Binary imaging medium single lens imaging system

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Abstract: Photography is becoming more and more common in civil and military, and it also occupies an important position. Macro photography due to the shallow depth of field (a clear picture of small range).

During the filming of two or more of the photographed object (a distance of more than depth of field) will not also will all be taken object taken clear. The feasible solution is to use a larger aperture, long focal length and appropriate shooting range. With the former two methods to increase the depth of field are in need of replacement specific scenes, the cost of a larger, with a method only in a certain extent increase the depth of field. A design of photoelectric imaging system, often because of the limitations of optical component in the system, thus limiting the depth of field (like clear distance range) size. Depth of field of photoelectric imaging system will lead to not one-time will two or more (a distance of more than depth of field) photographed objects while shooting clear. The imaging medium dual method can effectively in without sacrificing image quality on the premise to solve defects of lens imaging small depth of field.

Introduction:

Imaging media binary of single lens imaging is now to extend the depth of field of optical imaging system image quality better and lower cost easy to implement system. With the imaging medium can be changed by changing the depth of field size. For example if you want to make the distance from the focal length of the X lens distance of 500mm and 800mm of the object can be clearly imaged with a thickness of K9 3mm glass. When changing the glass material parameters can be accurate or change the size of the depth of field imaging.

Principle operation and experimental setup

according to coaxial spherical systerm's optical path calculation formula (plate(I)) and the imaging formula of paralle (plate(II)) calulate imaging.(As is shown in Fig.1)

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \qquad (I)$$

“u” is object distance ,“v” is image distance and “f” is the focal distance of convex lens .

$$H = D(1-\frac{n}{n}) \qquad (II)$$

“H” is optical path ,“D” is glass thickness , “n” is refractive index of glasses “n” is refracetive index of air .

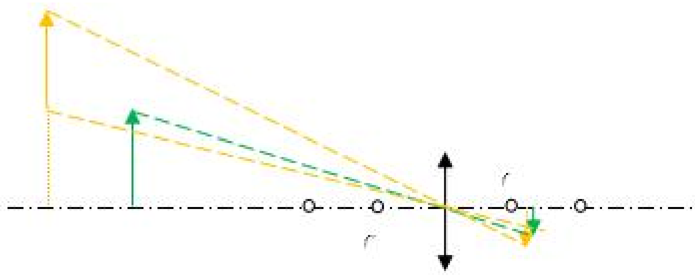

Fig.1 principle of Convex

The distance of the near test card from the lens is 500mm , and from beyond is 800mm,put into formula (I)to calculate its image distance are 37.6mm,36.7mm respectivel.
Fig 1 principle of convex lens imaging .

The depth of field is refer the range of distance which get pictures clearly in front of camera lens or other imagers' imaging .After complete the focusing , it form clearly imagering between back and front of focus point .This rang of distance is called the depth of field. (As is shown in Fig.2)

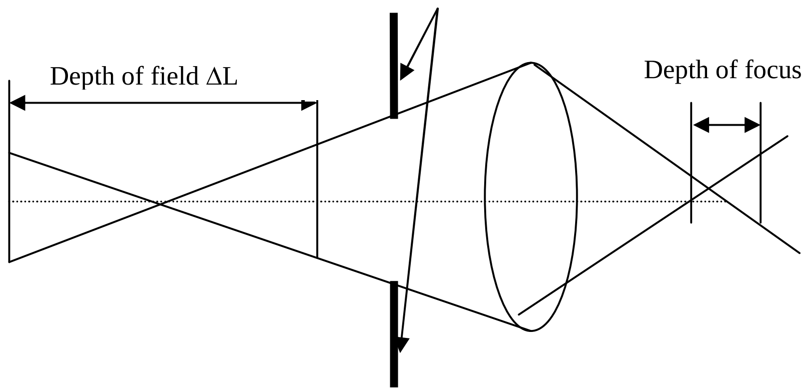

Fig.2 The depth of field in optical system.

According to the calculation of the distance imaging ,the two test cards of back and front couldn't form clearly in 500mm while the 800mm is not clearly vice versa.

