

# Scene Construction Methodologies and Techniques for Simulating Forest Areas

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# Synthetic Image Data: Application Areas

- **Sensor Prototyping**
  - **Construct and test a new sensor in a virtual environment**
  - **Evaluate design trades**
  - **Produce example products for customers**
- **Algorithm Testing**
  - **Decrease the amount of expensive field collections**
  - **Control all the image formation variables**
  - **Per-pixel truth allows for better evaluation of the algorithm**
- **Analyst Training**
  - **Create custom training examples**
  - **Test the sensitivity of the analyst to specific phenomenology**
  - **Provide a tool to hypothesis about the nature of phenomenology**

# Background

- **Intelligence mission requirements**
  - **Need wide-area coverage**
    - » Search algorithms and algorithm developers need to be challenged with large scenes featuring a low target count.
  - **True 3D models**
    - » Need accurate interactions between targets and the forest canopy.
    - » Need accurate interactions within the forest canopy.
    - » Low resolution tree models and texture techniques are not satisfactory.

# Background

- **Non-military mission requirements**

- **Forest studies**

- » Attempt to accurately reproduce species and condition specific spectroscopy.
    - » Provide a closed-loop environment to evaluate the performance of algorithms to map species and health.

- **Forest fire detection**

- » Attempt to accurately represent the geometry of the canopy and underbrush for potential forest fire modeling.
    - » Evaluate fire detection algorithms.

# Overview

- **Develop an process to streamline the construction and rendering of large area forested scenes.**
  - **Develop a feature extraction tool to automate the construction of forested areas.**
  - **Add smarter data management techniques to the DIRSIG ray-tracer to minimize the resources required for rendering scenes with potentially billions of facets.**

# Scene Construction: Feature Extraction

- Preliminary assumptions
  - Availability of high resolution air photo for most scene construction tasks.
  - Color, Color/NIR air photo and other available imagery offer the potential for simple image processing to extract forested regions or (at least) enhance tree/background contrast.
  - Trees crowns can be easily located using radially symmetric correlation methods.
    - » Good for coniferous species
    - » Potential problems for deciduous species

# Feature Extraction: Simplified Flow

- General approach
  - Use “circle” functions at various scales to isolate features with high radial symmetry.



**Input Image**



**Tree Extraction  
Algorithm**



**Extracted Features**

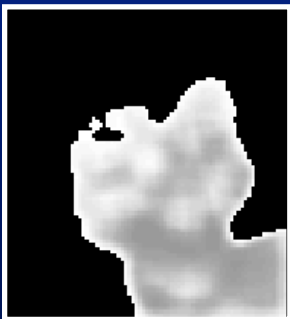
# Feature Extraction: Preliminary Processing



- Original air photo
  - Ideally Color/NIR film
    - » Green, red and NIR channels

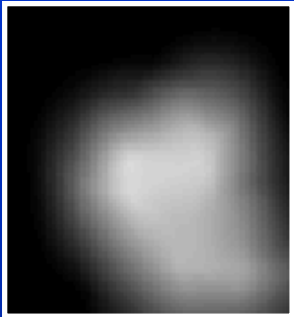


- Blurred image
  - Tree features assumed to be lower frequency.



- NIR/Red Ratio
  - Isolates trees with an adjustable “bio-mass” threshold.

# Feature Extraction: Feature Isolation

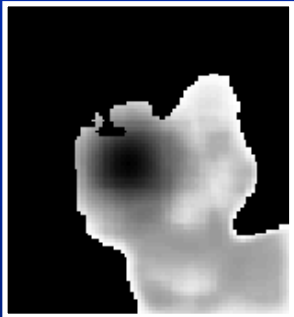


Correlate with largest filter

Rank pixel correlations to find highest probable locations.

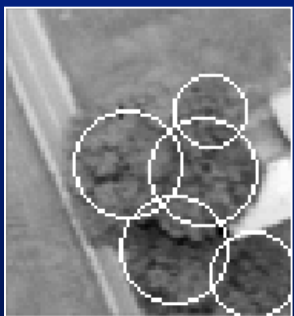
Remove isolated feature

Features above threshold are removed from image.



Smaller and smaller filters are applied

Locations and sizes are recorded.



