A review on the existing methods for identification of gender and blood group through fingerprint analysis

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Abstract- Dermatoglyphics is the study of patterns of fine ridges on fingers, palms etc. Cummins coined the term dermatoglyphics. Finger print is unique for each and every human being. Thepatterns are developed between 2nd to 3rd months of birth stage and remain unchanged in an individual, throughout life. Finger prints are considered as the most vital tool for personal identification. In forensic research, various studies have been conducted, in relation to various gender and blood groups.

Our study will include the implementation of a system which will be used to co-relate the relation between fingerprints of individuals with their gender and blood group. Volunteers of known blood group and gender will be selected for our research. To reduce the noise finger prints will be collected, studied and analyzed statistically.

Key words: Dermatoglyphics, ridges, gender, blood group

I. INTRODUCTION

Fingerprints are unique to every single individual and are formed in the human foetus. It remains same throughout life unless damage occurs to the finger skin layer. The fingerprint patterns become fixed when a person is about 14 years or older. Therefore, no two fingers are found to have identical prints.

As fingerprints are unique to every individual, they have been playing a vital role of identifying personals in both civil and criminal cases. Fingerprints obtained during crimes scenes are important as for valuable evidence. Fingerprint identification can be referred to identify individualized patterns that can be used to confirm or reject the association of a suspect with objects found at a crime scene.

One of the challenges faced by man in earlier days was to identity an individual. Identification of individuals is a requirement for personal, social, legal and many other reasons. Many methods likeDNA finger-typing,measurement of height, sex determination and age estimation, anthropometry, dermatoglyphics, autopsy reports and differentiation by blood groups were used for personal identification.Probably, fingerprints are the most common biometric technique used so far,for allowing secure and fast identification, among all of the above techniques.

Human fingerprints can be divided into three main categories:

1. Loops:

Loops accounts for approximately 65% of all fingerprints which are formed by ridges, which flow in from one side, goes up in the centre as a tented arch, curve back around and goes out from the side of their entrance. Based on which side of the fingerprint the lines enter, they are classified as radial or ulnar.

2. Whorls:

Whorls account for approximately 30%. There are four different patterns of whorls. All the four types have common features like, they have two or more deltas and one or more ridge line curves around the core to form a circle or spiral. A group of patterns or combination of patterns that do not fall into any of the above classifications makes up the accidental whorl.

3. Arches:

Arches are the simple pattern but rare (about 5%). Two types of arches exist, which are plain and tented arches. In both, the ridge lines flow into the print, then rise in the middle of the pattern and flow out to the other side of the print.

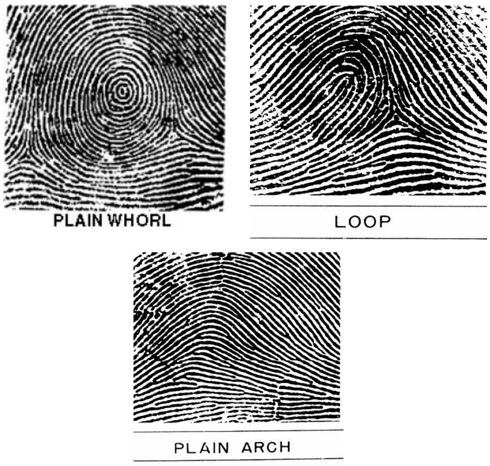

Fig 1: Different types of fingerprint patterns

The blood group system was discovered by Karl Landsteiner in 1901. It is made up of the 'ABO' and 'Rhesus' groups. The 'ABO' sub-group consists of A, B, AB and O blood group types according to occurrences of the corresponding antigen in plasma. 'Rhesus' system consists of Rhesus Positive (Rh +ve) and Rhesus Negative (Rh–ve) according to the presence or absence of 'D' antigen.

II. RELATED WORK TO DETECT GENDER AND BLOOD GROUP USING FINGERPRINT

Studies so far carried out in sex determination used theinked fingerprints and their findings are based on thespatial domain analysis. Generally parameters such as ridge count, ridge density, the ratio of ridge thickness to valley thickness, ridge width and fingerprint patterns and pattern types were used for genderdetermination. Whereas, the concept of,density of occurrences of loops, whorls and arches were used to determine the blood group of each individuals, approximately.

