Image Processing

RGB vs HSV Detailed Explanation

RGB (Red, Green, Blue) is an additive color model where colors are represented as combinations of red, green, and blue values.
HSV (Hue, Saturation, Value) is another color space that is more intuitive for humans, as it separates chromatic content from brightness.
RGB value [100, 255, 180] means red = 100, green = 255, blue = 180 when converted to HSV will be Hue = 100, Saturation = 255, and Value = 180.

The HSV matrix is RGb when we save or show an image, our eyes are used to recognizing the pixels as RGB and hence interpret the H channel as Red S as Green, and V as Blue.

Hue, Saturation, Contrast, Shadows

- Hue: The attribute of a color (red, blue, yellow).
- Saturation: The intensity or purity of a color.
- Contrast: The difference between light and dark areas of an image.
- Shadows: The darker areas of an image where details are less visible.

Hue Histogram

Hue represents the color type in the HSV color space (e.g., red, blue, green). In OpenCV, the range of hue values is scaled from 0 to 180 (corresponding to 0° to 360° on a color wheel).
Key Points:

- Peaks in Hue: The spikes in the histogram indicate the dominance of specific hues (colors) in the image. For example, a spike around 120 corresponds to cyan, while 0/180 corresponds to red.
- Flat Distribution: A relatively flat histogram means the image contains a wide variety of colors.
- Narrow Distribution: A narrow distribution with a prominent peak means that the image has a predominant color.

Saturation Histogram

Saturation indicates the intensity or purity of colors. The range is from 0 to 255, where:

- Low values (close to 0) represent more muted, washed-out colors (grays, pastels).
- High values (closer to 255) represent vivid, saturated colors (rich reds, blues, etc.).

Key Points:

- High Saturation Values: If the histogram has significant values in the higher range (toward 255), this indicates that the image contains vibrant, highly saturated colors.
- Low Saturation Values: A histogram skewed toward lower values means the image has more muted or pastel-like colors. Images with low saturation may look more grayish or have faded colors.

Value (Brightness) Histogram

The value represents the brightness or luminance of the image. Like saturation, its range is from 0 to 255, where:

- Low values (near 0) mean darker pixels (shadows, black areas).
- High values (near 255) mean brighter pixels (highlights, white areas).

Key Points:

- Peaks in the Lower Range: If you see a peak toward the left of the histogram (lower values), the image has a lot of dark regions (shadows, low-light areas).
- Peaks in the Higher Range: A peak toward the right indicates that the image contains many bright regions (sunlit areas, light sources).
- Balanced Distribution: A balanced histogram spread across the value range suggests that the image contains a good balance between bright, dark, and mid-tones.

Summary

- Hue Histogram: The peaks may show around the yellow/orange range (30-60), as sunsets have warm tones. You may also see secondary peaks for the blue sky (around 120).
- Saturation Histogram: You may see values both low and high. The sky might be desaturated (less intense), while the setting sun and clouds could have vivid orange hues (high saturation).
- Value Histogram: Expect more balanced values. The sky might be bright, so there will be some peaks toward the right (higher brightness), but the ground and shadows in the landscape might push some values toward the lower end.

Interpretation

- Vibrant Image (e.g., flowers, neon lights): Expect high saturation, balanced hue distribution, and brightness across the entire range.
- Muted Image (e.g., foggy scene): Low saturation and low to mid-brightness. The hue histogram might show fewer colors.
- Overexposed Image (e.g., too much sunlight): Brightness histogram will peak near the right end, suggesting loss of detail in highlights.
- Underexposed Image (e.g., low-light room): Brightness histogram will peak near the left end, indicating loss of detail in shadows.

Cool and Warm Image

Cool colors are typically in the blue and green range (hue values between 90-180 in HSV), while warm colors are in the red, orange, and yellow range (hue values between 0-60).

