Colour 101 for programmers

October 2020

Why should I care?

InstaTok

🕵️ PM: Our competitor has a new filter.

🕵️ PM: It takes a picture of an orange and turns you orange.

Peppered mandrill

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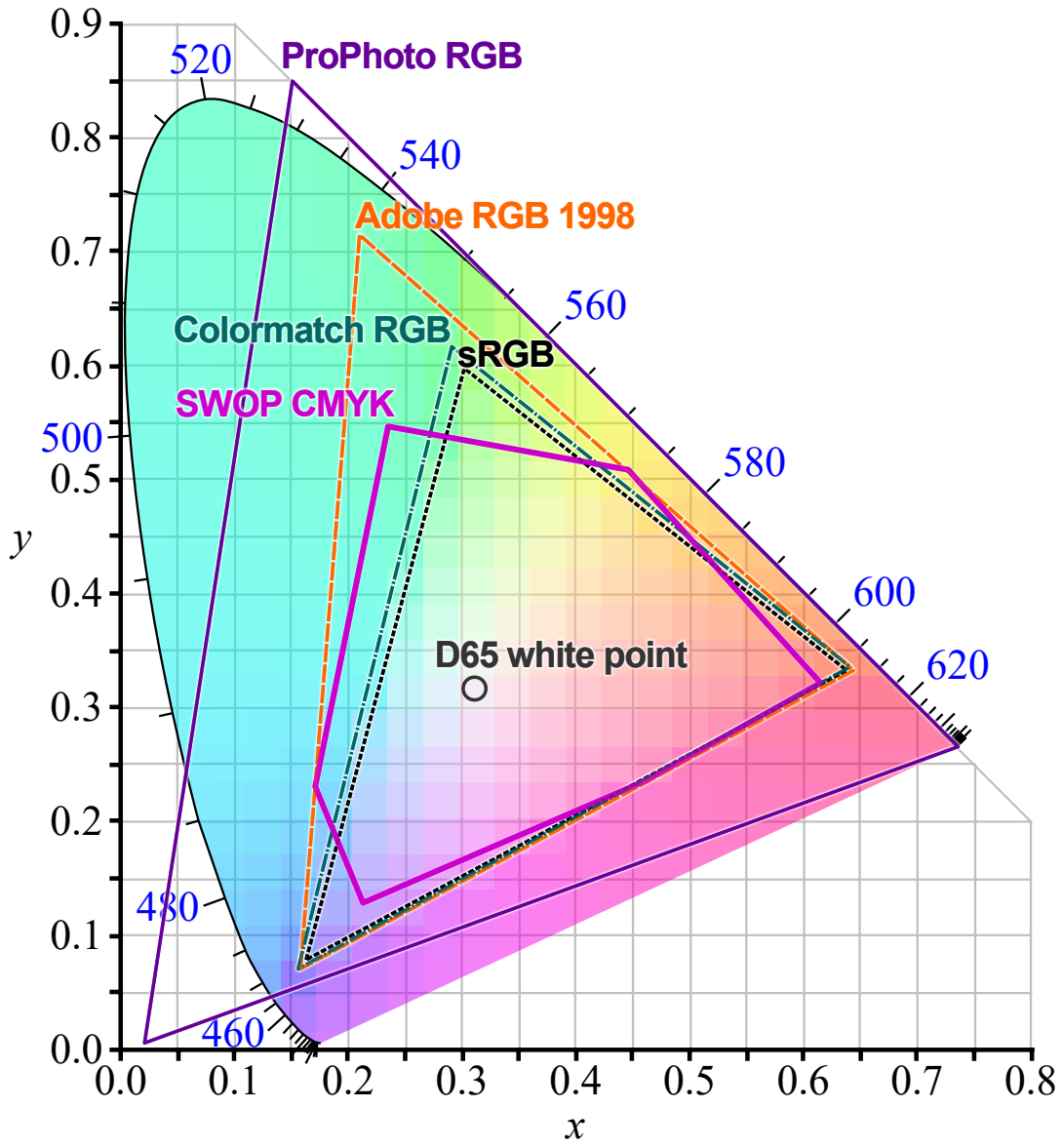
 10101110110 10

↓

```
struct MyImageSurface { ... }
```

Colour spaces



Basically, how to refer to a particular colour

```
--c: rgb(255, 255, 0)
```

CSS colours

- red, green, blue

```
--c: rgb(255, 255, 0)
```

- hue, saturation, lightness

```
--c: hsl(60, 100%, 50%)
```

CSS colours for the future

--c: rgb(0, 255, 0)

--c: color(display-p3 1 0.5 0)

WebKit only as of 2020

Subtractive colour spaces

CMY, CMYK

Additive colour spaces

sRGB, HSL, HSV etc.

