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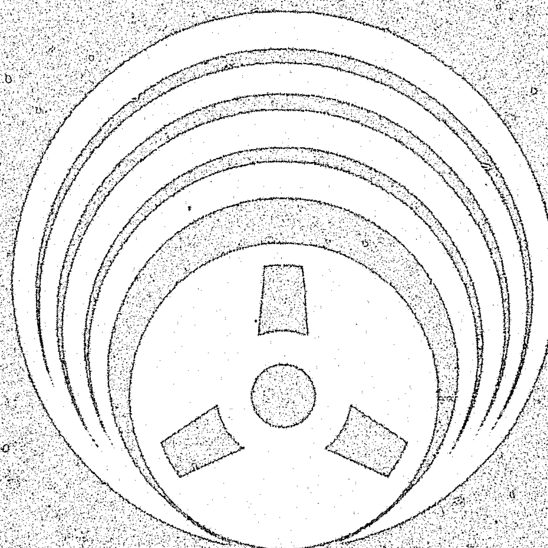

THE LX39 LATENT FINGERPRINT MATCHER

NBS Special Publication 500-36
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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COMPUTER SCIENCE & TECHNOLOGY: The LX39 Latent Fingerprint Matcher

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National Bureau of Standards Special Publication 500-36
Nat. Bur. Stand. (U.S.), Spec. Publ. 500-36, 18 pages (Aug. 1978)
CODEN: XNBSAV

Library of Congress Catalog Card Number: 78-606167

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1978

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Stock No. 003-003-01958-5 Price $1.10

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The LX39 Latent Fingerprint Matcher

J.H. Wegstein and J.F. Rafferty

A procedure is described for automatically determining if a latent scene-of-crime fingerprint matches an inked, rolled file fingerprint. The procedure uses the x and y coordinates and the individual directions of the minutiae (ridge endings and bifurcations). The identity of the latent print with a print on file is indicated by a high score resulting from computations based on differences in angle and coordinate values of minutiae that are found in going from one of the fingerprints to the other.

Key words: Automated-fingerprint-identification, pattern recognition

1. Introduction

An average rolled fingerprint impression exhibits about eighty ridge endings and forks or bifurcations in its ridge pattern. By comparing the data representing these minutiae, a computer can determine whether or not two fingerprint impressions came from the same finger. Figure 1 shows how the x and y coordinates and the direction θ are defined for a minutia. If the areas marked A are ridges then the minutia is a ridge ending, but if the areas marked B are ridges the pattern is a bifurcation . Since a ridge ending in one print may appear as a bifurcation in another print from the same finger, no distinction is made between ridge endings and bifurcations in recording data.

A portion of a fingerprint along with a plot of the corresponding minutiae are shown in Figure 2. The minutiae data are read automatically from the rolled impressions on fingerprint cards and in addition, the reader also produces ridge direction data at equally spaced grid-points over the entire print. In a fully automated identification system, this ridge-direction data is utilized in finding the core or "center" of a print as well as the angle through which the print should be rotated.[1] This registration information is used to translate and rotate the minutia data into a standard position. The ridge-direction data in the neighborhood of each minutia is also used to make slight corrections to the angle θ of that minutia. Those registered minutiae within a certain distance of the center are then sorted into a descending order on y and this data may then be placed in a file or used to search against minutia data in a previously established file.

While the high speed M40[2] and M41 matchers can compare data and identify rolled fingerprints, a different technique is used for identifying latent fingerprints found at the scene of a crime. Latent prints often produce only a portion of a fingerprint with correspondingly fewer minutiae than can be read from rolled fingerprints. Some typical latent fingerprints along with their mates from fingerprint cards are shown in Figure 3.

Because of their poor quality, latent fingerprint minutiae are read by a fingerprint expert using a semi-automated reader.[3] The semi-automatically read minutiae data from latent prints are then compared with the automatically read data from rolled prints by a special matcher that is slower and more elaborate than the high-speed rolled print matchers. It is often impossible to tell which of the ten fingers produced a latent print. Consequently, the search process is further delayed because the latent search print data must be compared with the data from several of the rolled prints on each file card.

The previously reported M40 matcher can be characterized as a two-stage matcher whose software version requires about 20ms to match a pair of prints and whose hardwired version matches a pair of prints in less than a millisecond. On the other hand, the LX39 latent print matcher described here is a seven stage matcher requiring about 100ms to match a pair of prints in its software version. This matcher includes a number of parameters that limit its time requirements at a slight risk of missing a match.

2. Selecting Minutiae - Stage I

Figure 4 shows a latent search print and its mating file print along with a ten-times enlarged plot of its manually-read minutiae —X superimposed on a portion of the machine-read minutiae —o from the inked file print. Note that there are the usual false and missing minutiae.

