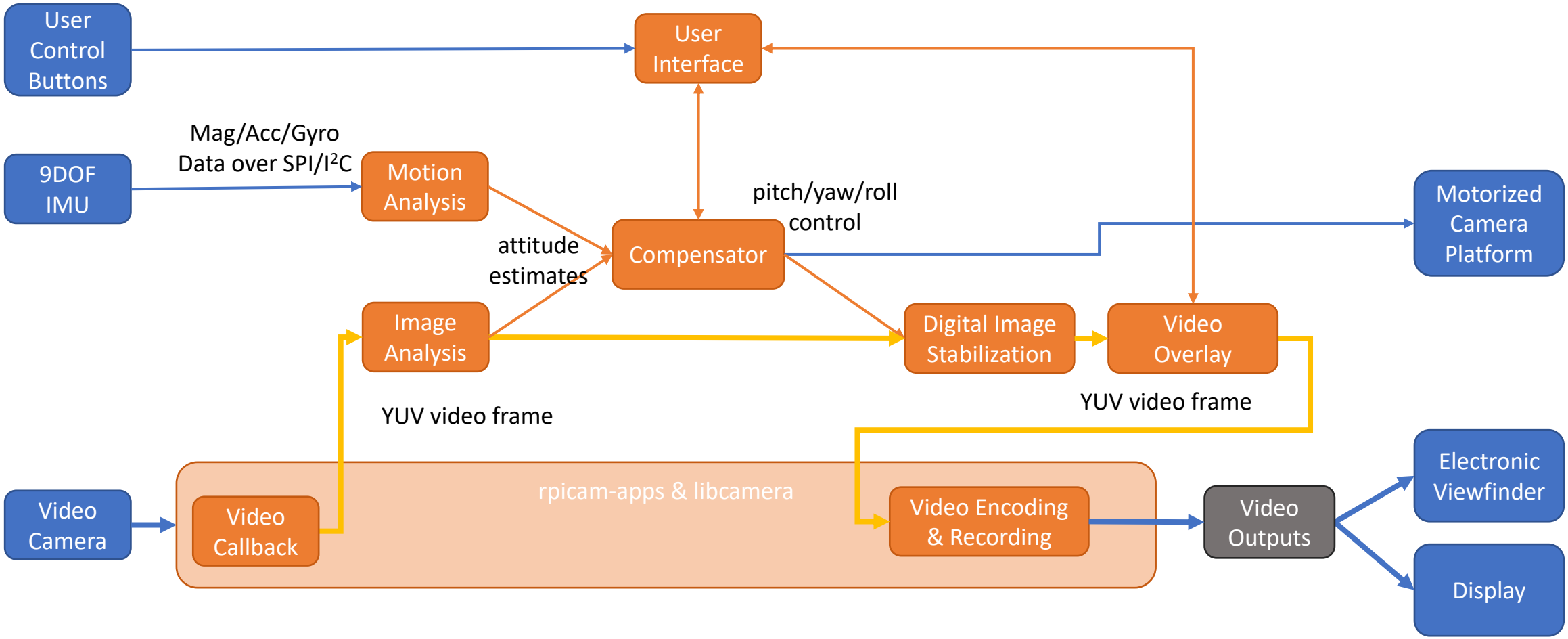
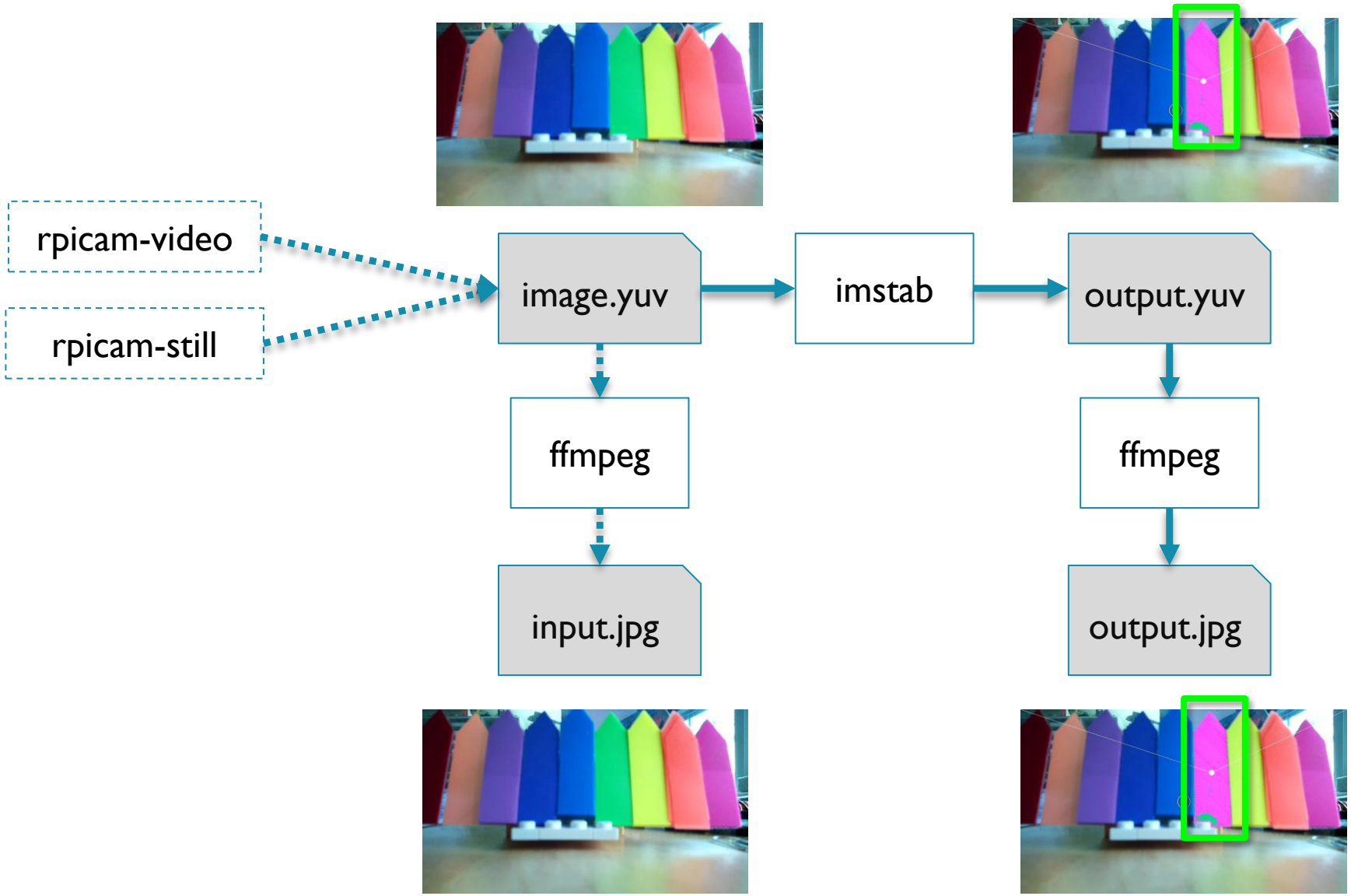
