Fingerprint and Palmprint Recognition using Neighborhood Operation and FAST Features

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ABSTRACT
In this paper presents biometrics based fingerprint and palmprint recognition and authentication system. Fingerprint and palmprint images are enhanced using preprocessing techniques such as morphological operations. The feature extraction techniques such as neighborhood operation and FAST feature algorithm is used to independently extract fingerprint and palmprint features. These techniques are more reliable and faster than traditional techniques used. Experimental results shown recognition rate 89.29% for fingerprint and 100% for palmprint this implies that the proposed methodology has better performance and is more reliable over the techniques proposed and used earlier.

Abbrevations
SF - Single Flat

SFF - Single Flat Flexi

LT - Left Thumb finger

LI - Left Index finger

LM - Left Middle finger

LR - Left Ring finger

LL - Left Little finger

RT - Right Thumb

RI - Right Index finger

RM - Right Middle finger

RR - Right Ring finger

RL - Right Little finger

ROC- Receiver Operating Characteristics

Keywords
Multimodal, Neighborhood operation, FAST features, Region properties, Single Flat (SF), Single Flat Flexi, Euclidean.

1. INTRODUCTION
Nowadays biometric authentication system becomes very popular in various applications such as physical access control, security, monitoring. Password based security systems are widely used for protection from theft and crackers. But it is not proper practice each time to remember long passwords. In biometrics an individual is identified with the help of behavioral and physiological characteristics. It gives more security than passwords based security systems. Biometrics can be employed on various traits like fingerprint, palmprint, handgeometry, iris, face, voice, signature, etc.

1.1 Biometrics overview
Biometrics is of three modes i.e. unimodal biometrics which can identify individual by using single trait. Second is bimodal biometrics in which identification is done with fusion of two modalities and the other is multimodal biometrics which uses combination of multiple traits for identification purpose of human. A unimodal biometric may fails to be accurate enough for the identification of a large user population and there is one more possibility of failure if physical characteristics of a person for the selected biometric is not available [1].

Biometrics system has two types i.e. verification systems and identification systems.

- In a Verification System the input is a claimed identity and a biometric record. The system compares that biometric record with the biometric record stored in database for that identity to verify the claimed identity. In this system only a comparison is performed.

- In an Identification System the input is a biometric record. The system must search a database looking for the biometric data most similar with an input query biometric data and must decide if both of them belong to the same person. Many comparisons are required for this system [2].

1.2 Biometrics Performance
In real practice the chance of any two people having the same characteristic will be optimized by highly unique features [3]. By combining information from different biometrics modalities we can achieve higher and more consistent performance levels [4]. A multimodal biometric system requires an integration scheme to fuse information obtained from the individual modalities [5].

In multi-modal biometric system, there are generally four sorts of fusion level i.e.

1. Fusion at sensor level: - In this strategy images are fused directly or using some transform technique then features are extracted from fused image.
2. Fusion at feature-extraction level: - In this strategy the features extracted using two or more sensors are concatenated.
3. Fusion at matching-score level: - In this strategy matching scores obtained from multiple matchers are combined.
4. Fusion at decision level: - In this strategy the accept/reject decisions of multiple systems are consolidated.

The widely accepted strategy is feature extraction level because many observers prove that this level fusion produces better results. Usually, the performance of the biometric system is given by the accuracy of the system. There are two most widely used standard metrics of the accuracy of biometric systems i.e.

False Accept Rate (FAR) and False Reject Rate (FRR). The FAR is the percentage of imposters that are incorrectly accepted by system. The FRR is the percentage of valid users who are incorrectly denied access by system.

In this paper new method is provided for personal authentication using fingerprint, palmprint that are simultaneously acquired from a single hand image. The database of subject for left and right hand is used in this system. Each of these palmprint images are used to extract specific features. Thus the palmprint and hand geometry features of an individual are obtained from the same hand image.

A fingerprint is composed of ridges and furrows which are parallel and have same width. A fingerprint image acquired by an Optical Sensor. The actual number of minutiae depends on the size of the sensor surface and how the user places his or her finger on the sensor [6]. They are distinguished by Minutiae which are features on the ridges. Two minutia types are more significant:-

1) Termination: - This is the immediate ending of a ridge.

2) Bifurcation: - This is the point on the ridge from which two branches derive.

The palm is the inner surface of a hand between the wrist and the fingers. There are different features that exists on a palm such as principle line, wrinkle line, delta point [7].

