Colour Image Processing

Joan Batlle, Lluís Pacheco,
Institute of Informatics and Applications
University of Girona. Technical School
Av. Lluís Santaló sn 17071 Girona, Spain
{jbatlle, lluispa@eia.udg.edu}

Abstract **– In the context of he round table the following topics related to image colour processing will be discussed: Historical point of view. Studies of Aguilonius, Gerritsen, Newton and Maxwell. CIE Standard (Commission International de l'Eclaraige). Colour Models. RGB, HIS, etc. Colour segmentation based on HSI model. Industrial applications. Summary and discussion. At the end, video images showing the robustness of colour in front of B/W images will be presented.**

Index Terms – colour processing, colour models.

I. Introduction

Colour perception can be broken down in four stages:

- The light source.
- The "coloured" object.
- The eye with a colour-sensitive mechanism.
- The brain to interpret the energy messages received.

The human eye:

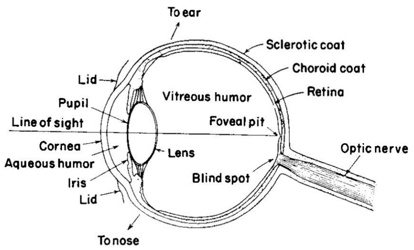


Fig. 1.1. A horizontal section through the human eye.

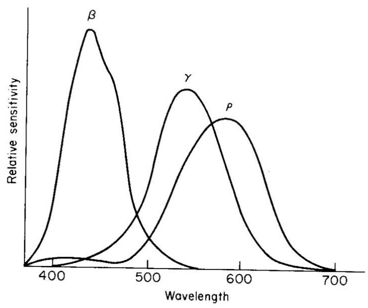
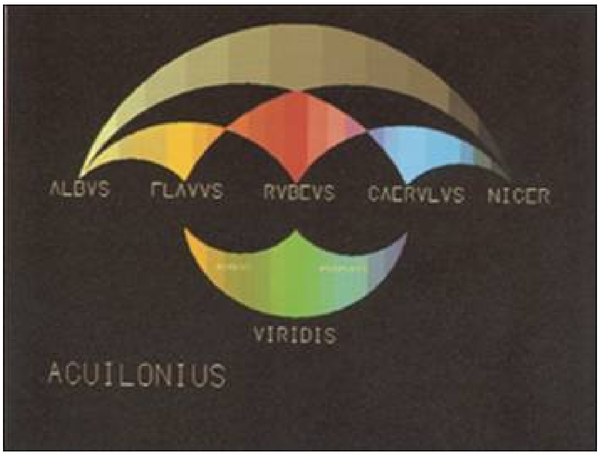


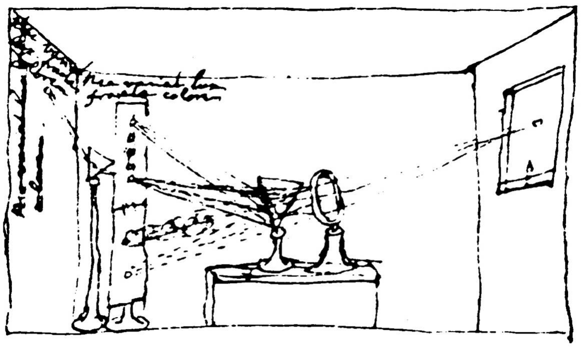
Fig. 1.2. Probable sensitivity curves of the colour receptors.

II. Human and Scientific Points of View of Colour Interpretation Trhought The History

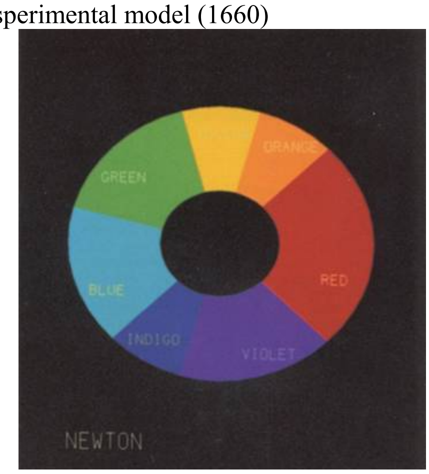
Aguilonius model - 1613



Newton's experiment

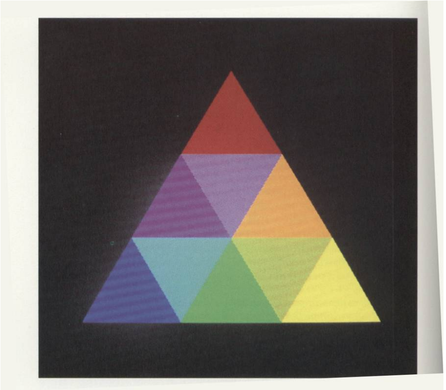


Frans Gerritsen adaptation (1988) of Newton's esperimental model (1660)