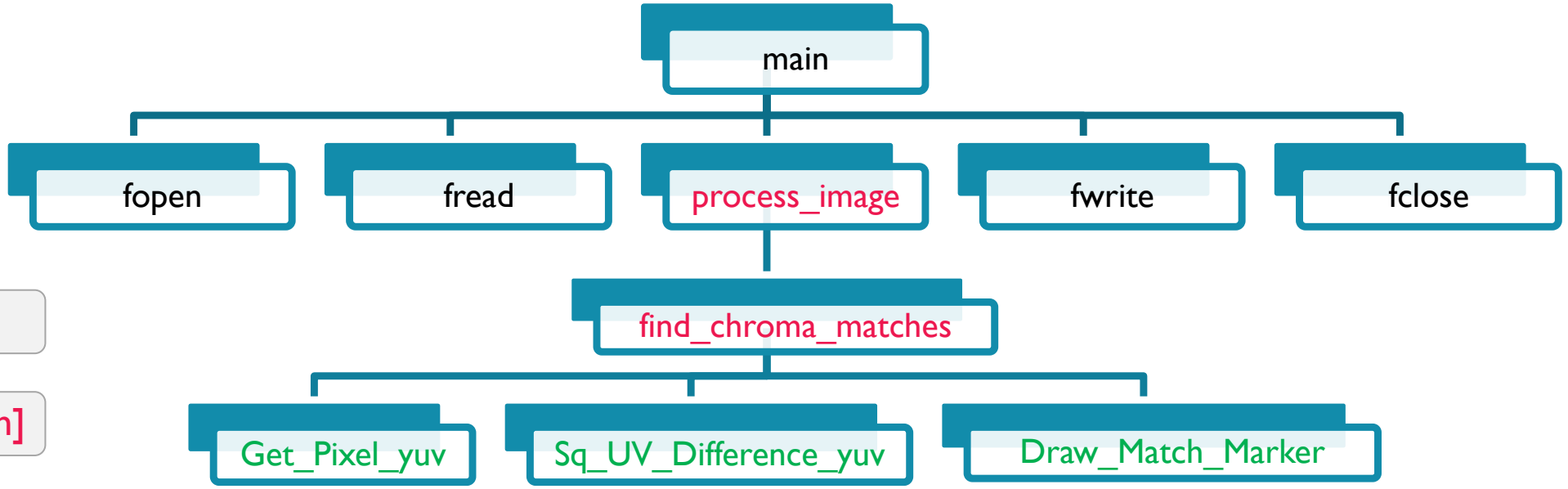
Image Stabilization System