2. RELATED WORK

Gawande, U. et al [1] proposed a feature-level fusion framework for combining features of Iris and Fingerprint and algorithm Radial Basis Function based neural network (RBFNN) with accuracy rate 97.3%. In paper[2] Teddy Ko gives various scenarios in multimodal biometric systems using fingerprint, face and iris recognition, the levels of fusion that are possible and the integration strategies that can be adopted to fuse information and improve overall system accuracy. How the image quality of traits will affect the overall identification accuracy and the need of staffing for the secondary human validation . V. C. Subbarayudu, et al [2] proposed general working of multimodal biometrics system with Iris and Palmprint and fusion is done at the matching score level by Sum Rule technique with recognition rate is 96.6%. Andrew Teoh, et al [4] introduced k-Nearest Neighbourhood (k-NN) based classifiers are adopted in the decision fusion module for the face and speech experts with Recogntion rate is 80.33%. Slobodan Ribaric, et al [5] gives a bimodal biometric verification system for physical access control based on the features of the palmprint and the face, palm matching is based on the adapted HYPER method. And for face the K–L transform is used for matching. bimodal system can achieve an EER (equal error rate) of 3.08% for T=0.748 and the minimum TER (total error rate) = 5.94% for T = 0.8. Anil K. Jain , et al [6] described an automated fingerprint recognition system and listed key challenges and research opportunities in the field. The recognition rate is 95%. Fan Yang et al [7] fingerprint, palm-print and hand-geometry are combined for person identity verification. Wavelet transform to extract the features from fingerprint and palm-print is used and hand-geometry feature (such as width and length) is extracted after the pre-processing phase. Feature level fusion and match score fusion together for identity.The weight values are calculated based on total minimum error. i.e. For weight1- 0.75,weight2- 0.25. X. Wu., et al [8] proposed a palm print recognition system by extracting features using Sobel operators and using Hidden Markov Models (HMM) as classifiers. Ajay Kumar, et al [9] attempts to improve the performance of palmprint-based verification system by integrating hand geometry features. These features are then examined for their individual and combined performances. The recognition rate is 98.3%.

Harpreet Singh, et al [10] have given iterative fuzzy approach for obtaining fused images Entropy values are provided in result as for Fuzzy algorithm entropy is 5.30 and for neuro fuzzy algorithm 4.89. Chun Wai Lau, et al [11] presents a multi-biometric verification system that combines speaker verification, fingerprint verification with face identification and equal error rates (EER) are 4.3%, 5.1% and the range of (5.1% to 11.5%) for matched conditions in facial image capture respectively. K. Ito, et al [12] suggested Multi-scale wavelet decomposition of palmprint images and using mean of each wavelet sub-block has been suggested .

M. Wang, et al [13] proposed 2D PCA and 2D LDA over conventional PCA have been reported to be better for palmprint recognition. V. Conti, et al [14] have proposed multimodal biometric system using two different fingerprints. The matching module integrates fuzzy logic methods for matching score fusion. Both decision level fusion and matching score level fusion were performed. Antonia Azzini, et al [15] given idea about using a fuzzy control system to manage a multi-modal authentication system, checking the identity of a user during the entire session. The first biometric acquisition takes matching score 0.725and the second biometric acquisition takes score 0.4860.

Kornelije Rabuzin, et al [16] had suggested active rules in fuzzy logic are used for effective decision making in person identification. The recognition rate is 97%.

Gawande, et al [17] used log Gabor filter can be used to extract the feature vectors from both Iris and Fingerprint and then they are concatenated. The phase data from 1 D log Gabor filters is extracted and quantized to four levels to encode the unique pattern of Iris and Fingerprint into bitwise biometric template. Hamming distance (HD) is used to generate a final match score. Yong Jian Chin, et al [18] proposed a multimodal biometrics system in which 2D gabor filter is used to extract features. The recognition rate is 98%. Asim Baig, et al [19] proposed a state of the art framework for multimodal biometric identification system which can be adapted for any type of biometrics to provide smaller memory footprint and faster implementation. The recognition rate is 90%. Cheng Lu, et al [20] suggested idea which utilizes two or more individual modalities, like face, ear, and fingerprint, to improve the recognition accuracy by new dimensionality reduction method called Dimension Reduce Projection (DRP). The recognition rate is 95.8%. Nicolas Tsapatsoulis, et al [21] presented an identification and authentication system based on hand geometry which used POLYBIO hand database. The recognition rate is 95%.

Anil K. Jain, et al [22] given an overview of biometrics, emerging biometric technologies and their limitations, and examines future challenges. Mohammad Imran, et al [23] proposed a new hybrid approach to verification aspect of a multibiometric system and comparative analysis with traditional approaches such as multialgorithmic and multimodal versions of the same. The average EER of hybrid approach from different levels of fusion is 3.87% which shows that hybrid approach yields lower average EER. Mohamed K. Shahin, et al [24] introduced a multimodal biometric system (MMBS) based on fusion of whole dorsal hand geometry and fingerprints that acquires right and left (Rt/Lt) near-infra-red (NIR) dorsal hand geometry (HG) shape and (Rt/Lt) index and ring fingerprints (FP). Accuracy rate is 99.71%. S. Palanikumar, et al [25] presented approach for enhancing

palmprint image. The enhancement is based on curvelet which preserves the fine features without noise. The result gives high PSNR (Peak Signal-to-Noise Ratio) value for the Curvelet method. i.e. 38.1047 .

