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Considerations for Standardization of VR Display

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IEEE P3333.3
HMD Based 3D Content Motion Sickness Reducing Technology
[Dong Il Seo and dillon@volercreative.com]

Considerations for Standardization of VR Display			
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Outline

- ✓ Introduction
- ✓ Considerations in VR Displays
  - Part I: Display Resolution
  - Part II: Chromatic Aberration and Correction
  - Part III: Display Technology Trend in VR
- ✓ Conclusion

Introduction

- ✓ Challenge of Virtual Reality
  - Users feel gaps on their sense between the reality and virtual reality because of a motion-to-photon latency
  - This causes dizziness and motion sickness to user
- ✓ Motion-to-photon latency must be measured and compensated!

Problems from latency of HMD

Blurring

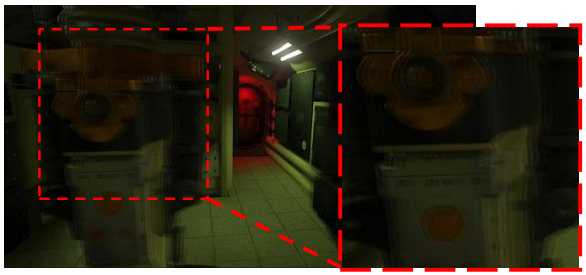


Image judder

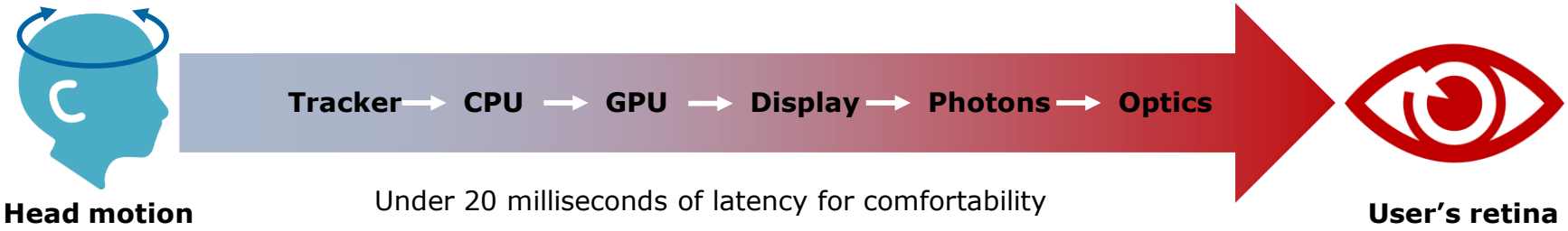
Human perception

Motion sickness

Dizziness

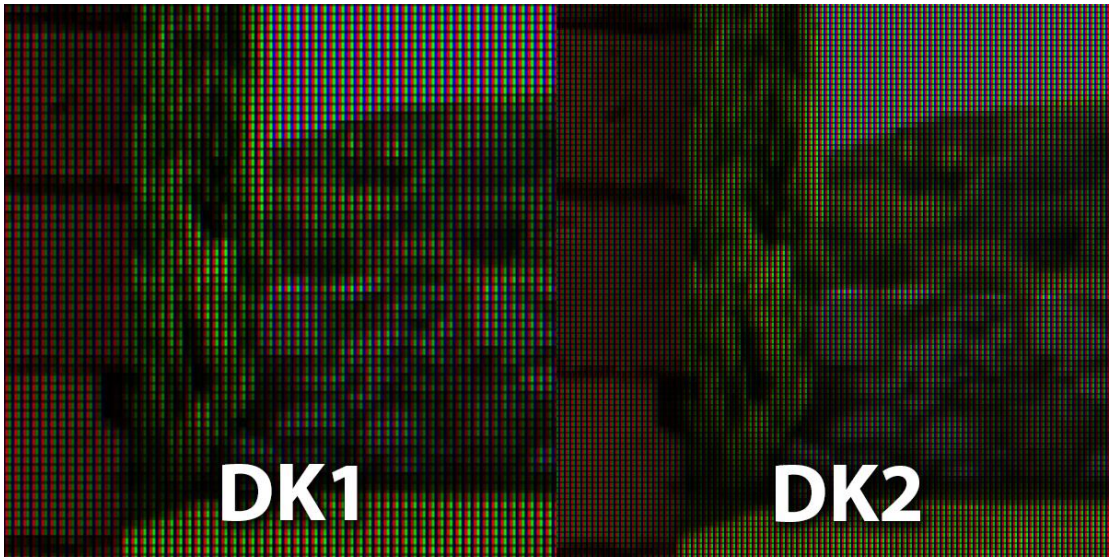
Introduction

- ✓ Motion-to-Photon Latency
  - Motion-to-Photon latency is the time needed for a user movement to be fully reflected on a display screen
  - Low motion-to-photon (< 20 ms) latency is a prerequisite to convince user's mind that user is in another place
  - A high motion-to-photon latency makes a poor virtual reality experience