In stage I, a box of parameter-determined size is centered on each of the search minutia and the enclosed file minutiae are tabulated in an array, JT, as shown in Table I. The angle of each of these tabulated file minutia must not differ from the angle of the corresponding search minutia by more than a parameter-determined limit (angles are measured in degrees and distance is measured in units of one-tenth millimeter).

Search Min.			File Minutiae					
I	LM	LI	JT1	JT2	JT3	JT4	JT5	JT6
1	3	3	8	12	15	0	0	0
2	6	1	5	6	7	9	11	16
3	2	4	13	14	0	0	0	0
4	4	6	11	17	18	19	0	0
5	6	7	9	11	16	17	18	19
6	4	2	13	26	27	29	0	0
7	4	5	26	27	29	31	0	0
8	6	8	24	26	27	30	32	33
9	0	10	0	0	0	0	0	0
10	6	0	26	27	30	32	33	34

Table 1.

For example, the box around search minutia 2 in Figure 4 encloses file minutiae 5,6,7,9,11,16 as indicated above. A parameter limits the number of file minutiae entered in the JT table to the first six found in the box and ignores 18 and 20. Column LM indicates the number of entries in each row. Column LI orders the rows in ascending order according to column LM. That is, the first value, LI=3, indicates that for I=3, LM_3=2 is the lowest value in column LM (zero excluded). The next value, LI=1 indicates that LM_1=3 is next lowest, and so on.

3. Trial Pair Selections - Stage II

The matcher next seeks pairs of search minutiae that coincide with pairs of file minutiae. The method of computing the score for a pair-fit is shown in Figure 5. DG,DH,DI, and DJ must each be less than an appropriate parameter. Then a large score, MS, indicates that the two pairs of minutiae fit each other well.

Following the order indicated by column LI in Table 1, search minutia IA=3 is first placed on file minutia JA=13. The matcher then tries to place search minutia IB=1, being the next item in column LI, on file minutia JB=8 or 12 or 15. Failing this, it will try to put minutia IB=4 on JB=11. After a very few of these failures, as determined by a parameter, the matcher will return and place search minutia IA=3 on file minutia JA=14 followed by placing IB=1 on 8, 12, and 15 where the first fit occurs. The fits are recorded in Table 2. This procedure continues, but the table length is limited by the trial terminating parameters.

M	MIA	MJA	MIB	MJB
1	3	14	1	15
2	3	14	4	19
3	6	26	8	27
4	7	26	10	33
5	7	27	8	30
6	7	27	10	32
7	2	7	5	9
8	8	24	10	30
9	8	27	10	33

Table 2.

Search minutia MIA=3 sitting on file minutia MJA=14 agrees with search minutia MIB=1 sitting on file minutia MJB=15 as can be seen in Figure 4. 3 on 14 also would agree with 4 on 19. Table 2 indicates that 8 might sit on 24, 27, or 30 and this inconsistency is resolved by further computation.

4. Pair Ordering - Stage III

All of the pairs in Table 2 are arranged in descending order according to the number of times, NJJ, that a pair occurs. Duplicates are eliminated. Each pair now appears as NIA-NJA along with its NJJ in Table 3.

					NQ													
N ↓	NIA	NJA	NJJ	JS	M→1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	• 3	14	2	291	-1	-1	16	-1	19	26	-1	22	-1	-1	-1	-1	-1	-1
2	• 8	27	2	297	-1	-1	13	-1	28	-1	11	19	-1	-1	-1	-1	-1	-1
3	• 10	33	2	374	16	13	-1	-1	23	14	18	18	-1	-1	-1	-1	-1	-1
4	7	27	2	0	-1	-1	-1	-1	-1	-1	-1	-1	15	20	-1	-1	-1	-1
5	• 1	15	1	290	19	28	23	-1	-1	-1	21	25	0	0	0	0	0	0
6	4	19	1	229	26	-1	14	-1	-1	-1	-1	16	0	0	0	0	0	0
7	6	26	1		-1	11	18	-1	21	-1	-1	-1	0	0	0	0	0	0
8	• 7	26	1		22	19	18	-1	25	16	-1	-1	0	0	0	0	0	0
9	8	30	1		-1	-1	-1	15	0	0	0	0	-1	-1	0	0	0	0
10	10	32	1		-1	-1	-1	20	0	0	0	0	-1	-1	0	0	0	0
11	2	7	1		-1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0
12	5	9	1		-1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0
13	8	24	1		-1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0
14	10	30	1		-1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0

Table 3.

The number of entries in Table 3 is limited by parameter to 30 thereby setting a limit on the computation time required.

In these tables, the correct mating minutiae are marked with dots to follow their behavior in the course of the matching process. It has been found in experimental searches that the true mating minutiae tend to float or rise to the top of Table 3. In actual practice the NJJ values are usually higher than those in the example shown here.

