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Offline Signature Verification using Grid Indices Based Template Matching

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Abstract: ***Signature verification is a standout amongst the most broadly utilized biometrics for confirmation. This paper shows a novel methodology for offline signature verification. The proposed strategy depends on the grid features extraction from the image. For confirmation, the separated highlights of test signature are contrasted and the effectively prepared highlights of the reference signature. The procedure of verification then follows by calculating white indices in each grid cell for template matching purpose. This procedure is reasonable for different applications for example, bank exchanges, travel papers and so forth. The limit utilized in the proposed procedure can be progressively changed as indicated by the objective application. Essentially, the grid of matrix is taken for the feature extraction from the image. The extracted features are then compared with grid-based template matching which is based on counting the numbers of cumulative erros in both signature elements. The proposed system manages skilled imitations and has been tried on two types of signatures database. The proposed method grid- based template matching gives better result of FAR and FRR for the given set of signature database. The results of proposed method for given set of database includes simple & skilled signatures gives 0.55% and 1.25% FAR respectively. The system gives 5.12% FRR which is superior to anything many existing confirmation procedures. This examination demonstrated that combination of white indices in the cell of the grid matrix and template matching may prompt better outcomes for offline signature acknowledgment and check. At last, creators outline the paper with some vital ends and call attention to the future potential research headings.***

Keywords: Statistical Features, Grid features, template matching, Discrete Wavelet Transform, Modified Direction Features, Geometric features

1. Introduction

Signature check is the creating biometrical recognizing confirmation methodology, with a high genuine affirmation. Yet composed by hand signature check has been comprehensively examined in the earlier decades, and even with the best techniques working at high precision rates, there are a huge amount of future research openings. Signature affirmation and affirmation systems are delegated on the web and separated structures. Online imprint affirmation and affirmation systems misuse dynamic features like accelerating, speed and the qualification among all over strokes.

Be that as it may, in the most widely recognized genuine situations, this data isn't accessible, in light of the fact that it requires the perception and recording of the marking procedure. This is the principle reason, why off-line signature examination is still in focal point of numerous analysts. Off-line techniques [1] don't require exceptional procurement equipment, only a pen and a paper, they are in this way not so much intrusive but rather easier to use. In the previous decade a great deal of arrangements has been proposed, to defeat the constraints of off-line signature confirmation and to make up for the loss of precision [2]. The majority of these techniques share one for all intents and purpose: they convey worthy outcomes, yet they have issues improving them.

Issues of signature confirmation are tended to by considering three unique sorts of frauds: [3] random forgeries, delivered without knowing either the name of the underwriter nor the state of its signature; simple forgeries, created knowing the name of the endorser however without having a case of his signature; and skilled forgeries, created by individuals who, subsequent to concentrate a unique occurrence of the signature, endeavor to copy it as intently as could be expected under the circumstances. Plainly, the issue of mark confirmation becomes increasingly more troublesome when going from random to simple and skilled forgeries, the last being so troublesome an assignment that even people make blunders in a few cases. To be sure, practices in emulating a signature of ten enable us to deliver fabrications so.

Manually written signatures come in various structures and there is a lot of inconstancy even in signatures of individuals who utilize a similar language. A few people essentially compose their name while others may have signatures [4] that are just dubiously identified with their name, a few signatures might be very intricate while others are basic and show up as though they might be manufactured effectively. It is likewise intriguing to take note of that the signatures style of people identifies with nature in which the individual built up their signatures.

Be that as it may, preprocessing is increasingly minded boggling and tedious in offline frameworks because of inaccessibility of the dynamic data. Concocting a proficient and precise offline signature confirmation framework is a testing undertaking as signatures are touchy to geometric changes, relational signature confirmation gathered in course of time, complex foundation of the signature, skilled forgeries, non-availability of time taken to sign, absence of adequate signatures tests for preparing the framework, versatility of the framework, the adequate reaction time of the framework when naturally preparing a lot of expansive

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records, noise introduced by scanning device, contrast in pen width, ink pattern and so forth.

In this paper, all experiments have been performed on skilled forgeries. The paper is organized as: section II gives the literature survey on the given offline signature verification techniques, Section III describe the proposed idea of this paper which includes signature acquisition, signature preprocessing, feature extraction, template matching and verification technique. In Section IV, experimental results have been presented including the results of the proposed technique and comparison with existing techniques. Section V concludes the technique discussed in the paper.

