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Title: RANGE GATING EXPERIMENTS THROUGH A SCATTERING MEDIA

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Range Gating Experiments through a Scattering Media

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ABSTRACT

This paper discusses range-gated imaging experiments performed recently at Redstone Arsenal in Huntsville Alabama. Range gating is an imaging technique that uses a pulsed laser and gated camera to image objects at specific ranges. The technique can be used for imaging through scattering media such as dense smoke or fog. Range gating uses the fact that light travels at $3*10^8$m/s. Knowing the speed of light we can calculate the time it will take the laser light to travel a known distance, then gate open a Micro Channel Plate Image Intensifier (MCPII) at the time the reflected light returns from the target. In the Redstone experiment the gate width on the MCPII was set to equal the laser pulse width (~8ns) for the highest signal to noise ratio. The gate allows the light reflected from the target and a small portion of the light reflected from the smoke in the vicinity of the target to be imaged. We obtained good results in light and medium smoke but the laser we were using did not have sufficient intensity to penetrate the thickest smoke. We did not diverge the laser beam to cover the entire target in order to maintain a high flux that would achieve better penetration through the smoke. We were able to image an Armored Personnel Carrier (APC) through light and medium smoke but we were not able to image the APC through heavy smoke. The experiment and results are presented.

Keywords: Range Gating, Micro Channel Plate Image Intensifier(MCPII), CCD Cameras.

I. Introduction

Range Gating is a well known imaging technique that can be used to image through scattering media such as smoke, fog, and turbid waters(1)(2). Using range gating we are able to record only the light that is being reflected from the vicinity of the target(see Figure1). We use a pulsed laser, which has a higher intensity than the background light. The imager consists of a Micro Channel Plate Image Intensifier (MCPII) coupled to a Charge Coupled Device (CCD) camera. The MCPII is shuttered with a gate pulse of about 8ns in width.

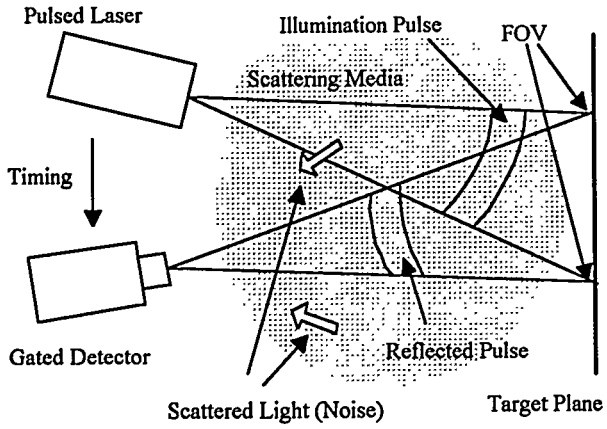

Figure 1: Illustration of range gated imaging. The laser source illuminates the target with a short pulse and provides a timing signal to the gated detector. The gated detector is set to accept light from the vicinity of the target plane and reject most of the light scattered by the intervening medium.

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For These experiments our primary target was an Armored Personnel Carrier about 500m down range from a 100ft tower where our equipment was located. Figure 2 shows a block diagram of our equipment set up. Although three cameras are shown in the block