User Control Buttons
User Interface
Mag/Acc/Gyro Data over SPI/I²C
9DOF IMU
Motion Analysis
pitch/yaw/roll control
Motorized Camera Platform
attitude estimates
Compensator
Image Analysis
Digital Image Stabilization
Video Overlay
YUV video frame
YUV video frame
Video Camera
rpicam-apps & libcamera
Video Callback
Video Encoding & Recording
Video Outputs
Electronic Viewfinder
Display

Simplified Test Harness



Function Call Graph and Function Source Files



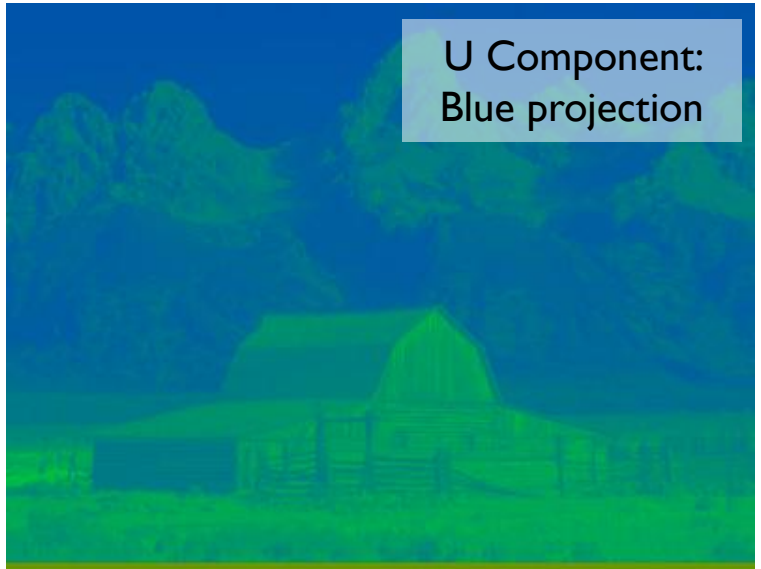
main.[c|h]

image_proc.[c|h]

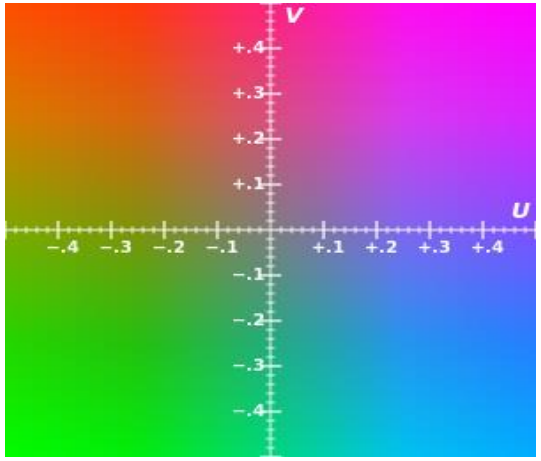
yuv.[c|h]

Image Format Information

YUV Color Space



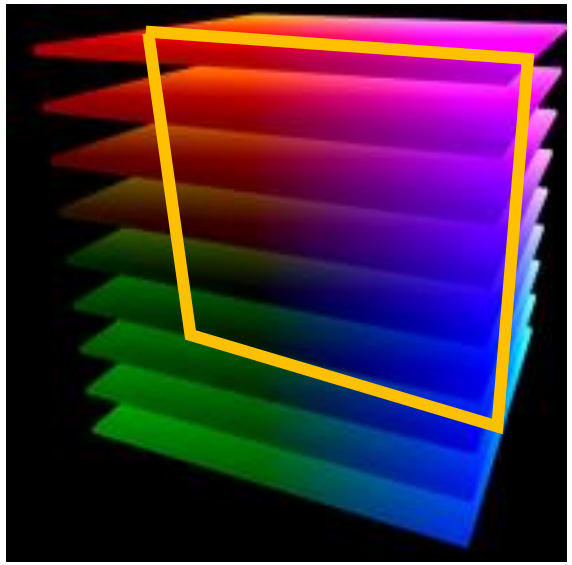
- Y: Luminance (brightness)
  - Y components alone give gray-scale image (no color)
- U,V: Chrominance (color)
  - U: Blue projection
  - V: Red projection

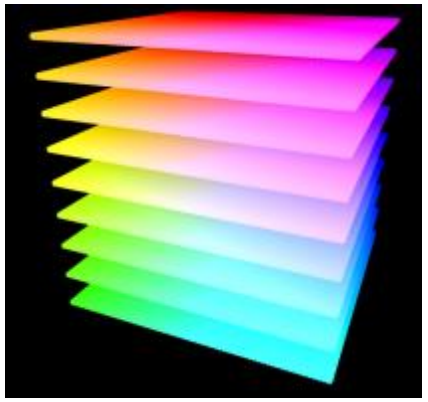


- References
  - https://softpixel.com/~cwright/programming/colorspace/yuv/
  - https://en.wikipedia.org/wiki/YUV

