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Recognition of Two Connected Handwritten Digits Based on User-Defined Algorithm

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Abstract: The present paper proposes a model for recognizing unconstrained offline two connected handwritten Numeral digit strings. The Numeral strings are segmented and isolated numerals are obtained using sliding window approach* with *user defined algorithm. Hence the present paper proposes a segmentation-recognition system using the sliding window approach with user defined classifier. The sliding window is used for discovery the interconnection spots and optimal angle for cutting the adjacent digits at the same time and a minimum of 5 features are extracted from each isolated digit for classification. The exploratory outcomes directed on a recently gathered database of manually written digits and got promising results. The overall efficiency obtained using the proposed method is about 98.51%.

Keywords: Connected Handwritten Digits, Segmentation, Classification, Sliding Window, Contour.

I. INTRODUCTION

From past two decades the efforts made over the recognition of handwritten digit string are still an open problem in pattern recognition. Automatic digit fields reading is an approach from an images manuscript which is been used in numerous applications, for example, bank cheques [1], pin code [2] and Car number plates [3]. The typical approach for designing an associated manually written scanned digit string recognition systems is depends on the segmentation and classification. General method for the most part comprises of four stages [4]: pre-processing, segmentation, feature extraction technique and order of classification. The preprocessing step for the most part permits changing type of the digit string image into the two valued image for encouraging further handling. In second step the segmentation which is applied for separating the overlapped or connected contiguous numerical digits into simple numerical digits in order to figure out the feasible distinct classes [5-9].

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Feature extraction, one of important steps to be applied on the scanned digit image for sinking the dimension of the image and thus makes the design easy for classification technique. Finally, classification transfers a digit image to predefined class.

Different unequivocal division calculations of two written by hand associated digit have been proposed in light of the structure or shape of the associated digits for discovering one or multiple segmentation focuses [9], which depend on the form [10, 11, 12], the skeleton [13,14], the reservoir [15] or by joining at the same time the shape, profile and the skeleton [8,16].More as of late, these calculations have been looked at unbiased utilizing manufactured and valid associated numerals [9]. In the accompanying, we quickly audit the most prevalent calculations to segment two associated numerals concurring the kind of the structure or shape for distinguishing the cutting way.

The division technique in light of the skeleton at first has been proposed by Chen and Wang(2000) [13] by utilizing both foundation and closer view investigation for basic or different touching digits. A diminishing calculation is utilized as a part of request to get the foundation and frontal area skeletons of the given digit string. division focuses, end focuses, and twist focuses from the single pixel width image is utilized as characteristics. This calculation permits expelling a futile stroke, which can exasperate classification. later, all division speculations are consolidated into a partition chart, and a inherited calculation is utilized to look among all the onceivable yields. The division and arrangement approach is utilized for perceiving the sectioned digits. All the more as of late, Carlos and Everton (2013) [17] proposed the grouping the component focuses chose from the skeletal touching districts by means of Self-Organizing Maps (SOM) for dividing single or different connected handwritten numerals. that strategy utilizes 2 similar procedures to characterize the division focuses.

The main disadvantages of the greater part of these calculations are the large number of cuts, which must be assessed by the recognition algorithm, and the quantity of heuristics that must be set. Away to decrease the quantity of division cuts has been proposed by Vellasques et al. [18]. To defeat the above indicated disadvantages, the present paper proposes a strategy for division in light of the situated sliding window calculation for portion the digits and 5 highlights are extricated from each sectioned digit image and outline the user define calculation for grouping fragmented digits. This paper is organized as takes after. Segment 2 displays an approach for the whole procedure i.e. database accumulation. Pre-process, division, include extraction and plan client characterize arrangement calculation for order the database in which the algorithms were surveyed.

Area 3 reports all the exploratory results and talks about them. At long last, Section 4 finishes up this work.

II. LITERATURE SURVEY

Andre G et.al [19] proposed a strategy for segmentation and recognition of handwritten numeral strings with unknown length. the proposed method segments the digit string with length of 2-, 3- and 4-digits. the proposed method utilizes synthetic dataset Convolution Neural Networks for testing the proposed method. the proposed method was got about 94% of success rate.

