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Performance Benchmarking in Colour Model

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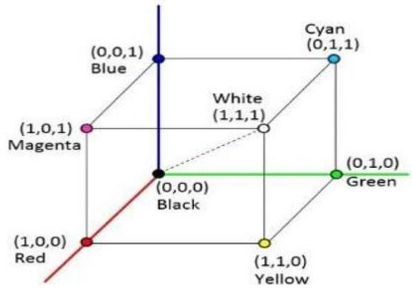
Abstract
This study of different colour models in Image processing aims for developing a comprehensive model that can be used for comparing the vast range of models.
The following comparison will be evaluated on the basis of some critical factors mainly listed as: accuracy, processing time, usage of space, graphical processing unit(GPU) performance, central processing unit(CPU) performance and some other relevant metrics. Many research work on colour models have been done mathematically like a comprehensive study on different available colour models for suitable computer vision tasks. The core intent of this paper is to analyse the colour models performance on the basis of the utilisation of a customised dataset. And perform conversion of each image in all the major colour models, followed by the conversion, we have employed convolutional neural network (CNN) for object detection tasks, supported by edge detection using morphological filtering with the operators like dilation and erosion for an enhanced and smoother detection. We have used YOLO V5 and Mediapipe from google for a lightweight model (key findings) .The significance of this project helps to identify the effective colour model without having to test out every model for a required task. Due to this comprehensive comparative table / survey one can choose the model efficiently for their required colour spaces and object detection task.

Keywords: RGB, CMYK, HSV, LAB, YCbCr

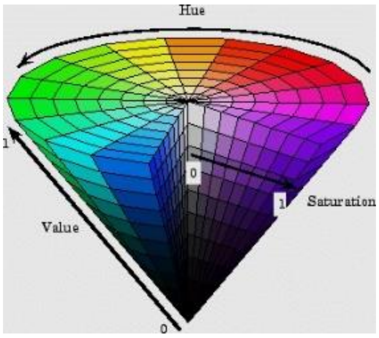
Introduction
Colour is what brings out the fun element in one’s life. Imagine having a world without colours.. It's nearly impossible as colour does not only bring life to an image but also provides information to human eyes and mind to process what they are looking at. An image as we all know is known as a collection of coloured or black and white groups of pixels. Colour or pixels are the most basic unit of images or information related to vision that can be provided and put to use for any image processing concept like our colour models. Colour models basically are models that are used to showcase the representation of colour mathematically. For example, we have the most basic colour model that is used in image processing and that is The RGB colour paradigm in which the letters R, G, & B characterise red, green, also blue separately. In any colour analysis to be done on an image, the first and foremost step of its processing begins with choosing the accurate and desired colour model that should be applicable to provide the most accurate and assumed result in the observer or the individual has come up with.

COLOUR MODELS
Choosing an accurate colour model (or colour space) is a talk for discussion as an a very long time, that has been the case. Among the most popular color models are:
A. RGB colour model: Each colour that is red, green and blue all appear in its primary state which on

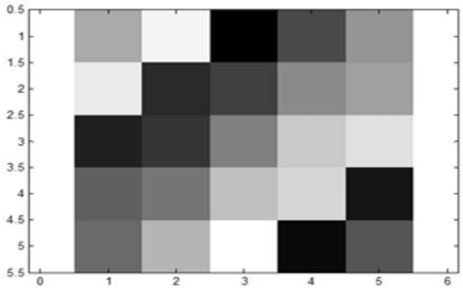
mixing gives the White component and this the additive color model, which is the foundation of color space, is built on the idea of a cartesian coordinate scheme.



B. HSI or HSV colour space model: Three specific elements make up the hue (H), saturation (S), & intensity (I) of color, which appears using the HSI color space model. Because it resembles how the human eye sees color, it is frequently utilized in computer vision and image processing applications. The color component hue defines a pure color, such as pure yellow, orange, or red. The saturation component is a measurement of how much color is blended with white. ● 0 degree – Red ● 60 degree – Yellow ● 120 degree – Green ● 240 degree – Blue ● 300 degree – Magenta Intensity ● Range is [0, 1] ● 0 means white **● 1 means black**



C. Grayscale colour space: Grayscale models usually have no colour information and are used to reduce or simplify any complex algorithm as well as reduce size of the image. The meaning of applying grayscale model onto an image is basically converting an coloured image into a black and white contrast image converting the varying range of 0 - 255 to either 0 or 1 simplifying the visual output also.



D. YCbCr colour space model: YCbCr was an analogous color space utilized in digital video & photography. that separates brightness from colour: ● Y: The luminance component that represents brightness ● Cb: The blue-difference component that shows how the blue component differs from a reference value. ● Cr: The red-difference component, which shows how much the red component differs from a reference value. ● Along with RGB, YCbCr is one of the main color spaces used in digital component video.