Introduction

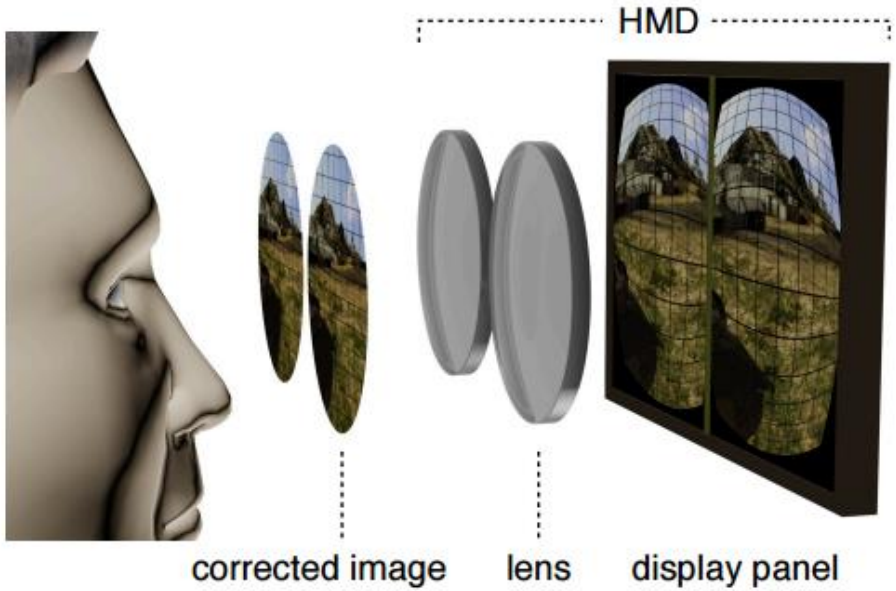
- ✓ We have to consider several factors in VR displays
  - Display Resolution
  - Chromatic Aberration and Correction

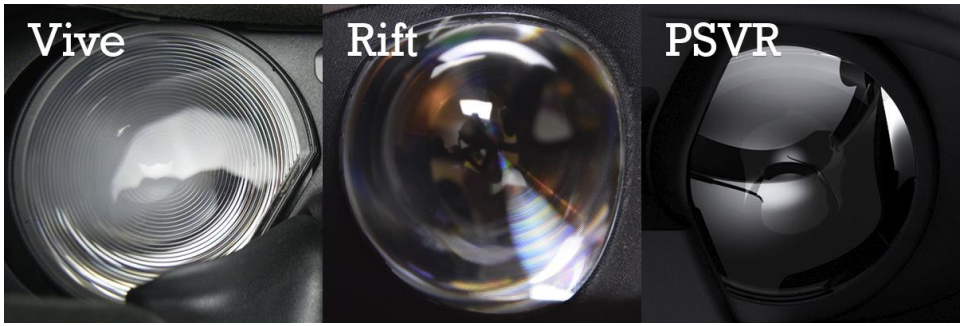


PART I:
DISPLAY RESOLUTION

Display Resolution

- ✓ Chromatic Aberration
  - General HW structure in HMDs
    - Display panel
    - Fisheye lens
    - Perceptional image





Fisheye lens

Display Resolution

- ✓ Pixels per inch (PPI)
  - Measurement of the pixel density (resolution) of an electronic image device such as a monitor or television display
  - A 100 × 100 pixel image printed in a 1 inch square has a resolution of 100 pixels per inch

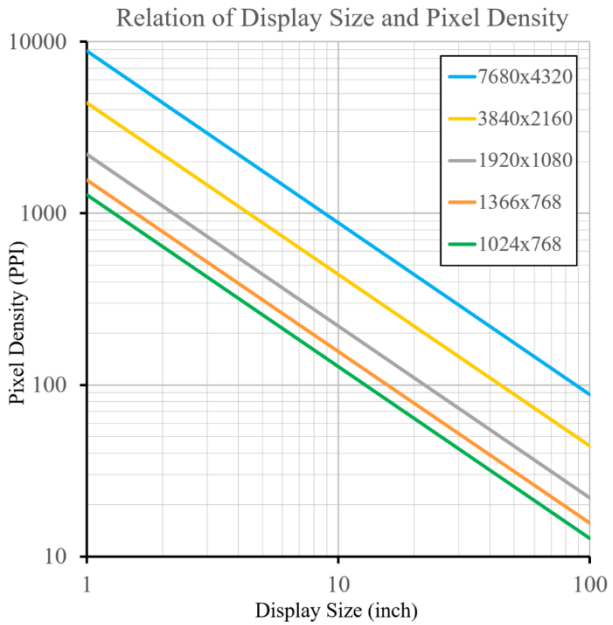
$$d_p = \sqrt{w_p^2 + h_p^2} \quad \Rightarrow \quad PPI = \frac{d_p}{d_i}$$

d_p is diagonal resolution in pixels

w_p is width resolution in pixels

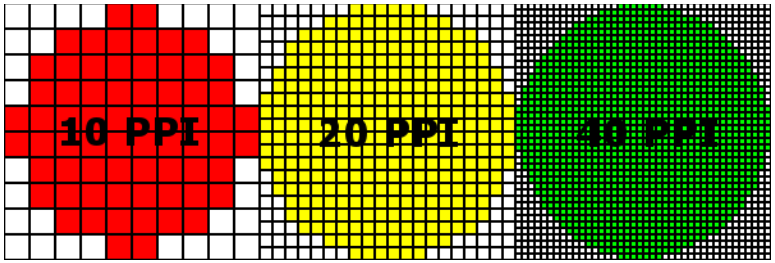
h_p is height resolution in pixels

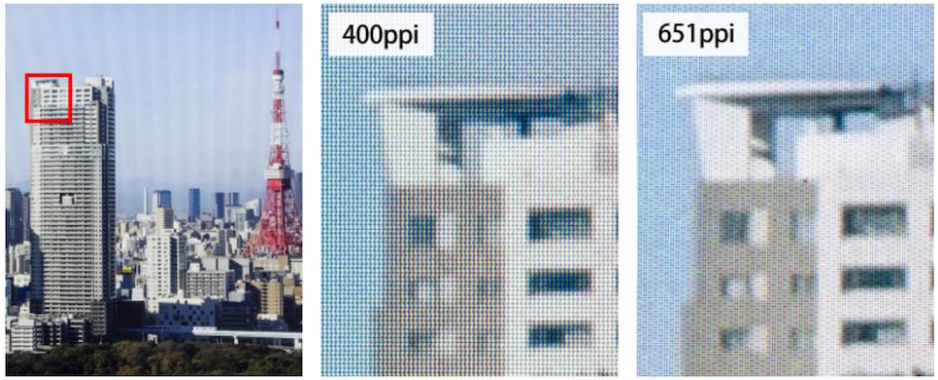
d_i is diagonal size in inches (this is the number advertised as the size of the display)

