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CSM neural network for degraded printed character optical recognition

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ABSTRACT

In pattern recognition applications, the classification power of a system can be improved by combining several classifiers. Obviously performance of the system cannot be improved if the individual classifiers make all the same mistakes, thus it is important to use different features and different structures in the individual classifiers. In this context, we propose a two subnets neural network called CSM net. The first subnet, or similarity layer, is operating as a similarity measure neural network; it is based on the complementary similarity measure method (CSM). The second subnet is a *competitive neural network* (CNN) based on the *winner takes all* algorithm (WTA) that is used for the classification. In the proposed neural architecture, the statistical CSM method is analyzed, and implemented in the form of a feed forward neural network, it is named "similarity measure neural network" (SMNN). We show that the resulting SMNN synaptic weights are modified versions of the model patterns used in the training set, and that they can be considered as a memory network. We introduce a relative distance data calculated from the SMNN output, and we use it as a *quality measurement tool* of the degraded characters, what makes the SMNN classifier very powerful, and very well-suited for features rejections. This relative distance is used by the SMNN and compared to a first rejection threshold to accept, or reject, the incoming characters. In order to guarantee a higher recognition and reliability rates for the cascaded method, the SMNN is combined with a second subnet based on the WTA for classification using a second specific rejection threshold. These two submits combination (CSM net) boost the performance of the SMNN classifier. This is resulting in a robust multiple classifiers that can be used for setting the entire rejection threshold. The experimental results that we introduce are related to the proposed method, but the tests are introduced with various impulse noise levels, as well as the tests with broken and manually corrupted characters, and characters with various levels of additive Gaussian noise. The experiments show the effective ability of the model to yield relevant and robust recognition on poor quality printed checks, and show that the CSM net outperforms the previous works, both in efficiency and accuracy.

1. Introduction

The processing of huge amounts of printed documents is a big task to be handled economically. In today's world of information, forms, reports, contracts, letters and bank checks are generated everyday in large quantities. Hence the need to store, retrieve, update, replicate and distribute printed documents, becomes increasingly important [1,2].

The automatic reading of bank checks poorly printed, is one of the most significant applications in the area of pattern recognition, specifically in the third world, where the needs are important. A local bank can have to process daily thousands of poorly printed checks. The treatment of these documents is expensive [3,4]. The main targeted application of our proposed method is thus to improve third world bank checks processing. This is the case selected as an example, for two reasons:

- The printings and papers are of poor quality.
- The important daily use of account check numbers (ACN) for customer balances.

The ACN is used to retrieve the following data from the customer's references database: the personal information about the customer's accounts, and the customer's signatures for checks validations by signatures verifications. Bank customers are often asking about their accounts balance at the bank counter before doing a money withdrawal operation. Thus, the account check number is used in many account balance operations. Hundreds of thousands

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of this kind of operations are operated daily in such banks. Our contribution consists in proposing a powerful system of characters recognition, able to read degraded printed ACN and customer's first and last name (see Fig. 1), in order to facilitate and speed up the treatments of bank checks with reliability, even if they are poorly printed. This system can be applied to the recognition of post checks printed by an old typesetting machine, as they can be met in the third world.

The recognition of degraded documents remains an ongoing challenge in the field of optical character recognition (OCR). This is due to the degradation that could be originated from: low quality originals, quantization errors in the digitization process, and non optimal lights and contrasts settings [5].

In spite of significant improvements in the area of OCR [5–8], the recognition of degraded printed characters, in particular, is still lacking satisfactory solutions for commercial uses. Studies on designing recognition systems with high performances for degraded quality documents and characters are in progress along three different directions. The first one is to use a robust classifier, the second one is to enhance the degraded documents images for a better display quality, and an accurate recognition, and the third one is to use several classifiers [9–14].

