
# Open Source Computer Vision and Analytics in Support of the UAS and ASPRS Communities

Heather James, Manager Innovative Applications
Computer Vision Group
Heather.james@kitware.com
(518) 290-6576

# Kitware

**Best known for open source toolkits and applications**

**Collaborative software R&D:**

- Algorithms & Applications
- Image & Data Analysis
- Software Process & Infrastructure
- Support & Training

**Supporting all sectors:** Industry, Government, Academia, Commercial

# What is Open Source Software

- OSI Definition:
  - Free redistribution
  - Source code available
  - Allow derived works
  - Author's integrity
  - No discrimination against persons or groups
  - No discrimination against fields of endeavor
  - Distribution of license
  - License not specific to a product
  - License must not restrict other software
  - License must be technology neutral


High Quality Software
Process is a MUST


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# Open Source: UAS/ASPRS Community

| Benefits |
| --- |
| Common Platform |
| Reduces times/resources invested in creating tools |
| Allows immediate tool improvement |
| Reproducibility and verification |
| Reduces costs |
| Community Sharing and Support |
| Promotes web tools |

| Challenges |
| --- |
| No tech support unless you pay for a consultant |
| Effectiveness requires community support |

*"Open source projects serve to cultivate an ecosystem of collaborative intelligence at a global scale, and are the foundation for enabling the Aerial Robotics Network."* [http://www.tmcnet.com/usubmit/2014/10/13/8065152.htm]

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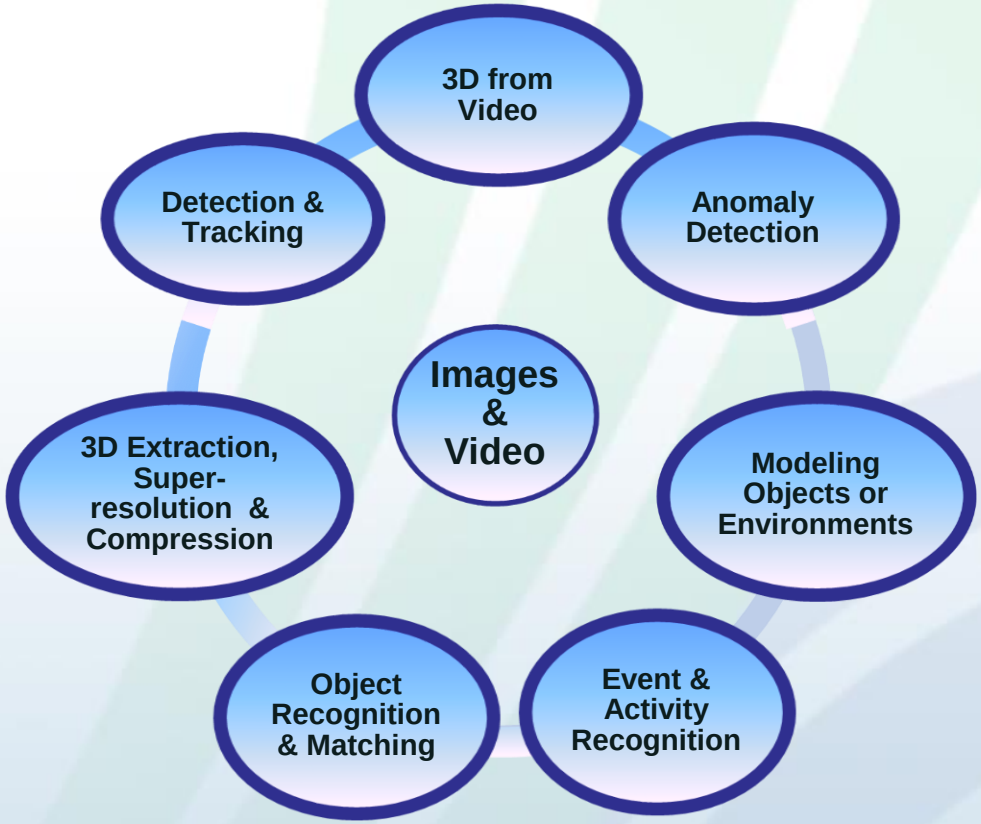
# Computer Vision & Analytics

- End Goal: Automatic Visual Understanding
- Applies models of human vision to extract knowledge out of different types of data
- Automatic extraction, analysis, and understanding of useful information to form decisions.
- Data Types:
  - Images
  - Video Sequences
  - Views from multiple cameras
  - 3D Point Clouds




