

# Features for Art Painting Classification based on Vector Quantization of MPEG-7 Descriptors

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# Introduction

Different point of view to thought the ocean of accumulated digitalized culture:

- semantic content of the artwork;
- cultural influences;
- specific techniques;
- emotional responses;
- Etc.

Many efforts are aimed at combining text-based and content-based search technologies in real-world image retrieval.



# Used MPEG-7 Descriptors

- *Scalable Color (SC)* – color histogram in the HSV color space (vector with 64 attributes);
- *Color Layout (CL)* – spatial distribution of colors using *YCbCr* color space. Needs of special similarity measure to account weight of coefficients (vector with 12 attributes in selected case);
- *Color Structure (CS)* – specifies both color content and the structure of the content (vector with 64 attributes);
- *Dominant Color (DC)* – shows up to 5 dominant colors and their variance. It needs specific distance measures such as EMD;
- *Edge Histogram (EH)* – spatial distribution of 5 types of edges in local image regions (vector with 80 attributes);
- *Homogeneous Texture (HT)* – characterizes the region texture using the energy and energy deviation in a set of frequency channels (vector with 60 attributes).



# Vector Quantization Approach

- Splitting image into  $m \times n$  non-overlapping tiles;
- For each MPEG-7 descriptor  $X \in \{SC, CL, CS, DC, EH, HT\}$ :
  - For all tiles of paintings from learning set feature vector for each descriptor is calculated;
  - Applying clustering procedure for received vectors. In this realization the number of clusters for all descriptors are equal number  $\alpha$ ;
  - The centroids of clusters are calculated;
  - For each tile a value, which corresponds to the number of the cluster where the tile belongs to, is assigned;
  - for tiles not in the learning set, the membership of their centroids is calculated using L1 metric, and the number of the corresponding cluster is assigned as a value of the tile.

(1,1)	(1,2)	(1,3)	(1,4)
(2,1)	(2,2)	(2,3)	(2,4)
(3,1)	(3,2)	(3,3)	(3,4)
(4,1)	(4,2)	(4,3)	(4,4)



# Software realization

- Algorithm is realized as additional function in our laboratory "Art Painting Image Color Aesthetic and Semantic" (APICAS).
- For obtaining the MPEG-7 descriptors we refer to Multimedia Content Management System MILOS.
- As clustering algorithm we use "vcluster", which is part of CLUTO open source software package.
- As knowledge analysis and testing environment, we used the data mining analysis environment PaGaNe.

Ivanova, K., Stanchev, P., Dimitrov, B.: Analysis of the Distributions of Color Characteristics in Art Painting Images. *Serdica Journal of Computing*, Volume 2, Number 2, Sofia, pp. 111-136 (2008)

Amato, G., Gennaro, C., Rabitti, F., Savino, P.: Milos: a Multimedia Content Management System for Digital Library Applications. *Research and Advanced Technology for Digital Libraries: Volume 3232/2004 in Lecture Notes in Computer Science*, Springer, pp. 14-25 (2004)

Karypis, G.: CLUTO: A Clustering Toolkit Release 2.1.1. University of Minnesota, Department of Computer Science, Minneapolis, MN 55455, Technical Report: #02-017 (2003)

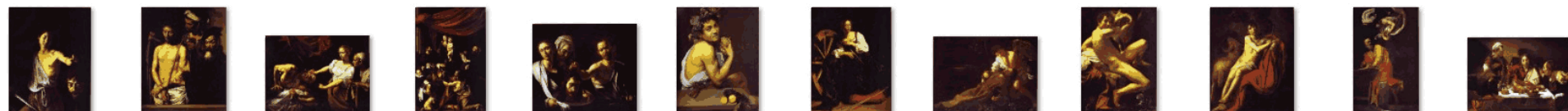
Mitov, I., Ivanova, K., Markov, K., Velychko, V., Vanhoof, K., Stanchev, P.: PaGaNe – a Classification Machine Learning System Based on the Multidimensional Numbered Information Spaces. *World Scientific Proceedings Series on Computer Engineering and Information Science*, No:2, pp. 279-286 (2009)



# Experiments

- 600 paintings of:
  - 18 artists from different movements of West-European fine arts;
  - one group represents Orthodox Iconographic Style from Eastern Medieval Culture.
- Sources:
  - different web-museums using ArtCyclopedia as a gate to the museum-quality fine art on the Internet;
  - different Eastern public virtual art galleries and museums for extracting Icons.