Hochuli et.al [20] proposed a method for segmentation of touched numeral digit string with different lengths with minimum number of hypotheses. the proposed method was postulate that handwritten digit segmentation can be successfully replaced by a set of classifiers trained to predict the size of the string and classify them without any segmentation. the successful rate of the proposed method was about 93.6%.

Yun Lei et.a l[21] proposed a segmentation method for numeral strings using surface contour analysis and outcrop analysis to determine contender division points. Among inner contour analysis, the contender division points are employed to determine the equivalent contender division outline with which the numeral string is over-divisional. Each associate-image of the over divisional string is defined as a fragment. The combination of one or more neighboring fragments is defined as a clique. Thus, each contender segmentation result is composed of one or more cliques. Subsequently, all the contender division results are described in a probabilistic model, and a classifier is embedded to recognize each clique.

III. PROPOSED METHOD

The proposed technique is primarily comprises of 4 stages steps. In the primary stage, gathering the numerals information from different information bases and assembling images from different individuals in AP and Telangana state. In the wake of gathering the numeral information pre-process information i.e. disposal of commotion and change of dim scale images into twofold images and furthermore the standardization of the parallel images by utilizing the standardization methods in the second stage. In the third stage, fragment the associated into separated digits and extricated the highlights from singular digit image and infer a calculation for acknowledgment of written by hand numerals framework in the last stage. The piece outline of the proposed technique is appeared beneath figure 1.

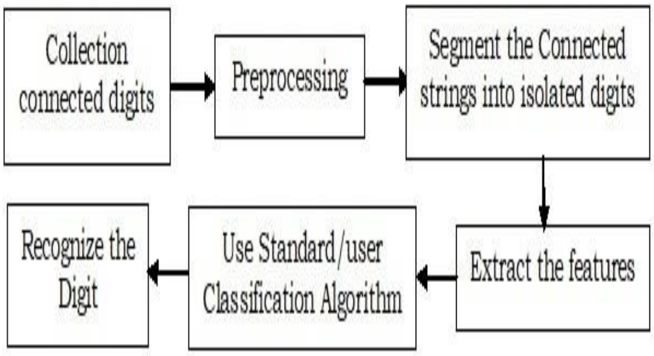

Fig. 1. Block diagram of the proposed method.

Collection connected digits

The distinctive two associated numerical string composed by 500 journalists are gathered from college graduates, secondary school youngsters, and grown-ups. Around 50% information is from secondary school youngsters. In this work, 200 examples two associated digits string are gathered from every essayist. A flatbed scanner was utilized for examine the composed archives for digitization with 300 dpi and spare records in jpeg arrange. An aggregate of 10000 (500X200) numerical strings of these examples contain an aggregate number of 20000 individual digits covering every one of the digits roughly equivalent.

Preprocessing

The correcting of scanned images from different noises is called preprocessing is producer done before the remaining phases. The preprocessing should have to done before image enhancement. It contains conversion of gray level to a binary image etc.

High performance in image processing can be achieved by using the preprocessing approach here we apply it to recognition of handwritten scanned digit image. In this approach the grayscale images are converting into binary images using the concept of threshold, where changes the value of the pixels to 0 or 1. After changing the scanned grayscale images into binary images, we surplus value of one's i.e. black color at unrequired places in the backdrop image. For efficient classification, need to remove the surplus from undesirable places. The following procedure is used for conversion of Grey to binary.

Grey-to-Binary Conversion

Examined input image is given as info. It is checked whether the image is shading or grayscale or double. In the event that the image isn't paired image it is changed over to double image.

1. Computing the span of the image.
2. Finding the aggregate of the pixels.
3. Computing the normal edge esteem utilizing the whole of the pixels and the measure of the image.
4. Contrasting the produced edge esteem and the pixel estimation of the image. In the event that the pixel is esteem is more prominent than the edge esteem, at that point dole out the pixel an estimation of '1' generally '0'.

Noise Removal

To expel these undesirable one's from the foundation, commotion evacuation algorithm[8] is utilized. The present paper utilized 3×3 layouts are utilized. The layout expected that the pixel (r, s) as focus pixel and neighbors of the middle pixel are (r-1, s), (r-1, s+1), (r, s+1), (r+1, s+1), (r+1, s), (r+1,s-1), (r, s-1), and (r-1, s-1), as is appeared in figure 2. Clamor expulsion in a image relies upon the kind of commotion in that image. The clamor can distinguished by utilizing 3×3 layouts. The format appeared in figure 3 is used to recognize the single pixel surplus information in digit image. Similarly 2-pixel, 3-pixel and 4-pixel clamor can be recognized by utilizing the layouts appeared in figure 4, 5 and 6 individually.