Feifei CUI, et al [26] proposed multimodal biometrics recognition based on score level fusion of fingerprint and finger vein. Recogntion rate is 98.74%. Romaissaa Mazouni, et al [27] proposed a comparative study of several advanced artificial intelligence techniques (e.g. Particle Swarm Optimization, Genetic Algorithm, Adaptive Neuro Fuzzy Systems, etc.) as to fuse matching scores in a multimodal biometric system is provided. The fusion was performed under three data conditions: clean, varied and degraded. Some normalization techniques are also performed prior fusion so to enhance verification performance. The population based techniques (PSO, GA) gave very good results. Nishant Singh, et al [28] presents an efficient multimodal biometric system based on 4 slap fingerprint images. The system utilizes 4 slap fingerprint scanner to simultaneously collect fingerprints of multiple fingers on a hand in one image**.** Decision threshold is 0.9869 and FAR is 5.08%. Ashutosh Kumar, et al [29] suggested the new approach where the palmprint images are mapped to Eigen-space and a robust code signature is generated from different camera snapshots of the same palm to incorporate tonal and lighting variations. To enable real-time identification, the signature is represented by a low dimensional feature vector to reduce computational overheads. Overall accuracy rate is 98.7%. P.U. Lahane , et al [30] given the comparison of data base template and the input data is done with the help of hamming-distance matching algorithm. If the templates are matched we can allow the person to access the system. Gabor filter is used for fingerprint. Accuracy is 99.5%.

Krishneswari, et al [31] proposed to investigate the performance of multimodal biometrics using palm print and fingerprint. Features are extracted using Discrete Cosine Transform (DCT) and attributes selected using Information Gain (IG). Results shows an average improvement of 8.52%. D. Y. Liliana, et al [32] studied about biometrics of palm for identification system using block-based line detection for palm print feature extraction process, and chain code solved the hand geometric feature extraction. We combined those two respective features and recognized it using Dynamic Time Warping (DTW) method which was able to measure the distance between two different features. The accuracy rate is 89%. Gawande, et al [33] gives use of the log Gabor filter to extract the feature vectors from both Iris and Fingerprint and then they are concatenated. Finally the phase data from 1 D log Gabor filters is extracted and quantised to four levels to encode the unique pattern of Iris and Fingerprint into bitwise biometric template. Hamming distance (HD) is used to generate a final match score. Experimental results was verified on database of 50 users accounting to FAR = 0% and FRR = 4.3%. M. Dale, et al [34] presented palm texture using transform features and hand geometry features are represented as distances between different boundary points. The final decision is made by fusion at decision level. And accuracy rate is 99.5%. S. Rao, et al [35] suggests image fusion using fuzzy and neuro fuzzy logic approaches utilized to fuse images from different sensors, for enhancing visualization.

Alima, et al [36] investigates a novel algorithm based on fusion of both fingerprint and fingervein biometrics which uses Monogenic Local Binary Pattern (MonoLBP). This operator integrate the original LBP (Local Binary Pattern) with both other rotation invariant measures such as local phase and local surface type. Recognition rate is 93%. Mohamad Abdolahi, et al [37] proposed two biometric traits such as iris and fingerprint which uses Decision level fusion and Fuzzy logic as technic for the effect of each biometric result combination. Recognition rate is 71%. H. Tyagi, et al [38] gives first process which is based on Gabor filter and second is based on Gaussian filter and in the fingerprint image preprocessing steps and after getting result by first step then use feature extraction and feature matching steps simultaneously and separately for each process. After apply all steps the FAR (False Accept Rate) and FRR (False Reject Rate) for both process separately are calculated and compare results on the basis of FAR and FRR of Gabor filter based and FAR and FRR of Gaussian Filter based. Which process has the reduced FAR and FRR this is the best process than other. The accuracy rate is 95%.

3. PROPOSED METHOD

The proposed method includes various steps such as image aquisition of user from sensor, preprocessing operation to enhance the quality of image and feature extraction process to identify the features of an image. Finally, matching is done on the basis of specific features with database image and decision is made for identification.

The figure 1 shows the block diagram of biometrics identification system.

