'92 KACC 1992. 10. 19~21

INFRARED RANGE FINDER DESIGNED FOR TARGET MOVING AT MEDIUM SPEED AND ITS APPLICATION TO LENS-POSITION CONTROL OF AUTOFOCUS CAMERA

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ABSTRACT

The measurable speed range of the self-mixing type semiconductor laser range finder has been greatly improved by employing a new processing circuit. Using this range finder as an external finder of a single lens reflex (SLR) autofocus (AF) camera, some clear photographs of an object moving at a medium speed of 20 mm/s is obtained.

1. INTRODUCTION

The self-mixing type semiconductor laser range finder is able to measure not only a distance to a moving object but its velocity.(1) We proposed to use the infrared (IR) range finder to position control of lens in autofocus (AF) camera.(2) Although some clear pictures of a slowly moving object have been obtained, the object speed was limited near 5 mm/s.

In order to increase the measurable speed of the object, it was necessary to enhance a sensitivity of the measuring circuit used in the range finder, which can overcome the increased error due to mechanical vibration of the target at higher speed. Recently, we devised a new signal processing circuit which can produce a precise mode hop pulse train even when the target is slightly vibrating.(3) The range finder employing the new circuit extended the measurable speed range of the object.

On the basis of the above mentioned results, we investigated the position control error of a lens used in a single lens reflex (SLR) autofocus (AF) camera. Furthermore, we tried to take some clear photographs of an object moving at a medium speed of 20 mm/s.

2. PRINCIPLE OF AUTOFOCUS

Figure 1 shows schematic configuration for open loop control of camera lens position.

Every time before photographing, the lens of an employed SLR camera is brought to the definite "infinity point", where is the just focusing point adjusted for an object placed at a great distance. The range and speed of the object are simultaneously measured by the self-mixing semiconductor laser range finder. The necessary forward shift of the lens from the infinity point is calculated from both the measured range and the calibration curve, when the object displacement induced during the response time i.e. the time interval between a range measurement and a following shutter release is taken into consideration. Then the required count number is preset in the pulse count circuit. When the lens driving motor stops in accordance with the stop signal which is produced just after the counting down ends, the lens stops at the required position suitable for just focussing. Then the camera shutter is released synchronously when the lens stops.

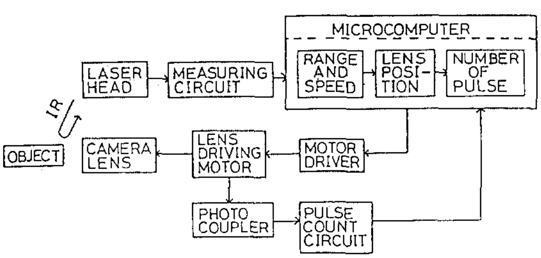


Fig.1 Schematic configuration for open loop control of camera lens position.

3. EXPERIMENT OF AUTOFOCUS

Figure 2 shows a bird's-eye view of the SLR camera with AF system and the laser head of the IR range finder. Instead of the installed mechanism to achieve a just focusing signal, the external IR range finder is employed. The laser head and the camera are placed side by side with those optical axes aligned parallel. The object panel consists of both an aluminium plate for measuring range and speed, and an object array to be photographed. The object panel is supported with its plane vertical to the optical axis, and the panel can be reciprocally moved on a linear rotary unit.

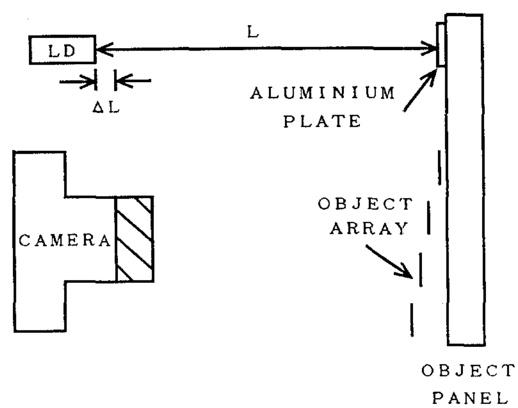


Fig.2 Bird's-eye view of the SLR camera with AF system and the laser head of the IR range finder.

Figure 3 shows range measurement error versus range when the target is moving at various constant speeds ranging 10 mm/s to 18 mm/s. The range measurement error remains within 1.2 %.