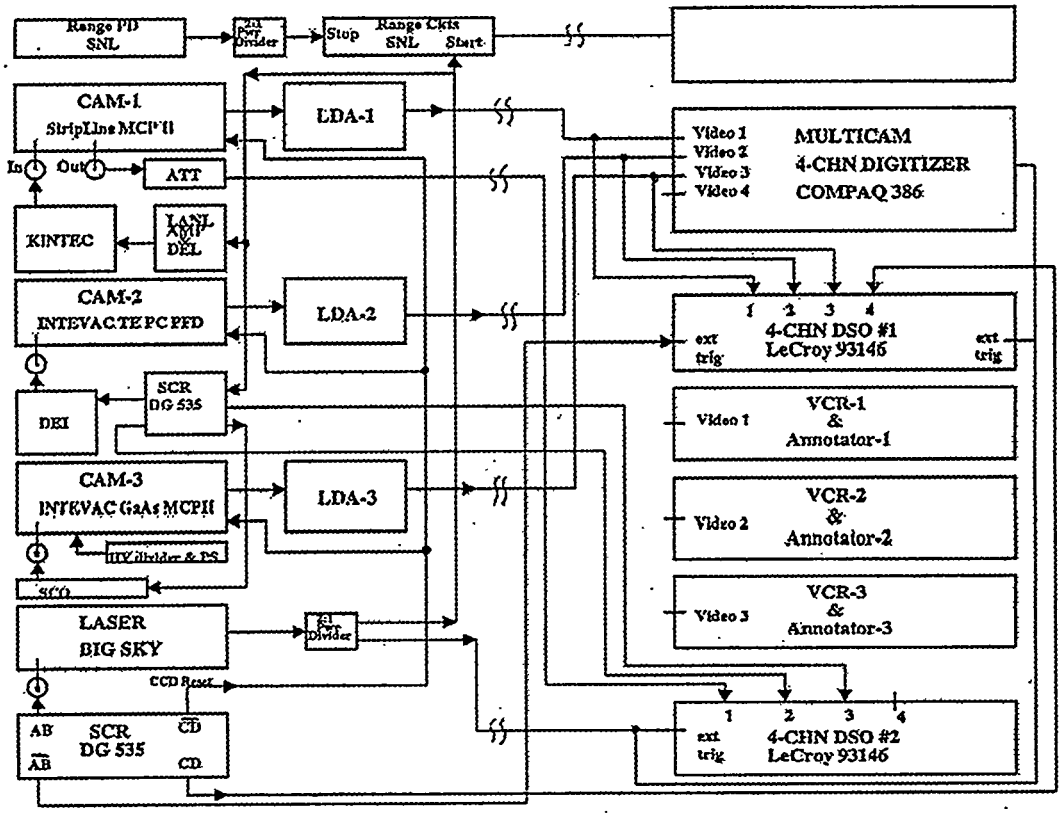

Figure 2: Block Diagram of System

diagram only one was actually used due to technical difficulties and safety requirements. A Big Sky Laser was used in the experiments. The laser operated at a wavelength of 532nm, had a pulse length of 8ns, and an energy of approximately 30mJ/pulse. Timing was provided by a Stanford DG 535 pulse generator. A frame grabber card installed in a Compaq computer was used to capture images from the camera and associated display and analyzing software was used to display and record the images. As a backup the image data were recorded on a VCR and on a LeCroy storage 9314L oscilloscope.

II. Experimental Results

In the Redstone experiments smoke was used as the scattering media. We qualitatively classified the smoke into three levels of density, Light, Medium, and Heavy. The smoke was produced by burning fog oil and then using a jet engine starter to blow the smoke across the field. Light smoke has a density such that an observer can just see the APC by eye. Medium smoke is at a level such that the target can easily be lost to the observer. Heavy smoke is at a level that the target can definitely not be seen. The

illustrations in Figure 3 show the test range at Redstone Arsenal with and without smoke. The range was about 5km long and about ½ to 1km wide. In Figure 3b you can see the fog oil just beginning to drift across the field. The range is about 450m and the APC can be seen by an observer with appropriate optics.

Figure 3a: Range without Smoke

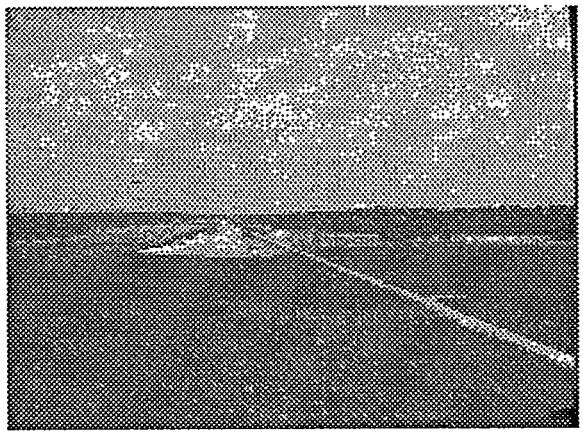

Figure 3b: Range with Smoke

Figures 4a and 4b show the APC as it looked from about 20m from an ordinary camera and from about 500m from one of our range gated cameras with a 300mm telephoto lens. The field of view in the two images is approximately the same. One can clearly see in the range-gated image the shape of the APC. Portions of the wheels and

