MASTER OF SCIENCE IN COMBAT SYSTEMS TECHNOLOGY

ATMOSPHERIC WINDOWS FOR HIGH ENERGY SHORT PULSE LASERS

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In this thesis, the authors aim to determine the optimal atmospheric windows for high energy, pico second, short pulse lasers. Computer simulations were carried out by convolving a pulse spectrum with the transmission spectrum and the absorption coefficient from the MODTRAN and FASCODE atmospheric codes. Transmission spectrum and absorption coefficient plots were compared to find the range of suitable wavelengths that give good transmittance and low absorption coefficient values. The molecular absorption spectrum was chosen over the extinction spectrum because of known limitations of the Navy Aerosol Model results incorporated into the MODTRAN and FASCODE calculations. Results showed that several suitable windows could be found within the 0.95 to 2.5 μm region that offer at least 90% transmittance with absorption coefficient values of not more than 0.02 per km. For 99% transmittance, optimal wavelengths are between 1.03 and 1.06 μm, and around 1.241 and 1.624 μm. However, the disadvantage of operating near the 1 μm region is the high aerosol extinction. The Navy Aerosol Model used in the atmospheric codes needs to be validated or replaced and actual aerosol data collected in the geographical areas of interest before a more accurate assessment of the optimal wavelengths can be made.

KEYWORDS: Atmospheric Transmission Spectrum, Optimal Wavelengths for Transmission of High Energy Lasers, MODTRAN and FASCODE Atmospheric Codes, Absorption Coefficient, Thermal Blooming

INVESTIGATION OF OUTER LENGTH SCALE IN OPTICAL TURBULENCE

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Atmospheric turbulence degrades the electromagnetic propagation medium and affects many military applications. The strength and spatial distribution of turbulence are critical parameters that arise in theoretical modeling and experimental situations. This thesis investigated three outer scales of turbulence using experimental data from two instruments: microthermal probes carried by a balloon and an acoustic sounder. The outer length scale is the size of the largest energy-containing eddy in a turbulent region of the atmosphere. The length scales considered were the thermal length scale l_h associated with temperature fluctuations, the momentum length scale l_m, which represents the size of the velocity fluctuations and the boundary thermal convective cell size. The microthermal balloon data had excessive scatter when the thermal outer scale was expressed in terms of the gradient Richardson number. A reasonable functional relationship was not found and unrealistic outer scales l_h > 1000m and Ri_g > 100 prevailed. The primary reason was that inadequate sampling of the turbulent layers prevented the computation of valid statistical averages. The volume backscatter cross-section measured by an acoustic sounder provided better statistical averaging of the optical structure parameter C_n^2 than the microthermal balloon data. The separation of daytime convective thermal plumes was found from the acoustic sounder data by computing average C_n^2

values between 20 to 50 meters for each acoustic pulse and performing an autocorrelation of these averages over 600 seconds. Multiplying the autocorrelation time by the wind speed gave the separation between the convective thermal maxima and their minima. The mean correlation length for March 2002 at the Starfire Optical Range was 1590 ± 770 meters, between 1000 and 1600 local time. This length is proportional to the convective thermal cell size and to the boundary layer inversion height. A smaller length scale of 200 meters also appeared in the acoustic sounder data associated with the local height of the data and the hill above the ground.

KEYWORDS: Atmospheric Structure Parameter, Atmospheric Turbulence, Outer Length Scale, Richardson Number, Acoustic Sounder, Thermosonde, Optical Turbulence

DIGITAL ENHANCEMENT OF NIGHT VISION AND THERMAL IMAGES

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Low image contrast limits the amount of information conveyed to the user. With the proliferation of digital imagery and computer interface between man-and-machine, it is now viable to consider digitally enhancing the image before presenting it to the user, thus increasing the information throughput. This thesis explores the effect of the Contrast Limited Adaptive Histogram Equalization (CLAHE) process on night vision and thermal images. With better contrast, target detection and discrimination can be improved. The contrast enhancement by CLAHE is visually significant and details are easier to detect with the higher image contrast. Analyzing the image frequency response reveals increases in the higher spatial frequencies. As higher frequencies correspond to image edges, the power increase is viewed as corresponding to edge enhancement and hence, an increase in visible image details. This edge enhancement is perceived as improvement in image quality. This is further substantiated by a subjective testing, where a majority of human subjects agreed that CLAHE-enhanced images are more informative than the original night vision images.

KEYWORDS: Image Enhancement, Night Vision Images, Contrast Limited Adaptive Histogram Equalization, CLAHE, Contrast Enhancement, Image Quality Assessment

TESTING AND PERFORMANCE CHARACTERIZATION OF THE SPLIT-FIELD POLARIMETER IN THE 3-5MM WAVEBAND

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The infrared (IR) radiation emitted or reflected in an off-normal direction from a smooth surface is partially polarized. This principle can be used for enhanced discrimination of targets from backgrounds in a marine environment. It has been shown that (man-made) targets do not demonstrate a pronounced polarization effect when observed at near normal exitance, whereas the sea background radiation has a significant degree of polarization in slant observation directions.

The NPS split-field polarimeter was previously designed and constructed to provide simultaneous image pairs in a single frame, differing only in the direction of linear polarization. The system can operate in both long wavelength (8-12 μm) and the mid wavelength (3-5 μm) with interchangeable polarizing splitter plates.

In this thesis, tests were conducted to visually compare the polarizing effect on objects in the 3-5 μm waveband using the polarimeter and with the external polarizer. The image recorded in the laboratory with the horizontal and vertical polarizations depicts a contrast enhancement differing with varied aspects of the target. With the successful demonstration of the polarimeter operability, the performance of the thermal imager operated with and without the polarimeter was characterized by measuring its Minimum Resolvable Temperature Difference (MRTD) as a function of different spatial frequency. The measured performance was then compared against the same thermal imager using an external polarizer. The measured MRTD curve is used to model the system detection and recognition range using the Johnson criteria.

KEYWORDS: Thermal Imaging, Polarization, Infrared Radiation, Split-Field Polarimeter