VD1
VD2

Retina-Inspired Demultiplexing of RGB Photodetectors into Six Perceptual Channels (RGBYCW)

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FIDE SPLENDET ET SCIENTIA

Diapositive 1

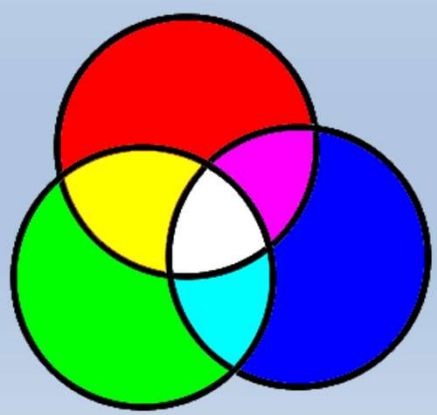
VD1 Welcome everyone. Today, I'll be sharing a new approach to imaging and display technology. Our goal is to transfer the world's true colors to screens, in a way that mirrors how we actually see them, not just how devices measure them

Vasil Diaconu; 2025-07-28

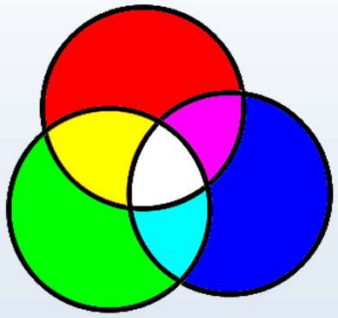
VD2 Vasil Diaconu; 2025-07-28

Introduction

- The current CIE colorimetric framework is founded on color matching and additive color mixing principles using three primaries. This framework produces a spectral locus in which all monochromatic lights are assigned a saturation of one by definition.



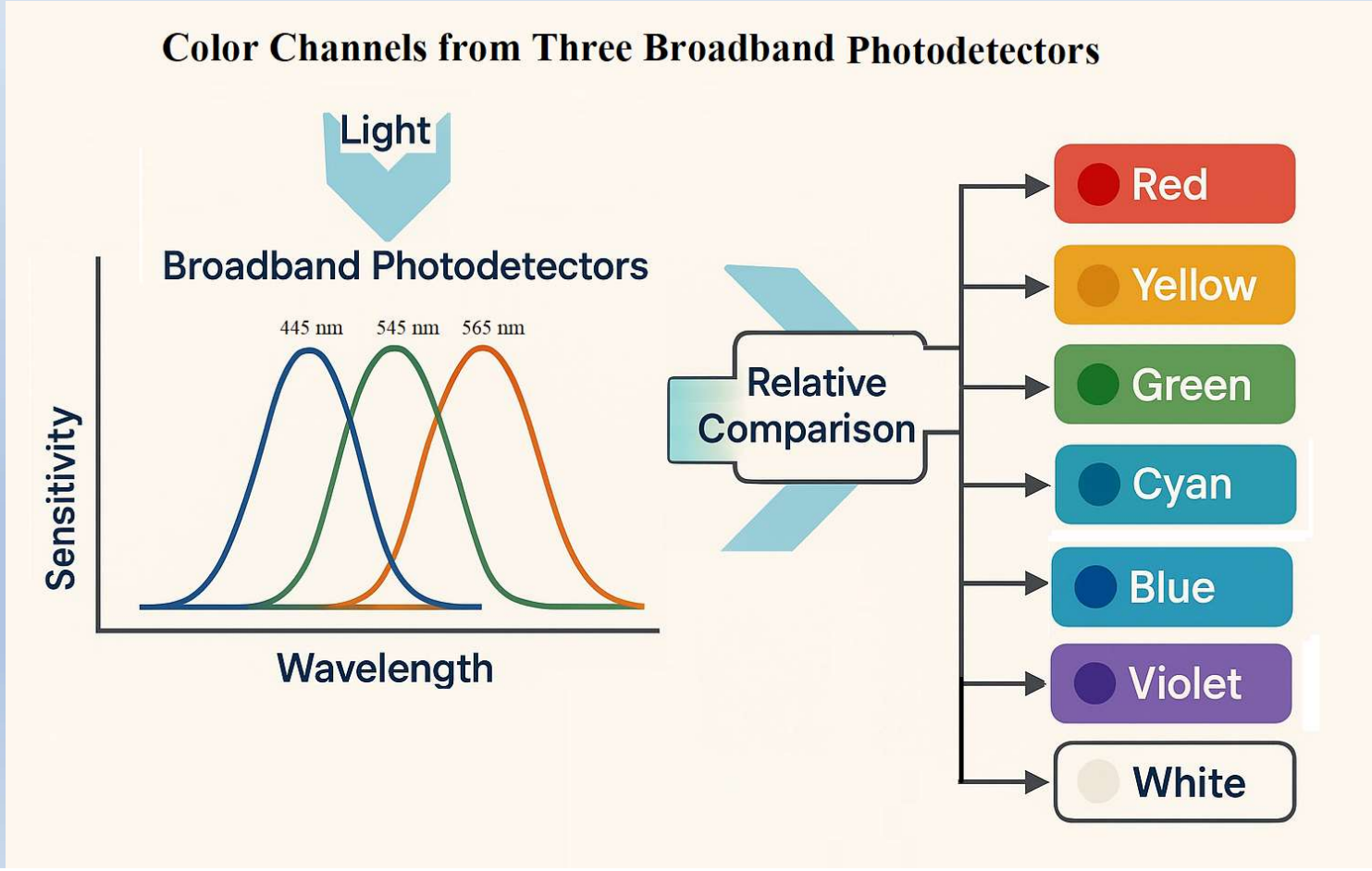
Introduction



- Recent advances in color coding retinal physiology, including my work on color signal de-multiplexing (Diaconu & Faubert, *Optics Continuum*, 2024), suggest that this assumption does not fully reflect human color perception. In the retina, monochromatic light cannot stimulate more than two chromatic channels and the white (achromatic) channel simultaneously

Human Retinal Color Coding

- Three cone types: S (445 nm), M (545 nm), L (565 nm)
- Neural comparison extracts R, Y, G, Cy, B, V, W



The Retinal Demultiplexing Model

- Based on Diaconu & Faubert (2024)
- Demultiplexing of two overlapping photoreceptor signals into three distinct color channels.

