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Experimental Analysis of Fingerprint Recognition System

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Abstract— The objective of this paper is to analyze the fingerprint verification techniques by extracting the features of fingerprints and enhance the fingerprint using image processing techniques to improve the matching percentage. It aims to perform the analysis on the matching results as FAR and FRR. Observe the ROC receiver operating characteristic curves. The method results in more time robust matching and enhance the values between two fingerprints. It is however equally important that the image enhancing process does not suppress distinct features since this would affect identification or verification process negatively leading to false mismatches or in worst case, to false matches.
Keywords: Fingerprint; FAR; FRR; ROC;

I. INTRODUCTION

Fingerprint recognition is still challenging with the increase in the number of commercial systems for fingerprint-based recognition, proper evaluation protocols are needed. The first fingerprint verification competition (FVC2000) was a good start in establishing such protocols. As fingerprints (biometrics) get increasingly embedded into various systems (e.g., cellular phones, laptops), it becomes increasingly important to analyze the fingerprint verification as well as identification on the overall integrity of the system and its social acceptability as well as the related security and privacy issues (Mansfield, 2002)

II.METHODOLOGY

The first approach, which is minutia-based, in which fingerprint comparison is made by extracting minutia from two fingerprints and stored a set of points in two dimensional planes. Here ridge ending and bifurcation are considered as minutiae (Espinosa-Duro, 2002).This approach has been intensively studied; this technique is the backbone of the current available Fingerprint recognition products. Concentrating on this approach in this experiment we make the analysis of each step and observe the result for both genuine and imposter fingerprints available the DB3 database.

III. EXPERIMENTAL ANALYSIS

Experimental analysis considering the fingerprint database DB3 available in public domain, experimental analysis is carried out for both genuine and imposter fingerprint using the program developed in MATLAB (Maltoni et al ., 2003).
Minutiae based matching percent is computed for genuine identifier. By considering some threshold value for percentage, the number of matched and non-matched fingerprints are evaluated to calculate FAR and FRR (Jinwei GU et al., 2004).
Observations (Table I) are taken to find the matching percentage of fingerprints from the database DB: fingerprints which are also used for different analysis of the performance of different fingerprint matching algorithm in the FVC2004 competition. Considering the matching percent threshold 85%, the number of fingerprint matches and non-matches using minutiae based matching from DB3 Database are shown in Table 1. The percentage of acceptance ratio and rejection ratio is shown below in Table II.
False Rejection Rate (FRR)*:*
Sometimes the biometric security system may incorrectly reject the access of an authorized user. To measure these types of incidents FAR is used. FRR is the ratio between the number of false rejections and the number of identification attempts.

(%) FRR= (FR/N)*100

FR=number of incidents of false rejections

N= number of sample

False Acceptance Rate (FAR):
Sometimes the biometric security system may incorrectly accept the access of an unauthorized user. To measure these types of incidents FAR is used. A system's FAR basically states the ratio between the number of false acceptances and the number of identification attempts.

(%) FAR= (FA/N)*100
FA= number of incidents of false acceptance
N=total number of samples

