High Speed Light Communication (LC) Using Color Space Modulation

Date: March 13, 2017

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High Speed Light Communication (LC) Using Color Space Modulation

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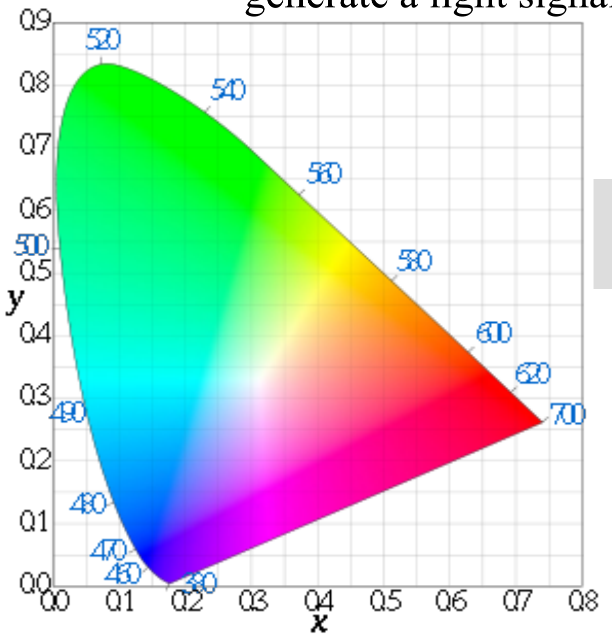
CONSIDERATIONS FOR HIGH EFFICIENT MODULATION FOR LIGHT SIGNALS

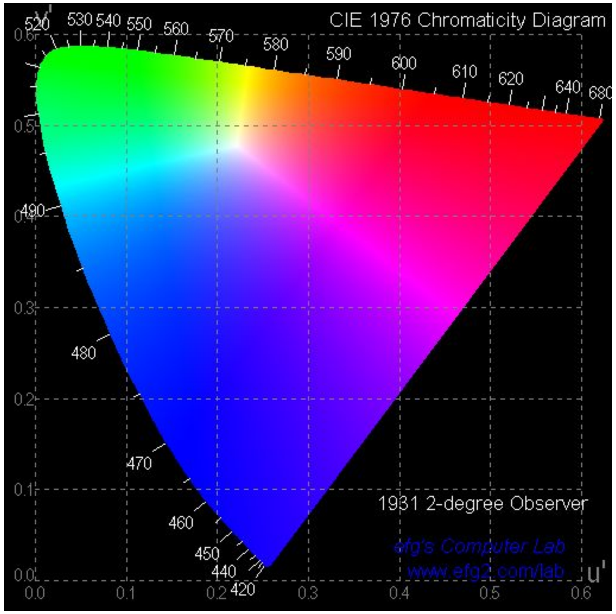
- Need of brightness control or not
  - Need superior brightness for optical wireless communications?
  - It is more desirable for performance not to be affected by brightness control.
- Dependency of light source characteristics
  - Is a modulation technique applied not dependent on technical characteristics of LEDs or other light sources deployed?
- Not (or negligibly) affected by background noise or not
  - Offsetting the impact of background light sources
  - Stable data transmission should be achieved even if the background noise is strong.
  - Offers high robustness to background light
- Data speed
  - Low to high data rates to be realized: adaptive to the amount of information delivered
  - **Adaptiveness to various data rates is important.**

COLOR SPACES UTILIZED FOR LC MODULATION

- Light color spaces
  - Light color spaces can be defined.
    - A point in a color space represents a color of light.
    - Linearity and uniformity work in the space for mixing multiple light signals to generate a light signal having a specific color.



1931 CIE *xy* Color space



1976 CIE *u'v'* Color space

ONE COLOR SPACE: CIE 1931 COLOR SPACE

The CIE *xy* chromaticity diagram and the CIE *xyY* color space

- The outer curved boundary is the spectral (or monochromatic) locus, with wavelengths shown in nanometers.
- The concept of color can be divided into two parts: brightness and chromaticity.
- The *Y* parameter is a measure of the brightness or luminance of a color.