2. Literature Survey

There are many existing frameworks and concentrates that are based on various strategies for offline signatures verification or identification. At present, a recent approach includes angle feature algorithm [5] to extract features of signatures, using Generalized Regression Neural Network (GRNN) which is often used for function approximation. It has a radial basis layer and a special linear layer. This paper [4] claims better results than Discrete Cosine Transform (DCT) however; it takes relatively more time than DCT. Angle features vary with changes in the block size, resulting into changes in performance.

Another approach [6] presents a set of geometric signature features for offline automatic signature verification based on the description of the signature envelope and the interior stroke distribution in polar and Cartesian coordinates. The features have been calculated using 16-bit fixed-point arithmetic and tested with different classifiers, such as hidden Markov models, support vector machines, and Euclidean distance classifier. The experiments have shown promising results in the task of discriminating random and simple forgeries [5]. The geometrical features proposed by this method are based on two vectors which represent the envelope description and the interior stroke distribution in polar and Cartesian coordinates.

In [7] presents Extraction of statistical parameters like of extent, solidity, number of objects, major axis length, Equivalent diameter, area, convex area, orientation and Euler number that can distinguish signatures of different persons. This method [7] shows the simple yet reliable solution to the problem of signature recognition and verification. Furthermore, a novel approach of reducing the dimensionality of data that is a very important phase of every recognition process is found in [8]. Static analysis deals with the matrix representing the signature image. In order to reduce the size of data while preserving the general features the view-based method is applied first. The algorithm chooses only those points with minimal and maximal value of y coordinate.

The performance of the Modified Direction Feature (MDF) [9] feature extraction technique in conjunction with three other simple global features has been investigated. Global features based on the boundary of a signature and its projections are described for enhancing the process of automated signature verification. The combination of these features with the MDF and the ratio feature showed promising results for the off-line signature verification problem [9].

A similar set of features including proportion factor, center of gravity and horizontal, vertical signature pixel density is presented [10]. This approach further uses grid features for finding densities of signature parts. 60 grid features by dividing signature into 60 equal parts and the image area in each divided part is calculated.

An off-line signature verification and validation system for Arabic handwritten signatures is proposed [11]; based on Discrete Wavelet Transform (DWT). DWT, reduction method, and common features method are applied to extract the features before the verification step. The method presents logical operations with mathematical formulae to verify signatures.

A paper [12] based on two sets of points in a two-dimensional plane; each set having six feature points which represents the stroke distribution of signature pixels in an image is presented [12]. These twelve feature points are calculated by Geometric Center, vertical splitting and horizontal splitting. This method performs much better than any other off-line signature verification methods by employing vertical and horizontal splitting to depth 2.

3. Proposed Methodology

The architectural diagram of the system is as shown in given Fig. (1), in which it consists of two phases. At the first, there is the training phase and second is the testing/matching phase. With the help of these two phases, it performs the pre-processing on given input image and at the end it gives result.

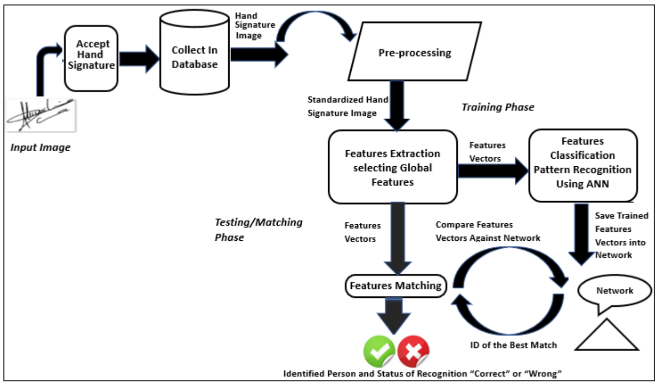

Figure 1: Architectural Diagram of system

From past examinations, it has been seen that a disconnected mark check process comprises of following advances:

3.1 Signature Acquisition

A4 paper were used to draw the Signature gained by scanner having normal 300dpi and put away in Portable Network Graphics (PNG) group, we can also took the

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same equivalent format. Fig.(2) shows images of some sample signatures from database on which proposed system have been tried.

3.2 Signature Preprocessing

To affirm a signature accurately, pre-processing of gained signature is needed. The procured signature picture as manifested in Fig. (2), may once in a while incorporate noise (additional pen spots other than signature). It is important to expel these additional pixels from procured picture for effectively check the signature. This should be possible by utilizing middle channels.

