Display Measurement Solutions For Augmented and Virtual Reality

Introduction

Augmented and virtual reality (AR/VR) opens a vast array of new possibilities across a wide spectrum of industries and are expected to grow into a $95 billion market by 2025. This strong demand currently comes from the gaming and entertainment industries, but will find wider applications in industries like retail, healthcare and education over time. This growth fuels an increasing need to measure the visual quality of the displays integrated within the AR/VR devices.

The AR/VR devices are currently based on near-eye displays (NEDs) technology where contents are magnified to fill the user's field of view (FOV) to deliver a seamless immersive experience. However, this also enhances defects like dead pixels or luminance and color non-uniformity; what would otherwise be subtle defects when seen from a distance become large and visible imperfections.

Most display measurement instruments used today are designed to evaluate displays such as televisions or smartphones and have significant limitations when it comes to comprehensive evaluation of NEDs.

Challenges Faced in NEDs Measurement

Resolution is vital for AR/VR application. To achieve an unprecedented level of realism, NEDs must have more display pixels per eye. A measurement system with high resolution and signal-to-noise ratio is required to test these pixel-dense displays. NEDs with wide FOV is necessary to provide a more immersive visual experience to the user. However, the wider the FOV of the display, the more difficult it is to fully capture and measure the display.

Furthermore, as NEDs are generally integrated within a head-mounted device (HMD) like headsets or goggles, the measurement system must be compact enough to be positioned within the HMD, at the exact location as the human eyes, to accurately capture the same FOV intended to be viewed by the user.

Figure 1 - Near-eye displays (NEDs), in fixed position within AR/VR device, with wide field of view to deliver a seamless immersive experience.

Additional Measurement Parameters

Standard display testing evaluates parameters such as luminance, chromaticity, contrast, uniformity, and pixel and line defects. For NEDs, additional parameters are necessary to obtain a comprehensive evaluation.

As NEDs are viewed near to the eye, image sharpness and clarity are crucial and testing them is conducted using modulation transfer function (MTF) test method. Characterizing image distortion caused by the HMD or display FOV is vital for projection alignment and spatial image accuracy.

Above all, measurement system for NEDs must also be capable of closely matching the visual capabilities of the human eye for true user experience evaluation. To replicate human vision for NEDs measurement, a measurement system must have the following capabilities.

- High resolution measurement
- Replicating size and position of human vision

High Resolution Measurement

NEDs are some of the highest-resolution displays with high pixel density to allow finer details to be visible that contribute to an overall more realistic content. With our eye being one of the highest resolution "imaging" mechanisms, a measurement system without enough resolution will never detect all the defects that our eye would notice at proximity and is inadequate for evaluating pixel dense display like NEDs.

Along with high resolution, the measurement systems used should also offer high dynamic range (to discern wider range of gray level values) and low image noise to simulate human visual perception with greatest accuracy.

Replicating Size and Position of Human Vision

Ideally, a measurement system should capture the full FOV of the NEDs, in a single image, like how the user sees it for efficient and consistent measurement of display characteristics and uniformity. However, one of the hardest challenges when attempting to measure NEDs within the AR/VR devices is to position the measurement system in such a way that it can capture the entire FOV of the display without occlusion within the devices.

The human eye is at a specific position within the AR/VR devices which few measurement systems can replicate. To overcome this, the aperture size and position play an important role in enabling a measurement system to capture the full FOV of the display.

Firstly, a measurement system with aperture that is able replicate the size of a human entrance pupil is important because:

- It enables the measurement system to capture the same amount of light from the display as the human eye.

- If aperture is smaller than the human pupil size, the imaged display would appear sharper, with less severe aberrations.

- If aperture is bigger than the human pupil size, the imaged display would have more aberrations than what human sees.

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By replicating the human pupil size, a measurement system can then capture equivalent detail and clarity as what the human eye would see, enabling similar assessment of quality.

Along with the size, the position of the aperture is equally vital in enabling full display FOV measurement. A measurement system with standard optics is not designed for measuring NEDs within the AR/VR devices from a human viewpoint.

For instance, a traditional 35 mm lens with internal aperture, as shown in *Figure 2*, is inadequate in capturing the full FOV of the display without occlusion by the lens housing or the device's entrance aperture. Furthermore, standard lenses aren't compact enough to fit inside the devices at the human eye position.

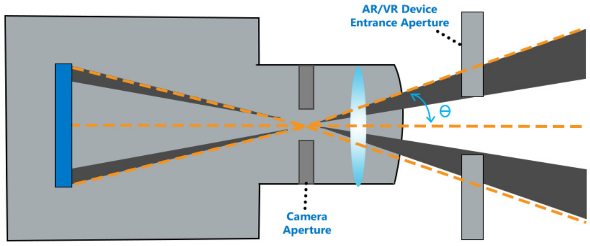

Figure 2 - Measurement system with standard lens and internal aperture.


Figure 3 – Example of eye positioned close to the hole(left) and far from the hole(right)

As seen in *Figure 3*, when the eye is positioned close to the hole, the full FOV can be seen. However, the view becomes limited as the eye moves further away from the hole.

Optimal NEDs Measurement Solution

An innovative measurement approach is necessary to test the optical quality of pixel-dense NEDs that are viewed in proximity from a fixed position within the AR/VR devices. Konica Minolta, along with group company Radiant Vision Systems, offers the only commercially available AR/VR display test solution that addresses the unique challenges of evaluating NEDs.

Radiant's AR/VR display test solution comprise of ProMetric imaging photometers/colorimeters, in 16, 29 or 43-megapixel options, and AR/VR lens that is engineered to replicate the size and position of human vision within the AR/VR devices.

Unlike traditional lenses, the aperture of the AR/VR lens is located on the front of the lens (*Figure 4*), at the same position as the human eye, with FOV to 120° (±60°) horizontal. With the aperture size of 3.6 mm, it matches the size of a human entrance pupil while also permitting a high MTF for the lens.

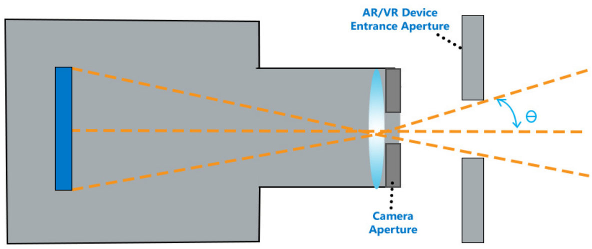

Figure 4 - Camera aperture located on the front of the lens, similar to the same to the human eye position.

Together with optional TrueTest software and TT-ARVR™ module, Radiant's AR/VR display test solution provides an extensive set of display tests, as shown in *Table 1*, to evaluate the quality of displays integrated within AR/VR devices.

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Table 1 – Standard and specialized test suite

• Uniformity	• MTF slant edge/line pair
• Chromaticity	• Distortion
• Line/Particle defects	• Focus uniformity
• ANSI brightness	• Pattern Mura
• Sequential/Checkerboard contrast	• Field of view (Device FOV)
• Points of interest	

Check out our interactive guide for more display evaluation solutions.

Need help measuring and evaluating the optical quality of pixel-dense NEDs within the AR/VR devices? Get in touch with us for a free consultation or to schedule a product demonstration.