Goethe Triangle (1747-1832)

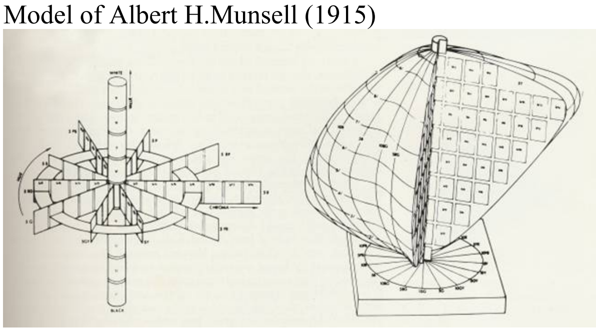
1-4244-2577-8/08/$20.00 ©2008 IEEE

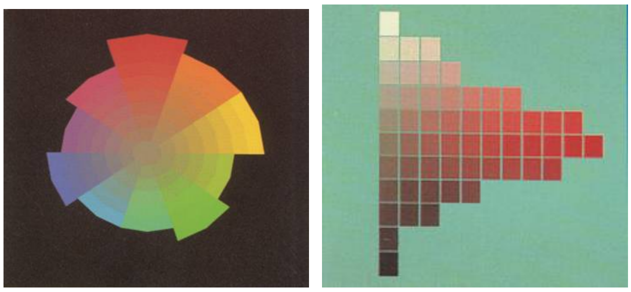


Maxwell Triangle (1872)

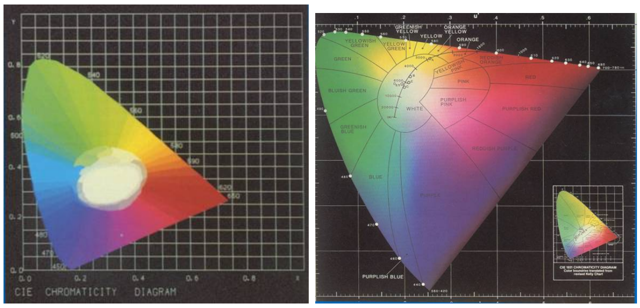
Modified Maxwell's Triangle (1747-1832)

Model of Albert H.Munsell (1915)

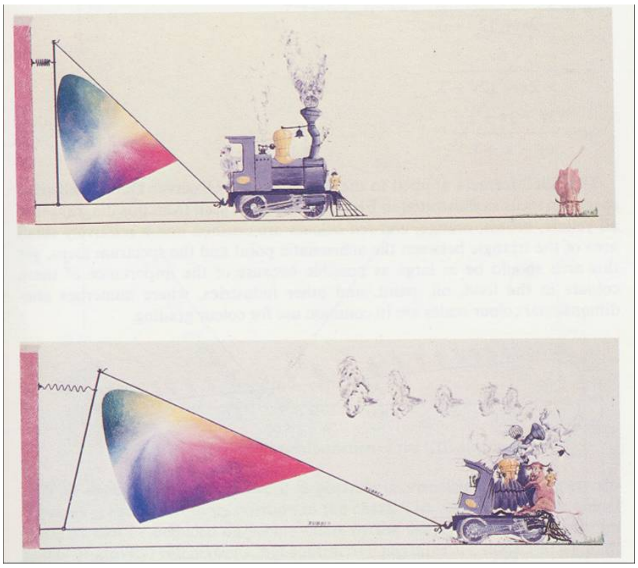




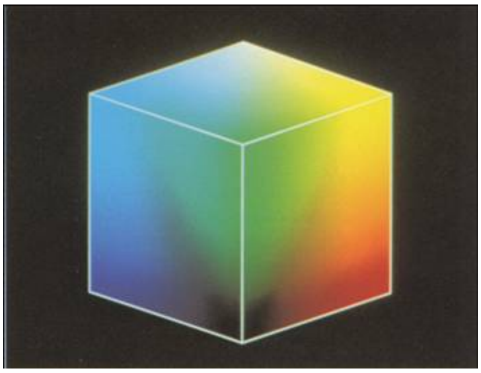
CIE - Commission International de l'Eclaraige (1931). Uniformed Space Colour (1976)