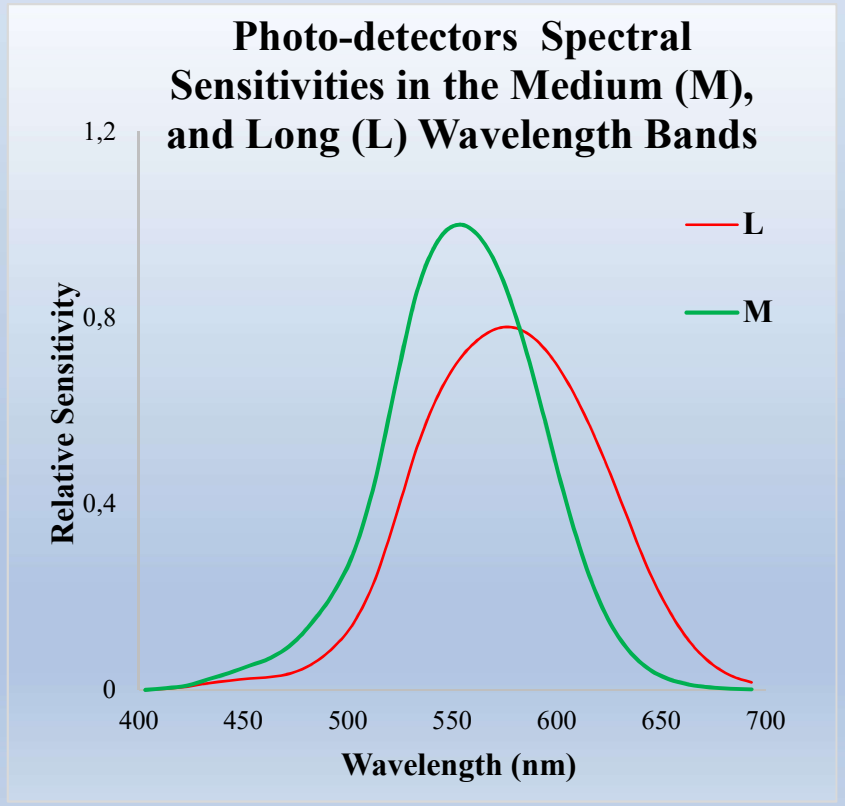


Figure 1a

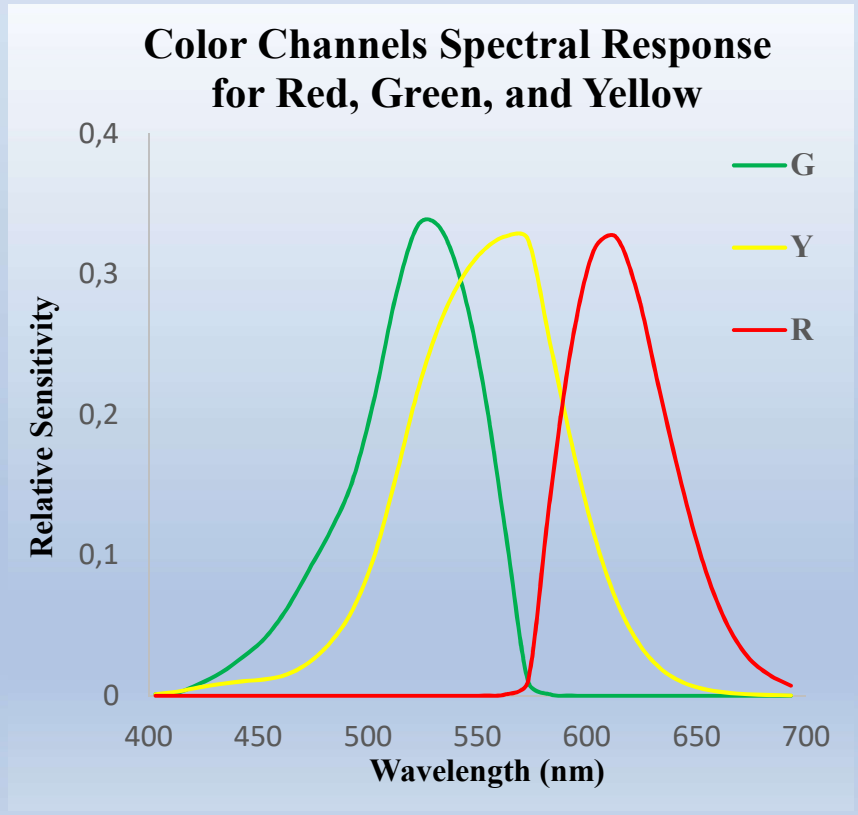


Figure 1 b

Mathematical Formulation

- Eq. (1). |L-M| = Distinctive Photodetector Signal
- Eq. (2). ((L+M) - |L-M|)$_*$1/2 = Common Photodetector Signal
- The solutions for Equation 2 are:
- a. ((L+M) - |L-M|)*1/2 = L, for L < M,
- b. ((L+M) - |L-M|)*1/2 = M, for M < L

