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Illumination Effect of Laser Light in Foggy Objects Using an Active Imaging System

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1. Introduction

Remote monitoring is a key technology to confirm safety in radiation area of nuclear industry. Especially, image monitoring technique is essential to check structural safety.

Active imaging techniques usually provide improved image information when compared to passive imaging techniques. Active vision is a direct visualization technique using an artificial illuminant. Range-gated imaging (RGI) technique is one of active vision technologies. The RGI technique extracts vision information by summing time sliced vision images. In the RGI system, objects are illuminated for ultra-short time by a high intensity illuminant and then the light reflected from objects is captured by a highly sensitive image sensor with the exposure of ultra-short time [1, 2]. The RGI system provides two-dimensional image data and range image data and it moreover provides clear images from low-visibility fog environment by using summing of time-sliced images.

Nowadays, the Range-gated imaging is an emerging technology in the field of surveillance for security application, especially in the visualization of darken night or foggy environment. Although RGI viewing was discovered in the 1960's, this technology is currently more applicable by virtue of the rapid development of optical and sensor technologies, such as highly sensitive imaging sensor and ultra-short pulse laser light. Especially, this system can be adopted in robot-vision system by virtue of the compact system configuration. During the past decades, several applications of this technology have been applied in target recognition and in harsh environments, such as fog, underwater vision [4, 5]. Also, this technology has been demonstrated range imaging based on range-gated imaging. Laser light having a short pulse width is usually used for the range-gated imaging system.

In this paper, an illumination effect of laser light in foggy objects is studied using a range-gated imaging system. The used imaging system consists of an ultra-short pulse (0.35 ns) laser light and a gated imaging sensor. The experiment is carried out to monitor objects in a box filled by fog.

2. Experiments for Motoring Foggy Objects Using a Range-gated Imaging System

A photo of experimental setup for detecting foggy objects using a range-gated imaging system is shown in Fig. 1. The system consists of an imaging camera, an illumination laser light, a time delay generator and a computer. An acquired image and a processed image are shown in Fig. 2(a) and Fig. 2(b), respectively.

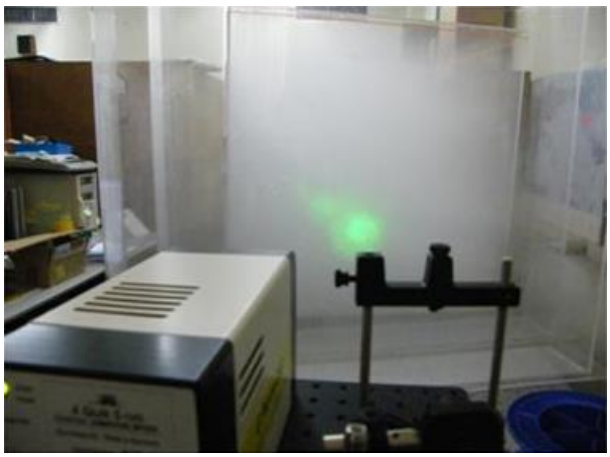
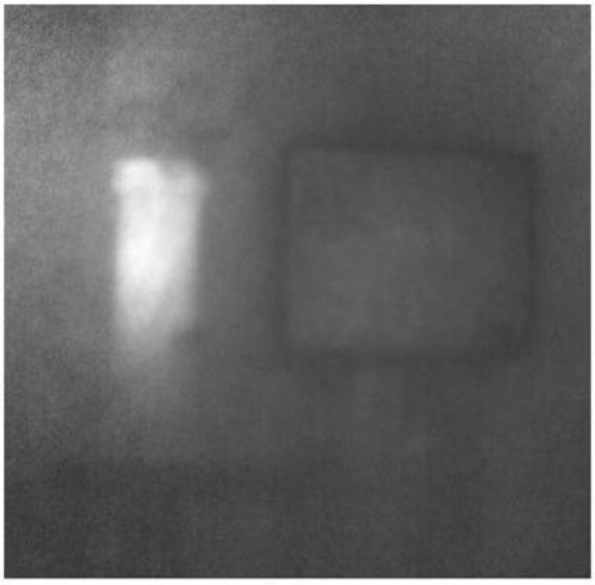
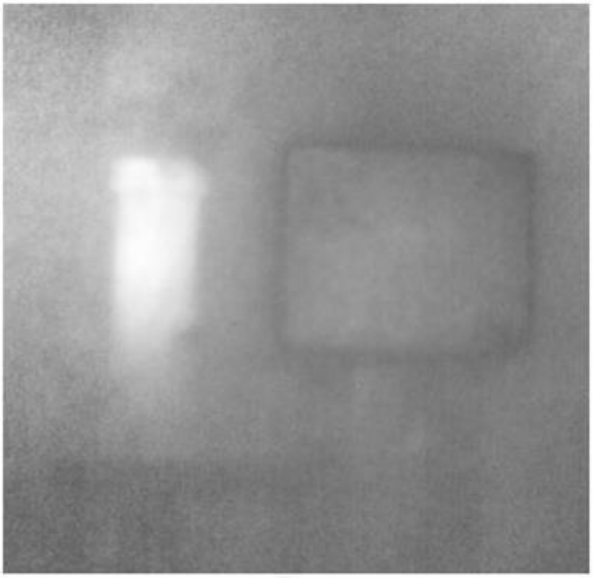