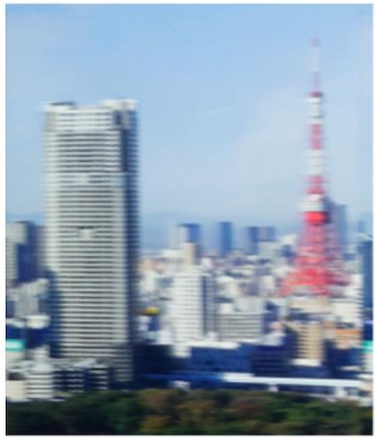


Display Resolution

- ✓ JDI
  - New displays will be 3.42-inch low temperature polysilicon (LTPS) TFT LCD specifically designed for virtual reality (VR) head mount displays







(a) Smartphone display

(b) VR display

Display Resolution

Display Resolution

- ✓ Samsung
  - A new display targeting use in VR headsets packs 2,024 x 2,200 pixels into a 3.5” form-factor, delivering an impressive 858 PPI
    (Nearly twice the 460 PPI of the Rift and the Vive)
  - The display is also capable of a 90Hz refresh rate and 100 nits brightness

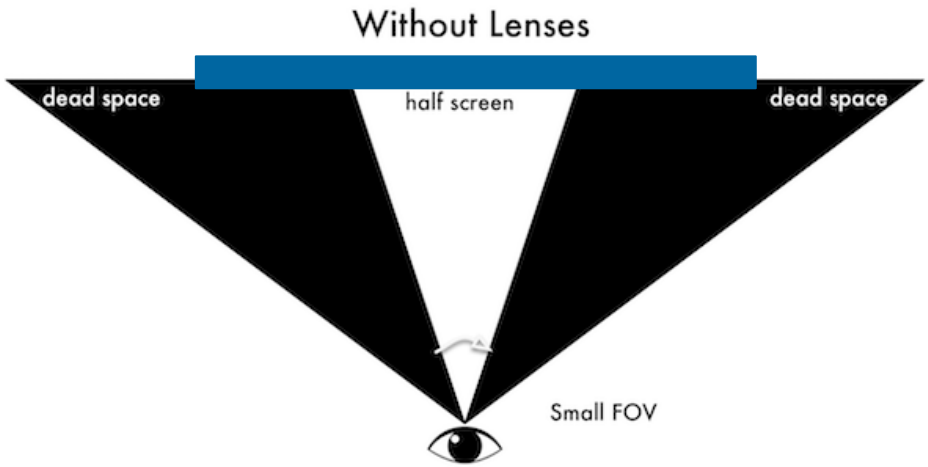
Previous VR display

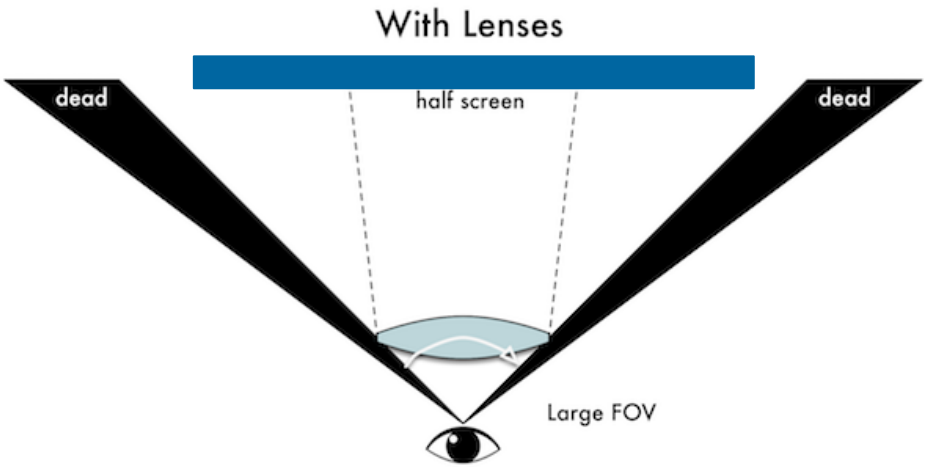
New VR display

PART II:
CHROMATIC ABERRATION AND CORRECTION

Chromatic Aberration and Correction

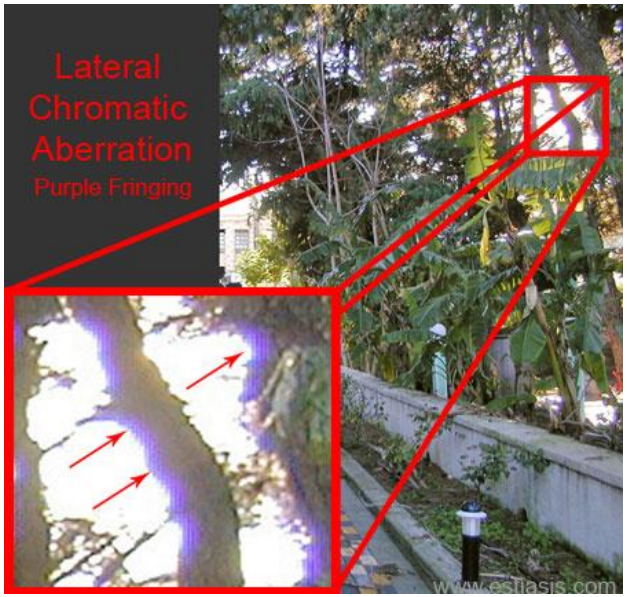
- ✓ Chromatic Aberration
  - – Fisheye lens
    - The Fisheye lens gives users a wide viewing angle
    - Normal HMDs provide a FOV(Field Of View) of over 110˚
    - Lens has a large refractive index