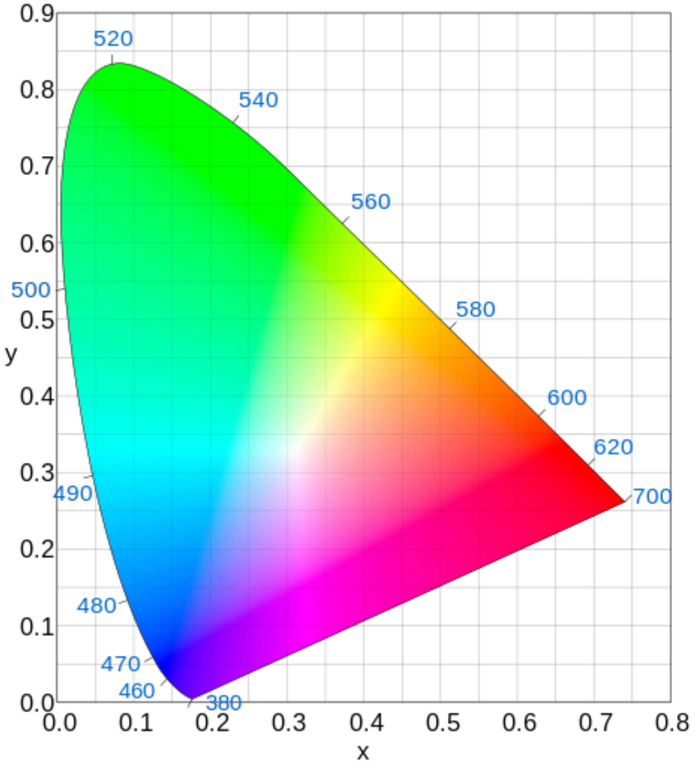
$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z} = 1 - x - y$$

