DO BIOMETRIC IMAGES FOLLOW BENFORD'S LAW?

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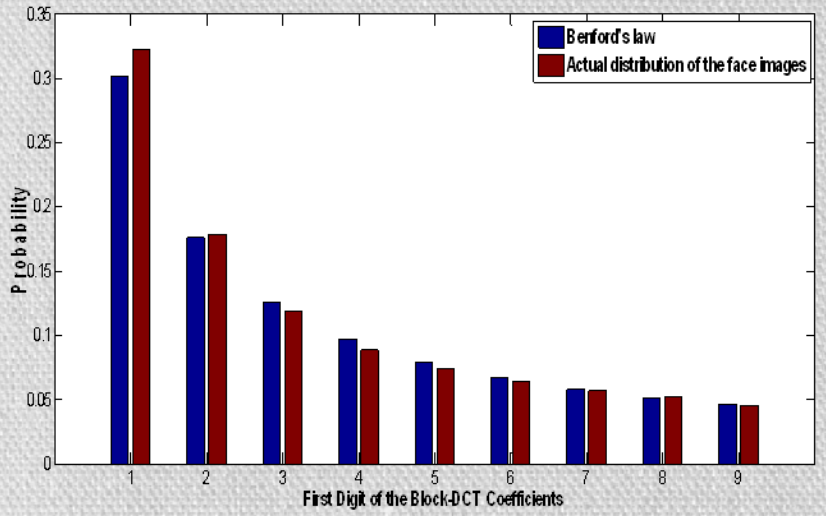
Experiments

- To investigate the Block-DCT and JPEG coefficients for both face and fingerprint images
- To determine whether they follow the Standard Benford's and generalised Benford's law
- The divergence is used to show how data samples departs from the Benford's law

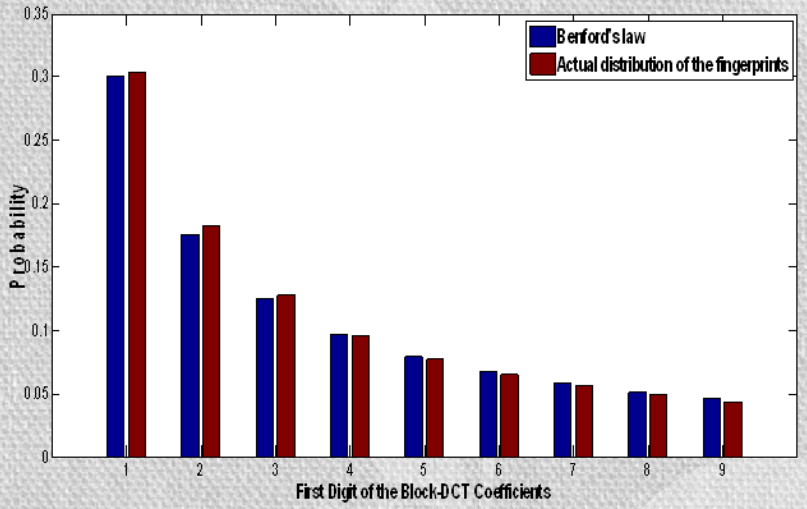
$$x^2 = \sum_{i=1}^{9} \frac{(p'_i - p_i)^2}{p_i}, i = 1,2, \ldots 9$$

Results for Standard Benford's law

- A divergence of 0.000917 and 0.000064 was obtained for the face images and fingerprint images, respectively.



(a) Block-DCT coefficients of face images closely follow Benford's law



(b) Block-DCT coefficients of fingerprint images closely follow Benford's law

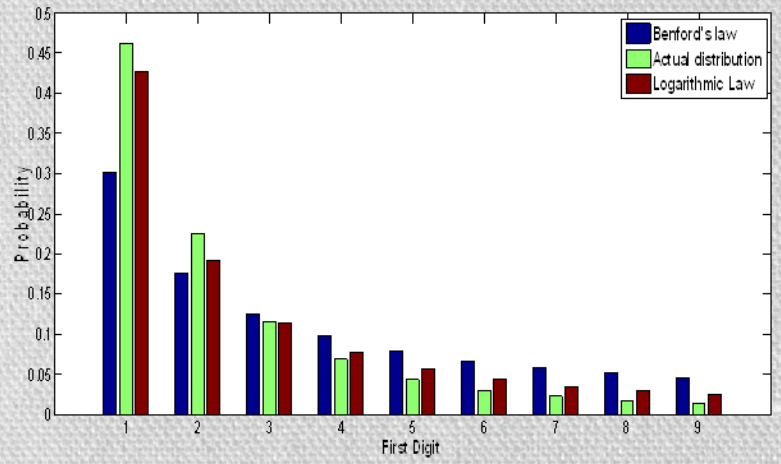
Results for Standard Benford's law cont.