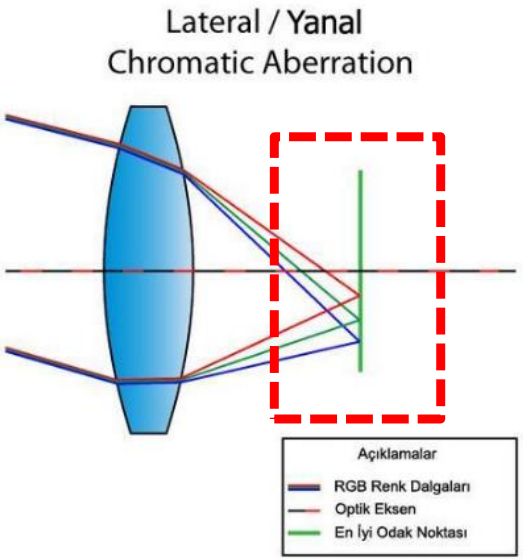




Chromatic Aberration and Correction

- ✓ Chromatic Aberration
  - Reason for chromatic aberration
    - The separation of light is called chromatic aberration because of different refractive indexes depending on the wavelength of light





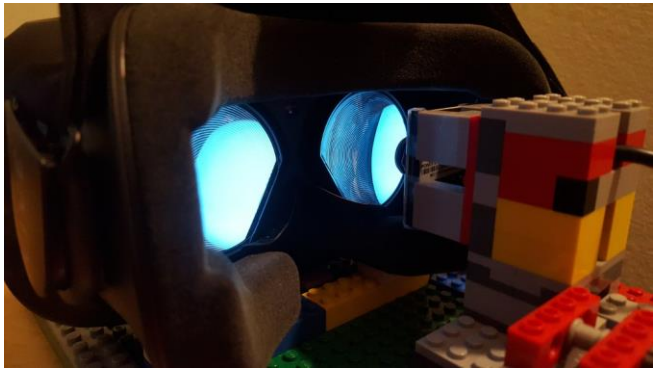
Chromatic Aberration and Correction

- ✓ Correction
  - Fisheye lens modeling
    - Modeling is required for the precise pre-distortion
  - Measurement method

    (a): Measuring HMD images with wide angle lens camera

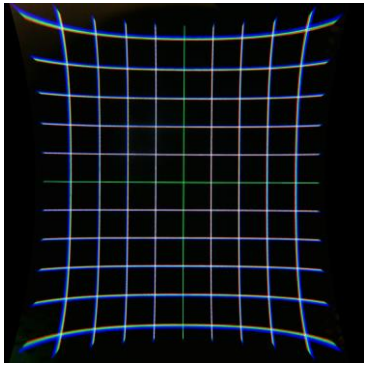
    (b): Camera calibration with the chess board

    (c): Photographed VR images



(a)

(b)



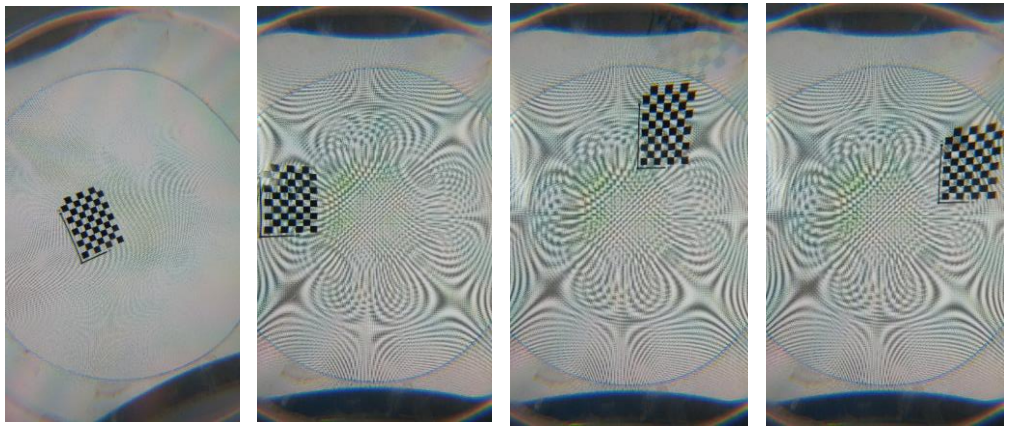
(c)

Chromatic Aberration and Correction

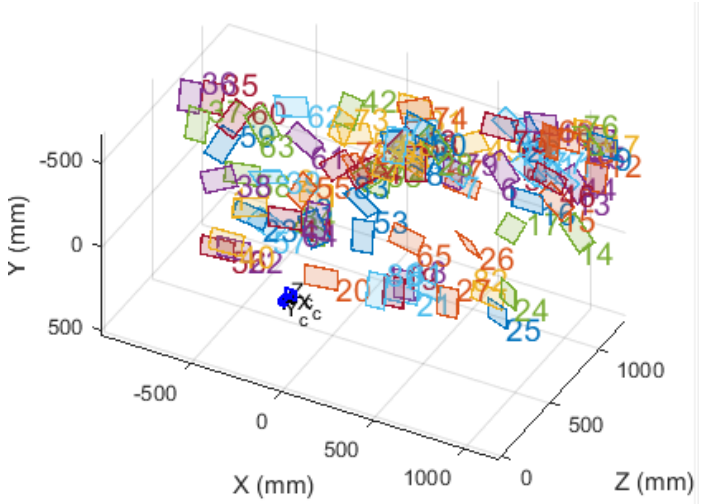
- ✓ Correction
  - – Measurement method
    - Parameter extraction through camera calibration