Figure 2: Image of Sample Resized Signature

Figure 3: Image of Signature

Pre-processing incorporates some more activities like resizing, binarization and revolution standardization. Incipient phase in preprocessing is to rescale the gained signature to a standard scale (100x200) by the aid of resize computation showed up in Fig. (3).

Binarization insinuates extremely contrasting (black and white combination) variation of the rescale (RGB) signature shown in Fig. (4).

Figure 4: Binarized Signature Image

Binarization implies highly contrasting (black and white combination) adaptation of the resized (RGB) signature shown in Fig. (4).

First standard inclination (baseline) edge [7] of the picture is to be determined by acquiring revolution invariant picture,

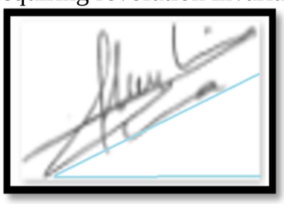

Figure 5: Image of signature with their baseline slant angle and afterward the picture is pivoted by that edge in clock-wise bearing as appeared in Fig. (5).

Figure 6: Image of Rotation Normalized Signature

The fig (6) shows the consequence of pre-processing stage is without noise, resized, binarized and rotation normalized signature picture which is at the end of process.

3.3 Feature Extraction

The purpose of this stage is to get rid of the highlights of test picture that will be contrasted with the features of preparing picture for check reason. There are two sorts of highlights: (I) Function highlights and (II) Parameter highlights. Capacity highlights incorporate position, speed, weight and so on and are utilized in online confirmation procedures. Parameter highlights are additionally partitioned into worldwide parameters and neighborhood parameters. Pixel-arranged highlights incorporate lattice based, power based and so forth. Here we are going to utilize grid-based element extraction.

Steps:

(I) After pre-processing we have a signature of size 100x200(pixels). A signature picture is isolated into 200 square cells where every cell is having 100 pixels. Such that we make a lattice of m x n where m<n, m<<100 and n<<200, over a pre-prepared signature as appeared in Fig.3. In this paper, we have taken m=10 and n=20. We have done such division of the signature picture with the goal that increasingly proficient and successful correlations should be possible which can without much of a stretch identify the fabrications.

(II) Next we discover the cells of a column of a grid that are containing the signature content. Notice that signature content is determined as far as dark pixels, in this way just those cells ought to be viewed as which are having at least 3 dark pixels. Rehash the procedure for all lines of a matrix. Consequently, we've everyone of these cell positions that are chunk of the signature image. Presently we tend to create a framework of size m x n concerning the lattice of size m x n as an example one cell of a grid relates to a element of a grid. The white indices in signature grid component [1] is equivalent to 1 if the cell of same position in the framework is the piece of signature, generally the grid component will be 0. Each cell block of grid is containing number of pixel elements. Here in our proposed method we are not proving the minimum pixel limit for verification signature content in the cell of grid. The earlier method having the limitation of 3 pixel is removed in our proposed method. In this manner, because of this progression, we have a framework of 0 or 1 appropriately matrix having components as appeared in Fig.7.

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

Figure 7: Matrix corresponding to Sample Grid

(III) We figure the quantity of dark pixels in cells of a column containing signature content. Rehash the procedure for all columns. At that point we put the estimations of m pushes in an exhibit. Essentially, a similar procedure can be connected to sections. Consequently, we get another exhibit having n components comparing to every segment.

Consequently, we have extricated three highlights: (i) a m x n matrix as portrayed above comparing to a m x n grid. (ii) A variety of size m where first component is the quantity of dark pixels in first line of a lattice, second component is the quantity of dark pixels in second line, etc., (iii) A variety of size n where the primary component is the quantity of dark pixels in first section of the matrix, second component is the quantity of dark pixels in second segment, etc.

4. Signature Verification: The reason for check stage is to contrast the test picture and preparing picture utilizing removed highlights and to choose whether the test picture is unique mark of the essayist or falsification.

4. Verification Steps

4.1 Calculate Column Matching Score (CMS)

(I) Consider M1 and M2 be the matrix frameworks of reference picture and test picture separately. Look at the sections of the grid M2 with M1. Every section is having m components. In the event that in any event β, where $\beta \geq 7$, components are same then that segment is said to be coordinated and increment the segment tally C1 (state) by one.