# Feature Extraction: Control Parameters

- **NDVI Threshold**
  - **Separate “trees” from scrub vegetation or grass**
- **Size range**
  - **Size range of correlation filters used.**
- **Tree spacing threshold**
  - **Minimum distance between extracted features.**
- **Correlation threshold**
  - **Minimum correlation value to be classified as a feature.**

# Feature Extraction: Control Parameters

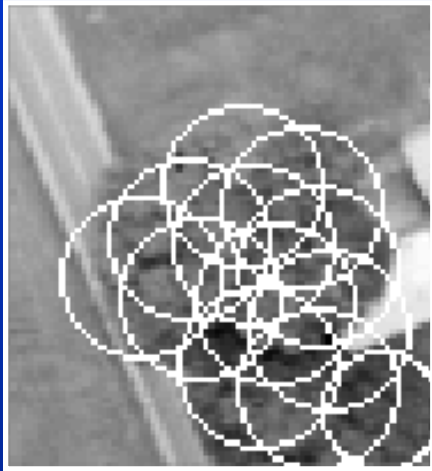


- **Smaller range of filter sizes**
  - **Identified smaller “branch” structures.**



- **Larger range of filter sizes**
  - **Identified larger “tree” structures.**

# Feature Extraction: Control Parameters



- **Smaller tree distance**
  - Isolates features closer together
- **Higher correlation threshold**
  - Removed lower probability features.



