Prime Shapes in Natural Images (Supplementary Material)

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This document is a supplementary material of our paper. In the original paper, the results which are obtained using Zernike moments have been presented in section 2.5. In this paper, we will present the results by using Chebyshev moments. The first section is a brief introduction about Chebyshev moments and the experimental results are presented in the second part. This result is another evidence to support our conclusion, which is *natural images contain simple shapes to a statistically significant degree.*

1 Chebyshev moments

Chebyshev moments [1] depend on Chebyshev radial polynomials of the second kind are defined as:

$$R_n(\rho) = \sqrt{\frac{8}{\pi}}(\frac{1-r}{\rho})^{1/4} \sum_{s=0}^{n/2} (-1)^s \frac{(n-s)!}{s!(n-2s)!} (2(2\rho - 1))^{n-2s} \qquad (1)$$

where n is a non-negative integer. Then, the Chebyshev moment is defined by:

$$C_{mn} = \iint_{unit\ disk} R_n(\rho)f(\rho,\theta)\ d\rho d\theta \qquad (2)$$

in which $f(\rho,\theta)$ is a binary image in radial polar coordinates.

2 Experimental Results using Chebyshev moments

	Thresholding	MSER	Berkeley		Classified Shapes	32507
MIT	52.55%	57.57%	52.06%		Un-Classified Shapes	24485
BSDS	44.90%	49.89%	46.86%		Classification Fraction	57.04%
Natural	49.93%	48.38%	64.30%			

Table 1: *Left:*The percentage of 'prime shapes' we detected as being statistically significant amongst total shapes detected from the MIT,BSDS500 and our Natural database, by using different segmentation algorithms. *Right:* Number of classified and un-classified shapes from all three database, and the fraction of classified shapes with total shapes.
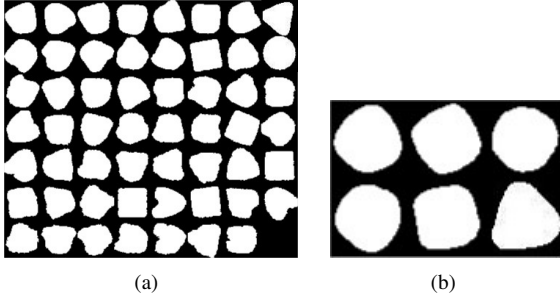
Figure 1:   A matrix of final results. (a):Shape icons yielded by **MIT databases**, **thresholding** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right..
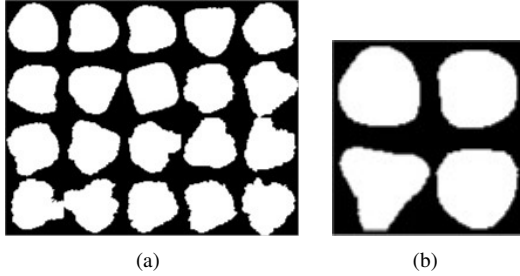

Figure 2: A matrix of final results. (a):Shape icons yielded by **BSDS500 databases**, **thresholding** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.
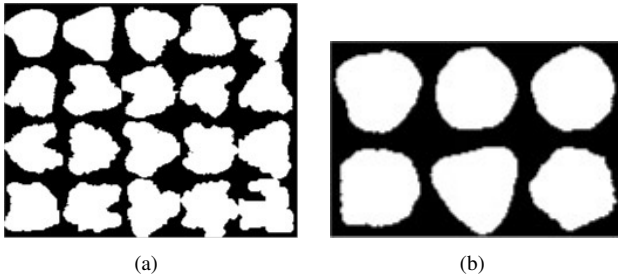

Figure 3: A matrix of final results. (a):Shape icons yielded by **Natural databases**, **thresholding** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.
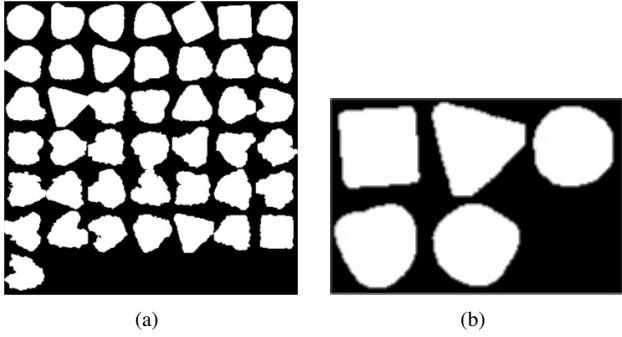
Figure 4: A matrix of final results. (a):Shape icons yielded by **MIT databases**, **MSER** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.
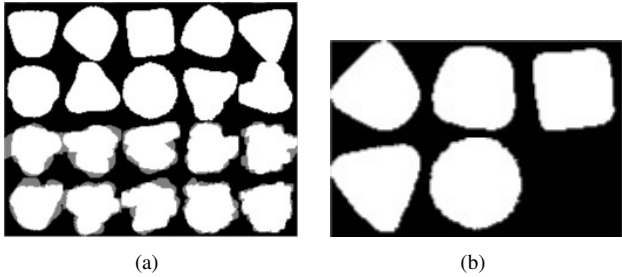

