



The First International Conference on Advances in Multimedia  
MMEDIA 2009  
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# COLOR HARMONIES AND CONTRASTS SEARCH IN ART IMAGE COLLECTIONS



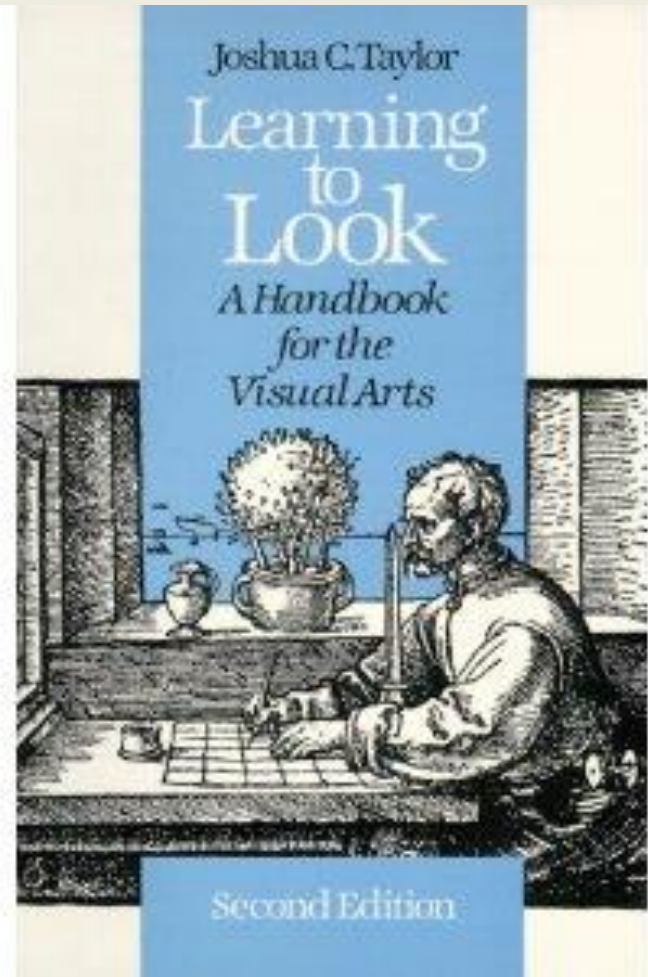
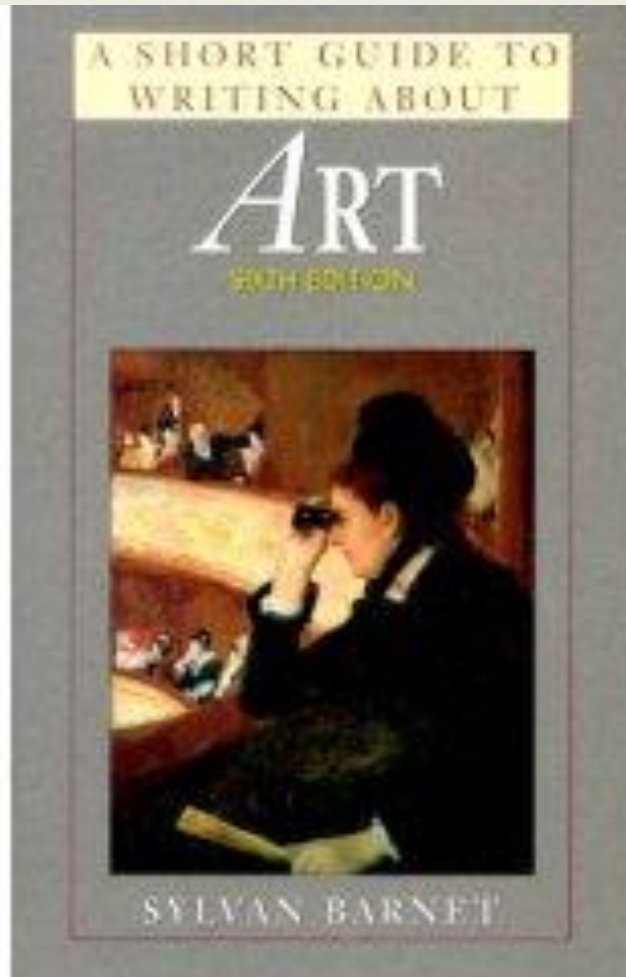
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# OBJECTIVES