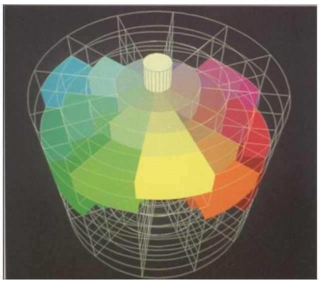
Judd Transformation (1931), adapted by CIE in 1960

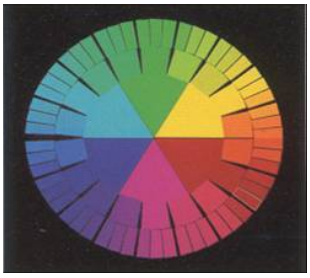


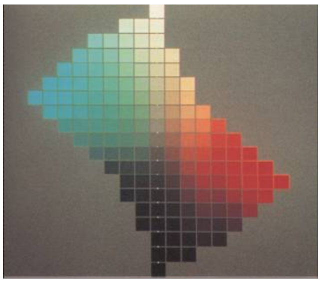
RGB Model of the CIE



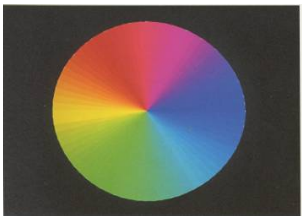
Gerritsen Space (1975)







HSI Model



Hue: wave length

$$H = \cos^{-1}\left(\frac{\frac{1}{2}\left((R-G)+(R-B)\right)}{\sqrt{(R-G)^2+(R-B)(G-B)}} \right)$$

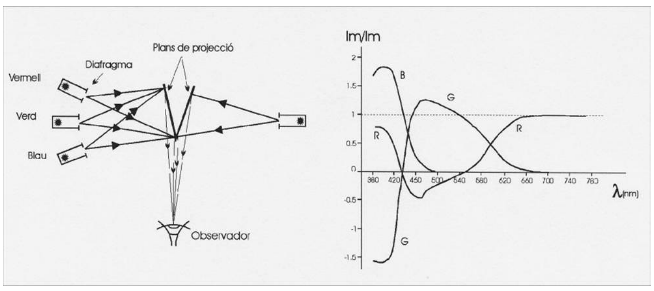
Saturation: colour purity

$$S = 1 - \frac{min\,(R,G,B)}{\frac{R+G+B}{3}}$$

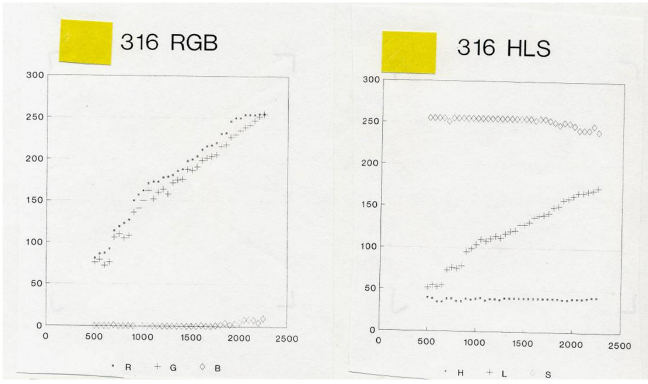
Intensity: amount of reflected light by one object

$I = (R + G + B) / 3$

Human perception and eye calibration.

