Active Imaging Simulation for Virtual Prototyping Using DIRSIG

What is Virtual Prototyping?

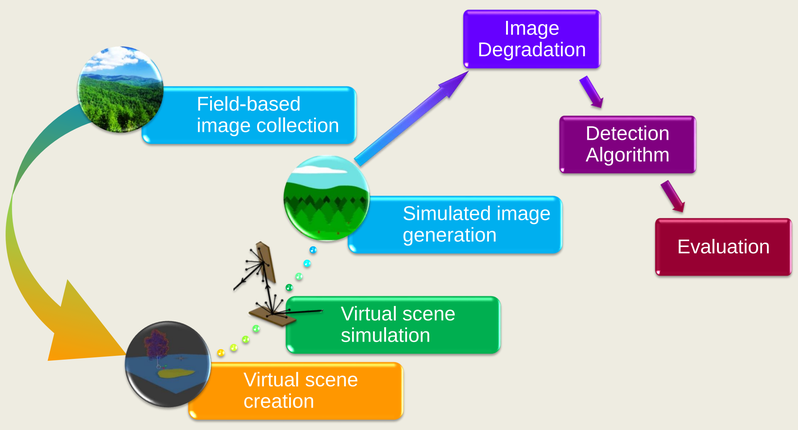
At the Night Vision and Electronic Research Directorate (NVESD), US Army develops night vision and other sensor capabilities to improve situational awareness and to provide combat capability overmatch for US and ally soldiers.

Detection, Recognition, and Identification (DRI) tests with active-duty soldiers have traditionally been the final test on operational performance for new equipment and instrument systems, as well as benchmarking tools during product and system development.

While these tests provide concrete evidence for whether a system meets performance requirements, they also have a number of drawbacks. These shortcomings include limited adaptability, constrained target and site availability, dependence on weather conditions, lack of repeatability, and large expense, among others.

There is currently no proven alternative to the live testing, but virtual prototyping could provide that capability. DRI performance can be modeled with improved software capabilities, leveraging the Night Vision Integrated Performance Model (NV-IPM), the Night Vision Image Generator (NV-IG), and the Digital Imaging and Remote Sensing Image Generator (DIRSIG). Simulated DRIs could reduce the risk involved in live DRI testing, providing high adaptability with high fidelity models for a variety of conditions, targets, backgrounds, etc. Virtual prototyping can also take advantage of simulated randomness, which is currently lacking in live DRI testing.

Development of existing physics-based models for virtual prototyping will result in high-fidelity simulations that can be evaluated against live DRI performance, and could eventually become a reasonable replacement for live DRI testing in some circumstances.

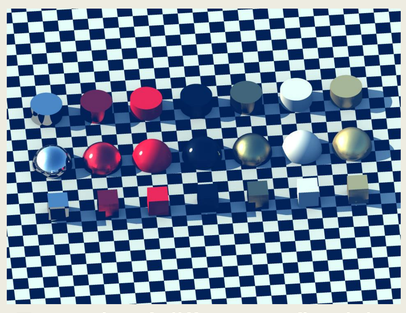


What is DIRSIG?

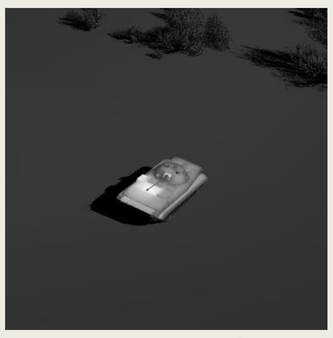
The Digital Imaging and Remote Sensing Image Generation (DIRSIG) model is a first principles based synthetic image generation model developed by the Digital Imaging and Remote Sensing Laboratory at Rochester Institute of Technology.

- passive single-band, multi-spectral or hyper-spectral imagery from visible through the thermal infrared wavelengths
- mature active laser (LIDAR) capability
- evolving active RF (RADAR) capability

DIRSIG has been developed over the course of over two decades through a combination of internal, commercial and government funding.



Example of different reflectivity settings available in DIRSIG, including spectral, diffuse, and custom BRDF modeling



DIRSIG-generated LWIR image of a tank on sand (MuSES model imported)

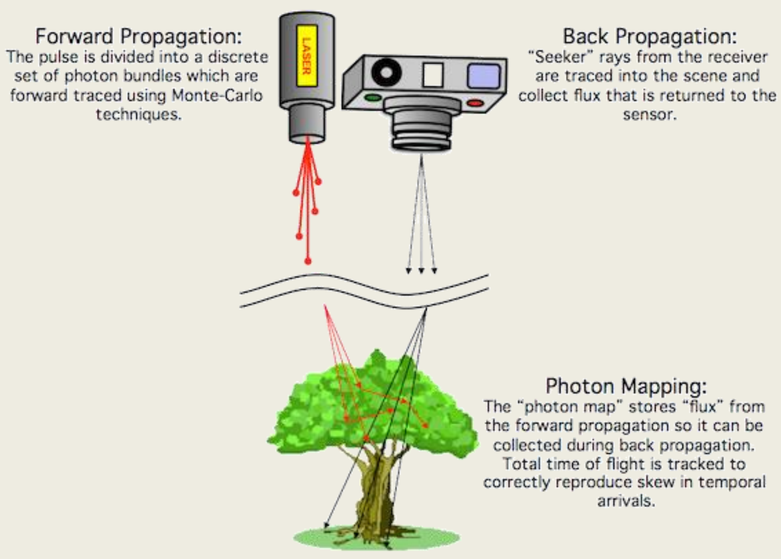
UAS flying over trees in a forest scene, simulated in DIRSIG at NVESD