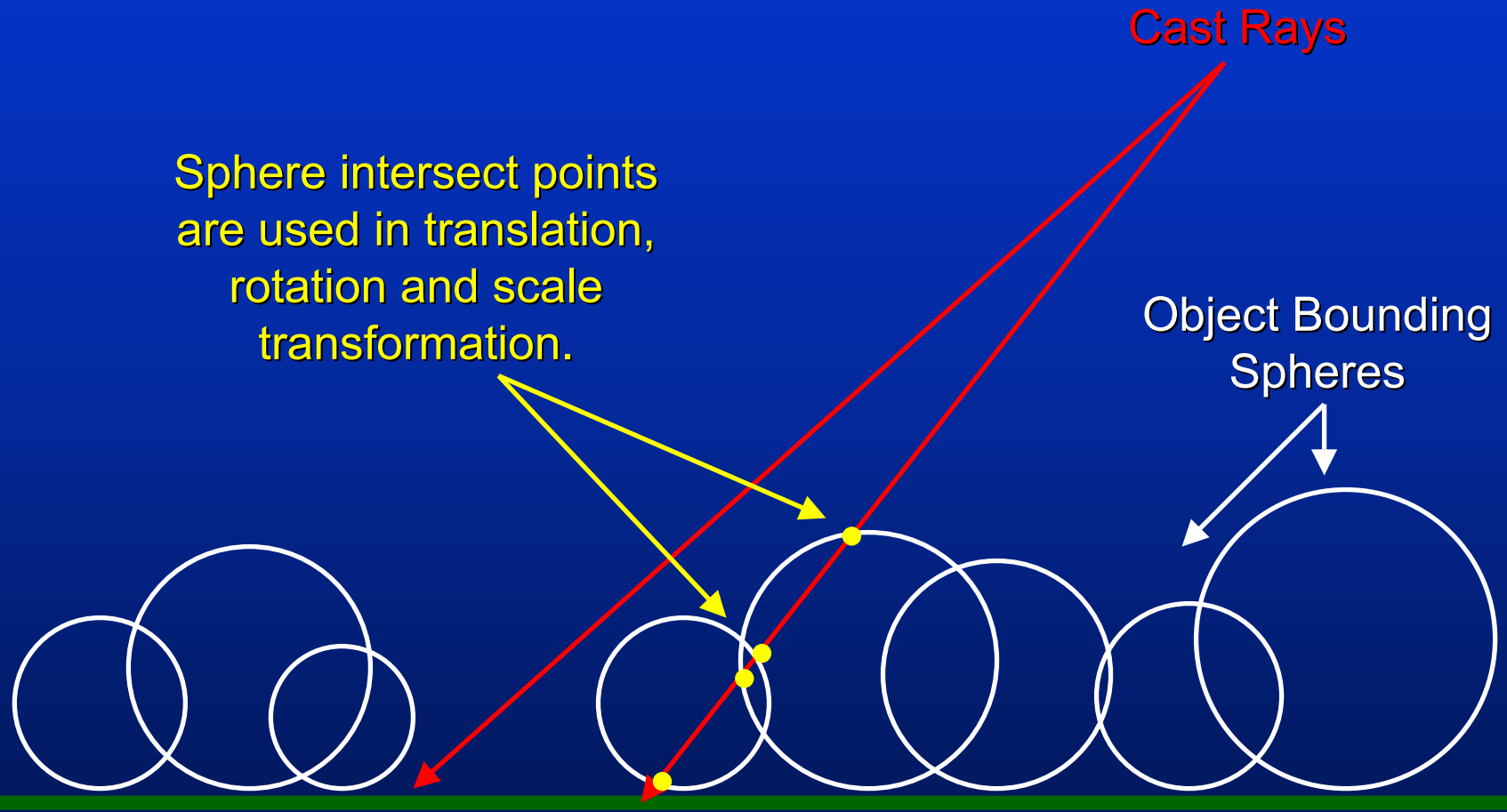
# Rendering Improvements: Justification

- **Common scene expectations**
  - **10 km X 10 km**
  - **Millions of trees and thousands of facets per tree.**
    - » Potentially billions of facets at render time places a huge burden on computing resources.
- **Utilize a smaller set of physical models and virtual “instances”**
  - **Each instance can have a unique location, 3D rotation and 3D scale.**

# Rendering Improvements: Implementation

- Load single instance of each object into memory.
  - Each object has an optimized octree for fast ray tracing.
- Place spherical bounding volumes at each virtual instance in the scene.
  - Spherical volumes simplify rotation and scaling in and out of “object” space.
- Develop a simple infrastructure to transform cast rays in and out of instance space.

# Rendering Improvements: Logical Flow



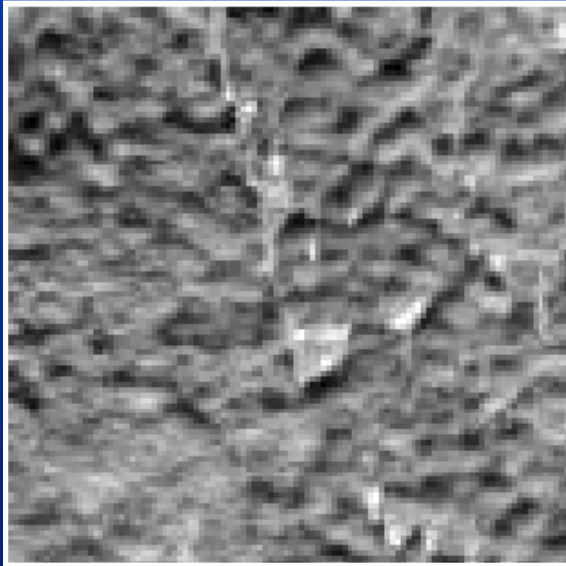
# Tree Geometry: Sources

- The physical tree geometry model can be acquired from a variety of sources.
  - **Commercial packages**
    - » Onyx Computing Tree Software
  - **Commercial vendors**
    - » ViewPoint
  - **Hand created**
    - » Using CAD tools (Rhino, AutoCAD, etc.)
  - **Home made programs**
    - » Statistical models