Although the fingerprint plays vital role in the identification and verification, relatively few machinevision method has been proposed for gender identification. In this section we briefly review andsummarize the prior researches in gender as well as blood group classification.

Rita Kaur [1] has used a novel method using Fast Fourier transform (FFT), discrete cosine transform (DCT) and power spectraldensity (PSD)to estimate gender byanalyzing fingerprints A dataset of 220 persons of different age and gender is collected as primary database. The manual analysis threshold was determined by carefully testing the fingerprints. Then, the gender is determined by comparing the frequency domain calculations and the predetermined threshold. Of the samplestested, 90% females and 79.09% males gave them the performance efficiency.

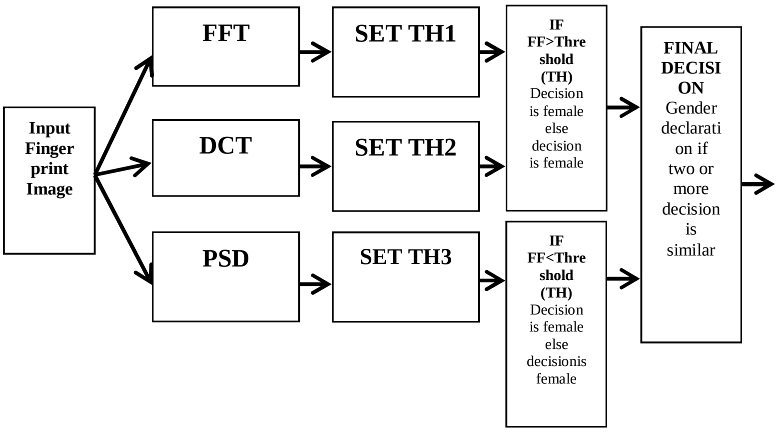

Fig 2: Block Diagram of the proposed Gender identification scheme.

The following steps are as follows:
1. Input from the database is given to the system.
2. FFT transforms the given input and generates the output. Threshold is set to TH1. A rule is setin such a way that if the fundamental frequency (FF) is greater than TH1 the decision isfemale and if the FF is less than TH1 the decision will be male.
3. DCT transforms the given input and generates the following output. Threshold value is set to TH2. A rule is setin such a way that if the fundamental frequency (FF) is greater than TH2 the decision isfemale and if the FF is less than TH2 the decision will be male.
4. PSD transforms the given input and generates the output. Here also threshold is set to TH3. A rule is set in such a way that if the fundamental frequency (FF) is less than TH3 the decision is femaleand if the FF is greater than TH3 the decision will be male.
5. Comparing the decisions of all the transforms, we conclude that if two of them are male, the result isdeclared as male and if two of them are female, the result is declared as female.

Initially 50 fingerprints of both male and female are examined with FFT, DCT and PSD and the fundamental frequencies were obtained for each case. After the manual analysis is done, a threshold was set, to classify as male or female. The table below shows the details of the transform, threshold and the threshold condition for the identification of gender.

Table 1: Threshold Setting Of FFT, DCT and PSD

Gender	Transform & threshold		
	FFT	DCT	PSD
Male	FF<150000	FF<1700	FF>9000000000
Female	FF>150000	FF>1700	FF<9000000000

Table 2: Results of FFT, DCT and PSD of female samples

Fingerprint Sample	FFT Threshold> 150000	DCT Threshold> 17000	PSD Threshold< 9000000000
1	2279661	21010.92356	16050830074
2	1570108	14471.19513	7648114668
3	1454314	13403.958	6569115014
4	2330334	21477.96078	16606900769

5	2258674	20817.49294	15758103976
6	1580512	14567.08555	7749077120
7	2284175	21052.52769	16114143245
8	2000917	18441.82716	12248922996
9	2182986	20119.90027	14578942394
10	1848986	17041.52657	10583366169

Table 3: Results of FFT, DCT and PSD of male samples

Fingerprint **FFT Threshold<** **Sample** **150000**	**DCT Threshold<** **PSD Threshold>** **17000** **9000000000**
1 1720734	15859.46794 9059365136
2 1010376	9312.320079 3124565177
3 1817095	16747.59719 10097.352413
4 1447936	13345.17396 6512066008
5 2249503	20732.96669 15480756894
6 1736023	16000.38188 9337090299
7 1666175	15356.61467 8489722112
8 1246556	11489.11739 4838737388
9 1369293	12620.34599 5737451302
10 1777807	16385.49196 9665436481

S. S. Gornale [2] carried out the gender classification using combined features like FFT, Eccentricity and Major Axis Length. Left thumb impression of each sample of the internal database of 450 male samples and 550 female samples of good quality are selected. An optimal threshold for each transform is chosen for better results. It is found that the proposed algorithm produces accurate decision of 80% of male and 78% of female.