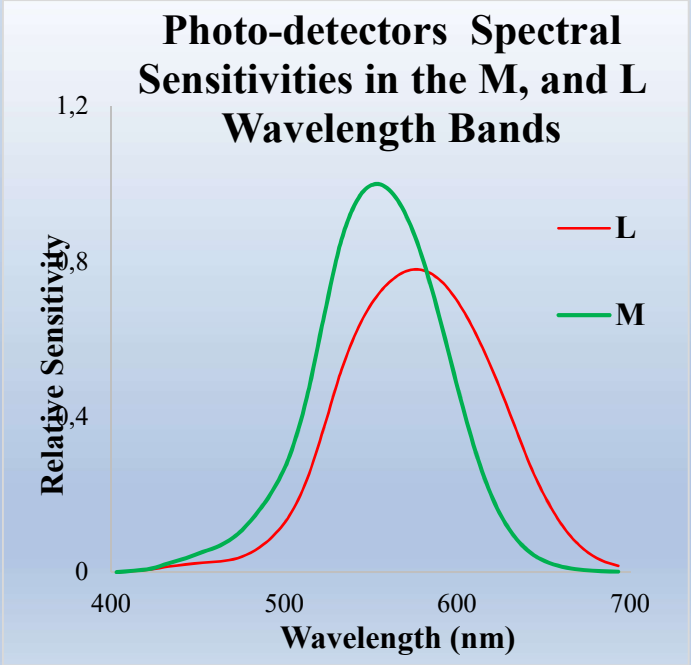


Figure 1a

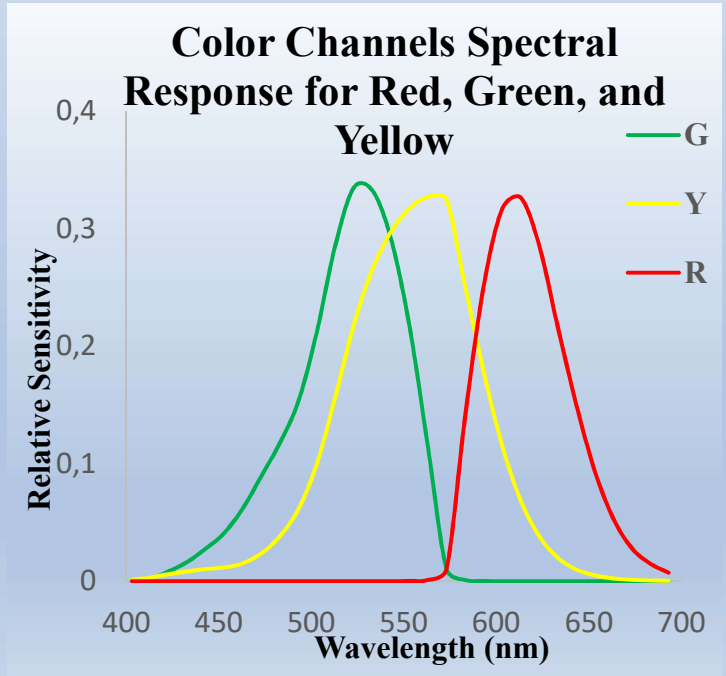
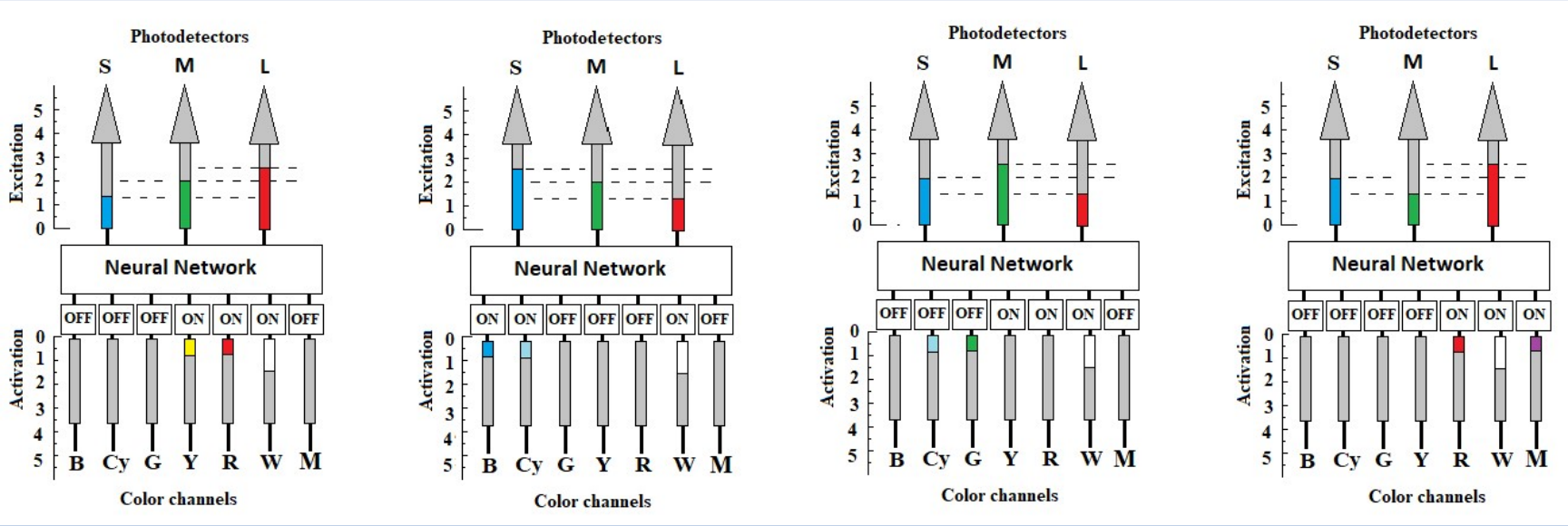


Figure 1 b

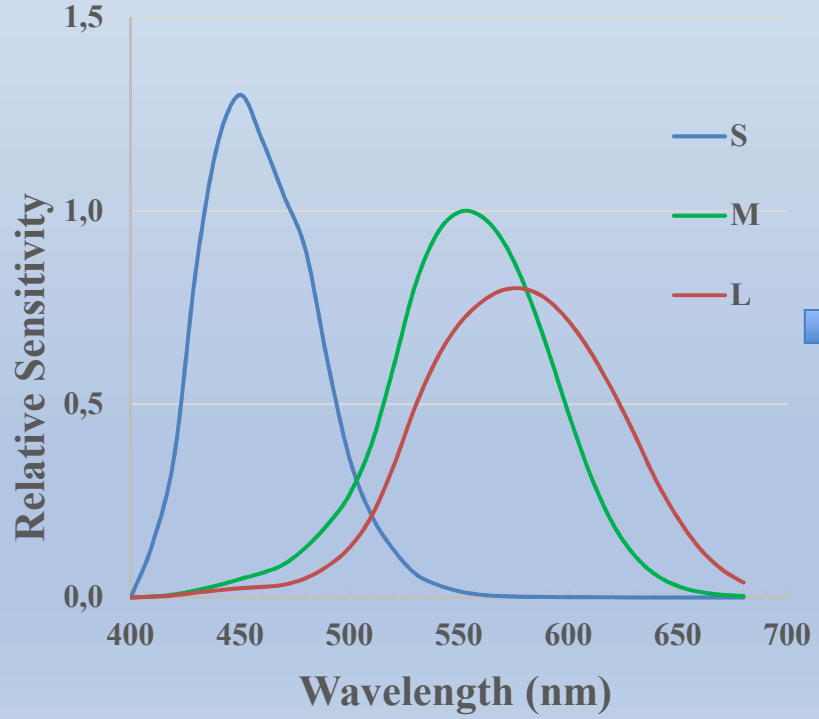
Signal Segregation by ON and OFF Neural Network



- Least excited photodetector modulates white chanel. The color channel representing this photodetector is OFF
- Only tow color channels are ON.
- The color channel representing the most excited photodetector.
- The color channel representing the common spectral sensitivity of the most excited with the intermediate-excited photodetectors.

