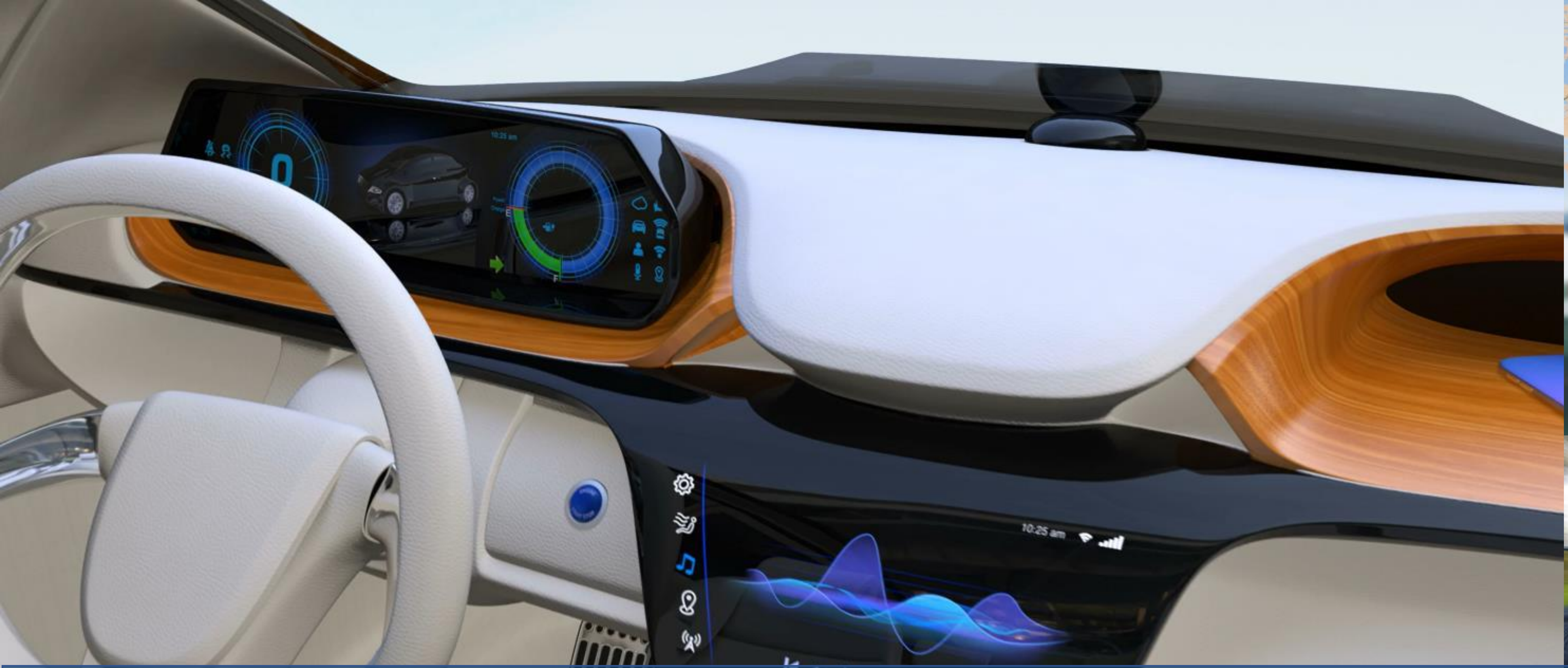

Color vision challenges in perceptual displays for automobiles

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CORM/CIE Vision Session VIII