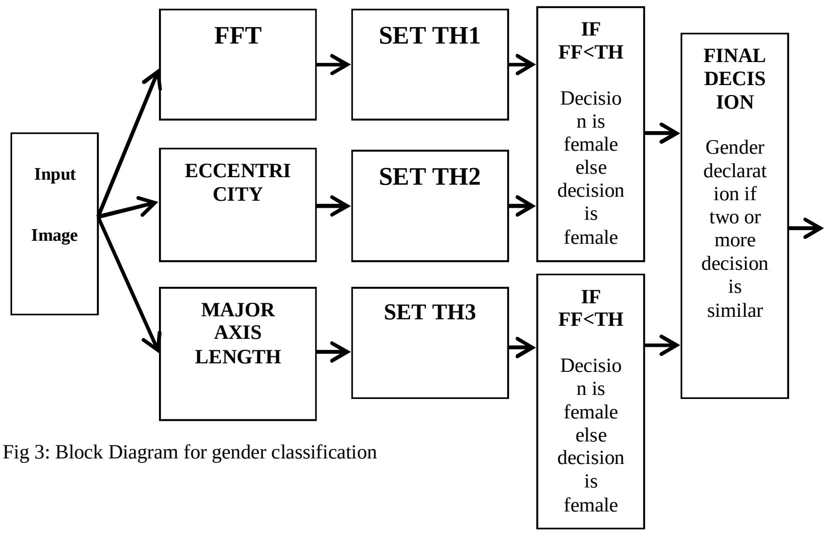

Fig 3: Block Diagram for gender classification

The proposed gender identification system follows the following steps:

1. Input from the database is given to the gender identification system.
2. FFT transforms the given input and gives the output. Threshold is TH1. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH1 the decision is female and if the FF is less than TH1 the decision will be male.
3. Eccentricity of the given input is computed and gives the output. Threshold is TH2. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH2 the decision is female and if the FF is less than TH2 the decision will be male.
4. Major Axis Length of the given input is computed and gives the output. Threshold is TH3. Rule is set in such a way that if the fundamental frequency (FF) is greater than TH3 the decision is female and if the FF is less than TH2 the decision will be male.
5. Comparing the decision from all the 3 steps above, if two decisions are male, the result is announced as male or else it is female.

An optimal threshold set for each transform is an important part of the gender identification process. Initially 20 fingerprints of both male and female are examined with FFT, Eccentricity and Major Axis Length was obtained for each case. For FFT, the threshold is set as 500000 and the samples having the fundamental frequency (FF) less than the threshold is identified as male and the samples with FF greater than the threshold is identified as female. For Eccentricity, the threshold as set to 0.6 and the samples having FF less than the threshold is identified as male and the samples with FF greater than the threshold is identified as female. For Major Axis Length, the threshold is set as 250 and the samples having FF less than the threshold are identified as male and the samples with FF greater than the threshold are identified as female.

Table 4: Results of FFT, Eccentricity and Major Axis Length of female samples

Fingerprint sample	**FFT threshold > 5000000**	**Eccentricity Threshold > 0.6**	**Major axis length Threshold > 250**
1	5075181.8	0.8495	269.22541
2	5910150.3	0.84051	261.21347
3	8010071.3	0.66843	277.39943
4	6269623.5	0.60265	253.10256
5	6831938.5	0.77789	273.74287
6	5668126.2	0.6764	256.03259
7	5946901	0.6764	257.11555
8	7562407.3	0.88811	250.47639
9	4968828.4	0.59602	246.66551
10	5795622.3	0.86555	273.17137