Figure 5: A matrix of final results. (a):Shape icons yielded by **BSDS500 databases**, **MSER** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.
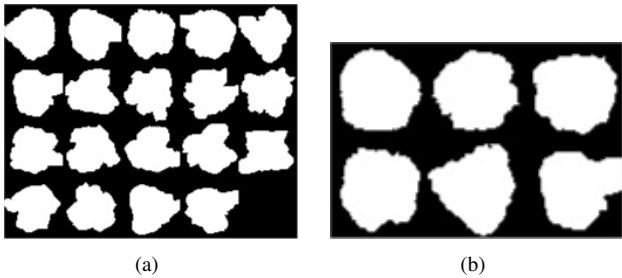

Figure 6: A matrix of final results. (a):Shape icons yielded by **Natural databases**, **MSER** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.

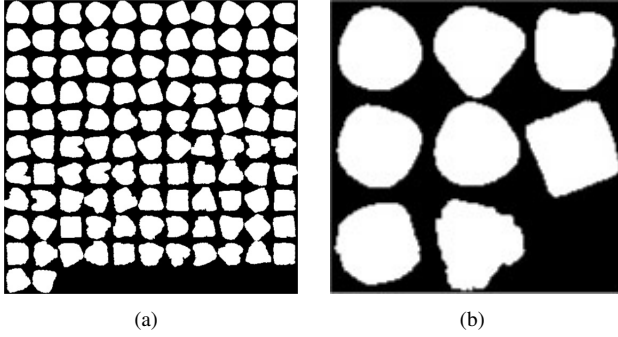|	
(a)	(b)

Figure 7:   A matrix of final results. (a):Shape icons yielded by **MIT databases**, **BSE** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.

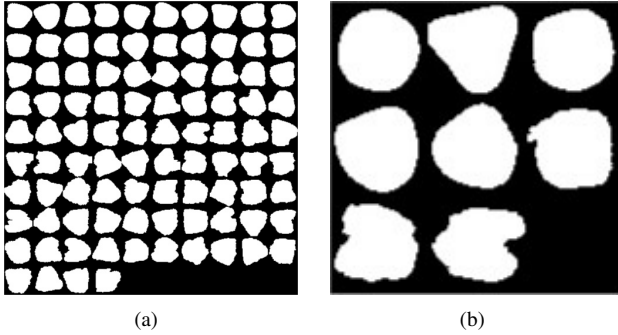|	
(a)	(b)

Figure 8:   A matrix of final results. (a):Shape icons yielded by **BSDS500 databases**, **BSE** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.

(a)	(b)

Figure 9:   A matrix of final results. (a):Shape icons yielded by **Natural databases**, **BSE** segmentation methods. (b): Shape icons yielded by our Agglomerative Clustering algorithm (Final Result).The shapes are ordered by descending frequency from top-left to bottom-right.
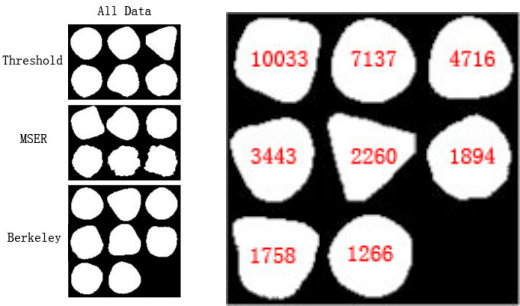
Figure 10: (a):Shape icons for **different segmentation methods** yielded by combining **all three databases**, different segmentation methods. (b):Final grouping result by combing **all databases and segmentations**. The shapes are ordered by descending frequency from top-left to bottom-right.

References

[1] Z.L. Ping, R.G. Wu, and Y.L. Sheng. Image description with chebyshev-fourier moments. *JOSA A*, 19(9):1748–1754, 2002.