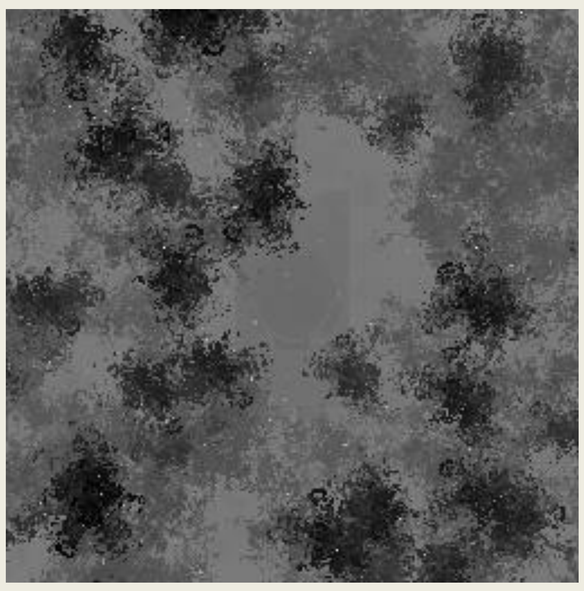
DIRSIG-generated scene of a tank at a virtual rural scene, simulated at NVESD

http://www.dirsig.org/
http://www.dirsig.org/get/

How Does Active Imaging in DIRSIG Work?

1. DIRSIG simulates the laser propagation to and from the target, taking into account back-scattering due to atmospheric conditions.
2. Photons may bounce more than once before being collected by the camera. To incorporate multiple bounce (scattering) contributions, DIRSIG employs a modified "photon mapping" approach that tracks total travel time.
3. Photon arrival time and number of photons are tracked in the simulation, and can be evaluated in a number of ways to simulate various active imaging modes and systems.





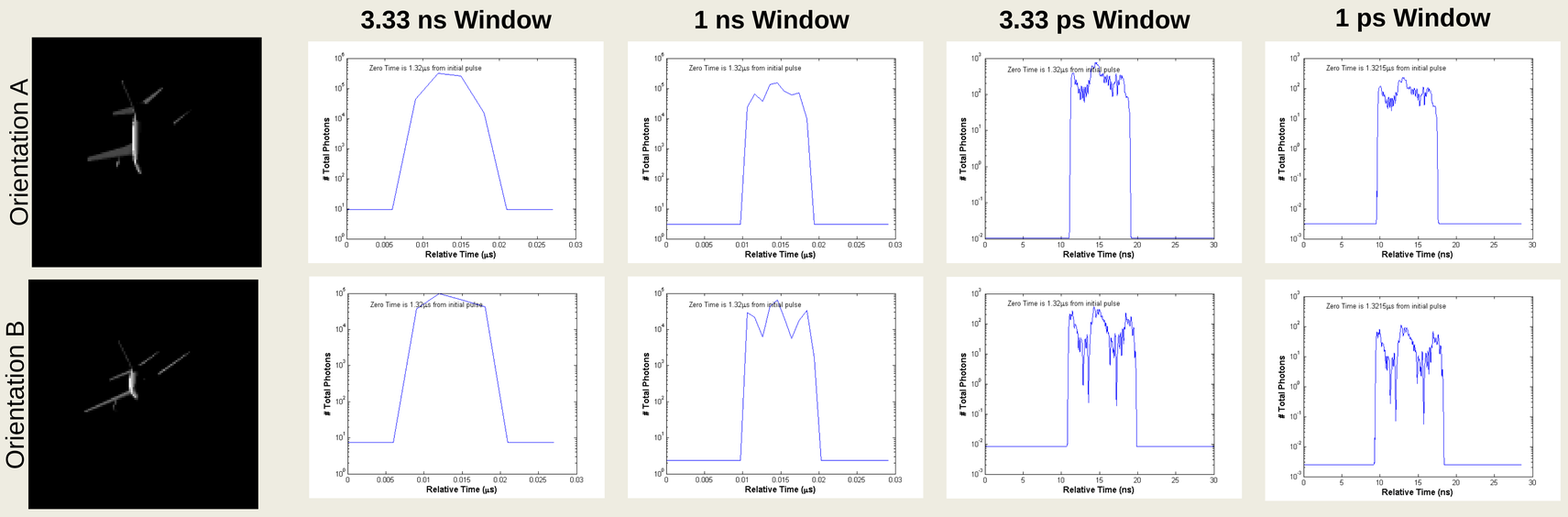
Example of range data simulated in DIRSIG: tank (center) via foliage penetration

