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<td><strong>Author(s)</strong></td>
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Paper No. 2
IMAGES

in a digital world

PHILOSOPHY,
THE LOVE OF WISDOM ...

Images, imagination: what we have in mind

Physical reality might be different from its representation in our brain

We perceive the outside world with our eyes

We name what we see from our experimental knowledge
We perceive the outside world with our eyes

What is colour in the outside world?
-> radiant energy with wavelengths in the 400 - 700 nanometer range
-> this physical phenomenon can be recorded with a spectrophotometer

What is colour in our eyes?
Our eyes distinguish different wavelengths by comparing the
relative strength of response in three types of retinal cell. The true
"primary" colours that correspond to these cells are a "red" (peak
absorption at 590 nm), a "green" (540 nm) and a "blue" (450 nm).

We name what we see from our experimental knowledge

We use the name of a material or object to name a colour, such as
 gold or silver.
Maoris have more than 100 words to describe what is commonly
called "red". The Welsh, Chinese, Japanese, Eskimo, Melanesian
and Tamil people have no word for "brown". The Thais and
Lapps call it "black-red".
Some languages do not have separate words for green and blue,
or for yellow and orange.
Eskimos have 17 words for white as applied to snow ...

COLOUR IS IN OUR BRAIN!
If colour is in our brain, how to put it within a computer?

-> "Easy", you say ... 
Computers display colour pictures by using Red, Green, Blue phosphors. Let us combine these three "additive primaries" in the correct proportion and we will get our colour.
A press uses Cyan, Magenta, Yellow and Black inks. Let us combine these four "subtractive primaries" in the correct proportion and we will get our colour.

-> "O.K. my friend", but could you define your "red" phosphor? would you give me the characteristics of this "magenta" ink?

If colour is in our brain ...

We cannot define it through the devices used to reproduce colour. (Relating to a specific device, we can only refer to samples or colour palettes. We can say, for instance: "Here is a sample of red as produced on my newsprint with 100% coverage of my magenta ink and 100% of my yellow ink").

We have to define it the way "we" (supposed to be an average sample of "normal" humanity) see it! With our rods and cones, and their signals interpreted by our brain, we sense three characteristics of colour: hue, saturation, brightness.
Hue, Saturation, Brightness

- **Hue** is the visual attribute of a colour to which names such as purple, green, orange, are associated ("this stone is green").

- **Saturation** (or Chroma) is the degree of colourfulness, or departure from the neutral axis where every colour looks grey.

- **Brightness** (or Luminance, or Lightness, or Value) is a measure of the amount of light emitted, transmitted or reflected.

**Chromaticity diagram:** This diagram sums up all colors that can be seen by the human eye. It uses Yxy coordinates (Y= brightness is not shown in the two-dimensional, colour-only diagram). Hue is represented at all points around the perimeter. Saturation is represented by a movement from the central (neutral) area towards the perimeter, where 100% saturation equals pure hue.
L*\(a^*b^*\) colour space

- Device independent

- Rectangular coordinates
  (allows calculation of \(\Delta E\))

- Used as reference in printing applications.
  Colour space transformation between two dependent colour
  spaces (e.g. RGB conversion to CMYK) must take into account
  how each dependent colour relates to Lab coordinates.

A picture in a computer

is composed of vectors or pixels

- Pixel = picture element in a computer file. Pixels are, for
  picture files, what ASCII codes are for text files.

- A pixel has:
  -> a position within the "bit-map" (or pixel-map) which locates
  each picture element
  -> light and colour values

- 8 bits (one byte) for black & white pixels allow 256 grey levels

- Colour pixels have one byte per dimension:
  -> in a three-dimensional colour space,
    pixels have three bytes (24 bits)
  -> in a four-dimensional colour space,
    pixels have four bytes (32 bits)
How do you get pixels into a computer?

This will be the subject of the next two lectures:
- digital cameras
- scanners

Later on we will study:
- how we can process pixels
- how we can output pixels

Digital Image Handling
= Pixels Handling

INPUT → PROCESSING → OUTPUT

of pixels
in Newspapers ...