SIMULATION OF AN INTEGRATED LADAR SYSTEM

INTRODUCTION

Lidar (Light Detection and Ranging) is a method for determining distance to an object using a laser beam. This distance is defined as the time it takes for a laser pulse to hit an object, reflect and then return to a sensor with the speed of light. Though the theory is similar to radar, using high intensity lasers instead of radio waves can produce higher resolution images.

LadarSIM is a Matlab and Simulink based LADAR system simulator designed and developed by the Center for Advanced Imaging LADAR (CAIL) at Utah State University. It is a tool for general system analysis, error modeling, and specifically assists in the design and development of new LADAR systems.

USU LadarSIM was originally funded by the Naval Air Warfare Center Weapons Division in China Lake, CA. to develop a computer simulation of their LADAR systems. This facilitated data gathering and analysis along with algorithm development. It also became a valuable design tool in predicting the behavior of new LADAR systems being investigated.

Over the years, LadarSIM became more capable and generalized in its function. Due to the most recent improvements in the areas of generic scanning, moving targets and waveform processing LadarSIM can now model a variety LADAR systems of use in a variety of applications.

RECENT IMPROVEMENTS

LadarSIM contains a LADAR scanner model with up to three scan elements allocated with either a steering, stabilization and/or pattern-scanning role. Algorithms automatically generate commands to the scan elements given beam-steering objectives, and the need to compensate for the base motion of the sensor platform.

The kinematic model of the mechanisms driving the separate scan elements predicts LADAR scanning performance. Given various dynamic characteristics of the these mechanisms, there exists some flexibility in the partitioning of the steering and stabilization commands. A new partitioning method is implemented that allows for an optimal partition based on the bandwidth capabilities of each mechanism. This approach replaces the alternative of arbitrarily dividing the steering and stabilization, operations between separate scan elements.

MOBILITY OF TARGETS AND SENSOR PLATFORM

Target and sensor platform motion can be simulated. The moving objects may be forced to follow the local terrain and rotate to be tangent to it. Additionally, an extra elevation offset above the ground may be applied in this mode. Motion due to turbulence may be also be added to moving objects, and high-frequency, low-amplitude jitter may be added to the sensor platform.

WAVEFORM PROCESSING

Modeling Return Signals

By over-sampling inside the area of a ladar beam footprint, an approximate return signal can be constructed by scanning all of the caustic return pulses. This give insight into phenomena that occur in and around edges.

Detection Methods

- Leading Edge: A detection is declared for the point at which the signal exceeds a set voltage threshold.
- Constant Fraction: A detection is declared for the point at which a delayed version of the pulse intersects with a fractional version of itself.
- Crossover (Derivative): A detection is declared for the point at which the derivative of the pulse and its negative crossover.
- Walk Error: Due to varying intensities of return signal waveforms, a phenomena called walk error can be seen using the leading edge method. As seen in the figure different range values are determined from different signal amplitudes.
- Multiple Returns: With waveform processing implemented into the simulation, LadarSIM can model and plot multiple return pulses. This is a common occurrence in actual LADAR systems and is valuable in studying objects beneath trees or shrubbery.

BRDF: A Bidirectional Reflectance Distribution Function has been implemented to more accurately model the amount of energy reflected by various materials at different incident angles.
The goal of the VISSTA program is to provide the U.S. Navy with the ability to simultaneously collect data from a variety of co-boresighted sensors mounted on a moving platform. Sensors include a millimeter wave radar, an in-house developed ladar with an integrated EO (color) camera, and a mid-wave infrared camera.

The VISSTA facility will explore multi-sensor performance in various scene conditions (vegetation, obscurants, rugged terrain, etc.), atmospheric conditions (fog, haze, etc.), and fields-of-view. It will also allow each sensor’s strengths and weaknesses in the detection, recognition and identification roles to be explored.

This project is a joint effort of Utah State University’s Center for Advanced Imaging Ladar and Space Dynamics Laboratory and the Naval Air Warfare Center, China Lake, California.