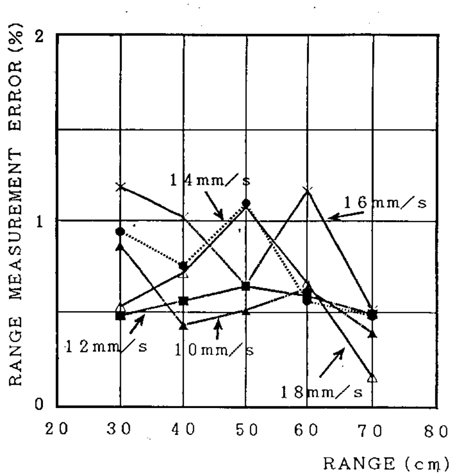


Fig.3 Range measurement error versus range when the target is moving at various constant speeds ranging 10mm/s to 18mm/s.

Figure 4 shows velocity measurement error versus range when the target moves at various constant speeds. The velocity measurement error stays within 2.2 %.

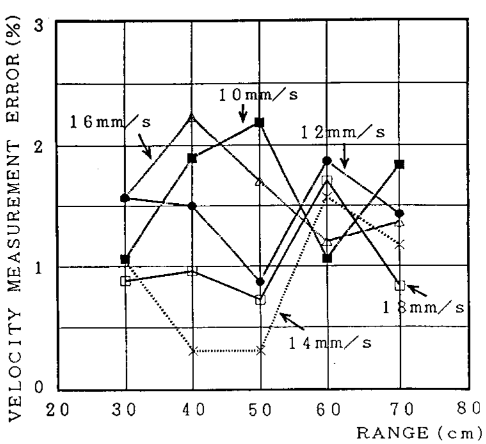


Fig.4 Velocity measurement error versus range when the target moves at various constant speeds.

Figure 5 shows the depth of field normalized by the preset range and the forward shift error as a function of range, which is obtained without considering the response time of the shutter. The measured depth of field is obtained by the finder installed in the employed camera. As seen from Fig.5, the forward shift error of the lens is above the theoretical or measured field of depth in position of 30cm-50cm. Therefore, if the response time is not considered, the clear photograph is not expected in this range.

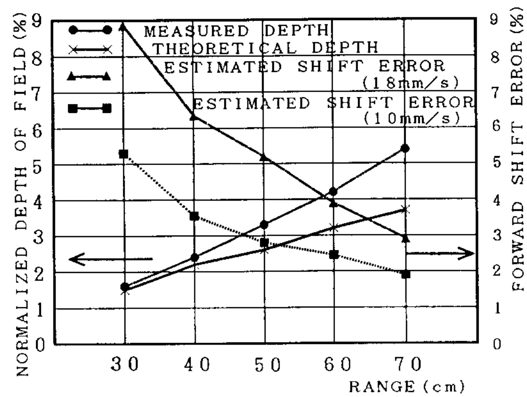


Fig.5 The depth of field normalized by the preset range and the forward shift error as a function of range, which is obtained without considering the response tome of the shutter.

Figure 6 shows the depth of field and the allowable range error.

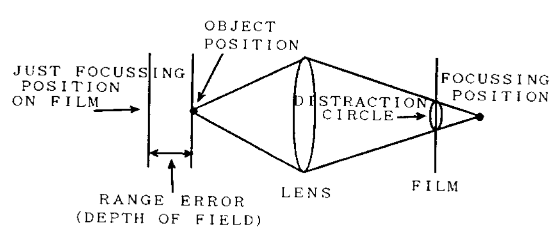


Fig.6 The depth of field and the allowable range error.

Figure 7 shows the depth of field normalized by the preset range and the forward shift error as a function of range, when the response time of the shutter is considered. In this case, the forward shift error of the lens is far below the theoretical or measured field depth normalized by the distance. Therefore, expected is the clear photographs of the object moving at medium speed of 20 mm/s.

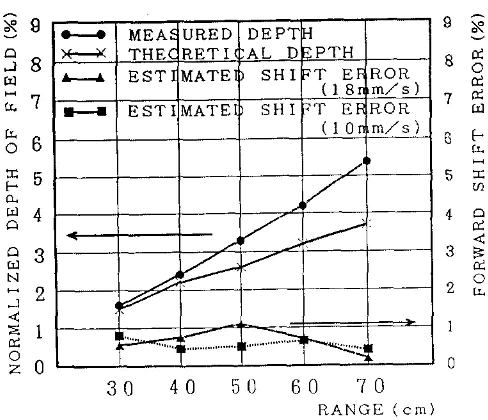
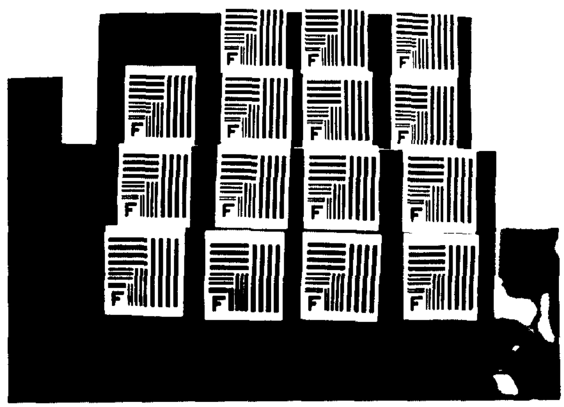