Sawaki and Hagita [9] proposed a robust recognition method based on a complementary similarity measure (CSM) for characters with graphical designs and degraded characters. Their experimental results concern newspaper headlines with graphical designs identifications. It shows a recognition rate of 97.7%. In their experiments, they used only the highest value of similarity and the rejection criterion was not considered. Hobby and Ho [10] proposed a method to enhance degraded document images (EDDI) for having a better display quality and a recognition method applied to fax images. Outline descriptions of the symbols printed are obtained, there are so rendered with an arbitrary resolution. Their enhancement method cannot be effective with: broken characters, missing parts of the characters or stains on the characters. Tonazzini et al. [12] proposed a recognition system for highly degraded printed documents (HDPD) for the purpose of recognizing text characters applied to ancient printed texts. They used blind deconvolution and Markov random field (MRF)-based segmentation techniques with a feed forward multilayer neural network for printed characters recognitions. Their experimental results show that their proposed system performs a very precise segmentation of the characters, and then, provides a highly effective recognition of even strongly degraded texts. In their work the considered degraded characters are "touched" characters that the system must segment. Hence, the resultant characters are finally only of a medium quality. Namane et al. [13] used the CSM method as features extractor for degraded characters recognitions applied to typewritten documents produced by typesetting machines. The CSM feature vectors are used to train a multilayer perceptron (MLP). The use of the CSM method, as features extractor, tends to boost the MLP, it makes it very powerful, and very well suited for rejection. Experimental results on typewritten A4 page documents show an achievement of 97.95% of recognition rate, 0.09% of rejection rate and 1.96% of error rate on poor quality typewritten characters. In this combination architecture (CSM-MLP) the decision is only made by the MLP, whereas the rejection is either made by the CSM or the MLP, what decreases the system performances. Likforman-Sulem et al. [14] proposed dynamic Bayesian networks (DBN) for the recognition of degraded characters from historical printed books. This framework allows capturing the 2D natures of characters images by the coupling of two Hidden Markov Models. The vertical HMM observes image columns, while the horizontal HMM observes image rows, respectively. Two coupled DBN architectures are proposed to model interactions between these two streams. For image characters with missing part or stains, both the image column and rows are strongly altered, what provide wrong data for the classification decision. Ramesh Babu et al. [15] proposed a novel approach based on gradient patterns (AGP) for recognizing degraded printed characters. Their approach makes use of the gradient patterns of an individual character for the recognition. Experiments were conducted on characters images that are either digitally written, or on degraded characters extracted from historical documents. The results are found to be satisfying. But this method is very sensitive to "added stains". These stains modify significantly the gradient pattern, what finally will decrease the performances of the method.

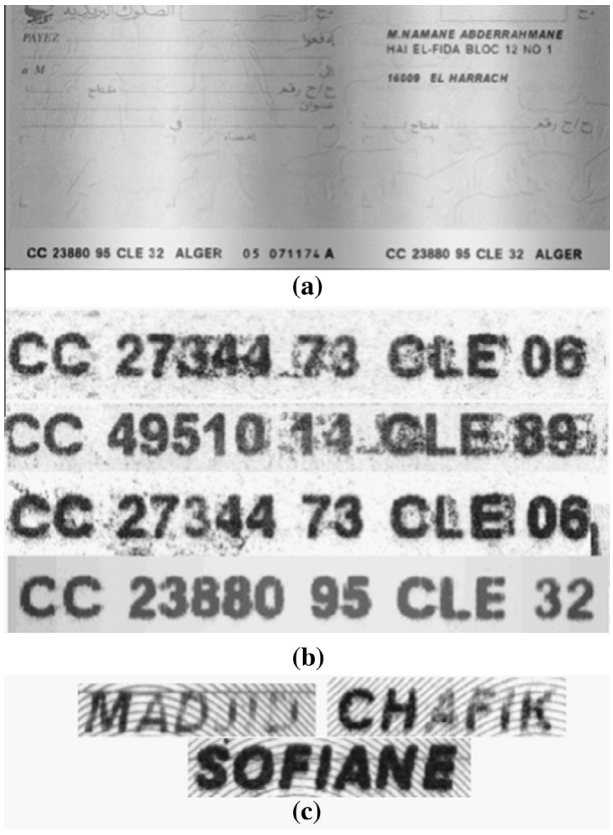

Fig. 1. Poor quality ACNs and alphabetic characters (a) post check (b) account check number (ACN) (c) customer names.

All the recognition methods that are based on the use of *features extractions* should use appropriate *classification* methods. Strong characters degradations can severely affect the enhancement results [10–12] and the extracted features [14] which subsequently affect the classifier decisions. This could happen in the cases of stained or broken printed characters, or characters with missing parts.

In this paper we propose a new method for degraded characters recognitions which consists in using only the models similarities in order to *accept* or *reject* an incoming character by a first classifier (SMNN), based on a *character quality measurement* compared to a first rejection threshold. This quality measurement parameter is also compared to a second rejection threshold, which represents a lower bound rejection threshold (R_{LB}) to reject definitely the highly and severely degraded characters that are not recognizable and avoid more errors with the classifier.

The second classifier (WTA) uses all the similarities produced by the first classifier (cases of rejection) as shown in Fig. 2. In general, these similarities must be higher, in order to make the subsequent