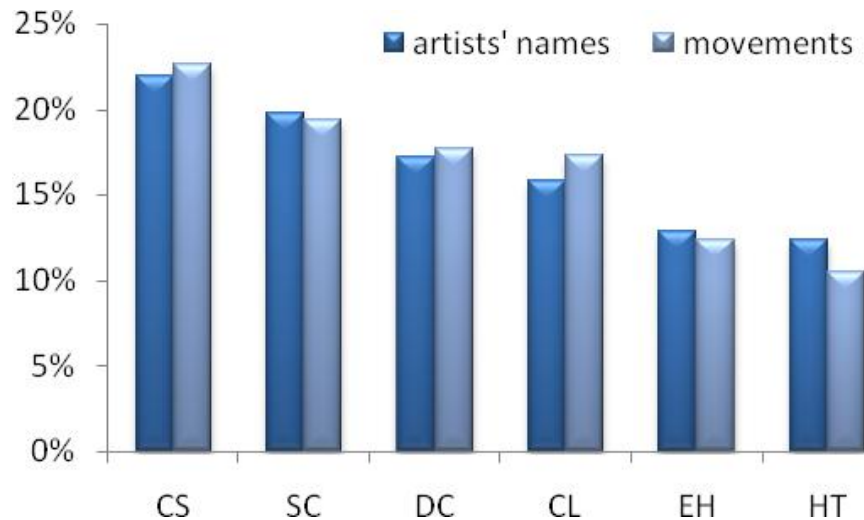
Movement	Artist
Icons (60)	Icons (60)
Renaissance (90)	Botticelli (30); Michelangelo (30); Raphael (30)
Baroque (90)	Caravaggio (30); Rembrandt (30); Rubens (30)
Romanticism (90)	Friedrich (30); Goya (30); Turner (30)
Impressionism (90)	Monet (30); Pissarro (30); Sisley (30)
Cubism (90)	Braque (30); Gris (30); Leger (30)
Modern Art (90)	Klimt (30); Miro (30); Mucha (30)





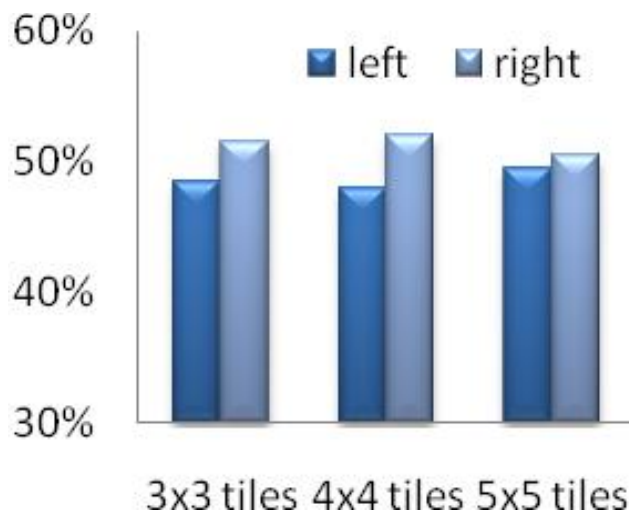
# Experiments

- Evaluation of the attributes in respect to the type of underlying MPEG-7 descriptor