(II) Consider A1 and A2 be the varieties of reference picture and test picture separately containing number of dark pixels in every section. Think about the comparing components of exhibit A2 with A1. Presently check the accompanying condition.

$$\sigma Ref - \alpha < \sigma Test < \sigma Ref + \alpha \quad \text{- - - - - - - - - - - (1)}$$

Where σRef is the component of reference cluster A1, σTest is the comparing component of the test exhibit A2 and α is the middle of the road factor which is the permitted variety in number of pixels. Decent factor is a dynamic incentive as it shifts for various columns relying upon the mark content in that section. Decent factor can be determined as

$$\alpha = (p \times \sigma Ref) / 100 \quad \text{- - - - - - -- (2)}$$

Where p is the level of dark pixels in a segment of a grid and σRef is the quantity of dark pixels in that section. P can be acquired as

$$P = \sigma Ref / N \times 100 \quad \text{- - - - - - - -(3)}$$

Where N is all out zone of the cells having dark pixels in that section and can be determined as

$$N = (width \times height) \times c \quad \text{- - -- - - - - -(4)}$$

Where c is the quantity of cells [13] which are a piece of the signature in that section of a matrix. width is the separation between two points in the vertical projection and must contain multiple pixels in a cell. Height is the separation between two points in the vertical projection and must contain multiple pixels in a cell.

In the event that condition (1) fulfils then that section is adequate and increment the counter C2 by one.

(III) If c1 = n, then CMS is said to be 100%. Similarly, for c1= n-I where i= 1, … ,8, CMS will be [(n-I)/n x 100] % i.e., marks upto 60 % CMS are considers for further preparing. On the off chance that CMS is underneath 60 %, at that point the test mark will be delegated fabrication at this progression itself.

4.2 Calculate Row Matching Score (RMS)

Suppose, CMS ≥ 60%, at that point just we are keen on figuring Row Matching Score (RMS). It very well may be gotten also as CMS. All correlations must be done line astute. For RMS, $\beta \geq 14$. Compute C1 and C2 for this case.

4.3 Calculate the Average of CMS, RMS and Threshold

The proposed grid-based template matching framework corresponding to high level design of the system is as shown in Figure 8 and it tries to demonstrate each and every working step of the system right from input signature to the verification of the signature. The thresholding parameter and statics of thresholding parameters is also given in the proposed framework. The aspect ratio is keen parameter in comparison of image. The aspect ratio for rows and column is stated for template generation. The generated templates are then compared by the system to find out similarity and mismatch.

The template generation is depending on RMS & CMS. CMS is calculated by taking 5 columns and 10 columns and RMS is calculated by taking 5 rows and 10 rows. If the given dimensions are not in proportional manner then the signature is mismatched. Otherwise it goes to check one by one for CMS and RMS. In this we have taking the pixeling the sign for verification purpose and also, we took the errors, Errors are finding out by template matching method. These are the basic building for given system to consider on which the comparison is expected.

In the scenario for 5 rows and 10 columns if cumulative error is greater than 2500000 then the signature is mismatched. And in the case of 10 rows and 10 columns and if cumulative error is greater than 3500000 the signature is

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mismatched. Otherwise if both the cases fail that means we didn't get any mismatch from the comparison then the signature is matched and it gives the output for matching the signature which is requires at the end of procedure. Figure 8 also show the basic working principle applied to the input images and algorithm which are used for finding the correct results.