RELATED LITERATURE

Colour models have been an integral part of image processing but has been grabbing the researcher's attention in recent years for the topic of variation of result and representation with the difference in accuracy for various industries like for medical industries the best colour space model has always been grayscale as it simplifies the visual output and helps in finding the required conclusion with ease without any error and with a very high accuracy.

For example, the use and analysis of colour models in image processing[1]. This study shows that the colour two elements comprise the basis of image processing: First colours are used in object identification and simplify extraction from a scene and colour is a powerful descriptor. Second, humans can use thousands of colour shades and intensities. An overview of different color models is provided, along with descriptions, comparisons, and evaluation findings. These models displayed on particular hardware platforms by using different parts of an image. A color model's function is to make it easier to specify colors in a way that is commonly recognized. Additionally, studies demonstrate how different models can be converted to expedite picture processing with little delays. However, complicated mathematical equations cause variations in the outcomes of different models. Adaptive histogram equalization coupled with contrast constrained adaptive histogram equalization are two image processing techniques that can be utilized in the future to speed up picture processing using these hue models.

A comprehensive study on colour model and their conversion is also done by Kondekar Vipul H, Bodhe S. K.[2] The many color spaces utilized in image processing are thoroughly examined in this paper. The selection of the color space may represent a crucial choice that has a significant impact on the processing outcomes. Selecting the right color space can be made easier with an understanding of different color spaces. According to the applications, this article provides a more comprehensive perspective on handling various color spaces. For some applications, color provides useful information, but many image processing programs transform color images to grayscale and use them for additional processing. The feature vectors underlying the images as well as the connections and correlations between various color components within the same color space can be produced using various color models.

A Review Paper concerning Color Image Processing in Research Mohammed Khan, Shifa Jaan [3]. Displaying visual information in human perception is the aim of color image processing. This study serves as an introduction to color image processing, covering subjects chosen to give the reader a firm understanding of the methods employed in this area for dealing with images. The foundation of a field that is broad in both technical breadth and application areas was laid by our examination of color basics and color models. In particular, we concentrated on color models which we thought may be useful for digital image processing and could possibly be the basis for further studies in this area regarding hue image processing.

The discussion these color model analyses for Human Perception along with Visual Color Difference research [4] delves into the critical aspect of colour perception and its representation in various colour models. By evaluating the alignment between human visual perception and colour models as XYZ, CIELAB, CIELUV, RGB, HSV, & HSL, we desire bridge the gap between computational colour representation and human subjective experience.

Our findings indicate that HSL and HSV exhibit the strongest correlation with human colour perception, demonstrating superior performance in accurately reflecting visual colour differences and dominant palette extraction. These models effectively capture the perceptual nuances of colour, making them valuable tools for image processing, digital design, and other visual applications.

Conversely, models like Euclidean RGB, weighted RGB, Lab CIE 2000, and Lab CMC exhibit lower correlation and higher Mean Absolute Error (MAE), suggesting a less accurate representation of human colour perception. These models may not reliably capture subtle colour differences or dominant colour palettes.

Despite the fact that this study offers valuable insights, it is crucial to recognize its limitations, particularly the minuscule sample size. To enhance our comprehension of human color perception also its computational representation, future studies should try to increase the number of participants and investigate a greater variety among color models.

An Investigation of Color Models regarding Human Perception & Visual Color Disparities provide an in depth study for the colour space conversion models to ensure the accurate conversion between various images and the images devices. In this they give findings on these algorithms with not only references but also a comparison of error analysis and various related fields for the same.

Abbreviations and Acronyms

Abbreviations used in this document are:

- RGB - Red, Green, Blue
- HSI or HSV or HSL - Hue, Saturation, Intensity or Value or Lightness
- YCbCr - Luma or Luminous or Brightness, Blue-difference chroma, which symbolizes the red-difference and the blue component's difference from a value reference. Chroma shows the difference between the red component and a reference value.
- CNN - Convolutional Neural network
- YOLO V5 - You only Look Once Version 5
- CIELAB - Commission Internationale de l'Eclairage (CIE) Lightness, Red/Green value, Blue/Yellow value
- CIELUV - The International Commission for Eclairance (CIE) Luminous and Chroma (U & V)
- Val - Validate dataset

METHODOLOGY

The methodology used for this research paper is purely through the technical and with the codes of python due to which we are able to find the accuracy of all the models on various kinds of images and its types.

A. Dataset preprocessing: The very first step for this process was to create a dataset that is completely customised and is entirely random including images like a crowded trail, computer table, people playing football, fruits basket, kitchen area, office area and many more.