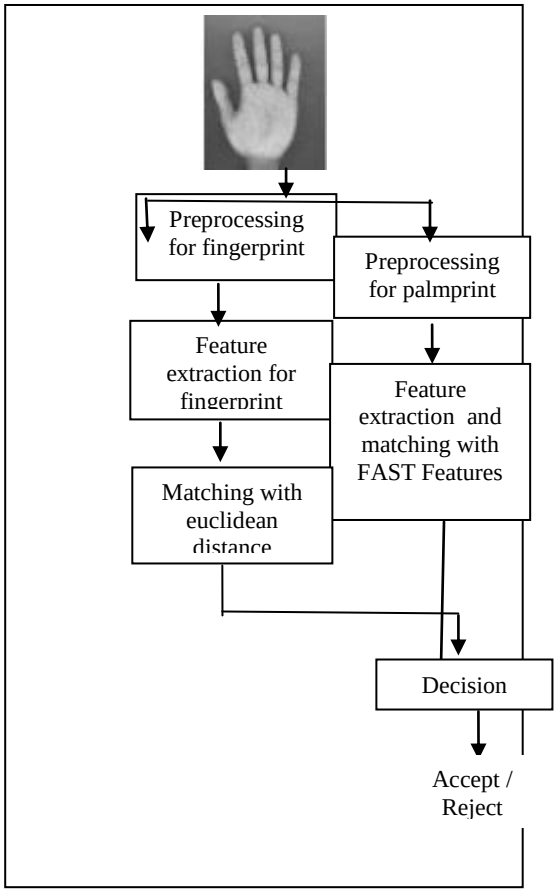

Fig 1 : Block Diagram Of Biometrics System

3.1 Image Acquisition

3.1.1 Extraction of fingerprint images

For extraction of image we used the Crossmatch sensor. This sensor provides the facility of acquisition of fingerprint in various modes. Amongst these modes we selected the two modes in our research.

1) Single Flat Finger (SF):- In this mode specific area for image acquisition is provided by sensor. User supposed to be put finger on that area only. Accordingly all 10 fingers are scanned starting from left and continuing towards right.
2) Single flat flexi finger (SFF):- In this mode there is not any restriction about acquisition area of sensor. User can put finger on any place on acquisition area. This mode acquires the images for all 10 fingers for both hand starting from left little finger to right little finger.

We used KVKR Multimodal Biometrics database. It contains data of total 1120 images for fingerprint of 7 subjects. For single flat mode we used 8 samples of each subject and each individual sample contains images for all 10 fingers. So total number of images for SF is 560 ans SFF is 560. Similarly for single flat flexi mode we use same procedure.

3.1.2 Extraction of Palmprint images

For extraction of palmprint images whole handgeometry images are employed. Palmprint images are taken from the center of rectangle that can enclose the whole area of interest in palm. These center coordinates are used to extract a square palmprint region of fixed size. We used total 112 images of palmprint from database 8 images for left and right hand of subjects. Hence 16 images of every subject.

3.2 Preprocessing techniques

3.2.1 Preprocessing for Fingerprint images

Fingerprint images are grayscale images. They are converted into binary images. Then we perform morphological operation such as morphological thining. It removes pixels so that an object without holes shrinks to a minimally connected stroke, and an object with holes shrinks to a connected ring halfway between each hole and the outer boundary. After that we used median fliter then general sliding-neighborhood operations to extract minutiae as feature for fingerprint.

3.2.2 Preprocessing of palmprint images

For palmprint images we used center region of handgeometry images of specific size. These images are also colored images and we convert them firstly into grayscale images. Then specific threshold value is set for images for further processing.

3.3 Feature extraction

3.3.1 Feature extraction for Fingerprint images

For fingerprint we had extracted minutiae as feature because this features are more widely appears in every user. There are many variations in finger placement and pressure applied on the sensor, the minutia points extracted from the template and query fingerprints must be aligned, or registered before matching. We had extracted minutiae such as ridge bifurcations and endings. These features called as level 2 features which are useful to establish a fingerprint's individuality or uniqueness. If fingerprint image resolution is high then only higher-level features. We used general sliding-neighborhood operations with median filter and nlfilter 3-by-3 neighborhood. With the help of we extract minutiae as termination and bifurcation for all samples. After this we divide the total population into training and testing matrix. First 6 samples were considered as training samples and mean is taken for those samples for all fingers for each subject. And remaining 2 samples of termination and bifurcation of each subject is considered as testing sample. Feature matrix for fingerprint of termination where SF and SFF feature matrix are taken is individually for left and right hand. And after this SF and SFF termination were considered in combination as shown below in Table1 and Table2.

