Offline Signature Recognition Using Maximally Stable Extremely Regions (Mser)

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ABSTRACT:

This paper describes an approach for signature is an offline environment based on Maximally Stable Extremely Regions (MSER) features. MSER features are the parts of the image where local binarization is stable over a large range of thresholds. We discuss a system designed using geometric and MSER based feature which provides efficient recognition for offline signature.

KEYWORDS: *Signatures, Centroid, FAR, FRR, MSER, TAR, TRR.*

I. INTRODUCTION

Biometrics refers to methods for uniquely recognize humans, based one or more intrinsic physical or behavioral traits. Handwritten Signature is an example of a behavioral feature and the term which has come to general acceptance for this class of biometrics is 'behavior metrics'. Signatures stand as the most accepted form of personal identification for bank transactions, credit card and most of the other routine billing systems [1]. Signature has been a distinguishing feature for person identification through ages. Even today an increasing number of transactions, especially financial, are being authorized via signature, hence methods of automatic signature verification must be developed if authenticity is to be verified on a regular basis. Approaches to signature verification fall into two categories according to the acquisition of the data: On-line and Off-line. On-line data records the motion of the stylus while the signature is produced, and includes location, and possibly velocity, acceleration and pen pressure, as functions of time [2].

An off-line or a Static Signature Verification (SSV) System takes in the scanned image of the signatures and extracts certain features for initial steps of processing before it is given as input to the verification system [3]. Online systems use information captured during acquisition. These dynamic characteristics are specific to each individual and sufficiently stable. Off-line data is a 2-D image of the signature. Processing Off-line is complex due to the absence of stable dynamic characteristics. Difficulty also lies in the fact that it is hard to segment signature strokes due to highly stylish and unconventional writing styles. The non-repetitive nature of variation of the signatures, because of age, illness, geographic location and perhaps to some extent the emotional state of the person, accentuates the problem. A robust system has to be designed which should not only be able to consider these factors but also detect various types of forgeries [4, 5]. The system should neither be too sensitive nor too coarse. It should have an acceptable trade-off between a low False Acceptance Rate (FAR) and a low False Rejection Rate (FRR). The rest of the paper is organized as preprocessing is described in section 2. Offline signature database is described in section 3. Section 4 is explains the extraction of parameters. Section 5 deals with implementation details and simulation of results followed by conclusion.

II. PREPROCESSING

Preprocessing involves removing noise, smoothing, skeletonization, space standardization and normalization.

2.1 Noise Removal

The goal of noise removal is to eliminate the noise. The Imperfection in the scanner intensity of light, scratches on the camera scanner lens introduces noises in the scanned signature images. For this noise reduction filtering function is used to remove the noises in the image. The Gaussian filter is used for the noise removal. Since Gaussian function is symmetric, smoothing is performed equally in all directions, and the edges in an image will not be biased in particular direction. The signature before and after removal of noise are as shown in the Figure 1 (A) and (B) respectively.

