Design Circuit for the single-lens high-definition imaging system

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Abstract: We proposed a method to resolve the problem of optical system defocus phenomenon by using the chromatic aberration of the single lens optical imaging system through reverse thinking. Furthermore, we designed and built the production which use SDRAM to collect data for CMOS image information literacy which was connected to the computer via USB transmission and the self-made circuit based on FPGA. Finally, some high-definition images can be obtained by using LabVIEW and MATLAB software programming to realize the data conversion, function calls, and image processing. The production is referred to the camera imaging system, specially, it can involves the problem which needs to solve the single lens of the depth of field and expand the depth of field in imaging system.

Introduction

Because of the need of using the shallow depth of field in macro photography, we cannot take photos for two or more objects clearly. Usually, in the design of photoelectric imaging system, because of the limitation of the optical elements in the system, the size of the depth of field also will be limited. Small depth of field in photoelectric imaging system cause we cannot take clear photos for two or more objects one-time.

There are many types of existing solution to the depth of field, can be roughly divided into two classes. The first is by increasing the depth of field to solve the problem of depth of field, such as spatial filter method, the optics apodization, wavefront coding and light sword optical element, etc. But the above methods all have in common is the technology is relatively complex and difficult to fit and part of the technology will increase accompanied by sacrifice or cost of image quality. The second category were taken according to the practical problems through many times focus or multiple sensor, along with depth of field synthesis technology (focus stacking) to solve the problem of depth of field. But as a result of operation will bring inconvenience to many focus or a lot and synthetic photos need to spend a lot of time.

To solve the single large depth of field lens imaging system from the focal problems in the process of filming, we can according to the actual situation, provides a simple and highly effective (and easy to learn) to solve in the design of photoelectric imaging system and macro photography in two or more subject to the depth of field problem.

Principle operation and experimental setup

As is shown in Fig. 1, the design of the device is mainly built from a single lens color difference phenomenon existing in the imaging system, the method of using different wavelength light source illuminate the depth of field objects to chromatic aberration compensation system, from the focal problems, so that objects of different depth of field in like as clear as the same position. Device is divided into three parts: the light path, circuit part and software part.
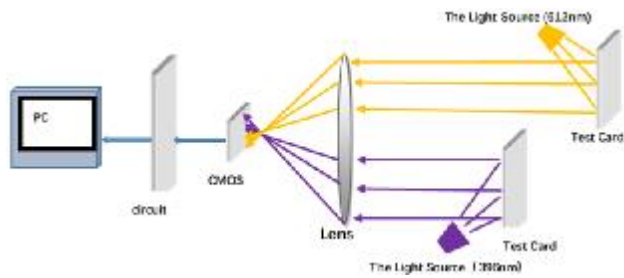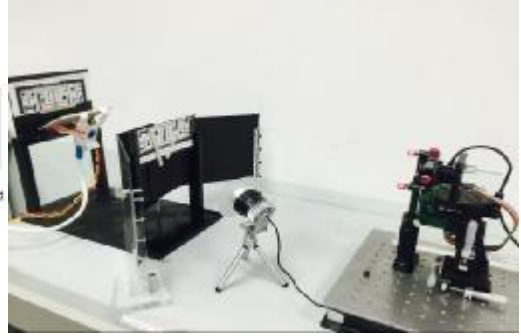

Fig．1 overall plan diagram　　　　　Fig．2 Real pictures

⑴Firstly, in aspect of light path. Light path portion of the building design is the use of single lens color difference in the formation of the principle of imaging system, through reverse thinking and use of different wavelengths of light source produce off color, in a certain depth range of several objects in the same position as party into clear like, while away from the focal problem, eliminates the position well color difference influence on imaging quality [1,2]. One way to determine the wavelength of light wave is to use the following formula

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

（1）

（ f is the focal length，u is the object distance，that is, subject to the lens, v is image distance, the distance of the lens to the photographic device) respectively,[3] the focus of 500 mm test card surface is 37.6344086 mm, 800 mm in the focus plane of the test card is 36.60130719 mm. Get the difference between the two test card like a distance of 1.03310141 mm（that is v'=1.03310141mm）