1. Introduction
2. Human Perception of the Color
3. Classification of Harmonies
4. Experimental Software System Functionality
5. Experimental Software System Realization
6. Experiment Results
7. Conclusion and Future Work

# 1. INTRODUCTION. ANALYZING ART



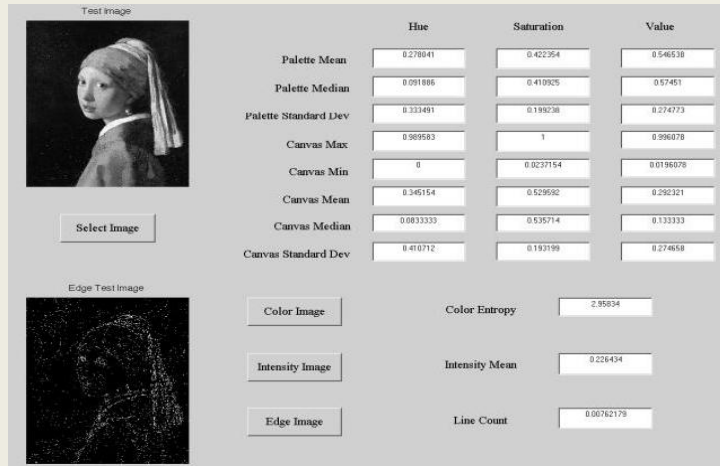
# IMAGE SEARCH

- ***Low level*** – this level includes basic perceptual features of visual content (dominant colors, color distribution, texture pattern, etc.).
- ***Intermediate level*** – this level forms next step of extraction from visual content, connected with emotional perceiving of the images, which usually is difficult to express in rational and textual terms. The visual art is area, where these features play significant role.
- ***High level*** – this level includes queries according to rational criterions. In many cases the image itself does not contain information which would be sufficient to extract some of the characteristics.

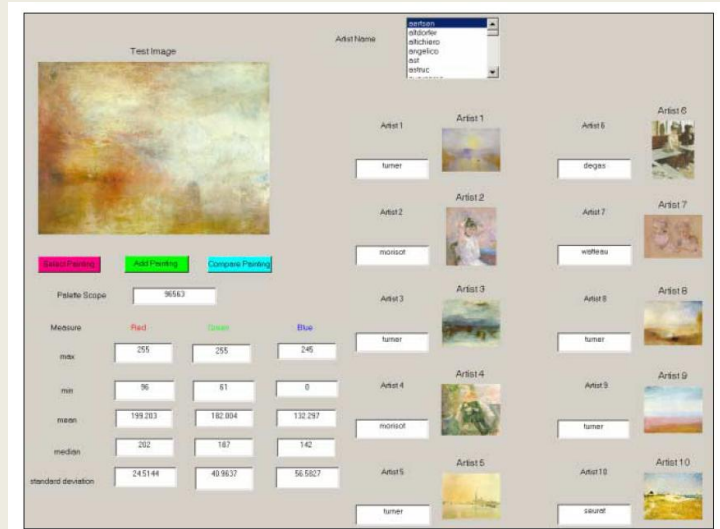
# PROJECTS IN THE ART DOMAIN

- *The Getty vocabulary databases* are produced and maintained by the Getty Vocabulary Program.
- *WordNet* is a large lexical database of English, developed under the direction of George A. Miller.
- *Iconclass* is a hierarchical system, developed by the Netherlands Institute for Art History. The "Pictorial Portrait Database" uses a hierarchical database indexing method based on Principal Component Analysis.