IRYStec™
Perception Is Reality

Outline

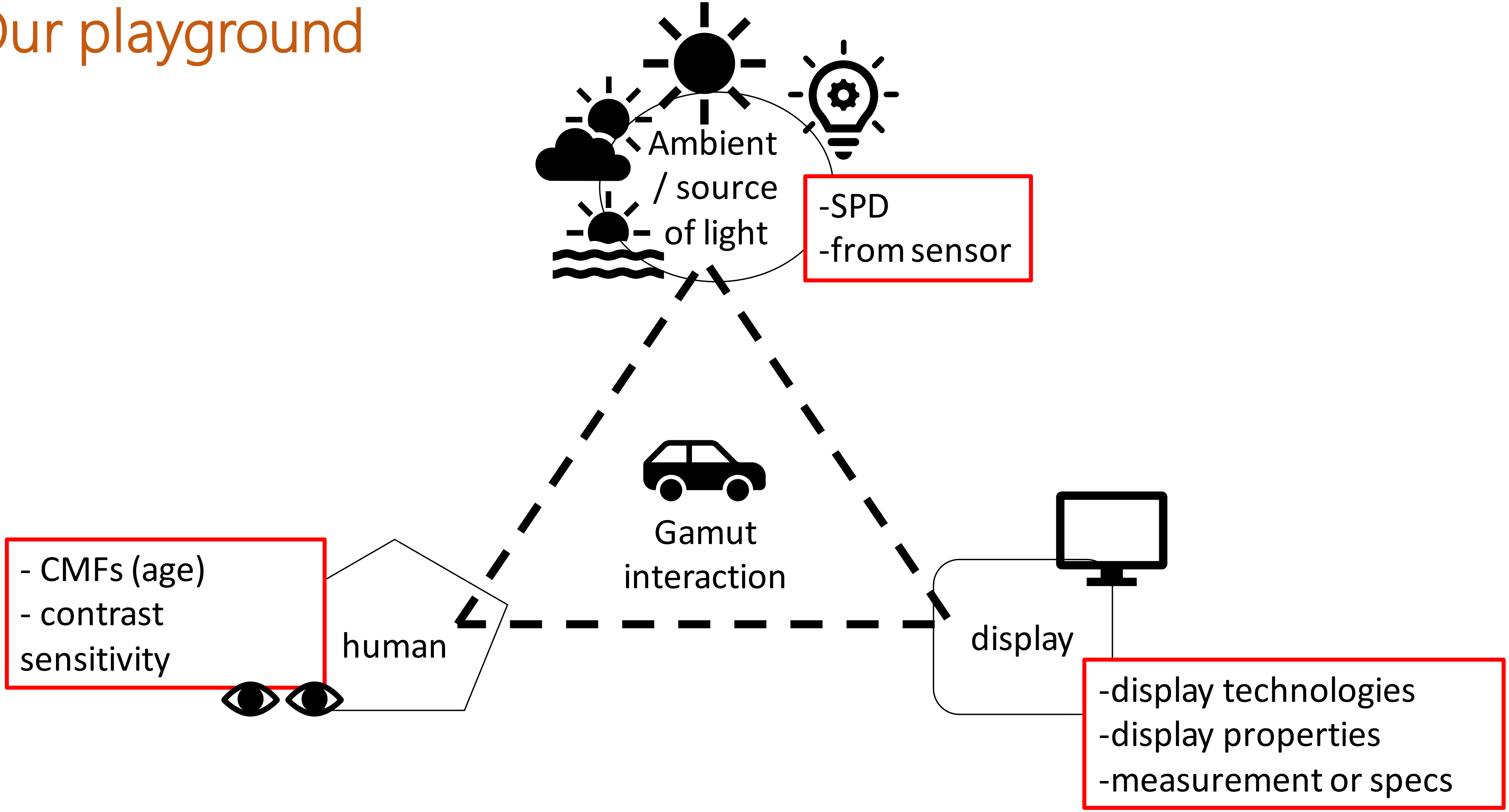
We are a **software company** for **display in automotive** industry.

Technology is evolving rapidly and available **configuration is always changing**. But the **challenges remain similar**: to offer the **best adaption of content** for drivers and passengers according to the in-vehicle **ambient light fluctuation**.

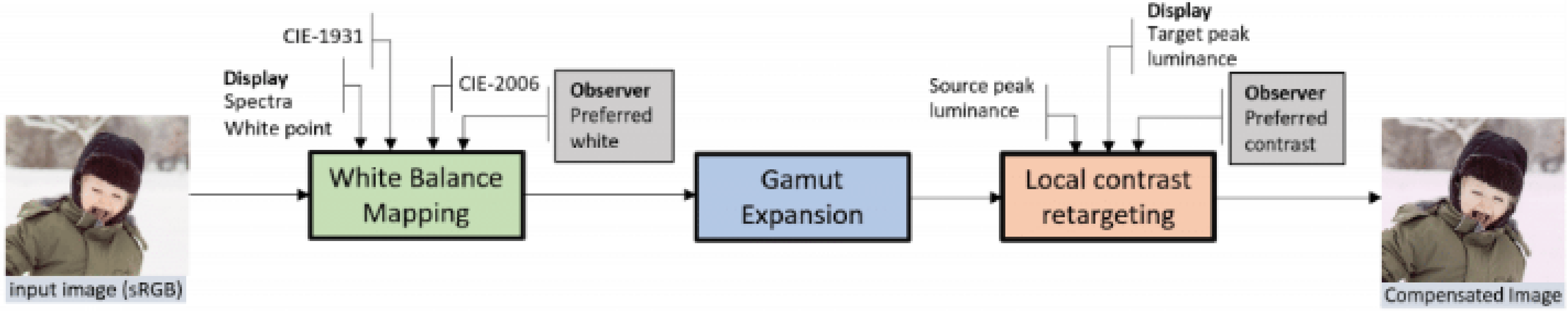
We do **perceptual display** meaning we can adapt our algorithm to the **viewer visual properties** such as **age** and **color deficiency.**