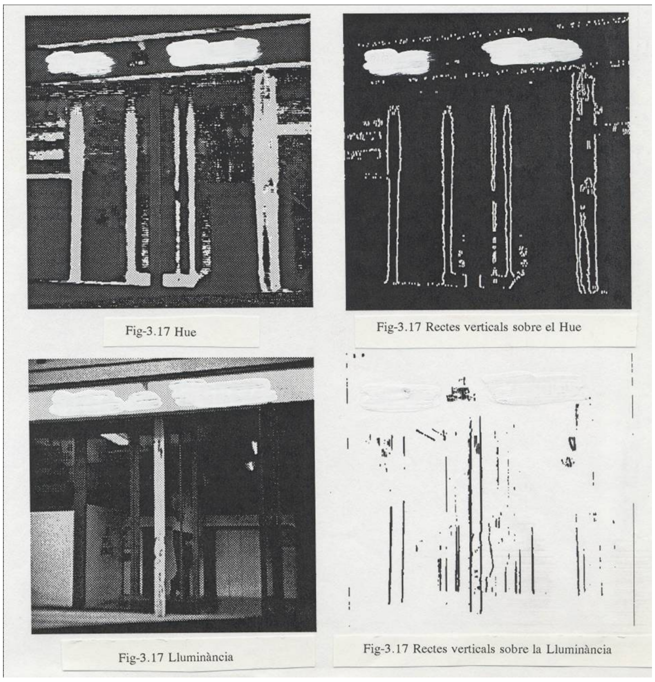


RGB versus HSI stability in front of illumination changes. Robustness of HUE.



Invariants (vertical straight lines). Colour versus B/W images.

Extracted vertical straight lines from colour and B/W information



Robustness in front of illumination changes

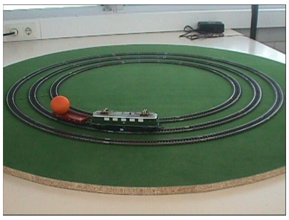
500 Lux

1600 Lux

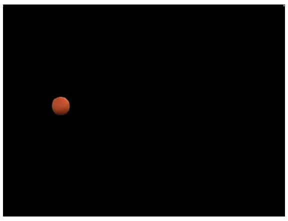
H= 37 R = 145
S= 189 G = 131
L= 18 B = 24

H= 33 R = 210
S= 199 G = 190
L= 35 B = 35

Real time segmentation using Hue component



Source image



Segmented imag

III. Common Colour Spaces

R G B: R or R/(R+G+B)
B or B/(R+G+B)
G or G/(R+G+B)

HSI (Carron i Lambert):

$$H = \begin{cases} \arccos\left(\dfrac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{(R-G)^2+(R-B)(G-B)}} \right) & if\, B \le G \\ 2\Pi - \arccos\left(\dfrac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{(R-G)^2+(R-B)(G-B)}} \right) & if\, B > G \end{cases}$$

$$S = 1 - \frac{min(R,G,B)}{I} \qquad I = \frac{R+G+B}{3}$$

HSV (Smith):

$$H = \begin{cases} 60 * (b' - g') & if\, R = max(R,G,B) \\ 60 * (2 + r' - b') & if\, G = max(R,G,B) \\ 60 * (4 + r' - g') & if\, B = max(R,G,B) \end{cases}$$

$$S = \frac{max(R,G,B) - min(R,G,B)}{max(R,G,B)}$$

$$V = max(R,G,B)$$

Where:

$$r' = \frac{max(R,G,B) - R}{max(R,G,B) - min(R,G,B)}$$

$$g' = \frac{max(R,G,B) - G}{max(R,G,B) - min(R,G,B)}$$

$$b' = \frac{max(R,G,B) - B}{max(R,G,B) - min(R,G,B)}$$

HSV (Tenenbaum):

$$H = arctan\left(\frac{\sqrt{3}(G-B)}{2R-G-B} \right) \qquad V = \frac{R+G+B}{3}$$

$$S = 1 - 3 * min\left(\frac{R}{R+G+B}, \frac{G}{R+G+B}, \frac{B}{R+G+B} \right)$$

Espai CIEL*a*b (Celenk):

