Real World Optical Design Teaching System By Robotic and the Vision Feed Back Process

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ABSTRACT: *Real world optical design teaching system which include the software design program and the hardware robotic optical bench with stock lens set as well as image evalution with CCD testing equipment has been build up. The datum of optical lens distance and the lens curvature are input to robotic the control program by digit meter and robotic which connected to the lens holder in the bench. The datum of the index of refraction and the curvature of stock lenses are stored in the lens library subroutine with code number in order easily to key in. According to the optical design program, servomotors drive the lens and its holders to suitable positions. The result of update optical system are checked by the resolving power projector to project test pattern through optical system to screen to be inspected and processed by CCD camera and image process system. The value of the square wave modular transfer functions are calculated and feed back to the optical design program to suggest the direction for the next turn of optimization. This system can show the aberration patterns with respect to the variance of lenses position and different sets of lenses. And in the lens optimizing process, by visualize and real time process which give the student real feeling to the abstract optical design course.*

1 INTRODUCTION

Today most of optical teachings are optical theory teaching and the testing demonstration separately. Here we make a real world close loop optical design teaching system that includes the software design program and the hardware optical bench with stock lens set as well as image processor with image testing equipment. The datum of optical lens distance is input to the program by digit meter, which connected to the lens holder in the bench. The datum of the index of refraction and the lens curvature of stock lenses are stored in the lens library subroutine with code number in order easily to key in. According to our design program, we get the lens distances. According to these datum servomotors drive the lens holders to suitable positions then the suitable lenses are put in these lens holders. The result of update optical system are checked by test pattern through this test optical system to its image plane which will be observed by CCD camera connected to the computer and its evaluation software system. The value of the square wave transfer functions are calculated and feed back to the optical design program to suggest the direction for the next turn of optimization.

2 RESOLVING POWER TEST PATTERN

There are several ways to evaluate the optical system during optical design such as interferometer, etc. The most simple and convenient way is the resolving power test pattern method. Test pattern, the MTF spatial frequency pattern and radial lines which is projected to a screen through tested optical system. The test pattern and the Moire technique are used to evaluate the off axis error of the lenses and the focal depth as well. The projection type require no processing of film for in-processing inspection of lens as many camera lens testing laboratory did, and provides quantitatively inspection of resolving power, its symmetry over the whole picture area, contrast, astigmatism as well as the Morie technique used in testing the off axis error and focal depth. However the human eyes are all different, the result of inspection is all different from person to person, therefore instead of human eyes we use the CCD camera to quantitatively recognize the test pattern. The MTF spatial frequency target are evaluated according to their modulation transfer function (MTF) values, the MTF is defined as image contrast divided by object contrast, and the contrast is the ratio of the difference of brightness to average brightness which is

proportional to the gray level of digitized CCD camera. A/D converter gives us 8 bit digital signal of all 512 or 1024 points along the vertical sampling line, and convert a full 512 points into a digital signal, which will display the intensity signal along a selected vertical lie on the target. Selection of scanning line can be control manually for calibration then automatically scan the frame according to the computer command. Since both the image contrast and the object contrast are measured with same camera, the camera error factors are canceled. Nevertheless, he resolution of CCD camera is still a limitation for inspection. Since we are not dealing with extra high precision optical system and the quantitative expression of CCD camera is much better than human eyes .The precision and the stability of CCD camera which are which are under 0.2 percentage in the temperature rang ten to forty centrigrade.

The real would optical teaching system contains I/O interface, artificial intelligent optical design, caustic optimization as well as test subroutines, constructed a close loop optical design teaching system. The testing subroutines included both hardware evaluation from CCD and the MTF spatial frequency test pattern and the software MTF evaluation. Display numerical values both the hardware and software results to help us easily to check the measurement value with their theoretical values and find out alignment and assemble errors. The picture of test pattern and measurement value as well as optical design software calculated values the aberrations appear in the display simultaneously make students understand optical system deeply, the quantities of off axis can be checked by image process to measure the overlapping of two radial patterns of the pattern from the test lens system and the original one in the computer. The values of decenter will appear with the Morie pattern picture simultaneously help us understand the decenter property of system quantitatively. The radial line target also shows astigmatism; if the lines running one way will appear to be darker than those which are at right angles to them. The difference of darkness is measured and appears with the theoretical calculated astigmatism value as well as pattern picture together.

3 DISCUSSION

In the process to convert the image to digital matrix, some errors from CCD camera occur; the gray level correction, the geometric aberrations etc., which is the limitation to recognize the targets can be improved by preprocessing. The chromatic aberration also should be examined. We suggest using color resolution grid and color image process to examine the difference MTF values of it.

4 CONCLUSIONS

The real world optical design teaching system , include the optical design software and with the feed back of hardware testing integrate the design, testing demonstration together, will increase the speed of design, and the understanding of optical principal as well as to make a real time optical design possible. Testing pattern and the Morie appear with measurement values and calculated theoretical calculated aberrations value expression together could help students to feel the optical system directly.

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