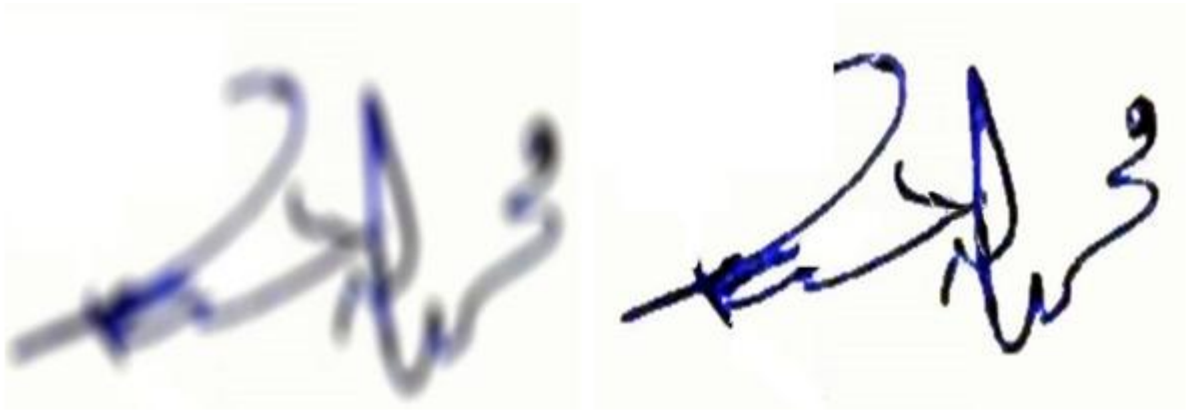


Figure 1. (A) Noisy signature Image (B) Preprocessed Image

2.2 Smoothing

The edge feature demonstrates the border line of the image, in this research the figure 2 (A) described the edge feature of the image which demonstrates the border point of the image. For the preprocessing we concentrated toward special domain image enhancement such as histogram, on the basis of this histogram behavior we understand the nature of signature as noisy or not. The figure 2(B) describes the histogram feature of signature image.

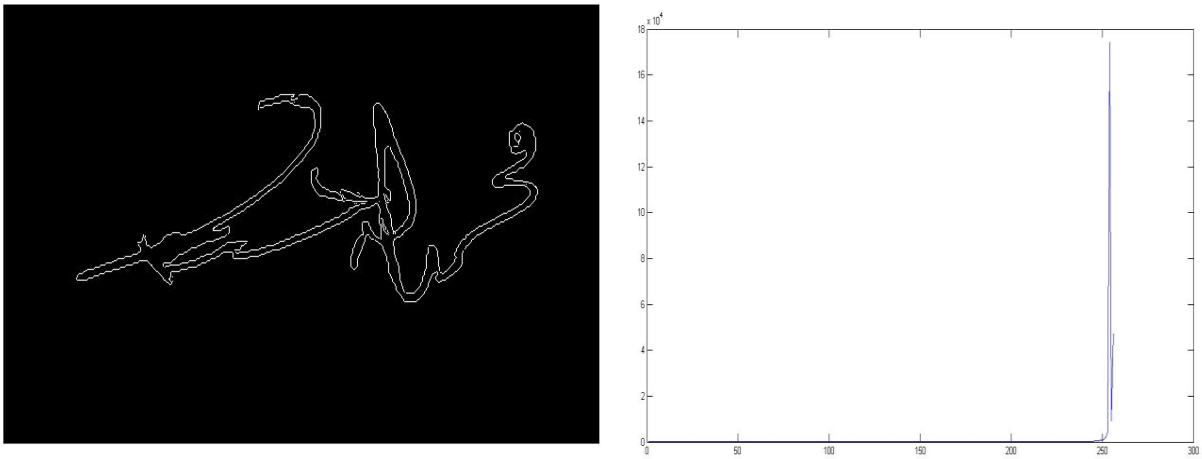


Figure 2. (A) Edge feature of the signature (B) Histogram of the signature

2.3 Skeletonization

A simplified version of the skeletonization technique described by Lam and Suen (1991) is used. The simplified algorithm used here consists of following three steps:

Step 1: Mark all the points of the signature that are candidate for removing black pixel.

Step 2: Examine one by one all of them, following the contour line of the signature image, and remove these as their removal will not cause a break in the resulting pattern.

Step 3: If at least one point was deleted go again to step 1 and repeat the process once more.

2.4 Standardization and normalization.

It is supposed that the features of the process of signing originate from the intrinsic properties of human neuromuscular system which produces the aforementioned rapid movements. Knowing that this system is constituted by a very large number of neurons and muscle, fibers is possible to declare based on the central limit theorem that a rapid and habitual movement velocity profile tends toward a delta-log normal equation [7]. This statement explains stability of the characteristics of the signature. Thus, the signature can be treated as an output of a system obscured in a certain time interval necessary to make the signature. This system models the person making the signature [6].Normally any person while putting his signature uses an arbitrary baseline. The positional information of the signature is normalized by calculating an angle θ about the centroid (x, y) such that rotating the signature by θ brings it back to a uniform baseline. The size normalization in the offline signature recognition is very important because it create a common platform for image comparison. In this paper the database as scanned image files in jpg format with standard size of 200 × 100 pixels.