Additive colour spaces

sRGB, HSL, HSV etc.

- Super convenient
- Well-supported
- Easy to reason with

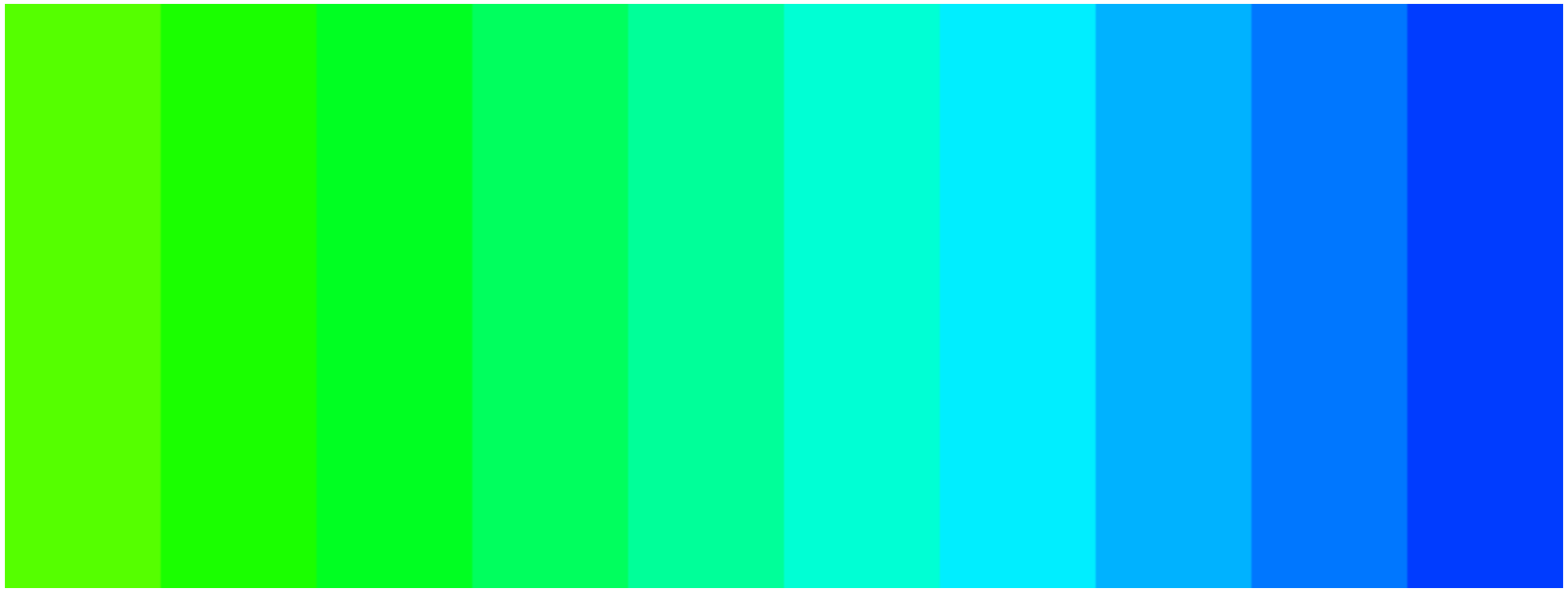
HSL is great for colour hashes

```
const hue = hash(username) % 255;
const color = `hsl(${hue}, 50%, 50%)`;
```