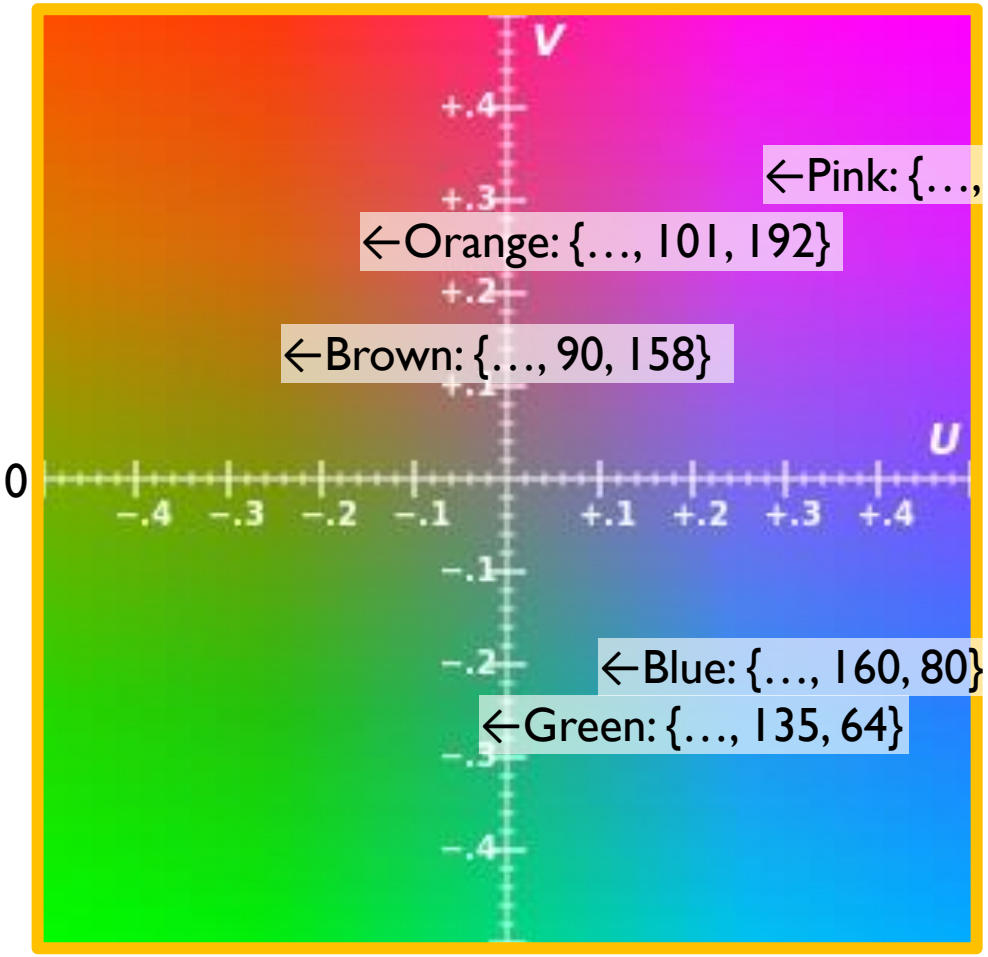
By User:Brianski - Concept from en:Image:YUV_components.jpg, original public domain image at en:Image:Barns_grand_tetons.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=2792866

YUV Color Space





V = 255



←Pink: {…, 200, 200}

←Orange: {…, 101, 192}

←Brown: {…, 90, 158}

U = 0

U = 255

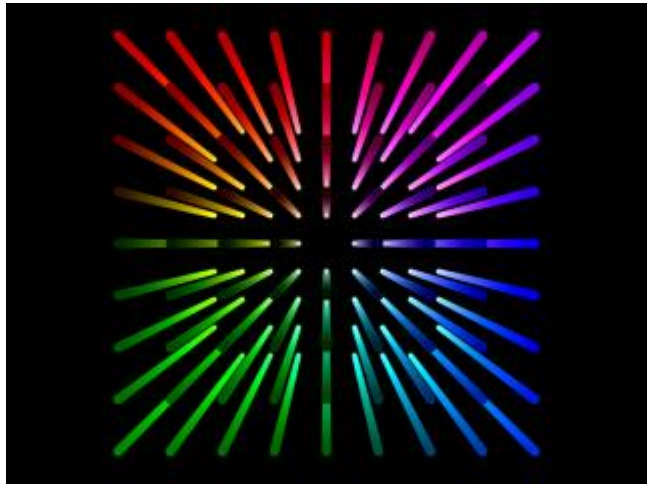
←Blue: {…, 160, 80}

←Green: {…, 135, 64}

V = 0

https://en.wikipedia.org/wiki/YUV#/media/File:YUV_UV_plane.svg

max U,V



min U,V

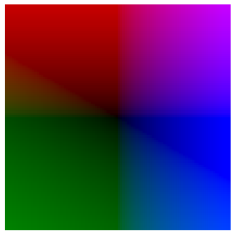
Looking up from minimum Y

max U,V

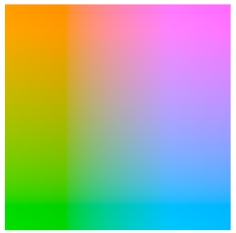
min U,V

Looking down from maximum Y

- Slices of color space with fixed Y (luminance)