Fig. 1. Photo of monitoring experiments for foggy objects using a range-gated system.



(a) Visualized image



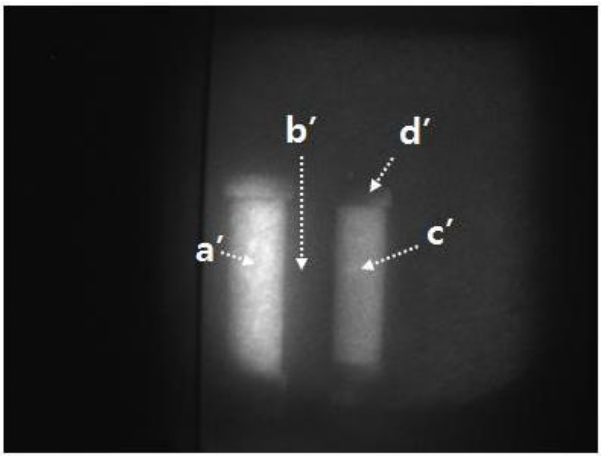
(b) Visualized Image after Image processing

c) Convention camera image

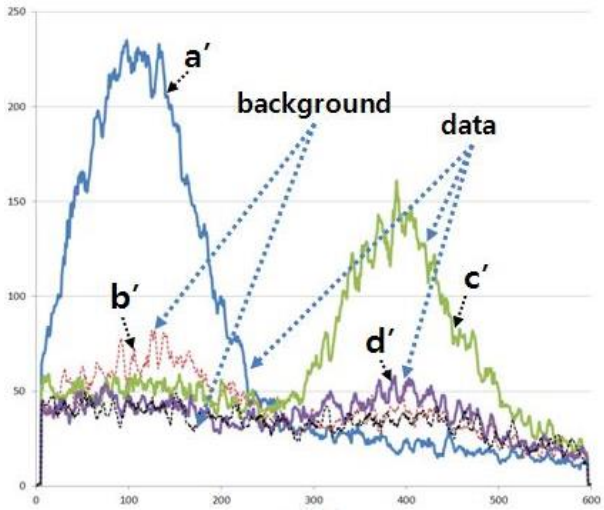
Fig. 2. Comparison of acquired images for darken foggy objects (distance: 6m).

Conventional camera image for foggy objects is shown in Fig. 2(c). As shown in the experimental results, the RGI technique provided improved object shape information. But, the edge areas of detected object images are blurred by fog particles. Also, the detection capability highly depends on the light reflectivity of the objects. Here, the reflectivity of the back object is higher than the front object.

Another acquired image for foggy objects is shown in Fig. 3(a), and the pixel intensity graph along to range direction is shown in Fig. 3(b). As shown in Fig. 3, the RGI technique can provide simultaneously a two-dimensional image and a range data image. But, the front part intensity of an object is biased and the bias level is in proportional to the fog density. Thus, after reducing the bias effect caused by fog particles, the system should extract the range image data to improve measurement resolution.



(a) Visualized darken foggy objects



(b) Intensity profiles along to range direction

Fig. 3. Acquired two-dimensional image and intensity profile graph along to range direction.

3. Conclusions

In this paper, the effects by fog particles in range-gated imaging technique are studied. Edge blurring and range distortion are the generated by fog particles. Thus, a range-gated imaging system applied to the low-visibility foggy environment needs to extract range data after reducing the intensity bias.

REFERENCES

[1] Gillespie, L. F., "Apparent illumination as a function of range in gated, laser night-viewing systems," *JOSA* **56**, 883–887 (1966).

[2] Belin, E., Christnacher, F., Taillade, F., and Laurenzis, M., "Display of an analytical model for backscattered luminance and a full-field range gated imaging system for vision in fog," *Proc. SPIE* **7088**, 708800 (2008).