Photo-detector Sensitivity and Color Channels Spectral Response in Human

Photo-detectors Spectral Sensitivities in the Short (S), Medium (M), and Long (L) Wavelength Bands



Color Channels Spectral Response for Red, Green, Blue, Yellow, Cyan and White

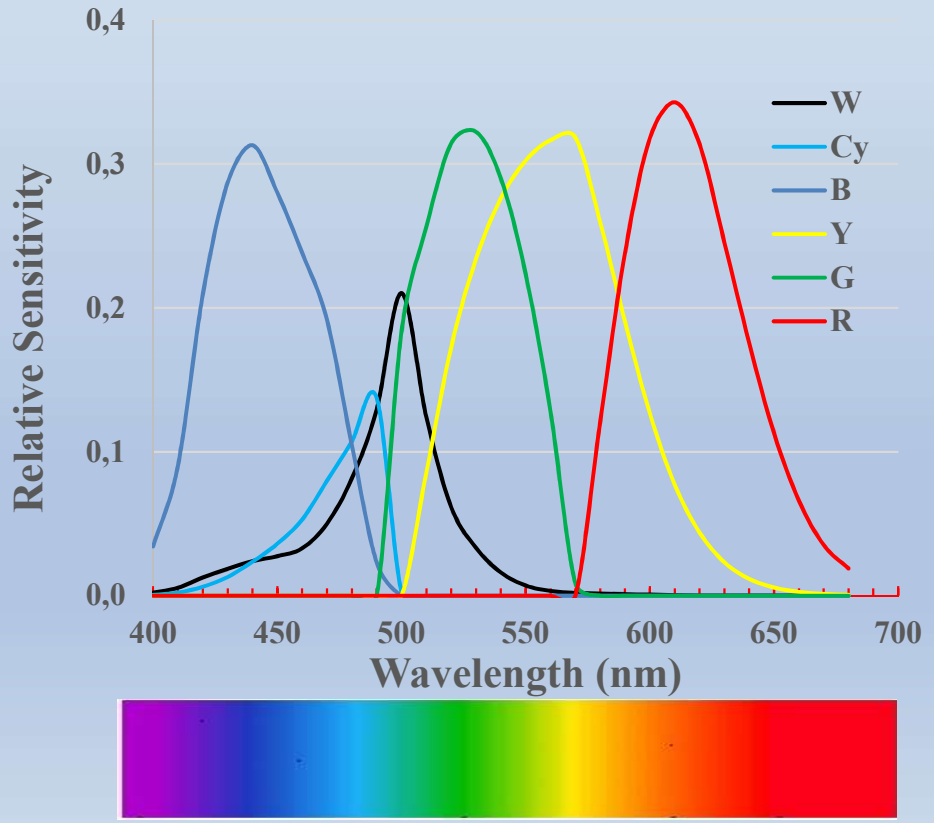
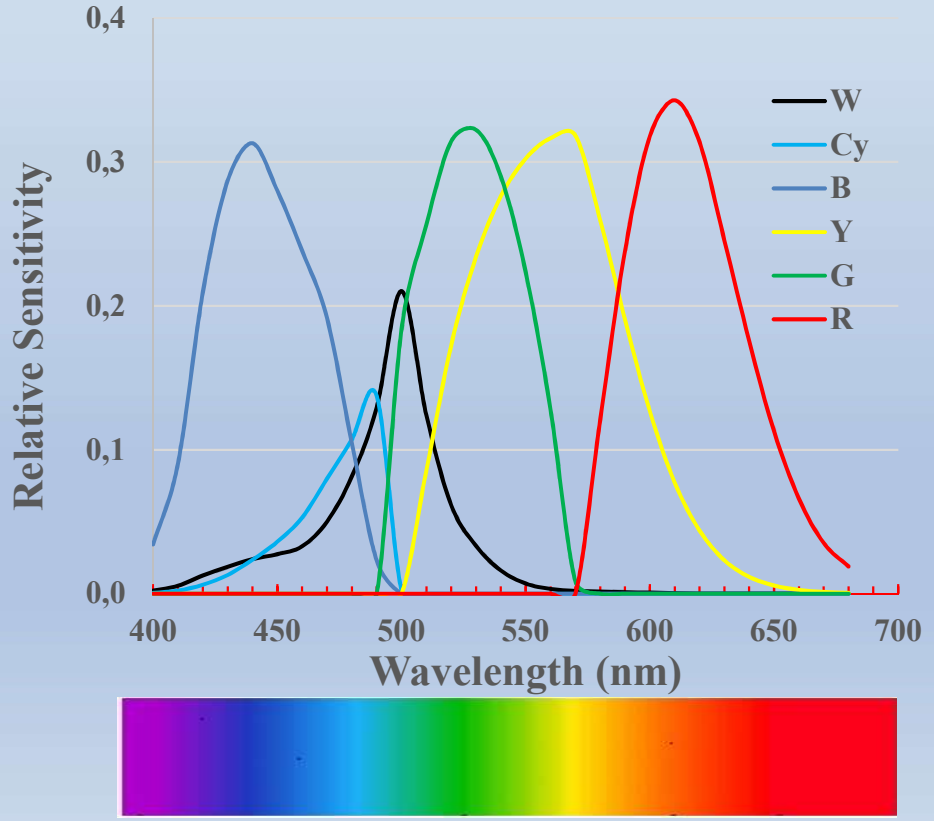


Photo-detector Sensitivity and Color Channels Spectral Response in Human

The achromatic channel is not simply the sum of S+L+M

An achromatic response in the 450–500 nm spectral range is observed but not in green red spectral zone.

