

Realtime MTF measurement of CMOS and CCD cameras

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ABSTRACT

The measurement of the Modulation Transfer Function (MTF) has become the most accepted test in the range of quality control of optics. Years ago only high quality optics like e.g. satellite or professional camera objectives have been MTF-tested. Nowadays even simple optical systems like cell phone cameras objectives are 100% tested. But not only single objectives have to be tested. If a perfect objective is badly aligned with respect to the sensor the result will be a bad MTF too. Therefore it is also recommended for the final camera inspection to measure the total MTF of the system objective plus sensor (CMOS or CCD). TRIOPTICS developed a MTF equipment to measure the MTF on 9 different field positions and different object distances of a complete camera in a few seconds. The system comprises a special target generator with slanted crosses as targets and new developed software to grab images and to calculate the MTF of the complete camera in realtime.

Keywords: MTF, objective, imaging quality, CMOS, CCD

1. INTRODUCTION

The system to measure the MTF comprises two main parts. I: A special target generator and II: a sophisticated image analysis software. The target generator developed at TRIOPTICS projects simultaneously targets under different object angles on to the sample. It is also possible to simulate different target distances from infinity to 2m. We use illuminated crosses on opaque ground as targets. This enables the measurement of the MTF in two different scan directions (x / y or saggital/tangential) at the same time. To receive subpixels resolution the slanted slit procedure is provided. That means the crosses are slightly tilted with respect to the lines and columns of the CCD or CMOS sensor.

1.1 Target generator

The principle of the target generator is displayed in figure 1. In the heart of the setup there is a highly corrected large field optics.

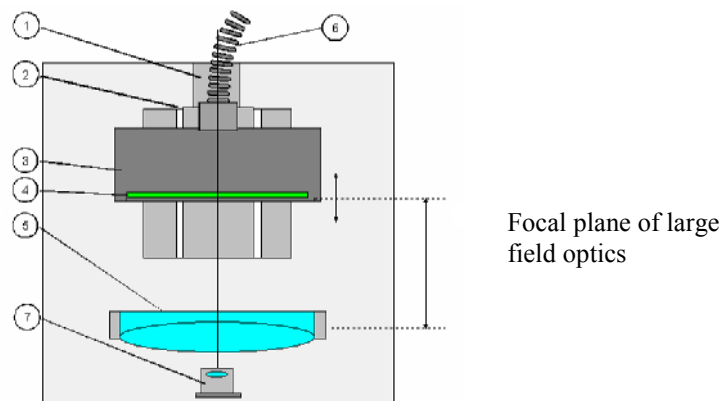


Fig. 1 Top View of the target generator. 1) Light fibre guide 2) motorized stage to move target 3) Target chamber 4) target with cross hairs 5) highly corrected large field optics 7) Sample (optics + sensor)

The large field optics images the complete target to infinity if the target is perfectly adjusted in the focal plane of the optics. To simulate different object distances the target has to be shifted with respect to the large field optics. To generate a finite distance the target has to be moved towards the optics (see figure 2). The target has one cross on axis one cross at 8 different crosses in the field of view. These crosses cover a field of view of 40 degree. The motorized movement of the target is controlled by measurement software as well as the image analysis. Distances between infinity and 2m can be reached in a few second. A distance scan from infinity and 2m including measurement at 12 different field positions can be made in approx. 15 seconds.

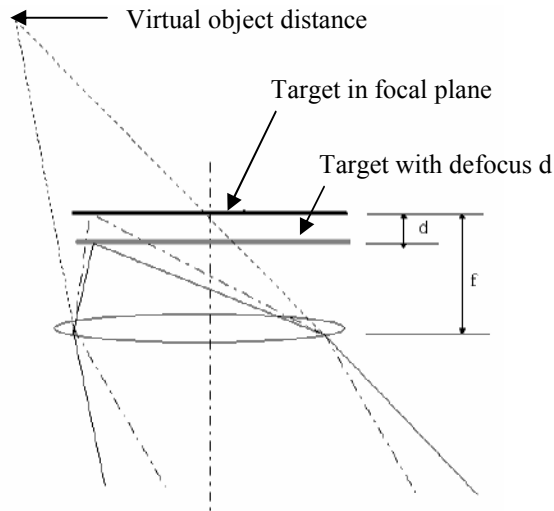


Fig. 2. To simulate different object distances the target will be defocused with respect to the objective.

1.2 Image analysis

The software has a special DLL-interface that enables the user to connect any camera with the standard software of the camera tester. The software acquires images on request from the camera. Each image has the information of the MTF in two scan directions on all desired field positions. For a fixed object distance the system provides real time MTF for all field positions.