5. Verification of Pairs - Stage IV

Each of the first six pairs of minutiae in Table 3 that has a NJJ>1 is compared with the rest of the entries in the table using the procedure described in Figure 5. The resulting MS score is entered as $NQ_{m,n}$ and $NQ_{n,m}$ in the array shown in Table 3. No computation is allowed if the NIA's or NJA's are the same. The -1's indicate that the computation failed to produce a match or that no computation is allowed. Zeros indicate that no computation was made.

From the NQ array it may be seen that pair 3 on 14 produces an MS score of 16 when tested with pair 10 on 33. A score of 19 occurs with pair 1 on 15 and so on. It can be seen from Table 3 that the true mating minutiae tend to produce the most scores along the appropriate rows of the NQ array.

6. The IS Score

The LX39 matcher computes two scores, IS and RS. Either or preferably both of these scores can be used in a latent print search. The IS score is obtained by examining each of the first six rows in the NQ array except for those rows where NJJ≤1. Each row is scanned from left to right. Whenever a positive number is encountered, all of the other positive numbers in that column are added together. The total of these sums, JS, is the score for that row. For example, in row one, 16 produces a sum of 13 + 23 + 14 + 18 + 18 = 86; 19 produces a sum of 97; 26 produces 30; and 22 produces 78. Then JS = 86 + 97 + 30 + 78 = 291. The JS scores for the different rows are shown in Table 3. The highest of these JS scores, IS = 374 is one of the final scores for the fingerprint match.

7. Relocation of Search Print Center Point - Stage V

The pairs of mating minutiae named by the matrix row that produced the IS score are used to locate a new center point for the search minutiae data. In Table 3, the third row names pairs 1, 2, 5, 6, 7, 8.

To develop the formulas for this procedure it must be noted that prior to being placed in file, the file data were registered so that the core or center point of the finger print was at a standard location cx,cy. Therefore this point can be located relative to any file minutia F with datum XF,YF,θF. In Figure 6, the point cx,cy can be located relative to F using angle ϕ and distance R where $\phi = \theta F - AF$.

If a search minutia S is supposed to lie on the file minutia F then a search print center xc,yc can be located relative to S using its datum, XS,YS,θS along with R and ϕ as shown in Figure 6. Accordingly, each of the mating minutiae pairs named for getting IS is used to compute a point xc,yc. The resulting xc,yc points are in a small cluster and the center of this cluster (xx,yy), is taken as the new center point for the search minutiae. The angle, N, through which the search minutiae must be rotated is the mean value of $\Delta\theta$ where $\Delta\theta = \theta F - \theta S$ corresponding to each of the mating pairs of minutiae that were selected earlier.

8. Re-registration of Search Minutiae - Stage VI

The set of all search minutiae which had been centered at the standard location cx,cy are translated so that the point xx,yy is now at cx,cy and at the same time, the set is rotated through the angle N.

9. The RS Score - Stage VII

Once again considering the search minutiae to be superimposed on the file minutiae, a small parameter-determined box is centered on each search minutia. Any file minutia falling in this box with an angle that differs by only a small amount, determined by a parameter, from the search minutia angle is paired with the search minutia for determining the final matching score: RS. In the example used earlier, six mating pairs of minutiae emerge as shown in Figure 7.

M	Search	File
1	1	15
2	2	16
3	3	14
4	7	26
5	8	27
6	10	33

Table 4.

Note that one pair, 2 on 16, had not been used in previous stages of the matching process. The minutiae data of each of these pairs is used to compute a score, FRS, where:

$$FRS = \text{constant} - |XS - XF| - |YS - YF| - |\theta S - \theta F|$$

The final score, RS, equals the summation of these FRS scores.

10. Testing the Matcher

In order to test the performance of the LX39 matcher, 50 latent fingerprints including the four shown in Figures 3 and 4 were read with a semi-automated reader by latent fingerprint experts. These prints were then searched against a file of fifty fingerprint cards where each card was known to contain a print corresponding to one of the latent prints. (For convenience, a search print was given the same identification number as the file card containing its mating print.) The minutiae data from eight fingers of each card (little fingers excluded) were read by a fully automatic minutiae reader.[4]

Because it was originally impossible to tell which of the ten fingers produced the latent prints, each latent print was compared with all eight fingerprints from each card in the file. That is, the LX39 matcher compared each search print with 400 file prints. For each search print, the highest and second highest RS scores were determined along with their appropriate card and finger identifications. The highest and next highest IS scores with their card and finger identifications were also determined. When each search print was being compared with the eight prints of a given file card, the sum of the eight RS scores, RST, was also computed and the sum of the IS scores, IST, was also computed. For each file search, the highest RST score with its card identification and the highest IST score with its card identification were then determined. The resulting card numbers and scores are tabulated on page 15. In this table, the matcher has produced six file card numbers for each search print. The search print is considered to be identified if any of these six numbers agrees with the number of the search print.

