Figure 5: *The models that are retrieved by Chaouch's MDLA method for an airplane as the query object.*

Table 2 shows the retrieval statistics for all the methods and runs. It is clear that based on all the five scalar measures the MDLA approach proposed by Chaouch and Verroust gave the best performance among all 22 methods. Lian's composite descriptor, which is a combination of four methods (RECT + SHD + GSMD + MR) got the second place considering overall performance. Nearest Neighbor indicates the relevance to the query of the first retrieved result. If we based the evaluation on NN, Napoleon's MCC-Run2 and MCC-Run3 would be in second and third places. But we take into account all the performance evaluation measures then Chaouch's MDLA is in the first place, Lian's Rect+SHD+GSMD+MR is in the second place and Napoleon's MCC-Run3 is in the third place.

PARTICIPANT	METHOD	NN	FT	ST	E	DCG
Akgül	DBFc8	0.825	0.433	0.550	0.383	0.748
(sect. 5.6)	DBFc10	0.825	0.443	0.574	0.398	0.757
	DBFc12	0.813	0.449	0.578	0.406	0.759
Bustos	DSR_segment	0.863	0.561	0.696	0.49	0.825
(sect. 5.5)	DSR_nosegment	0.85	0.546	0.691	0.479	0.819
	Entropy_123_6_segment	0.838	0.526	0.663	0.464	0.803
	Entropy_6789_6_segment	0.838	0.528	0.668	0.467	0.805
	W1_segment	0.838	0.528	0.666	0.466	0.806
Chaouch (sect. 5.1)	MDLA	0.963	0.730	0.848	0.602	0.917
Daras	3D_shape_impact	0.8	0.447	0.567	0.396	0.749
(sect. 5.3)	Compact_multiview	0.8	0.49	0.626	0.437	0.771
	Compound_SID_CMVD	0.875	0.558	0.69	0.487	0.83
Furuya	BF-SIFT	0.850	0.483	0.624	0.433	0.777
(sect. 5.6)	MR-SPRH-UDR	0.875	0.550	0.703	0.491	0.824
Lian	SHD+GSMD	0.875	0.597	0.733	0.514	0.85
(sect. 5.2)	RECT+SHD+GSMD	0.925	0.633	0.778	0.542	0.875
	RECT+SHD+GSMD+MR	0.925	0.724	0.844	0.595	0.904
Napoléon	Run1	0.900	0.522	0.665	0.459	0.814
(sect. 5.4)	Run2	0.950	0.615	0.701	0.502	0.864
	Run3	0.950	0.639	0.771	0.540	0.882
	Run4	0.900	0.550	0.662	0.465	0.826
	Run5	0.887	0.570	0.709	0.497	0.838

Table 2: *The retrieval statistics for all the methods and runs.*

We have selected the best runs of each participant and displayed them in Figure 6, which shows their performance results in a bar graph. Three methods (Chaouch's, Lian's and Napoléon's) are particularly successful in that they give NN and DCG values close to or larger than 0.9. Figure 7 gives the precision-recall curves of the seven methods (the best of each participant). For recall values up to 0.67 Chaouch's MDLA approach performs better than any other method. For recall values higher than 0.67, Lian's composite descriptor (RECT + SHD + GSMD + MR) yields higher precsion values. Since the first half of the precision-recall curve is more significant in terms of retrieval purposes, Chaouch's MDLA method clearly performs best with respect to the precision-recall measures. The precision values of Napoleon's MCC-Run3 are better or as good as the values obtained by Lian's method for recall values upto 0.4. However, they significantly drop to the third place when the recall valued are higher than 0.4.

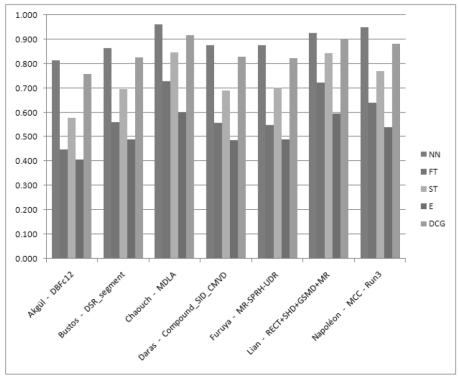

Figure 6: *Bar plot of the Nearest Neighbor (NN), First Tier (FT), Second Tier (ST), E-measure(E) and Discounted Cumulative Gain (DCG) for the best runs of each participant.*

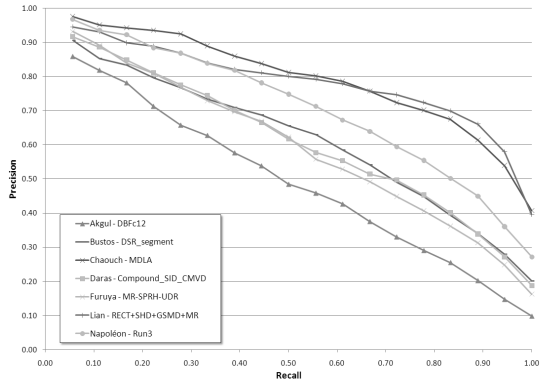

Figure 7: *Precision-recall curves of the best runs of each participant.*

We can classify the submitted methods as individual methods and hybrid methods. Hybrid methods have a better chance of describing the different local and global characteristics of the object and thus are expected to yield better results than the individual methods. This is clear from Table 2: whenever a participant fused more individual methods together, the retrieval statistics got better. In addition to the combination of methods, incorporation of a variety of pose normalization schemes (e.g. Lian's composite descriptor and Daras's CMVD method), consideration of various scales (e.g. Napoleon's MCC method) and combining partial and global descriptors (e.g. Bustos's DSR-segment) can also be beneficial.

7. Conclusions

In this paper, we have described and compared the performance of different algorithms submitted by seven research groups that participated in this track. The participants have submitted 22 sets of rank lists in total, based on different methods and parameters. Based on all the performance evaluation measures: Chaouch's MDLA is in the first place, Lian's Rect+SHD+GSMD+MR is in the second place and Napoleon's MCC-Run3 is in the third place. This track is based on the NIST shape benchmark that we hope will provide valuable contributions to the 3D shape retrieval community.

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