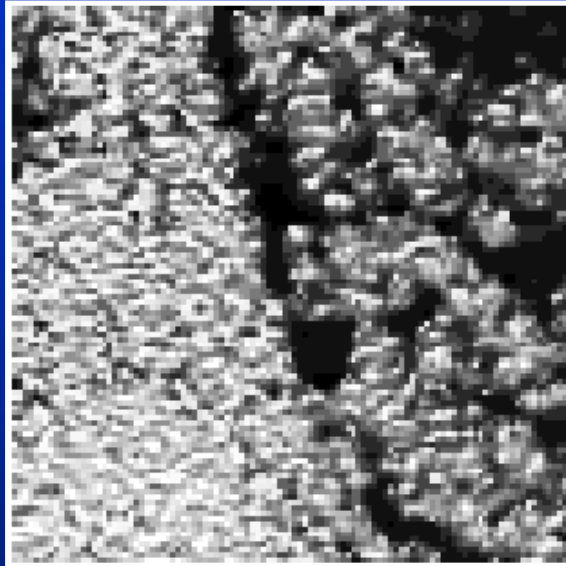


Simple Statistical  
Model

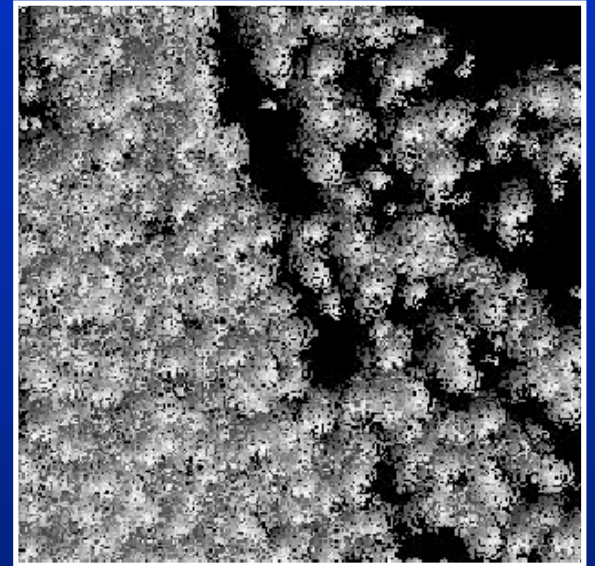
# Preliminary Results



Input Color/IR  
Air Photo Image



NIR/Red Ratio of  
Air Photo Image

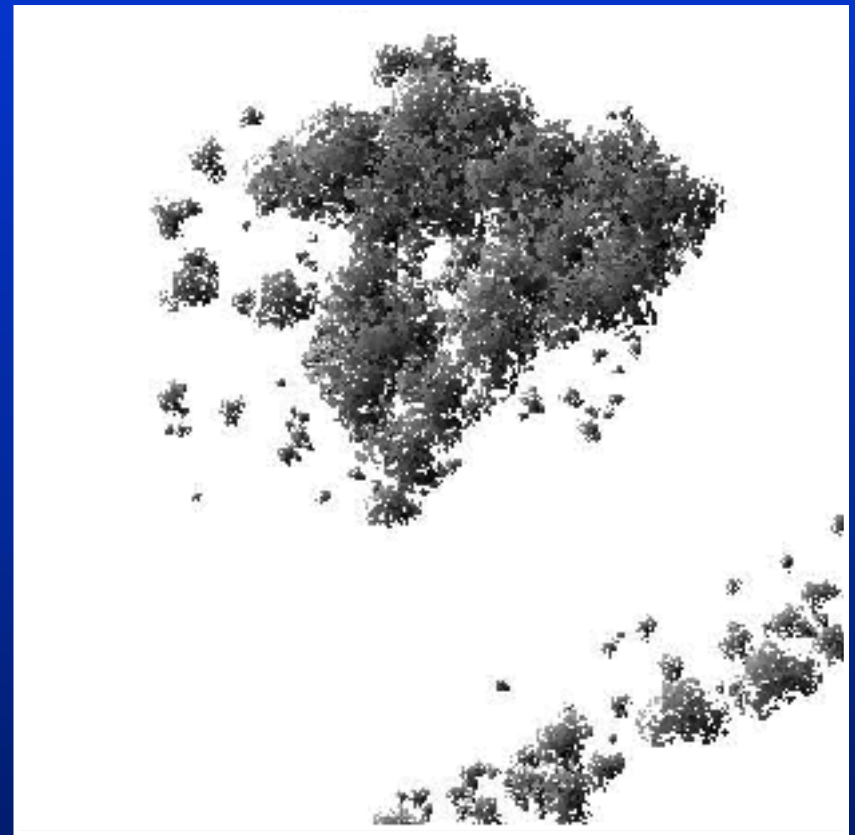


