A COMPARISON OF FUSION ALGORITHMS AND METRICS AND THEIR AGREEMENT WITH VISUAL PERCEPTION LABORATORY DETECTION PROBABILITY VALUES (U)

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ABSTRACT (U)

(U) The Visual Perception Laboratory (VPL) of TARDEC has developed a camera system that provides panoramic image fusion that can be integrated into various types of vehicles. The camera system is a combination of infrared (IR) and visual cameras that generates a panoramic image and provides situational awareness to the crew of an armored vehicle prior to egress as well as hemispherical awareness during patrol activity. Image fusion is being used more and more by the US Army for target recognition and situational awareness. Several algorithms for fusing imagery are tested by the authors and the quality of the fused images are assessed using metrics from the literature and compared to experimental values obtained in the Visual Perception Lab. This work supports a joint TARDEC/NVESD STO on Situational Awareness.

Introduction (U)

(U) A requirement of the Future Combat System (FCS) and homeland security is that armored vehicles have a system that is able to provide close-in situational awareness and understanding to the crew within the whole 360 degree hemisphere (Fig. 1) of the vehicle. TACOM, Ford Laboratories, and Sarnoff Labs are partnering to meet this requirement. [1]

Fig. 1: (U) 360 degree panoramic image fusion

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The Visual Perception Laboratory (VPL) of TARDEC has developed a camera system that provides panoramic image fusion that can be integrated into various types of vehicles. The camera system is a combination of infrared (IR) and visual cameras that generates a panoramic image and provides situational awareness to the crew of an armored vehicle prior to egress as well as hemispherical awareness during patrol activity. Image fusion is being used more and more by the US Army for target recognition and situational awareness. Several algorithms for fusing imagery are tested by the authors and the quality of the fused images are assessed using metrics from the literature and compared to experimental values obtained in the Visual Perception Lab. This work supports a joint TARDEC/NVESD STO on Situational Awareness.

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System Description (U)

(U) Elmo QN42 visual cameras (Fig. 2) are used in the system because of their small size and excellent color fidelity. The cameras have a field of view of approximately 53 degrees by 39 degrees. The Elmo cameras have a 410,000 pixel color CCD that results in 786 (V) X 470 lines (H) resolution with simultaneous Y/C and composite video outputs.

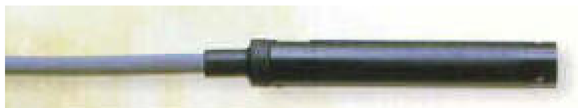

Fig. 2 (U) Elmo QN42 Camera

(U) Indigo Omega infrared cameras (Fig. 3) were also selected because of their small size and clear image and have an image array resolution of 160 by 120 pixels, with a 51 by 51 micron pixel size. The detector is an uncooled microbolometer. The infrared cameras are fitted with 8.5 mm lenses that provide a field of view of approximately 55 by 40 degrees. The Indigo Omega cameras are sensitive to the 7.5 to 13.5 micron band of the electromagnetic spectrum.

Fig. 3 (U) Indigo Omega IR camera

(U) There are four visible cameras and four IR cameras in each of the housings in the front and rear of the vehicle, hence a total of eight visible and infrared cameras. The output of the eight cameras are combined using multiplexers and with the Sarnoff stitching and image registration software provide a panoramic view that is scrollable and adjustable in magnification. The imagery from the cameras is combined, registered, and fused to provide a real-time panoramic stitched view of the world around the vehicle onto which they are mounted. The sensors are an open configuration for testing and characterization. Future plans for hardening include the use of transparent covers and lenses.

Fused Images: Contrast

Fig. 4 (U): Fused images using the contrast fusion algorithm

Fused Images: Discreet Wavelet Transform

Fig. 5 (U): Fused images using the Discreet Wavelet Transform

Fused Images: Laplacian

Fig. 6 (U): Fused images using the Laplacian fusion algorithm

Fused Images: Morphological

Fig. 7 (U): Fused images using the Morphological fusion algorithm

(U) Method

(U) A total of 46 IR and visible images taken with the IR camera and visible camera of the PIF system were fused using the MATLAB FuseTool program. Four fusion algorithms were chosen for comparison in this test. See Figures 1 through Fig. 4 below for samples of the images. Subjects were told to view the image and designate with a mouse where a person was standing. Laboratory probability of detection values were obtained for each image. Image metrics were computed for each image and compared to detection values.