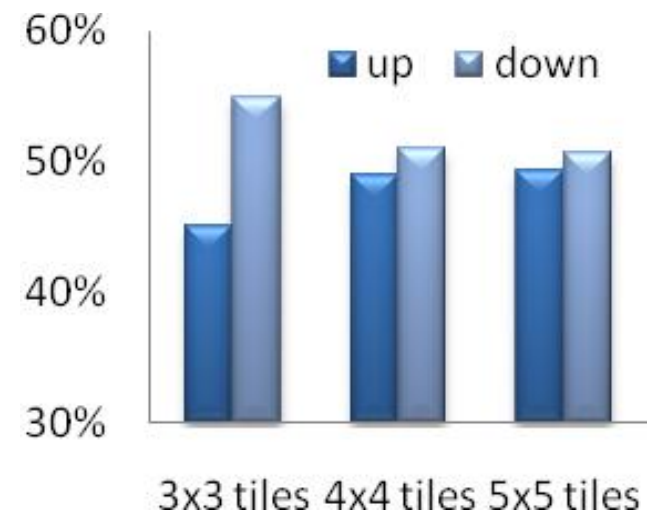


# Experiments

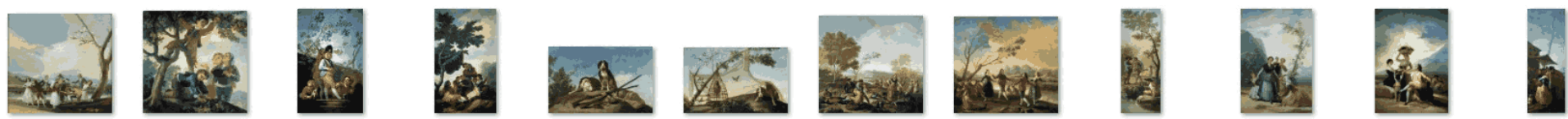
- Evaluation of the attributes in respect to the position of tiles (1)



Distribution of significance of left side and right side of the images



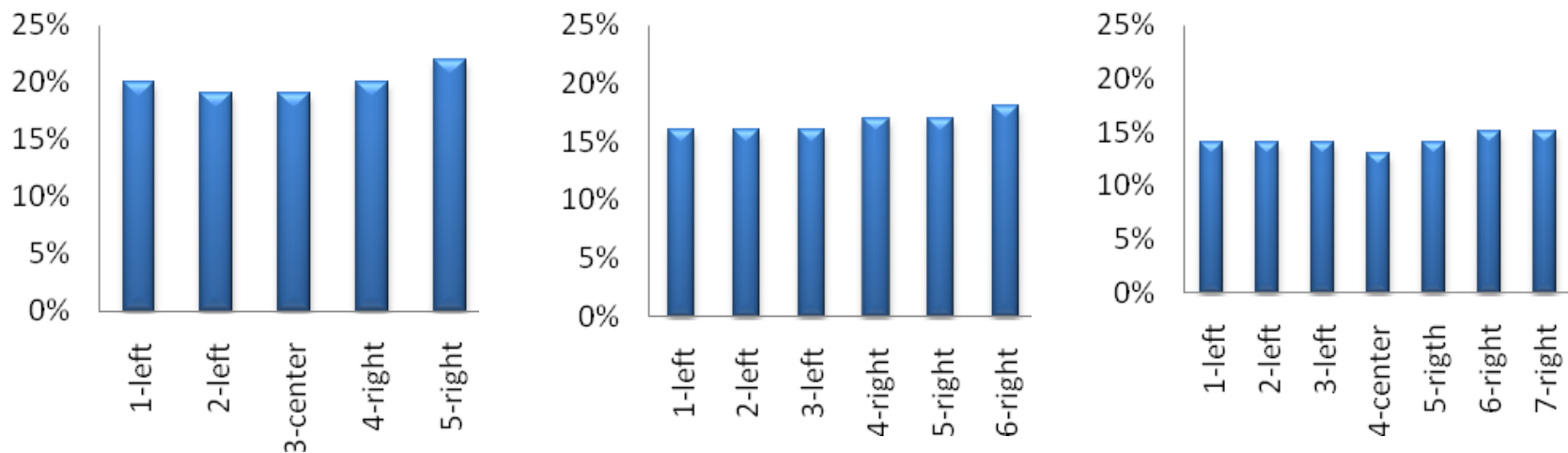
Distribution of significance of upper and lower zone of the images