Color Channels Spectral Response for Red, Green, Blue, Yellow, Cyan and White

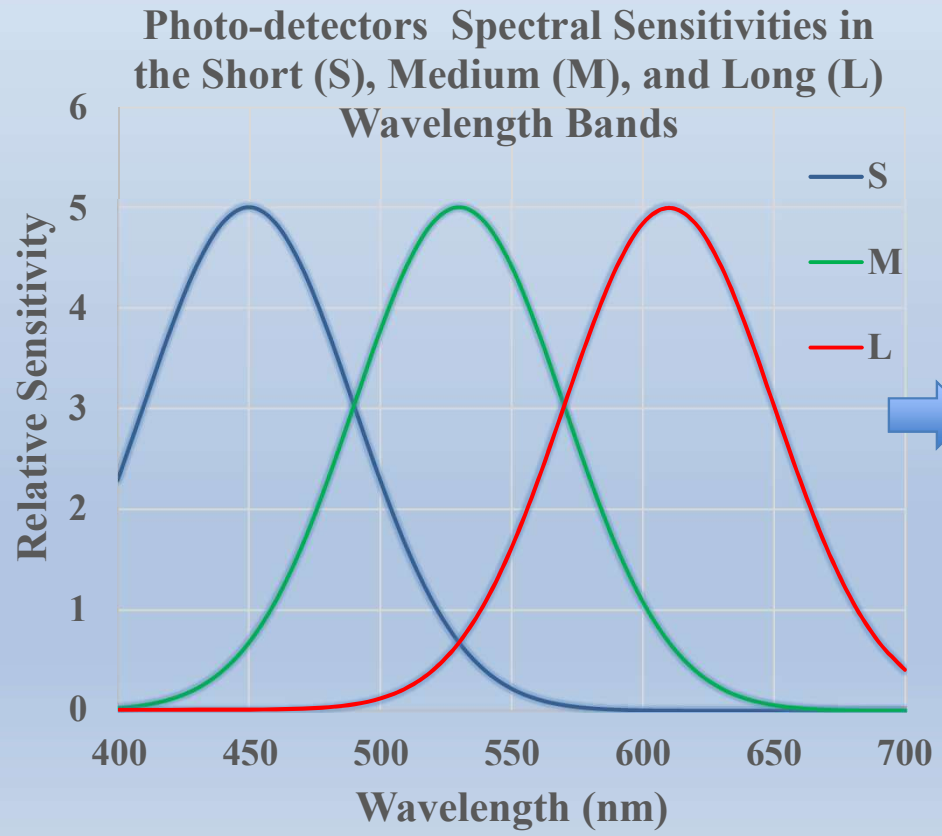


Bridging the Gap with Multispectral Technology

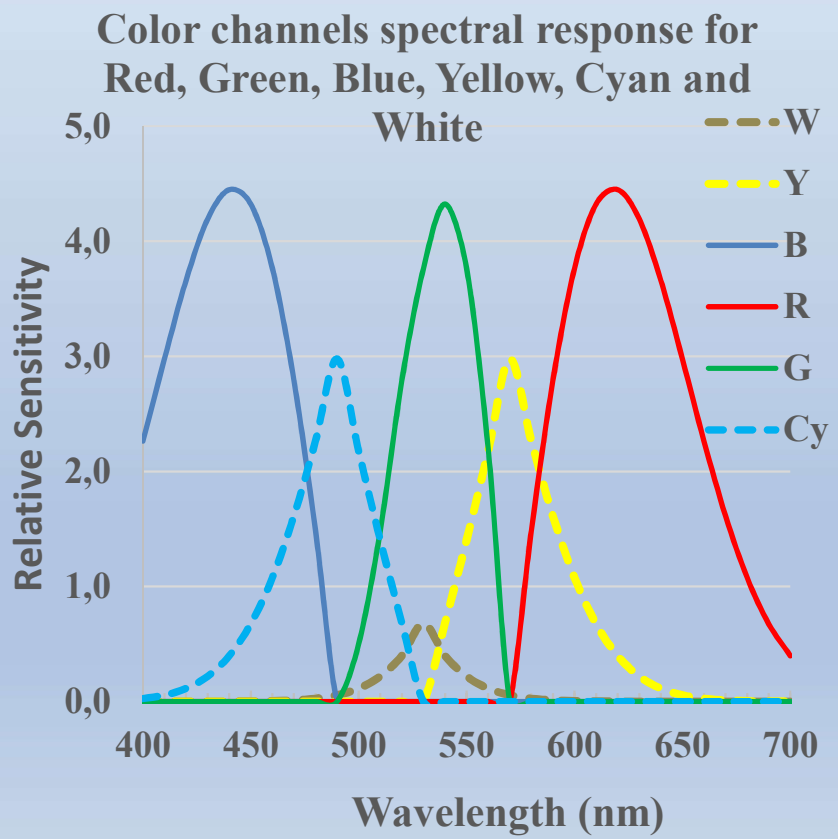
- We propose multi spectral technology solution inspired by recent discoveries on how the retina encodes color.
- Mimics retinal color-coding.
- Derives multiple color channels from RGB camera.
- Offer displays with multispectral pixels (e.g., RGBYCy) to reproduce true colors.

Photo-detector Gaussian Sensitivity and Color Channels Spectral Response

- Three photodetectors Gaussian Curves
- R, Y, G, Cy, B, W responses



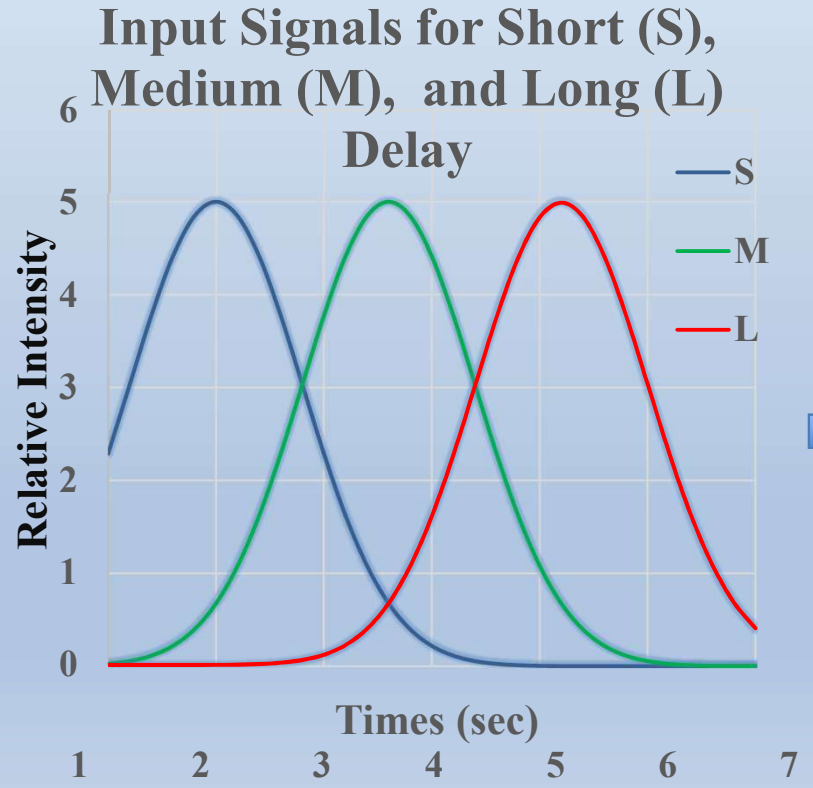
(a)