The choice of features depends on the parameters by which the classification needs to be done. The relevant features used by the classification are listed below

i) Centroid: This feature gives the row and column of the centre of mass in the logical matrix.

ii) Length and Width: Length and width of the signature in the 200 × 100 pixels image box.
This involves finding the best fit rectangular box for the signature and calculating the actual length and width of this rectangle in pixels. The size normalization using the best fit image is described in figure 3.

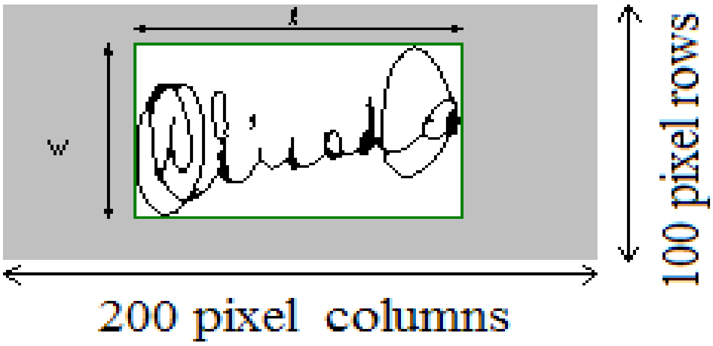


Figure 3. The best fit image box.

III. DATABASE DESIGN

This research contributed towards the creation of offline signature database. The signatures are collected using either black or blue ink, on a white A4 sheet of a paper, with forty signatures per page from thirty four volunteer. Using MF4350D scanner the scanner the four signatures are digitized, with 300-dpi resolution in 256 grey levels. The volunteer selected are from students of Department of Computer science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University. The 16 subject are from 20-25 age group and 18 subjects are in the 25-30 age group. The total size of dataset is 1360. The signatures are stored in the offline database is scanned image files in jpg format with standard size of 200 × 100 pixels. The basic preprocessing operations include the spatial alignment of the image, followed by binarization, which converts the image files into logical matrices and finally a skeletonization process that extracts the thin path or contour of the signature.

IV. FEATURE EXTRACTION

The choice of a powerful set of feature is crucial in signature recognition systems. The features used must be suitable for the application and for the applied classifier. In this system, maximally Stable Extremely Region (MSER) features are used such as grid features and global features. The global features provide information about specific cases concerning the structure of the signature grid feature. This method of extracting a comprehensive number of corresponding image elements contributes to the wide-baseline matching, and it has led to better stereo matching and object recognition algorithms. The original algorithm is proposed by Mates [9] is in the number of pixels. It proceeds by first sorting the pixels by intensity. This would take time, using BINSORT. After sorting, pixels are marked in the image, and the list of growing and merging connected components and their areas is maintained using the union-find algorithm. This would take time. In practice these steps are very fast. During this process, the area of each connected component as a function of intensity is stored producing a data structure. A merge of two components is viewed as termination of existence of the smaller component and an insertion of all pixels of the smaller component into the larger one. In the extremely regions, the 'maximally stable' ones are those corresponding to thresholds where the relative area change as a function of relative change of threshold is at a local minimum, i.e. the MSER are the parts of the image where local binarization is stable over a large range of thresholds[8][10].

The component tree is the set of all connected components of the thresholds of the image, ordered by inclusion. Efficient (quasi-linear whatever the range of the weights) algorithms for computing it do exist [11]. Thus this structure offers an easy way for implementing MSER [12]. The steps for MSER feature extraction are as follows [13].