# Experiments

- Evaluation of the attributes in respect to the position of tiles (2)

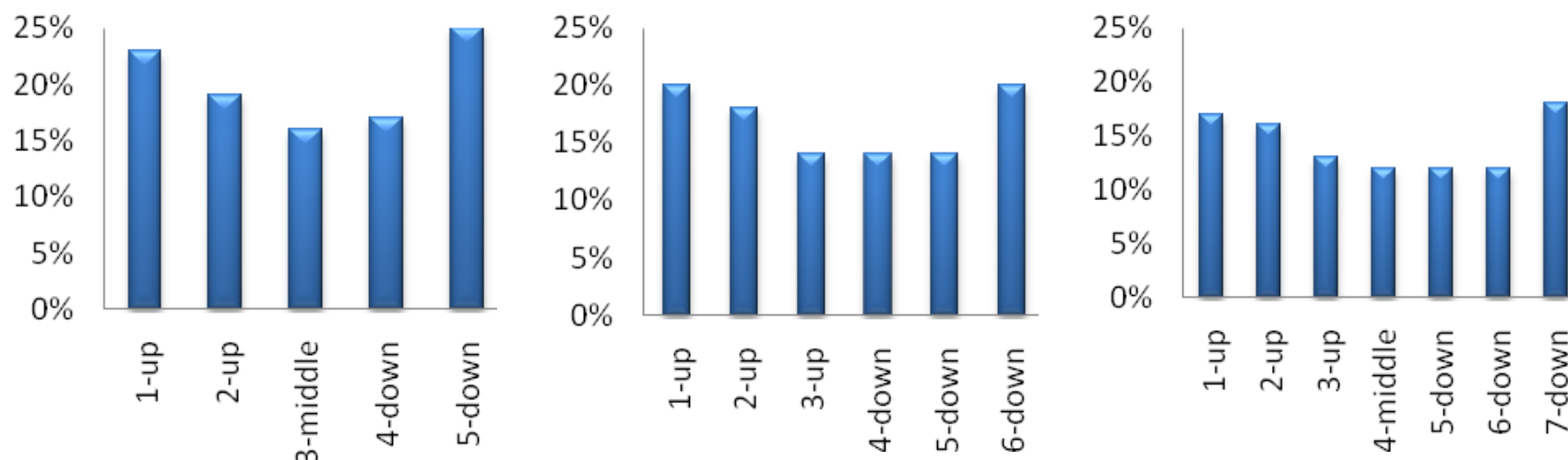


Distribution of significance of the tiles by position of **width** for different numbers of splitting: (a)  $m=5$ ; (b)  $m=6$ ; (c)  $m=7$ .

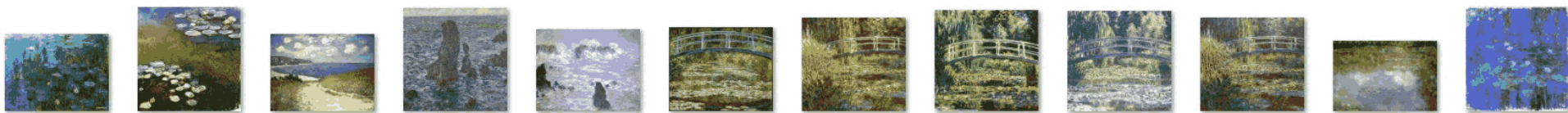


# Experiments

- Evaluation of the attributes in respect to the position of tiles (3)