- Other divergence values for uncompressed face and fingerprint images for different QF from 100 to 50 in step of -10

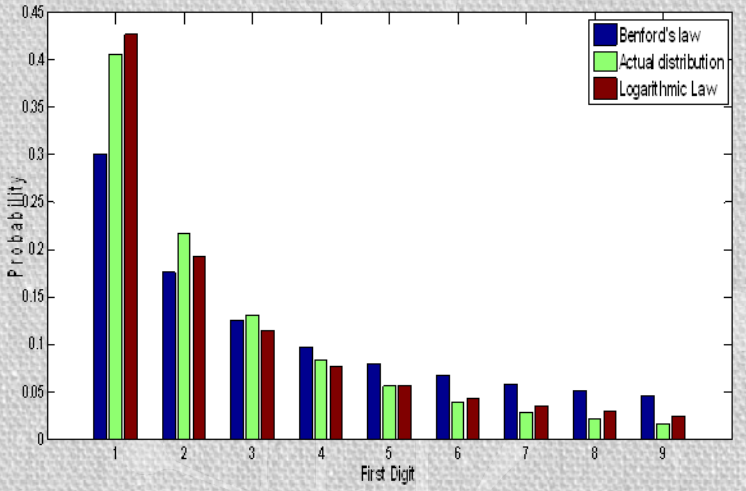
Quality Factor	Divergence (face images)	Divergence (fingerprint images)
100	0.052	0.0231
90	0.1313	0.0994
80	0.1625	0.1143
70	0.1663	0.1167
60	0.1638	0.1109
50	0.1701	0.1168

Results for Generalised Benford's law

- The divergence of 0.0031 and 0.0014 were obtained for QF=100 for both the biometric face and fingerprint images respectively, which showed a good fitting. Other QF's were also found to give a good fitting.

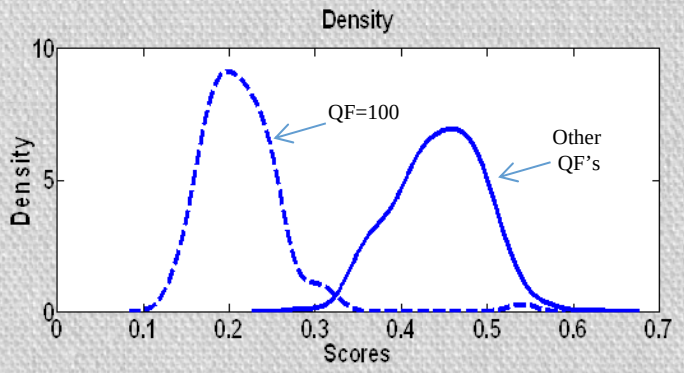


(a) JPEG coefficients of face images closely follow generalized Benford's law at QF=100

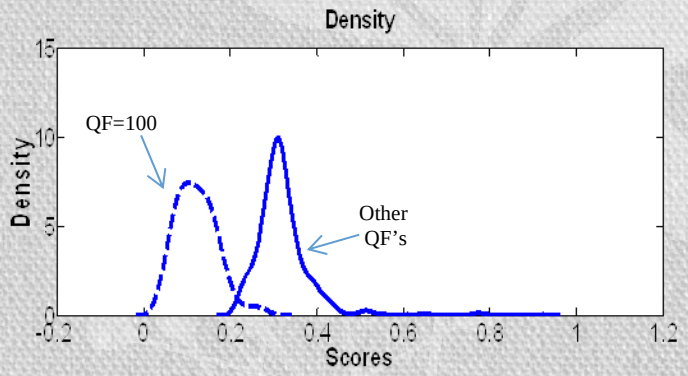


(b) JPEG coefficients of fingerprint images closely follow generalized Benford's law at QF=100

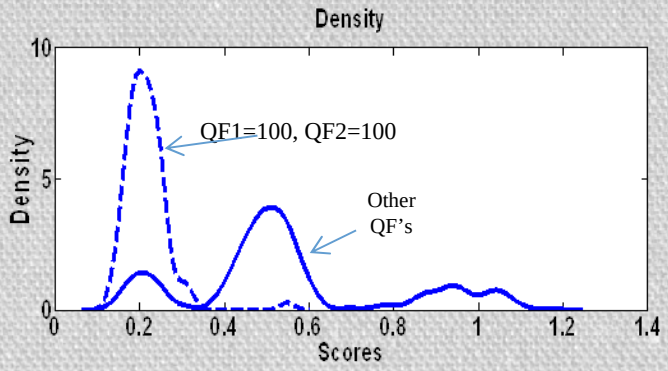
Results for Performance Evaluation



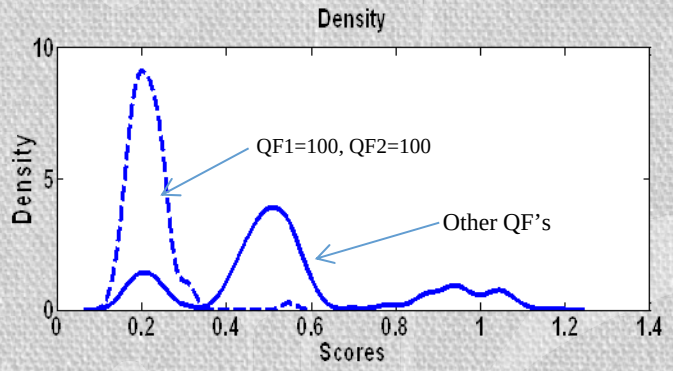
a)



b)



c)



d)