# A LIGHTWEIGHT IMAGE RETRIEVAL SYSTEM FOR PAINTINGS

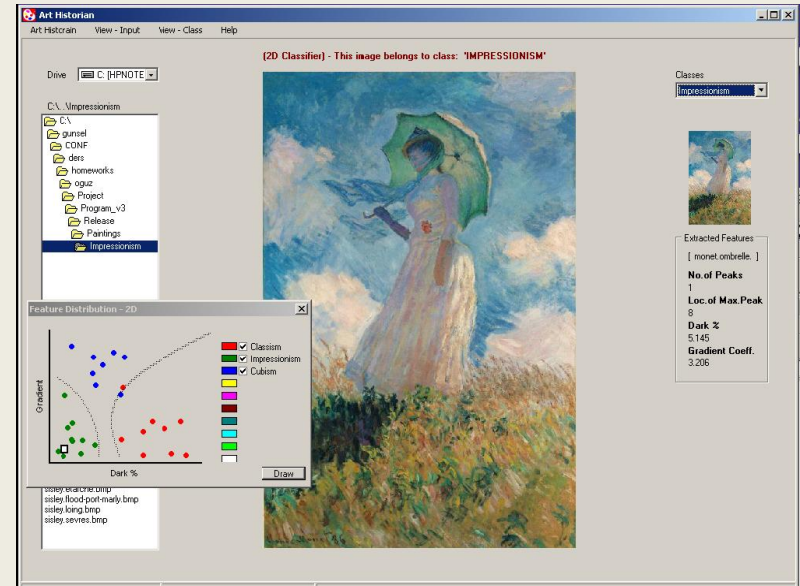
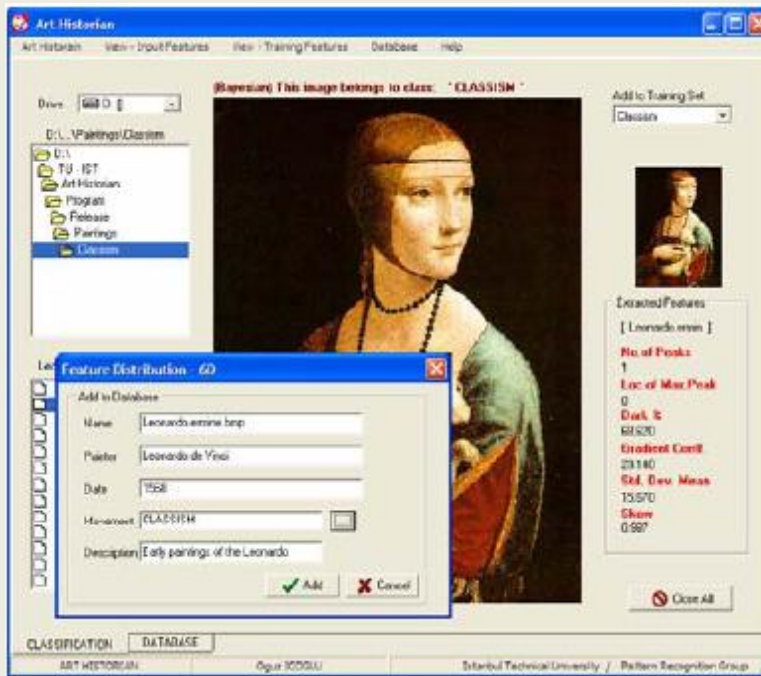


- canvas features: max, min, mean, median, and standard deviation from each of the red, green, and blue color channels;
- color features: intensity mean (measures the global brightness of a grayscale image), color frequency distribution (measures the degree of disorder found in the frequency distribution of colors in a painting);
- edge characteristics: line count (uses the Sobel edge detector to identify lines in the image).



# ART HISTORIAN SYSTEM

In the classifier design, statistical pattern recognition approach is exploited and Bayesian, k-NN and SVM classifiers are employed



The system automatically classifies the art movement that the query example belongs to and brings the best matching paintings belonging to the same movement in a ranked order

# PICTORIAL PORTRAIT DATABASE



The system uses a hierarchical database indexing method based on Principal Component Analysis.

The description incorporates the eyes, as the most salient region in the portraits.