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Once the 1-4-pixel commotion (Black pixel) distinguished, the dark pixel is supplanted with white-pixel. Figure 7 demonstrates the pre-preparing comes about, a) digits contains some measure of clamor, b)the resultant images in the wake of evacuating the commotion by utilizing the 3×3 window designs indicated figures from 3 to 6.

P1(r-1,s-1)	P2(r-1,s)	P3(r-1,s+1)
P8(r, s-1)	P1(r,s)	P4(r,s+1)
P7 (r+1,s-1)	P6(r+1,s)	P5(r+1,s+1)

Fig. 2. 8-neighbors pixels of size 3×3 window.

0	0	0
0	1	0
0	0	0

Fig. 3. Isolate pattern 3x3 windows.

0	0	0
0	1	1
0	0	0

0	0	1
0	1	0
0	0	0

0	1	0
0	1	0
0	0	0

1	0	0
0	1	0
0	0	0

0	0	0
1	1	0
0	0	0

0	0	0
0	1	0
1	0	0

0	0	0
0	1	0
0	1	0

0	0	0
0	1	0
0	0	1

Fig. 4. Two pixel patterns of 3x3 windows for preprocessing.

0	0	0
0	1	1
0	0	1

0	1	0
0	1	1
0	0	0

1	1	0
0	1	0
0	0	0

1	0	0
1	1	0
0	0	0

0	1	0
1	1	0
0	0	0

0	0	0
1	1	0
1	0	0

0	0	0
1	1	0
0	1	0

0	0	0
0	1	0
0	1	1

Fig. 5. Three pixel patterns 3x3 windows for preprocessing.

1	1	0
1	1	0
0	0	0

0	1	1
0	1	1
0	0	0

Fig. 6. Four pixel patterns 3x3 windows for preprocessing.

Fig. 7. Pre processing Operation a) Noise image b) Noise removed image.

Segment the Connected strings into isolated digits

Digit Segmentation is the procedure of separating the string of numeral scanned digits into individual digits. Cutting the stroke of interconnected digit strings is the segmentation method to find the best path for insulated elements [6] [7] [9] [13] [14]. In general there are 3 different types are used for separating the string of numerals into individual digits. They are

1) External Segmentation (ES), prior knowledge on the digit boundaries is found.

2) Internal Segmentation (IS), digit boundaries are used for determination and

3) No segmentation, finding at string point

The main difficult job for separation of interconnected scanned digits is to find the interconnection point and the most favorable way for cutting the scanned digit image into isolated digit. Figure 8 illustrates some difficult samples extracted from the database.

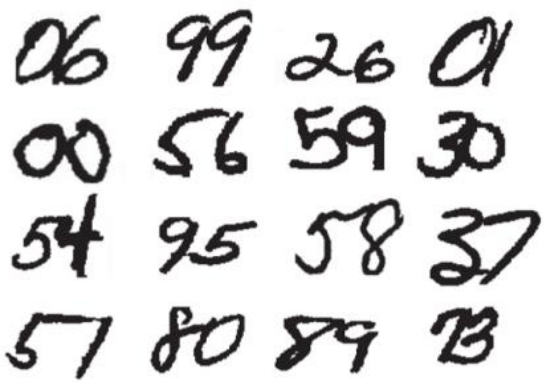

Fig. 8. Sample connected digits.

The division of two associated digits for the most part in light of the Segmentation focuses and based focuses. It includes dissecting the number and nature of Segmentation Points (SP)and Base Points (BP) between two neighboring digits so as to characterize the ideal position for cutting an associated digit image [2]. For distinguishing the Segmentation focuses, base focuses, the present approach utilizes two auxiliary highlights: form and skeletal focuses. These highlights are additionally useful for finding the ideal way.

The division calculation for two associated transcribed digits:

Stage 1: Design the Segmentation Points (SPs) and the Bases Points (BPs). SPs are figured utilizing the Freeman code as per the 8 bearings in the clock-wise.

