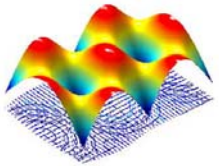


NEAR-Lab
Northwest Electromagnetics & Acoustics Research

Electromagnetic Modeling For Advanced Radar Processing

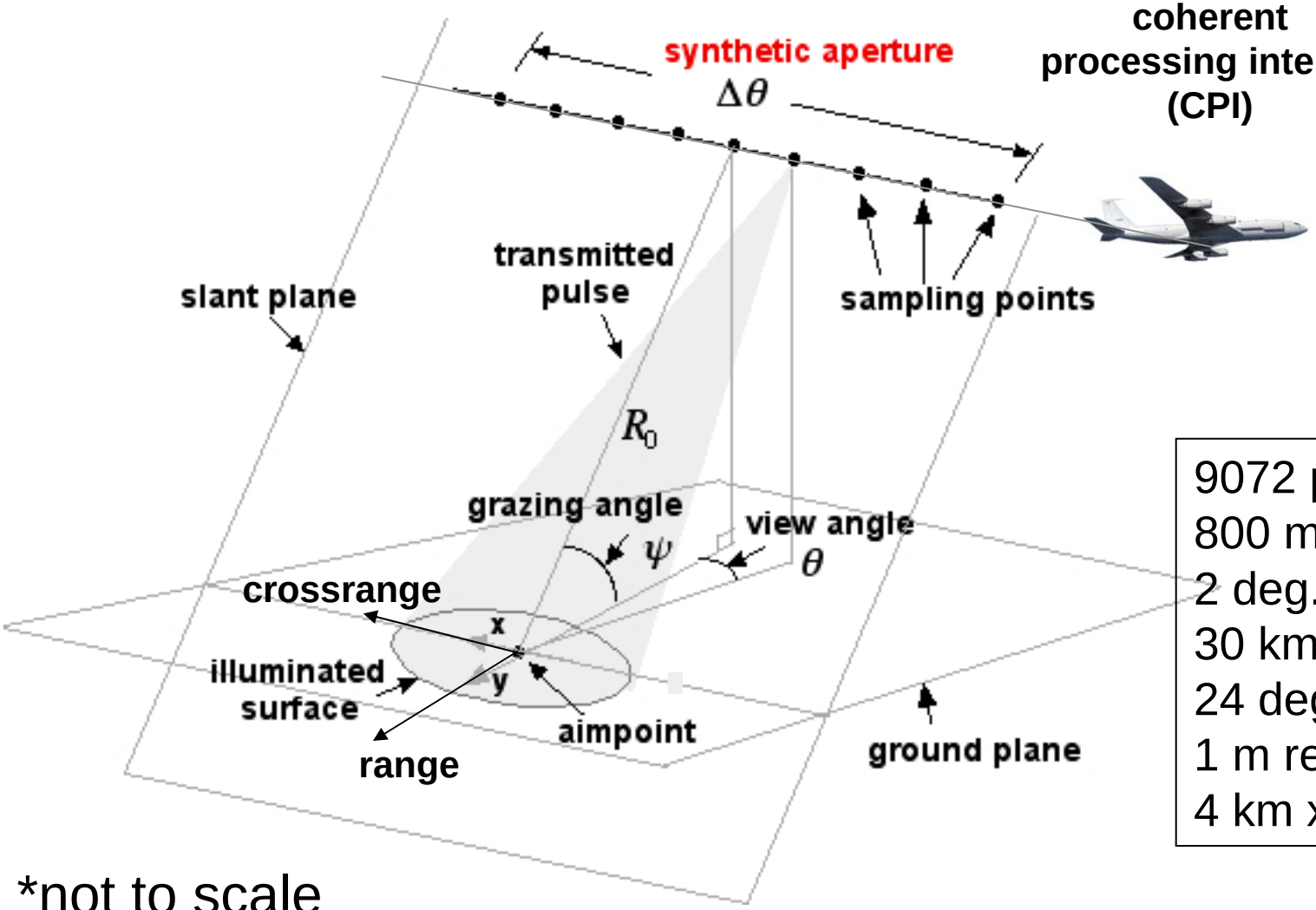
Historically, processing for airborne radar has been based on a simple electromagnetic scattering model: uncorrelated discrete scatterers randomly distributed on a spherical earth surface. While this model has been adequate to drive the development of basic Synthetic Aperture Radar (SAR) image formation algorithms and Moving Target Indication (MTI) algorithms, it does not fully exploit the highly structured scattering signatures of terrain features and constructed objects such as buildings, roads, vehicles, etc.