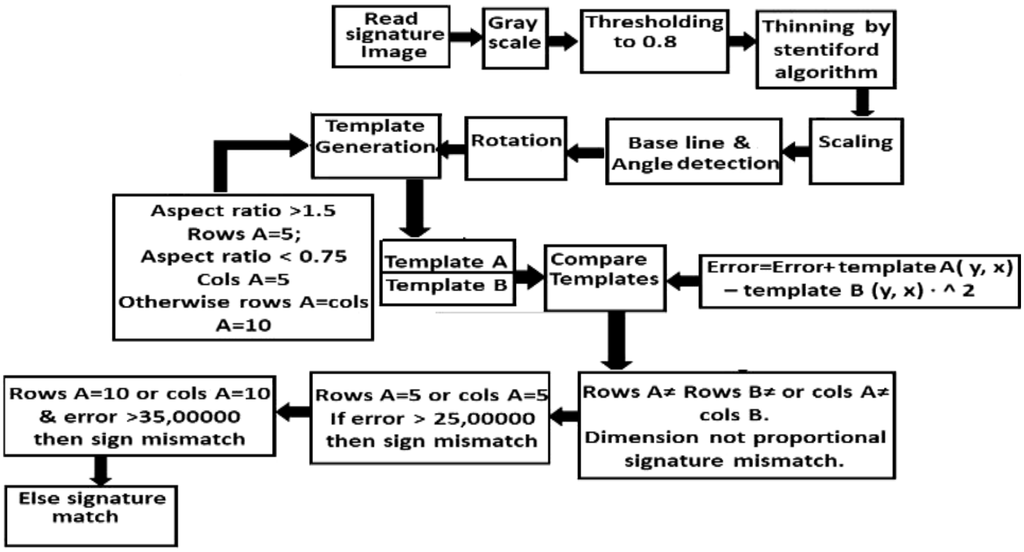

Figure 8: Proposed Verification System Framework

Some of the major difference are been taken for our proposed method with respect to previous methods in some of the parameters. The details parameter wise table is given in the figure 9. The figure 9 shows the major differences or proposed work with other methods.

Parameter	Other methods	Implemented method
Grid size	100 x 200	100 x 100
Sign content	If sign contents in grid is 3 or less pixels It is neglected.	All pixels of sign contents are considered. No min pixel limit
Scaling	100 x 200	100 x 100
Feature extraction	If a grid contains 3 or more white pixels(sign content) it is taken as 1 in 2d matrix Else 0.	No of white pixels in each grid are counted and this count value is taken in 2d matrix
Comparison	Based on CMS & RMS	Each element of input sign 2d matrix is subtracted from corresponding element of trained image 2d matrix
Criteria	If CMS & RMS Score > 60 % then Sign accepted. Else rejected.	For 10 x5 or 5x10 matrix if square of error diff. is < 2500000 Or For 10 x10matrix if square of error diff. is <3500000 Then sign accepted Else rejected.

Figure 9: Parametric Differences

In next section, we see experiment wise working of the proposed system.

5. Experiments

Two signatures databases are taken for this experiment which includes genuine signatures and forgery signatures. Forge signatures were asked to make by skilled forgeries. Thus, we have input to select from the two databases in order to compare this signature for finding out the results. Firstly, the images are undergone through various image processing operations which were stated in proposed methodology section. Features are extracted from the input signatures and arranged in the matrix grid for further comparison purpose. The ranges of the grid and the how the initial input signature is loaded is shown in the figure 10. Figure 10 is the real time system snapshot of the experiment in which loaded input signatures is mapped with grid.

The proposed signature representation involves division of signature into square grid of size N x N. In this case, we have used N=10. Hence, the signature is split into a matrix having ten rows and ten columns mistreatment equal horizontal density methodology. For each cell in the matrix, the signature normalized area is computed. The normalized space is calculated by taking total of pixels in every box and dividing it by total range of pixels within the signature.

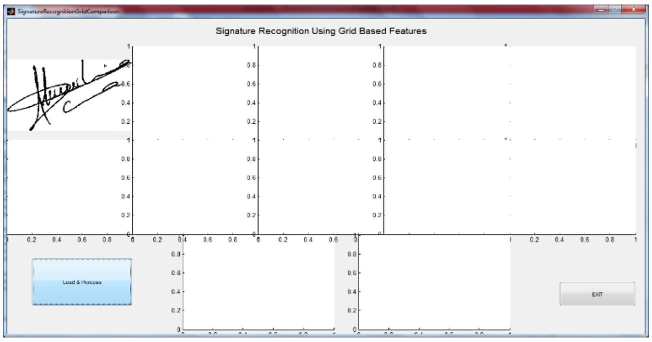

Figure 10: Input Signature Loaded

The cell having white pixel element indices is set to one (1) while the other are set to zero (0). Thus, we tend to obtained, for every signature, a binary matrix of 10x10 representing a compact signature code. The grid is computed the white pixel elements indices which is the principle comparison complements for both the signature. The template is matched at the both side by this component. Both the loaded signatures are having the comparative parameters like height, width, aspect ratio, bit depth, angle etc. through which the comparison is based for both the signatures