Challenge of **algorithm adaptation and validation**: **image quality** and **power consumption** as LCD and OLED behave differently, prove our solution is best for the human observers and the display with **OLED display age modeling**.

Our playground



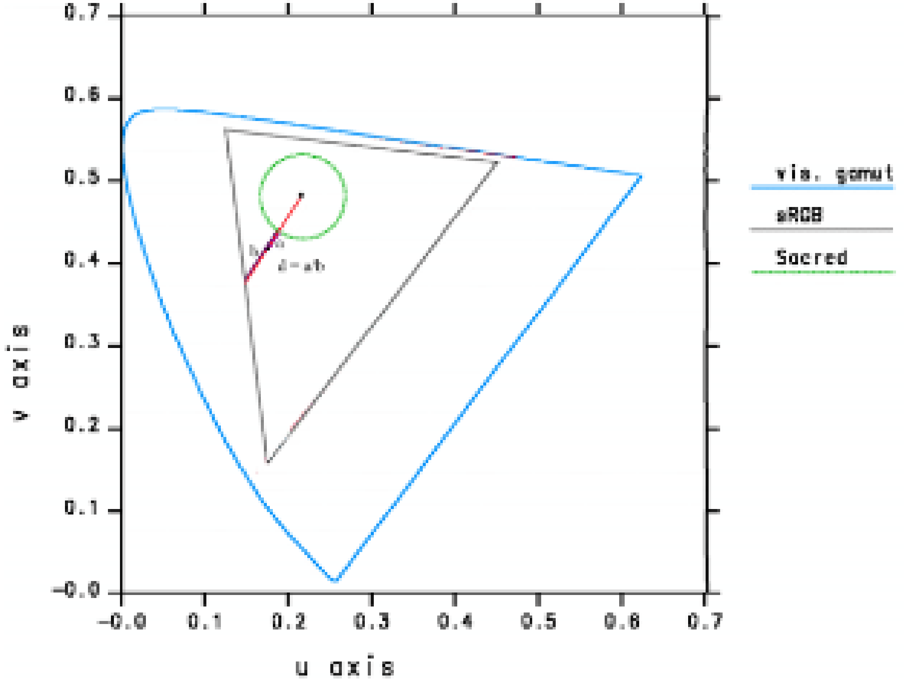
A Unified Color and Contrast Age-Dependent Visual Content Adaptation (2017)



- CIE-2006 model of age-based observer CMFs
- Both white balance and local contrast are based on observer preferences

Exploiting Wide-Gamut Display (2016)

- Hybrid color mapping (HCM) algorithm:
  - Preserves a region in chromaticity space
  - Exploits the larger space by stretching outside the preserved area



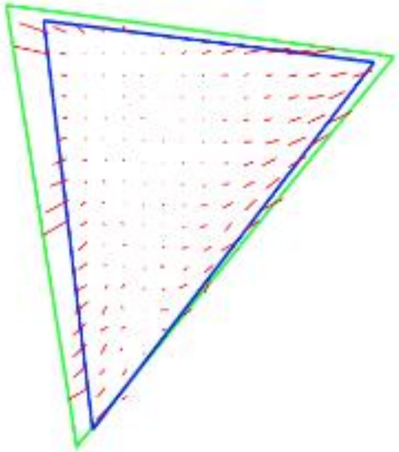


Figure 2. Mapping from an sRGB gamut to AMOLED primaries. The red lines represent color motions for our HCM method.