Active Imaging Simulations at NVESD

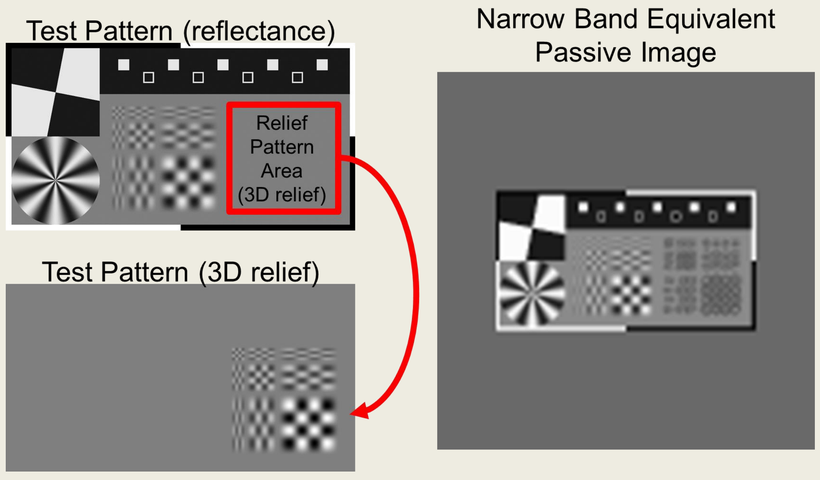
1D Waveform Measurement
Single-element Photodiode

The target shown to the right, a 0.05x scaled 737 airplane (to approximatee a UAS) was placed in a virtual scene at a range of 200m from the camera.

The plots to the right show the temporally sampled waveform recorded by the photodiode for the corresponding gating window (shown above the plots). As the gating window decreases in duration, the resolution of the waveform increases.



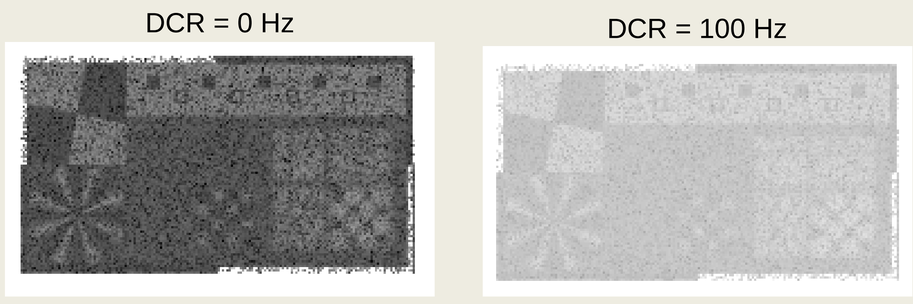
3D Virtual Test Target



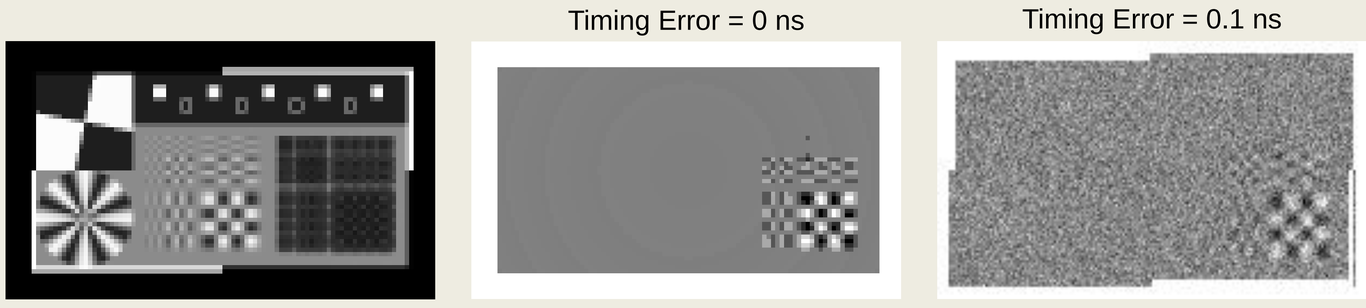
The virtual target (upper left) was used to simulate 2D and 3D active imaging systems (see sections to the right). The portion of the target outlined in red has a 3D relief pattern (shown bottom left).

A narrow-band (laser wavelength) image is shown on the right. It shows the intensity pattern as well as the reflection losses from the 3D relief pattern.

2D Range Measurement
Geiger Mode Avalanche Photodiodes



3D Range and Intensity Measurement
Linear Mode Avalanche Photodiodes



Intensity Image

Range Images