TABLE I. MINUTIAE BASED MATCHING

Sr.no	Image 1	Image 2	Percentage	Time taken	Actual result	Expected result	Result
1.	012_1_1.tif	012_1_2.tif	94.3061	6.0613	Match	Match	TRUE
2.	012_1_1.tif	012_1_3.tif	71.5827	6.5098	No Match	Match	FALSE
3.	012_1_1.tif	012_1_4.tif	87.8847	6.1599	Match	Match	TRUE
4.	012_1_1.tif	012_1_5.tif	85.0424	6.2726	Match	Match	TRUE
5.	012_1_1.tif	012_1_6.tif	77.7423	5.8954	No Match	Match	FALSE
6.	012_1_1.tif	012_1_7.tif	75.5532	6.2434	No Match	Match	FALSE
7.	012_1_1.tif	012_1_8.tif	95.951	6.1536	Match	Match	TRUE
8.	012_1_1.tif	012_2_1.tif	99.4241	6.5714	Match	No Match	FALSE
9.	012_1_1.tif	012_2_2.tif	90.9438	6.4829	Match	No Match	FALSE
10.	012_1_1.tif	012_2_3.tif	73.8541	5.8169	No Match	No Match	TRUE
11.	012_1_1.tif	012_2_4.tif	83.4758	6.103	No Match	No Match	TRUE
12.	012_1_1.tif	012_2_5.tif	90.9946	5.971	Match	No Match	FALSE
13.	012_1_1.tif	012_2_6.tif	96.2945	6.2826	Match	No Match	FALSE
14.	012_1_1.tif	012_2_7.tif	97.4994	6.3273	Match	No Match	FALSE
15.	012_1_1.tif	012_2_8.tif	97.8857	6.0633	Match	No Match	FALSE
16.	012_1_2.tif	012_1_3.tif	67.5068	5.9267	No Match	Match	FALSE
17.	012_1_2.tif	012_1_4.tif	82.8806	6.0766	No Match	Match	FALSE
18.	012_1_2.tif	012_1_5.tif	90.1771	6.2542	Match	Match	TRUE
19.	012_1_2.tif	012_1_6.tif	73.3157	6.4914	No Match	Match	FALSE
20.	012_1_2.tif	012_1_7.tif	71.2512	6.2681	No Match	Match	FALSE
21.	012_1_2.tif	012_1_8.tif	98.2857	6.2596	Match	Match	TRUE
22.	012_1_2.tif	012_2_1.tif	93.7629	6.1955	Match	No Match	FALSE
23.	012_1_2.tif	012_2_2.tif	96.4348	6.0282	Match	No Match	FALSE
24.	012_1_2.tif	012_2_3.tif	69.6489	6.1017	No Match	No Match	TRUE
25.	012_1_2.tif	012_2_4.tif	78.7227	6.1116	No Match	No Match	TRUE
26.	012_1_2.tif	012_2_5.tif	96.4886	6.2939	Match	No Match	FALSE
27.	012_1_2.tif	012_2_6.tif	90.8116	6.2317	Match	No Match	FALSE
28.	012_1_2.tif	012_2_7.tif	96.7248	5.9978	Match	No Match	FALSE
29.	012_1_2.tif	012_2_8.tif	96.3431	6.0391	Match	No Match	FALSE
30.	012_1_3.tif	012_1_4.tif	81.4507	5.9942	No Match	Match	FALSE
31.	012_1_3.tif	012_1_5.tif	60.8757	6.0449	No Match	Match	FALSE
32.	012_1_3.tif	012_1_6.tif	92.077	6.1318	Match	Match	TRUE
33.	012_1_3.tif	012_1_7.tif	94.7448	6.2498	Match	Match	TRUE
34.	012_1_3.tif	012_1_8.tif	68.6843	5.9845	No Match	Match	FALSE
35.	012_1_3.tif	012_2_1.tif	71.9974	6.1517	No Match	No Match	TRUE
36.	012_1_3.tif	012_2_2.tif	65.1001	6.2699	No Match	No Match	TRUE
37.	012_1_3.tif	012_2_3.tif	96.9245	6.1818	Match	No Match	FALSE
38.	012_1_3.tif	012_2_4.tif	85.7527	6.115	Match	No Match	FALSE
39.	012_1_3.tif	012_2_5.tif	65.1364	6.2559	No Match	No Match	TRUE
40.	012_1_3.tif	012_2_6.tif	74.3373	6.0446	No Match	No Match	TRUE