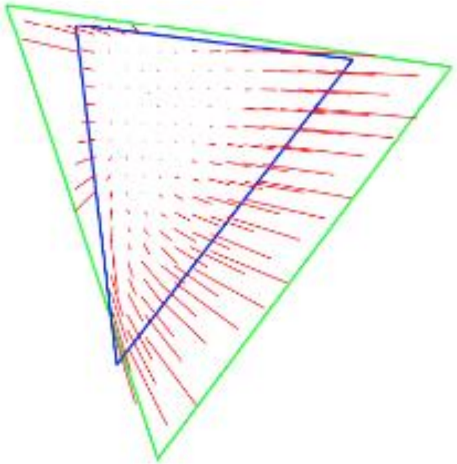
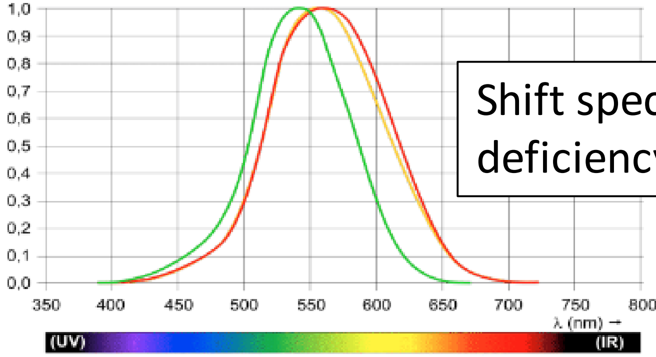


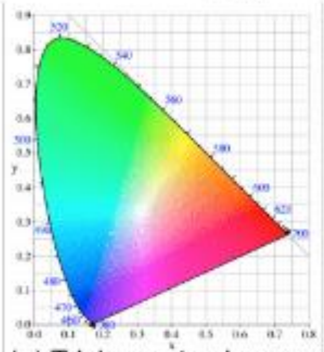
Figure 3. Mapping from an sRGB gamut to laser primaries used in subject study with example color motions.

Mitigating Color Deficiency in Graphical Display (2018)

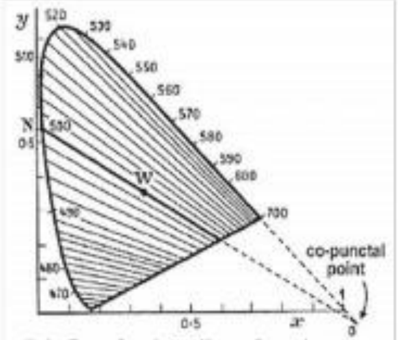
- Method to compensate viewer CVD
- Detects graphical element and recolors according to the deficiency



Shift spectrum for deutan deficiency.

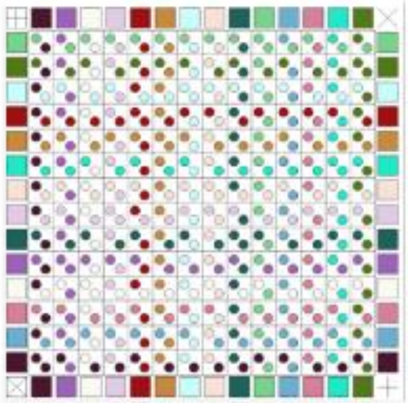


(a) Trichromat color space



(b) Confusion line for deutan

(a) Sample color chart



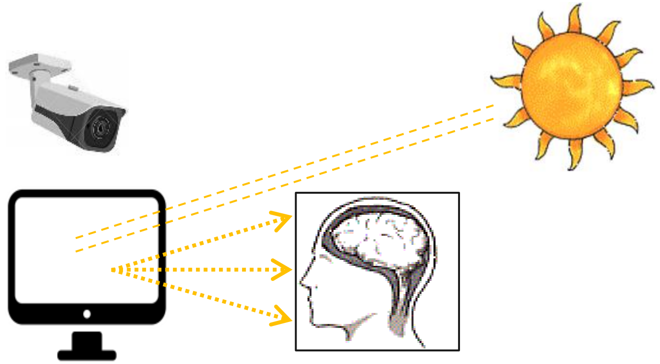
(b) Recolored sample color chart using the proposed method

(c) Sample color charts as perceived by a deutan

(d) Recolored color chart as perceived by a deutan

Reducing Glare from Reflected Highlights in Mobile and Automotive Display (2017)

- reflection reduction: find reflection position and intensity and apply compensation to the displayed image



Reducing Glare from Reflected Highlights in Mobile and Automotive Display (2017)