$$X = \frac{Y}{y}x$$

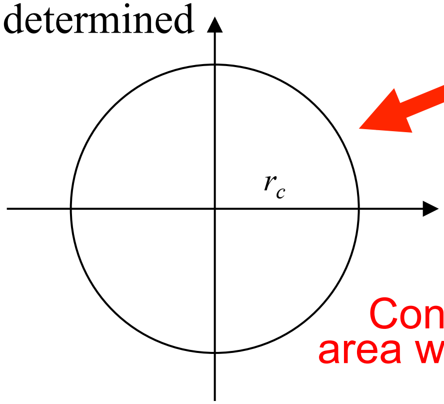
$$Z = \frac{Y}{y}(1 - x - y)$$

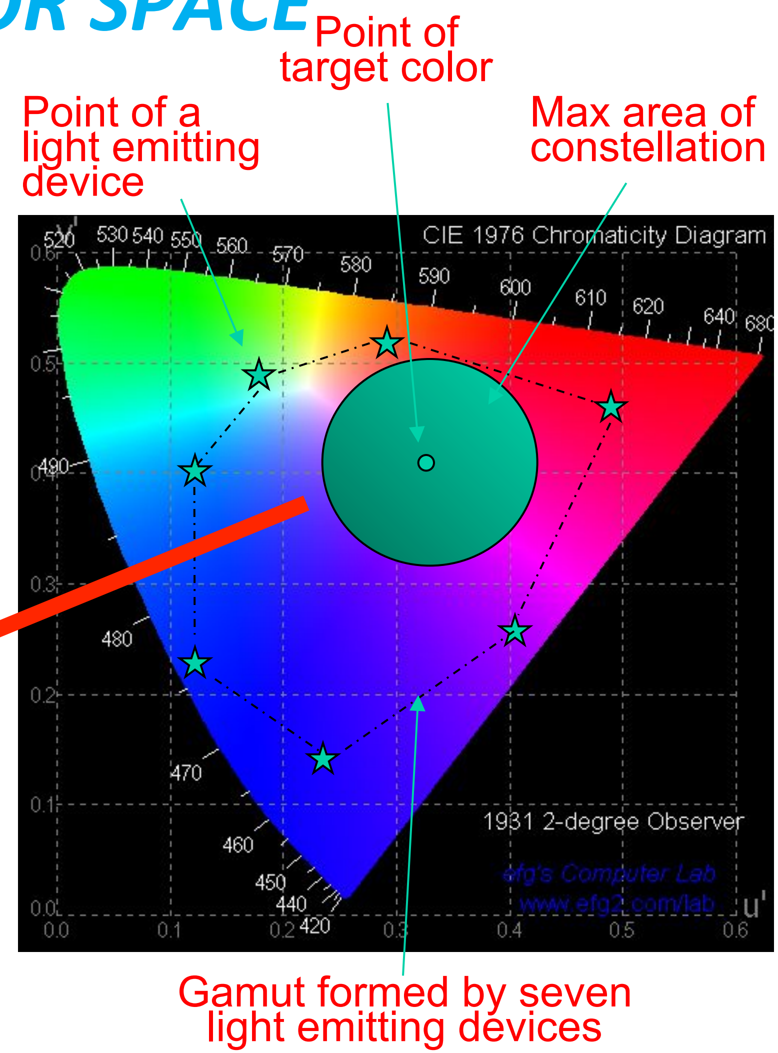


UTILIZATION OF CONSTELLATION ON A COLOR SPACE

- Maximum area of constellation is determined by two factors:
  - Point of a target color visible to human eyes: this point becomes the origin of constellation.
  - Gamut formed by primary color points which represent points of light emitting devices used.

  → Maximum constellation area determined

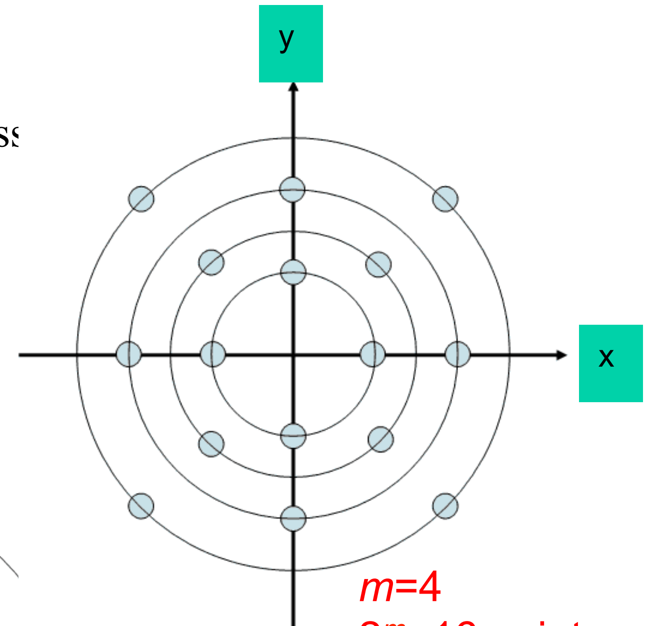




GENERATION OF CONSTELLATION

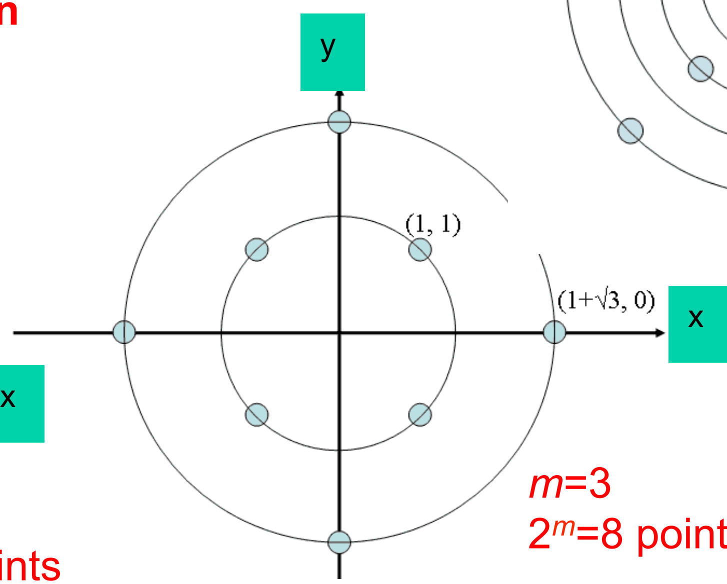
Normalized constellation

Inside a unit circle centered at the original, 2^m points are ass
distance between any two points be maximized.