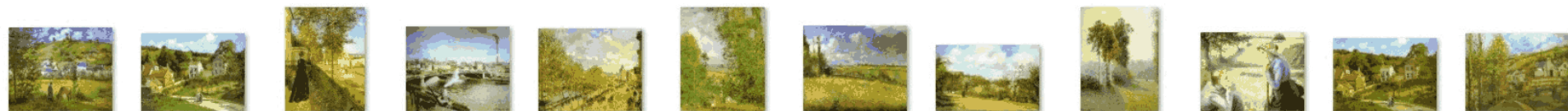
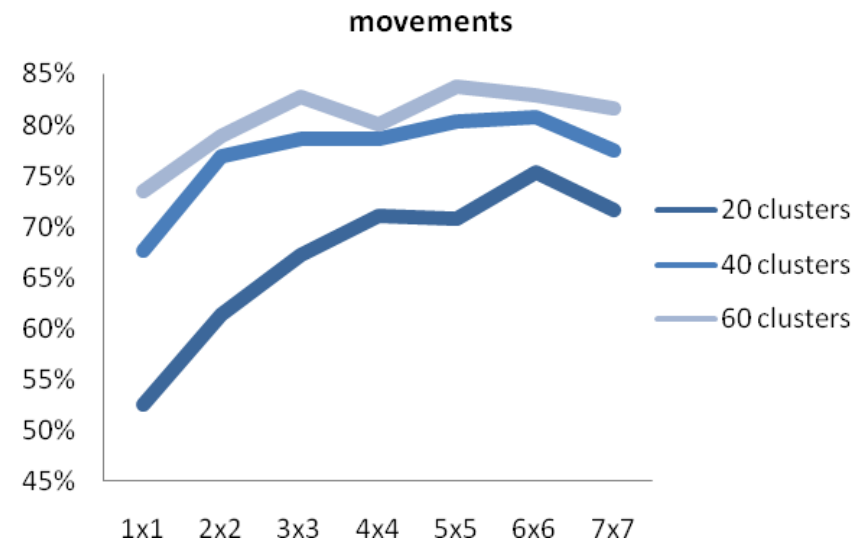
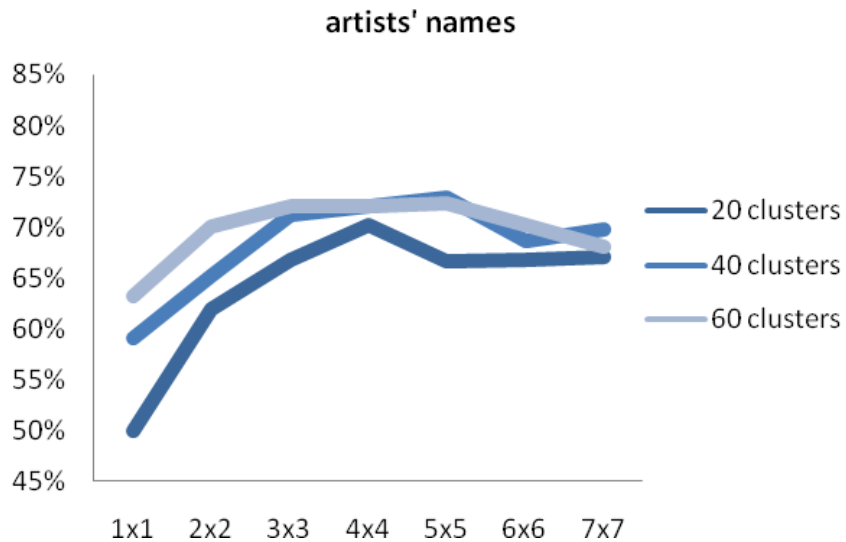


Distribution of significance of the tiles by position of **height** for different numbers of splitting: (a) n=5; (b) n=6; (c) n=7.