In this work we identify, develop, and extend appropriately sophisticated electromagnetic models to capture the frequency- and angle-dependent backscatter from terrain and embedded objects. These models are then applied to geometries corresponding to the advanced SAR sensor developed by MIT Lincoln Laboratory, the Lincoln Multi-mission ISR Testbed (LiMIT). LiMIT is an airborne, multi-channel, wideband phased array sensor designed to emulate the current and future capabilities of the Space-based Radar Constellation. Finally, intuition gained from the models and processing of collected data is utilized to develop and evaluate advanced signal processing algorithms.

For her Ph.D. thesis, Shari Matzner is developing a scattering model for a typical building that can be used as a matched filter for SAR signal processing in order to extract information about buildings present in the imaged scene.

This work is a three year effort (2005-2008) in collaboration with MIT Lincoln Laboratory.

SAR Spotlight Mode



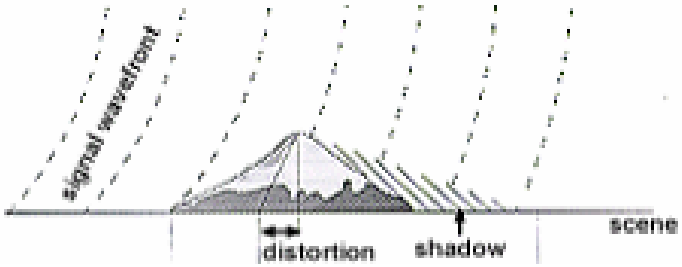
LiMIT

9072 pulses
800 m aperture
2 deg. $\Delta\theta$
30 km standoff range
24 deg. grazing angle
1 m resolution
4 km x 2 km area

*not to scale

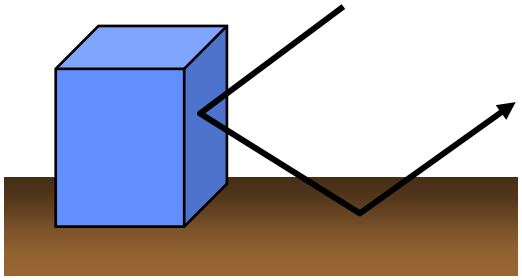
Scattering Phenomenon and Effect on Conventional SAR Imagery

- **Range Dimension:**



Objects above earth surface:

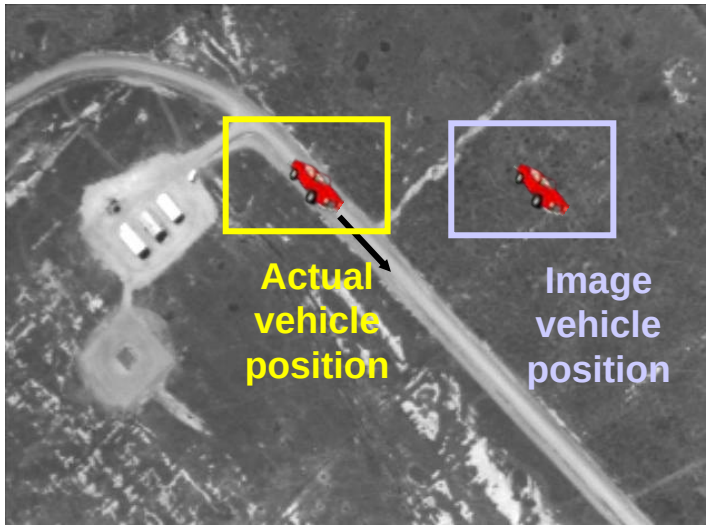
Object height shortens time delay, and observed return is erroneously displaced (forward) in range