X = 2.769 R – 1.751 G + 1.130 B
Y = 1.000 R – 4.590 G + 0,060 B
Z = 0.000 R – 0.056 G + 5.594 B

$$L^* = 116[Y/Y_0]^{1/3} - 16 \quad Y/Y_0 > 0.01$$

$$a^* = 500\left[(X/X_0)^{1/3} - (Y/Y_0)^{1/3}\right] \quad X/X_0 > 0.01$$

$$b^* = 200\left[(Y/Y_0)^{1/3} - (Z/Z_0)^{1/3}\right] \quad Z/Z_0 > 0.01$$

$$L^* = L^* \qquad H^\circ = tan^{-1}(b^*/a^*)$$

$$C^* = \left(a^{*2} + b^{*2}\right)^{1/2}$$

OHTA Model:

$$I_1 = \frac{R+G+B}{3} \qquad I_2 = R - B \qquad I_3 = \frac{2G - R - B}{2}$$

Joblove/Greenbegr's model

This is a linear model almost the same as Smith one that presents a small modification on the saturation, the transformation you can see below:

V = (max(R,G,B) + min (R,G,B))/2

$$S = \begin{cases} \dfrac{\max(R,G,B) - \min(R,G,B)}{\max(R,G,B) + \min(R,G,B)}, & si V \le 0.5 \\ \dfrac{\max(R,G,B) - \min(R,G,B)}{2 - \max(R,G,B) - \min(R,G,B)}, & \text{en alters casos} \end{cases}$$

Tenenmaum's model

This is a non linear model that presents almost the same bases as the HIS model complemented before (previous page). Its transformations are presented below:

$$H = \arctan \frac{\sqrt{3}(G-B)}{(2R-G-B)}$$

$$S = 1 - 3\min\left(\frac{R}{R+G+B}, \frac{G}{R+G+B}, \frac{B}{R+G+B}\right)$$

$$V = \frac{R+G+B}{3}$$

Yagi/Abe/Nakatani's model

These authors present two similar models which origin/bases are in Smith's model

Model 1: H = the same as Smith's model

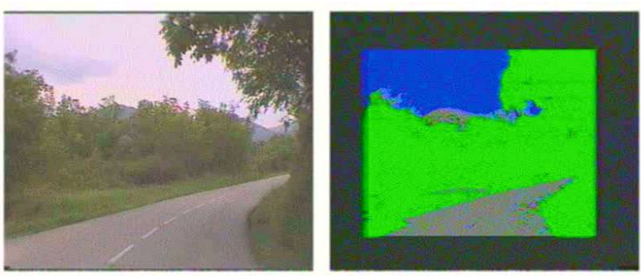
$$S = \max(R,G,B) - \min(R,G,B)$$
$$V = \frac{\max(R,G,B) + \min(R,G,B)}{2}$$

Model 2: H = the same as Smith's model

$$S = \max(R,G,B) - \min(R,G,B)$$
$$V = \frac{R,G,B}{3}$$

IV VIDEO IMAGES

Some results about colour applications in industrial environments will be presented. Real time segmented images will show how colour features can provided much more information than B/W when colour is a feature of the scenario. Real time colour segmentation of natural environments will be also presented.



REFERENCES

[1] Richard B.Norman, "*Electronic Color*", Van Nostrand Reinhold. New York.

[2] Batlle, J.; Casals, A.; Freixenet, J.; Marti, J. *"A review on strategies for recognizing natural objects in colour images of outdoor scenes"* Image and Vision Computing, 2000

[3] Marti, J.; Freixenet, J.; Batlle, J.; Casals, A. *"A new approach to outdoor scene description based on learning and top-down segmentation"* Image and Vision Computing, 2001

[4] Lladó, X.; Martí, J.; Petrou, M. *"Image texture prediction using colour photometric stereo"* Lecture Notes in Artificial Intelligence, 2002

[5] Freixenet, J.; Muñoz, X.; Martí, J.; Lladó, X. *"Color texture segmentation by region-boundary cooperation"* Lecture Notes in Artificial Intelligence, 2004

[6] Garcia, R.; Batlle J,; Salvi, J. *"A New Approach to Pose Detection using a Trinocular Stereovision System"* Real-Time Imaging

[7] Muñoz, X.; Freixenet, J.; Cufí, X.; Martí, J. *"Strategies for image segmentation combining region and boundary information"* Pattern Recognition Letters , 2003

[8] Bosch, A.; Muñoz, X.; Martí, R. *"Which is the best way to organize/classify images by content? A Review"* Image and Vision Computing, 2007

[9] Bosch, A.; Muñoz, X. ; Freixenet, J. *"Segmentation and descrition of natural outdoor scenes"* Image and Vision Computing, 2007