Introduction to computational and biologic vision course project:

# Interaction of visual channels in color images

## Background

The subjective experience of surface color has a very different structure from that of the physical light. All the surface colors experienced by a person with normal color vision can be described in terms of just three dimensions: *hue, saturation,* and *lightness.* Together these dimensions define **color space**: a three-dimensional coordinate system within which each possible color experience can be represented as a single point with a unique position (see image no.1).

**Hue.** The dimension we normally associate with the basic color of the surface is **hue.** In color space , hue corresponds to the direction from the central axis to the location of the point representing a given color.

**Saturation.** The second dimension of color, called **saturation**, captures the purity and vividness of color experiences. In color space, it corresponds to the distance outward from the central axis to the position of the point representing a given color. (Also called chroma).

**Lightness.** The third dimension of the surface color is **lightness.** In the coordinates of color space, lightness refers to the height of a color position as it is drawn in image no.1. All surface colors have some value on the lightness dimension, although it is perhaps most obvious for the achromatic colors (grays) that lie along the central axis, with white at the top and black at the bottom.

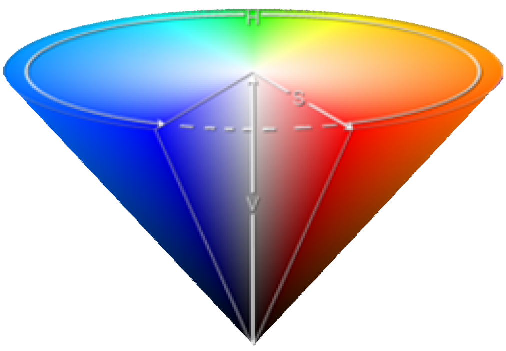


image no.1

We all familiar with the RGB color space. The translation between the two spaces can be computed:

MAX- the maximal value of R G B.
MIN- the minimum value of R G B.

H:

MAX=R and G>=B ➔ 60*(G-B)/(MAX-MIN)

MAX=R and G<B ➔ 60*(G-B)/(MAX-MIN)+360

MAX=G ➔ 60*(B-R)/(MAX-MIN)+120

MAX=B ➔ 60*(R-G)/(MAX-MIN)+240

S:

MAX=0 ➔ 0

OTHERWISE ➔ 1-MIN/MAX

V=MAX

## GOAL.

The goal of my work is to build a tool that will help in the research of the connection between the HSV channels. Similar works checked the connection between the value channel and the hue and saturation channels in this way: color image was divided in to areas which the value channel is constant inside them, compute the mean of the hue and saturation channels and produce a new image with the new mean value at each channel. The new image was very much the same as the original image and the conclusion was that the color does not contribute much more to the image then the gray level.

## Approach.

I compare the channels with covariant derivative.
Each channel will be represented as a vector field and the covariant derivative between each two channels will be computed.
The hue field had a natural representation as a vector field since each point in the hue channel is an angel in the unit circle (see image no.1).
The saturation and the value fields are intensity fields and the vector field is computed by first representing the level-set of the channel and then at each point- compute the tangent vector to the level-set contour at that point.
The covariant derivative definition:
Let W be a vector field on R2, and let *v* be a vector at point *p*.
Then the covariant derivative of W with respect to *v* is:
W(*p*+*tv*)`(0)
Evidently we measure the initial rate of change of W(*p*) as *p* moves in the *v* direction.

Or discreet covariance derivative of vector field W with respect to vector field V- at each point *p* in V- check the direction of the vector *v* at *p* and check how the vector *w* at point *p* in W change when moving in *v* direction.

Especially interesting is the covariant derivative of the hue filed with respect to the value field. This will check the same thing as the work I deceived before- if the covariance derivative between those two fields will be close to zero at all points it will hint that those two field carries the same information and that maybe the value filed is enough to represent the scene in the image.
In order to enable continued work the tool will provide the covariant derivative of all 3 channels.

