Sabanci University, FENS
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Assignment 3

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Basic Shape Descriptors

In total, 31 different combinations of basic shape descriptors were tested. These cover starting from combinations with 3 elements, up to combinations with all 6 elements. In the Table 1, results for an example from each combination group is presented.

Euclidean distance and Manhattan distance have similar score, with Manhattan being a little better. Chi-squared distance seems to perform better than both. Mahalanobis distance score varies more compared to other three functions. Most significant result that can be observed is the combination of convexity, rectangularity, and eccentricity resulted in the highest score for all distance functions, which is around 0.47 for all.

Fourier Descriptor

To decide with how many coefficients that the Fourier descriptors must be tested, minimum, maximum and median values for descriptor lengths were obtained for both train and test sets. Both sets have the median around 400 coefficients, thus the number of coefficients were decided as 50, 100, 200, and 400. Another important note about the Fourier descriptors is that the Mahalanobis function used in other tests did not work for the Fourier descriptors, due to the singular matrices occuring while calculating the inverse of covariance matrix. Thus, instead of using inverse of covariance matrix, pseudo-inverse was used. Another issue is that, not all of the images had equal amount of descriptors. In the case of finding distance between two uneven feature vectors, longer vector was truncated to the size of the shorter. Results are presented on the Table 2.

Interesting part is that the scores for Euclidean, Manhattan and Chi-squared stayed almost same over all numbers of coefficients. Mahalanobis distance has

Combinations	**Distances**			
	Euclidean	Manhattan	Chi-squared	Mahalanobis
Area, Perimeter, Convexity	0.2914	0.2957	0.34	0.037
Area, Perimeter, Circularity, Rectangularity	0.2914	0.2985	0.3457	0.0357
Area, Perimeter, Convexity, Circularity, Eccentricity	0.2914	0.2985	0.3442	0.0385
Area, Perimeter, Convexity, Circularity, Rectangularity, Eccentricity	0.28	0.2914	0.3757	0.05

Table 1: Table of sample basic descriptor results according to different distance functions.

the highest variance. Overall, 50 coefficients seems to have the best results, even if it produced just slightly better results.

Shape Histogram

Number of bins for the histogram values used in the test were arbitrarily decided as 3, 5, 7, and 11. One note about the histogram values is that the values are normalized with total surface to have scale invariance. The results are presented for all bin numbers in Table 3.

An important result that can be observed is the fact that, regardless of the distance function, scores are increasing as the number of bins increases. Euclidean and Mahalanobis distance have exactly same score for each bin number, whereas Manhattan performs slightly better than them. On the other hand, Chi-squared performs visibly worse than other three functions.

Coefficients	**Distances**			
	Euclidean	Manhattan	Chi-squared	Mahalanobis
50	0.3357	0.2842	0.3842	0.0114
100	0.3357	0.2828	0.3842	0.0042
200	0.3357	0.2828	0.3842	0.0057
400	0.3357	0.2828	0.3842	0.0057

Table 2: Table of Fourier descriptor results according to different distance functions.

Bin Number	**Distances**			
	Euclidean	Manhattan	Chi-squared	Mahalanobis
3	0.2271	0.23	0.2	0.2271
5	0.3857	0.3842	0.3442	0.3857
7	0.4357	0.4457	0.3585	0.4357
11	0.4642	0.4771	0.3457	0.4642

Table 3: Table of shape histogram results according to different distance functions.

Moment Invariants

In total, 37 different combinations of Hu moments were tested. These cover starting from combinations with 6 moment invariants, up to combinations with all 8 moment invariants. In the Table 4, results for an example from each combination group is presented. Numbers are indices, thus n in the table must be read as (n+1)th Hu moment.

Combinations	**Distances**			
nth index corresponds (n+1)th invariant	Euclidean	Manhattan	Chi-squared	Mahalanobis
(0, 1, 2, 3, 4, 5)	0.1585	0.1614	0.2985	0.1585
(0, 2, 3, 4, 5, 6, 7)	0.1557	0.1557	0.1557	0.1557
(0, 1, 2, 3, 4, 5, 6, 7)	0.1585	0.1614	0.2928	0.1585

Table 4: Table of Hu moments results according to different distance functions.

Highest score for Euclidean and Manhattan distance, 0.2257 and 0.2114 respectively, were observed with the combination I3, I4, I5, I6, I7, I8. Mahalanobis distance also has score of 0.2257, the highest for it in this test. Chi-squared has its score maximized, 0.2985, at the combination I1, I2, I3, I4, I5, I6.

Arbitrary Combinations

Arbitrary combinations decided randomly from all combinations and values tested for different descriptors. Resulting scores can be seen on Table 5.

Most significant result from this test is obtained from Chi-squared distance with "('area', 'perimeter', 'convexity', 'circularity'), (0, 1, 2, 4, 6, 7), 3, 100" combination. These values are basic shape descriptors, Hu moments used, number of bins for Shape Histogram, and number of coefficients in Fourier descriptors respectively. The score is 0.4942, which is the highest overall score.

Combinations	**Distances**			
(basic descriptor combination), (Hu moments combination), bin number, Fourier coefficients	Euclidean	Manhattan	Chi-squared	Mahalanobis
(perimeter, convexity, eccentricity), (0, 2, 3, 4, 5, 6), 3, 200	0.3414	0.2942	0.3785	0.0085
(area, circularity, eccentricity), (1, 2, 3, 4, 6, 7), 11, 200	0.4642	0.4614	0.3942	0.01
(area, perimeter, convexity, circularity), (0, 1, 2, 4, 6, 7), 3, 100	0.4671	0.47	0.4942	0.0071
(area, perimeter, rectangularity), (0, 1, 3, 4, 5, 6), 7, 100	0.4671	0.4714	0.4128	0.01
(area, perimeter, convexity, eccentricity), (0, 1, 2, 3, 4, 5), 5, 50	0.4671	0.47	0.4285	0.01

Table 5: Table of arbitrary combination results according to different distance functions.