The illumination system design of Integrated Screen 3D Display.

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Abstract

The 3D display has been used in optical projection technology to connect twenty mini- projectors with seamless image tiling. In this way, we can improve the projected resolution by reducing each project screen and increase projected area by connect several mini-projectors. In this article, the illumination system uses the LED light source, non- telecentric structure and LCOS panel, and it's total length is less than 10 centimeter. It can build a seamless large display by tiling multiple projectors.

1. Introduction

3D display has been well-received as part of the growing display technology. In recent years, the 3D display technology has developed rapidly because of the advancement in 3D digital technology, optical projection technology and illumination design. The design of illumination system was used on Integrated Screen 3D Display technology in order to improve the uniformity of energy distribution. In general , the illuminated system consist of LED, ROD, illuminated lenses, polarized light and imaging components .The Integrated Screen 3D image arrays are connected by several mini-projectors, as shown in Fig.1:

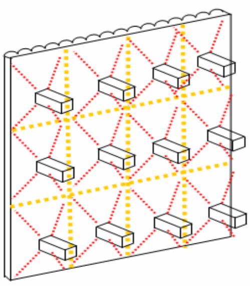


Fig.1: 3D image array diagram

2. Experimental

There are too many kinds of projection system element, the design of most illuminated system will be different. therefore, before designing the illuminated system, we must choose imaging components.

In the first, and confirm optical system specification , as shown Table1 :

Table1.

ROD	3×4×5mm^3
Paraxial F-number	3.5
Image height	8.25
magnification	-3.3
Exit pupil position	60mm in front of panel
Total length	< 85mm
Imaging components	0.59" LCOS panel

The lighting system is mainly divided into three parts, the first part is the light source, the second part is about optical illumination lenses design, the third part is the brightness and uniformity of projector, as the following :

2-1 light source

The light source for mini-projector is LE_W_E3A LED, luminous intensity about 280 ~ 820 lumens. In the past, we usually use collector to increase light gathering efficiency. In this design, the light source of LED was lighting in hemisphere , not in all directions. The design of LED directly close to the ROD in order to avoid the loss of light. When the LED light into the ROD, the light reflect several times in the wall of ROD. The light output from the ROD, and have a uniform illuminated area. The size of ROD is 3mm x 4mm x 10mm, and inner wall was plated with Ag, the reflectivity about 97~98% , as shown in Fig. 2.

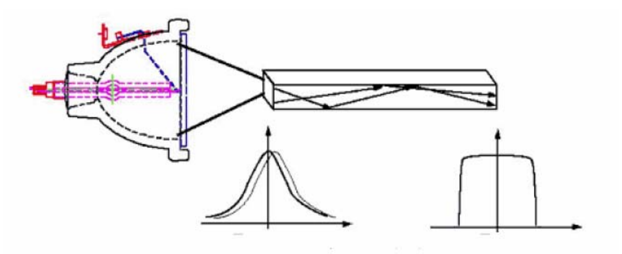


Fig. 2

2-2. Illumination lenses design

The 0.59" LCOS panel (14.986mm) is used in this system, and it had RGB color filter on each pixels. The white light LED is suited for this design. The illumination F/# is set to be 3.5 for collecting more light. The light was emitted from the LED, rod, illumination lenses and focus on the panel. From the etendue estimation, the rod size to be 3×4 mm^2. The estimation is shown in bellow, the etendue of panel, E_{panel} is

$$E_{Panel} = A_{panel} \times \Omega_{panel} = \frac{\pi A}{4(F/\#)^2} = \pi \times \left(\frac{14.986}{2}\right)^2 \times \frac{1}{4\times(3.5)^2} \quad (1)$$

and etendue of rod E_{rod} is

$$E_{rod} = A_{rod} \times \Omega_{rod} = \pi \times \left(\frac{5}{2}\right)^2 \times \sin\theta \quad (2)$$

We can capture the light's angle about 25.35 degree on the ROD output from equation (1) and (2). The maximum object height is a half diagonal of ROD is 2.5mm, and image height is a half diagonal of panel is 7.493mm. The illuminted area must large than panel , the image height design 8.25mm in the ZEMAX merit function.