11. Experimental Results

The "hits" are marked by dots on page 15 and the 42 "identified" latents are marked with an X. Latent print number 12 (finger 9) shown in Figure 4 failed to achieve any of the highest RS scores, but it did get the highest IS score (374) as well as the highest IST score (488). Latents 23 and 54 shown in Figure 3 were identified (see page 15). Latent 20 failed to be identified in spite of the fact that matching minutiae from its true file mate were at the top of the NQ array during stage III of that comparison.

In this test there were five cases where the right card was hit by the wrong finger. In three of these cases the right finger was also hit by an even higher score as is shown in Table 5.

Case	Latent Finger Type	File Finger Type	Score
1	4-3 U	4-4 U	IS=1418, RS=133
2	22-2 W	22-3 W	IS=484
3	38-3 U	38-3 U	RS=208, IS=1538
	38-3 U	38-4 W	RS=143
4	70-2 W	70-2 W	RS=157, IS=850
	70-2 W	70-9 W	RS=103
5	88-8 W	88-8 W	RS=231, IS=1588
	88-8 W	88-6 W	RS=168, IS=1458

Table 5

In another experiment with the same prints where the minutiae data were read with a different semi-automated reader, there were seven of these cases of correct cards hit with wrong fingers. In these cases the contributing minutiae were examined on the fingerprints and were indeed found to match each other. This suggests that there is a tendancy for two or more fingers from the same person to have similar minutiae patterns. It would be interesting to compare minutiae patterns from the right hand with reflected patterns from the left hand where the ridge patterns are already known to often be similar. This experiment also suggests that latent examiners seeking to verify a hit should compare the latent print with other prints from the same card when a file print that was "hit" by a search fails to agree with the latent print.

12. Conclusion

The LX39 fingerprint matcher appears to be capable of making latent fingerprint identifications in a practical latent search system. The software version of the matcher requires about 100 ms to compare a pair of prints, and consequently a large file might require a hardware version of this matcher. The small number of prints tested here are not sufficient to predict the performance on a large file or to indicate how many retrieved cards for each search print must be examined by an expert to confirm identification.

The authors are indebted to R.M. Stock of the FBI for advice and assistance and to I.R. Futrell and J.E. Ridgely of the FBI for reading the latent print data. The work was financially supported by the FBI. The authors also appreciate the assistance of Masatada Seto of the National Police Bureau of Japan who was a guest worker at NBS for a year.

13. References

1. Wegstein, J.H., Manual and Automated Fingerprint Registration, National Bureau of Standards Technical Note 730, U.S. Government Printing Office, Washington, D.C., 1972

2. Wegstein, J.H., The M40 Fingerprint Matcher, National Bureau of Standards Technical Note 878, U.S. Government Printing Office, Washington, D.C., 1972

3. Moore, R.T., and Park, J.R., "The Graphic Pen, an Economical Semiautomatic Fingerprint Reader," Proceedings of the 1977 Carnahan Conference on Crime Countermeasures, University of Kentucky, Lexington, Kentucky, 1977, p. 59-62.

4. Stock, R.M., "Automatic Fingerprint Reading," Proceedings of the 1972 Carnahan Conference on Electronic Crime Countermeasures, University of Kentucky, Lexington, Kentucky, 1972, p. 16-28.