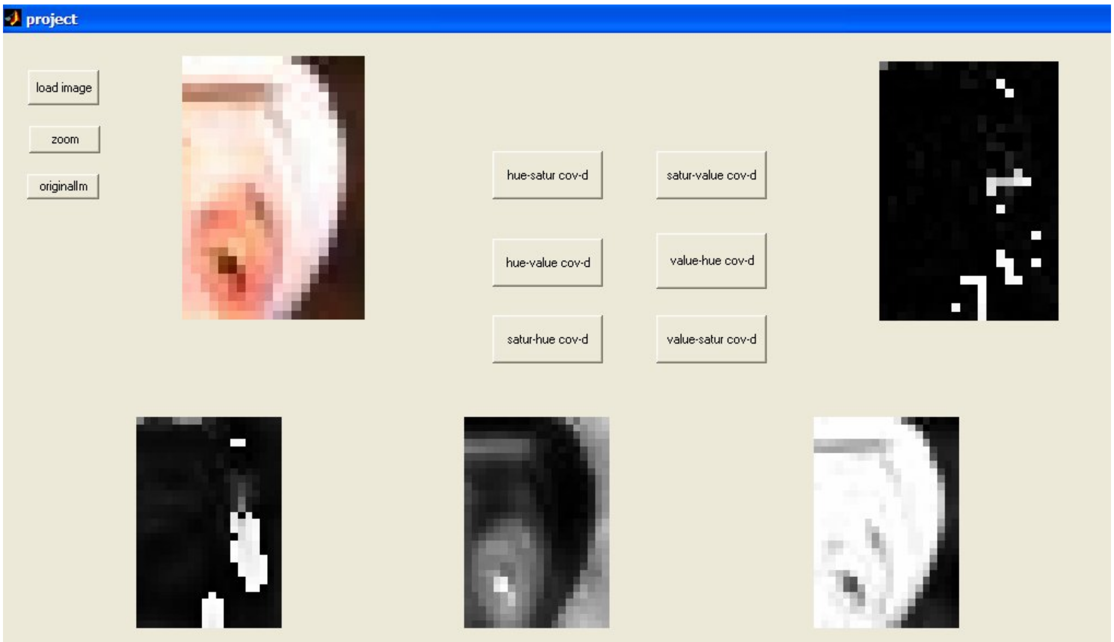
## Implementation.

The tool is a GUI built in MATLAB.
In order to activate the tool write *project* at matlab workspace.
Next I will describe the tool different buttons:
**Load image**- this button will allow you to choose an image to work with. (you can use the collection of images at the directory *projectImages*). After loading an image it will be shown in the left top frame and the tree channels of the image will be shown in the tree frames at the bottom of the GUI as an intensity image. You can also watch each channel image as vector field by pressing the button under the image.
**Zoom-** after pressing this button you can choose a rectangle in the original image and the chosen area will appear at all frames I described till now.
OriginalIm- pressing this button will act like zoom out- the original image will present at all frames I described till now.
At the center of the GUI there are 6 buttons for computing the covariant derivative between all 6 pairs of channels. For example- pressing the value-hue-cd button will compute the covariant derivative of the hue field with respect to the value field. You can watch the result as intensity image at the right top frame.

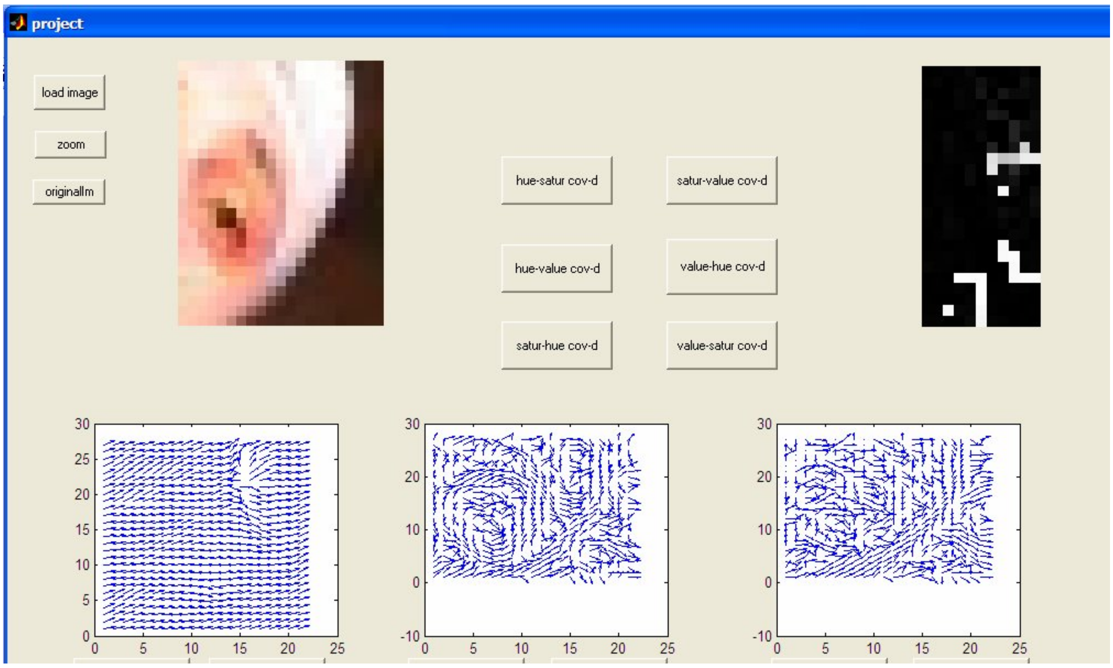
## Results and conclusions.

