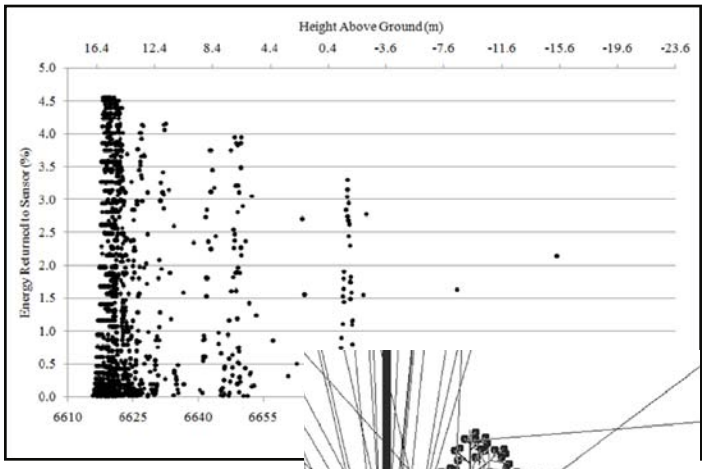
RSC
Remote Sensing Center
at the **Naval Postgraduate School**

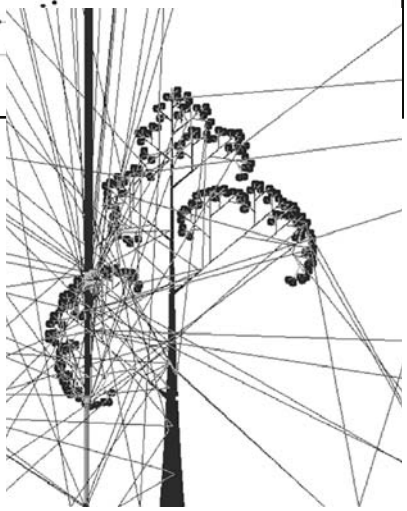
Foliage Penetration

Modeling Laser Propagation Through Canopy and Foliage

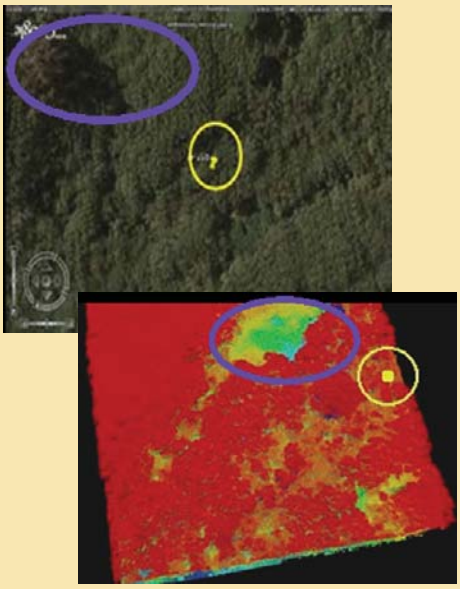
LiDAR (Light Detection And Ranging) is used to remotely measure the three-dimensional shapes and arrangements of objects with high efficiency and accuracy by making precise measurements of time-of-flight of pulses of light. Discrete return LiDAR systems provide a discrete series of elevation points corresponding to reflections from objects in the scene.



Full-waveform LiDAR systems measure the intensity of light returned to the sensor continuously over a period of time. Relatively little research has been done on full-waveform LiDAR signals. This thesis presents a Monte Carlo model of laser propagation through a tree which allows simulation of full-waveform LiDAR signatures. The model incorporates a LiDAR system and a 'natural' scene, including an atmosphere, tree and ground surface. Test cases are presented which enlighten various aspects of the model, and give insight into full-waveform LiDAR data collection and analysis. Changes in the scene such as varying ground reflectance, sloped versus flat ground, and comparisons of 'leaf-on' and 'leaf-off' conditions are analyzed. Changes in the LiDAR system are also studied, such as changing laser wavelength, shape and length of transmitted pulses, sensing geometry, etc. Results of the simulations and analysis of the effects of physical changes in the scene and sensor are presented.



Graph: Simulated LiDAR waveform for a sensor located 1000 m above ground level.
Illustration: Interaction of first pulse of LiDAR energy with a tree. The tree is 15 m tall.



Detection of Hidden Trails Under Canopies Utilizing LiDAR

LiDAR data collected from four geographic regions are studied to determine the feasibility of reliably identifying roads and trails hidden under dense jungle and forest canopies. The four analyzed regions include the Elkhorn Slough in Central California (2005), Kahuku Training Area on the North side of Oahu Island in Hawaii (2005), La Selva Biological Station near Puerto Viejo de Sarapiqui, Costa Rica (1997), and Cougar Mountain Park in Bellevue, Washington (2001). Using the commercial product, Quick Terrain Modeler, 3-D interactive analysis was done to identify roads and trails hidden under canopy. Results are compared to overhead panchromatic imagery and verified by significant ground truth. Trails with widths of 2.5 meters and narrower were found with overall accuracies up to 85%.

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