Multiple scattering:

Return from multiple scattering (building reflection, multipath, volume scattering) erroneosly displaced (backward) in range

- **Cross-range dimension:**



Scene motion:

Motion during synthesis (vehicles, boats, trains, propellers, etc.) changes apparent doppler and return is erroneously displaced in cross-range (proportional to radial velocity)

Goal: Understand and exploit scattering phenomenon

LiMIT SAR End-to-End Processing Chain

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LiMIT

Receiver Signal → Down modulation → Sampling → Recording

NEAR-Lab Simulated LiMIT Data

part. Sig. read → DC eval. on first pulse → DC removal → Windowing → FFT

for each pulse

Match filter Equalization → Phase correction → Beam forming → LP filtering → Decimation

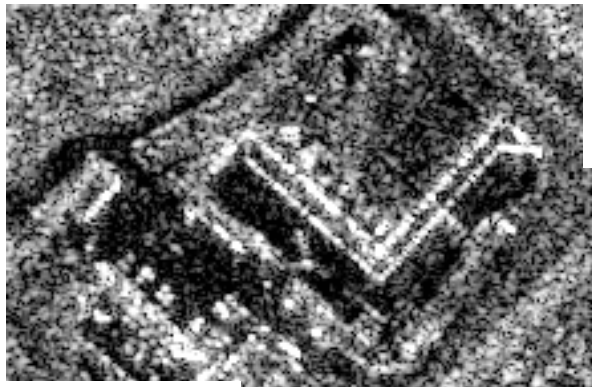
NEAR-LAB processing

Re-sampling → Windowing → 2D inv. FFT → Image (abs) averaging

Process actual or simulated data

Portland State UNIVERSITY

Model-based SAR Signal Simulation



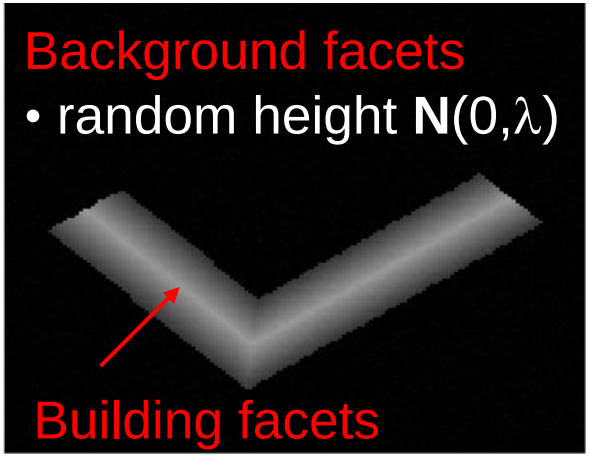
LiMIT SAR Image of L-shaped building on San Clemente Island, CA.

Model

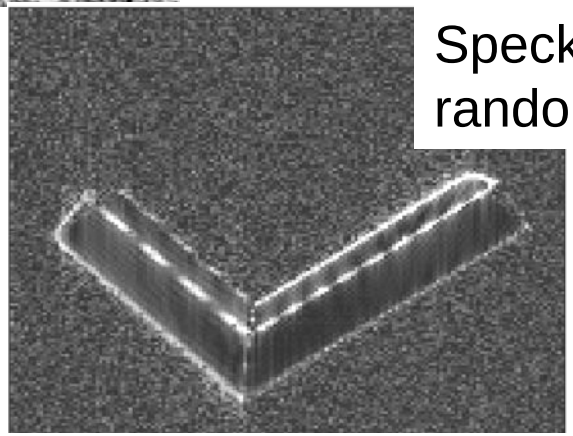
Compare

Reproduces bright lines.

Input to simulation is synthetic scene composed of square, flat facets.



Simulate



Speckle due to random height.

- 3x reflectivity of background
- height function for peaked roof

Image is 2D inverse Fourier Transform of simulated phase history.