



# Strategic Collaboration to Implement GPU Accelerated 3D Shearlets in a Photogrammetric Context

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# Overview

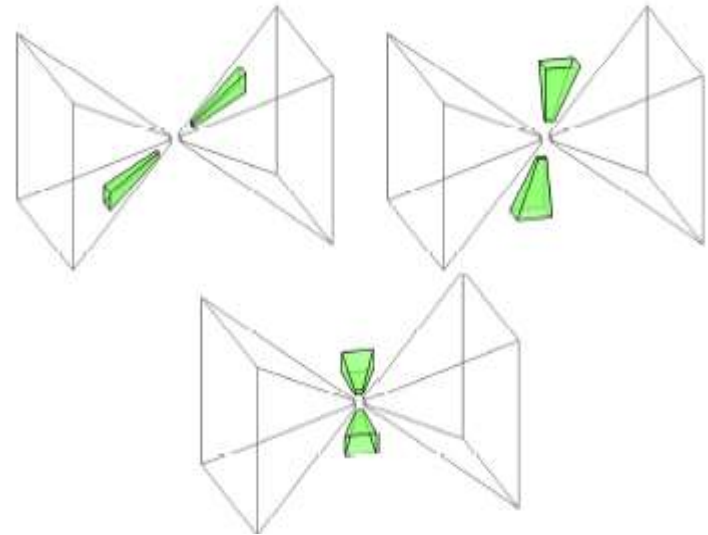
- **3D Shearlet Origin and Definition**
- **Motivation**
- **Strategic partnerships**
  - **Government**
  - **Academic**
  - **Private sector research groups**



# Government Research: Naval Innovative Science & Engineering (NISE)

## Definition : 3D Shearlet Transform

- Numerical operator on volumetric data sets
- Signal decomposition according to frequency of information present
  - Multi-scale
  - Multi-directional
- Independent of human intervention or prior knowledge



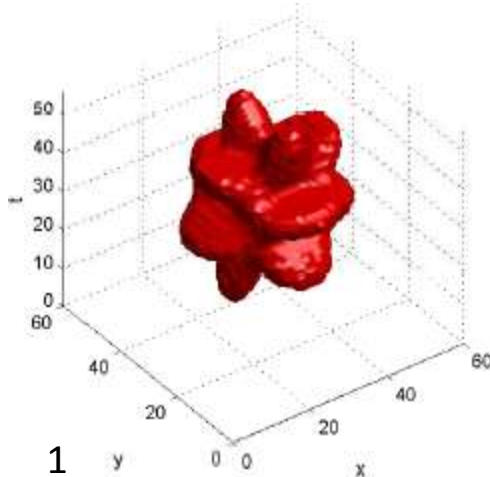
Frequency domain representations of 3D shearlet atoms at different scales and orientations (93 cases).



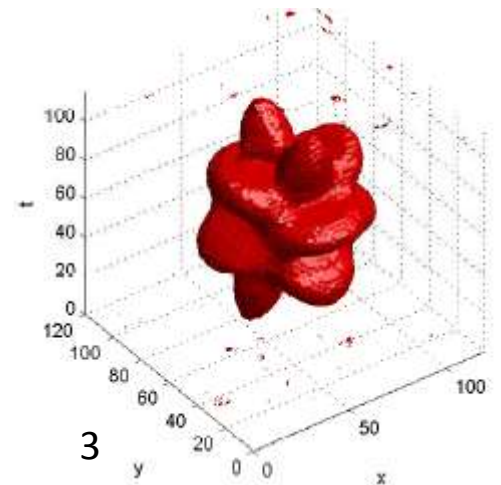
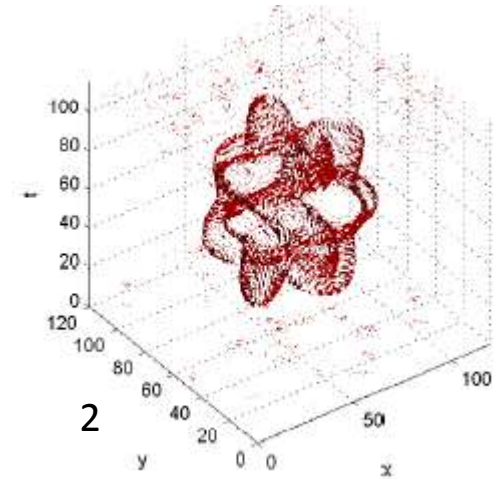
# Government Research: 3D Shearlet Edge Detection