Takeλ_1=656.3nm wavelength in the index of refraction of K9 glass n_1 =1.53154. According to

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

（2）

(n is the index of refraction of wavelength on the glass; d is the thickness of the single lens; r_1, r_2 is single lens curvature radius) [4] Where n= n_1=1.51432, r_1 =-r_2,d=6.8 mm, for f1=31.86137724 mm. 'because v=1.03310141 mm, the focal length of the corresponding wavelength λ_2 f_2= 30.82827586 mm, and the corresponding wavelength in the refractive index of K9 glass: n_2= 1.53154, according to the wavelength and the refractive index of diagram, λ_2 =396 nm.

⑵After are part of a circuit and this is also our main research part. Circuit part of the main function is CMOS image information acquisition and exposure control. To realize the high-speed image acquisition, adopted FPGA as Cyclone IV as the master control chip. Using high-speed SDRAM ping-pong image cache, and then by high-speed USB2.0 communication chips, according to the data back to the computer processing circuit parts mainly divides into the FPGA image acquisition and USB image transmission parts.
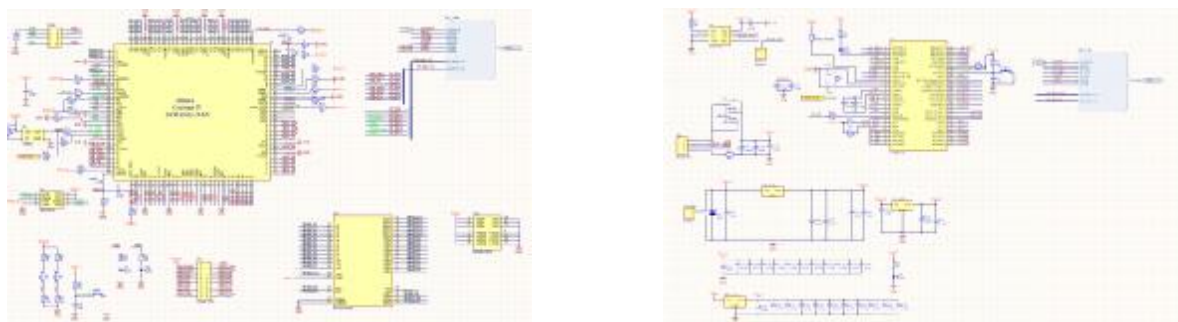
Fig．3 circuit principle diagram

① The FPGA image acquisition part

The FPGA chips we use is Cyclone IV EP4CE6E22C8 series chip of Altera company. The chip inside have 6272 LE unit. Top speed of 200 MHZ. And the highest speed of CMOS is 48 MHZ, so the chips enough to meet the needs of high-speed data acquisition. 24 MHZ system adopts active crystal to cheer for the clock source, and then through the internal PLL frequency doubling for cmos and sdram clock.

SDRAM is used MT48LC8M16,capacity for 128 MBB (2 Meg x 16 x 4 Banks), the highest reading and writing the clock is 133 MHZ, can read and write speed to realize the ping-pong cache video data, in order to realize the purpose of the high-speed image data acquisition.

Exposure Settings using the button real-time control scheme. Convenient to test and adjust.

② USB image transmission parts.

USB drive circuit adopts USB drive chip CY7C68013, it integrates USB transceiver, SIE (serial interface engine), enhanced 8051 microcontroller and programmable peripheral interface. FX2 this ingenious structure can make the data transfer rate reach 56 MB/s, namely the USB2.0 allow maximum bandwidth, in FX2, intelligent SIE hardware can handle many USB1.1 and USB2.0 protocol, so as to ensure the compatibility of USB. GPIF (General Programmable Interface) and SlaveFIFO) (8 bit or 16 bit data bus for the ATA, UTOPLA, EPP, DSP and PCMCIA Interface provides a simple and seamless connection.
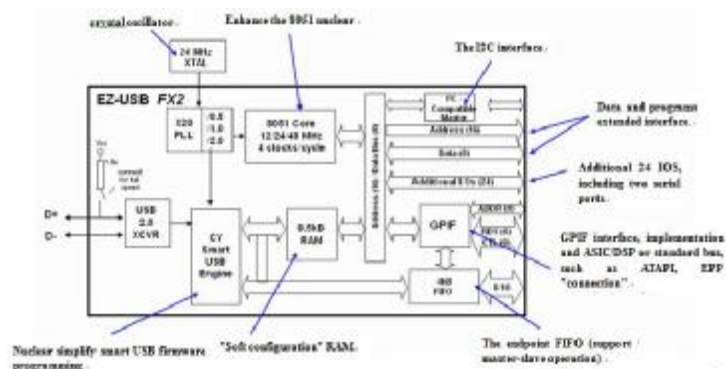

