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Development of a Compact Range-gated Vision System to Monitor Structures in Low-visibility Environments

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1. Introduction

Image acquisition in disaster area or radiation area of nuclear industry is an important function for safety inspection and preparing appropriate damage control plans. So, automatic vision system to monitor structures and facilities in blurred smoking environments such as the places of a fire and detonation is essential.

Vision systems can't acquire an image when the illumination light is blocked by disturbance materials, such as smoke, fog and dust. Also, the image captured on a sensor can be blurred and dimmed by the distortion of incoming light.

To overcome the imaging distortion caused by obstacle materials, robust vision systems should have extra-functions, such as active illumination through disturbance materials. One of active vision system is a range-gated imaging system. The vision system based on the range-gated imaging system can acquire image data from the blurred and darken light environments.

Range-gated imaging (RGI) is a direct active visualization technique using a highly sensitive image sensor and a high intensity illuminant [1]. Currently, the range-gated imaging technique providing 2D and range image data is one of emerging active vision technologies [2-3]. The range-gated imaging system gets vision information by summing time sliced vision images. In the RGI system, a high intensity illuminant illuminates for ultra-short time and a highly sensitive image sensor is gated by ultra-short exposure time to only get the illumination light. Here, the illuminant illuminates objects by flashing strong light through disturbance materials, such as smoke particles and dust particles. In contrast to passive conventional vision systems, the RGI active vision technology enables operation even in harsh environments like low-visibility smoky environment.

In this paper, a compact range-gated vision system is developed to monitor structures in low-visibility environment. The system consists of illumination light, a range-gating camera and a control computer. Visualization experiments are carried out in low-visibility foggy environment to see imaging capability. The experimental results using the developed vision system are described in this paper.

2. Configuration of a Compact Range-gated Vision System to Monitor Structures

A photo of a configured range-gated vision system is shown in Fig. 1. The distance between monitoring objects and the active vision system was about 3m and the objects were installed in a transparent box filled by fog.

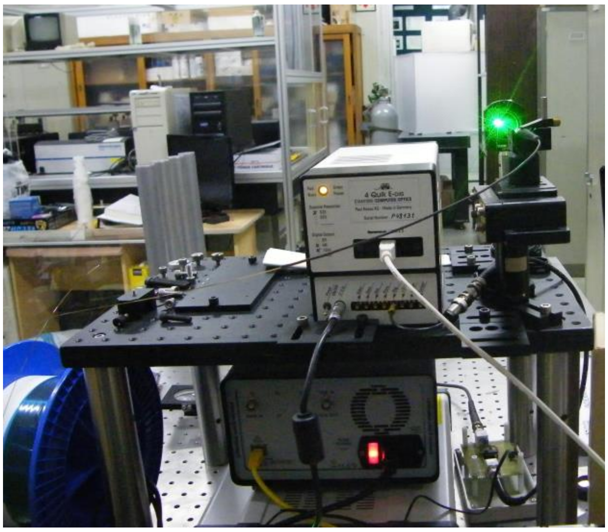

Fig. 1. Photo of a configured range-gated vision system to monitor structures.

Captured main-image of the developed operating software is shown Fig. 2. The software can provide two-dimensional image and range image.

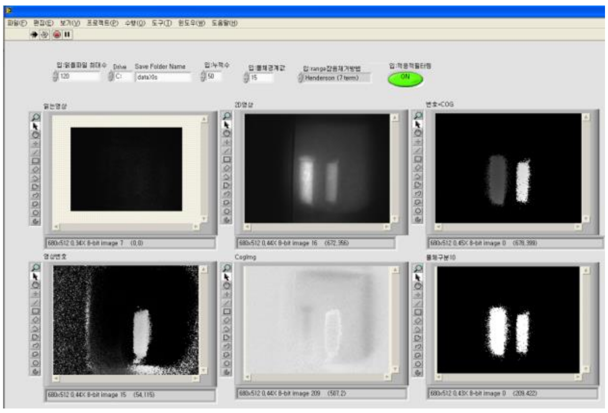

Fig. 2. Main image of the operating software for the range-gated vision system.

The signal processing flowchart of the developed software is shown in Fig. 3. As shown in Fig. 3, during acquisition of the range-gated images, the system catches maximum intensity area along each pixel position and memories its updating image position. After total image acquisition, the system extracts two-dimensional image and range data from the caught range-gated images.