- Sweep threshold of intensity from black to white, performing a simple luminance Thresholding of the image
- Extraction of the connected components ("External Regions")
- Find a threshold when an extremely region is "Maximally Stable", i.e. local minimum of the relative growth of its square.

- Approximation of a region with an ellipse.
- Creation of feature vector of region description.

  The border (corner) point of the signature play an important role for the identification of signature match area, the figure 4 (A) described the corner point detection of the signature. The Extracted MSER feature of signature is described in figure 4 (B).

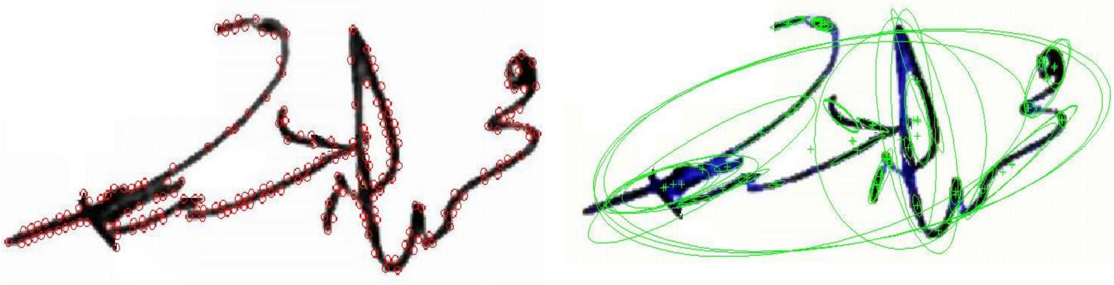


Figure 4. (A) The corner point detection of signature recognition (B) Extracted feature of signature using MSER

V. EXPERIMENTAL RESULT

The Centroid function is calculated in preprocessing because of fully understanding the descriptor which is based on centroid distance function. The position of the centroid, the center of gravity, is fixed in relation to the shape. The shape in this particular context is a binary image. The centroid can be calculated by taking the average of all the points that are defined inside a shape. Under the assumption that our shape is simply connected, we can compute the centroid simply by using only the boundary points. The centroid is having unique values which are arises as Mean X and Mean Y. The length and width are also responsible for morphological feature in the matching of the signature. The detail Numerical results of Centroid X, Centroid Y, Height and width are discussed in table 1.

Table 1. The centroid of the test sample

Sr. No	Sample	Centroid X	Centroid Y	Height	Width
1	Signature 1	111	100	199	231
2	Signature 2	282.506	124.997	249	564
3	Signature 3	166.5	102.5	204	332
4	Signature 4	62.5	42.5	84	124
5	Signature 5	40	33	65	79
6	Signature 6	53.5	34.5	68	106
7	Signature 7	49.5	32.5	64	89
8	Signature 8	168	81.5	162	335
9	Signature 9	121	100	199	241
10	Signature 10	219	128.5	256	437

We are extracted the feature using MSER technique. The graphical representation of Extracted feature of signature using MSER is presented in figure 5.