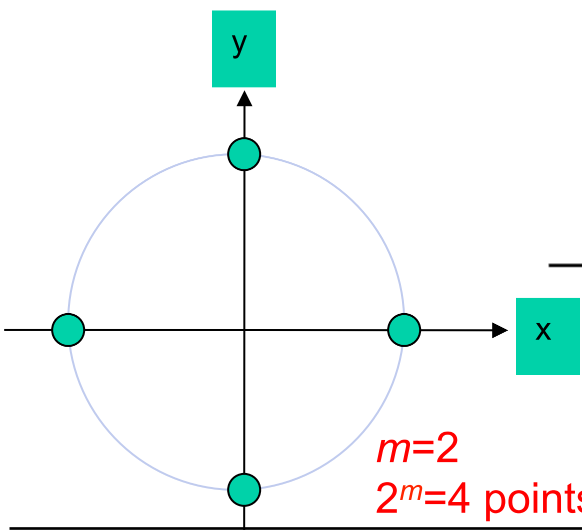


m=4
2^m=16 points

Examples of constellation

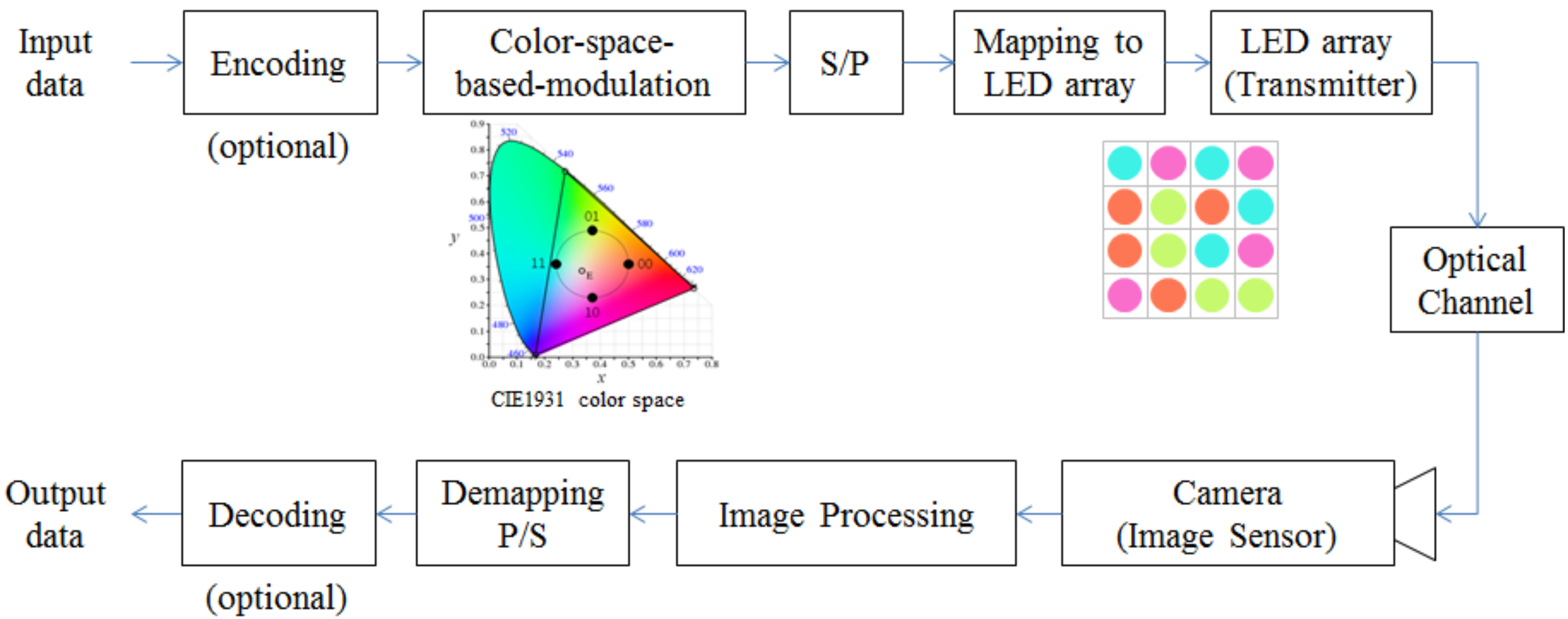


m=3
2^m=8 points



m=2
2^m=4 points

LC SYSTEM DIAGRAM USING COLOR SPACE MODULATION



Color independent Visual-MIMO tranceiving procedure

CONCLUSIONS

- Color space modulation scheme has some advantages
  - Independent of brightness control
    - Not to be affected by brightness control.
  - Dependency of light source (such as LEDs) characteristics
    - Modulation technique applied is not directly dependent on technical characteristics of LEDs or other light sources deployed.
  - Not (or negligibly) affected by background noise
  - Adaptiveness to various data rates
  - Simple implementation
- This modulation scheme may have better performance than other intensity modulations.
  - Need more simulation results .
- This modulation scheme can be applied to High Rate LC areas as well as other low rate LC areas.