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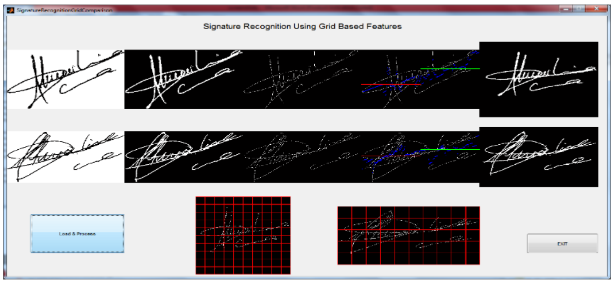

Figure 11: Template Matching Procedure

The figure 11 shows the grid matching procedure by template matching. Here the grid is matched with all dimension's parameters and white pixel elements indices. Here in this figure 11 the first signature grid of 10 × 10 and second signature grid of 5 × 10. So dimensional not proportional and signature can't be compared. The figure 12 and figure 13 shows the template A and B generated by 10 × 10 matrix and 5×10 matrix returning white pixel elements indices respectively.

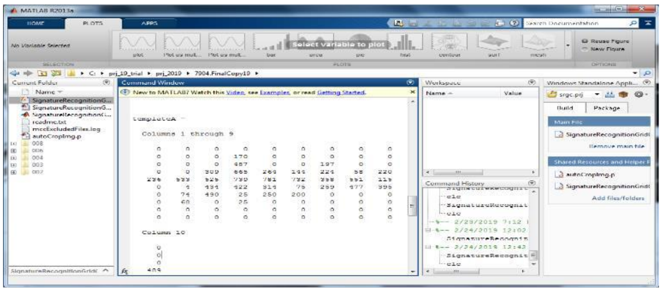

Figure 12: Template Generated by A

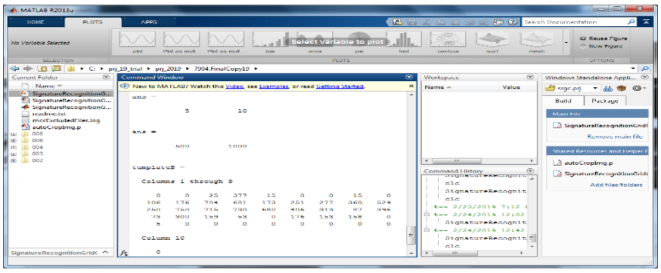

Figure 13: Template Generated by B

The signature grid 10 × 10 & 10 × 10, 5 × 10 & 5 × 10, 10 × 5 & 10 × 5 are compared by template matching method. This is due the aspect ratio of input signature that we are taking as an input. If the aspect ratio of input signature image is greater than 1.5 then grid 5 × 10 is taken. If the aspect ratio of image is less than 0.75 then grid of 10 × 5 is taken, otherwise grid of 10 × 10 is taken. Similarity score: To work out the similarity between 2 signature's grids, we follow template matching rule and the Signature grid's cell are mapped and matched with respect to position. For this purpose, simultaneously, the two grids i.e., the Test Signature's grid and the kth signature grid's cells are scanned and compared for a possible match. If the check signature grid cell's information is adequate to the kth signature grid cell information the score is incremented as a step operate. The Match Function is - - - - - -(1)

$$\text{Match (I, j)} = \begin{cases} 1 & \text{Test (I, j) equal K (I, j)} \\ 0 & \text{otherwise} \end{cases}$$

- - - - - -(1)

Match (i, j) has a value of one (1) if the data is equal i.e., both grid's cell has a 0 and both grid's cell has a 1and it is calculated by finding out the white pixel elements indices on given signature grid. Score is computed as associate degree aggregation operate supported the quantity of times the info within the 2 grids matches.

$$\text{Score}_{t,k} = \sum_{i=1}^{n} \sum_{i=1}^{m} \text{Match (I, j)}$$

- - - - - - - - (2)

Where n represents the number of rows and m represents number of columns in the grid. The grid similarity computed in percentage is a normalized score between the two grids showing the percentage match and closeness of the two signatures. The Grid similarity is given by - - - - - (3)

$$\text{Grid}_{\text{similarity } t,k} = \frac{\text{Score}_{t,k}}{n * m} \times 100$$

- - - - - ---(3)

This database consists of 1000 signatures that are categorized into 100 classes with each class containing 10 signatures. These are the signatures belonging to 10 subjects and for each person there are 10 genuine signatures and 10 forgery signatures.