Depth formula: $\Delta L = \frac{2f^2 F\sigma L^2}{f^4 - F^2\sigma^2 L^2}$ Where ΔL is the depth of field, f represents the focal length, F represents the aperture size, L said the distance, σ indicates diffuse spot diameter , By the formula of aperture, lens, and the shooting distance is an important factor affecting the depth of field.the method for calculating the thickness of the required parallel glass plate is as follows Refractive index is "n" , the thickness is "d" two sides parallel glass plate. The refraction effect of the beam at the point of convergence. The following method can be used to find out Ray CP' near the axis at any point P', the light path through which the light is reflected by the parallel glass plate is $CDEP''$,The incident angle on the first surface of the plate i and the *refractive angle R are small angles* Reverse extend D to E point normal to F, $CDEP''$ is a parallel quadrilateral.

$$P'P'' = DF = \frac{b}{tan\gamma} - \frac{b}{tani} \quad \text{(IV)}$$

$$d = \frac{b}{\tan\gamma} \quad (V)$$

$$pp'' = d\left(1 - \frac{\tan\gamma}{\tan i}\right) (VI)$$

Because both i and r are small.

$$\frac{\tan\gamma}{\tan i} \approx \frac{\sin\gamma}{\sin i} \approx \frac{1}{n} \qquad (VII)$$

$$p'p'' = d\left(1 - \frac{1}{n}\right) \quad (VIII)$$

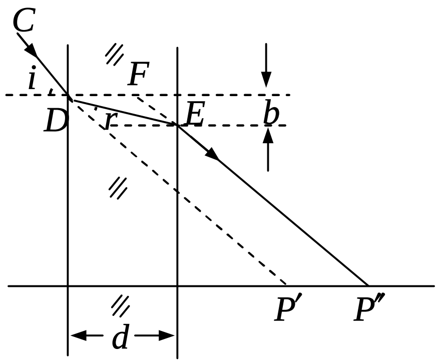

Fig.3 Parallel plate principle

The results of the above results for any convergence of the P point of the beam near the axis are established so the beam passing through the parallel glass plate on the point of the convergence of the axial point is converged to the axis of the P point. The action of the parallel plate is to make the image point to the moving distance away from the flat plate P’P’’.

Experimental device

The whole system (Figure 4) mainly includes three parts: optical part, circuit acquisition and PC software. The optical part is illuminated with a special monochromatic light source to the far and near side of the two test card. The reflected light on the test card is imaged on the CMOS by a convex lens, wherein the plane medium is an out of focus problem to solve the near far test card imaging. The circuit part is used to FPGA as the core, Using SDRAM to carry out ping pong image cache, The high speed USB communication interface is connected with the PC for data transmission. PC software to LabVIEW as the framework for the preparation of Call DLL C++ dynamic library to obtain data Processed by Matlab, and then display and save the picture.

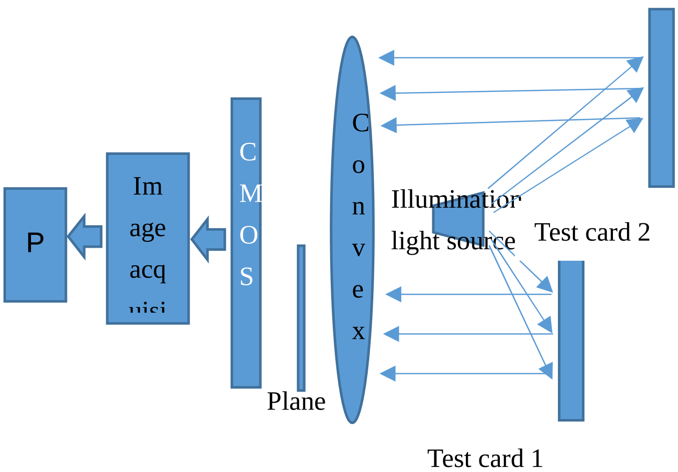

Fig.4 System schematic diagram

Design of lighting source

The image formula of optical system $\frac{f'}{l'}+\frac{f}{l}=1$, Single lens focal length formula

$$\frac{1}{f^2}=(n-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)+\frac{((n-1)^2 d)}{n r_1 r_2} \quad \text{(IX)}$$

The imaging properties of flat glass . In addition to determining the thickness of the light source glass, we can also determine the light condition by the known thickness of the glass.