Measuring the line spread function (LSF) of optics with an array sensor usually requires the magnification of the LSF. The magnification of relay optics in standard MTF testers typically ranges from 10 to 20 times. This is required to cope with aliasing. In the case of measurement of a complete camera the magnification is fixed. It is 1 and it can not be increased. To avoid aliasing the crosses were tilted with respect to the lines and columns of the sensor. This is according to the ISO standard (Ref. 1). The tilt is about 5 degrees. This procedure enables a sub pixel resolution of the LSF that can be compared to a magnification of 10 times.

2. MEASUREMENT RESULTS AND CONCLUSION

2.1 Results

The following figure shows the screenshot of a real time image. Simultaneously the MTF of all field positions can be calculated and displayed. Figure 4 (left side) shows the real time MTF of the on axis and some off-axis positions. The MTF curves are smooth and drop down to 0 at frequencies above 70 lp/mm. There is no aliasing at high frequencies. The last figure on the right side shows the distance scan of the MTF from infinity to 3.2m. For the distance scan the target generator moves to 12 different distance positions takes one image and continues to the next position. The displayed contrast values refers to 30 lp/mm. Depending on the application the distance between the sensor and the objective lens has been aligned to a certain distance. In this example the best image quality has to be for a distance of about 15m. But the through focus curves (fig. 4 right side) show the best focus (maximum MTF) around 4m. For all positions (off axis

and on axis) the best focus can be found for the same position. It is clear the sensor is parallel to the image plane of the objective lens but it is defocused with respect to the desired position

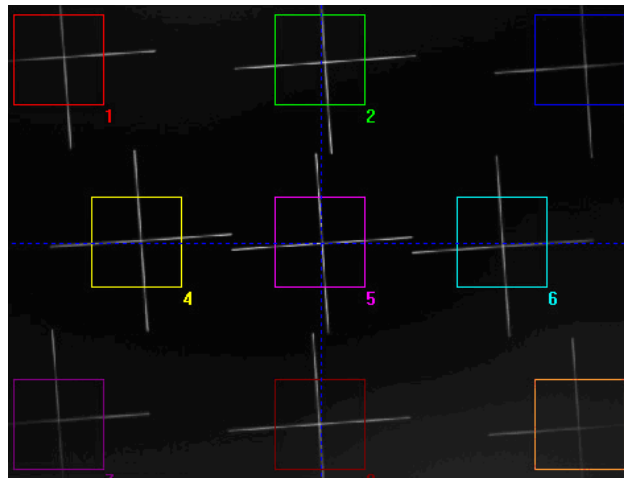


Fig. 3 Screenshot from the camera tester software of the real time image

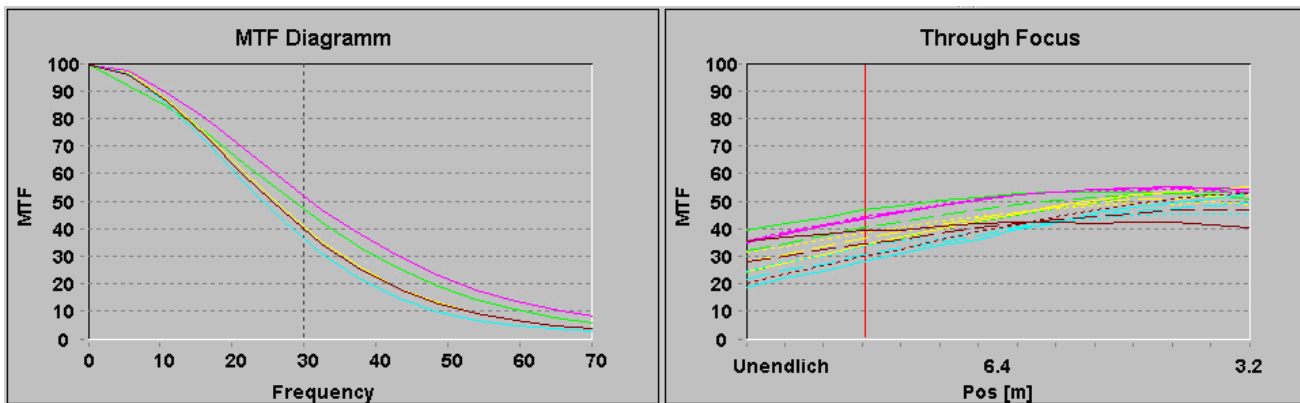


Fig. 4 Screenshot of the real time MTF (left side) and distance scan from infinity to 3.2m

2.2 Conclusion

The CAM-Tester is a perfect tool to measure the MTF of complete cameras on and off axis in real time. The tester provides detailed information about the contrast as well as defocus and tilt conditions of the image plane.

REFERENCES

1. "Optics and optical instruments- Optical transfer function-Principles of measurement of modulation transfer function (MTF) of sampled imaging systems" ISO standard 15529:1999