41.	012_1_3.tif	012_2_7.tif	69.7927	6.2415	No Match	No Match	TRUE
42.	012_1_3.tif	012_2_8.tif	70.0692	6.2593	No Match	No Match	TRUE
43.	012_1_4.tif	012_1_5.tif	74.7393	6.0606	No Match	Match	FALSE
44.	012_1_4.tif	012_1_6.tif	88.4594	6.2768	Match	Match	TRUE
45.	012_1_4.tif	012_1_7.tif	85.9686	5.9408	Match	Match	TRUE
46.	012_1_4.tif	012_1_8.tif	84.3262	6.1429	No Match	Match	FALSE
47.	012_1_4.tif	012_2_1.tif	88.3937	6.2561	Match	No Match	FALSE
48.	012_1_4.tif	012_2_2.tif	79.9257	6.1021	No Match	No Match	TRUE
49.	012_1_4.tif	012_2_3.tif	84.0353	6.0071	No Match	No Match	TRUE
50.	012_1_4.tif	012_2_4.tif	94.9833	6.1961	Match	No Match	FALSE
51.	012_1_4.tif	012_2_5.tif	79.9703	6.104	No Match	No Match	TRUE
52.	012_1_4.tif	012_2_6.tif	91.2665	6.2246	Match	No Match	FALSE
53.	012_1_4.tif	012_2_7.tif	85.687	6.1688	Match	No Match	FALSE
54.	012_1_4.tif	012_2_8.tif	86.0265	6.0829	Match	No Match	FALSE
55.	012_1_5.tif	012_1_6.tif	66.1139	6.0561	No Match	Match	FALSE
56.	012_1_5.tif	012_1_7.tif	64.2523	6.3561	No Match	Match	FALSE
57.	012_1_5.tif	012_1_8.tif	88.6311	6.361	Match	Match	TRUE
58.	012_1_5.tif	012_2_1.tif	84.5527	6.3635	No Match	No Match	TRUE
59.	012_1_5.tif	012_2_2.tif	93.5109	6.1772	Match	No Match	FALSE
60.	012_1_5.tif	012_2_3.tif	62.8073	6.2541	No Match	No Match	TRUE
61.	012_1_5.tif	012_2_4.tif	70.9898	6.2577	No Match	No Match	TRUE
Sr.no	Image 1	Image 2	Percentage	Time taken	Actual result	Expected result	Result
62.	012_1_5.tif	012_2_5.tif	93.4588	5.9606	Match	No Match	FALSE
63.	012_1_5.tif	012_2_6.tif	81.8912	6.1491	No Match	No Match	TRUE
64.	012_1_5.tif	012_2_7.tif	87.2236	6.1643	Match	No Match	FALSE
65.	012_1_5.tif	012_2_8.tif	86.8793	6.2938	Match	No Match	FALSE
66.	012_1_6.tif	012_1_7.tif	97.1842	6.0463	Match	Match	TRUE
67.	012_1_6.tif	012_1_8.tif	74.5945	6.2427	No Match	Match	FALSE
68.	012_1_6.tif	012_2_1.tif	78.1926	6.0602	No Match	No Match	TRUE
69.	012_1_6.tif	012_2_2.tif	70.7018	6.2727	No Match	No Match	TRUE
70.	012_1_6.tif	012_2_3.tif	94.9987	6.1601	Match	No Match	FALSE
71.	012_1_6.tif	012_2_4.tif	93.1315	6.4186	Match	No Match	FALSE
72.	012_1_6.tif	012_2_5.tif	70.7413	6.1624	No Match	No Match	TRUE
73.	012_1_6.tif	012_2_6.tif	80.7338	5.9455	No Match	No Match	TRUE
74.	012_1_6.tif	012_2_7.tif	75.7982	6.0291	No Match	No Match	TRUE
75.	012_1_6.tif	012_2_8.tif	76.0985	6.1485	No Match	No Match	TRUE
76.	012_1_7.tif	012_1_8.tif	72.494	6.5317	No Match	Match	FALSE
77.	012_1_7.tif	012_2_1.tif	75.9908	6.5979	No Match	No Match	TRUE
78.	012_1_7.tif	012_2_2.tif	68.711	6.6964	No Match	No Match	TRUE
79.	012_1_7.tif	012_2_3.tif	97.7511	6.2868	Match	No Match	FALSE
80.	012_1_7.tif	012_2_4.tif	90.5091	6.6564	Match	No Match	FALSE
81.	012_1_7.tif	012_2_5.tif	68.7493	6.2128	No Match	No Match	TRUE
82.	012_1_7.tif	012_2_6.tif	78.4605	6.2759	No Match	No Match	TRUE
83.	012_1_7.tif	012_2_7.tif	73.6639	6.0145	No Match	No Match	TRUE
84.	012_1_7.tif	012_2_8.tif	73.9557	6.0854	No Match	No Match	TRUE
85.	012_1_8.tif	012_2_1.tif	95.3984	6.0747	Match	No Match	FALSE