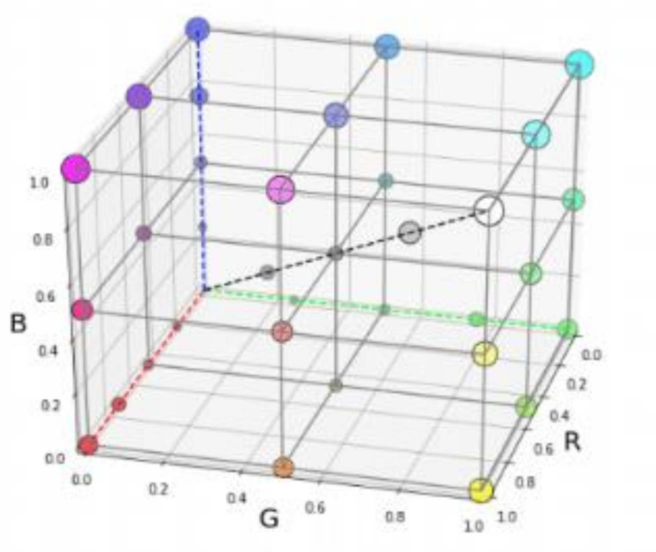
What the camera sees and deduces the viewer perspective.

Original image displayed.

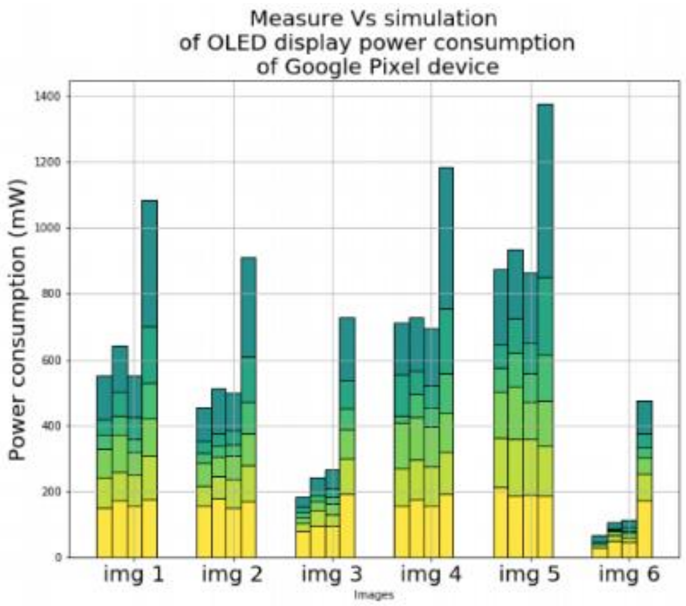
Processed image after getting viewer perspective.

OLED power consumption model and its application to a perceptually lossless power reduction algorithm

- New display power consumption model (dpcm) taking into account channel dependency
- OLED power consumption image content dependent



Sampling of the RGB cube



dpcm validation

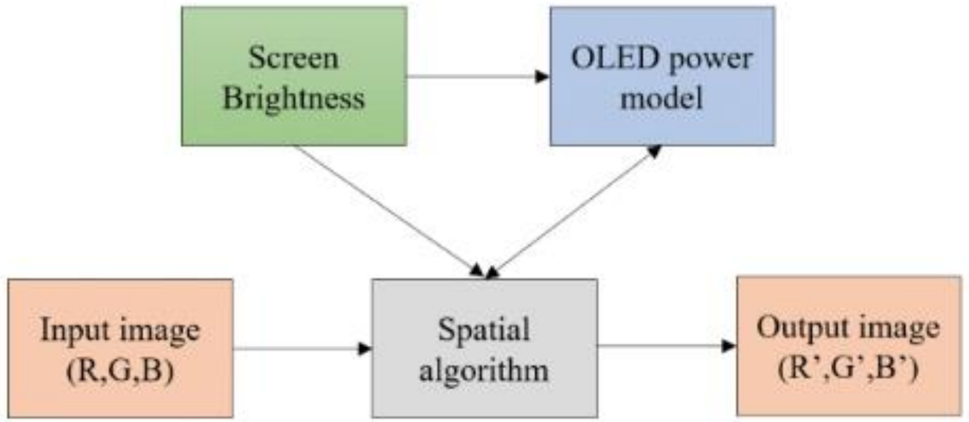


Figure 5. *Basic framework for the evaluation of power consumption and image quality of spatial algorithm on OLED display.*

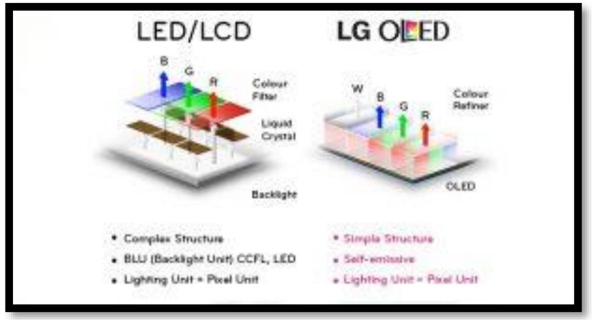
Example of dpcm use

Estimating OLED Display Device Lifetime from pixel and screenbrightness and its application (2019)