The BPs is gotten through the neighborhood extrema (minima and maxima) distinguished on shape. The present approach utilizes two forms (external shape and internal form) for identifying external BP and inward BP. Frequently, the association focuses on SPs, BPs or both in the meantime.

Stage 2: Often, the association focuses hold SPs, BPs or both in meantime. Accordingly, 3 theories are considered for division.

Theory 1: If the Euclidean separation between the projection of the BP and the SP is inferior to an edge, the division is made among SP with upper BP and furthermore between SP with down BP which appeared in figure9.

Theory 2: If the lower fragment of SP is identified with a higher section of SP (or the other way around) and the two SPs are close to a BP, the skeleton way connecting the two SPs (Skeleton way) is utilized as a component of the division cut with corresponding ways amongst BPs and SPs (Composed way) (Figure 10)

Theory 3: now and again, regardless of whether there is an association between 2 numerals, the single pixel width way don't have SP. Along with this, to maintain a strategic distance from the under segmentation (absence of division point), the calculation develops a division way in view of the perpendicular projection of the BP. For our situation, the division way depends upon the insignificant Euclidean separation between upper BP and lower BP (nearest focuses) of center (Figure11).

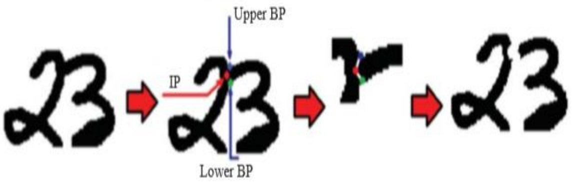

Figure 9. Division paths based on SP and BP positions using Hypothesis 1.

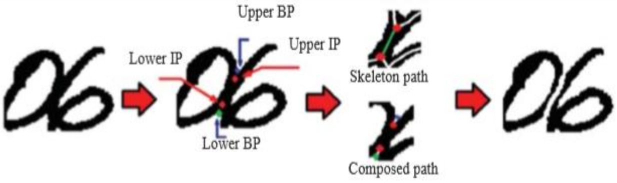

Figure 10. Division paths based on SP and BP positions using Hypothesis 2.

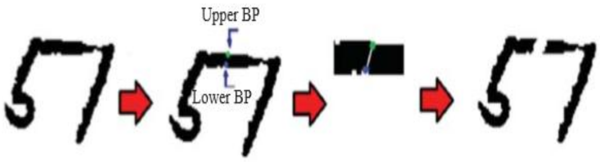

Figure 11. Division paths based on SP and BP positions using Hypothesis 3.

Stage 3: the stage 2 is sufficient for portion the associated section, however for more viable, the present approach utilizes sliding-layout for decision in the meantime the SP and for viable the cutting way.

Finding the cutting way depends on the scan of the rakish cutting for the ideal division. This pursuit is led from end to end the accompanying sub steps.

a) Identifying the nearness of SP by utilizing a sliding-layout having an indistinguishable range from the first digit and a steady width W1, the SP is subsequently situated amidst this width.

b) Revolving the layout in the range θ=[-∝,… ,+] with a rakish advance around SP. Figure 6 demonstrates different intersection of the arranged window around SP.

c) Finding the cutting way for each arranged window: if a solitary SP is discovered, at that point the division is made between SP with Upper BP and in addition among single SP with Lower BP when the Euclidian partition amongst SP and BP (both BPs) is lower than a threshold value T1. On the off chance that there are two SPs (Upper SP and Lower SP), at that point the theory 2 is connected. Something else, the theory 3 is connected on the full digit image as indicated by introduction point inside the range θ. In order to dodge under-division. Figure 12. shows different division ways agreeing the introduction of the window. Subsequent to portioning the digits, image is standardized into 28×28 size utilizing a standard bi-cubic approach and highlights are removed from these standardized images.