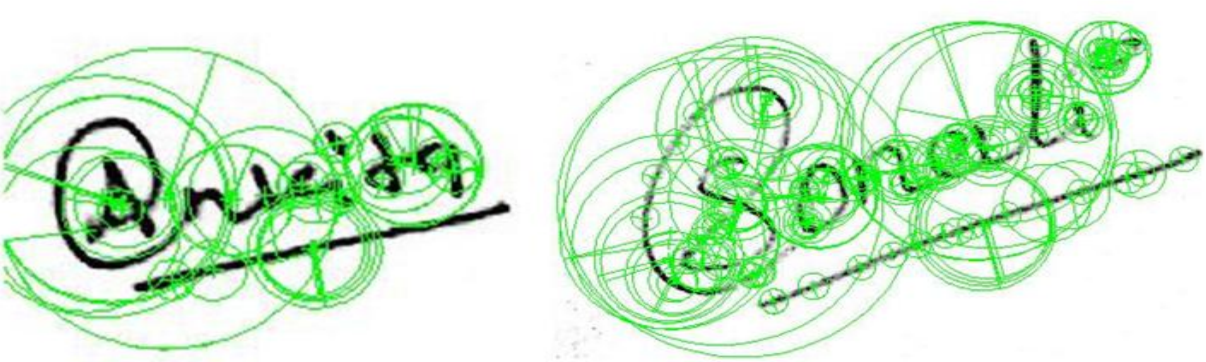


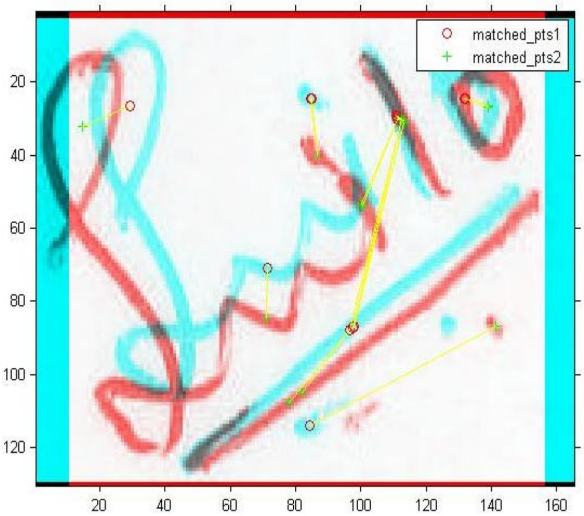
Figure 5. Graphical representation of extracted feature using MSER

The MSER feature is the combination of the centroid, Axes location, orientation as well as pixel list point, so detail MSER feature set are described in table 2.

Table 2. The Extracted MSER Feature of signature

Feature	Centroid		Axes		Orientation	Pixel point	
	Min	*Max*	*Min*	*Max*		*Min*	*Max*
1	123.41	545.61	5.7696	8.7965	-1.2460	120	548
2	175.15	416.37	416.56	79.21	-1.2054	134	429
3	173.94	416.37	22.67	79.21	-1.3972	132	431
4	162.17	232.28	30.84	90.05	0.2338	101	256
5	159.62	232.97	30.98	118.71	0.2535	81	258
6	214.41	224.30	6.5997	26.77	0.2153	210	237
7	190.94	243.29	3.7177	31.4282	0.1891	178	246
8	224.02	244.08	6.9389	18.4363	0.2714	221	253
9	219.79	233.36	7.1262	99.3435	0.3355	176	256
10	169.80	229.51	29.9482	147.67	0.2892	80	259

Figure 6 [A] is represents the graphical match point of two different signatures on the basis of MSER feature. The graphical representation of match point of two different signature is describes in figure 6 [B].



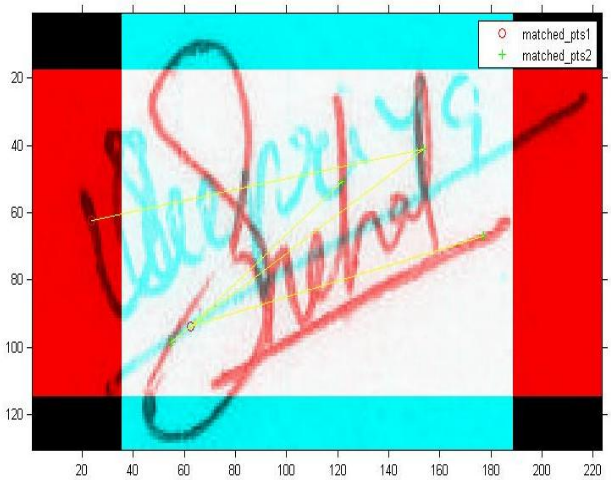


Figure 6. The graphical representation of matching of two [A] same signature [B] Different signatures

The match point such as location, scale and orientation of single signature is described in table 3.