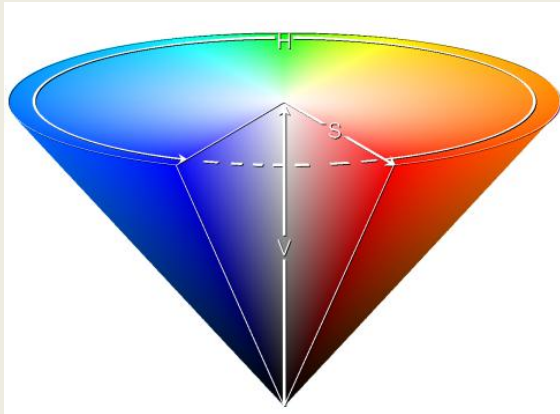


# HAND DRAWINGS OF EUGENE DELACROIX

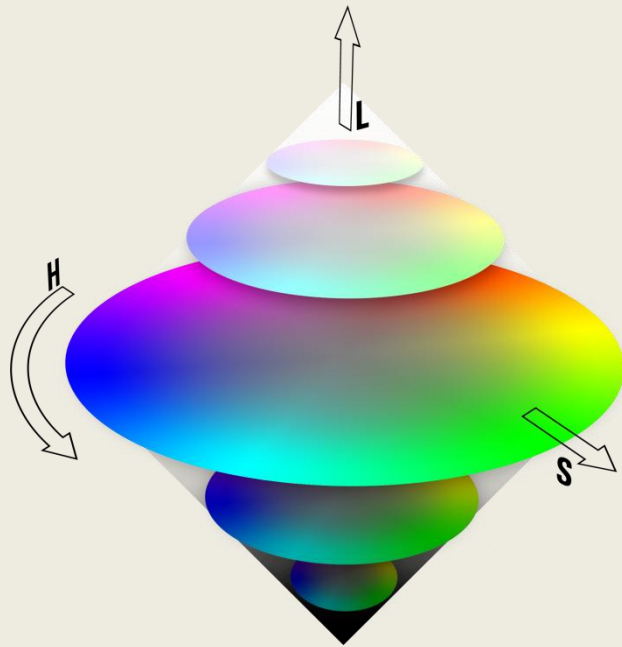


Using only five features:  
three measured the ratio of black  
and white pixels  
and two measured stroke  
direction.

## 2. HUMAN PERCEPTION OF THE COLOR – COLOR MODELS



HSV



HSL



Munsell

## 2. HUMAN PERCEPTION OF THE COLOR - HARMONIES AND CONTRASTS

- 1510 - Leonardo da Vinci had probably been the first to notice that when observed adjacently, colors will influence each other;
- 1772 –Johann Lambert constructed color pyramid and demonstrated for the first time that the complete fullness of colors can only be reproduced within a three dimensional system;
- 1772 - Ignaz Schiffermüller has published color circle where complementary colors are arranged opposite one another;
- 1810 - Goethe was the first to specifically draw attention to these associated contrasts;
- 1839 - Michel Eugène Chevreul had established a law of "Simultaneous Contrast“;
- Johannes Itten has defined and identified strategies for successful color combinations;
- Later additional contrasts such as Split-complementary contrast, Double-complementary contrast, Triads contrast, etc. have been suggested by various researchers.

## 2. HUMAN PERCEPTION OF THE COLOR – ARTISTS' COLOR WHEEL



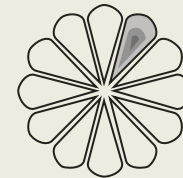
Artists' color wheel



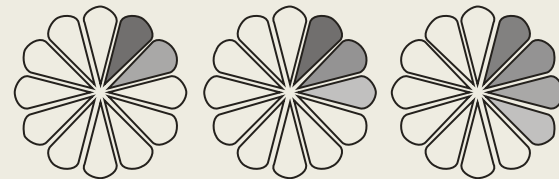
Hue positions in  
HSL and HSV color spaces

# 3.1. HARMONIES FROM POINT OF VIEW OF HUE

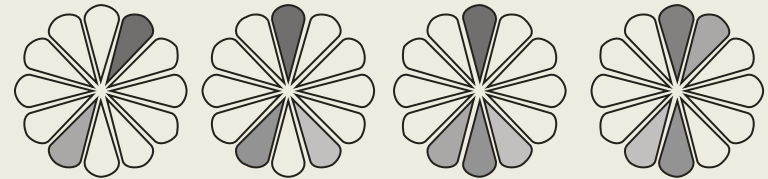
a) Monotone compositions



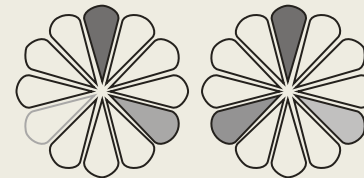
b) Analogous hues



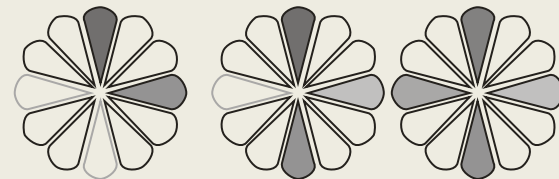
c) Complementary contrasts



d) Triads



e) Tetrads



f) Achromatic compositions

## 3.2. HARMONIES BASED ON THE GROUP OF HUES (WARM-COLD CONTRAST)

- a) *Warm*: The image is warm when composition is built from family of warm colors
- b) *Cold*: By analogy – the image is cold when it is composed only (or predominantly) with cold colors
- c) *Neutral*: The composition contains colors mainly from neutral zones
- d) *Warm-cold*: The composition lays in this category when the percentage of cold family is in some proportion to the percentage of warm family
- e) *Warm-neutral*: In such compositions there is proportion between warm colors and neutral ones
- f) *Cold-neutral*: The image contains cold and neutral tones in some proportion