Because of the distance between the size of the refractive index also and light source wavelength, different light source, lens refractive index are also different, refractive index different two objects imaged is also different, based on this property, we can in the known parallel the thickness of the glass case, inverse lighting light source wavelength.

The system uses thickness 3.04mm, by the optical system of the object image formula, single lens focal length formula and parallel plate imaging properties. Through software calculation that this glass refractive index for 1.515. In corresponding to different wavelength of K9 glass by different refractive index of available light wavelength of about 635.5nm. Results are as shown in Figure 5.

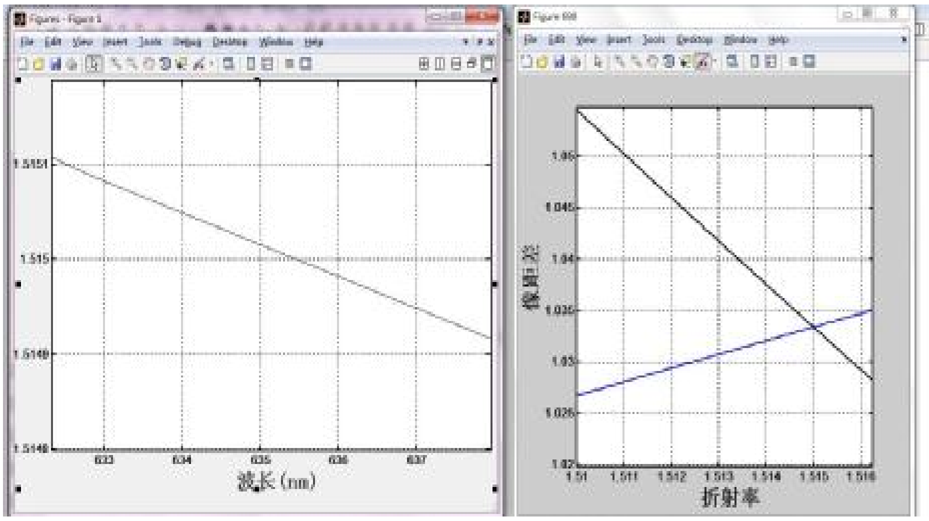

Fig.5 Software calculation results

Circuit acquisition and software processing section

Image acquisition circuit we use image information using FPGA as the core control read CMOS sensor (MT9M001C12STM) collected communicates with the computer through the USB module and the realization of real-time image display using LabVIEW and M mixed PC software.

Experimental results and discussion

This experiment we use the system imaging medium using 3.014mm glass success lens distance 500mm and 800mm Standard Test and clear image card and extend the depth of field of high-definition imaging were implemented to verify the reliability of the system.

When the imaging medium does not change, such as image, imaging results evaluation