Fig．4 The frame of CY7C68013 chip

This system mainly apply CYUSB SlaveFIFO mode to implement high-speed data upload images, realize the real-time display of the image data. In this mode the highest transmission rate is above 30 MB \ S, and fully meet the 1280 x1024 30 BPS real-time processing of image data to display.

Main circuit procedure is the FPGA program and CY7C68013, including the FPGA program for the Verilog hardware description language, compiled by Altera corporation Quartus II software. And CY7C68013 program is written by C51 program, compiled for the keil software, through the

③Software part adopts a key to "prison break" control, is a key to the whole process of operation, simple operation, a key control. In LabVIEW software design is called interconnection in

the interface call library functions in the library and the executable program. Calls a DLL function, and then control the CMOS camera.

In addition, the LabVIEW calling MATLAB nodes, for the collection of image data, image processing. MATLAB image processing, the calling function imadjust, histeq, imsharpen, adapthisteq, imhistmatch, decorrstretch functions such as basic image processing. Including grayscale processing, histogram specification, sharpen, adaptive histogram and histogram matching, and contrast stretching method, make the image can achieve the effect of.

Experimental results and discussion

We used to make the experiment device and program, double color single lens high-definition imaging system is constructed. Using the standard test card to 0.5 times ISO12233 system imaging, and the imaging quality of visual degree and Imatest software use objective score. Test results as shown in the figure below:
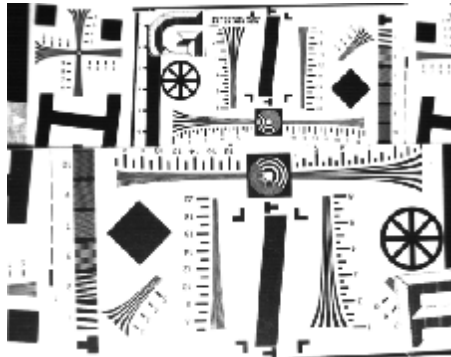

Fig. 5 Shooting figure

Fig. 6 Software evaluation results

Table 1 Score calculation results

test card	wedge	multiple	Visual reading	0.3	image height	length	distinguishability	Data rate
far	across	100	8	0.3	1280	270	1137.778	MAX
	vertical	100	8	0.3	1024	270	910.2222	2133.333
near	across	100	12	0.3	1280	270	1706.667	MIN
	vertical	100	15	0.3	1024	270	1706.667	796.4444
far	across	100	8	0.3	1280	270	1137.778	AVE
	vertical	100	8	0.3	1024	270	910.2222	1317.333
near	across	100	12	0.3	1280	270	1706.667	
	vertical	100	15	0.3	1024	270	1706.667	
far	across	100	7	0.3	1280	270	995.5556	
	vertical	100	7	0.3	1024	270	796.4444	
near	across	100	12	0.3	1280	270	1706.667	
	vertical	100	11	0.3	1024	270	1251.556	
far	across	100	7	0.3	1280	270	995.5556	
	vertical	100	8	0.3	1024	270	910.2222	
near	across	100	15	0.3	1280	270	2133.333	
	vertical	100	12	0.3	1024	270	1365.333	

Conclusion

For single lens imaging system of imaging surface due to the existence of large depth of field from the focal problems, we build the double light single lens of high-definition imaging system experiment.The results show that the method of using double color light to illuminate objects can effectively compensate the depth of field to solve the problem of defocus.

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