Perceptual colour spaces

CIE L*a*B*, CIE LUV

- When colour matters
- When calculating colour difference
- When humans are involved



https://programmingdesignsystems.com/color/perceptually-uniform-color-spaces/

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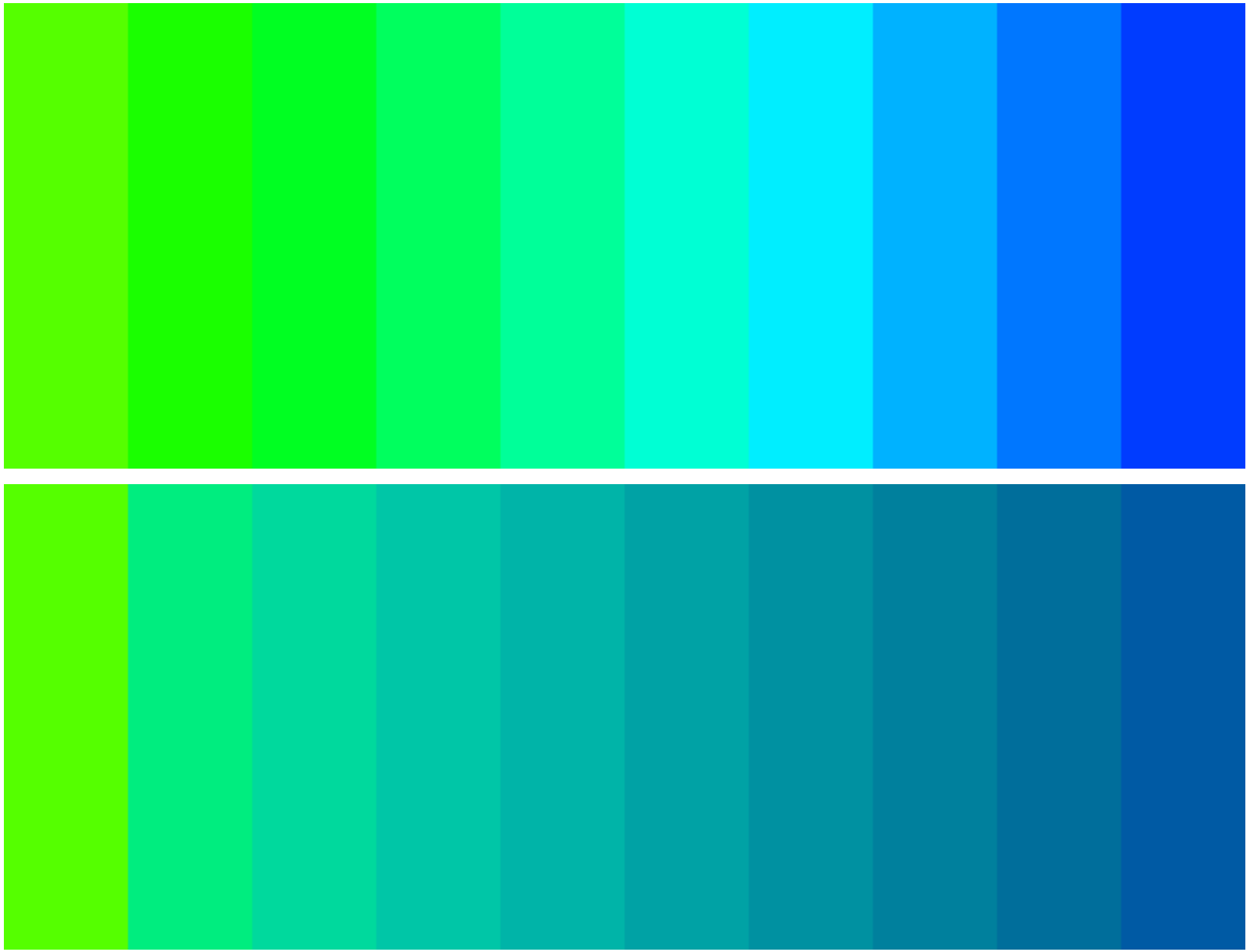

https://programmingdesignsystems.com/color/perceptually-uniform-color-spaces/

Colour in design systems

Usually, design systems specify colour variants using the same values in RGB


HSLuv
HSL
Lightness: 60%
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Lightness: 60%