The pdf of the divergence of:

(a) singly compressed face images of QF=100 versus the pdf of other QF's from 90 to 50 in step -10;

(b) singly compressed fingerprint images of QF=100 versus the pdf of other QF's from 90 to 50 in step -10;

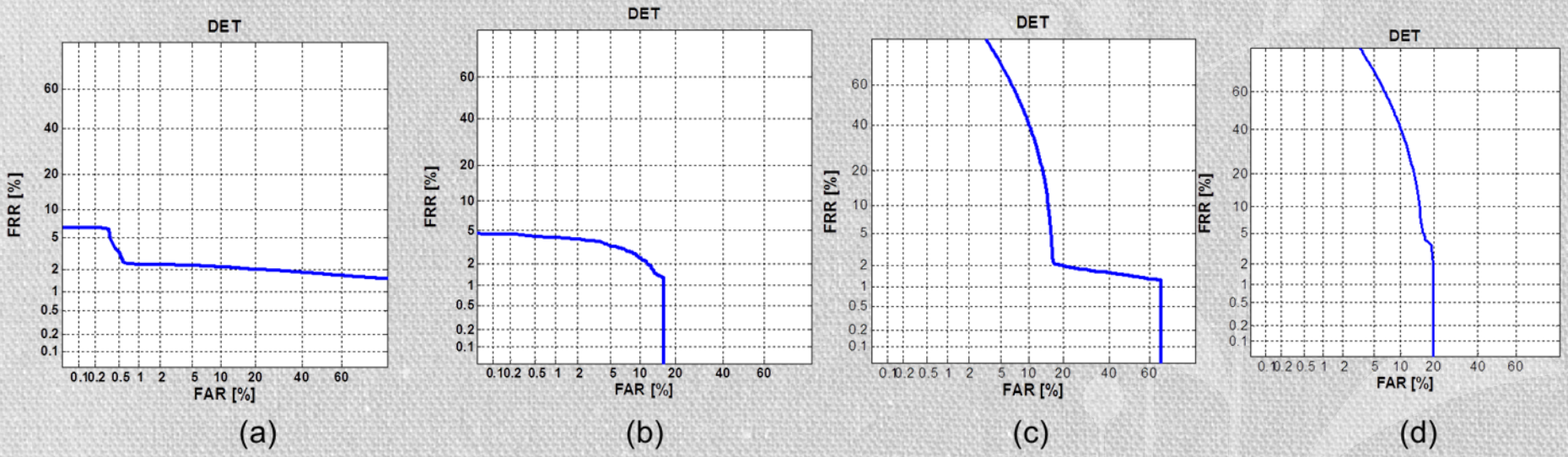
(c) doubly compressed face images of QF1=100, QF2=100 versus other QF's including QF1=55, 65, 75, 85 and QF2=70, 80, 90, 95;

(d) doubly compressed fingerprint images of QF1=100, QF2=100 versus other QF's including QF1=55, 65, 75, 85 and QF2=70, 80, 90, 95.

Results for Performance Evaluation cont.

- $FAR(\Delta) = \frac{\#\ of\ falsely\ accepted\ uncompressed\ images\ at\ \Delta}{Total\ \#\ of\ uncompressed\ biometric\ images}$

- $FRR(\Delta) = \frac{\#\ of\ falsely\ rejected\ compressed\ images\ at\ \Delta}{Total\ \#\ of\ compressed\ biometric\ images}$



DET curve for: (a) singly compressed face images; (b) singly compressed fingerprint images; (c) doubly compressed face images; (d) doubly compressed fingerprint images

Results for Performance Evaluation cont..

- EER for various compressions of data sets

Biometric Data	EER
Single compressed face images	0.55%
Single compressed fingerprint images	2.7%
Double compressed face images	4.3%
Double compressed fingerprint images	3.7%

Applications to Biometric Images

- The Benford's law is very useful when no clear information is given about biometric face or fingerprint images like in the case of CASIA-FACEV5.

- This law can assist in determining uncompressed, and JPEG face and fingerprint images which has a potential to be very useful in the field of forensic biometrics for biometric images information.

Discussion

- Benford's law does not require training ; it works well in detecting uncompressed and JPEG biometric images.

- It is easier to detect singly compressed biometric images than the doubly compressed biometric images.

Conclusion

- The probability distributions of the first digits of the block-DCT coefficients of Biometric faces and fingerprint images when uncompressed closely follow the standard Benford's law.

- JPEG coefficients of biometric face and fingerprint images also closely followed the generalized Benford's law.

- A technique from forensics is applied to biometrics, therefore contributing to the field of forensics biometrics.

THANK YOU FOR YOUR ATTENTION

Questions and comments are welcome