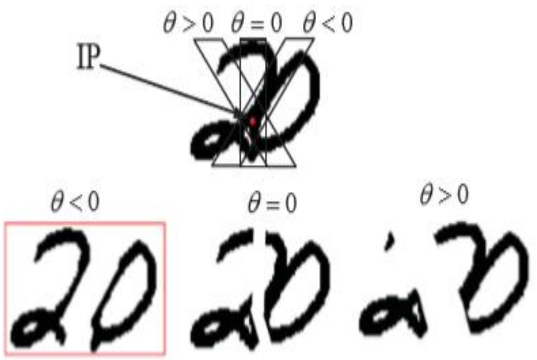

Figure 12. Window concept used to find the paths by crossing and segmentation.

Feature extraction

After section the associated digits, highlights are extricated from divided digits for arrangement. For successful order, fragmented digits are standardized to 28×28 without changing the perspective ratio. This is an essential stage as its compelling working expands the acknowledgment rate and reductions the misclassification. The highlights are extricated for all images subsequent to portioning the series of numerals into singular digits.

The present approach extracts number of contours, skeleton features, Number of watersheds, and ratio between the number of foreground pixels in upper half part and lower half-part of the numerical digit image for classification. Based on these features the present paper designed user defined classification algorithm for hand written digit recognition.

Algorithm1: Classification of Handwritten numeral strings

Input: numeral strings

Output: Classification of the Numeral Digit 0 or 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9.

Method: Structural, Statistical features extraction.

Step 1: Divide the numeral string based on the segmentation procedure.

Step2: Eliminate the noise using preprocessing technique

Step3: Find the “Number of Contours” (*NoC*) and classify the digit as Group1 or Group2 or digit 8.

Step4: Skeleton features such as “Number of End Points” (*NoEP*) are extracted from single-width in Group1 and Group2.

Step5: Based on NoEP in digits in Group1 further divide into 3 sub-groups Group1a, Group1b, Group1c, Group2a and classify the digits 0, 2, 4

Step6: Calculate the Number of water sheds (NoW) of the Digits in Group1a.

Step7: Based on NoW values further divide into Subgroup Group1aa and classify the digits 1, 7, and 2 noJ

Step8: Calculate the Number of Joints of digits in Group1aa.

Step9: Based on the NoJ values divide the image is either digit 3 or 5.

Step10: Crop the Digits in Gropu1b.

Step11: Calculate the Number of watersheds (NoW) of the Digits in Group1b

Step12: Based on NoW values classify the digits either 3 or 4.

Step13: Calculate the ratio between the numbers of foreground pixels in upper half part and lower half-part (ULR) of the numerical digit images in Grop1c.

Step14: Based on the ULR value classify the digit either 4 or 7.

Step 15: Calculate ULR value of the digits in Group2a

Step16: Based on the ULR value recognize the digit either 6 or 9.

IV. RESULTS AND DISCUSSIONS

The proposed acknowledgment calculation is tentatively assessed with recently made database. To assess the framework for perceiving manually written digits by incorporating division and classification. All tests are done on a PC machine with i3 processor 2.7GHz CPU and 2 GB RAM memory under MatLab 10.0 stage. From the preparation set images extricate the component esteems which are indicated in area 3 and put away in Feature Vector (FV) and concentrate the highlights of test database and put away in Test Vector (TV).

Examinations are led on recently gathered database from the distinctive essayists. Each example of numerical string is portioned into singular digits by above determined calculation and concentrates the highlights as indicated previously. By utilizing the calculation characterized in segment 3, the digits are grouped. The proposed calculation is tried with 8000 digits and the individual consequences of the test database are recorded in table 1.

Table 1.Results of Numerical Recognition for 8000 Test Digits Using User-Defined Classifier

Digit	No. of Images	Correctly Classified	Not Correctly Classified	% Accuracy
0	798	786	12	98.50
1	819	803	16	98.05
2	768	757	11	98.57
3	807	797	10	98.76
4	794	781	13	98.36
5	774	760	14	98.19
6	832	822	10	98.80
7	815	804	11	98.65
8	797	784	13	98.37
9	796	787	9	98.87
Average recognition percentage				98.51

V. CONCLUSIONS

The paper presented segmentation and classification approach for manually written associated connected digits based on the sliding window to get the preeminent cut to isolate two contiguous digits. The present technique permits us improving the performance for connected digits and decides almost all the problems that meet. Here we used the sliding window for generate isolated digits. The present paper extracts minimum number of features and obtained good classification results with an accuracy of 98.51% . The benefit of proposed method is that it takes less time for both segmentation and classification.

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