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Impact of Henry System of Classification on the Entropy of Fingerprint Images

Vandhana Chandrasekaran, Stephen Elliott, Elisa Bertino, Matthew Young

Overview

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Research question – Does fingerprint images classified based on the Henry system of fingerprint classification have statistically significant difference in the amount of entropy? This is a follow on study from Young (2007).

Review of Literature

O'Gorman
- Biometric keyspace K_b [1/FMR(1)] = Password keyspace K_P [M^n]

Ratha et al.
- Determine the probability of randomly guessing a fingerprint feature set through brute force attack
- Determine entropy of fingerprint with 25 matching minutiae – 82 bits of information == 16 character long password

Pankanti et al.
- Derived formula – determine probability of matching minutiae at random between two fingerprint samples
- Fingerprint image with 36 minutiae – failing to match at all 36 minutiae – $5.5e^{-49}$; estimated entropy – 193 bits

Zhu et al.
- Follow-up study conducted by Pankanti et al.;
- Included minutiae clustering properties; correlation between minutiae location and angle
- Probability increased – entropy decrease

Wayman
- Proposed cotton ball model – estimate FAR, FRR in Euclidean spaces
- Cauvokian and Stoianov (2009) claim model – estimate biometric entropy

Adler et al.
- Proposed concept of relative entropy – KL distance ;
- Applying theory to face recognition – estimated 45 bits of entropy for PCA features

Young
- Frequency of minutiae in the middle of images > edges
- Establish method to determine keyspace and entropy of fingerprint
- Shannon's joint entropy equation – estimated entropy of fingerprint images

Henry System of Classification

Henry	LI		LM		RI		RM	
	#	%	#	%	#	%	#	%
Whorl	322	31.6	235	23.0	301	29.5	212	20.8
Left Slant Loop	421	41.3	675	66.2	259	25.4	46	70.0
Right Slant Loop	190	18.6	35	3.4	366	35.9	714	4.5
Tented Arch	54	5.3	46	4.5	24	5.2	5	2.8
Plain Arch	32	3.1	24	2.4	39	3.8	14	1.4
Scar	1	0.1	5	0.5	2	0.2	5	0.5

Statistical Results

ANOVA /Tukey's post hoc HSD criterion among fingerprints of different patterns, finger types, image qualities, and age groups

ANOVA – statistically significant difference in the amount of entropy among fingerprints of different patterns, *F(4, 5207) = 93.32, p < .0001.*

	Tukey Grouping	Mean	Group
	A	13.81	Whorl
	B	12.71	Left Slant Loop
	B		
C	B	12.36	Right Slant Loop
C			
C	D	12.12	Tented Arch
	D		
	D	11.63	Plain Arch

ANOVA – statistically significant difference in the amount of entropy among fingerprints of different patterns, *F(4,5207) = 93.32, p < .0001,* finger types, *F(3, 5207) = 139.73, p < .0001;* finger type – fingerprint patterns, no statistically significant difference , *F(12, 5207) = 0.84, p=0.6058*

Tukey Grouping	Mean	Group
A	13.60	Ring
B	13.17	Middle
C	12.68	Index
D	11.60	Little

ANOVA – statistically significant difference in the amount of entropy among fingerprint s of different image qualities, *F(3,5582) = 25.67, p < .0001*

Tukey Grouping	Mean	Group
A	12.85	Good
A		
A	12.64	Adequate
C	11.81	Marginal
D	10.86	Poor

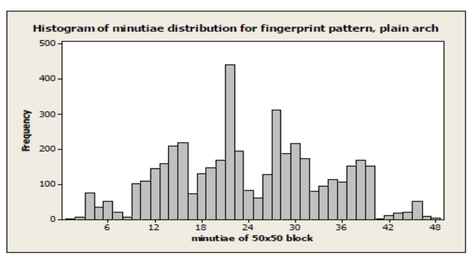
ANOVA – statistically significant difference in the amount of entropy among fingerprints acquired from participants of different age groups, (18-27: G1, 28-37: G2, 38-47: G3, 48-57: G4, and 58-67: G5); *F(4, 5131) = 9.39, p < .0001*

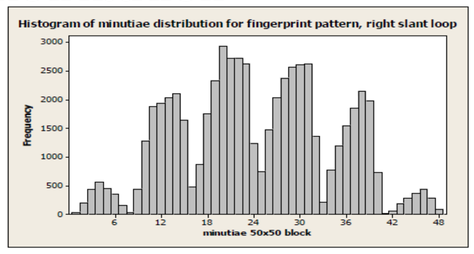
	Tukey Grouping	Mean	Group
	Tukey Grouping	Mean	Group
	A	13.96	G5
	B	13.12	G4
	B		
C	B	12.76	G2
C	B		
C	B	12.76	G1
C			
C		12.40	G3

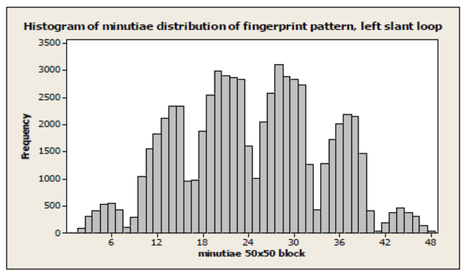
Analysis showed statistically significant difference in the amount of entropy among different genders, F(1, 5124) = 98.64, p < .0001

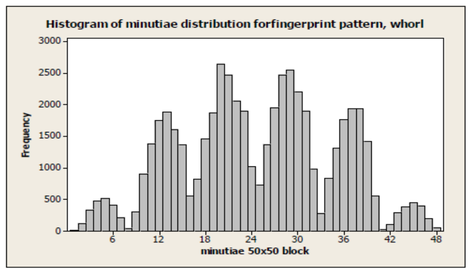
Tukey Grouping	Mean	Group
A	13.10	Male
B	12.42	Female

Results: Minutiae distribution









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