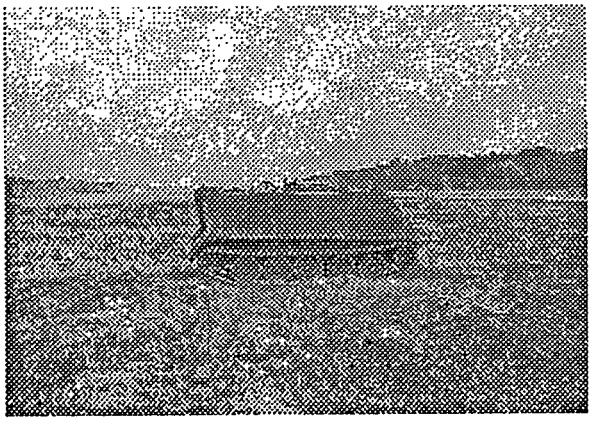

Figure 4a: The Picture of the APC on the left from a digital camera.

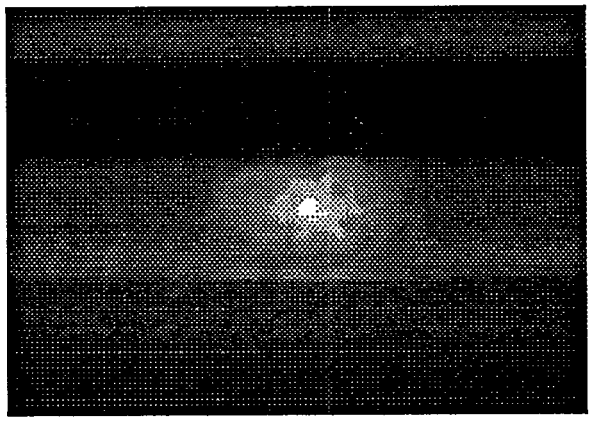

Figure 4b: Range Gated Picture of APC on the right notice the hotspot in the middle of the target.

tread can be observed. The bright spot in the middle of the APC is due to the non-uniform intensity of the laser beam. No attempt was made to obtain a more uniform laser beam profile in order to increase penetration of the smoke.

Figure 5 shows a series of range gated images taken through light, medium, and heavy smoke. Figure 5a shows the APC imaged through light smoke. One can see the APC but not as many details can be seen due to the fact that the gain of the MCPII was adjusted high in order to ensure detection of the return signal. Figure 5b shows the APC covered with medium smoke, which is at a level that almost completely obscures the target and an observer could easily miss or lose the APC in the smoke. Again, the gain on the MCPII was adjusted high and, the recorded image was saturated and had no detail. Had the gain

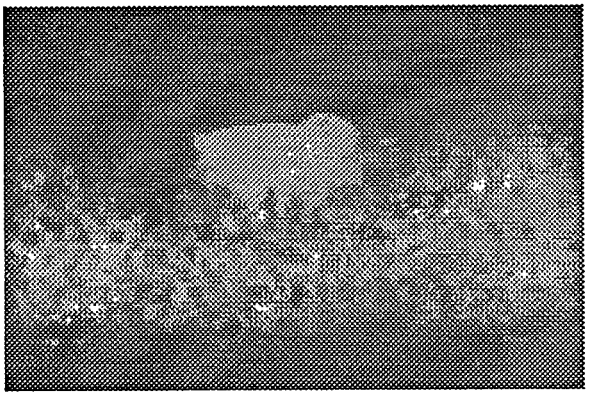

Figure 5a: APC through light smoke

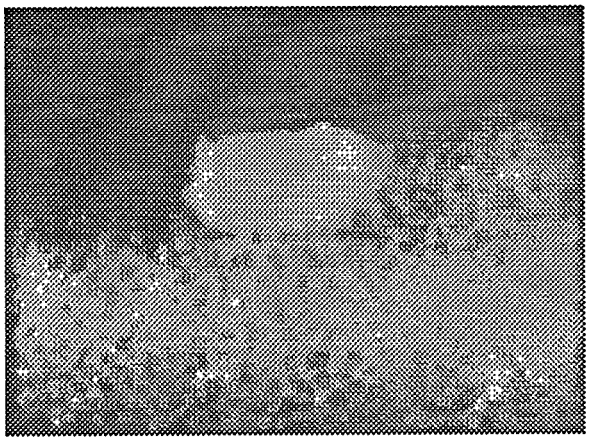

Figure 5b: APC in Medium Smoke there is no detail due to high intensifier gain.