Y = 0

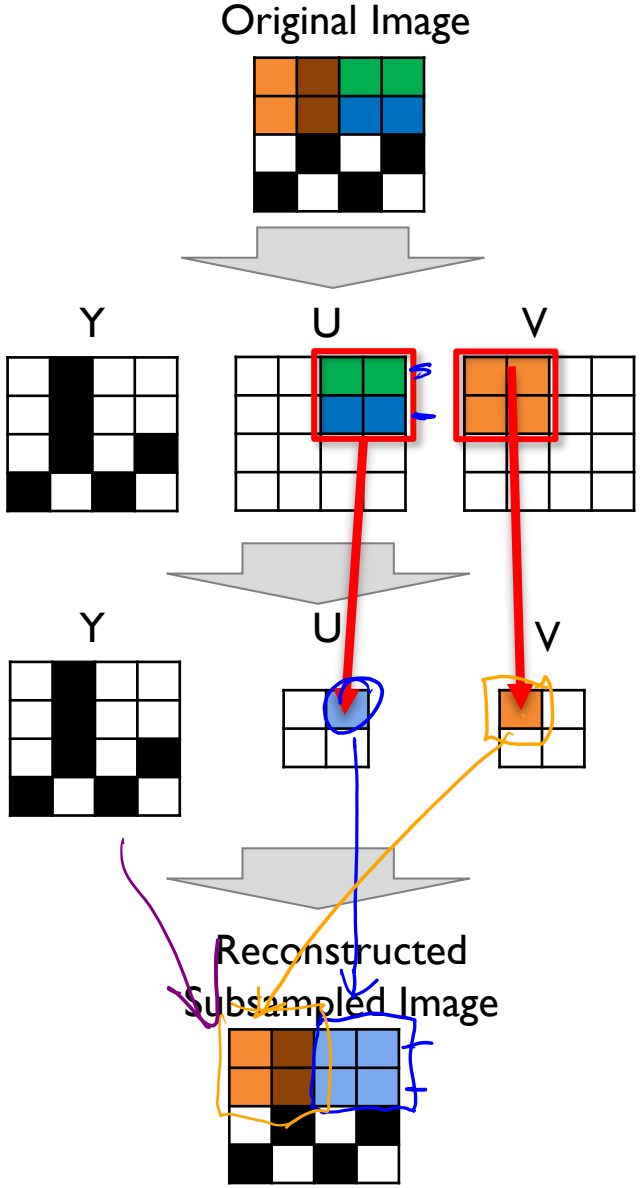


Y = 0.5

Y = 1.0

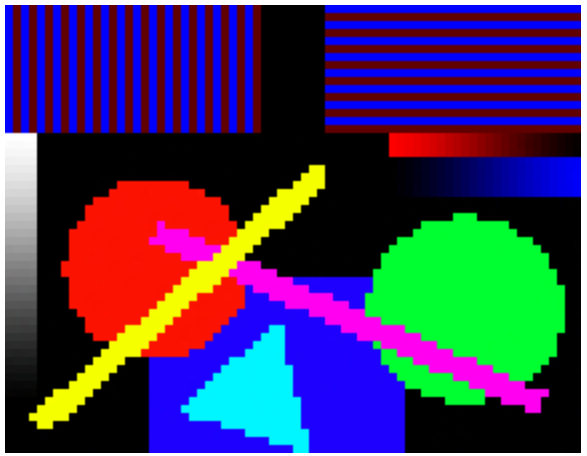
- References
  - https://softpixel.com/~cwright/programming/colorspace/yuv/
  - https://en.wikipedia.org/wiki/YUV

YUV Chrominance Subsampling



- Retina in human eye has many more sensors for brightness (rods) than for color (cones)
  - → Worse spatial resolution for color than brightness (except in very center of vision)
- Color in digital images is often spatially sub-sampled
  - Removes information we can't see, saving time and space
  - Good explanation: https://www.impulseadventure.com/photo/chroma-subsampling.html
- 4:2:0 (aka 2x2) subsampling
  - Average together chroma values of 4 adjacent pixels
  - Reduces chrominance resolution by half horizontally and half vertically compared with luminance resolution
- Example:
  - 1 MPixel image needs to represent 3 million elements: 1M Y, 1M U, 1M V
  - Subsampling reduces it to 1.5 million elements: 1M Y, 0.25M U, 0.25 M V