### 3.3. HARMONIES FROM POINT OF VIEW OF SATURATION

- a) *Dull*: An image can be classified as dull when composition is constructed mainly from dull colors
  
- b) *Clear*: Clear images have been build mostly from clear (spectral and near to spectral, respectively only with varying in lightness) colors
  
- c) *Different proportion of saturations*: Usually in composition of clear colors in combination of dull ones. Depending on content of different saturation and of distance between predominate quantities harmonies can be defined such as *smooth*, *contrary*, etc.

## 3.4. HARMONIES FROM POINT OF VIEW OF LIGHTNESS

- a) *Dark*: Dark compositions are built mainly from dark colors
- b) *Light*: Light images contain mostly colors near white
- c) *Different proportion of lightness*: Light colors combined with dark ones compose the image. Depending on content of different lightness and of distance between predominate quantities contrasts can be defined as: *smooth, contrary, etc.*



# 4. EXPERIMENTAL SOFTWARE SYSTEM FUNCTIONALITY

The screenshot shows a software window titled "Pictures list 0-DataM.Arm" with a menu bar containing "Help" and "About". The working directory is "C:\AICSS\\_images\Art". The "Settings" tab is active, displaying three color quantization sliders and several numerical input fields.

**Quantization of Hue:** A horizontal color bar with 14 segments. The number of quanta is set to 11. The values for each segment are: [0] (Red) 0.0, [1] 7.5, [2] 22.5, [3] 37.5, [4] 52.5, [5] 75.0, [6] 105.0, [7] 150.0, [8] 210.0, [9] 255.0, [10] 285.0, [11] 315.0, [12] 345.0, [13] (Red) 360.

**Quantization of Saturation:** A horizontal saturation bar with 6 segments. The number of quanta is set to 4. The values are: [0]-Dull 0.000, [1] 0.200, [2] 0.400, [3] 0.600, [4] 0.800, [5]-Clear 1.000.

**Quantization of Luminance:** A horizontal luminance bar with 6 segments. The number of quanta is set to 4. The values are: [0]-Black 0.000, [1] 0.200, [2] 0.400, [3] 0.600, [4] 0.800, [5]-White 1.000.

**Minimal percentage of color content:** Hue: 80.00, Saturation: 80.00, Luminance: 80.00.

**Minimal quantity of values of corresponded feature to define image as:**  
warm: 80.00, clear: 50.00, light: 50.00  
cold: 80.00, dull: 50.00, dark: 50.00

**Contrast settings:** warm/cold contrast: 50.00, clear/dull contrast: 50.00, light/dark contrast: 50.00.

A "Fill default values" button is located at the bottom right of the settings area.

The status bar at the bottom shows "View", "+", "-", "Ins", "15%", and "15.02.2009 r. 17:58:44".

# HUE HARMONY

Hue array:

$$H (h_{-1}, h_0, \dots, h_{NH-1})$$

$$NH=12$$

$h_{-1}$  contains percentage of achromatic tones;

$h_0$  to  $h_{NH-1}$  contain percentage of colors, ordered from reds ( $h_0$ ) to purples ( $h_{NH-1}$ )

Hue order vector:

$$(nh; p_1, p_2, \dots, p_{nh}),$$

$$nh \in \{0, \dots, 5\}$$

$$p_i \in \{-1, \dots, NH-1\} \text{ and } h_{p_i} \geq h_{p_{i+1}}, i \in \{1, \dots, nh-1\}$$

$$nh : \begin{cases} nh = 1 & \text{if } h_{p_1} \geq x \\ nh = n & \text{if } \sum_{i=1}^{n-1} h_{p_i} < x \text{ and } \sum_{i=1}^n h_{p_i} \geq x \end{cases}$$