    (a):Photos taken by using the chess board in virtual space

    (b):Optimal parameter extraction using multiple photographs



(a)



(b)

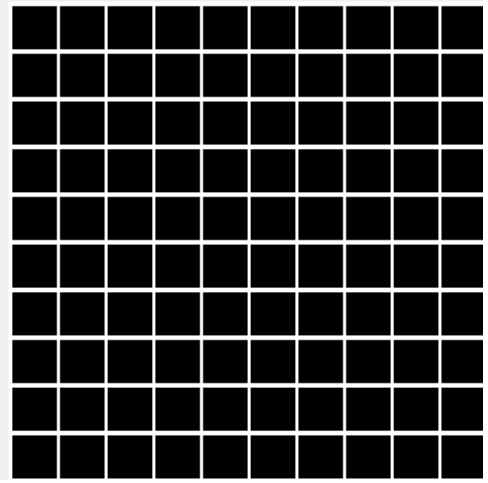
Chromatic Aberration and Correction

- ✓ Correction
  - – Calibration result

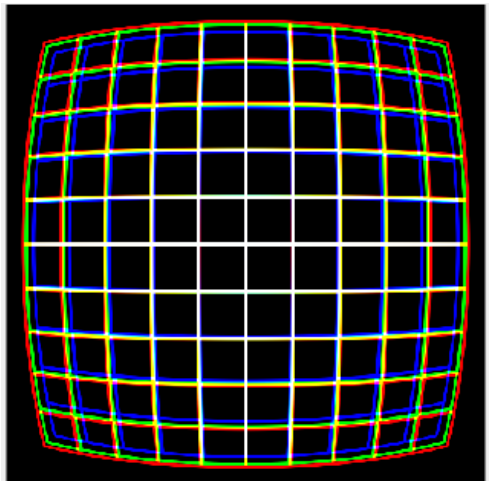
    (a): Original image

    (b): Image with the pre-distortion

    (c): User's perceptional image



(a)



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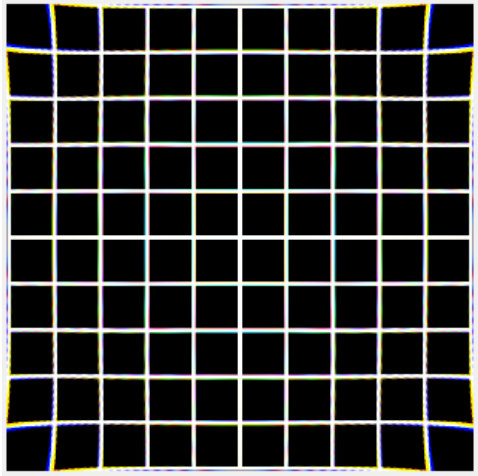
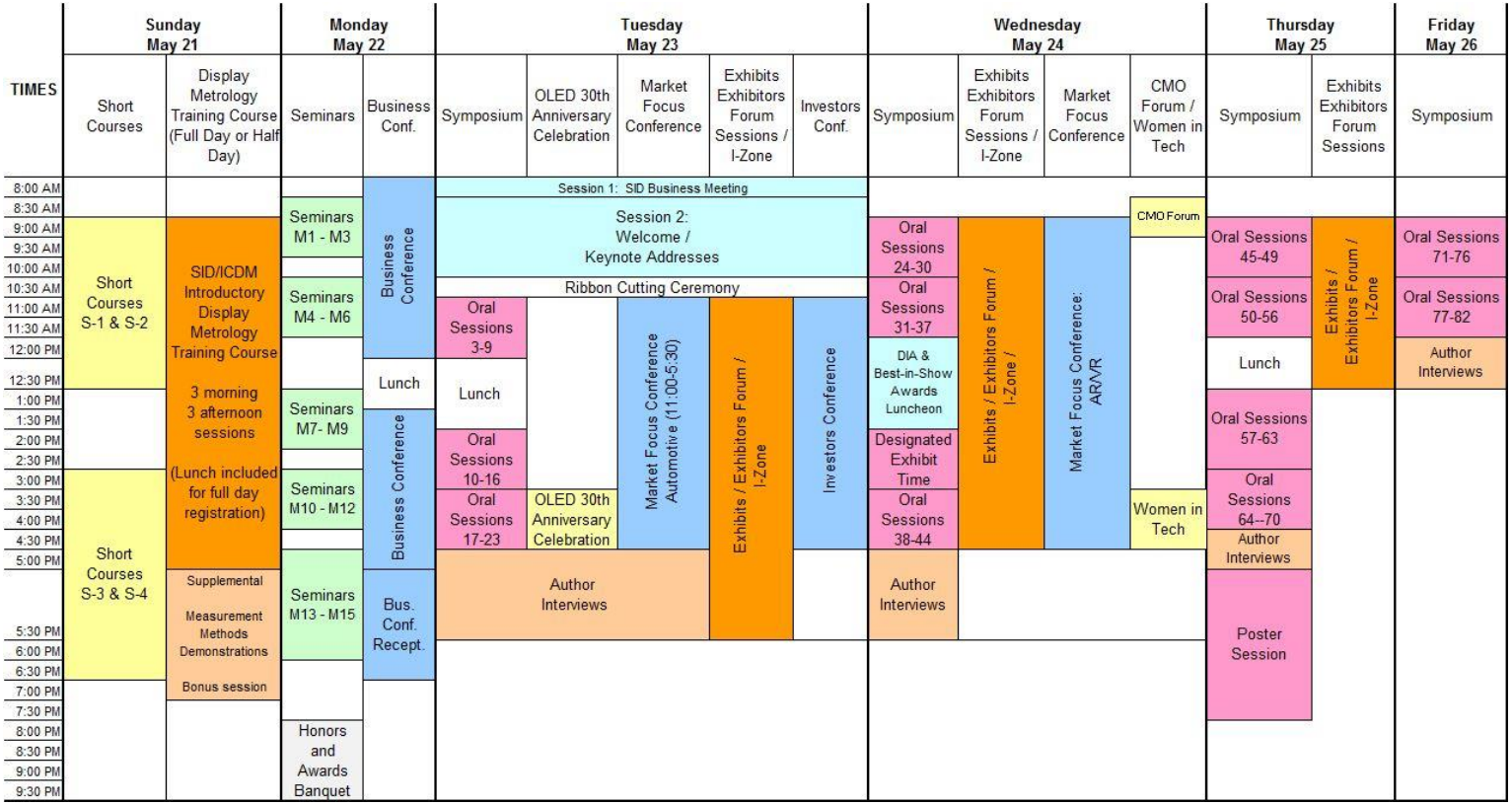