Original Image



Reconstructed
Subsampled Image

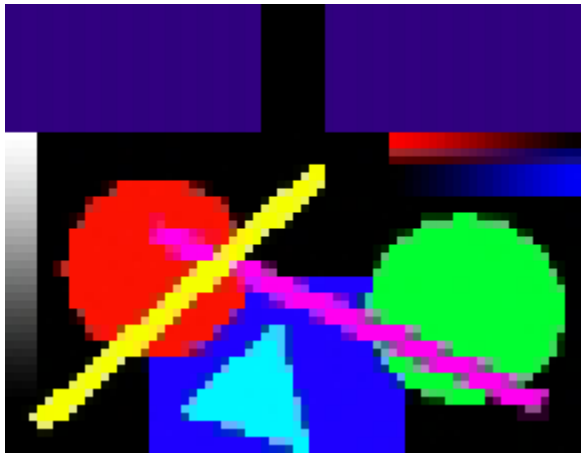
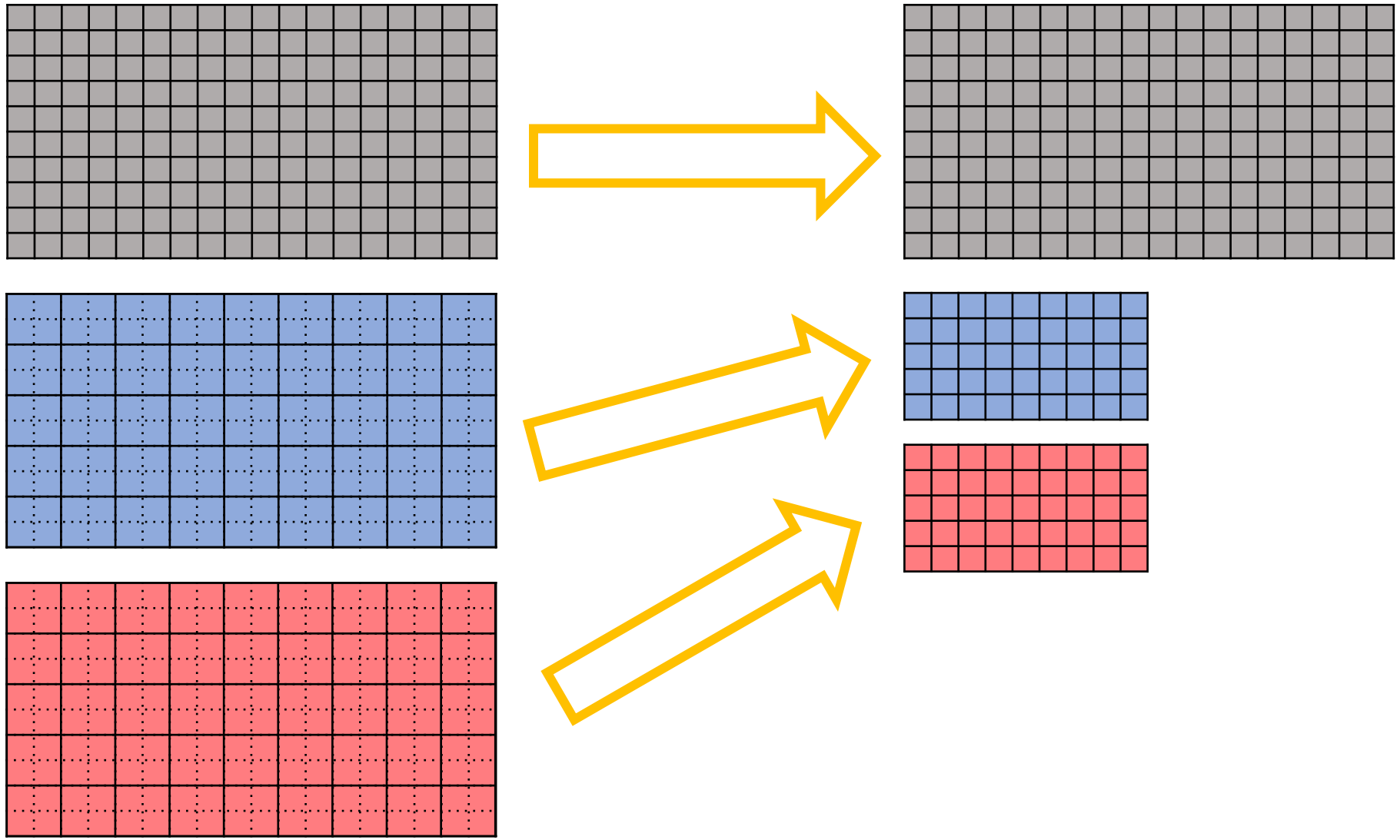
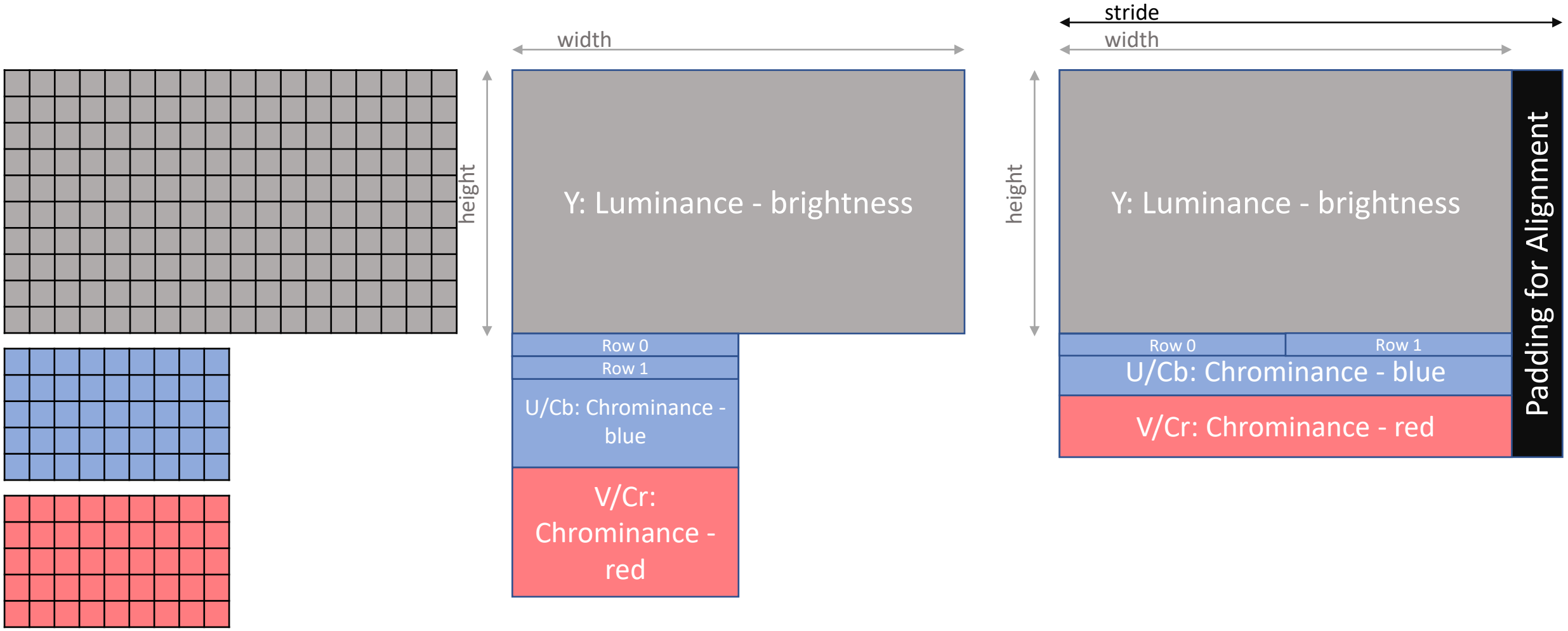