# Experiments

- Evaluation of the attributes in respect to the number of clusters



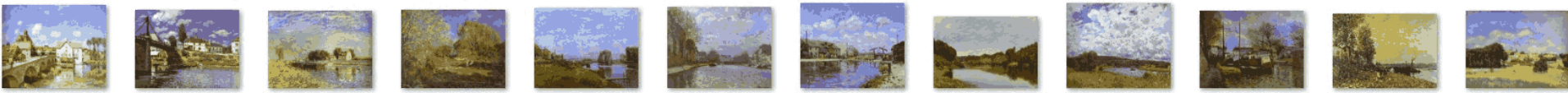
# Experiments

- **Evaluation of the classification accuracy by different types of classifiers**

We have compared classification accuracy for different type of classifiers, realized in Waikato Environment for Knowledge Analysis (WEKA) as well as with PGN-1 classifier, which is realized in our system PaGaNe.

We have made ten-fold cross validation.

Two datasets were used, which were both created with tiling and 40 clusters. The first data set uses the artist's name as the class variable and the second data uses the artist's movement as the class variable.



# Experiments

- **Evaluation of the classification accuracy by different types of classifiers**

We have aggregated some received results per group of classifiers as follows:

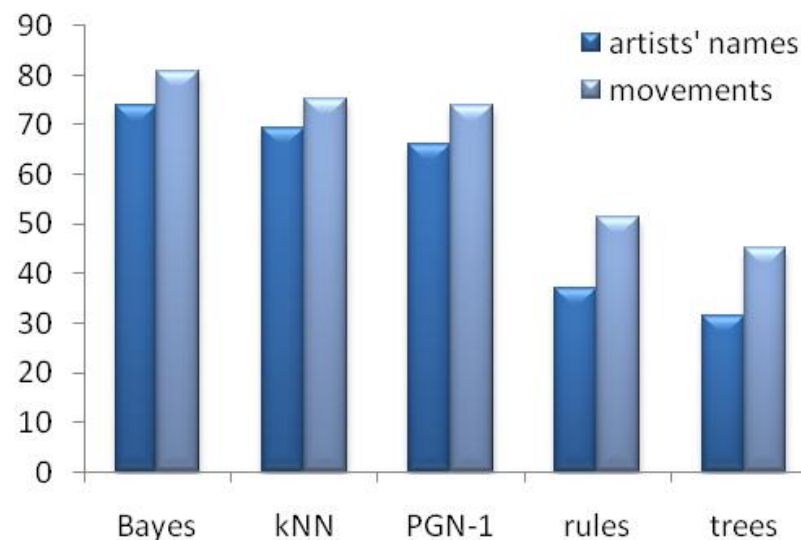
- Bayes (BayesNet, NaiveBayes, NaiveBayesSimple, NaiveBayesUpdateable, LBR);
- kNN (IB1, IBK, Kstar, HyperPipes, NNge);
- trees (ID3, J48, RandomTree, REPTree, SimpleCart, OLM);
- rules (DecisionTable, JRip, OneR, PART).

The rest of classifiers did not produce good results and we excluded them from the discussion.



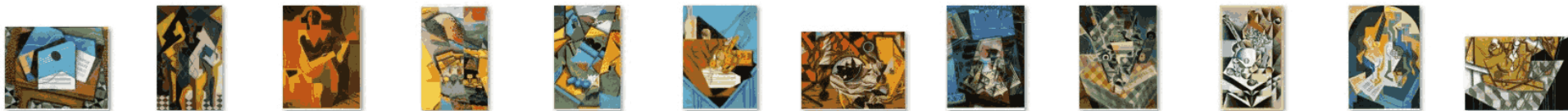
# Experiments

- **Evaluation of the classification accuracy by different types of classifiers**



PGN-1 has the accuracy precision like kNN classifiers, but with priority to build the set of generalized non-contradictory association rules.

We attend to use this property in further investigation, in order to search for definition of profiles of the artists or movements.