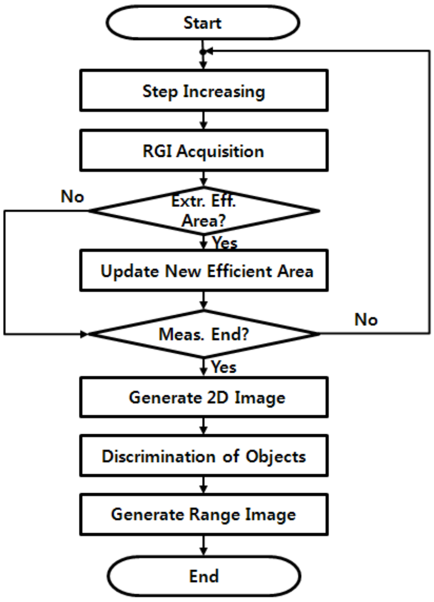

Fig. 3. Signal flowchart of a developed range-gated vision system.

A conventional camera image for the foggy objects is shown in Fig. 4. As shown in Fig. 4, the conventional camera image can't provide precise object information by foggy smearing.

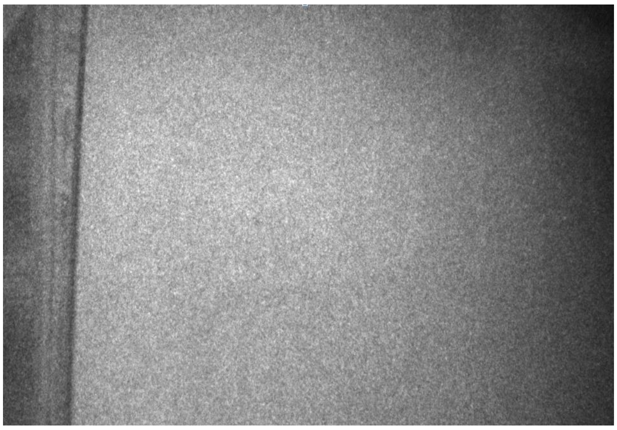

Fig. 4. Camera image acquired from the low visibility foggy environment.

Extracted two-dimensional and range images are shown in Fig. 5 and Fig. 6, respectively. As shown in these experiments, the compact vision system provided distinguishable object image data and their range information.

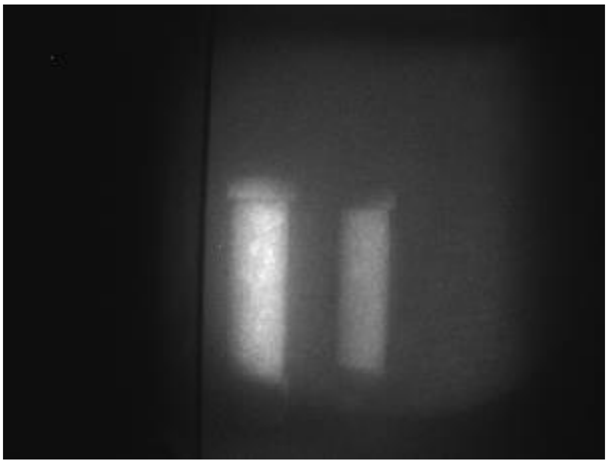

Fig. 5. Two-dimensional image acquired from the low visibility environment.

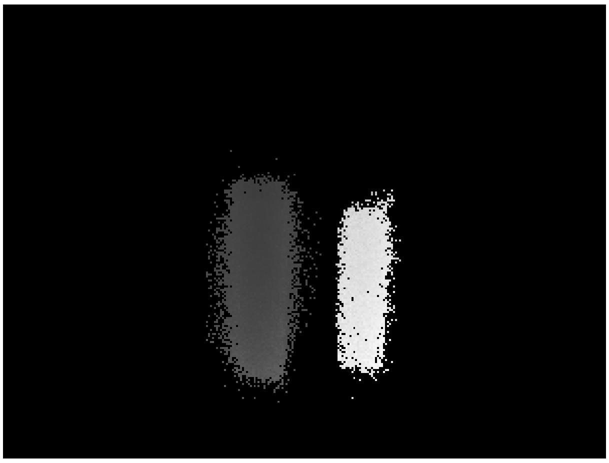

Fig. 6. Three-dimensional image acquired from the low visibility environment.

3. Conclusions

To overcome the image smearing caused by fog disturbance, a compact robust vision system based on range-gated imaging is developed and its imaging capability is experimented. As the results, the range-gated vision system with active illumination light provided useful image information of objects under the low-visibility environment and it also provided their range data for objects.

REFERENCES

[1] Gillespie, L. F., "Apparent illumination as a function of range in gated, laser night-viewing systems," *JOSA* **56**, 883–887 (1966).
[2] Digger, R. G., Vollmerhausen, R. H., Devitt, N., Halfort, C., and Barnard, K. J., "Impact of speckle on laser range-gated shortwave infrared imaging system target identification performance," *Opt. Eng.* **43**, 738–746 (2003).
[3] 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**, 7
08800 (2008).