dimensions (based on the cheque's width) (Figure 5).



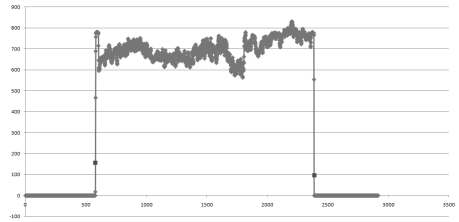
(a) Original Cheque. (b) Fourier transform.

Figure 3: Angle detection.

(a) Rotated Cheque.

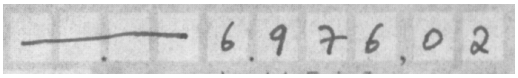


(b) Horizontal projection.

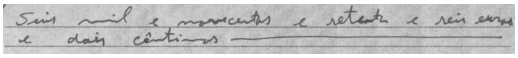


(c) Vertical projection.

Figure 4: Bounding box detection.



(a) Courtesy amount.



(b) Legal amount.

Figure 5: Extracted fields.

2.3.1 Courtesy Amount Recognition

The recognition of the courtesy amount involved first the segmentation of the individual digits composing the courtesy value. This operation uses an a priori knowledge about the number of boxes in the courtesy field and filters the region by eliminating small blobs, assumed to result from artefacts left by an inaccurate field extraction and cleaning. The bounding box of each digit is then determined by vertical projection analysis followed by horizontal projection analysis. This separation avoids cutting digits in half because of inaccurate thresholding of the courtesy field.

To maximize the performance of the classification stage, we assessed different set of features and different families of learning algorithms. As fea-

tures, we considered to input to classifier the matrix of grayscale values, the matrix of the binary values (after thresholding the pixel values), and the digit contour, represented as the distance of the contour pixel to the margin of the bounding box (see Figure 6). As classifiers, we evaluated both multi-layer-perceptron neural networks and support vector machines.

(a) Grayscale. (b) Threshold. (c) Contour.

Figure 6: Representation of digits.

2.3.2 Legal Amount Recognition

The support lines in this field, necessary for a human writer, are an obstacle to word segmentation. Therefore, a first step is to remove them. The goal of line removal is to remove the lines as much as possible while leaving the words on the lines intact. This operation was accomplished by counting horizontally the number of white pixels and building its histogram. This way the module was able to identify the positions of both lines as maximum on the histogram and eliminate them. The word extraction was then performed with vertical projection analysis. The result of these individual steps are illustrated in Figure 7.

(a) Legal field after the introduction of noise reduction filters and blob filters.

(b) Legal field after the line removal algorithm.

(c) Word obtained after vertical projection.

Figure 7: Processment of the legal amount.

Three features were computed for word recognition: the existence of ascenders and descenders; loop detection, and finally the aspect ratio of the word. The selected features were used to train different classifiers: k-nearest neighbour, support vector machines and multi-layer-perceptron neural networks. Finally, the improvement of the legal amount recognition is being researched with support on Hidden Markov Models (Rabiner, 1990), which have shown to be robust for word identification in handwritten text. The results obtained on several studies indicate that its use on the legal amount recognition improves the recognition and validation rates in bank cheques.

3 RESULTS

The results obtained in digit recognition are shown in Table 1. The same methods used to obtain and recognize the digits in the courtesy field were also applied to the date of issue field. Table 2 shows the results obtained.

Table 1: Recognition rate for different learning algorithms and sets of features.

	grayscale	threshold	countour	
MLP	88.8	87.6	91.3	89.2
RBF	85.7	70.2	86.3	80.7
Poly SVM	88.8	87.6	92.5	89.6
SVM RBF	89.4	88.2	93.2	90.3
	88.2	83.4	90.8	

Table 2: Recognition rate for the date of issue field.

	grayscale	threshold	countour	
MLP	78.7	65.8	93.0	79.2
RBF	70.3	75.1	87.3	77.6
Poly SVM	77.7	65.3	92.1	78.4
SVM RBF	81.2	79.3	94.0	84.8
	91.6	71.4	77.0	

A simple inspection of the results allows us to conclude that the features based on the digit contour produced the best results, followed by grayscale and binarized formats. As for the recognition algorithms, Support Vector Machines have shown the best performance, followed closely by the Multilayer Perceptron neural network.

The analysis of results for the recognition of the legal amount, presented in Table 3, shows that the SVM classifier with RBF has the best results for any features type. Even though the overall results are insufficient they can be used as a baseline for HMM and Elastic Matching algorithms, which are both still under development.

4 CONCLUSIONS

The automatic processing of bank cheques is of paramount importance in the sector. Retail banks

Table 3: Results of the recognition of the legal field obtained by the combination of the features with the classifiers.

	A/D	A/D + Loop	AD + Loop + Size	
MLP	27.4	36.5	37.4	33.8
KNN	25.3	34.3	36.2	31.9
Poly SVM	24.0	38.6	39.3	34.0
SVM RBF	28.6	40.1	41.0	36.6
	26.3	37.4	38.5	

need to assure a prompt answer to these payment requests, which amount to a significant number each day. Optimizing this decision-making entails the decision to be uniform, objective and fast, with the minimum of mistakes and losses. In this work we have presented an automatic system for the handling of Portuguese cheques.

A database was created containing digitalized images of Portuguese cheques for the system training and validation. Also, a study of pre-processing methods allowed the correct elimination/attenuation of existing noise in images, and the successful extraction of cheques and the necessary fields. Cheque preprocessing and fields extraction were aided by the cheque layout standardization applied in Portuguese financial institutions, allowing precise localization of the required fields.

The results obtained in the machine learning algorithms comparison showed that the courtesy amount recognition by Support Vector Machines with a RBF kernel based on digit contour analysis obtained the best results, with a 93.2% recognition rate.

Future work involves the implementation of a legal amount recognition module, using Hidden Markov Models (Rabiner, 1990) and Elastic Matching (Uchida and Sakoe, 2005), which can successfully identify the written words, compare it to the previously recognised courtesy amount and validate the cheque.

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