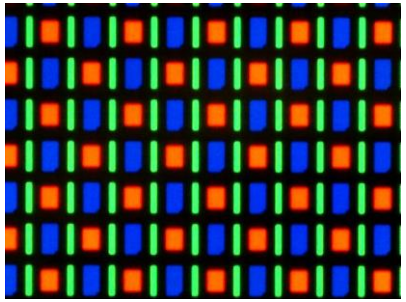
- Experimental challenges

Functioning RGB OLED display

Research article on single color emitting cells



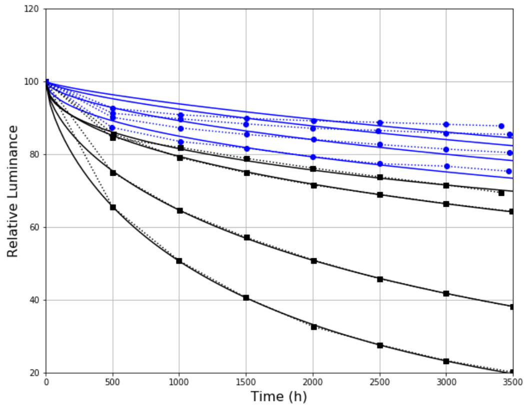
Understanding of color emitting cells design



Notion of **efficiency** and **current density** to describe the OLED material properties.

$$d(p, scbr) = \frac{current(p, scbr)}{area}$$

State of the art and assumptions



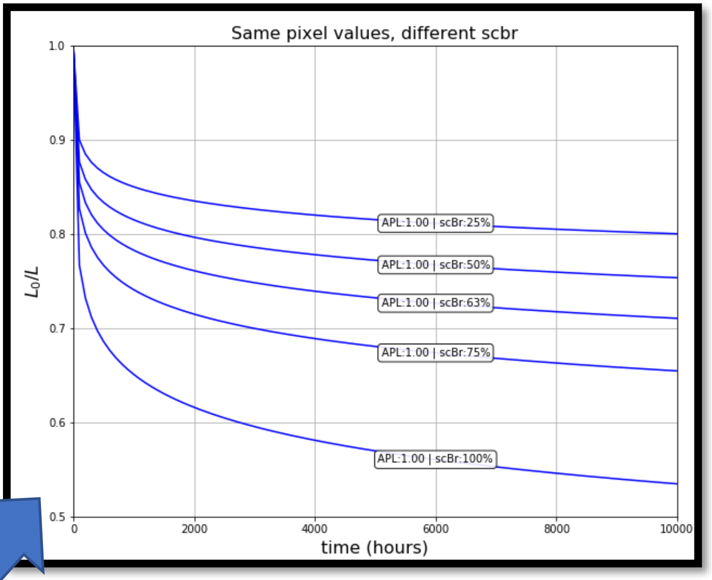
Ref: Ultrastable and efficient red organic light emitting diodes with doped transport layers. 2006.

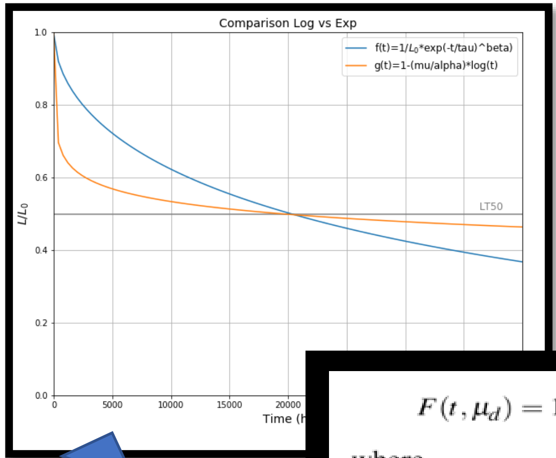
What we wish to have:
- PM and LM at different pixel and screen brightness values
- time t0 to tn for n = LT50
- OLED material properties

Available data:
- PM and LM at different pixel and screen brightness values
- time t0

Assumptions:
- LT50 = 20000h
-calibrated display, i.e. similar decay at R=G=B=255 and scbr=100%

What we do
- Approximate DF(t) as a log(t)
- log(t) shape R, G, B functions parameters obtained from PM at t0 and different pixel and screen brightness values

