**CMY Colour Space**

# 1. Introduction to Colour Spaces

A colour space is a specific organization of colours that enables consistent reproduction and representation of colour across various digital and physical devices. These include monitors, printers, scanners, and cameras. Colour spaces define how colours can be displayed or interpreted in a digital environment.

**Some common colour spaces include:**

* **RGB (Red, Green, Blue):** Used mainly in electronic displays.
* **CMY (Cyan, Magenta, Yellow):** Used primarily in colour printing.
* **CMYK (Cyan, Magenta, Yellow, Black):** An enhancement of CMY for better print quality.
* **HSV (Hue, Saturation, Value):** Used in image processing and editing tools.

Each colour space serves a particular purpose. Understanding them is essential in fields like image processing, computer graphics, and printing technologies.

# 2. CMY Colour Space – An Overview

The CMY colour model is a subtractive colour model used mainly in colour printing. It uses three primary colours — Cyan, Magenta, and Yellow — which are the complements of the primary RGB colours.

* Cyan is the complement of Red
* Magenta is the complement of Green
* Yellow is the complement of Blue

The subtractive model works by removing (subtracting) brightness from white light. For example, when you apply cyan ink to a white page, it absorbs red light and reflects green and blue, making the page appear cyan.

This model is different from the RGB model, which is additive (combining light to create colours). CMY is ideal for situations where colours are created by filtering light, like in printing or painting.

# 3. Subtractive Colour Mixing in CMY

Subtractive colour mixing is based on the concept of absorbing light rather than emitting it. In this process, colours are formed by subtracting light wavelengths.

The combinations in CMY are as follows:

* Cyan + Magenta = Blue
* Cyan + Yellow = Green
* Magenta + Yellow = Red
* Cyan + Magenta + Yellow = Ideally Black, but practically results in a muddy dark brown.

In the subtractive model, when no ink is applied to white paper, all colours are reflected, and the paper looks white. When more inks are added, more light is absorbed, producing darker colours.

However, due to imperfections in ink and pigment, combining C, M, and Y does not produce a pure black, which leads us to the need for CMYK.

# 4. Relationship Between CMY and RGB

The CMY and RGB colour spaces are inverses of each other.

To convert RGB to CMY:

* C = 1 − R
* M = 1 − G
* Y = 1 − B

To convert CMY back to RGB:

* R = 1 − C
* G = 1 − M
* B = 1 − Y

These formulas work with normalised values (ranging from 0 to 1). This inverse relationship allows devices to translate colours between screen (RGB) and print (CMY) formats effectively. When we design something digitally in RGB, it's converted to CMY for printing.

This relationship is foundational in digital printing, image editing, and graphic design tools like Adobe Photoshop or Illustrator.

# 5. CMYK – An Extension of CMY

Although theoretically, combining CMY should give black, in practice, the result is a dark, muddy brown. Therefore, a fourth colour — K (Black) — is added to enhance contrast, improve print quality, and reduce ink usage.

* K is calculated as the minimum value among C, M, and Y.
* Black ink also improves text clarity and depth in images.

CMYK is now the standard colour model used in inkjet and laser printers, as it provides better output quality, especially for dark or detailed images.

# 6. Advantages of the CMY Colour Model

The CMY model, especially when extended to CMYK, offers several benefits:

* Optimized for Printing: Designed specifically for subtractive mixing used in print media.
* Simple Conversion from RGB: Easy mathematical relationship allows straightforward conversions.
* Efficient Colour Separation: Used for creating printable layers for each ink.
* Economical Ink Usage: Adding K reduces the need for high amounts of coloured ink.
* It plays a vital role in publishing, packaging, textile printing, and other design industries

# 7. Disadvantages of the CMY Model

Despite its usefulness, the CMY model has some limitations:

* Not Ideal for Digital Displays: RGB is more suitable for screens due to additive light nature.
* Conversion Issues: CMY to RGB conversions can cause colour shifts or artifacts.
* Limited Gamut: CMY can’t represent as many colours as RGB, especially vibrant ones.
* Inefficient Black Reproduction: Requires additional black ink (K) for true dark shades.

These drawbacks restrict CMY’s use in areas like computer vision or 3D modelling, where RGB dominates.

# 8. Applications of CMY Colour Space

The CMY colour model is widely used in:

* Printing Industry: Standard for inkjet, laser, and offset printers.
* Image Editing Tools: Used in photo correction and colour separation layers.
* Object Tracking: In machine vision, colour segmentation using CMY can track objects.
* 3D Printing: Helps simulate ink behaviour and colour blending.
* Surveillance Systems: CMY-based segmentation can help with background removal in video feeds.

These applications show how CMY is still vital in physical reproduction of visuals and some automated systems.

# 9. Conclusion

The CMY colour space is a core model for subtractive colour processing, primarily used in printing and image processing. While not as versatile for digital screens as RGB, its compatibility with print technologies and ease of conversion make it essential in several fields.

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