Subtractive

CMY, CMYK

Back to InstaTok

We want to get the dominant colours so we can transfer them

RGB

LAB

```
let colours: Vec<RGBA> = extract_colors(&peppers_image);
```

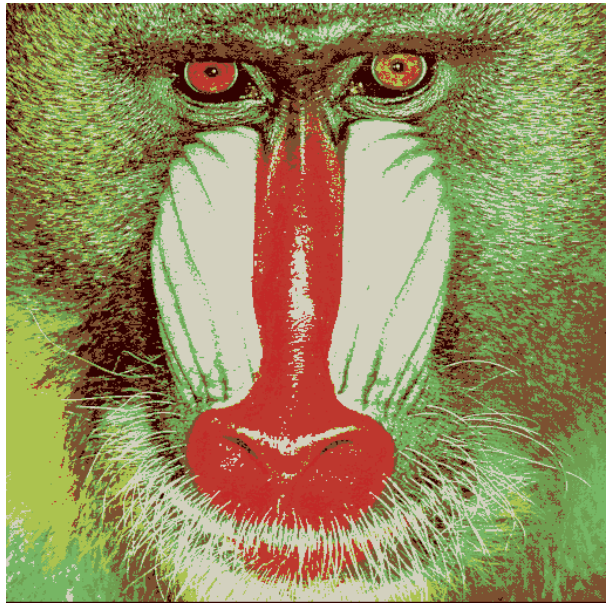
```
let colours: Vec<RGBA> = extract_colors(&peppers_image);
let green_monkey = apply_palette(&blue_monkey, &colours);
```

apply_palette

```
foreach(pixel):
  foreach(palette_color):
    find_and_return_smallest_difference(pixel, palette_color)
```

apply_palette

```
foreach(pixel):
  foreach(palette_color):
    // We need to define "difference"
    find_and_return_smallest_difference(pixel, palette_color)
```

	RGB+RGB	LAB+LAB
		

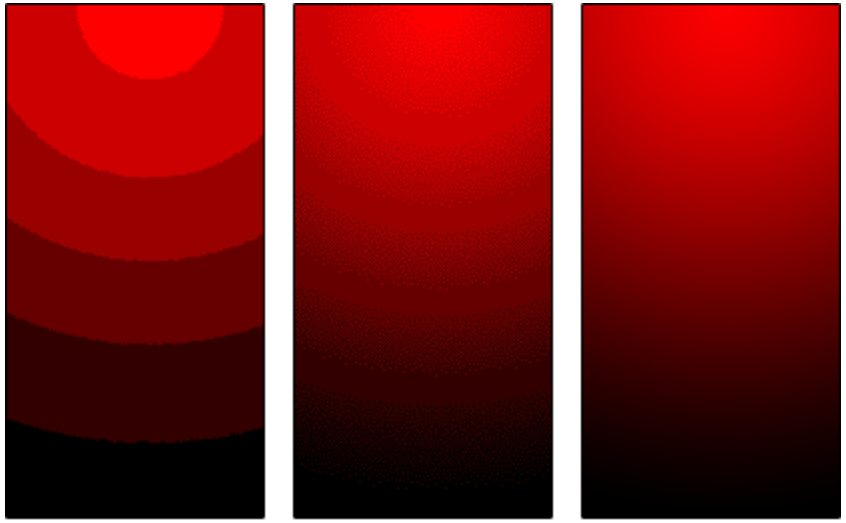
🕵️ PM: Rejected. Users *need* to save their snaptoks!