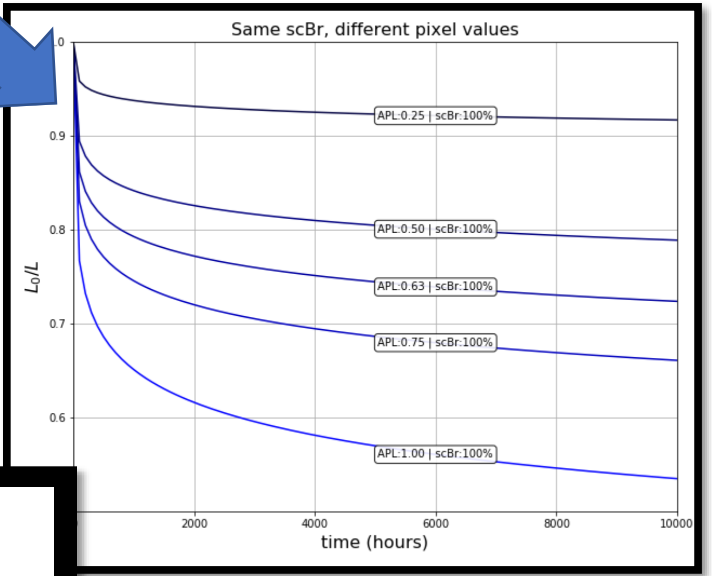




$$F(t, \mu_d) = 1 - \mu_d \log(t)$$

where

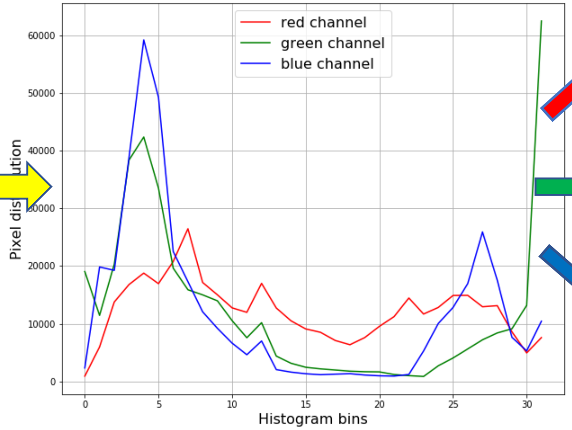
$$\mu_d = \frac{d(p, scbr)}{\alpha}$$

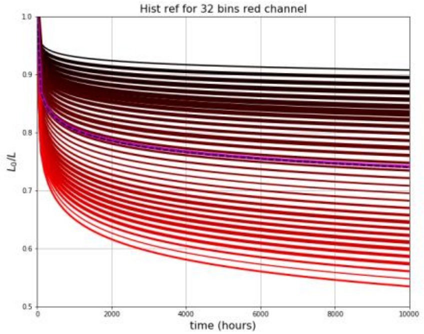


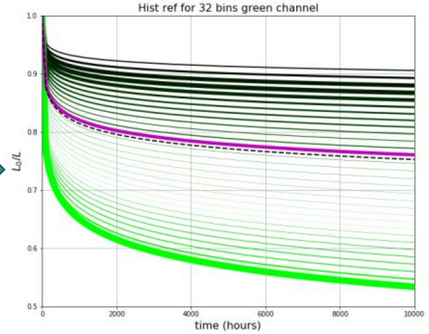
PM = power measurement
LM = luminance measurement
scbr = screen brightness
DF= Decay Function

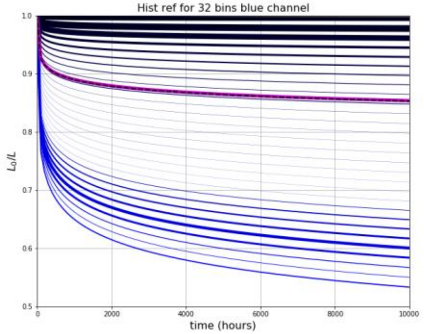
Image representation

Magenta and black dashed lines compare OLED decay APL value Vs histogram representation.