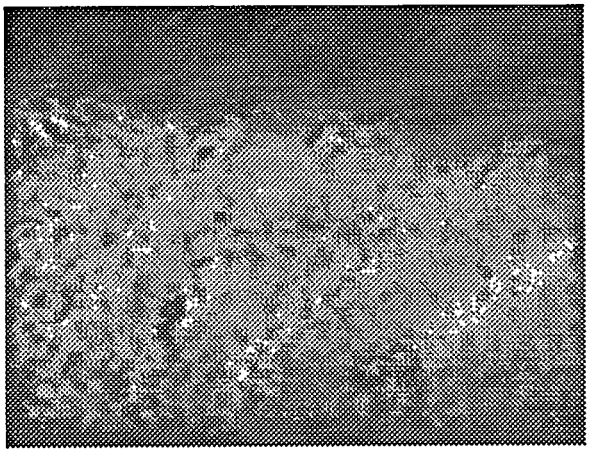

Figure 5c: APC covered in Heavy smoke and not visible to without data extraction.

been adjusted lower, more detail of the APC would have been observed. Figure 5c shows imaging through heavy smoke. Except for an indication of the high intensity spot of the laser, no reflected signal from the APC was recorded. A higher energy laser pulse would have been required to penetrate the smoke and provide a recordable return signal from the APC.

In Figure 6a the APC is covered in heavy smoke. Although no detail of the APC is evident in the picture, it may, nonetheless, be possible to extract data from such imaging using data analysis techniques. Figure 6b shows a data enhancement of the image in Figure 6a, which brings out a bright-spot return from the APC. We speculate that the bright return in the lower left corner of the image is a reflection from a small pool of water near the APC. The speckled pattern seen in the images is the typical granular light distribution associated with laser light.

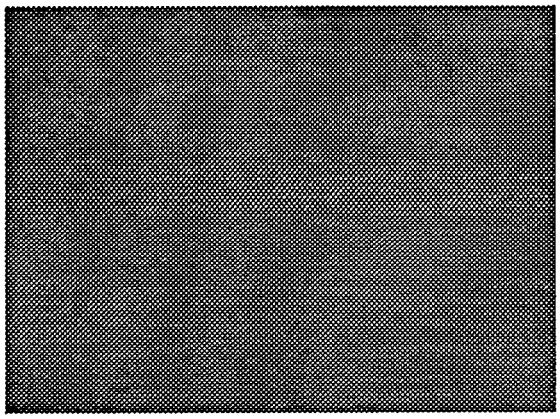

Figure 6a: APC in Heavy smoke

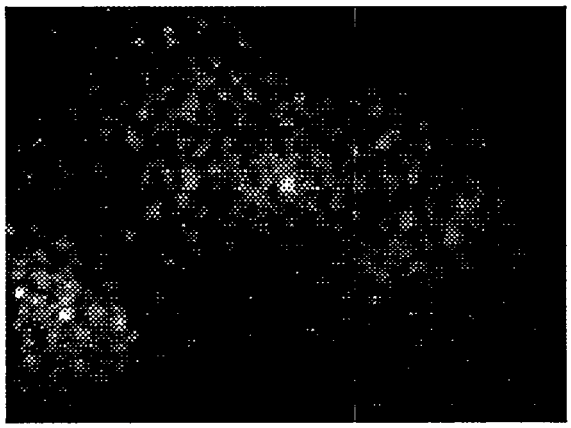

Figure 6b: APC after Data Extraction

III. Conclusion

We have demonstrated the use of range gating in imaging through smoke and scattering media. With range-gating techniques we where able to image a target in three different levels of smoke. Although the photon return was low through the heavy smoke, it is speculated that a laser that has a greater pulse energy would be able to correct this problem.

IV. Bibliography

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2. George J. Yates, Robert A. Gallegos, Thomas E. McDonald, F. J. Zutavern, W. D. Helgeson, G. M Loubriel," Range-Gated Imaging for Near-Field Target Identification," SPIE 22nd International Congress on High-Speed Photography and Photonics, January 96