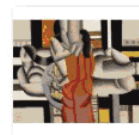


# Experiments

- Local analysis of the classification accuracy

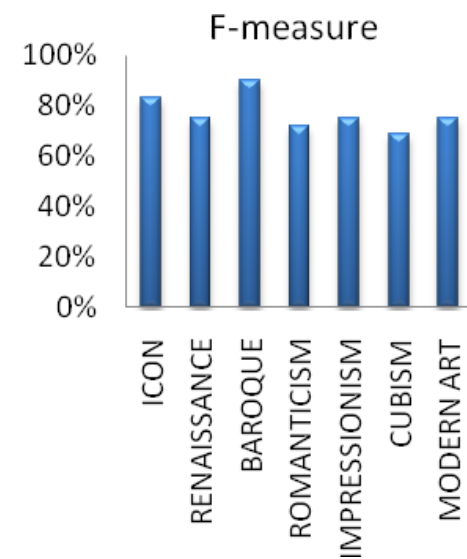
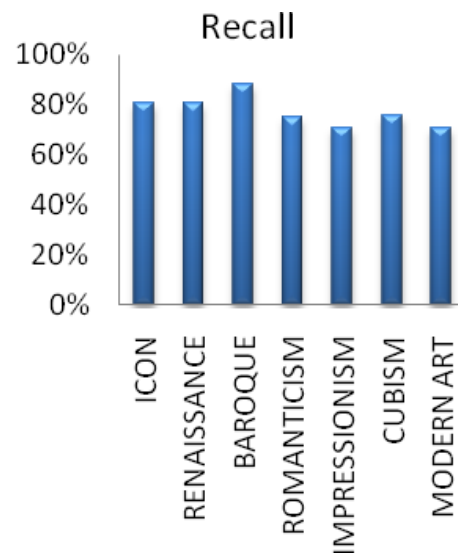
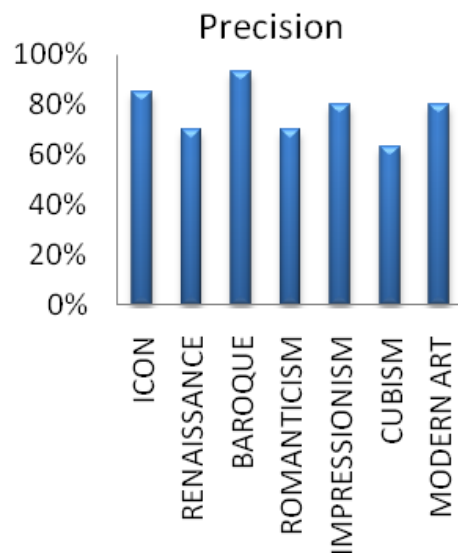
Confusion matrix for dataset with classes “movements”

	ICON	RENAISSANCE	BAROQUE	ROMANTICISM	IMPRESSIONISM	CUBISM	MODERN ART	<i>Sum by row</i>
ICON	17						3	20
RENAISSANCE		21		3	2	4		30
BAROQUE	1		28		1			30
ROMANTICISM		1	1	21	5		2	30
IMPRESSIONISM	1	1		1	24	1	2	30
CUBISM		2	2	3	1	19	3	30
MODERN ART	2	1	1		1	1	24	30
<i>Sum by column</i>	21	26	32	28	34	25	34	200



# Experiments

- Local analysis of the classification accuracy



# Conclusion

- In this article we have presented an approach for analyzing visual characteristics, based on MPEG-7 descriptors.
- The method allows huge reduction of the dimensionality of the data.
- For the used data sets, 4x4 tiling and 40 clusters seemed optimal.
- From the analysis we saw that the artist's palettes, which are captured in color descriptors, are a powerful tool for creating the profiles of art painting images. The texture descriptors (*EH*, *HT*), in our specific presentation, can not produce sufficient quality attributes to present the specifics of the brushwork of the artists.



# Thank you for attention !

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