In order to match up proiect lenses, the exit pupil position is 60mm in front of panel. The total length set to be 85mm. Optimization from the above conditions, the system layout is shown in Fig.3 :

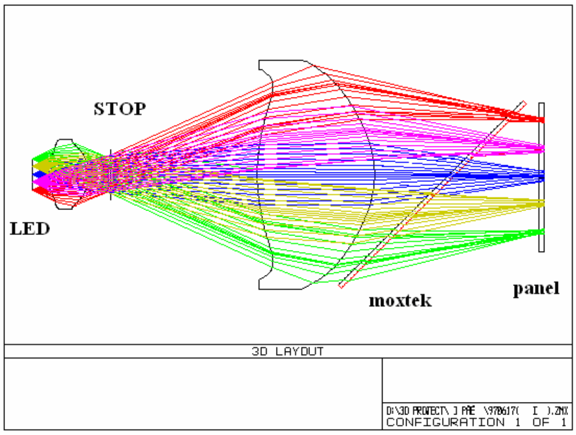


Fig.3 The layout of illumination lenses

The uniform part of optical system design is two aspherical lenses. The illuminated lenses material is PMMA, because of the high transparency and good weather resistance, high hardness.

In back of two aspherical lenses is a tilt 45 degrees polarizing film PBS02 (moxtek). The polarizing film will leaving only one type of polarization, to enhance the contrast. Finally, the illuminated area is uniform on panel, as shown in Fig.4 :

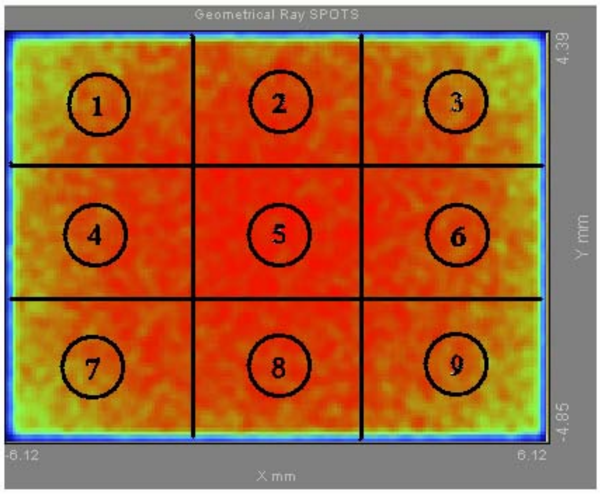


Fig.4 The simulated illumination distribution on panel

The simulated energy distribution of panel divides into nine equal regions,and calculate the average of the surrounding region. Comparing the result with the center region gets the uniformity is about 85.902% .

2-3 The screen illumination and uniformity

Combination with the projector lenses, and the light reflected from moxtek passing through the project lenses and fell on the screen, as shown in Fig.5 :

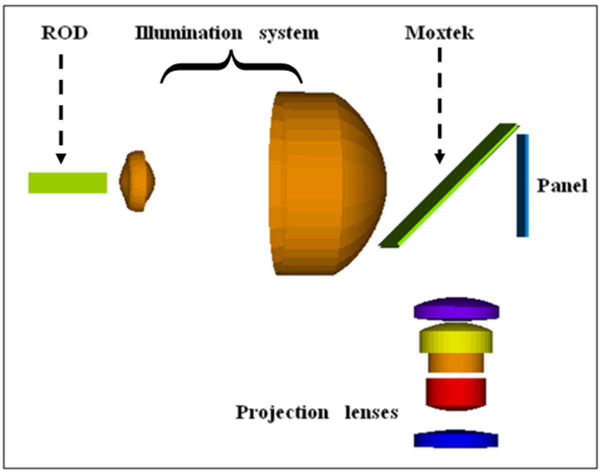


Fig.5 The projector frame

The screen energy distribution simulation divided i ntonine equal region, and calculate the average of the surrounding region , and compare with center region. After calculating , the simulated uniformity of screen is about 98.34% , as shown in Fig.6.