Image encoding

- Lossy vs lossless
- YUV and chroma subsampling

Bit depth

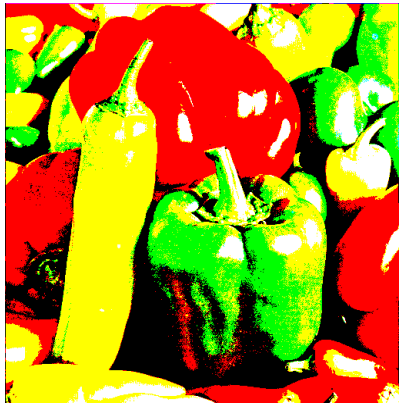
Number of bits to represent a channel



8-bit gradient

8-bit gradient, dithered

24-bit gradient

1-bit	2-bit	3-bit	4-bit	8-bit
				

Images

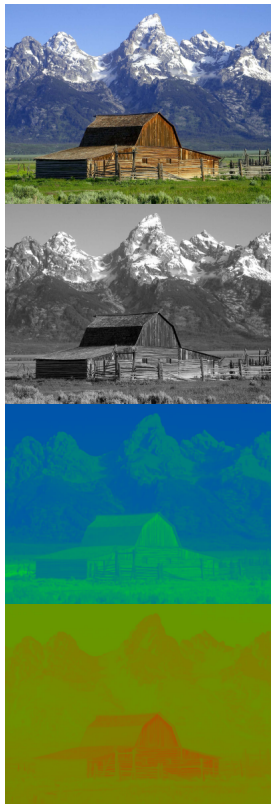
lossless	lossy	vector
BMP, PNG	JPEG	SVG
illustrations, UI	photos	illustrations, UI

Videos

lossless	lossy	vector
APNG, GIF*	GIF*, MPEG, h264	SVG, SWF

YUV

Common in videos



YUV

- RGB888 = 24-byte pixel
- YUV420p = 6-byte pixel~

YUV takeaways

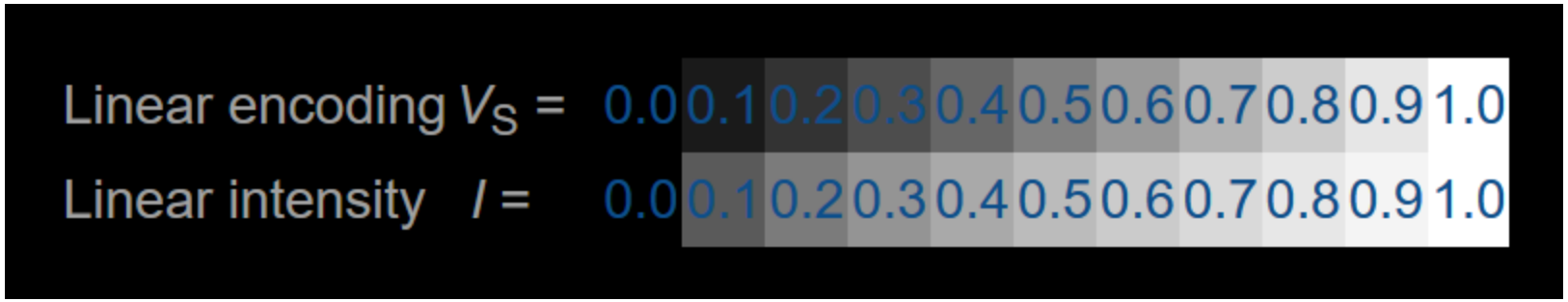
- hard to work with on a per-pixel basis
- luma usually encoded at twice the resolution of colour
- video is hard

Colour spaces for video

- sRGB: computers
- Rec. 709: TVs
- DCI P3: cinema

PM: Rejected. QA reports the colours are wrong!