Externally Rendered  
Tree Features

# Preliminary Results



**Input Color/IR  
Air Photo Image**

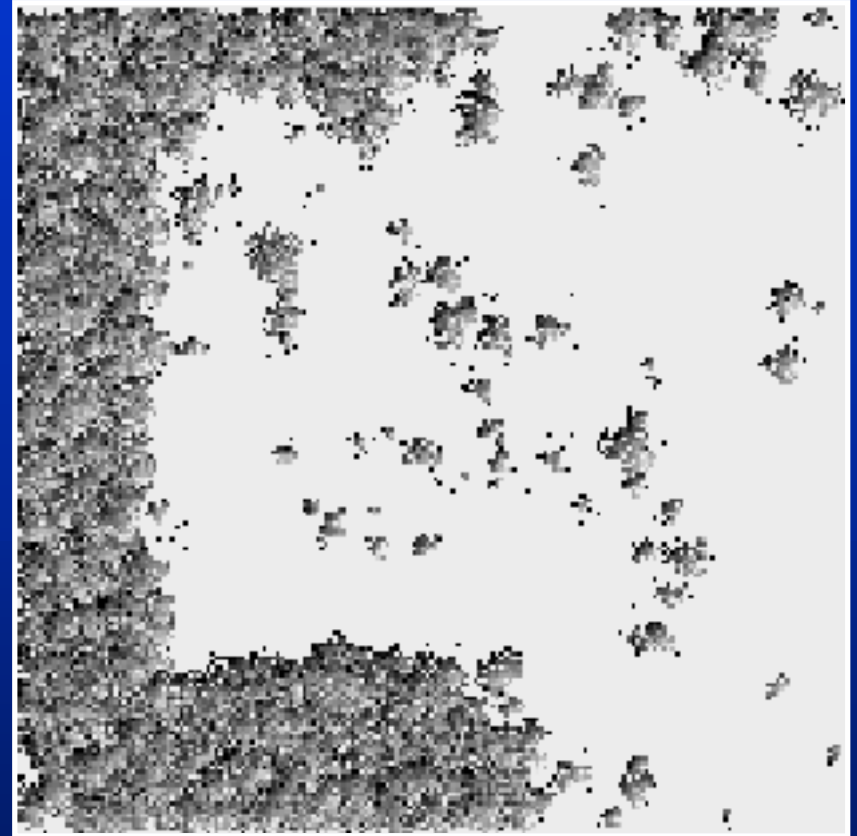


**Externally Rendered  
Tree Features**

# Preliminary Results

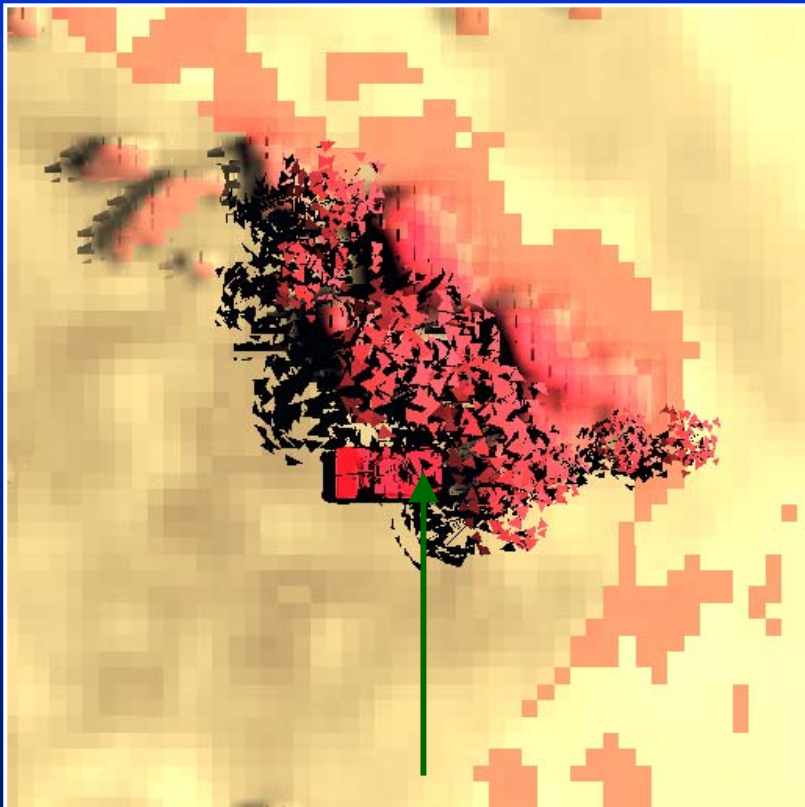