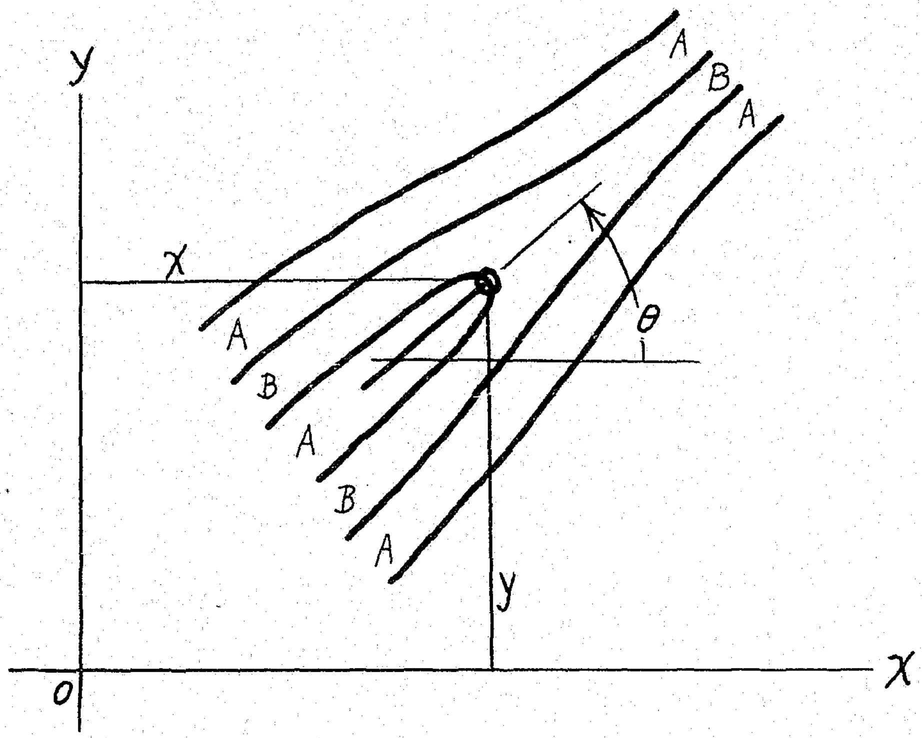


Figure 1. Definition of Minutia Data

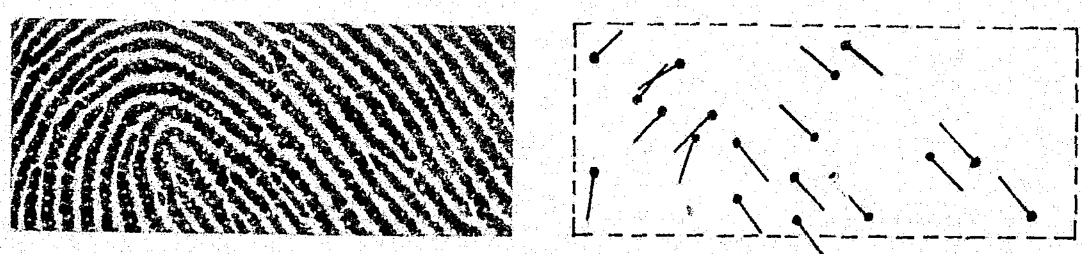


Figure 2. A Portion of a Fingerprint with a Plot of Corresponding Minutiae

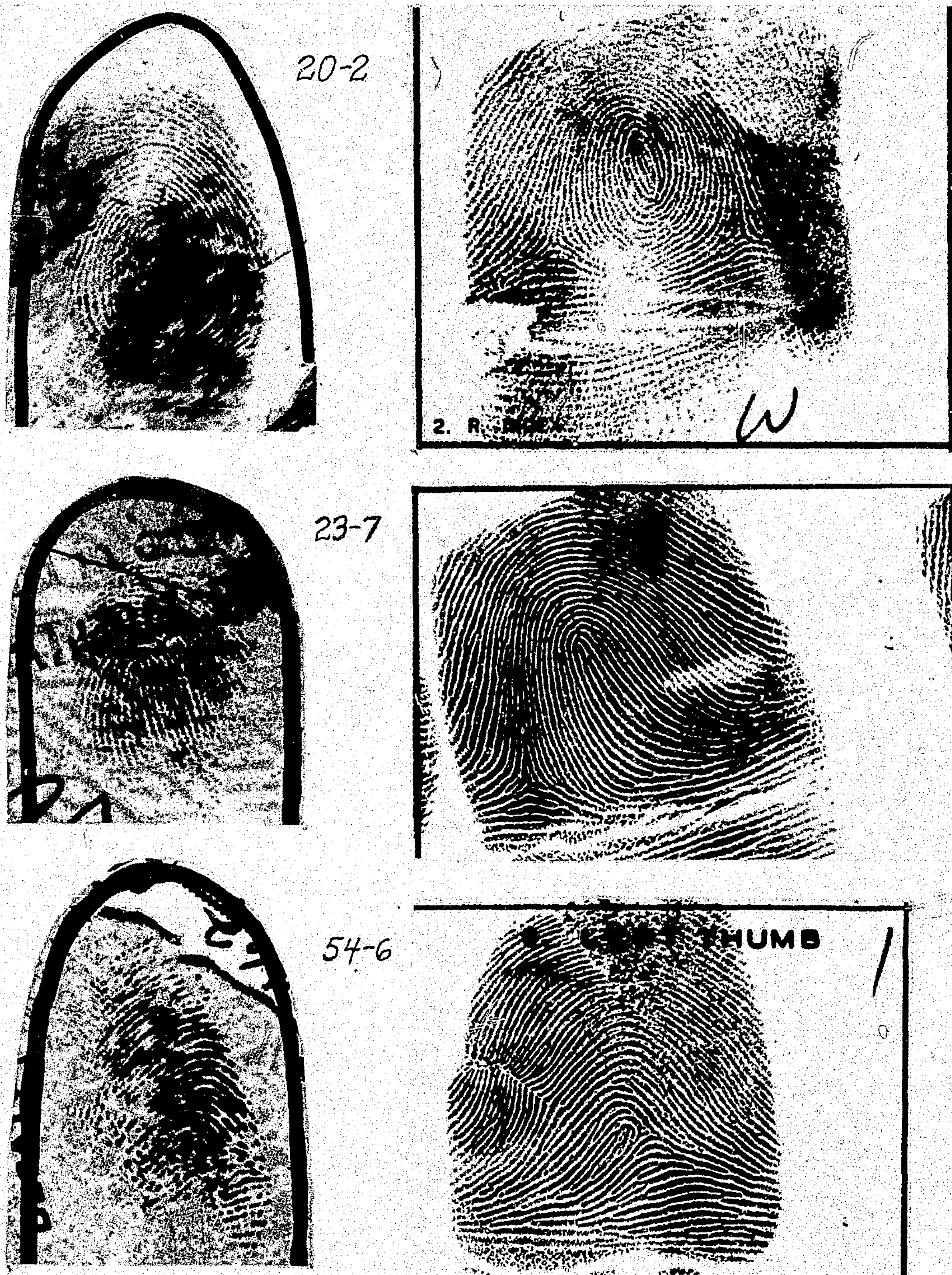


Figure 3. Latent search fingerprints (left) with mating rolled file fingerprints (right).