Given volumetric data from time varying nonlinear dynamic system

- Faithful preservation of information
- Magnitude and direction of surface over the time series
- 3D Parameters and higher order derivatives



Spherical Harmonic Truth (1),  
Canny2D (2), Shearlet 3D (3)  
with noise (standard deviation  
 $\sigma = 0.2$ )





# Motivation for 3D Shearlet Applications

- Image feature detection for acquisition
- Tracking and estimation
- Measurement generation
- Signal denoising
- Signal compression
- Analysis of sensor data to verify performance specifications



**GOAL: Transition technical research into  
*Production Systems***



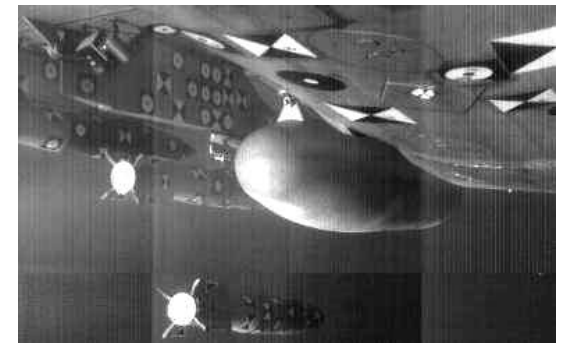
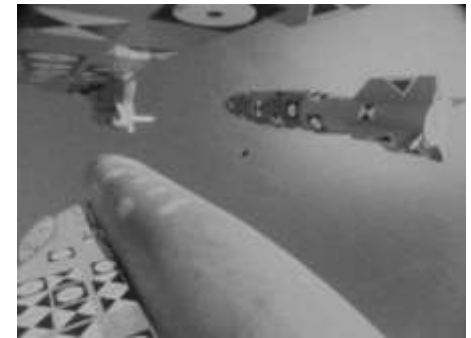
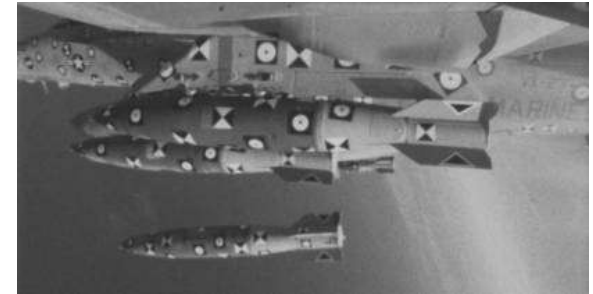
# 3D Shearlet Applications for Photogrammetry

## Background

- PhotoG product: (x,y,z,yaw,pitch,roll) 6-DoF time history of store trajectory
- Primarily for safety of flight
- Results verify/refine wind tunnel and CFD based predictions
- Fewer test points, but next test point has to wait until photoG results are compared to predictions
- Standard turnaround time is 24 hours (3 hours if rushed)
- Automation of photoG is reaching its limits without technology assist

