Printed Hindi Number Recognition

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Abstract

A new simple, fast, and efficient method is used in this research for recognizing Hindi numerals (٠،١،٢،٣،٤،٥،٦،٧،٨،٩), that are usuallyused by Arabic population. This method is simply depends on determining number of terminal points and its positions. Only four features are added when there are similarity between numerals (have the same number of terminals and position). Different fonts with different sizes are tested and the result of the recognition rate for 13 font type is 100%.

Keywords: Hindi numerals, Terminal points, Feature Extraction, Recognition.

Introduction

There are two fundamental approaches to implement a pattern recognition system: statistical and structural. Each approach employs different techniques to implement the description and classification tasks. Hybrid approaches, sometimes referred to as a unified approach to pattern recognition, combine both statistical and structural techniques within a pattern recognition system [1].Structuralapproaches are selected in this research to implement recognition.

One of the most frequent tasks in computer vision and image processing is the recognition of an image or an object in the image. Amongthesetasks,Optical Character Recognition (OCR).

Numeral recognition still one of the most important challenge in OCR, it is used in reading of bank checks, postal sorting, car plates recognition and automatic data entry. Several researchers have researched the recognition of Arabic (Indian) printed and handwritten digits; most of these researches are based on neural network, mathematical method, template matching, and feature extraction methods.For example:Seong-W.[3] proposed a methoddepends onusing a simple multilayer cluster neural network trained with the backpropagation algorithm, and show that the use of genetic algorithmsavoids the problem of finding local minima in training the multilayercluster neural network with gradient descent technique, and improvesthe recognition rates,the recognition rate reached 97-99%. HerminchS. [4]proposed a method, where a feature extraction technique is presented and applied to printed Hindi numerals. Classification is performed using neural networks,the results show that some fonts perform much better than others, also there are some fonts where, achieve classification rate up to 100%**.** Hussein Al-Zoubi,*et al*. [5], present a new method of using motion estimation for the purpose of offline recognition of machine-print Hindi digits, whileYun L. [6] proposed an algorithm employs template matching,the recognition rate of this algorithm is 99, 25%**.**Huda M. [7] proposed a method, wheredifferent forms of printed Arabic characterswritten in three different style was recognized using back-propagation neural network, theresult of recognition rate is 97%**.**Li Y., *et al*. [8] they present a novel method of character stroke feature extraction based on the histogram of gradient angles, the recognition accuracy is up to 99%.

Image Acquisition

Our proposed method dependsmainly on determiningterminal points and its position in addition to only four features. It begin by acquiring image,in this stage the image of a list ofdigit are scanned using scanner device, and saved as bitmap, then three stages where used to recognize a number; these stages are preprocessing, feature extraction and recognition. As shown in Fig.(1). The result is recognized digit.

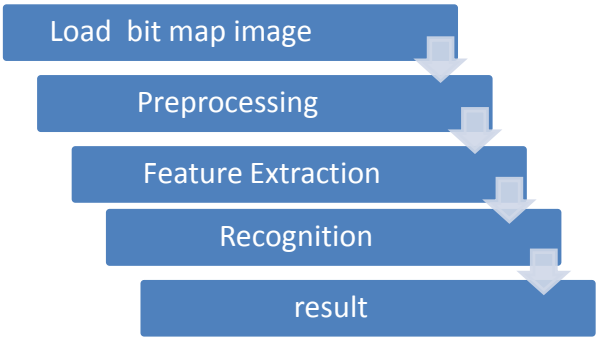

Fig.(1) Themain stages of the system.

PreprocessingStages

The details of the preprocessing steps(image enhancement, image binarization, thinning and segmentation) as shown in Fig.(2).

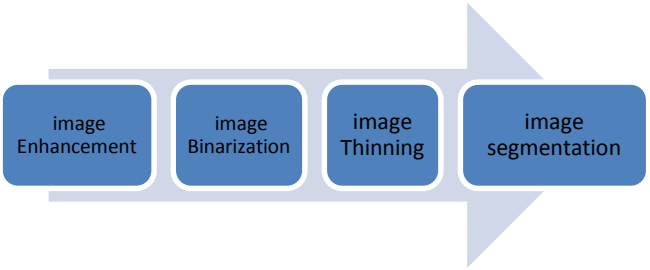

Fig.(2) Preprocessing stage.