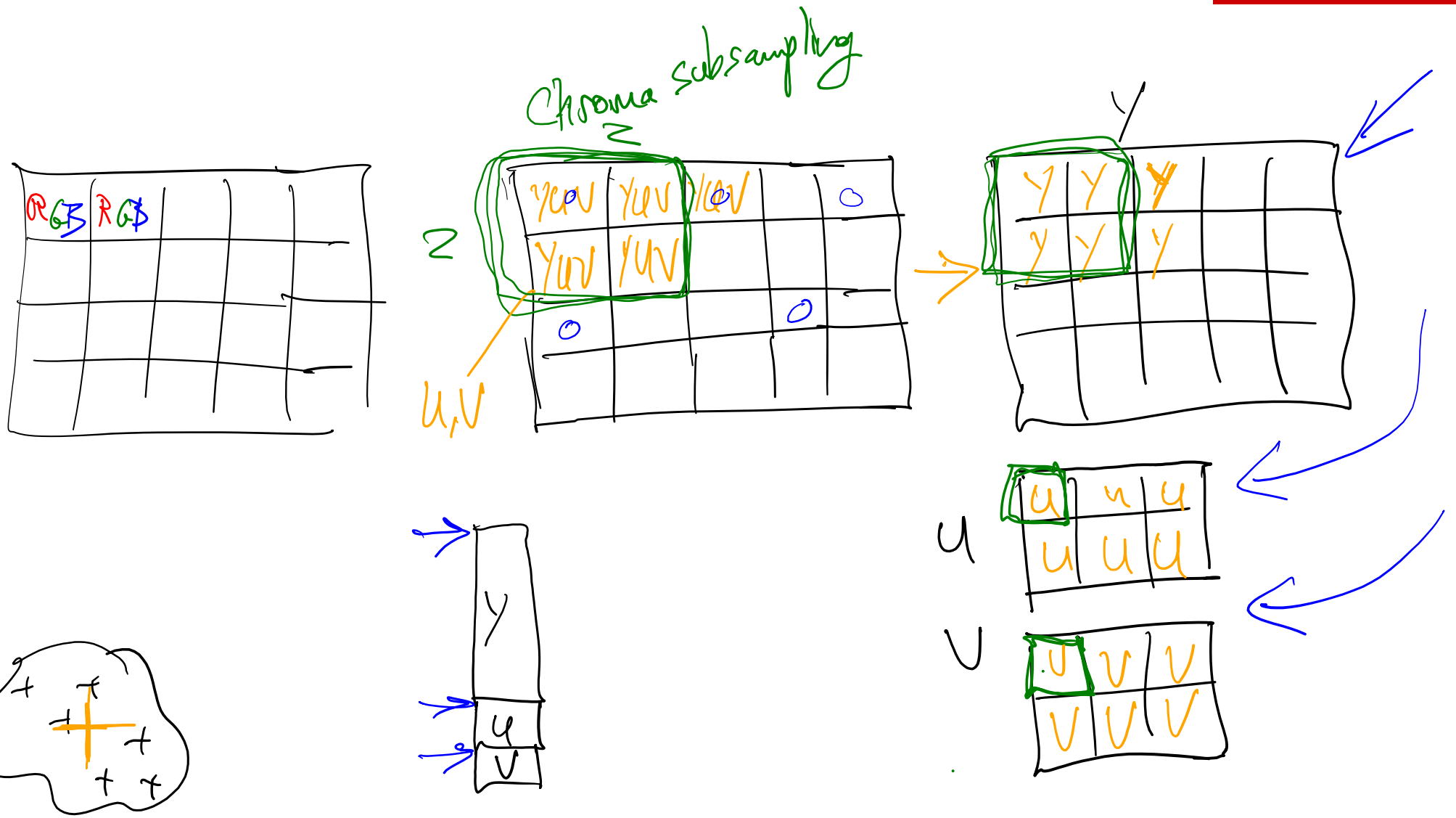
Image Data Storage: Effect of Chroma Subsampling