Dull and Bright Image

Dull images tend to have low saturation and value (brightness), while bright images have higher values for both. We can use thresholds to classify an image as dull or bright based on these properties.

What is Contour?

A contour is a curve that connects all the continuous points along the boundary of an object that has the same color or intensity. Contours are the boundaries of objects detected in an image.

OpenCV Filters: Blurring and Sharpening

Blurring

Blurring is useful for reducing noise.

- Gaussian blur is a technique to reduce noise and detail by averaging pixel values in a neighborhood, weighted by a Gaussian kernel (a bell-shaped curve). A larger kernel size will result in more blurring, while a smaller kernel size will cause less blurring. Decreasing it (e.g., (3, 3)) will reduce the blurring effect.
- (5, 5) is the size of the kernel, which determines how much the image will be blurred. Larger values result in a blurrier image.
- 0 specifies the standard deviation for the Gaussian function. Here, it is automatically calculated based on the kernel size.

Sharpening

Sharpening enhances edges.

- The sharpening effect is controlled by the values in the convolution kernel applied with cv2.filter2D(). The larger the center value (the 5 in your kernel), the sharper the result. The surrounding values (-1 in your case) determine how much contrast is applied between the current pixel and its neighbors.
- Increase sharpening by increasing the center value (e.g., changing 5 to 7 or 9).
- Decrease sharpening by reducing the center value (e.g., changing 5 to 3 or 1).

Enhancing Images: Contrast Adjustment, Sharpening

I use CLAHE (Contrast Limited Adaptive Histogram Equalization) to improve contrast. CLAHE function is designed for grayscale images, but I will separate each channel to LAB and apply for RGB as well

To apply CLAHE on RGB images we will use LAB colour space. LAB color space is a color model designed to approximate human vision, often used for image-processing tasks like color correction and contrast adjustment.

L Channel (Lightness)

- Values range from 0 (black) to 100 (white).
- Modifying this channel affects the brightness and contrast of the image without altering its color.

A Channel (Green-Red)

- Represents the color information on the green-to-red axis.
- Negative values indicate green and positive values indicate red.

B Channel (Blue-Yellow)

- Represents the color information on the blue-to-yellow axis.
- Negative values indicate blue and positive values indicate yellow.

Image Rotation

- GetRotationMatrix2D() function generates a 2D rotation matrix that can be used to rotate an image around a specified center point by a given angle.
  - M = cv2.getRotationMatrix2D(center, angle, scale)
  - center: A tuple (x, y) representing the center point around which the image will be rotated.

    - Angle: The angle of rotation in degrees. Positive values indicate counter-clockwise rotation, while negative values indicate clockwise rotation.
    - Scale: A scaling factor. A value of 1 means no scaling, values greater than 1 increase the size of the image, and values less than 1 decrease the size.
    - Returns a 2x3 rotation matrix that can be used with cv2.warpAffine() to apply the rotation to an image.
- cv2.warpAffine() function applies an affine transformation to an image. It can be used to perform various transformations such as rotation, translation, and scaling.
- dst = cv2.warpAffine(src, M, dsize)
- src : source image
- M : The 2x3 transformation matrix, which can be obtained from cv2.getRotationMatrix2D() or other transformation functions.
- dsize : The size of the output image as a tuple (width, height). This specifies the dimensions of the resulting image after the transformation.
- Returns the transformed image.

Affine transformations can be represented using a 2x3 transformation matrix.
Common Affine Transformation
Translation: Moves every point of an image or shape by the same amount in a specified direction.
Scaling: Resizes an image or shape by a scaling factor.
Rotation: Rotates an image or shape around a specified point (often the center).
Shearing: Slants the shape of an object along the x or y axis.

Flipping Image

Syntax: image = cv2.flip(img, flipCode)

- flipCode = 0: Flips the image vertically (around the x-axis).
- flipCode = 1: Flips the image horizontally (around the y-axis).
- flipCode = -1: Flips the image both vertically and horizontally (180-degree rotation).