Table 1: Feature matrix for SF and SFF termination in combination for Left hand

	SF					SFF				
	LT	***LI***	***LM***	***LR***	***LL***	***LT***	***LI***	***LM***	***LR***	***LL***
Sub1	270	232	346	333	216	229	122	287	318	183
Sub2	480	202	210	387	248	338	172	140	256	284
Sub3	427	350	399	440	277	410	334	429	419	272
Sub4	853	468	953	868	596	699	395	804	742	556
Sub5	421	283	525	662	482	319	292	368	588	491
Sub6	309	282	325	429	161	392	425	546	750	472
Sub7	968	584	994	661	423	756	433	672	596	476

Table 2 : Feature matrix for SF and SFF termination in combination for Right hand

	SF					SFF				
	RT	***RI***	***RM***	***RR***	***RL***	***RT***	***RI***	***RM***	***RR***	***RL***
Sub1	223	220	213	273	345	159	138	197	317	389
Sub2	455	240	145	241	222	297	229	157	182	181
Sub3	467	350	292	378	269	391	259	298	293	278
Sub4	771	612	742	645	479	612	549	751	796	641
Sub5	410	487	563	500	559	299	388	344	404	462
Sub6	419	365	517	480	297	443	628	679	712	459
Sub7	1064	707	871	695	530	1075	736	868	829	675

Similarly, We had taken the feature matrix for bifurcation of left hand and right hand of each subject for Single Flat (SF) and Single Flat Flexi (SFF) individually. An after that SF and SFF in combination for each subject. Feature matrix for fingerprint of bifurcation where SF and SFF feature matrix are combine as shown below in Table 3 and Table 4.

Table 3 Feature Matrix For SF And SFF Bifurcation In Combination For Left Hand

	SF					SFF				
	LT	***LI***	***LM***	***LR***	***LL***	***LT***	***LI***	***LM***	***LR***	***LL***
Sub1	260	236	367	372	239	219	110	296	341	186
Sub2	471	194	198	419	251	312	155	124	244	284
Sub3	454	374	439	492	292	427	354	480	473	302
Sub4	871	500	1199	990	705	718	437	414	823	649
Sub5	415	345	606	778	563	297	294	395	652	540
Sub6	320	302	368	525	189	401	444	618	944	574
Sub7	1103	585	755	725	480	794	424	682	669	481

Table 4 Feature Matrix For SF And SFF Bifurcation In Combination For Right Hand

	SF					SFF				
	RT	***RI***	***RM***	***RR***	***RL***	***RT***	***RI***	***RM***	***RR***	***RL***
Sub1	220	228	221	292	396	148	133	184	329	424
Sub2	456	244	136	233	224	286	222	144	166	175
Sub3	461	366	313	400	287	405	269	319	323	291
Sub4	847	714	892	764	550	809	596	885	964	756
Sub5	431	569	684	590	690	294	427	353	451	533
Sub6	434	402	58	580	345	446	720	781	886	554
Sub7	1195	787	1030	860	622	1218	771	962	967	782

3.3.2 Feature extraction for Palmprint images

For palmprint we extracted features such as corners points in grayscale images with the Features from Accelerated Segment Test (FAST) algorithm to find feature points. Then from these corner points we extract interest point descriptors. These corner points are common for both images in the form of *Index Pair*. This algorithm also gives value of total number of Index pairs in images. Greater the value of index pair indicates that the images belongs to same subject and smaller value of index pair shows that the images belongs to different subject. The descriptors are extracted feature vectors and their corresponding locations, from a binary or intensity image. The function derives the descriptors from pixels surrounding an interest point. These pixels describe and match features specified by a single-point location. Each single- point specifies the center location of a neighborhood. The method used for descriptor extraction depends on the class of the input points such as SURFpoints, MSERobjects, corner points. FASTfeatures technique uses parameters as image, name and its scalar threshold value in the range (0,1). Name is MinContrast i.e. Minimum intensity difference between corner and surrounding region, specified as the comma-separated pair consisting of MinContrast. The minimum intensity represents a fraction of the maximum value of the image class. Increasing the value reduces the number of detected corners. The default value is 0.2. A standard threshold value used in this experiment is 0.031 beacuse at this particular threshold value we get maximum number of matching index pairs in images.

Table-5 : Feature Matrix Palmprint Palmprint Images For Left Hand

Sub	Index Pair1	Index Pair2	Index Pair3	Index Pair4	Index Pair5	Index Pair6	Index Pair7
Sub1	31.6	33	31	29.4	24.14	29.6	27.4
Sub2	16.9	31	33.8	26.3	41.12	41.4	31.6
Sub3	18.6	17.37	65	69.6	7	18.8	17.8
sub4	15.5	15.12	5.12	5.5	11.25	10.8	56.5
sub6	2.62	4.87	3.25	3.25	3.62	3.25	4
Sub7	1.5	1.25	1.63	1.75	1.12	2	2.37

