Feature Extraction Algorithm for 3D Non-Linear Sparse Apertures

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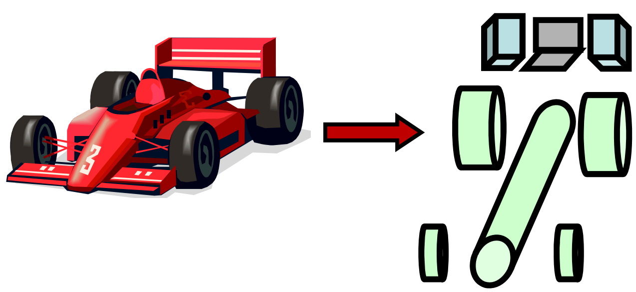
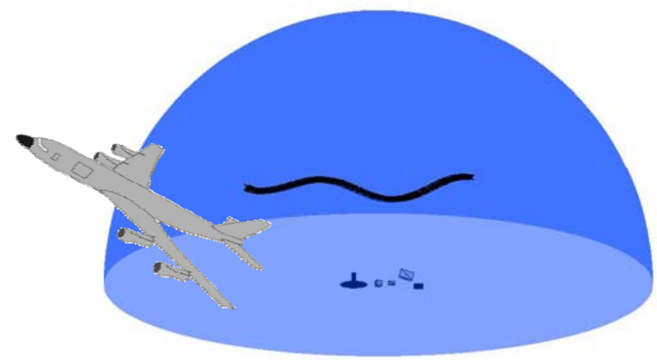
Research Goal

- Develop a Feature Extraction Algorithm for application in **ATR** and 3D scene visualization using monostatic SAR data from non-linear, sparse apertures



Complex objects modeled by canonical "feature" objects



Non-linear, sparse data sampling of 3D aperture

Observed data → Detect → Estimate → Reconstruct → Scene Visualization

Parametric Scattering Models

$$S = \sum_m \begin{bmatrix} A_{vv} & A_{vh} \\ A_{hv} & A_{hh} \end{bmatrix} S_{T(m)}(f, \theta, \phi; \Theta_m) \exp\left(\frac{-j2\pi f}{c}\Delta R_m\right) = \begin{bmatrix} S_{vv} & S_{vh} \\ S_{hv} & S_{hh} \end{bmatrix}$$

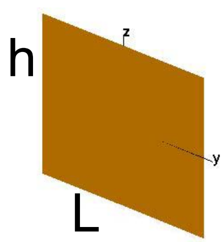
Complex, Polarization Amplitudes

Scatterer Frequency and Aspect Dependence

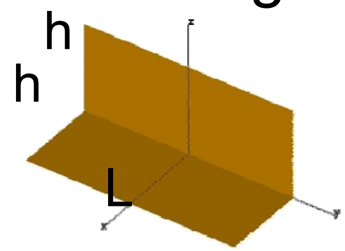
Linear Phase term

$S_{T(m)}$ depends on type of scattering center. We consider:

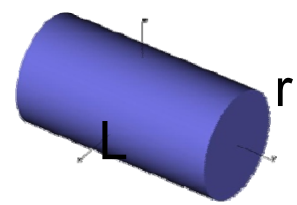
Plate



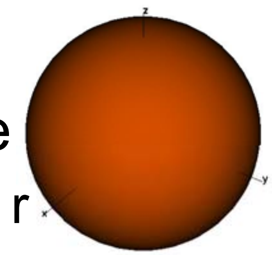
Dihedral



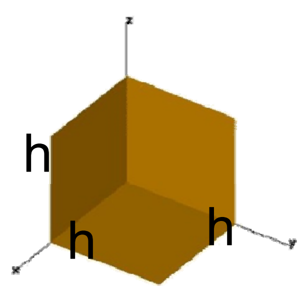
Cylinder



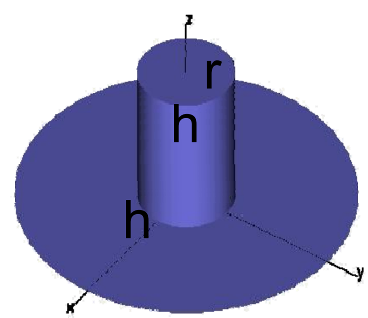
Sphere



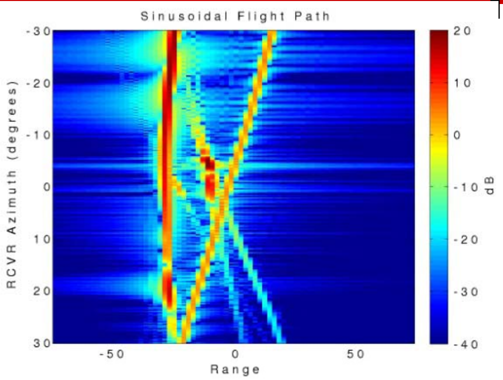
Trihedral



Top-hat



Current Work
Non-linear Sparse Aperture Processing



Fully-Polarimetric,
Complex Range Profiles

Input Data

Order Selection → **Shape Classifier** ⇄ **Parameter Estimator**

Chip out a group of scattering centers

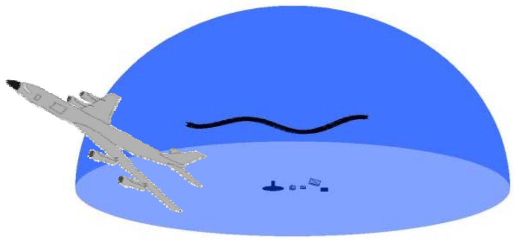
Iterative detection and joint estimation scheme

Output: Scene Geometry

Scattering center shape,
3D location (X_m,Y_m,Z_m),
3D size, orientation, and RCS.

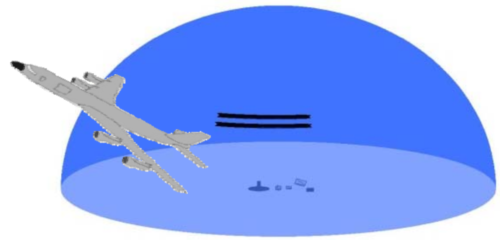
Trade-offs in Feature Extraction vs. Aperture Type

Non-linear Sparse Aperture



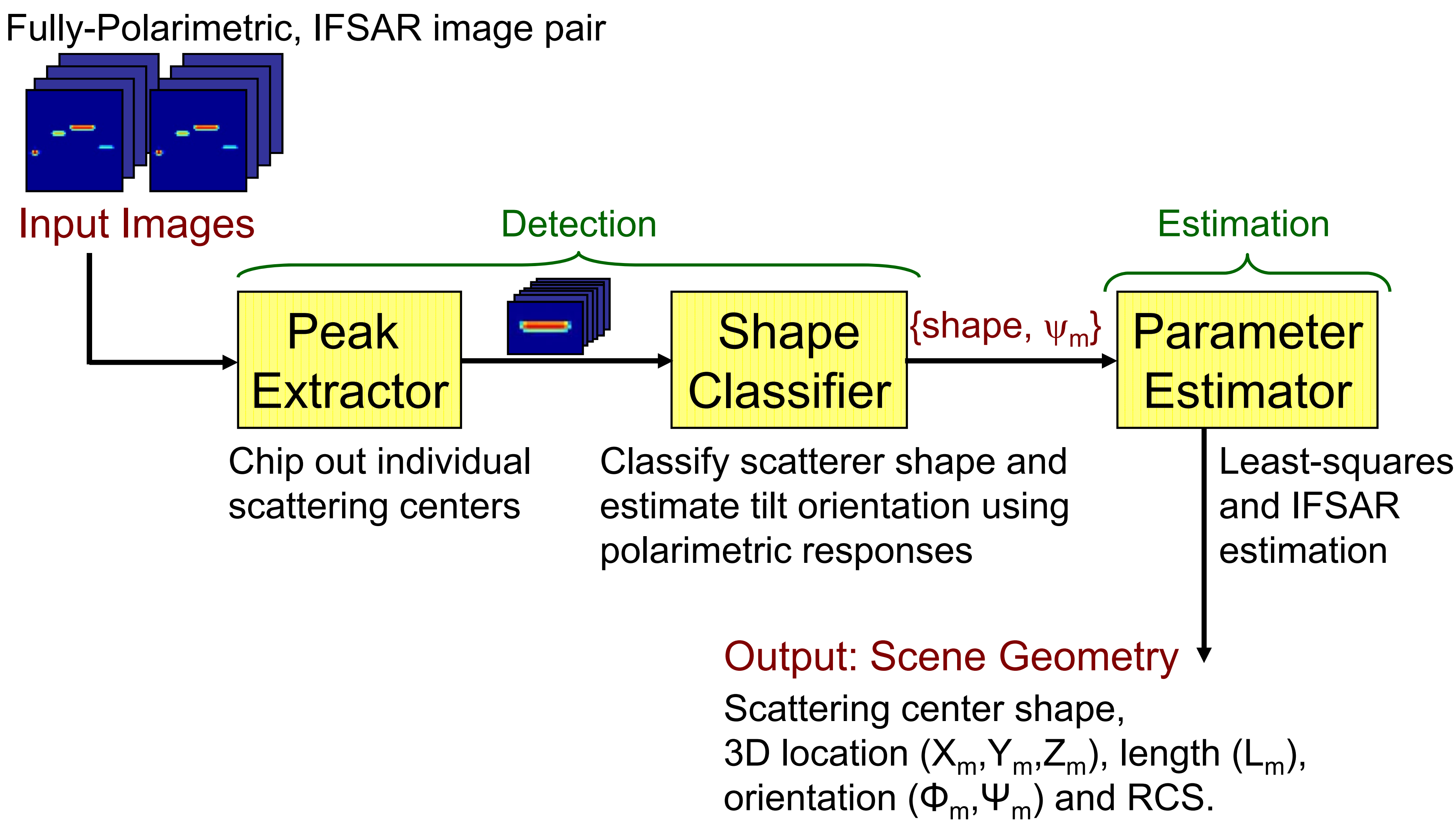
- \+ Manageable 3D data set
- – No image-based feature segmentation due to large sidelobe interference
- – Order selection and joint estimation required
- \+ Angular diversity allows for 3D parameter estimation