If the grid matching score of the question signature image with relation to models signature image is below the edge vary, the query signature is detected as forged otherwise it is detected as genuine one. There are three different percentages that have been used to measure the performance. These are False Acceptance Rate (FAR), False Rejection Rate (FRR), and Accuracy. FAR is the percentage of forgeries that are incorrectly classified.

$$\text{FAR} = \frac{\text{Number of forgeries accepted}}{\text{Number of forgeries tested}} \times 100$$

- - - - - - (4)

FRR is the percentage of original signatures that are incorrectly classified.

$$\text{FRR} = \frac{\text{Number of original rejected}}{\text{Number of original tested}} \times 100 \quad \text{----(5)}$$

The following graph in figure 14 shows the FAR and FRR graph for our proposed system in which we have taken 200 sample signatures of skilled categories. The graph in figure 14 clearly indicates that it has better result for both FAR & FRR by using our proposed grid-based template matching.

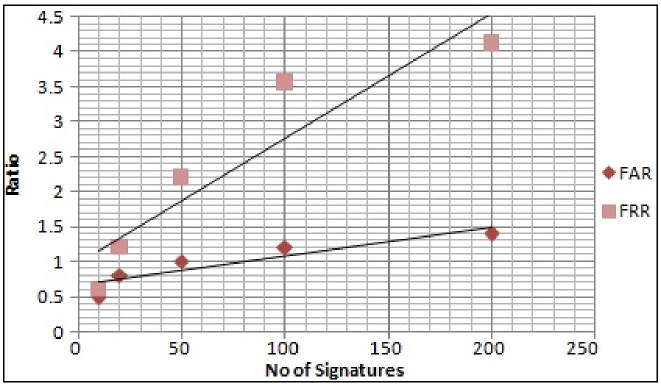

Figure 14: FAR & FRR Graph of proposed system

Accuracy is the level of marks which are actually grouped. The Score of closeness in graph for same individual

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coordinating is constantly above 90% a sign that the proposed technique is equipped for overlooking slight variety that a individual ordinarily have among given signatures. The graph in the figure 15 shows the comparison of three signature verification technique and clearly it shows that our proposed system gives the better accuracy as compared to other techniques.

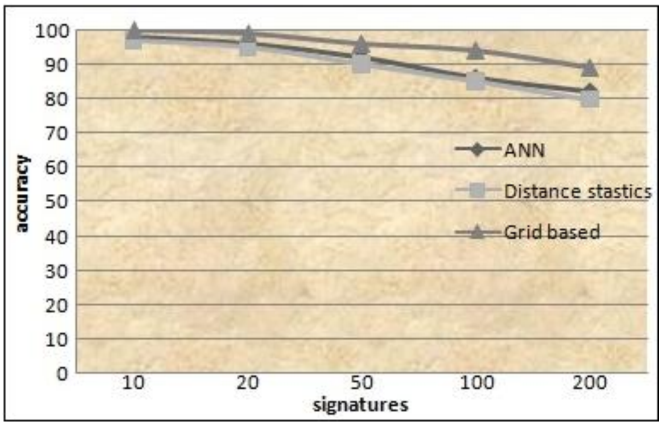

Figure 15: Comparison of proposed method with ANN and Distance statics

Our proposed algorithms that were based on grid template matching got better results than ANN [7] and distance statics [2]. The instructed algorithms have successfully rejected hot forgeries with terribly satisfying and sensible rate and have rejected the easy forgeries very utterly as shown in Table. 1 and Table. 2. The values of way and FRR of our technique is healthier than alternative schemes.

Table 1: Comparative analysis for FAR

Forgery Type	ANN [7]	Distance Statics [2]	Proposed Method Grid Based Template
Simpled	0.97	0.70	0.55
Skilled	3.2	2.8	1.23

Table 2: Comparative analysis for FRR

False Rejection Ratio (FRR)	
ANN [7]	22.44
Distance Statics [2]	18.45
Proposed Method Grid Based Template	5.12

6. Conclusion

Dispensation of offline signature is problematical because no steady self-motivated features are accessible and segmenting the signature strokes is incredibly intricate because of distinction in writing styles of each person and the dissimilarity that can occur in person's signature.

The aim of the investigation was to cultivate an algorithm which should be comparatively fast. We were able to design an offline signature verification system by using grid-based template matching which is exceedingly precise with condense false acceptance rate and false rejection rate.

The proposed method removes the earlier limitation of pixel elements which can effectively applied for all types of grids. The proposed method inspires the new area of research for other verification techniques which uses grid-based structure.

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