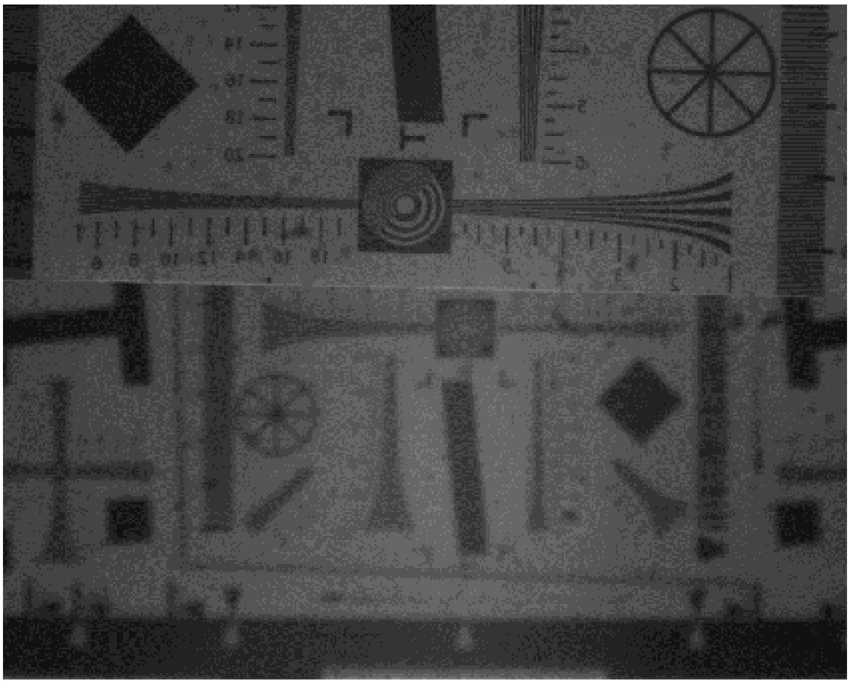

Fig.6 Before changing the imaging

When the imaging medium as described above changes, such as the map, the results of imaging evaluation

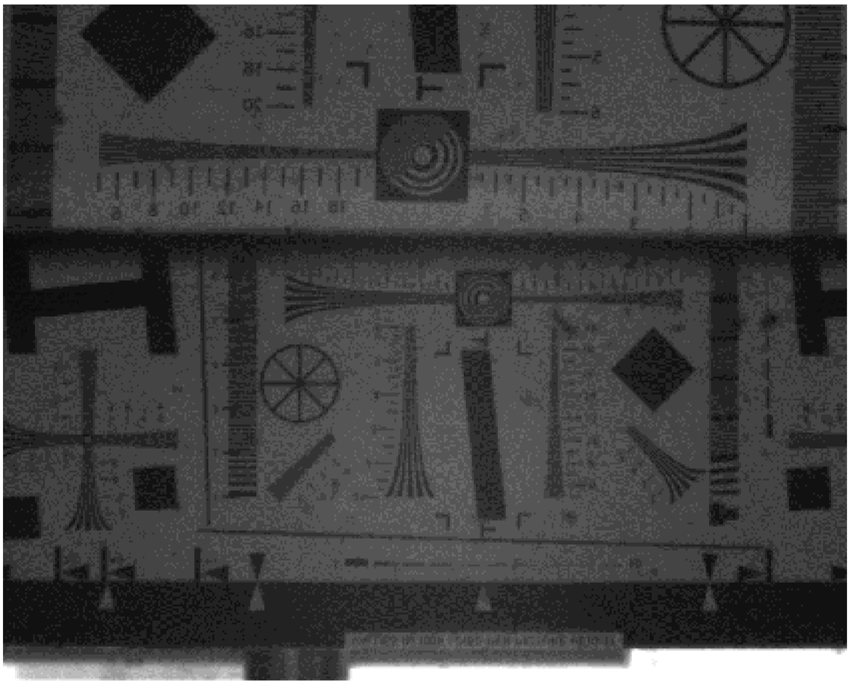

Fig.7 After changing the imaging medium

Experimental error analysis

Factors affecting the results of this study, as well as improved methods:

1 the influence of the external environment, the different light through the system will have a certain error. Exclude ambient light interference by shading or the use of barrel.

2 the choice of the imaging medium, the better transmittance of the calculation and selection of the glass to meet the requirements of the experiment.

3 Lighting lamps and lanterns choice. In order to obtain the corresponding wavelength of lamps and lanterns, first find out the zone close to the lamps and lanterns is filtered by the filter, obtained the corresponding wavelength lighting lamps and lanterns

Conclusion

The system from the single lens imaging of in parallel plate imaging as the core, to solve the problem of large depth of field imaging by the imaging medium dual by using FPGA as the core circuit of data acquisition card and computer communications, to mixed programming of LabVIEW and matlab program achieve real-time display and some image processing the image with a nice. Experiments prove that binary imaging medium can be an effective solution to the problem of the depth of field, at the same time, through changing the imaging medium, can realize the different depth of field of imaging, application prospect is very extensive.

Acknowledgements

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