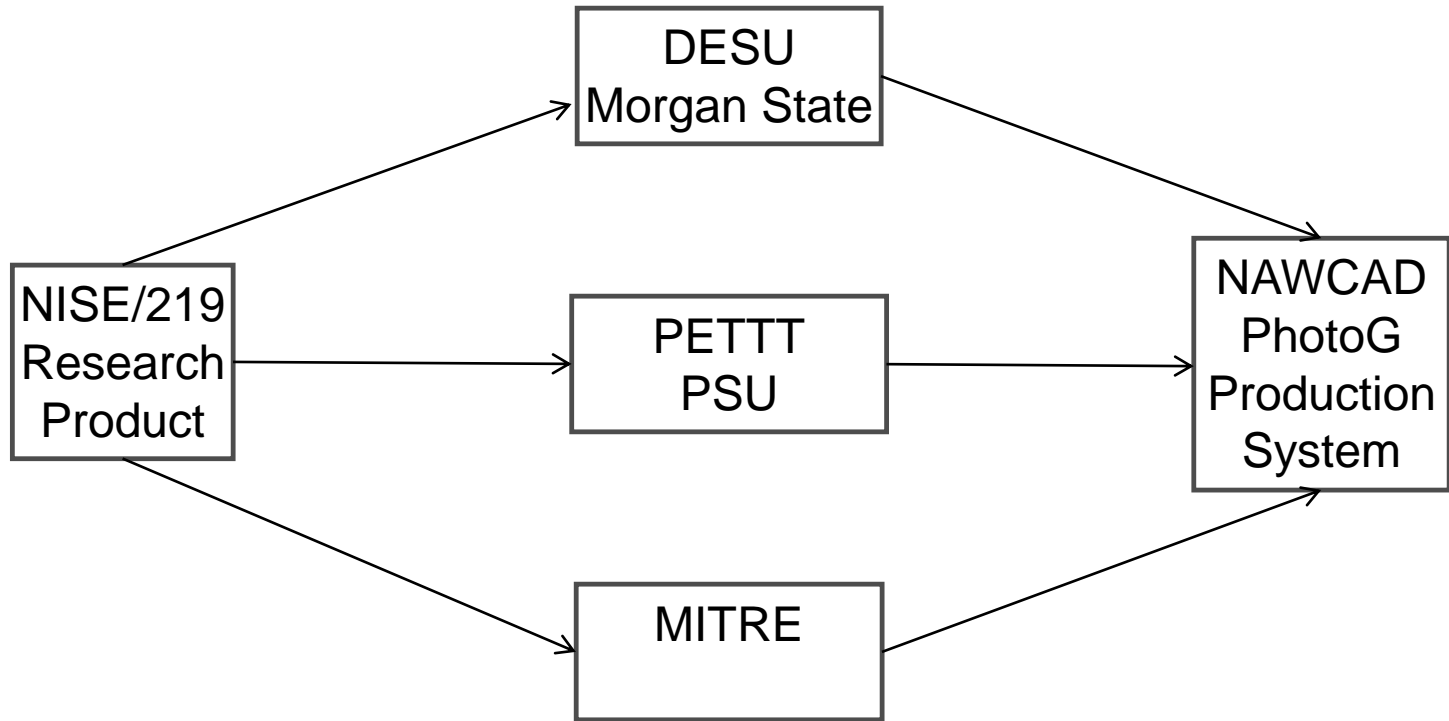
## Four Process Steps:

- 1) Target acquisition
- 2) Target identification
- 3) Target tracking through image sequence
- 4) Analysis: Use 2-D tracking data to compute cameras' 6-DOF, store's 6-DOF, derivatives and then miss distances





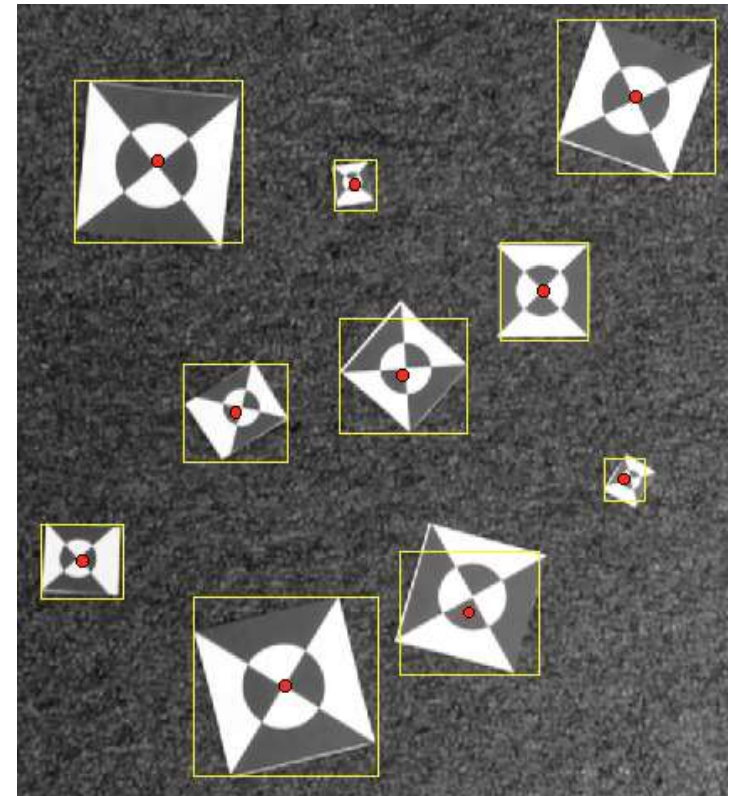
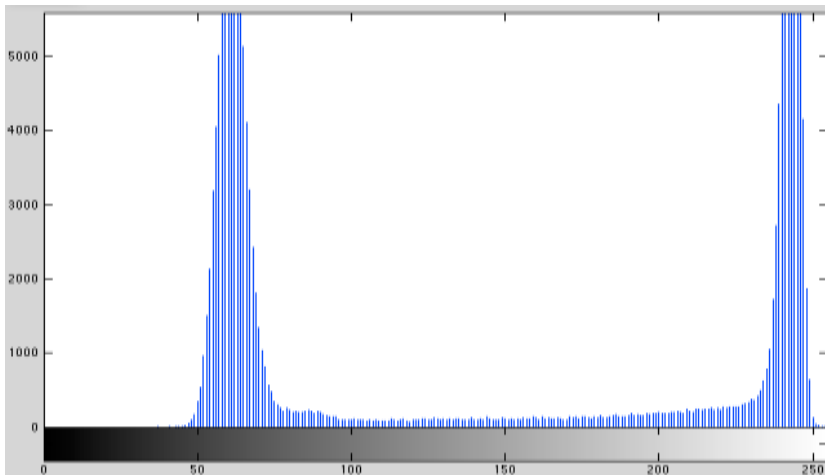
# Transition to Production Product Strategy