(c)

PART III:
DISPLAY TECHNOLOGY TREND IN VR

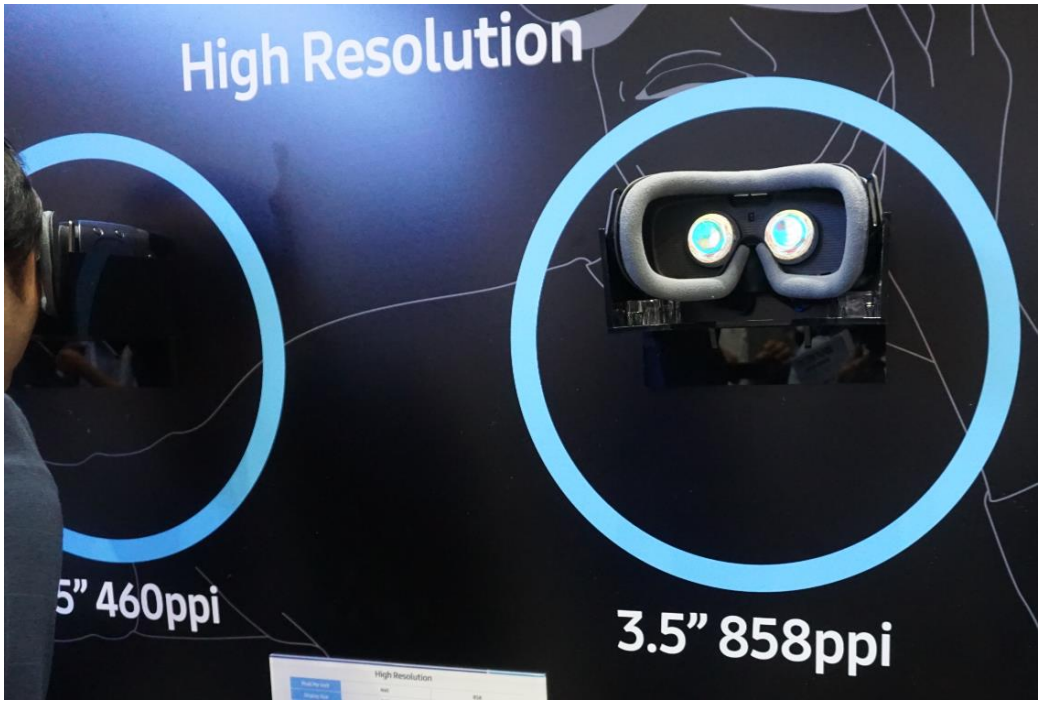
Display Technology Trend in VR

- ✓ 2017 Display Week



Display Technology Trend in VR

- ✓ Samsung
  - HMD panel
  - High PPI panel

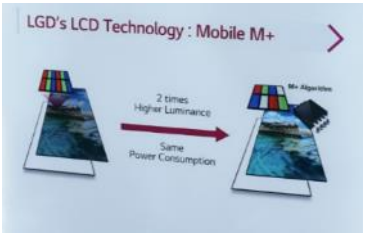


Display Technology Trend in VR

- ✓ Samsung
  - High speed
  - HDR panel
    (Peak Brightness = 1000 nit)