86.	012_1_8.tif	012_2_2.tif	94.7816	6.3207	Match	No Match	FALSE
87.	012_1_8.tif	012_2_3.tif	70.8637	6.4889	No Match	No Match	TRUE
88.	012_1_8.tif	012_2_4.tif	80.0958	6.7185	No Match	No Match	TRUE
89.	012_1_8.tif	012_2_5.tif	94.8345	6.0226	Match	No Match	FALSE
90.	012_1_8.tif	012_2_6.tif	92.3955	6.2171	Match	No Match	FALSE
91.	012_1_8.tif	012_2_7.tif	98.4119	6.2195	Match	No Match	FALSE
92.	012_1_8.tif	012_2_8.tif	98.0235	6.1122	Match	No Match	FALSE
93.	012_2_1.tif	012_2_2.tif	90.4201	6.999	Match	Match	TRUE
94.	012_2_1.tif	012_2_3.tif	74.2819	6.4079	No Match	Match	FALSE
95.	012_2_1.tif	012_2_4.tif	83.9593	6.3909	No Match	Match	FALSE
96.	012_2_1.tif	012_2_5.tif	90.4705	6.8893	Match	Match	TRUE
97.	012_2_1.tif	012_2_6.tif	96.8523	6.6951	Match	Match	TRUE
98.	012_2_1.tif	012_2_7.tif	96.9379	6.3345	Match	Match	TRUE
99.	012_2_1.tif	012_2_8.tif	97.3219	6.2208	Match	Match	TRUE
100.	012_2_2.tif	012_2_3.tif	67.1658	6.2478	No Match	Match	FALSE
101.	012_2_2.tif	012_2_4.tif	75.9161	6.5031	No Match	Match	FALSE
102.	012_2_2.tif	012_2_5.tif	99.9442	6.5028	Match	Match	TRUE
103.	012_2_2.tif	012_2_6.tif	87.5739	6.4772	Match	Match	TRUE
104.	012_2_2.tif	012_2_7.tif	93.2763	6.3648	Match	Match	TRUE
105.	012_2_2.tif	012_2_8.tif	92.9082	6.4015	Match	Match	TRUE
106.	012_2_3.tif	012_2_4.tif	88.4737	6.3909	Match	Match	TRUE
107.	012_2_3.tif	012_2_5.tif	67.2032	6.5412	No Match	Match	FALSE
108.	012_2_3.tif	012_2_6.tif	76.6961	6.1646	No Match	Match	FALSE
109.	012_2_3.tif	012_2_7.tif	72.0073	6.2568	No Match	Match	FALSE
110.	012_2_3.tif	012_2_8.tif	72.2926	6.1513	No Match	Match	FALSE
111.	012_2_4.tif	012_2_5.tif	75.9584	6.1885	No Match	Match	FALSE
112.	012_2_4.tif	012_2_6.tif	86.688	6.0949	Match	Match	TRUE
113.	012_2_4.tif	012_2_7.tif	81.3884	6.027	No Match	Match	FALSE
114.	012_2_4.tif	012_2_8.tif	81.7108	6.013	No Match	Match	FALSE
115.	012_2_5.tif	012_2_6.tif	87.6228	6.1327	Match	Match	TRUE
116.	012_2_5.tif	012_2_7.tif	93.3284	5.9865	Match	Match	TRUE
117.	012_2_5.tif	012_2_8.tif	92.9601	6.1679	Match	Match	TRUE
118.	012_2_6.tif	012_2_7.tif	93.8865	6.1409	Match	Match	TRUE
119.	012_2_6.tif	012_2_8.tif	94.2585	6.1624	Match	Match	TRUE
120.	012_2_7.tif	012_2_8.tif	99.6054	6.0854	Match	Match	TRUE

TABLE II. THE PERCENTAGE OF ACCEPTANCE RATIO AND REJECTION RATIO

Images	No. of matched fingerprints	No. of non-matched fingerprints	Acceptance ratio	Rejection ratio	False acceptance	False rejection	FAR	FRR
012_1_1.tif	11	5	68.75	31.25	6	3	62.5	18.75
012_1_2.tif	10	6	62.5	37.5	6	4	62.5	25
012_1_3.tif	5	11	31.25	68.75	2	3	37.5	18.75
012_1_4.tif	9	7	56.25	43.75	5	2	31.5	12.5
012_1_5.tif	8	8	50	50	4	2	25	12.5
012_1_6.tif	6	10	37.5	62.5	2	1	12.5	6.25
012_1_7.tif	6	10	37.5	62.5	2	1	12.5	6.25

012_1_8.tif	10	6	62.5	37.5	6	0	37.5	0
012_2_1.tif	6	2	37.5	12.5	0	2	0	12.5
012_2_2.tif	6	2	37.5	12.5	0	2	0	12.5
012_2_3.tif	2	6	12.5	37.5	0	4	0	25
012_2_4.tif	3	5	18.75	31.25	0	3	0	18.75
012_2_5.tif	6	2	37.5	12.5	0	0	0	0
012_2_6.tif	7	1	43.75	6.25	0	0	0	0
012_2_7.tif	6	2	37.5	12.5	0	0	0	0
012_2_8.tif	6	2	37.5	12.5	0	0	0	0

IV. CONCLUSION

Experimentally combined fingerprint matching and verification method was done by building a minutia extractor and a minutia matcher. The combination of multiple methods comes from a wide investigation into research paper. It is an attempt on our part to show, to make familiar with this technique of analysis which is widely used in the biometric system: comparing the performance analysis by experimental and statistical results. The analysis shows that the Minutiae based matching technique gives the best results since the FAR and FRR are optimal values.

