International Journal of Signal Processing, Image Processing and Pattern Recognition
Vol.8, No.6 (2015), pp.9-14
http://dx.doi.org/10.14257/ijsip.2015.8.6.02

A Comparison between the Performances of Several Distances for Isolated Handwritten Arabic Numerals Recognition

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Abstract

In this paper we have achieved a comparison between the performances of different types of distances used in the k nearest neighbors classifier for recognition of isolated handwritten Arabic numerals extracted from Mnist database, more precisely these distances are those of Euclid, of Manhathan, of Minkowski, and of Tchebychev, to do this, we have used for pre-processing the image numerals the median filter, the thresholding, the centering and the skeletonization techniques and in order to extract the features from numerals we have employed the zoning method. The simulation results that we obtained demonstrates that all these distances are generally almost equivalents.

Keywords: *Isolated handwritten Arabic numerals, Mnist database, Median filter, Thresholding, Centering, Skeletonization, zoning method, k-nearest neighbors classifier, Euclidean distance, Manhathan distance, Minkowski distance, Tchebychev distance*

1. Introduction

Recently isolated handwritten character recognition has been truly one of the most activE and dynamic research domains in the Optical Character Recognition (OCR), it is really applicable in many different fields such as postal address resolution, bank cheque recognition and signatures recognition, etc. Otherwise, handwritten character recognition is considered as a very challenging task given that the multitude of variability of writing styles from one person to another even just for a given person. On the other hand, several research papers has published for recognition of isolated handwritten Arabic or Latin character or numerals by using the zoning method [10-15] or the k nearest neighbors [1-7] Even so, this research is interested to isolated handwritten Arabic numerals recognition extracted from Mnist database [8, 9]. Moreover, a set of three principal phases can be partitioned each OCR system. In First time, there is a pre-processing phase used in order to render the character image in a best quality. In Second time, the features extraction phase exploited to extract the features from character and to convert it to a vector. Then, in last time the recognition or the learning-classification phase employed for entraining all character images of learning database and classifying those of test database. In this research, we have pre-processed all numeral images by the median filter, the thresholding, the centering and the skeletonization techniques and we have extracted the features from each numeral by the zoning method, while we used in the recognition phase the k nearest neighbors. Hence, our desired goal is to achieve a comparison between the precision of many distances used in the classification method that is the k nearest neighbors which are the Euclidean, the Manhathan, the Minkowski and the Tchebychev distances.
Furthermore. This paper is organized as follows. First, section I presents the proposed recognition system, Section II introduces methods for image preprocessing. Section III presents the zoning method. In Section IV, describes the k nearest neighbors classifier and different distances employed in this framework. Section V shows the experimental results. Finally, the study is ended by a conclusion.

ISSN: 2005-4254 IJSIP

2. Recognition system

Our recognition system is presented in the following figure:

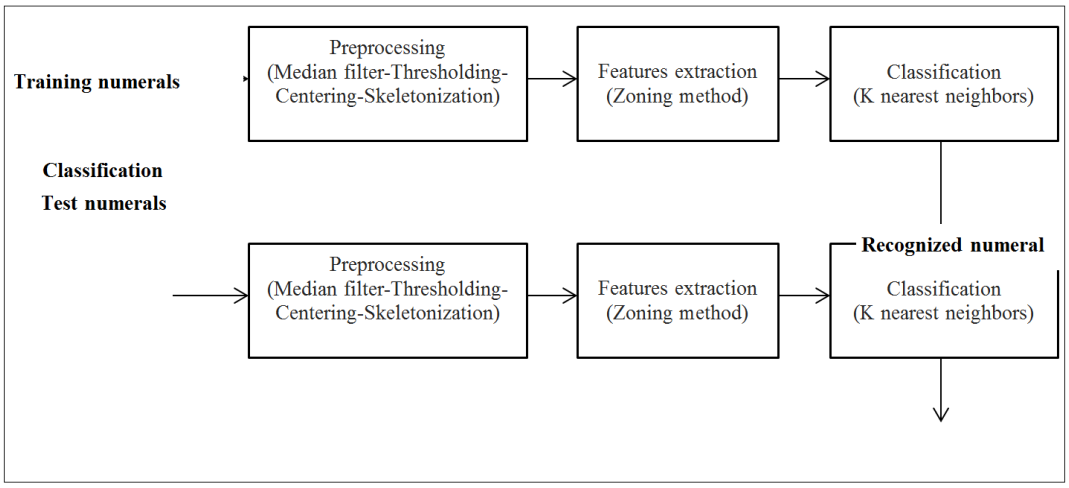

Figure 1. The Proposed Recognition System

3. Pre-processing

Pre-processing is the first phase of Arabic numerals recognition system, it is used to remove the noise and to suppress the redundant and the undesired information's in order to render the image of each numeral in a best quality so that it can be used efficiently in the features extraction phase. In this research, we have preprocessed the images by the following techniques:

- The median filter used to perform a filtration of image.
- The thresholding just for to construct the images contains only the black and white colors according a pre-selected threshold.
- The centering employed for localizing the numeral just in center of the image which encompasses it.
- The skeletonization applied to find the skeleton of numeral.