Table 6 : Feature Matrix Palmprint Palmprint Images For Right Hand

Sub	Index Pair1	Index Pair2	Index Pair3	Index Pair4	Index Pair5	Index Pair6	Index Pair7
Sub1	23.38	25.50	90.50	11.50	33.13	28.00	7.88
Sub2	16.88	31.00	33.75	26.25	41.13	41.38	31.63
Sub3	5.13	5.00	8.25	7.50	8.38	9.88	9.63
Sub4	23.63	21.25	14.25	15.75	12.75	15.25	24.25
Sub5	9.88	15.00	19.63	14.75	20.25	16.25	15.00
Sub6	10.88	12.75	14.63	12.63	15.75	13.88	14.50
Sub7	3.25	3.25	2.63	3.25	4.38	1.38	0.63

4. EXPERIMENT AND RESULT ANALYSIS

4.1 Fingerprint Recognition

In Fingerprint we used termination and bifurcation as features. For this we used general sliding-neighborhood operations with nlfilter 3-by-3 neighborhood. With the help of this we can extract minutiae as feature for fingerprint. After this we calculated the pairwise Euclidean distance between training matrix and testing matrix for SF mode of Left hand and right hand for termination. In same manner we calculated the pairwise Euclidean distance for SFF mode Left hand and right hand for termination. For better performance we take the Euclidean distance for SF and SFF in combination for left and right hand termination. The resulting distance matrix is as shown in following table:-

Table 7: Distance Matrix for SF And SFF Termination In Combination For Left Hand

	Sub1	Sub2	Sub3	Sub4	Sub5	Sub6	Sub7
Sub 1-7	296.28	452.22	678.92	1725.58	907.01	882.78	1645.73
Sub2-7	469.77	184.61	472.81	1392.50	695.88	750.44	1294.54
Sub3-7	474.41	484.32	324.26	1242.91	500.63	433.14	1213.14
Sub4-7	1493.30	1533.37	1170.11	473.58	976.00	1071.91	703.06
Sub5-7	932.17	952.99	741.77	879.63	465.66	915.72	957.83
Sub6-7	1115.87	1146.61	771.09	564.47	569.34	733.26	663.77
Sub7-7	1335.42	1292.50	958.48	422.32	904.85	1072.35	341.68
Sub1-8	264.50	382.36	591.41	1611.61	866.76	865.47	1489.60
Sub2-8	569.40	362.89	534.08	1416.94	768.65	814.06	1318.31
Sub3-8	385.23	524.69	342.87	1213.05	398.47	577.77	1200.56
Sub4-8	1340.34	1337.85	989.68	613.43	905.50	863.77	754.09
Sub5-8	674.70	634.80	451.89	880.90	328.80	692.82	853.17
Sub6-8	1068.42	1143.77	830.68	1226.89	855.71	455.58	1275.80
Sub7-8	1255.47	1242.15	860.42	515.62	843.19	904.37	398.21

In table 7 the highlighted cells indicates the correctly classified samples of each subject. And the highlighted values indicates the misclassified values for each subject.

Table 8: Distance Matrix For SF And SFF Termination In Combination For Right Hand

	Sub1	Sub2	Sub3	Sub4	Sub5	Sub6	Sub7
Sub1-7	138.45	450.11	522.88	1458.52	773.10	1030.60	1979.31
Sub2-7	514.97	162.27	375.28	1409.26	837.30	1062.07	1830.45
Sub3-7	502.68	407.67	212.93	1072.36	556.86	702.57	1524.83
Sub4-7	1380.39	1341.61	1110.60	769.53	1044.44	831.63	855.72
Sub5-7	746.39	832.73	556.33	730.12	169.05	563.67	1259.20
Sub6-7	1191.54	1239.41	949.81	391.54	786.03	388.57	900.31
Sub7-7	1903.16	1866.66	1572.03	619.06	1334.06	1137.22	185.57
Sub1-8	261.75	413.10	365.28	1242.43	551.17	891.40	1763.50
Sub2-8	446.58	123.78	330.21	1382.68	758.00	1035.09	1835.13
Sub3-8	538.68	514.88	293.07	1092.38	492.84	761.16	1553.20
Sub4-8	1494.54	1519.44	1249.83	616.56	1055.92	781.86	735.45
Sub5-8	655.94	800.23	566.27	923.57	243.14	754.16	1454.58
Sub6-8	836.79	864.61	614.81	759.01	617.33	324.19	1258.37
Sub7-8	1741.73	1703.60	1426.94	522.90	1200.99	1031.92	445.08

After we take the euclidean distance for bifurcation of SF and SFF left and right hand individually and then in combination for left and right hand. The distance matrix of SF and SFF in combination for bifurcation is as shown in following table:-

Table 9 : Distance Matrix For SF And SFF Bifurcation In Combination For Left Hand