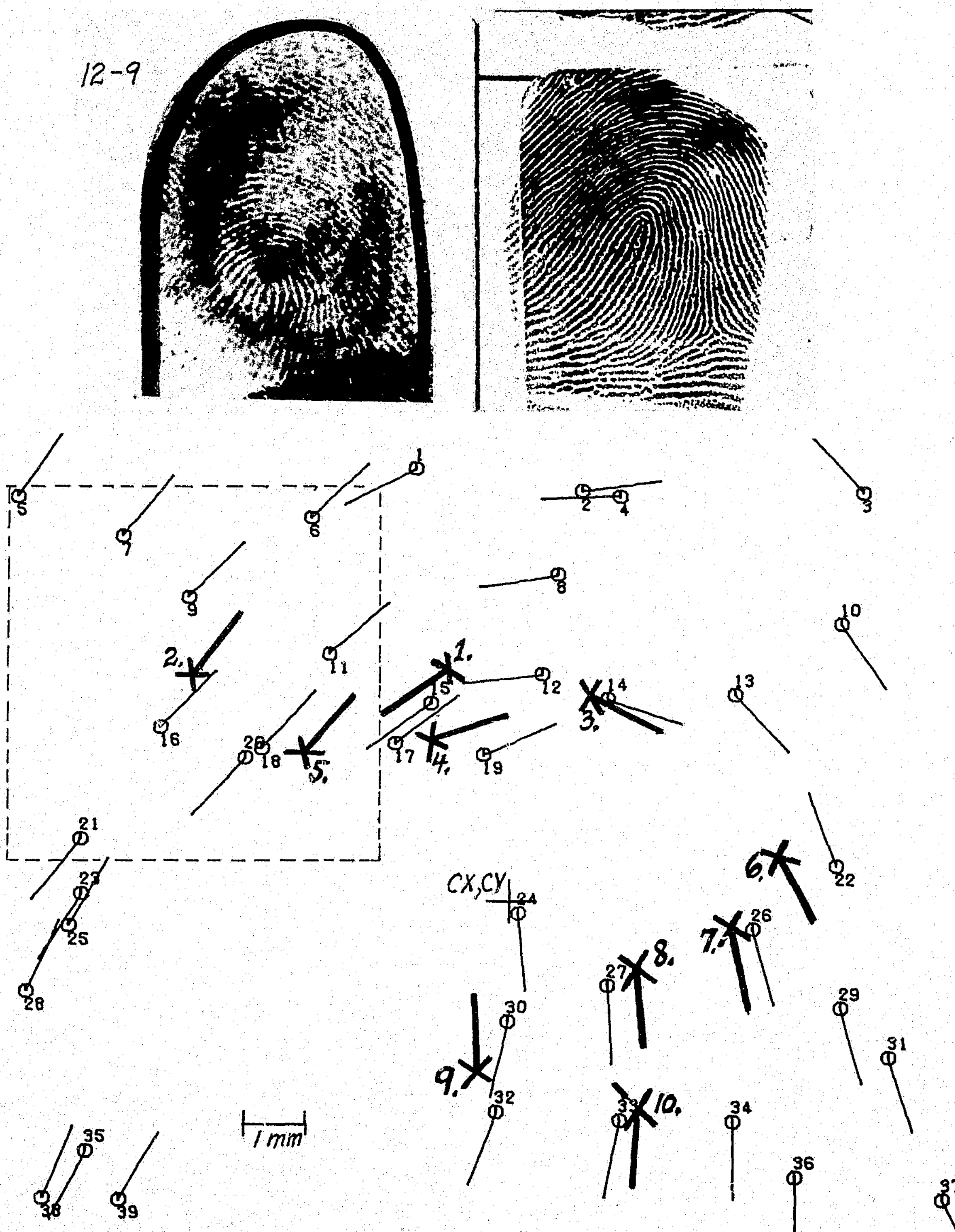
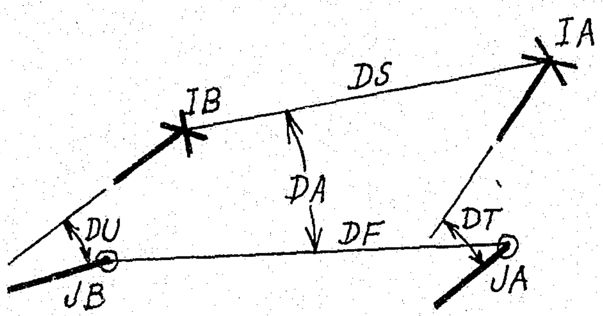