- Total space reduced to ½



rpicam YUV420 Image Representation




Chroma subsampling
2
2
u,v
y
u
v

OLD SLIDES

main

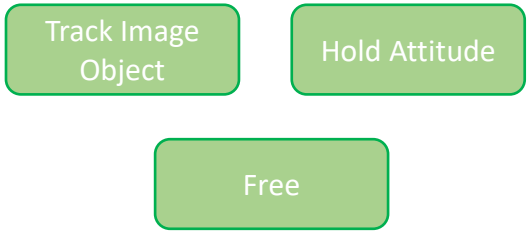
NegateStage Additions

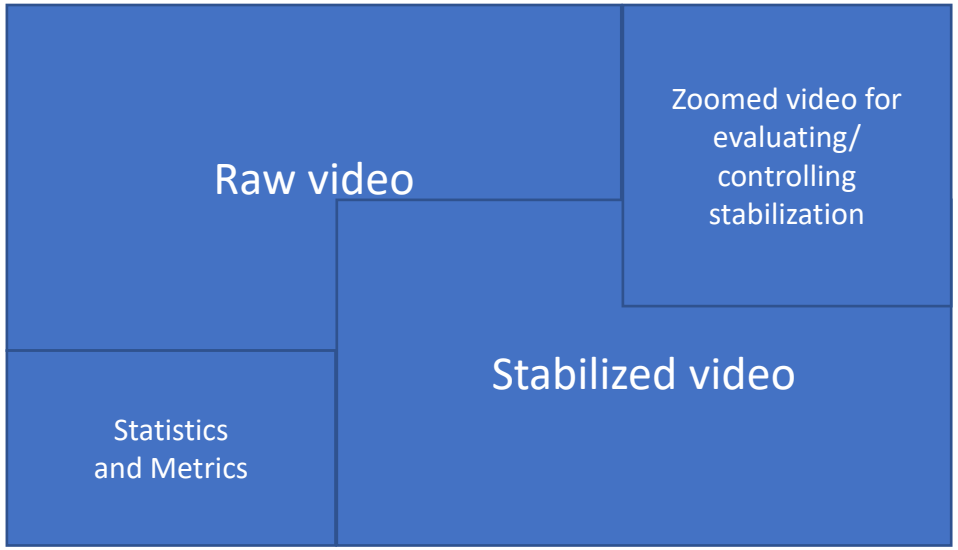
- info_: contains .width, .stride, .height, pixel_format
- u_offset, v_offset: byte offsets from start of frame buffer data
- uv_len: byte length of u or v portions

Controls

Category	Control
Recording	Start recording
	Stop recording
Tracking Mode	Select track object in image
	Select hold attitude
	Select free mode
Nudges	Joystick for nudges: left/right, up/down
	Knob for rotation nudge
Aiming Help	Zoom in/out
	Adjust estimated object distance

Modes




Raw video
Zoomed video for evaluating/ controlling stabilization
Stabilized video
Statistics and Metrics

Example rpicam-apps

- negate.cpp/hpp
  - gets frame of data, inverts every pixel (regardless of format)
- hdr.cpp/hpp
  - gets frame of data, handles Y, U, V differently