	Sub1	Sub2	Sub3	Sub4	Sub5	Sub6	Sub7
Sub1-7	327.37	447.39	780.41	1885.33	1066.77	1107.93	1684.61
Sub2-7	487.61	181.80	576.23	1573.54	879.71	988.84	1284.16
Sub3-7	593.12	621.20	404.29	1366.62	589.80	530.29	1183.67
Sub4-7	1798.01	1900.30	1416.86	997.20	1193.38	1229.40	1010.50
Sub5-7	1204.77	1203.43	967.63	797.02	631.30	1222.45	922.24
Sub6-7	1550.31	1633.80	1160.34	730.43	837.45	981.38	915.26
Sub7-7	1478.56	1459.60	1049.32	674.43	976.80	1226.85	299.97
Sub1-8	297.16	382.55	690.74	1775.03	1022.85	1091.72	1535.80
Sub2-8	608.20	398.22	657.36	1610.95	971.70	1065.57	1335.34
Sub3-8	509.27	649.48	466.53	1281.90	421.77	764.32	1216.39
Sub4-8	1588.86	1636.66	1166.68	1050.20	1085.09	971.40	763.88
Sub5-8	633.03	710.52	418.16	1045.42	285.15	721.24	931.01
Sub6-8	1345.03	1451.16	1051.40	1544.45	1082.98	550.35	1380.10
Sub7-8	1389.05	1414.74	912.55	713.31	899.27	974.38	439.03

Table 10: Distance Matrix For SF And SFF Bifurcation In Combination For Right Hand

	Sub1	Sub2	Sub3	Sub4	Sub5	Sub6	Sub7
Sub1-7	178.55	504.50	582.19	1837.71	983.50	1216.46	2340.76
Sub2-7	543.33	152.41	450.93	1813.64	1070.59	1264.92	2231.93
Sub3-7	552.14	463.27	207.08	1402.25	753.60	890.53	1852.13
Sub4-7	1662.94	1654.81	1357.80	884.74	1293.60	1126.69	989.78
Sub5-7	921.87	1085.91	760.31	1027.96	201.50	1039.76	1519.71
Sub6-7	1477.08	1579.17	1215.52	593.41	1020.22	692.60	1094.31
Sub7-7	2350.36	2362.33	1998.57	735.44	1644.79	1743.78	303.11
Sub1-8	330.02	532.85	454.50	1601.87	710.08	1137.16	2087.78
Sub2-8	489.32	136.38	413.30	1787.33	993.57	1264.51	2221.24
Sub3-8	672.16	702.07	416.75	1369.54	608.19	1041.00	1810.75
Sub4-8	1781.69	1854.23	1515.50	738.85	1285.00	1114.80	960.88
Sub5-8	848.14	1039.08	751.74	1203.03	339.37	1082.42	1683.88
Sub6-8	1053.28	1128.74	805.11	975.85	820.84	602.08	1480.38
Sub7-8	2055.24	2073.44	1731.93	629.85	1402.87	1405.04	603.33

The table 11 gives the analysis of results for SF and SFF termination when the samples tested individually.

Table-11 : Recognition Rate For SF And SFF Termination When Tested Individually

Test	Total no of sample	Correct classified	Miss classified	RR
SF Left hand Termination	14	10	4	71.42 %
SF Right hand Termination	14	10	4	71.42 %
SFF Left hand Termination	14	13	1	92.85 %
SFF Right hand Termination	14	10	4	71.42 %

It is observed that SFF mode gives better recognition rate for left hand than SF for termination.
Similarly, we analysed the results for bifurcation of SF and SFF when tested individually. Table 11 shows that recognition rate for SFF is better than SF for bifurcation also.

Table-12 : Recognition rate for SF and SFF bifurcation when tested individually

Test	Total no of sample	Correct classified	Miss classified	RR
SF Left hand bifurcation	14	7	7	50 %
SF Right hand bifurcation	14	9	5	64.28 %
SFF Left hand bifurcation	14	11	3	78.57 %
SFF Right hand bifurcation	14	11	3	78.57 %

When we test the samples of SF and SFF in combination for termination and bifurcation then it is observed that the recognition rate is increased to 100% as compare to when test is done for individual for each mode.

Table 13 : Recognition Rate For SF And SFF Termination When Tested In Combination

Test	Total no of sample tested	Correct classified	Miss classified	RR
SF and SFF Left hand termination	14	13	1	92.75 %
SF and SFF Right hand termination	14	14	0	100 %

Table 14 : Recognition Rate For SF And SFF Bifurcation When Tested In Combination

Test	Total no of sample tested	Correct classified	Miss classified	RR
SF and SFF Left hand bifurcation	14	11	3	78.57 %
SF and SFF Right hand bifurcation	14	12	2	85.71 %

Total 56 test samples are tested for fingerprint. Out of which 50 are correctly classified and 6 are misclassified. The reason for miss-classification is the poor quality of images.