# HUE HARMONY

$$\textit{opposite}(p) = \begin{cases} p + NH \textit{ div } 2 & \textit{ if } p \leq NH \textit{ div } 2 \\ p - NH \textit{ div } 2 & \textit{ if } p \geq NH \textit{ div } 2 \end{cases}$$

$$\textit{l\_neighbour}(p) = \begin{cases} NH - 1 & \textit{ if } p = 0 \\ p - 1 & \textit{ if } p \textit{ in } \{1, \dots, NH - 1\} \end{cases}$$

$$\textit{r\_neighbour}(p) = \begin{cases} 0 & \textit{ if } p = NH - 1 \\ p + 1 & \textit{ if } p \textit{ in } \{0, \dots, NH - 2\} \end{cases}$$

$$\textit{l\_triad}(p) = (NH + p - NH \textit{ div } 3) \textit{ mod } NH$$

$$\textit{r\_triad}(p) = (p + NH \textit{ div } 3) \textit{ mod } NH$$

$$\textit{l\_tetrad}(p) = (NH + p - NH \textit{ div } 4) \textit{ mod } NH$$

$$\textit{r\_tetrad}(p) = (p + NH \textit{ div } 4) \textit{ mod } NH$$

Achromatic  
Monochromatic

Analogous

Complementary  
Split complementary  
Double Complementary

(Partial) Triad

(Partial) Tetrad

Multicolor

# TERM DEFINITIONS

- Cold/warm contrast

$$P_{warm} = \sum_{i \text{ in } \{0,1,2\}} p_i + \frac{1}{2} \sum_{i \text{ in } \{11,3\}} p_i$$

$$P_{cold} = \sum_{i \text{ in } \{7,8\}} p_i + \frac{1}{2} \sum_{i \text{ in } \{6,9\}} p_i$$


$$P_{neutral} = \sum_{i \text{ in } \{4,5,10\}} p_i + \frac{1}{2} \sum_{i \text{ in } \{11,3,6,9\}} p_i$$

# TERM DEFINITIONS

- Saturation order vector
- Saturation combinations
- Lightness order vector
- Lightness combinations

# 5. EXPERIMENTAL SOFTWARE SYSTEM REALIZATION

**BABUREN - THE PROCURESS, 1622, OIL ON CANVAS.JPG**



BABUREN - THE PROCURESS, 1622, OIL ON CA  
NVAS.JPG

dominant hues: %

1 :	1 Orange	51.20
2 :	2 Yellow	34.50

Warm 2-Analogous  
2-1/2

dominant saturations: %

1 :	2 neutral	49.90
2 :	1 dull	34.70
3 :	3 clear	11.40
4 :	very dull	3.20
5 :	4 very clear	0.70

Neutral smooth-2  
2-2/1

dominant luminances: %

1 :	1 dark	47.10
2 :	very dark	23.70
3 :	2 middle	20.70
4 :	3 light	8.10
5 :	4 very light	0.40

Dark smooth-3  
3-1/0/2


# 5. SOFTWARE SYSTEM REALIZATION

Result

Help

Hue contrast: \*Analogous  
 Warm/cold: Warm  
 Dark/Light: Light

1  1




**AVERCAMP**  
 WINTER SCENE AT YSELMUIDEN  
 3-2/1/3 3-Analogous Warm  
 3-1/2/0 smooth-3 Dull  
 3-4/1/2 3- Light



**FRIEDRICH**  
 MOON RISING OVER THE SEA  
 2-2/3 2-Analogous Warm  
 3-4/3/2 smooth-3 Clear  
 3-3/0/1 3- Light




**FRIEDRICH**  
 WOMAN ON THE BEACH OF RUGEN  
 3-1/2/0 3-Analogous Warm  
 4-4/3/2/1 variety-4 Clear  
 4-4/1/3/0 variety-4 Light




**Leger**  
 Three Women and Still Life (De  
 3-2/3/1 3-Analogous Warm  
 2-0/1 smooth-2 Dull  
 4-3/4/1/0 variety-4 Light



**MORISOT**  
 THE CRADLE  
 3-0/1/11 3-Analogous Warm  
 2-0/1 smooth-2 Dull  
 3-3/4/1 3- Light



**MORISOT**  
 YOUNG GIRL IN WHITE  
 2-2/1 2-Analogous Warm  
 3-4/3/2 smooth-3 Clear  
 3-3/2/4 smooth-3 Light



**Picasso**  
 Female Bather with Raised Arms  
 2-2/1 2-Analogous Warm  
 4-1/0/2/3 variety-4 Dull  
 3-4/3/0 contrary-3 Light