Table 5: Results of FFT, Eccentricity and Major Axis Length of male samples

Fingerprint sample	**FFT threshold > 5000000**	**Eccentricity Threshold > 0.6**	**Major axis length Threshold > 250**
1	4733106.5	0.5356	249.15157
2	1996323.8	0.28955	244.83074
3	4845580.2	.25252	244.98633
4	2570111.5	0.26499	239.58606
5	4844242.1	0.44792	247.83936
6	4535371.9	0.19157	129.75999
7	5337723.4	0.81617	260.24727
8	4054619.6	0.09282	240.87762
9	4626589	0.19163	245.95536
10	5325927.6	0.50575	240.83456

Lalit Kumar [3] during 2012-2013, studied the fingerprints of 100 males and 100 females. In this study, the subjects in the age group of 18-60 were taken from the state of Uttarakhand. The materials used were black ink, horseshoe lens, transparent film strip, pencil and Performa.The prints were taken with regular pressure on the Performa.Based on Baye’s theorem,authors calculated a likelihood ratio for obtaining the probability of gender inference by taking the ridge density values.LR is the probability of a given fingerprint originating from either male contributor (C) or female contributor (C1).Nearly 77% of males tend to have less number of ridges than females, with a maximum number of ridges that is 11 to 12 ridges. Beyond 12 ridges, the number of males decreases rapidly and no male was found to have more than 15 ridges. On the other hand, female was found to have more ridges. The number of female's with14 and 15 ridges (70%) was very high as compared to males.The ridge density ranges from 11-15 ridges/25mm2 in male and 11-16 ridges/25mm2 in females.The analysis of variance (ANOVA) results show that males have significantly lesser density than females (P<0.001). The mean value of ridge count for male was 11.9 and that of female was 14.8.LR value tends to decrease in males and when we see the other LR value (C1/C) in females, it is found that it increases drastically from 14 ridges onwards.The statistical analysis of LR shows that a ridge count of <13 ridges/25mm2 are more likely to be of male origin, whereas, a ridge count of >13/25mm2 are more likely to be of female origin.

Table 6: Sex wise distribution of epidermal ridges

No. Of ridges	Male	Female
11	49(39.2)	1(0.8)
12	48(38.4)	11(8.8)
13	16(12.8)	19(15.2)
14	10(8)	44(35.2)
15	2(1.6)	43(34.4)
16	-	7(5.6)
TOTAL	125	125

Table 7: Ridge density in both males and females

	Male	Female
Mean	11.9	14.1
SD	0.9	1
Se	0.088	0.095
Minimum	11	11
Median	12	14
Maximum	15	16

Table 8: Probability densities and likelihood ratios from observed ridge count

Ridge count	Probability density		Likelihood ratio		Favoured odds	
	Male (C)	Female (C1)	LR(C/C1)	LR(C1/C)	Males	Females
11	0.39	0.01	49.00	0.02	0.98	0.02
12	0.38	0.09	4.36	0.23	0.81	0.19
13	0.13	0.15	0.84	1.19	0.46	0.54
14	0.08	0.35	0.23	4.40	0.19	0.81
15	0.02	0.34	0.05	21.50	0.40	0.96
16	0.00	0.06	0.02	56.00	0.02	0.98

Muralidhar Reddy Sangam, [6] 2011, conducted a study of 506 individuals with known blood groups. Fingerprints of the subjects were obtained using Cummins ink method. A glass surface was used, where Printers ink was uniformly distributed using a roller. Then, the fingerprints were obtained after thoroughly washing the hand and after complete drying. Fingerprints were then classified as whorls, loops and arches using Henry's system of classification. With the help of hand lens, fingerprint patterns, total and absolute ridge counts were examined.

