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General method for direct transfer function estimation using parallel, non-redundant, complex exponential phase difference chains, with applications to high-speed, high-spatial resolution atmospheric turbulence compensated imaging systems

We present a general method for directly estimating 1-D (time-based) or 2-D (spatial domain-based) transfer functions from only irradiance measurements, applicable to linear, time and/or space invariant detection systems. A relevant example of a 2-D linear, space-invariant system is an atmospheric turbulence compensating imaging system. For well designed optical imaging systems, the turbulent atmosphere dominantly and strongly limits the imaging system's spatial resolution when the entrance pupil aperture is much larger than the atmospheric coherence length r0. In this case, the uncorrected optical imaging system in atmospheric turbulence falls far short of achieving its potential classical diffraction-limited spatial resolution. Atmospheric turbulence compensation (ATC) methods can provide a D/ro improvement in spatial resolution where D is the diameter of the entrance pupil of the imaging systems and ro is the atmospheric coherence length (a.k.a Fried parameter). In this paper, we briefly describe the nature and effects of atmospheric turbulence on passive, incoherent optical imagery (e.g. imaging systems that use natural illumination sources such as sunlight or moonlight), describe the theoretical basis and mathematical underpinnings used to simulate the effects of atmospheric turbulence, describe the model for our direct optical transfer function (OTF) estimation method, and show how our new OTF estimation method applies to representative atmospheric turbulence compensation paradigms. Our OTF estimation method is shown to have increased computational speed, reduced computational and physical complexity, eliminates inherent computational redundancies, potentially provides higher accuracy in estimating the OTF, and has built-in constraints for faster solution convergence over contemporary methods.

Biography

William W Arrasmith completed his Engineering in Physics from the Air Force Institute of Technology in Dayton, Ohio in 1995. Currently, he is the Professor of Engineering Systems at the Florida Institute of Technology (FIT) in Melbourne, Florida. Prior to FIT, he served in the United States Air Force over 20 years, working on various engineering, science, and technology programs, and retiring as Lieutenant Colonel in 2003. He has authored the book, *"Systems Engineering and Analysis of Electro-Optical and Infrared Systems"*, CRC Press (2015), developed six patents, and has over 30 journal/conference papers.

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