1. Image Enhancement:

In this research, the enhancement is done by removing the noise using median filter.Medianfiltering is a nonlinear signal processing technique that is useful for noise elimination in images. In one-dimensional form, the median filter consists of a sliding window encompassing an odd number of pixels. The center pixel in the window is replaced by the median of the pixels in the window[9]. A median filter is able to preserve sharp signal changes and is very effective in removing noise(or salt and pepper noise).It's very widely used in digital signal and image/video processing applications [10].The result is shown in Fig.(3).

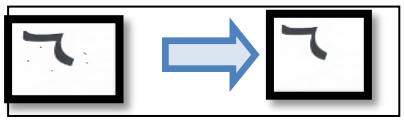

Fig.(3) Image enhancement step.

2. Binarization:

Images in this stage are considered to be binary. The pixels in binary image can assume only two values, 0 or 1; [11]. The goal of binarization is to separate the character from the background in the gray image and make the image color into Black and White [12]**.** The digit image is converted to gray scale using equation (1).

$$GRY_{xy} = \frac{R_{xy}+G_{xy}+B_{xy}}{3} \quad ..(1)$$

At the next step, the gray image is converted to binary imageusing globalthresholding method [13]. The result is shown in Fig.(4).

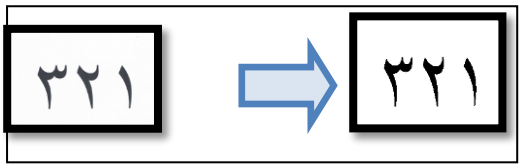

Fig.(4) Binarization step.

3. Thinning:

Thinning is very important preprocessing step for many image analysis operations, such as optical character recognition and finger print recognition [14].Thinning algorithm is a morphological operation that is used to remove selected foreground pixels from binary images. It preserves the topology (extent and connectivity) of the original region while throwing away most of the original foreground pixels.Thinning algorithms can be divided into two types [15]:

1. Sequential thinning algorithms: result of n^{th}iteration depends on result of $(n-1)^{th}$iteration as well as pixels already processed in the n^{th} iteration.
2. Parallel thinning algorithms :(that used in this work) deletionofpixelsin of n^{th} iteration depends only on the result that remains after $(n-1)^{th}$iteration.

Table (1) shows, the result of thinning algorithm for all tested numbers font samples, note thatthe digits have got different shapes for different font types, and have different terminal point number and positions.

Table (1)

Different font types number before and after thinning.

Font type	*Numbers before thinning*	*Numbers after thinning*
Arial	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Arial Unicode MS	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Akhbar MT	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Andalus	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Courier New	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Diwani	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Deco Type Thuluth	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Farsi	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Micro Soft Sans Serif	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Mudir MT	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Simplified Arabic	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Times New Roman	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩
Tohama	٠١٢٣٤٥٦٧٨٩	٠١٢٣٤٥٦٧٨٩

4. Segmentation:

Image segmentation involves the division or separation of the image into regions of similar attribute. Segmentation does not involve classifying each segment. There is no theory of image segmentation. As a consequence, no single standard method of image segmentation has emerged. Rather, there are a collection of ad hoc methods that have received some degree of popularity [9].The result of segmentation is shown in Fig.(5).

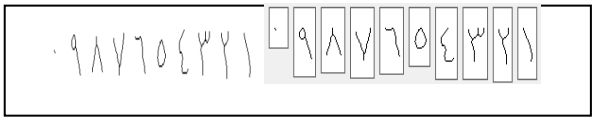

Fig.(5) Segmentation step.

Feature Extraction

Feature extraction is the process of generating features to be used in the classification task. Featureselection reduces the number of features provided to the classification task. Those features which are likely to assist in discrimination are picked out and allowed to be used in the classification task. Features which are not selected are discarded [1].

In this stage (3×3 pixel) window moves over the digit image in order to analysis the relation between adjacent pixels, and then the following two steps are implemented:

1- Image pixels description: in this step the type of each digit image pixel is determined like (terminal pixel, connection pixel, split pixel and cross pixel) see Fig. (6), alsopixels location are determined and their accounts (number of terminal pixels, number of connection pixels and number of cross pixels).

