Well Optimized Linear Finder (WOLF) Atmospheric Turbulence Compensation (ATC) computational speed improvement through the adoption of parallel, pre-calculated constant complex exponential phase difference chains.

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The Well-Optimized Linear Finder (WOLF) high-speed, phase-dominant, transfer function estimation method, developed by Professor William W. Arrasmith at Florida Institute of Technology, is a novel, high-speed, transfer function estimation method that, among other things, can be applied to atmospheric turbulence compensation (ATC)/blind deconvolution optical imaging problems. The WOLF methodology uses a diversity-based approach and an adapted error metric to quickly remove the effects of atmospheric turbulence and system noise effects that are present in an incoherent, optical imaging system. In our research, we improve the performance of the WOLF algorithm by investigating the impact of applying parallel processing technology to pre-calculate an expanding set of constant complex exponential phase difference sums that lie at the core of the WOLF methodology. Depending on the number of entrance pupil plane sample points in the image, these complex exponential phase differences can range from an initial single complex exponential phase difference term to sums of millions of complex exponential phase difference terms. We use order analysis on the WOLF algorithm to evaluate the theoretical implications of pre-calculating the constant exponential phase difference chain terms in parallel, and in advance, of when they are needed. We validate the theoretical predictions by using computer simulations to isolate the timing associated with the determination of the constant complex exponential phase difference terms and show that a conservative estimate of approximately 18 percent faster performance can be achieved by just implementing the pre-calculation of the sums of constant complex exponential phase difference terms themselves. A representative 256 x 256-pixel image was used in our analysis and computer simulation. The computer used in the study was an un-modified 2014 MacBook Pro computer with a 2.8 GHz (Quad-Core, Intel Core i7) with 16 GB of 1600 MHz DDR3 memory, and a NVIDIA GeForce GT 750M 2 GB video card running Matlab 2020b. Removing the atmospheric turbulence from the 256 x 256 image took approximately 8 seconds with the nonoptimized WOLF algorithm without taking advantage of parallel processing, or the precalculation of the constant complex exponential phase difference terms.

Keywords: Atmospheric Turbulence Compensation, Image Processing, Blind Deconvolution, Image restoration, High Spatial Resolution Imaging, Incoherent Imaging

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