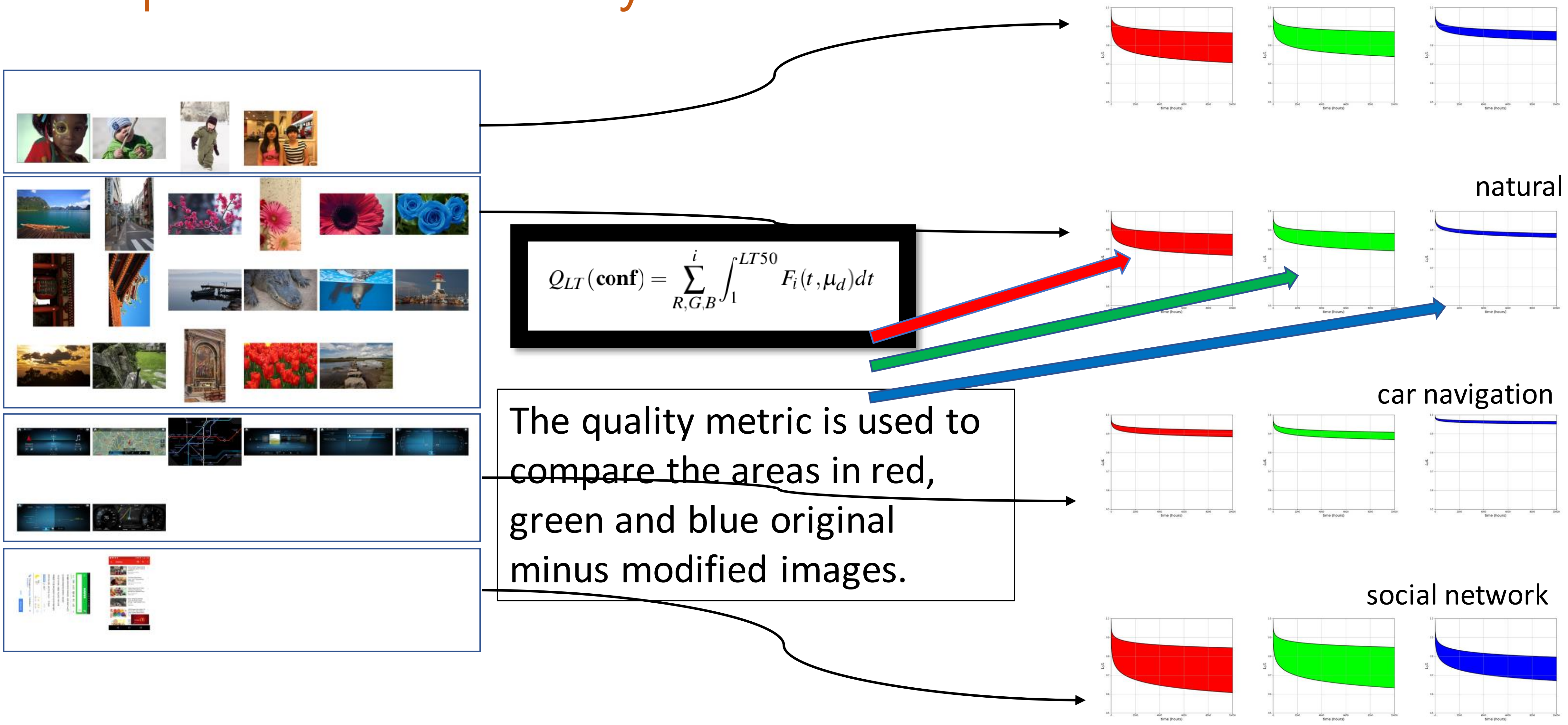




From image to RGB pixel representation for OLED decay simulation.

APL = average pixel level

Experiment results analysis



$$Q_{LT}(\mathbf{conf}) = \sum_{R,G,B}^{i} \int_{1}^{LT50} F_i(t,\mu_d)dt$$

The quality metric is used to compare the areas in red, green and blue original minus modified images.

References

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- **Solving Challenges and Improving the Performance of Automotive Display** [Information Display 2019 – T. Akhavan, H. Yoo and A. Chubareau]
- **OLED power consumption model and its application to a perceptually lossless power reduction algorithm** [CIC 2018 – J. Gerhardt, M. Kedjar, H. Yoo, T. Akhavan and C. Vasquez]
- **Mitigating Color Deficiency in Graphical Display** [SID 2018 – G. Ward, M. Nazari, A. Soudi, T. Akhavan, H. Yoo, J. Gerhardt and J.C. Clark]
- **A Unified Color and Contrast Age-Dependent Visual Content Adaptation** [ICIAP 2017 – M. Kedjar, G. Ward, H. Yoo, Soudi, T. Akhavan and C. Vasquez]
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- **Reducing Glare from Reflected Highlights in Mobile and Automotive Display** [SID 2017 – G. Ward, H. Yoo, A. Soudi and T. Akhavan]
- **Exploiting Wide-Gamut Displays** [CIC 2016 – G. Ward, H. Yoo, A. Soudi and T. Akhavan]
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