B. Conversion: After creating the custom dataset using a python syntax we need to convert the original images to the respected colour models like grayscale, YCbCr, RGB, & HSV color spaces can be produced employing the following syntax:

For grayscale conversion - gray_image = cv2.cvtColor(image,cv2.COLOR_BGR2GRAY)

For HSV conversion - hsv_img = cv2.cvtColor(original_img,cv2.COLOR_BGR2HSV)
For YCbCr conversion – ycbcr_img = cv2.cvtColor(original_img,cv2.COLOR_BGR2YCrCb)
C. Training and Validating dataset: After conversion of all the images we need to split the dataset into two major parts ,i.e. the training dataset and the validating or the testing dataset. So that we can feed the algorithm the training dataset as an input. And use the validating set of the dataset to check the accuracy of the algorithm on dataset that were not feeded into the algorithm. D. The algorithm: For creating the algorithm for object detection, we have applied YOLO V5, CNN. To apply Yolo V5 there are some set of steps like: Detect: YOLOv5 inference is performed on several sources through detect.py, which also automatically downloads models from the most recent YOLOv5 version as saves the results to runs/detect. Validate: Verify the correctness of a model using the val the test splits from the customized dataset. Train: Training the YoloV5 model on the customised dataset, beginning with weights the fact have been pretrained or with weights that have been initialized at random. Labelling the dataset on roboflow: Roboflow facilitates the simple organization, labelling, and preparation of a high-quality dataset using your own unique data. Visualise: After all the following steps comes the visualisation part through various kinds of line graphs and many more.

RESULT

The findings of this comprehensive study on various colour models in image processing underscore the substantial impact that selecting an appropriate colour model has a major impact on enhancing performance metrics across a broad range of computer vision tasks.

Using a customised dataset, we converted each image into multiple colour spaces, following which object detection was performed via convolutional neural networks (CNN), specifically employing YOLO V5 and Google's Mediapipe for their efficiency in lightweight model application allowing low usage of system resources. This approach allowed us to assess a range of critical factors, such as accuracy, processing time, GPU utilisation, CPU performance, and memory consumption, which are pivotal in determining model suitability.

Edge detection was refined using morphological filtering operators, including dilation and erosion, which significantly improved smoothness and clarity of the edges, enabling finer detail in object recognition and overall detection accuracy. Our findings reveal considerable variability in these metrics across different colour models, with certain models offering superior results based on image characteristics and processing requirements. Models with higher accuracy often corresponded with longer processing times, while those with faster speeds exhibited moderate detection precision, underscoring the trade-offs inherent in model selection.

This study provides a valuable framework that not only consolidates the strengths and limitations of each colour model but also offers actionable insights to help practitioners identify the optimal model based on specific project needs. In sum, this research delivers a practical, accessible guide to selecting colour models that optimally balance accuracy, resource efficiency, and processing demands, thereby enabling effective, resource-conserving image processing and object detection.

A. Tables We have tested all these metrics on a customised dataset of 50 images of various kinds including nature, crowd trail, living room, computer desk , people playing, fruits baskets, offices with a tv or a screen background, and to make it a little complex we have used images where there are more than one object detection done on it. Like a computer desk with a person on it sides to detect two items in one frame.

TABLE I. RESULT

Colour model	*Accuracy (%)*	*Processing Time*	*Space Usage*	*GPU Performance*	*CPU Performance*
RGB	92.3	25	12.5	0.032	0.045
Grayscale	88.7	20	6.25	0.028	0.038
YCbCr	91.5	28	15.6	0.035	0.048
HSV	90.2	23	11.8	0.03	0.042

TABLE II.

Colour model	*Description*	*Common Application*
RGB	Red, Green, Blue	Displaying images on screens
Grayscale	Single Channel, Intensity values	Image processing, feature extraction
YCbCr	Luminance and Chrominance	Video Compression, Colour Space Conversion
HSV	Hue, Saturation, Value	Colour based image segmentation, Object detection

References

1. Er. Bhubneshwar Sharma, Rupali Nayyer, "Use and analysis of colour models in image processing", International Journal of Advances in Scientific Research, October 2015.
2. Kondekar Vipul H, Bodhe S. K, "A Comprehensive Investigation of Colour Models used inImage Processing", International Journal of Computer Applications, February 2018.
3. Shifa Jaan Mohammed Khan, "Study on Color Image Processing", International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), April 2022.
4. Aruzhan Burambekova, Pakizar Shamoi ,"COMPARATIVE ANALYSIS OF COLOUR MODELS FOR HUMAN PERCEPTION AND VISUAL COLOR DIFFERENCE", June 2024.