4. Features Extraction

Features extraction is considered as a very important step for pattern recognition in general, especially for handwritten optical character recognition, in fact the precision of an certain system recognition depends principally to features extraction process because if it have realized at the same time a small inter-class and a great intra-class, the recognition system will be at that time very precise. In this context, we have chosen to use a method that is both simple and effective, which is zoning method that can be explained as follow:

At first, given a black image containing an numeral written in white, the zoning method consists to divide this image to a several zones then calculating in each of them the number of white pixels, all these numbers are stocked in a vector, that is to say the image is converted to a vector has a number of components equal to that of zones. It comes in fact therefore of a vectorization process, which will allow thereafter to realize efficiently its learning thus its classification

Even more, the following figure explains the process of zoning method that we have used in this work.

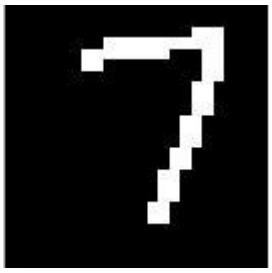

Figure 2. The Numeral Seven

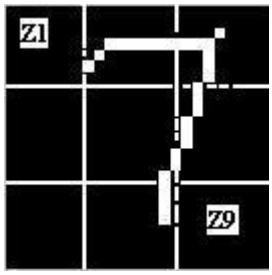

Figure 3. The Numeral Seven by Zoning Method

5. Recognition

In practice, it is very important to use a efficient classifier in such a way that a system recognition becomes very performant. In this framework, we have exploited the k nearest neighbors which is a method used for classifying pattern based on closest training examples in the feature space. The k-nearest neighbor algorithm is considered as amongst and simplest of all machine learning algorithms: its principle of functioning consists to classify an unknown pattern (pattern of test) by a majority vote of its nearest neighbors in terms of distance, that is to say the unknown pattern is attribued to the class containing the greatest number of k nearest neighbors, it is noteworthy in this sense that the number k is a positive integer, typically not great. For well explaining how the classification by this method is carried, we present the following example:

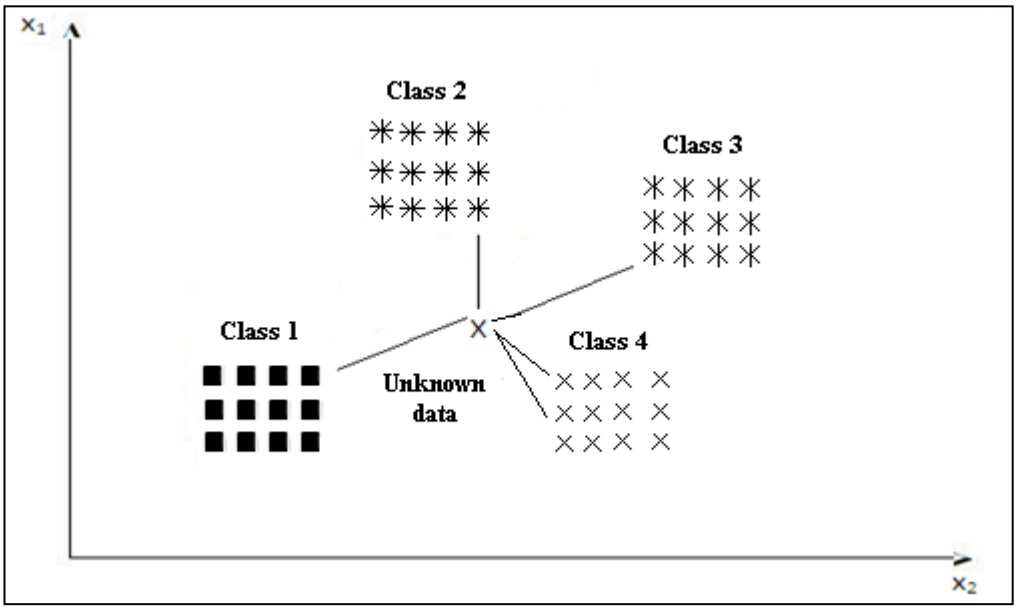

Figure 4. The Process of k Nearest Neighbors Classifier

The Figure 4 shows that the unknown data is attribued to class 4.

Furthermore, hence several types of distance can be used for calculating the k nearest neighbors of unknown pattern, in this side there we have employed the following distances in order to compare between their performances in the isolated handwritten Arabic numerals recognition.