It can be noticed that the comparison between the hue and the value field usually suit the assumption that this two fields carries the same information. At areas where the image is constant it is obvious but the exception point are usually on the boundary in the image. I will give some examples of those points later.
The same results can be seem for the covariant derivative of the hue field with respect to the saturation field.

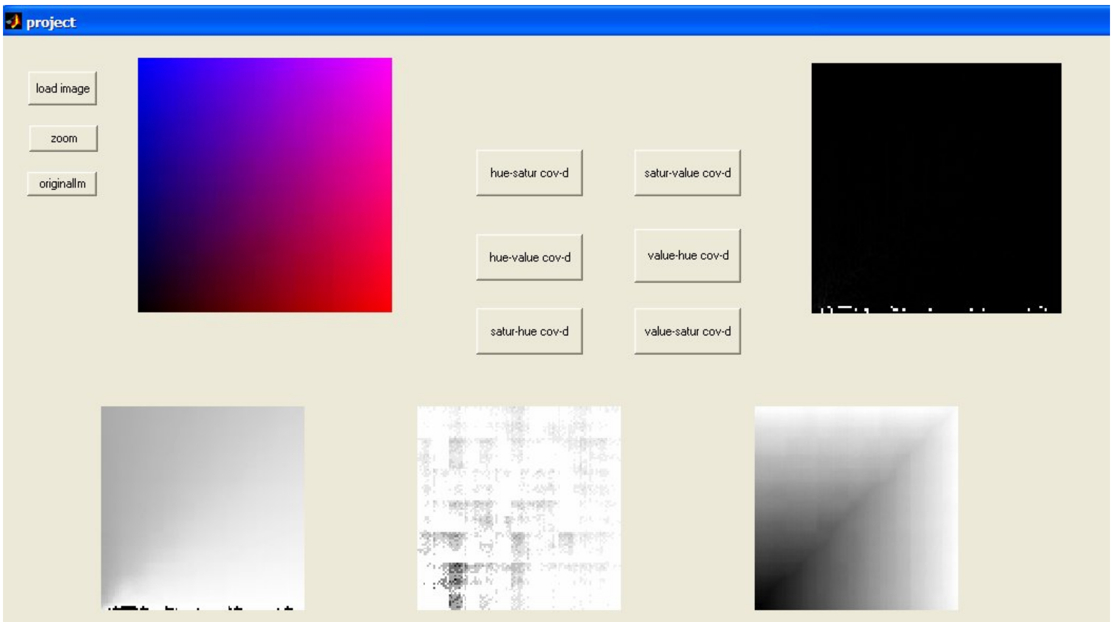
As for the 4 others comparisons- it does not seem to carry any immediate meaningful information and maybe a more deeply work is necessary.
I will focus now at the covariant derivative of the hue with respect to the value and present some examples to the points where the covariance derivative does not produce a close to zero value.
First example: (image number 26 from he directory *projectImages)*
Let take a look at a small part of the image- the boundary between the man hat and his head.




We can see that there are points at the hue image that are irregular at theirs neighborhood. I am not yet sure for the reason for this irregularity but the this example raises the question that maybe the hue field does carry information that value field don't- the boundary between the hat and the head is clear in the original image but not at the value image.
Another question from this example is that maybe need to consider some kind of mergence of the value or the hue field with the saturation field since at the saturation field it is easy to see the boundary.
The next image displays the channels as vector fields.




The next example shows that in constant area and when the image is changing continuously, the covariant derivative is close to zero:




Another assumption for the reason of irregularity at the covariant derivative is that maybe the irregularity at the hue field is a result of noise at this channel and maybe some kind of diffusion can be done before comparing the fields.

## References.

B. O`Neill. Elementary Differential Geometry. Academic Press, 1966. 4
Stephen E. Palmer, Vision Science.
O. Ben-shahar, A. Glaser and S. Zucker. Good Continuation in Layers: Shading flows, color floes, surfaces and shadows.