Figure 4. (Above), Latent search fingerprint with its mating file print (x2). (Below), a portion of file minutiae —o read automatically with superimposed latent minutiae —X read manually on a semi-automated reader (x10).



$$DG = |DT - DU|$$

$$DH = |DS - DF|$$

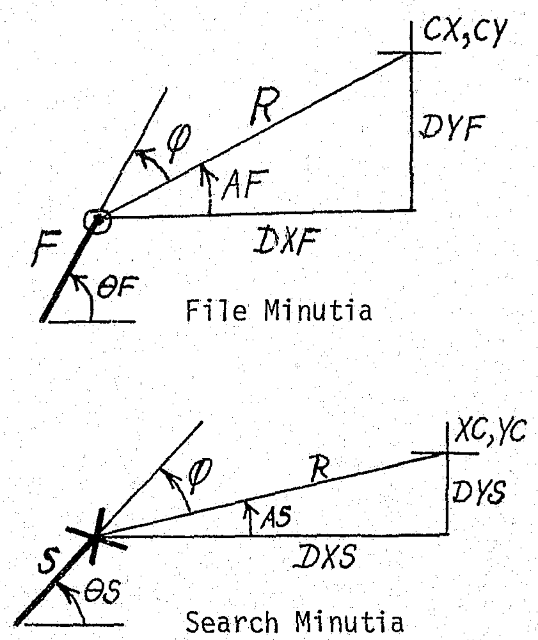
$$DI = |DU - DA| \quad DJ = |DT - DA|$$

DZ=Lesser of DI and DJ

DW=Greater of DI and DJ

Score: MS=Constant-DH-DZ-DW

Figure 5. Matching Pairs of Minutiae



$$DXF = CX - XF$$

$$DYF = CY - YF$$

$$R = \sqrt{DXF^2 + DYF^2}$$

$$AF = \arctan \frac{DYF}{DXF}$$

$$\phi = \theta F - AF$$

$$AS = \theta S - \phi$$

$$DXS = R \cos AS$$

$$DYS = R \sin AS$$

$$XC = XS + DXS$$

$$YC = YS + DYS$$

$$D\theta = \theta F - \theta S$$

Figure 6. Locating a New Search Minutiae Center

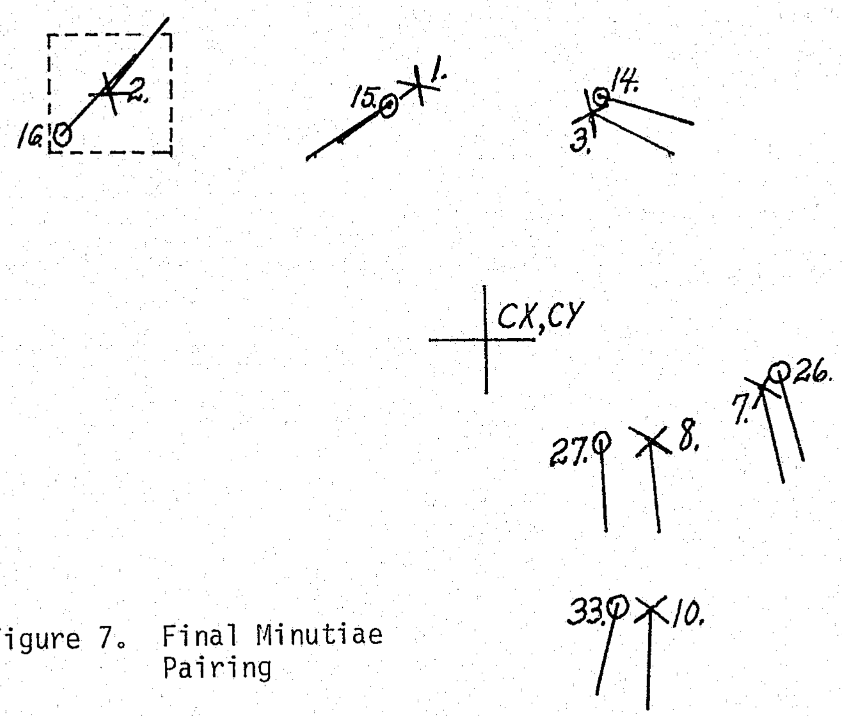


Figure 7. Final Minutiae Pairing

Search Print	1 St Card	RS	2 nd Card	RS	1 St Card	RST	1 St Card	IS	2 nd Card	IS	1 St Card	IST
X 1	1•	250	78	181	46	706	1•	4324	40	770	1•	4672
X 4	78	150	4•	133	46	483	4•	1418	78	936	90	1884
X 6	62	118	60	117	12	477	6•	642	22	500	27	930
X 8	8•	161	25	143	46	588	8•	1350	40	610	46	2178
X 12	73	109	15	96	22	342	12•	374	15	232	12•	488
X 14	14•	318	24	237	14•	893	14•	1528	64	1142	14•	2884
X 15	63	190	90	189	62	927	90	1554	15•	1172	90	3138
X 17	17•	229	90	221	90	1049	21	2244	76	1320	21	3298
19	14	92	46	87	43	210	14	210	46	162	46	326
20	8	131	88	115	83	425	15	436	8	408	15	784
X 21	21•	243	93	178	88	804	21•	2972	42	1072	21•	4550
X 22	46	139	71	129	46	572	46	584	22•	484	46	1228
X 23	23•	136	83	135	90	545	23•	400	90	288	90	1000
X 24	64	153	24•	136	22	460	64	510	38	458	88	1108
X 25	25•	456	19	199	25•	796	25•	7624	54	1334	25•	7936
27	43	168	83	165	43	780	62	968	25	784	15	1608
28	12	239	93	232	93	835	93	1274	12	988	42	2078
X 30	57	204	15	193	15	706	30•	1832	57	836	30•	1964
32	27	192	76	176	43	614	17	610	57	586	83	1044
X 34	44	180	34•	165	25	480	71	1546	43	878	71	2144
X 38	38•	208	38•	143	38•	548	38•	1538	60	894	38•	1998
X 40	40•	303	42	225	42	1063	40•	1950	90	830	22	2400
X 42	63	221	42•	204	42•	1147	42•	1982	73	1690	42•	7000
X 43	43•	314	79	174	43•	747	43•	1870	14	898	43•	2800
X 44	44•	180	42	169	46	523	44•	1398	21	574	44•	1770
X 46	46•	365	42	227	62	861	46•	1720	62	858	46•	2196
X 54	15	115	54•	90	54•	225	54•	838	78	170	54•	934
55	63	155	12	148	40	658	63	1356	19	742	63	1562
X 57	57•	164	88	147	46	638	57•	1530	88	952	90	2048
X 60	88	179	60•	156	88	684	62	682	88	682	88	2494