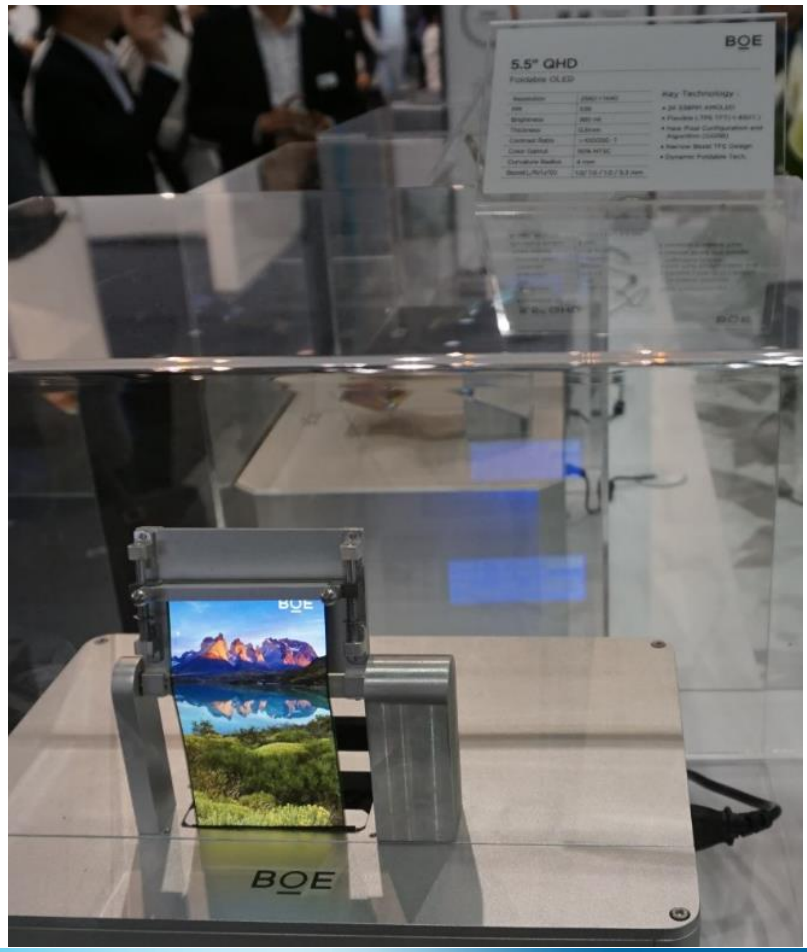
Display Technology Trend in VR

- ✓ LG
  - HDR
  - Curved
  - 8K / UHD



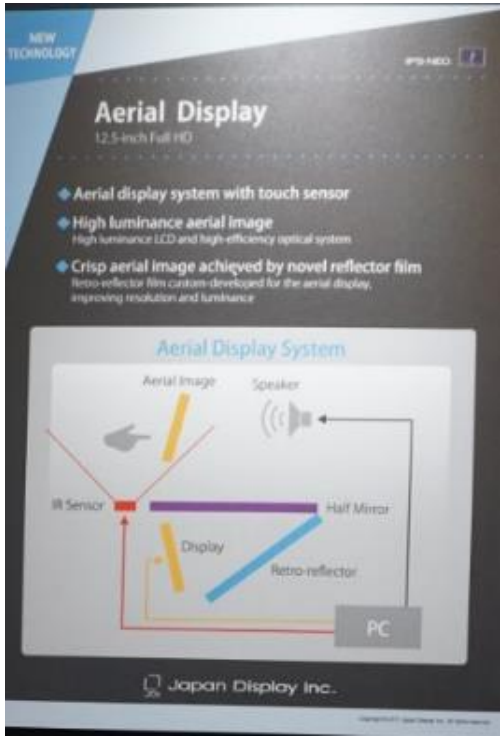
Display Technology Trend in VR

- ✓ BOE
  - 1900 PPI panel
  - 8K Picture
  - Foldable



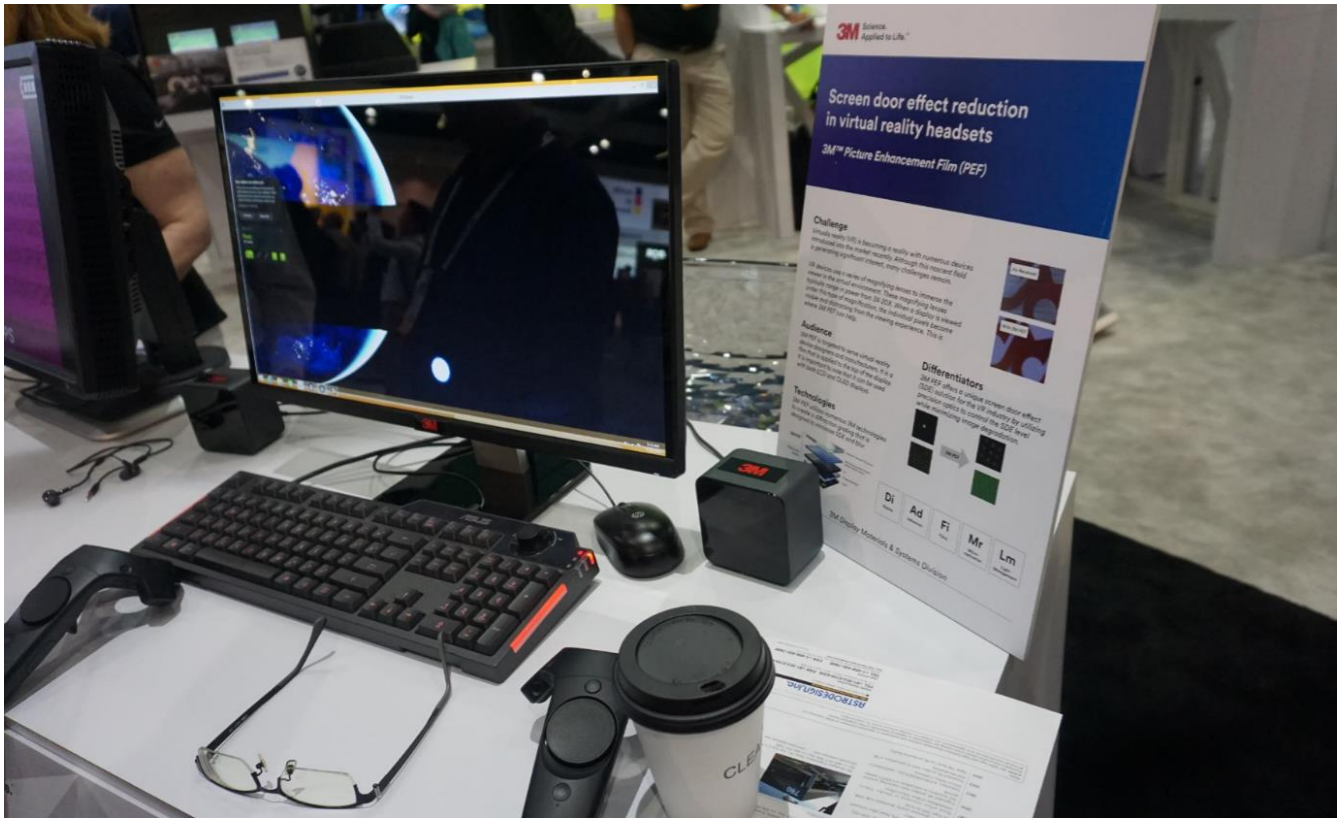
Display Technology Trend in VR

- ✓ Japan display
  - Aerial display
  - Fast response panel



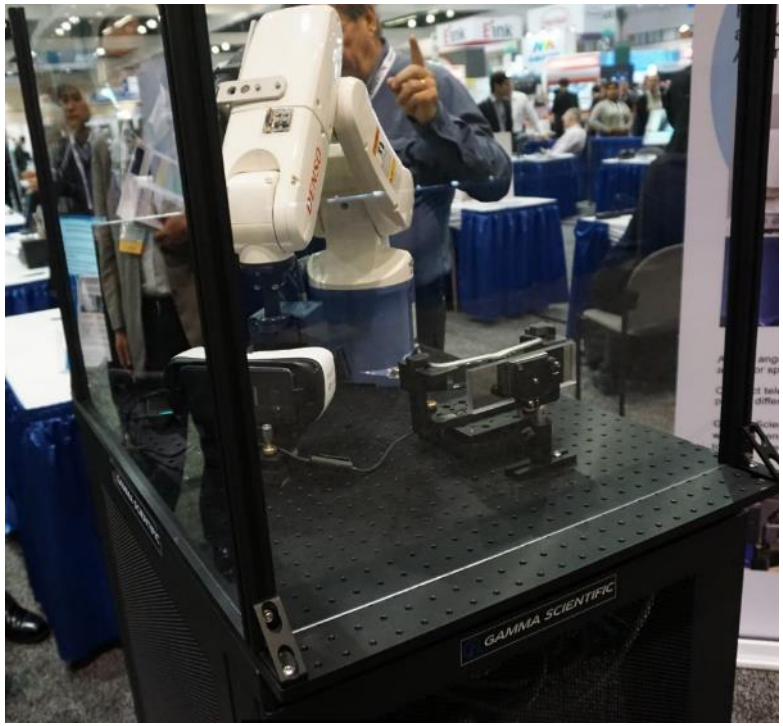
Display Technology Trend in VR

- ✓ 3M
  - Screen-door-effect reduction in virtual reality headsets



Display Technology Trend in VR

- ✓ Display measurement system
  - Near-eye display measurement



Display Technology Trend in VR