IFSAR Aperture



- \+ Manageable 3D data set
- \+ Image-based feature segmentation due to energy compactness
- \+ Estimate each feature separately
- – Not all 3D parameters are identifiable

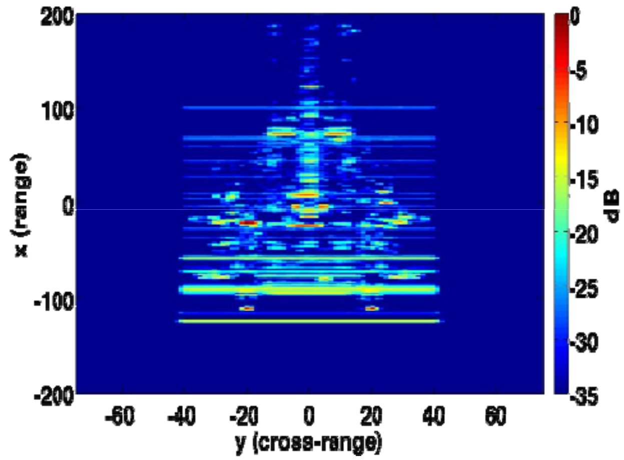
Previous Work
IFSAR Image-based Processing



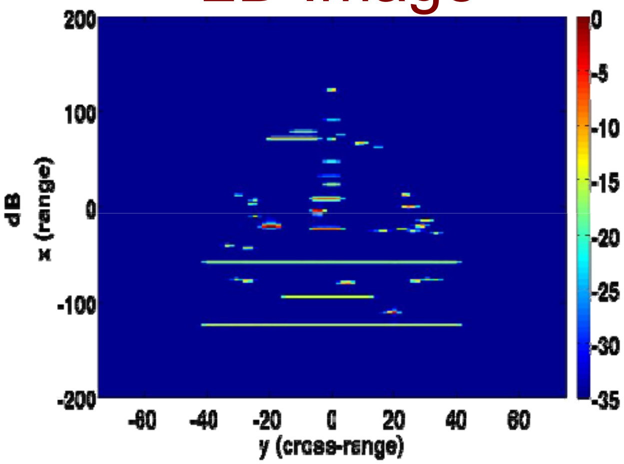
Backhoe Results
IFSAR Processing

- Complex Target
- 2 Radar Apertures
  - XpatchT
  - 30°, 30.05° elevations
  - 0° center azimuth
  - X-Band: f_c = 10.16GHz B = 3.96GHz
  - Kaiser window: effective resolution 1.79”

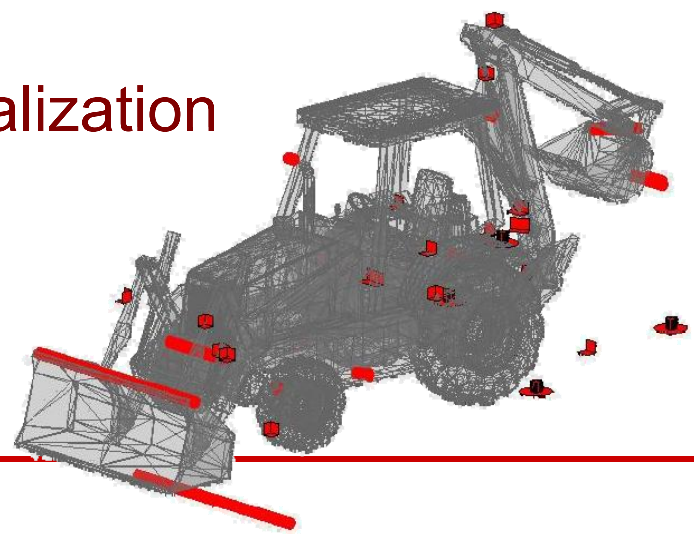
Xpatch 2D Image



Reconstructed 2D Image



3D Visualization



*See **www.ece.osu.edu/~jacksoj** for related papers*