X 62	62•	185	90	146	62•	834	62•	2578	90	1172	62•	4078
X 63	63•	172	23	124	88	354	63•	1046	83	536	63•	1046
X 64	64•	162	94	148	27	478	42	1336	69	1126	69	1840
X 69	69•	245	34	175	34	586	69•	1060	14	754	69•	1424
X 70	70•	157	70•	103	28	350	70•	850	12	414	70•	938
X 71	71•	203	24	188	27	633	71•	1756	12	1178	71•	2728
X 73	73•	220	28	204	28	918	73•	1838	28	1422	28	3316
X 76	54	128	40	124	76•	590	90	694	27	510	76•	1116
X 77	85	161	54	116	46	457	85	844	77•	734	22	1034
X 78	78•	181	38	168	46	582	12	898	6	656	40	1584
79	85	228	94	184	27	555	85	1642	71	1110	85	1956
80	57	105	54	99	22	383	43	416	8	278	43	514
X 83	70	209	62	187	46	737	70	1616	83•	1574	83•	2348
X 84	69	124	93	121	79	298	38	334	8	312	84•	842
X 85	85•	231	12	154	85•	720	85•	1338	40	798	85•	2042
X 88	88•	290	88•	168	88•	777	88•	1588	88•	1458	88•	3906
X 90	90•	232	6	197	90•	978	90•	1796	46	1310	90•	3992
X 91	4	123	91•	122	69	323	91•	1040	90	606	91•	1078
X 93	93•	245	42	220	46	1018	93•	1528	88	1282	93•	3030
X 94	94•	202	93	164	93	800	94•	2962	93	1438	93	3680

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBS SP 500-36	2. Gov't Accession No.	3. Recipient's Accession No.
4. TITLE AND SUBTITLE The LX39 Latent Fingerprint Matcher			5. Publication Date August 1978 6. Performing Organization Code
7. AUTHOR(S) J.H. Wegstein and J.F. Rafferty			8. Performing Organ. Report No.
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234			10. Project/Task/Work Unit No. 6004400 11. Contract/Grant No.
12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)* Federal Bureau of Investigation J. Edgar Hoover Bldg. Washington, D.C. 20535			13. Type of Report & Period Covered Interim 14. Sponsoring Agency Code FBI

15. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number 78-606167

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A procedure is described for automatically determining if a latent scene-of-crime fingerprint matches an inked, rolled file fingerprint. The procedure uses the x and y coordinates and the individual directions of the minutiae (ridge endings and bifurcations). The identity of the latent print with a print on file is indicated by a high score resulting from computations based on differences in angle and coordinate values of minutiae that are found in going from one of the fingerprints to the other.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Automated-fingerprint-identification, pattern recognition

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