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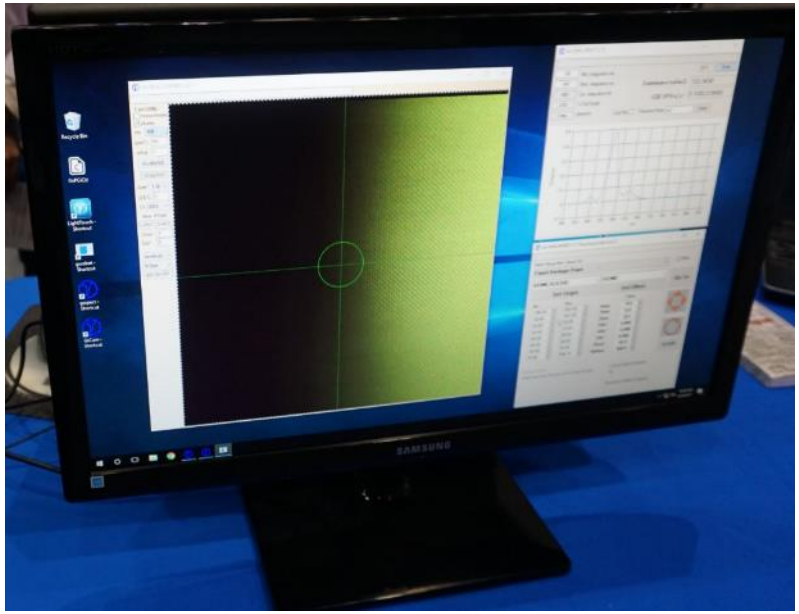
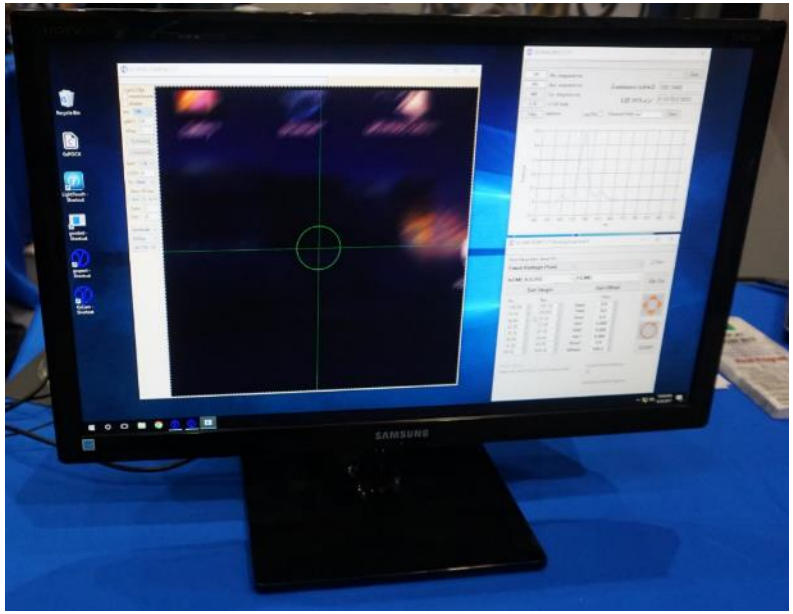
  - Near-eye display measurement





Display Technology Trend in VR

- ✓ Display measurement system
  - Perceptual resolution measurement

Conclusion

- ✓ We have to measure and reduce the motion-to-photon latency
  - The latency measurement system is required for quantitative numerical calculations
  - Finally, the latency compensation technique is required to reduce the motion sickness
- ✓ Considerations in Displays
  - We have to use the high PPI display, but consider HW resources to render the output image
  - In order to reduce the chromatic aberration, we have to use the pre-correction technique