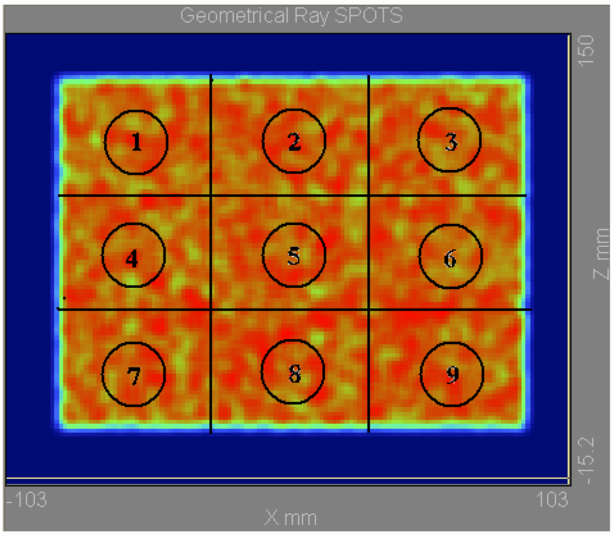
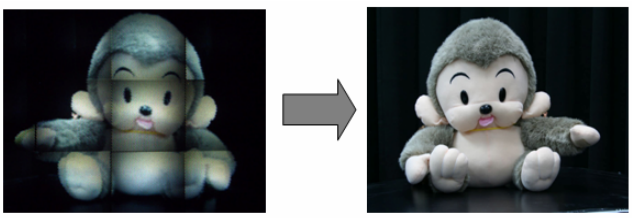


Fig.6 The simulated illumination distribution on screen

In Fig.7, high uniformity of screen can achieve seamless image tiling, as shown in Fig.7:



3. Results and discussion

The picture of the mini-projector prototype is shown in Fig.9. The final size is 18×8×5 cm^3.

The light emitted from the LED focuses on the panel after passing through two aspheric lenses and the moxtek. After passing through the moxtek and projection lenses, the illuminated area of the screen is 113 × $151mm^2$. The framework of mini-projector is shown in Fig.7.

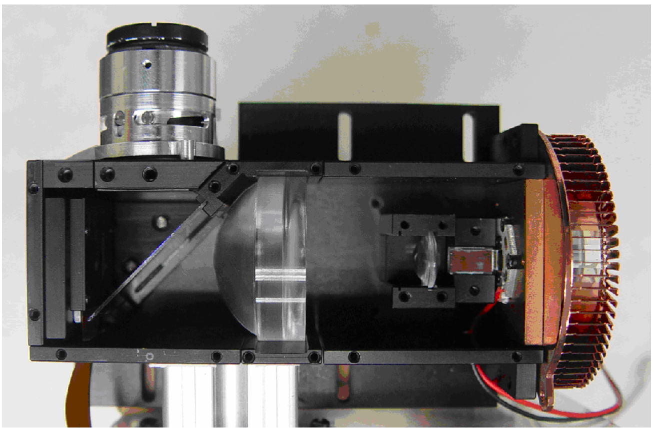


Fig.7 The framework of mini-projector

Table2 show the system efficiency estimation, both the light collection efficiency and polarization loss are the major loss in this system.

Table2. System efficiency list.

LED lumens	280 (lm)
ROD	$(97\%)^3$=91.3%
Collection efficiency	18.33%
Illumination LENS	$(96\%)^4$ = 84.93%。
PBS transmittance (moxtek)	85%
Panel reflectivity	19%
Polarization loss	50%
Projection lenses loss	$(98\%)^{10}$=81.71%
Final lumens	2.62 (lm)

There are 2.62 lumens on the screen, and the contrast is approach 100:1.

4. Summary

The uniformity of the LED illuminator system with non-telecentric structure and LCOS panel is about 98.34%. It can build a seamless large display by tiling multiple projectors. In this system, it major loss is in polarization loss. Two-panel structure could solve the polarization loss but result in high cost. The design of nice polarization conversion is still the best choice to reduce the loss.

Acknowledgement

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