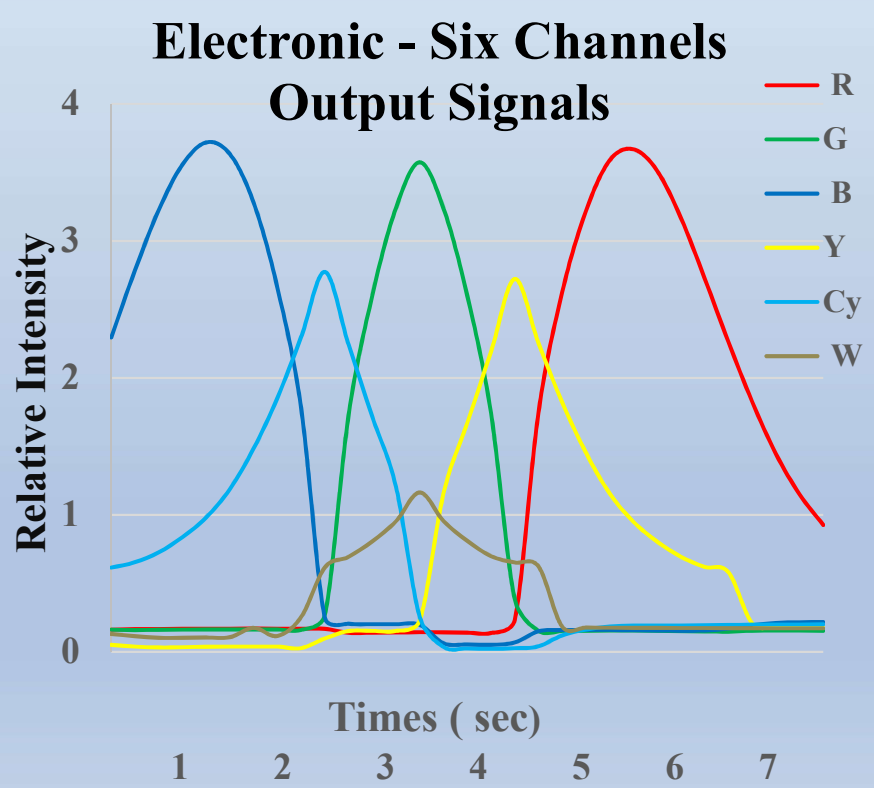
(b)

Experimental Implementation

- An electronic module to simulate the model
- Inputs: three signals -> Outputs: six signals analogous to color signals for R, G, B, Y, Cy, W



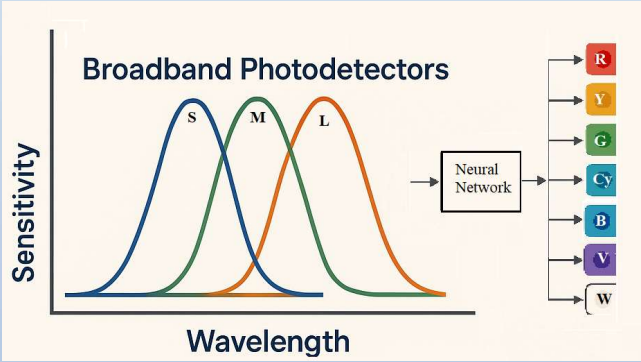
(a)

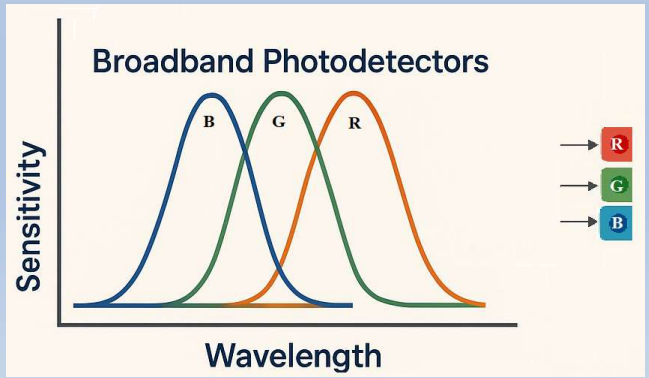


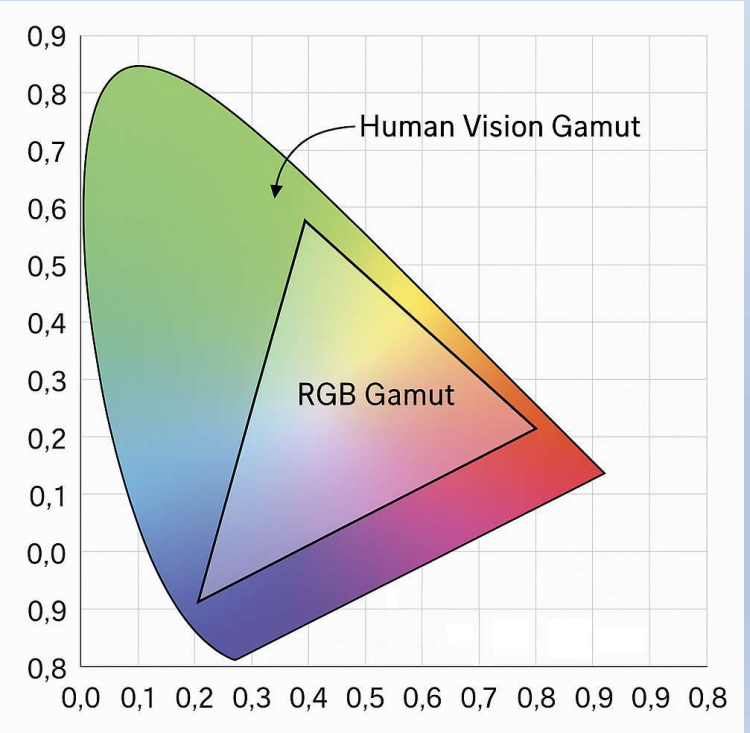
(b)