**Input M7  
Multi-Spectral Image**



**Externally Rendered  
Tree Features**

# Target Region Zoom: Vehicle in Partial Shade

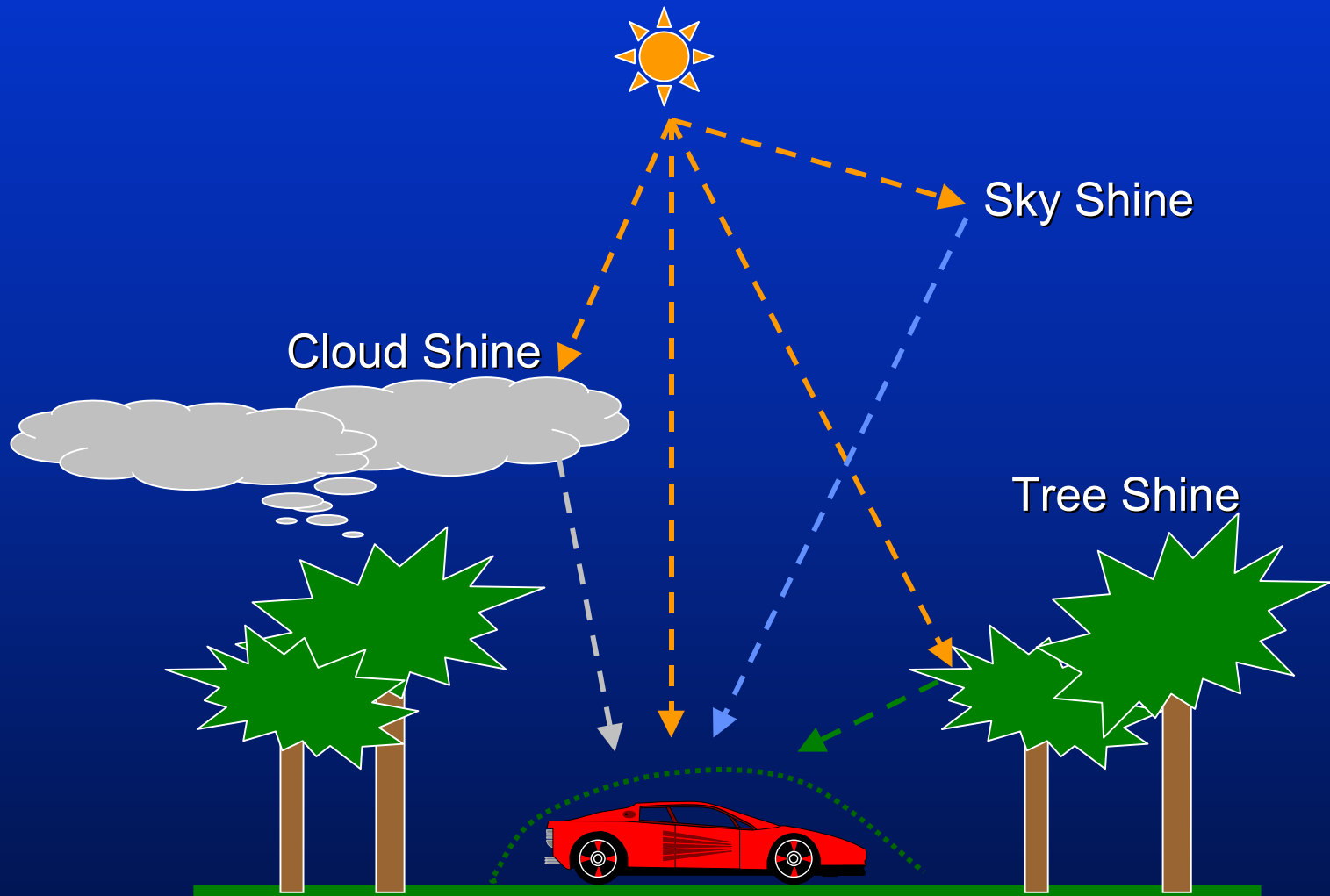


Target area  
(oversampled 10x)