0	1	0	0	1	0	0	1
0	1	0	0	1	0	0	1
0	1	1	1	0	1	1	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0

Fig.(6) Digit image pixels types, where:

Represent terminals pixels.

Represent connection pixels.

Represent cross pixels.

Important information obtained from this step that is the number of terminal pixels for all digits in different font types see Table (2).

Table (2)

Numberof terminalsin each digit.

Number of terminal point	*Digits*	*Examples*
0	٥	
1	٥,٩	
2	٠,١,٢,٤,٦,٧,٨	
3	٢,٣,٤,٦,٧,٨	
4	٣	

2- Feature extraction: in this step each 3×3 Pixels windows) are tested starting from terminal pixel to determine their features like (horizontal line, vertical line, diagonal line, and turn line (with its direction).

Recognition

From the information of image pixels description step and the features that are extracted, the following results were obtained, see Table (3). This table illustrates the features that are used to recognize each digit with different font types.Note that the main feature is number of terminal points, see Table (2), where this table shows, that there are many digit have the same feature (number of terminal point), so the position of each terminal point is used to solve this problem for the most digit and makes it recognized simply see Table (3), but in certain case (for different font types) there is a needed for additional feature is appeared, so only four feature are added, that are illustrated below:

1. Numbers of 3×3 windows to recognize the digit zero, where digit zeros have less number of windows than other digits.
2. Horizontal line to recognize digit one, where digit ١ and digit ٤ have the same number and position of terminal point but digit one have no horizontal line feature, so it's used for recognizing digit ١.
3. Intersection point position to recognize digit ٢,٣,٦,٧ that have 3 terminal, where these four digits have the same number and position of terminal point (two terminal point top and one bottom, so the feature intersection point position is used to recognize the four digits, but digit ٣, that have three terminaldidnotRecognized because of its similarity with digit ٢so there was a need to add fourth additionalfeature.
4. Number of curves in top side to recognize digit ٣ that have 3 terminal point, where digit ٣have 2 curve in top side while digit ٢ have only one curve, by adding this feature the recognition of digit ٢ ,٣ is done.

Table (3)
Main and additional features.

digit	*Number of terminal points*	*Terminals position*	*(3*3) window number*	*Horizontal line*	*No horizontal line*	*Intersection position*	*Curve number*
٠	2	No restriction	✓				
١	2	Top, bottom			✓		
3	2	Top right, bottom left or center					
	3	Top right, top left, bottom				✓	✓
٣	3	Top right, top left, bottom				✓	✓
	4	No restriction					
٣	2	Top, bottom		✓			
٤ ٤	3	Top, bottom, middle center					
	0						
	1	Top					
	3	Top left, bottom right					
	3	Top right, top left, bottom				✓	
	2	Top, top					
٧ ٧	3	Top, top, bottom				✓	
	2	Bottom, bottom					
٨ ٨	3	Bottom, bottom, top					
٩	1	Bottom					

Finally depending on this features the result of recognition rate is 100% for 13 different font type that is tested.

Conclusion

The proposed method is simple, fast and gives 100% accurate result using minimum features comparing with former similar studies. Itsdepend only on number of terminal points and its position for each digitplusonly four additional features in certain cases.The system applied perfectly on printedHindi numbers, with thirteen font types.

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الخلاصة

في هذا البحث تم استخدام طريقة جديدة بسيطة، سريعة، كفؤة لتمييز الأرقام الهندية (٩،٨،٧،٦،٥،٤،٣،٢،١، ٠)، والتي تستخدم عادةً في البلدان العربية. الطريقة المستخدمة وببساطة تعتمد بصورة رئيسية على تحديد عدد النقاط الطرفية ومواقعها لكل عدد. وتم إضافة أربع خصائص أخرى عندما وجد تشابه بين الأعداد (أي لها نفس عدد ومواقع النقاط الطرفية). تم الفحص باستخدام أنواع مختلفة من الخطوط وبإحجام متباينة وكانت نتيجة التمييز هي ١٠٠% لـ ١٣ نوع من الخطوط.

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