Table 3. The Match Feature of signature

Match point	Location		Scale	Orientation
	Min	*Max*		
1	190.94	243.29	1.600	1.7280
2	169.80	229.51	8.2667	1.8837
3	1.8540	258.73	2.1333	2.0377
4	163.77	292.35	1.6000	2.2402
5	163.77	292.35	1.6000	2.2402
6	153.66	303.32	1.8867	2.3237
7	153.66	303.32	1.8867	2.3237
8	292.52	274.05	1.600	1.7948
9	200.01	355.60	2	1.9420
10	200.01	355.60	2	1.9420

Table 4. Template of signature for Training the system

Sr. No	Sample	Mean	Std
1	Subject 1	246.8304	23.7681
2	Subject 2	240.4696	34.3885
3	Subject 3	238.6819	22.1952
4	Subject 4	246.7398	19.153
5	Subject 5	249.4727	14.059
6	Subject 6	250.3945	18.7765
7	Subject 7	243.2835	16.9837
8	Subject 8	241.8306	25.5672
9	Subject 9	243.9682	22.0494
10	Subject 10	239.3624	27.3068

4.1 Performance parameters

Performance Analysis of the system includes an evaluation of all possible errors – False Acceptance and False Rejection give a fairly good idea of the efficiency for verification. The True Acceptance Rate (TAR) and the True Rejection Rate (TRR) are the correct-classification rates.

a) False Acceptance Rate(FAR)

The false acceptance rate, or FAR, is the measure of the probability likelihood that the system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

b) False Rejection Rate (FRR)

The false rejection rate (FRR), is the measure of the likelihood that the system will incorrectly reject an access attempt by an authorized user. A system's FRR typically is stated as the ratio of the number of false rejections divided by the number of identification attempts.

c) True Acceptance Rate (TAR)

True Acceptance Rate (TAR) measures representation of the degree that the system is able to correctly match the information from the same person. Researcher of the current era is attempting to maximize this measure.

d) True Rejection Rate (TRR)

True Rejection Rate (TRR) represents the frequency of cases when information from one person is correctly not matched to any records in a database because, in fact, that person is not in the database. Researcher is attempting to maximize this measure.

The detail of False Acceptance rate and false rejection rate with appropriate matching are described in table 5. The False Acceptance Rate and False rejection Rate counts for different individuals (40 samples each) are presented in Table 5.

Total accuracy is calculated by following formula:

$$Accuracy = 100-(FAR+FRR)/2$$

The system result is compare to available statistics performance in the literature, in that the author got the highest accuracy as when FAR is 5.24 and FRR is 4.0 . The results are slightly improves as compare to other results. The system performance is the compare with the other system available in literature for offline signature recognition. The proposed research attempted best accuracy as compared to reported result in literature [14, 15, 16, 17, 18, and 19].

Table 5. False acceptance rate and false rejection rate for the system

Test signature	No. of toke passed	FRR (%)	FAR (%)	Accuracy
Subject 1	40	5	7.5	87.5
Subject 2	40	7.5	0	80
Subject 3	40	2.5	10	87.5
Subject 4	40	5	2.5	90
Subject 5	40	5	7.5	87.5
Subject 6	40	2.5	7.5	90
Subject 7	40	7.5	10	82.5
Subject 8	40	2.5	2.5	95
Subject 9	40	2.5	10	92.5
Subject 10	40	0	5	95
Average	40	4	5.25	95.374

VI. CONCLUSION

Signature is a behavioral biometric used to authenticate a person in day to day life. The paper gives in depth review of offline signature recognition systems. The performance metrics of typical systems are compared along with their feature extraction mechanisms. We have discussed the offline signature recognition on the basis of maximally stable extremely regions (MSER) feature extraction. The MSER is the most robust and dynamic feature extraction technique in the computer vision. The system is has reported accuracy of 95.371% where FAR is 5.25 % and FRR are 4 %, which is higher than individual performance metrics.

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