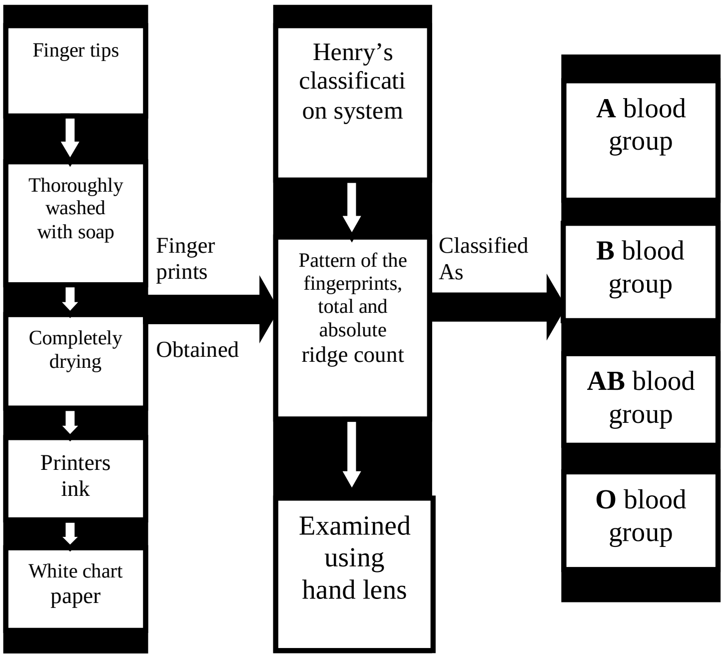

Fig: 4: Flow chart of the proposed methodology

Table 9: Distribution of Rh factor

	Males(2680)	Females(2380)	Total
Loops	1400	1442	2842
Whorls	1180	817	1997
Arches	100	121	221

Table 10: Fingerprint pattern sex-wise

Rh factor	O	A	B	AB
Rh+	205	78	149	30
Rh-	12	14	14	4

Table 11: Fingerprint pattern

	Loops			Whorls	Arches
	Ulnar	Radial	Total		
O	1242	33	1275	814	81
A	490	18	508	389	23
B	851	38	889	626	115
AB	156	14	170	168	02

Anila Koneru [7] conducted a study that consists of 200 students out of which 57 were male candidates and 143 were female candidates. The subjects were in the age group of 17-22 years. Ink pads and white chart papers were used to obtain all the 10 fingerprints of the each subject. Fingerprints were examined with the help of a magnifying lens on the basis of the appearance of ridge lines. Classification of the fingerprints was done according to the classification scheme of Galton. Blood group of each subjects were analyzed by treating them with anti-A and anti-B sera. The data was then statistically analyzed for distribution of fingerprints in relation to ABO and RH groups, using Z-test. Statistically significant values of P were less than 0.05.

Table 12: Percentage-wise distribution of finger print patterns among males and females

Patterns	Males (n=143)	Females (n=57)	Total (n=200)
Loops	272(46%)	794(56%)	1066(53%)
Whorls	236(41%)	549(39%)	785(39%)
Arches	73(13%)	76(5%)	149(8%)
Total	581	1419	2000(100%)

Table 13: Distribution of blood groups according to gender and Rh blood groups

Blood groups	Males	Females	Rh-positive	Rh-negative	Total
A	16(28%)	39(27%)	54(28%)	1(10%)	55(27%)
B	16(28%)	35(24%)	45(24%)	6(60%)	51(20%)
AB	6(11%)	9(7%)	15(8%)	0(0%)	15(13%)
O	19(33%)	60(42%)	76(40%)	3(30%)	79(40%)

Table 14: Association of finger print patterns in relation to blood groups

Patterns	Loops	Z-score p-value	Whorls	Z-score p-value	Arches	Z-score P-value
A	284 (52%)	0.918 0.358	216 (39%)	0.013 0.992	50 (9%)	1.721 0.085
B	308 (60%)	3.605 p<0.001 (S)	164 (32%)	-3.801 P<0.001 (S)	38 (7%)	0.001 1.000
AB	72 (48%)	-1.353 0.177	72 (48%)	2.282 0.023	6 (4%)	-0.918 0.358
O	402 (51%)	-1.705 p<0.001 (S)	333 (42%)	2.148 0.032	55 (7%)	-1.673 0.095

Table 15: Association of finger print patterns in relation to Rh blood groups

Type of fingerprint	A(28)		B(53)		AB(19)		O(40)	
	Rh +ve (24)	Rh -ve (4)	Rh +ve (50)	Rh -ve (3)	Rh +ve (18)	Rh -ve (1)	Rh +ve (36)	Rh -ve (4)
Loops	111 (46.3)	23 (57.5)	310 (62.0)	20 (66.7)	87 (48.3)	8 (80.0)	227 (63.1)	26 (65.0)
Whorls	113 (47.1)	15 (37.5)	174 (34.8)	9 (30.0)	85 (47.2)	2 (20.0)	113 (31.4)	12 (30.0)
Arches	17 (7.1)	16 (3.2)	16 (3.2)	1 (3.3)	8 (4.4)	0 (0)	20 (5.6)	2 (5.0)