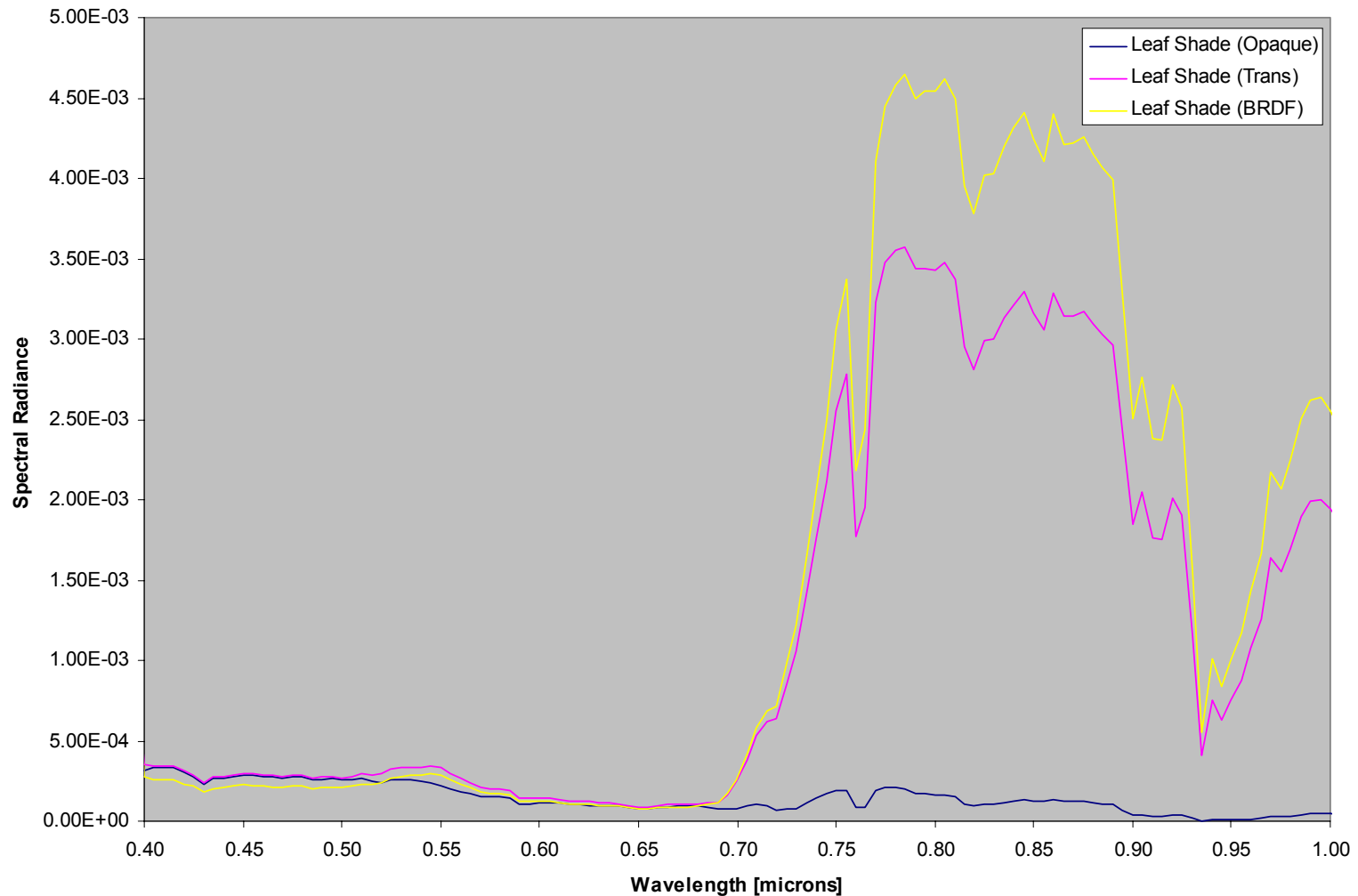


Target area  
(final resolution)

# Target Phenomenology: Background Interactions



# Target Phenomenology: Vehicle shaded by tree



# Summary

- **Accomplishments to date**
  - Initial “tree” extraction tool with flexible parameters has been constructed.
  - DIRSIG has been outfitted with an “instancing” capability to minimize run-time resource requirements.
- **Basic tool provides a baseline for future ...**
  - Extract a “health” metric (leaf droop, leaf spectra).
  - Extract species type (tree geometry, leaf spectra).
  - Characterize canopy “thickness” (tree geometry).
  - Characterize crown shape/curvature (tree geometry).
  - Add support for non-symmetric trees.

# **DIRSIG:**

## **Contact Information**

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