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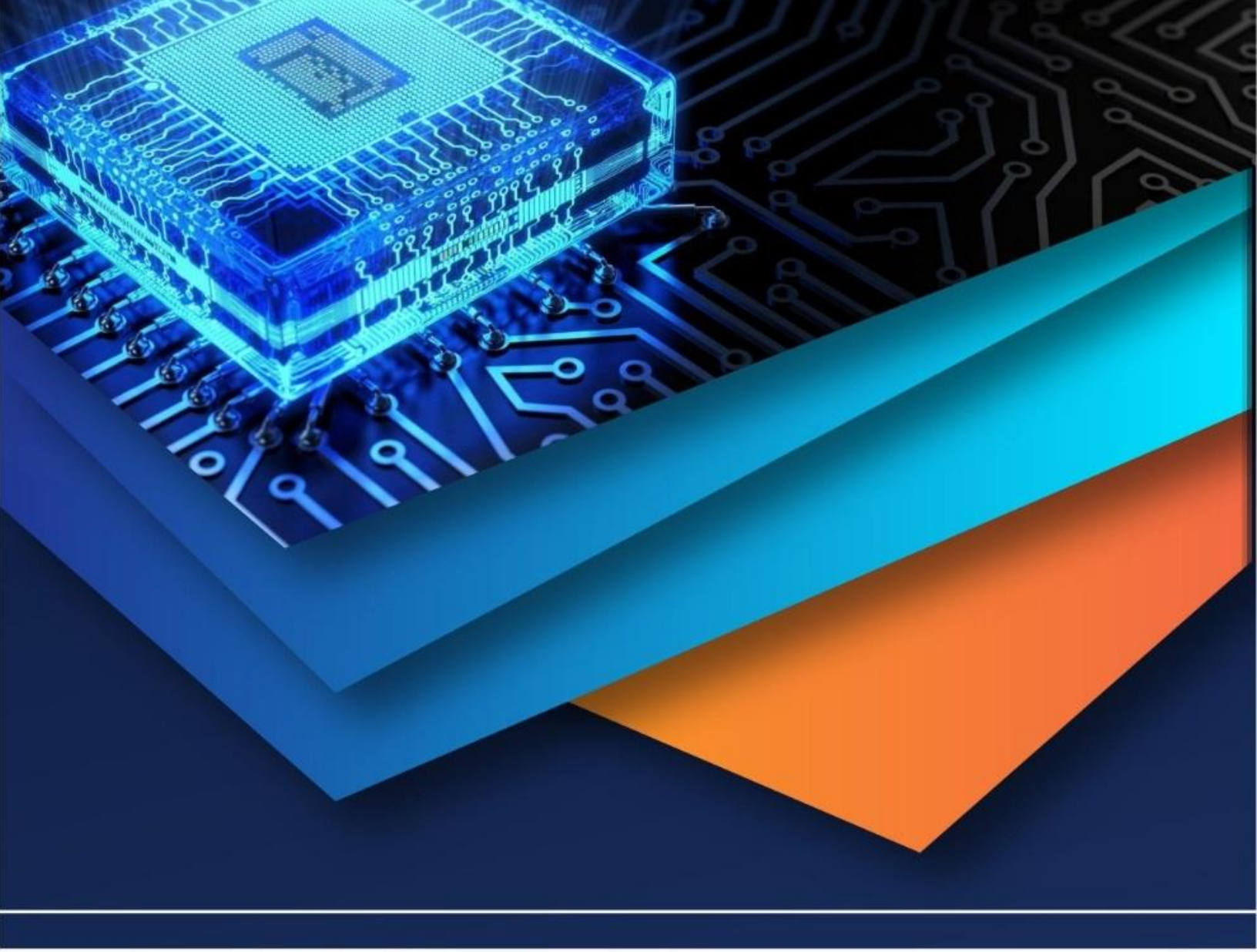

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