Table 16: Relation of blood group with fingerprint patterns

Patterns	Loops	Z-score p-value	Whorls	Z-score p-value	Arches	Z-score P-value
Rh-positive	1020 (56%)	3.501 P<0.001 (S)	660 (36%)	-1.452 0.177	135 (8%)	3.723 P<0.001 (S)
Rh-negative	46 (25%)	-1.673 0.095	125 (67%)	-8.280 P<0.001 (S)	14 (8%)	-0.064 0.002

Deepa Deopa [8],in 2014, conducted a study to relate the blood group with the fingerprint of an individual. A total of 140 subjects participated in the study out of which 75 were females and 65 were males. They were all in the age group of 18-25 years. The study was carried out for over a period of 6 months. Fingerprints were taken using the ink method suggested by Cummins, where each subject was asked to wash their hands thoroughly with soap and dry them using a towel. The subjects were then asked to press their fingertips on the stamp pad and then on the chart paper in order to obtain their fingerprints, respectively.

The details of blood group of each individual were noted along with their gender and age, against each fingerprint. The fingerprint patterns were classified as whorls, loops and arches based on the appearance of ridge lines by using a magnifying glass lens. Beginning with the right thumb as number1, each finger was assigned a number.

III. CONCLUSION

As fingerprints are one the best method towards person identification, further analysis of fingerprints can reveal many aspects about a person, which can be very useful in forensic sciences and forensic departments.

The results have shown that a ridge count of <12 ridges/25 mm2 are to be of male origin and that of >14 ridges/25 mm2 are to be of female origin.In future, the work can be extended to build robust algorithm for frequency domain and region properties to find different parameters (like age group, Rural, Urban people) and different features it can be applied in gender classification which will be more accurate and suitable for all types of applications.

For blood group, whorls frequency predominate in A+ and AB+, loops frequency predominate in O and arches were high in B.

In our this research work, we desire, intend and propose to determine blood group of fingerprint contributor through computer analysis taking advantages of science of determination of sex based on fingerprint analysis; which will open a field that may lead us to multi various developments in different fields.

REFERENCES

[1] Ritu Kaur, Susmita Ghosh Mazumdar, "FINGERPRINT BASED GENDER IDENTIFICATION USING FREQUENCY DOMAIN ANALYSIS," International Journal of Advances in Engineering & Technology, March 2012. ©IJAET.

[2] S. S. Gornale, Mandya-Karnataka-INDIA , Geetha C D, Kruthi R, "ANALYSIS OF FINGERPRINT IMAGE FOR GENDER CLASSIFICATION USING SPATIAL AND FREQUENCY DOMAIN ANALYSIS," American International Journal of Research in Science, Technology, Engineering & Mathematics, ISSN (Print): 2328-3491, ISSN (Online): 2328-3580, ISSN (CD-ROM): 2328-3629.

[3] Lalit Kumar, Sandeep Agarwal, Rajesh Garg, Amit Pratap, V K Mishra, "Gender Determination Using Fingerprints In the Region of Uttarakhand ",J Indian Acad Forensic Med. October-December 2013, Vol. 35, No. 4.

[4] Muralidhar Reddy Sangam, A. Ramesh Babu, K. Krupadanam, K. Anasuya, "FINGER PRINT PATTERN IN DIFFERENT BLOOD GROUPS", J Indian Acad Forensic Med. October- December 2011, Vol. 33, No. 4.

[5] Anila Koneru, Santosh Hunasgi, Parul Sinha, Surekha R, Vanishree M, Shamala Ravikumar, "ASSOCIATION OF DIFFERENT FINGER PRINTS IN RELATION TO ABO AND RH BLOOD GROUPS", Int J Biol Med Res. 2014; 5(3): 4287-4292.

[6] Deepa Deopa, Chandra Prakash, Ishwer Tayal, "A STUDY OF FINGERPRINT IN RELATION TO GENDER AND BLOOD GROUP AMONG MEDICAL STUDENTS IN UTTARAKHAND REGION", J Indian Acad Forensic Med. January-March 2014, Vol. 36, No. 1.