**Picasso**  
 Les Femmes d'Alger (O. J.)  
 3-1/0/2 3-Analogous Warm  
 2-0/1 smooth-2 Dull  
 3-3/2/1 smooth-3 Light



**Picasso**  
 Nude (Bust)  
 2-2/1 2-Analogous Warm  
 3-2/1/3 smooth-3 Neutral  
 3-3/2/1 smooth-3 Light



**Picasso**  
 The Girl with a Goat  
 2-2/3 2-Analogous Warm  
 2-3/4 smooth-2 Clear  
 3-3/4/2 smooth-3 Light



**SCHIELE**  
 SELF-PORTRAIT WITH OUTSTRETCHED ARMS  
 2-2/3 2-Analogous Warm  
 3-2/1/3 smooth-3 Neutral  
 3-3/1/4 3- Light



**SCHIELE**  
 SEMI-NUDE GIRL  
 2-2/1 2-Analogous Warm  
 2-2/1 smooth-2 Neutral  
 3-3/2/4 smooth-3 Light

Ins15%

19.02.2009 r. 00:51:53

**HLSIA**

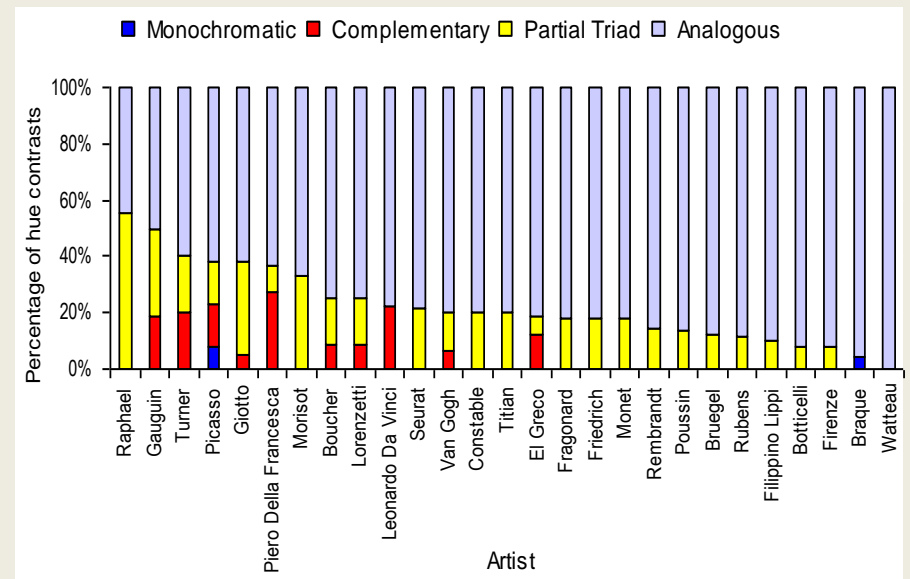
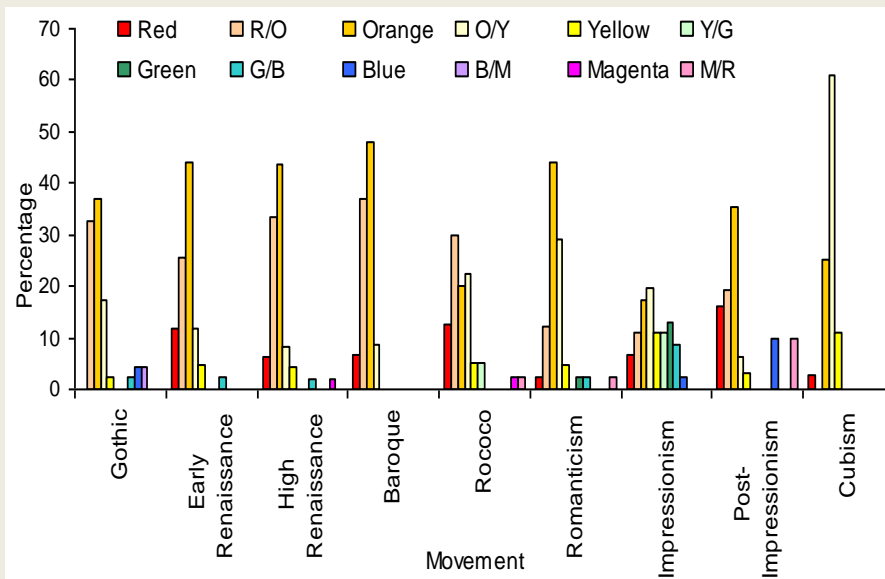
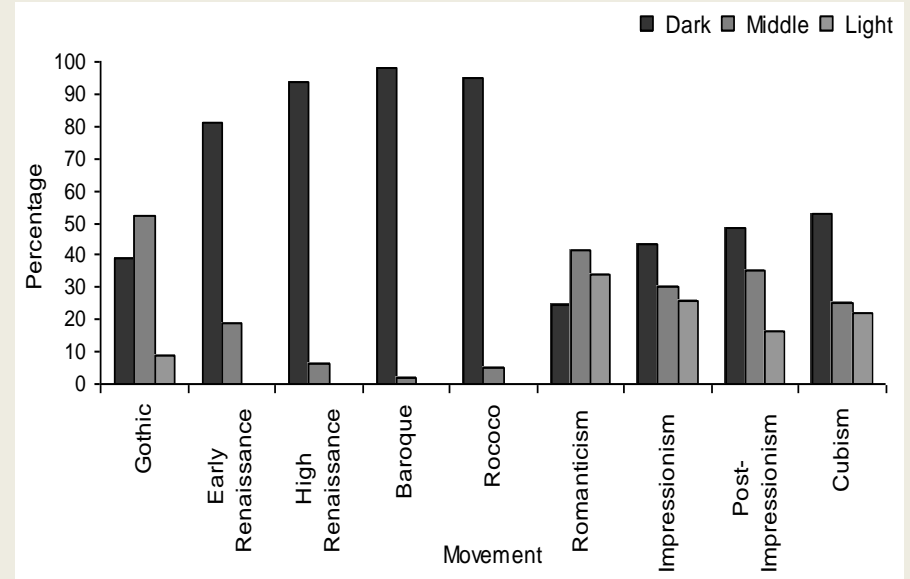
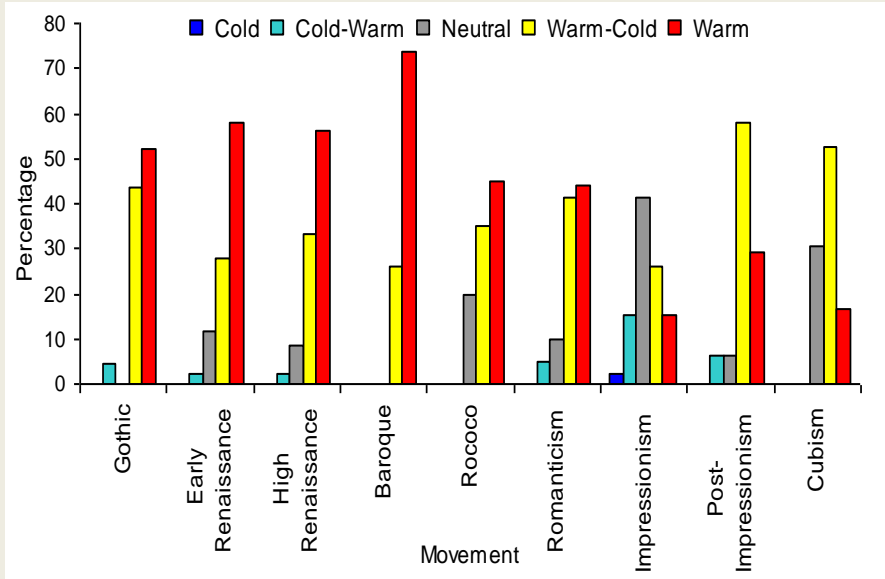


# 6. EXPERIMENTAL RESULTS

TABLE I. LIST OF THE ARTISTS, WHICH PAINTINGS WERE USED IN EXPERIMENTS, CLUSTERED BY MOVEMENTS

<i>Movement</i>	<i>Artist (number of images)</i>
Gothic (46)	Firenze (13), Giotto (21), Lorenzetti (12)
Early Renaissance (43)	Botticelli (13), Leonardo Da Vinci (9), Filippino Lippi (10), Piero Della Francesca (11)
High Renaissance (48)	Bruegel (8), El Greco (16), Raphael (9), Titian (15)
Baroque (46)	Poussin (15), Rembrandt (14), Rubens (17)
Rococo (40)	Boucher (12), Fragonard (22), Watteau (6)
Romanticism (41)	Constable (15), Friedrich (11), Turner (15)
Impressionism (46)	Monet (17), Morisot (15), Seurat (14)
Post Impressionism (34)	Gauguin (18), Van Gogh (16)
Cubism (36)	Braque (23), Picasso (13)

# 6. EXPERIMENTAL RESULTS



# 7. CONCLUSION AND FUTURE WORK



Cold-warm-contrast in “Le Moulin de la Galette” by Auguste Renoir, and “Houses of Parliament” by Clode Monet



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