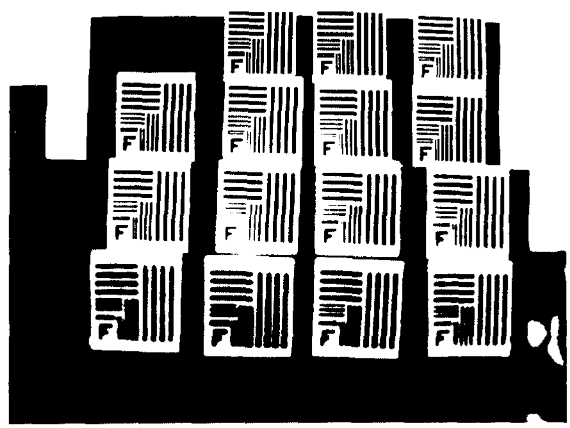
Fig.7 The depth of field normalized by the preset range and the forward shift error as a function of range, the response time of the shutter is considered.

Figure 8 shows some pictures taken by the proposed AF camera. Figure 8(a) shows the picture of the still target taken by the finder installed in the employed camera. The range Lt to the target is Lt=30cm. This is a very clear photograph. Figure 8(b)and(c) show the pictures of the moving target taken by the IR range finder. The target velocity is kept constant, Vt=17mm/s. As the picture(b) is obtained without considering the response time, it is not a clear one. On the other hand, as the picture(c) is obtained considering response time 610ms, this picture is clearer than the picture(b). Therfore, the proposed IR range finder has been confirmed to have sufficient accuracy as a range finder of an AF camera.

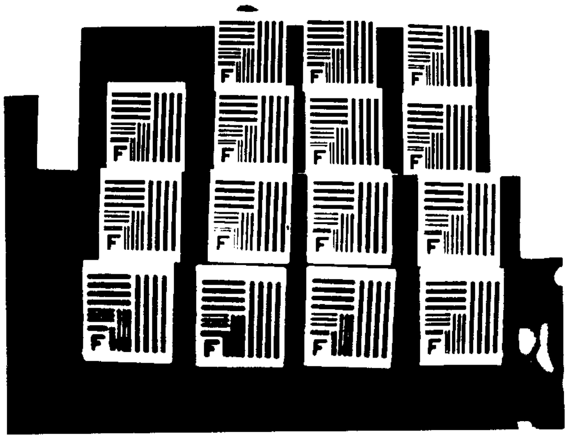
Fig.8 The pictures taken by the proposed AF camera.



(a) The picture of the still target taken by the finder installed in the employed camera.(Lt=30cm,Vt=0mm/s)



(b) The picture of the moving target taken by the IR range finder, without considering the response time. (Lt=30cm,Vt=17mm/s)



(c) The picture of the moving target taken by the IR range finder, considering the response time.(Lt=30cm,Vt=17mm/s)

4. CONCLUSION

The measurable speed range of the self-mixing type semiconductor laser range finder has been greatly improved by employing a new processing circuit. Using this range finder as an external finder of an autofocus (AF) single lens reflex (SLR) camera, some clear photographs of an object moving at a medium speed of 20 mm/s has been obtained.

REFERENCES

(1)S.Shinohara et al.: "High Precision Range Finder for Slowly Moving Target with Rough Surface", Proc. 16th Annual Conf. of the IEEE Industrial Electronics Society (IECON'90), FA7.7, pp.659-664, Nov., 1990.

(2)Y.Yoshida et al.:"Application of Semiconductor Laser Range Finder to Position Control of Lens in Auto-Focus Camera", Proc. IECON'91, Vol.3 of 3, pp.2357-2361, Oct., 1991.

(3)S.Shinohara et al.: "Improvement of Self-Mixing Semiconductor Laser Range Finder and Its Application to Range-Image Recognition of Slowly Moving Object", '92 Korean Automatic Control Conference ('92KACC), Oct., 1992.