To this effect, given two vectors:

$$X = (x_1, x_2 \ldots\ldots x_N),\ Y = (y_1, y_2 \ldots\ldots y_N) \in IR^N \quad (1)$$

Between X and Y different distances d (X,Y) are defined by :

- **The Euclidean distance :**

$$d(X,Y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \quad (2)$$

- **The city bloc distance or Manhattan distance:**

$$d(X,Y) = \sum_{i=1}^{n}|(x_i - y_i)| \quad (3)$$

- **The Tchebychev distance:**

$$d(X,Y) = \lim_{p\to\infty} \sqrt[p]{\sum_{i=1}^{n}|x_i - y_i|^p} = \sup_{1 \le i \le n} |x_i - y_i| \quad (4)$$

- **The Minkowski distance:**

$$d(X,Y) = \sqrt[p]{\sum_{i=1}^{n}|x_i - y_i|^p} \quad (5)$$

These distances can be briefly expressed by:

$$d_\lambda(X, Y) = \left[\sum_{i=1}^{n} |x_i - y_i|^\lambda\right]^{\frac{1}{\lambda}} \quad (6)$$

- λ=1 Manhattan distance.
- λ=2 Euclidean distance.
- $\lambda \to \infty$ Chebyshev distance.
- $\lambda \to p$ Minkowski distance.

6. Experiments and Results

Firstly, we present a image of some isolated handwritten Arabic numerals extracted from database MNIST [9].

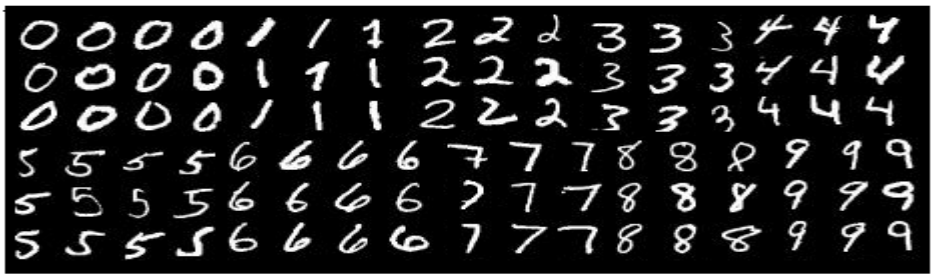

Figure 5. Example of Some Isolated Handwritten Arabic Numerals Extracted from Mnist Database

In order to achieve the desired comparison, we have used the following data:

- Each numeral image has a size equal to images 24x24 pixels.
- The number of all images of learning and of test that we have used is equal to 10000 images.

After several tries, we have chosen:

- The number k of nearest neighbors equal to 7
- The number p used in Minkowski distance equal to 4.

- The number of zones that we have devided each numeral image is equal to 9 zones.

Therefore, we grouped the values that we obtained of the recognition rate τ_n of each numeral (given in %) and of the global rate τ_g of all numerals (given in %) in the following table:

Table 1. The Obtained Recognition Rates τ_n and τ_g by Different four Distances

Numeral	τ_n (Euclidean distance)	τ_n (Manhathan distance)	τ_n (Minkowski distance)	τ_n (Tchebychev distance)
0	95.00	96.67	91.67	88.33
1	100.0	100.0	100.0	100.0
2	96.67	98.33	96.67	93.33
3	78.33	78.33	81.67	76.67
4	91.67	90.00	88.33	83.33
5	68.33	66. 67	68.33	66. 67
6	73.33	76.67	68.33	65.00
7	100.0	93.33	93.33	91.67
8	65.00	63.33	58.33	58.33
9	68.33	63.33	63.33	60.00
τ_g	**83.67**	**82.67**	**81.00**	**78.33**

The graphical representation to recognition rate of each numeral τ_n is:

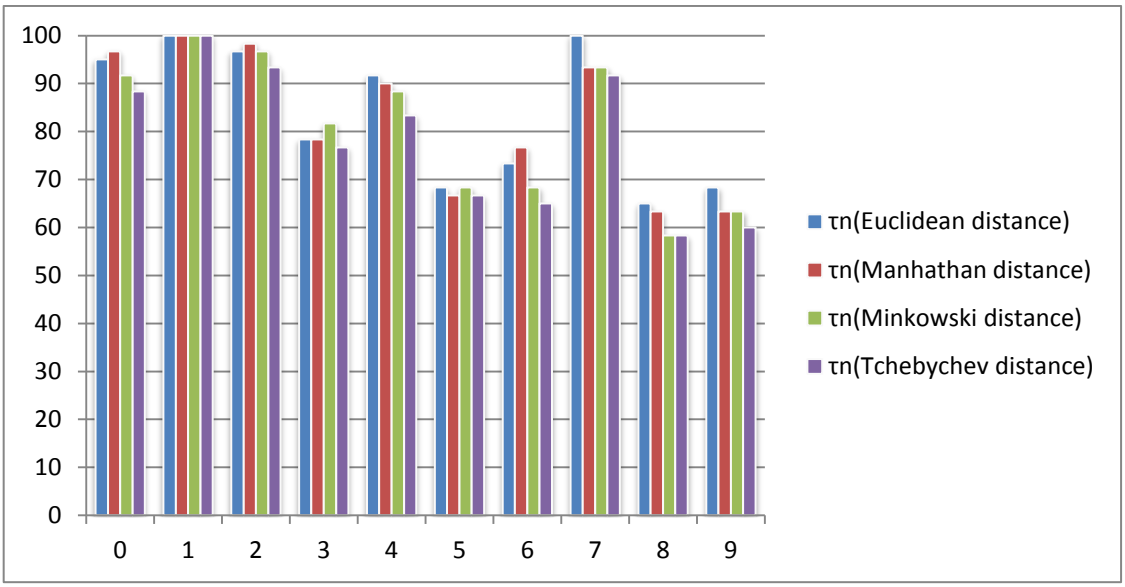

Figure 6. The Graphical Representation of Recognition Rate of Each Numeral of Each Type of Distance

The graphical representation to recognition rate of all numerals τ_g is presented in the following figure:

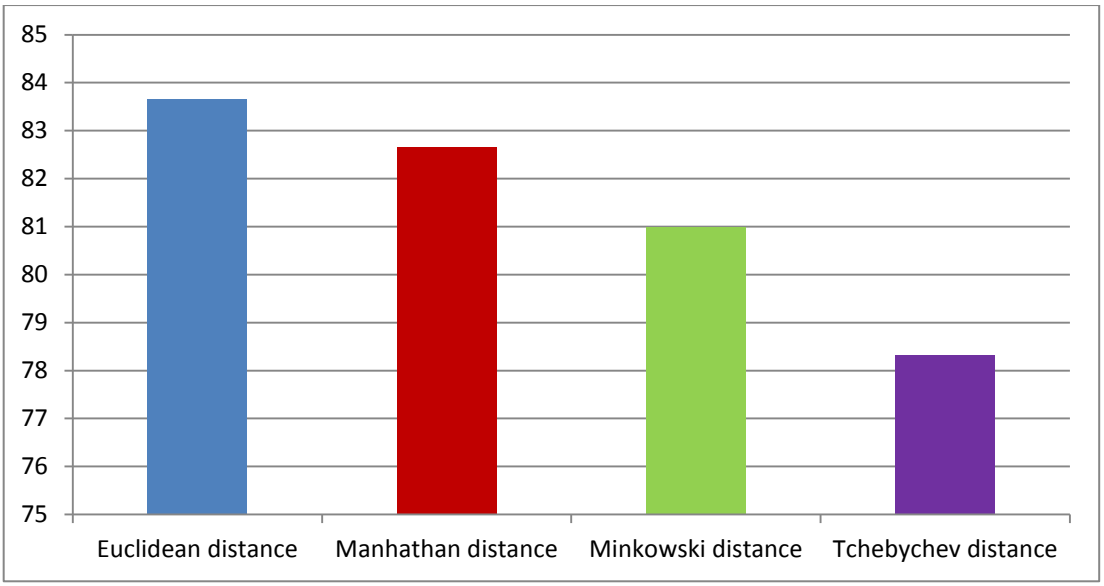

Figure 7. The Graphical Representation of Global Rate Recognition of Each Type of Distance

✓ **Analysis and comment:**

Taking into account all the results that we obtained, we can to conclude in one side that :

- The numerals with most correctly recognized are : 1, 0,2, 7.
- The numerals with less correctly recognized are : 5, 8,9.

And all the distances exploited in the k nearest neighbors classifier are generally almost equivalents on the other side.

7. Conclusion

In this paper, we have presented a comparison between the performances of several genres of distances which are those of Euclid, of Minkowski, of Manhathan and of Tchebychev used in k nearest neighbors classifier for recognition of isolated Arabic handwritten numerals extracted from Mnist database.

In this sense we have verified that the recognition system used in this approach which contains in the preprocessing phase the median filter, the thresholding, the centering and the skeletonization and in the features extraction phase the zoning method and the k nearest neighbors in the classification phase has produced a very convincing results in one hand and all the distances exploited in the k nearest neighbors classifier are generally almost equivalents on the other hand.

Acknowledgement

We are very grateful to our professors Mister **Cherki DAOUI** and Mister **Belaid BOUIKHALENE** for their continuous encouragements, their great cooperation, their pertinent advices and their appropriate guidance in the realization of this work. Many thanks again to them.

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