3-D Laser Radar Using Arrays of Geiger-Mode Avalanche Photodiodes

R.M. Heinrichs
M.I.T. Lincoln Laboratory
244 Wood St. Lexington, MA 02420
heinrichs@LL.mit.edu

Abstract

Three-dimensional (3-D) laser radar is a class of laser-radar-imaging systems that generate angle-angle-range images where two dimensions come from the angular resolution of the imager and the third dimension results from performing a time-of-flight range measurement for each pixel. These systems have until recently consisted of a short pulse laser, a single-element detector, and a two-axis scanning system. 3-D images were generated by raster scanning the transmit laser and detector fields of view to each pixel individually in the image and performing a separate time-of-flight range measurement.

Lincoln Laboratory has been developing technologies for improved 3-D laser radars. These include miniature short-pulse lasers and highly sensitive detector arrays. These arrays are a sandwich of an array of Geiger-mode avalanche photodiodes and a commensurate array of CMOS timing circuitry. The advantages of this approach include single-photon sensitivity, high bandwidth, and scalability to large arrays sizes. Lincoln Laboratory has also incorporated these technologies into laser radar systems that have demonstrated their capability.

This presentation will include an overview of the laser and detector array technologies along with a discussion of the implications of making measurements in the photon-counting, or statistical regime. Following this, a discussion of the development and performance of two example laser-radar systems will be presented.

Dr. Richard M. Heinrichs is leader of the Laser and Sensor Applications Group at M.I.T. Lincoln Laboratory. His most recent areas of interest include 3-D imaging using advanced focal planes and coherent laser radars for tactical measurements. His group is continuing the development of 3-D laser radars and high-resolution coherent laser radars, as well as the integration of advanced radar techniques to the optical regime. Dr. Heinrichs joined Lincoln Laboratory in 1986. His efforts have included nonlinear optics for atmospheric turbulence correction of propagating laser beams. His interests then shifted to laser remote sensing, where he has been involved in efforts to measure backscatter from the atmospheric sodium layer and to develop coherent laser radars for the detection and tracking of aircraft-generated wake-vortex turbulence. Prior to that, he performed post-doctoral work at the University of California, Santa Barbara, in the area of nonlinear fluid dynamics. He was the chairman of the International Coherent Laser Radar Conference in 2003. Dr. Heinrichs holds B.S. degrees in physics and electrical engineering and an M.S. degree in electrical engineering from the Massachusetts Institute of Technology and a Ph.D. degree in physics from the University of Massachusetts.