(U) Analysis

(U) The graph below in Fig. 5 shows a comparison of the laboratory percent correct detection rates to three metrics that were used on each image. The metrics used were, 1) a Shannon entropy measure, 2) a textured clutter metric, and 3) a Schmeider-Weathersby variance clutter metric. [2,3]

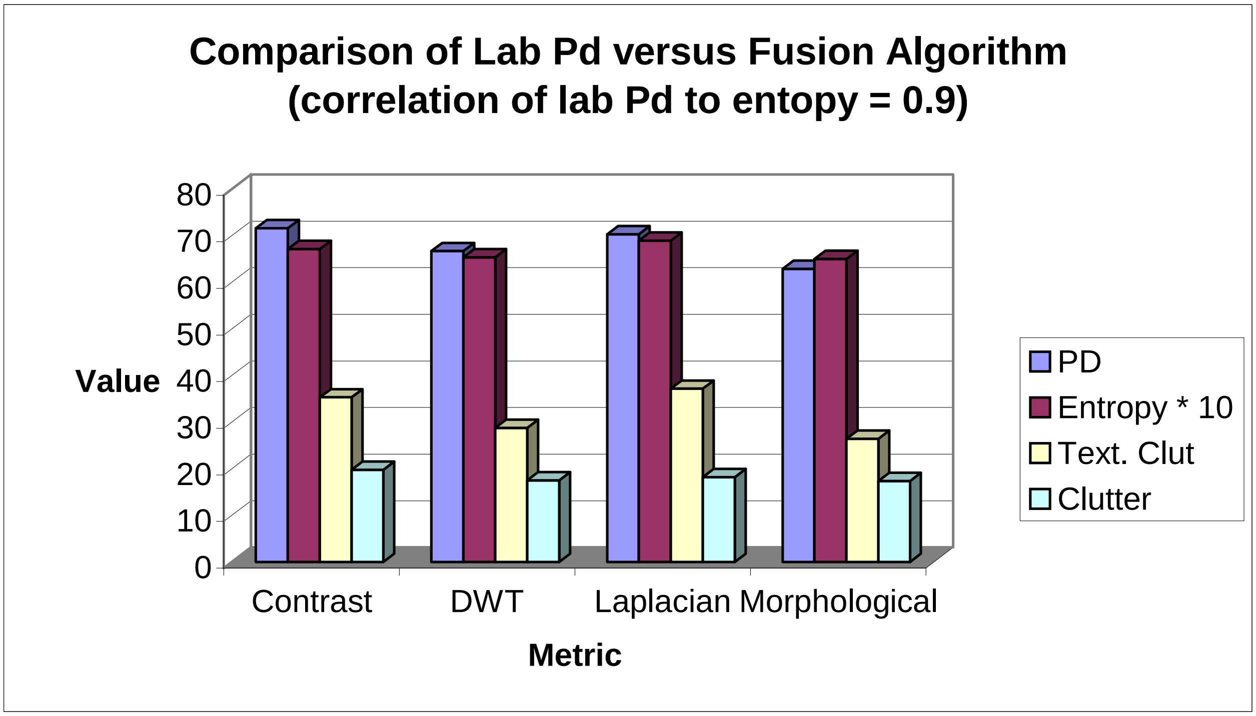

Fig. 8 (U): Graph of laboratory detection and image metric values

(U) The analysis shows that the Laplacian and Contrast image fusion algorithms perform the best. The PIF system currently used in the Survivability prototypes uses a Laplacian image fusion algorithm.

Results and Future Work (U)

The authors have developed a statistical method to compare and rank image fusion algorithms. The Laplacian and Contrast image fusion algorithms performed the best in this series of laboratory tests. The authors pan to capture more complex data sets involving color, more background clutter, and noise for metric and fusion algorithm comparison.

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