Luminance perception



Apply gamma (de)correction when needed

Colour sensitivity

Contrast

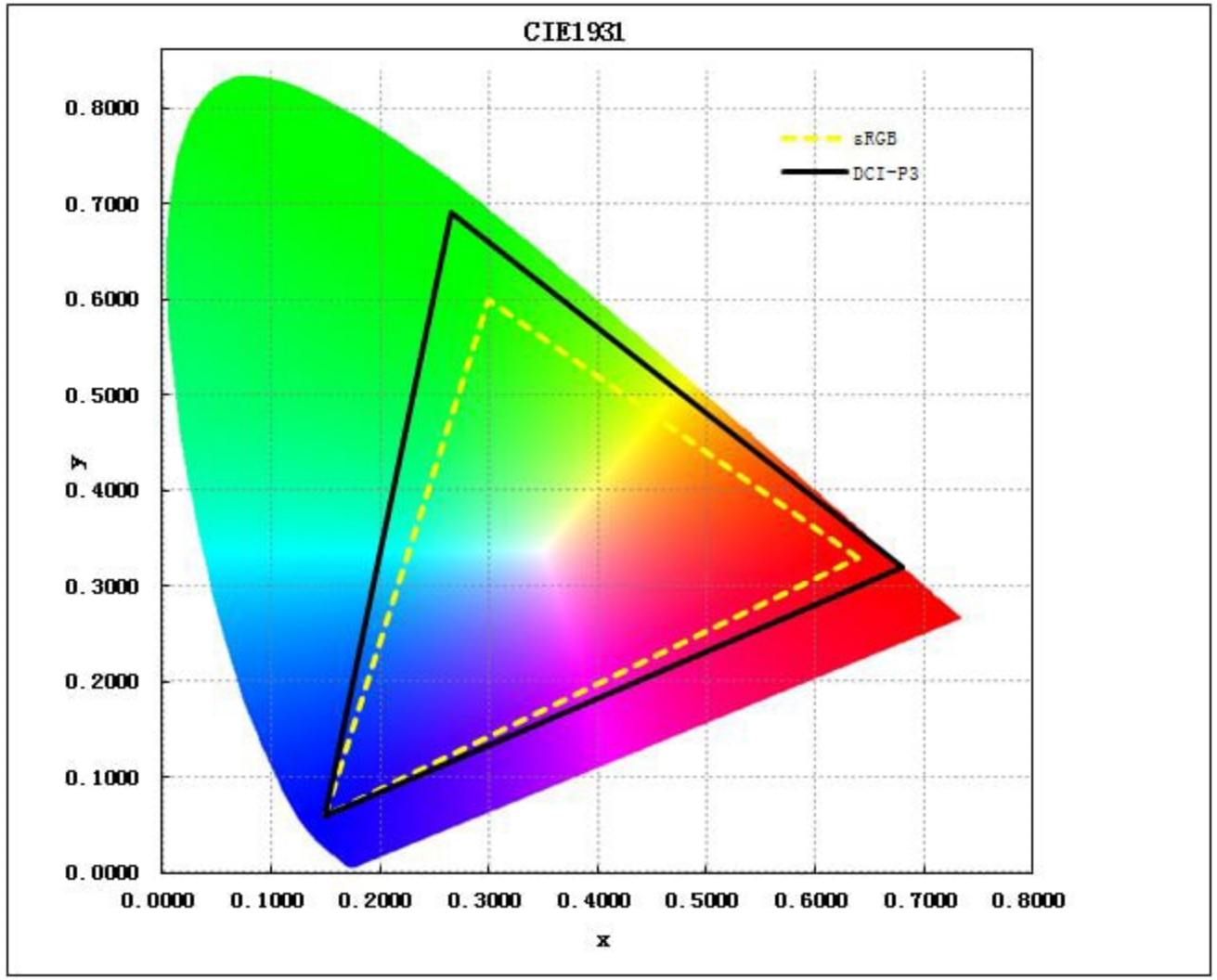
Colour management

Too much out there, too much I don't know about

- Web browsers: depends
  - Firefox has issues as of 2020
- OS: set up colour profiles
- Photoshop: I can't get it to work
- Monitors: calibration needed

"Oversaturation"

sRGB → DCI P3



Colour blindness

- ≈ 8% in males, ≈ 0.5% in females
- Use luma for contrast, not colour
- Colour contrast can be more difficult to see
- Simulate using tools in browser

https://commandcenter.blogspot.com/2020/09/color-blindness-is-inaccurate-term.html

Side note: Photoshop is broken

- Desaturation doesn't work in Photoshop?

Tim Soret @timsoret · Apr 19

Desaturating in Photoshop doesn't accurately portray brightness at all.

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Tim Soret @timsoret · Apr 19

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GIF


GIF

In my experience

- Don't treat pixels as RGB
  - format (YUV, RGB)
  - channel (R, G, B, Y)
- Pixel data might not be contiguous

- Don't treat images as bitmaps
  - convert if needed
  - have a `Surface` abstraction to get pixels

- Manipulate images as bitmaps

- Work in a single colour space

- Consider the pipeline
- Including the human

Easy if you don't need to care

Everything is a RGB bitmap

You will need to care soon

- Wide gamut screens with >100% sRGB coverage
- HDR displays
- CSS support
- OS, OpenGL, DirectX support

Everything can go wrong

- input
- manipulation
- encoding
- display
- human