4.2 Palmprint Recogntion

In palmprint we used 112 images for 7 subject of both left and right hand. From 112 we used 98 for training and remaining 14 for testing matrix. We test at least two images at a time for palm. By comparing results of these two images we can easily recognize the particular subject. If the image sample belongs to same person then the both image contains maximum no of matching corner points in common called as index pair. If the images doesn't belongs to same person then they have no matching points in common or negligible matching points in common. We can compare the test image against no of images at the same time with this process. The resultant matrix contains total no of index pairs for each pair of tested image samples. This test gives appropriate idea about the test sample belongs to which subject. Afterwards this matrix for further analysis and ease of use is reduced to the classification matrix which contains the total no of samples correctly classified in particular class for each subject. And 'x' entry indicates that no match in corresponding class. The table 14 shows classification matrix for palmprint samples.

Table 15 : Classification Matrix For Palmprint Samples

Test Sample	**Sub1**	**Sub2**	**Sub3**	**Sub4**	**Sub5**	**Sub6**	**Sub7**
	Class-1	***Class-2***	***Class-3***	***Class-4***	***Class-5***	***Class-6***	***Class-7***
Sub1-8	8	x	X	x	x	x	x
Sub2-8	x	8	X	x	x	x	x
Sub3-8	x	x	8	x	x	x	x
Sub4-8	x	x	X	8	x	x	x
Sub5-8	x	x	X	x	8	x	x
Sub6-8	x	x	X	x	x	8	x
Sub7-8	x	x	X	x	x	x	8

Table 16 : Recognition Rate For Palmprint Samples

Sub	Total no of sample tested	Correct classified	Miss Classified	RR
Sub1	8	8	0	100%
Sub2	8	8	0	
Sub3	8	8	0	
Sub4	8	8	0	
Sub5	8	8	0	
Sub6	8	8	0	
Sub7	8	8	0	

From table 15 it is observed that all samples of palmprint are classified into corresponding classes correctly. So the recognition rate achieved for palmprint images is 100 %.

Table 17 : Overall Recognition Rate For Fingerprint And Palm

Test	Total no of sample tested	Correct classified	Miss classified	RR
Fingerprint	56	50	6	89.29 %
Palm	56	56	0	100 %

Figure 2 shows the Receiver Operating Characteristic curve for fingerprint images and Figure 3 ROC curve for palmprint images. The ROC is based on observed frequency and cumulative frequency. Performance True positive rate and false positive rates are analyzed with the ROC.

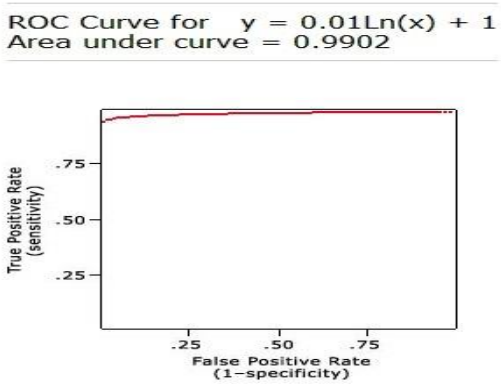

Fig 2 : ROC curve for fingerprint

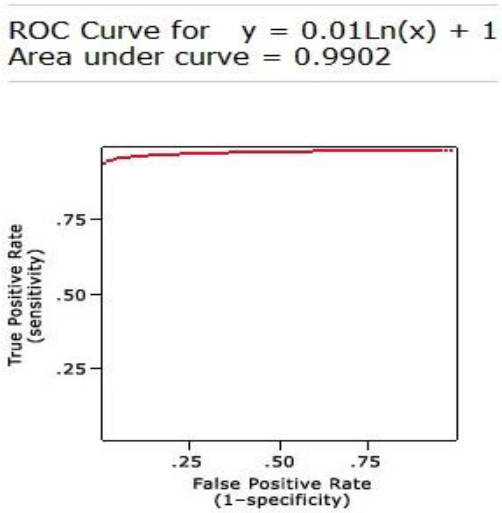

Fig 3 ROC curve for palmprint

5. CONCLUSION

The results clearly indicates the significance of the method used in this research work. The results of fingerprint recognition was improved because of combination of features of SF, SFF and achieved 89.29% recognition. Similarly for palm print recognition the FAST features were utilized for classification for palm into appropriate classes. The observed classification success is 100%. These two methods can be collectively used for development of multimodal biometric recognition system in very effective way.

This paper presents a novel idea about person identification based on fingerprint and palmprint images. This work is more reliable because it gives faster results as compare to traditional biometric techniques. Fingerprint recognition consist of two modes of image acquisition. i.e. Single flat (SF) and Single flat flexi (SFF). Amongst which we get better recognition rate for Single flat flexi mode than Single flat mode. And the recognition rate is also increased upto 100% when tests are done in combination for Single flat and Single flat flexi as compare to test done individually.

For palmprint recogntion the new approach FAST feature algorithm reduces number of comparisons ad provides easy recognition rate because it gives direct discrimination between image samples.

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