# Academic Partnerships: Target Acquisition

- Morgan State University project Decision Engine for Structured and Unstructured Data (DESU)
- Bimodal Histogram Quad-Tree Decomposition (or Construction) approach to accomplish target acquisition

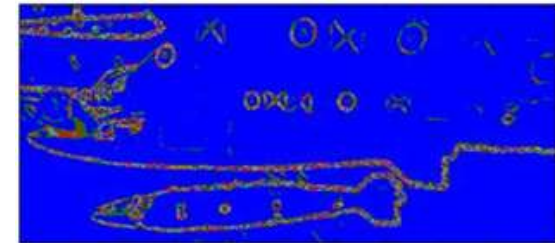
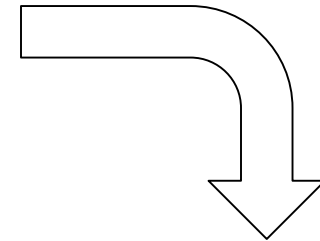
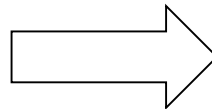






# Academic Partnerships: 3D Shearlet on GPU

- **Current PENTT funded project with Penn State University**
- **Address time intensive computation**
- **GPU-accelerated implementation of existing PHOTO-G edge detection algorithm**



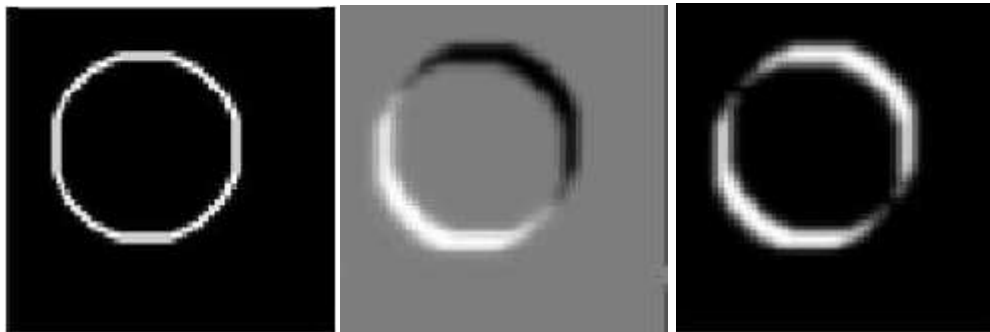


# Private Sector Partnerships: 2D Tracking

- Collaboration with MITRE
- 2D Tracking using 3D edge detection
- Provides additional image velocity information
- Increased reliability for high dynamic objects under illumination variations and noise



a



b

c

d

Spiraling disk (a),  
2D edge (b), 3D  
edge (c), sum of  
components (d)



## Conclusion:

- **3D Shearlet Transform adds value to broad spectrum of applications**
  - Provide more information from the same time-series of data
  - Maintain performance for complicated objects under illumination variations and noise
  - Side-step need for human intervention/analysis process to enable automation
- **Partnerships**
  - Distribute knowledge to advance state-of-the-art
  - Save time and money
  - Maintain potential for future work



# Future Work

- **Image denoising before 2D tracking**
- **Shorten turnaround time of photoG process using improved 2D tracking (< 1hour)**
  - **Incorporate 3D edge detection into 2D tracking production system**
- **Incorporate image feature velocity and accelerations into model for Bayesian filter (Unscented Kalman filter) to model nonlinear system dynamics**

## Questions?



# Backup Slides