RGB Camera vs Human Retina

- Both use three sensors, but process signals differently
- RGB: Compresses color gamut
- Retina: Demultiplexes L,M,S signals: seven color channels

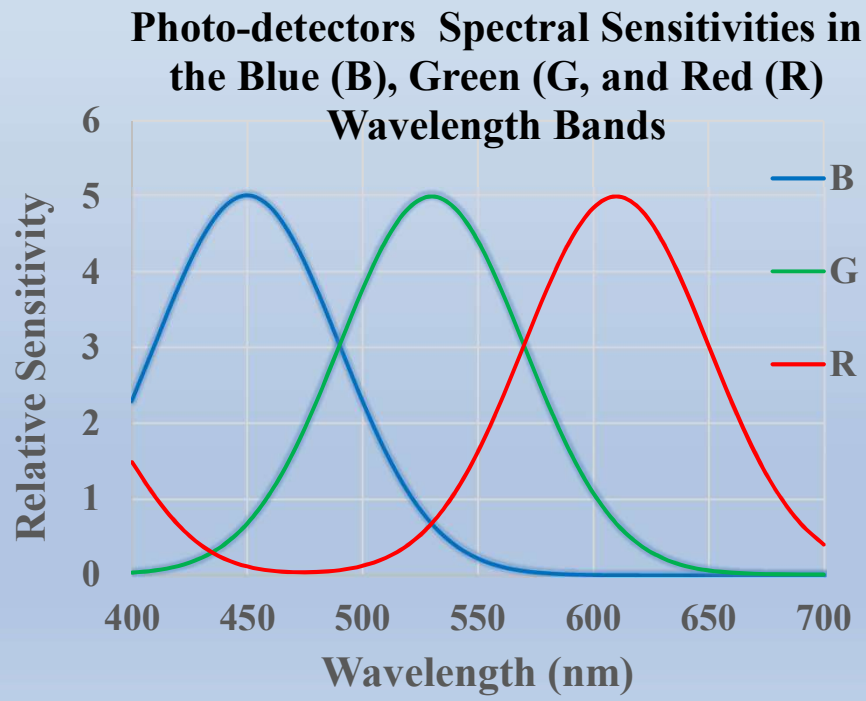


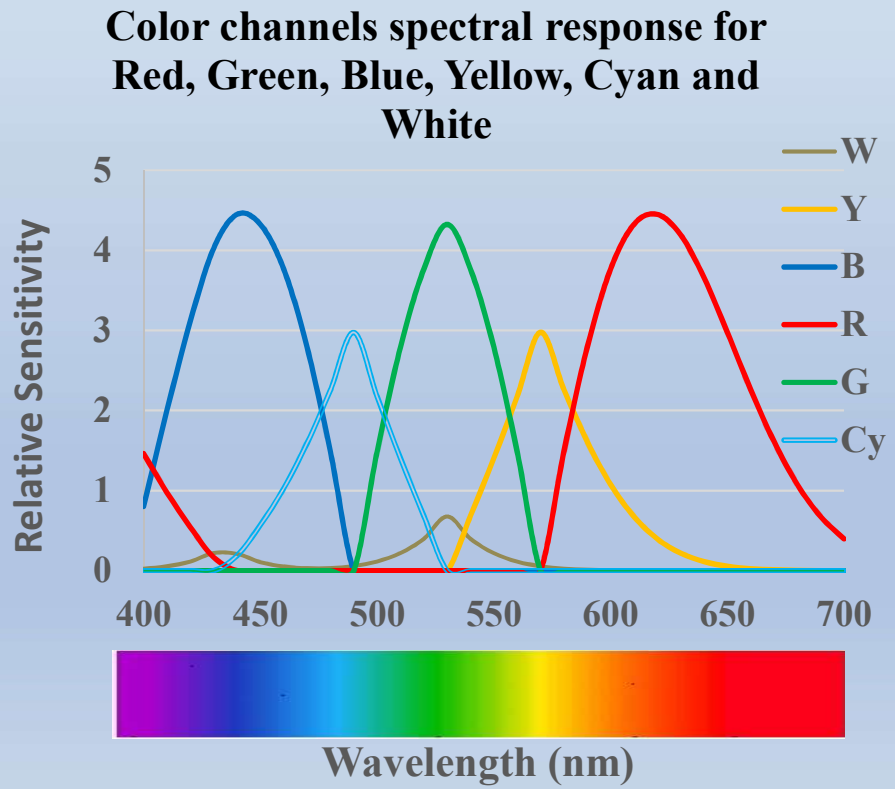




Enhancing RGB Cameras

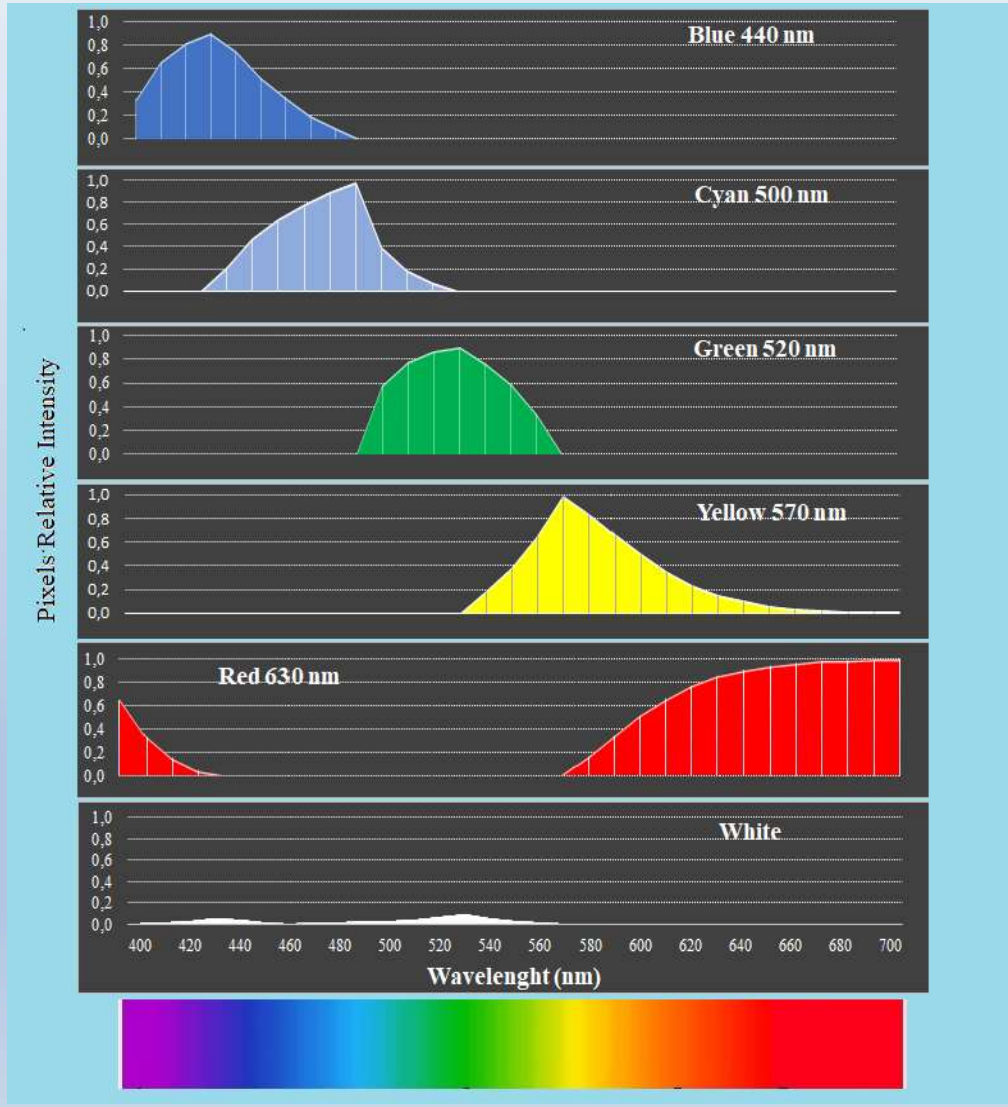
- Demultiplexing of RGB input into a seven-channels color output
- Significant sensitivity in the 400–420 nm range for red photodetectors





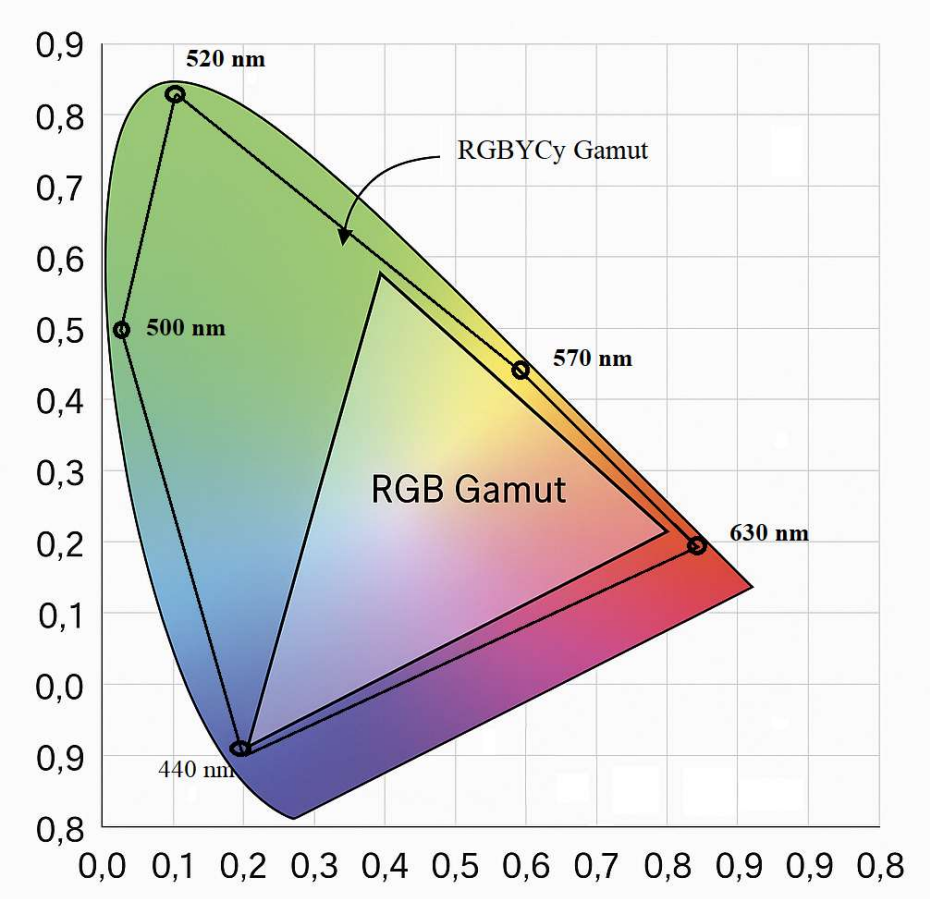
Displays with 6 Color Pixels

- Intensity profiles of RGBYCyW pixel set for monochromatic color rendering
- At any given wavelength monochromatic color is rendered by lighting only two-color pixels.
- Residual intensity of white pixel appears in the blue-green spectral region



Comparison: RGB vs RGBYCyW Displays

- **RGBYCyW displays expand the color gamut, increase brightness and color depth, and offer more realistic color rendering**



Conclusion

- Next study aims to develop a revised CIE-style color map derived directly from the spectral sensitivity functions of the three photoreceptor types in agreement with the On and OFF antagonistic processing mechanisms in the retina.
- The proposed map will incorporate five principal chromatic zones delimited by the six chromatic channels representative for single-color perception, as red, yellow, green, cyan and blue, aligned with the established concept of color antagonism

Conclusion

- The proposed algorithm offers a novel approach for adapting RGB content for displays with RGBYCW pixel arrangements to enhance color reproduction and brightness and reduce power consumption.
- By decomposing the color information into white, yellow, cyan, and adjusted RGB components, the algorithm leverages the capabilities of an RGB camera to function like a multispectral imaging system.

Contact and References

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- References:

- 1. Optics Continuum, 2024
- 2. US Patent 2025/0016463 A1