Advanced Tools/Applications Across the UAS Community

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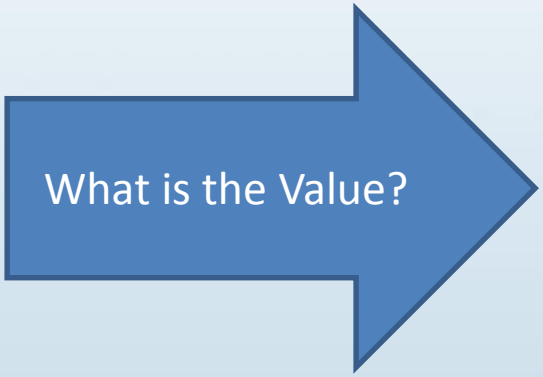
# CV Integration into UAS Community

| Differ From Traditional Methods |
| --- |
| Lesser degree of focus on the precision of measurements/direct calibration of devices. |
| Analysis of image content is through recognition of objects |
| Higher level of analysis and interpretation |
| Learns from previous results |

| Complimentary to Traditional Methods |
| --- |
| Adds analysis based on temporal dynamics |
| Approaches to improve accuracy |
| Approaches to improves performance |
| Approaches to 3D analysis |
| Approaches to image/video enhancement |




- “Data to Decision”
- Automation
- Improves Exploitation of Data
- Increases Data Analysis Efficiency
- Improves Performance

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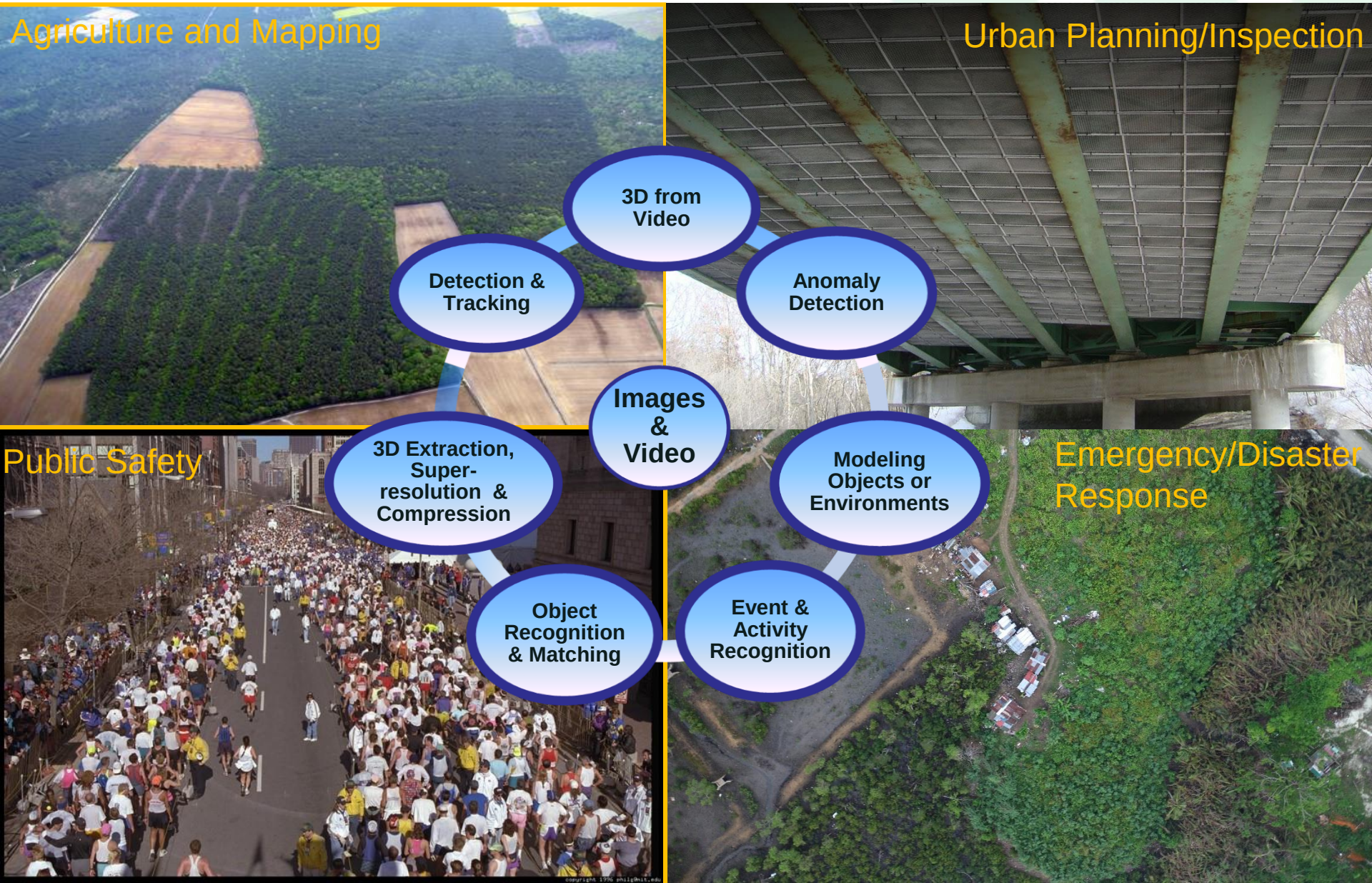
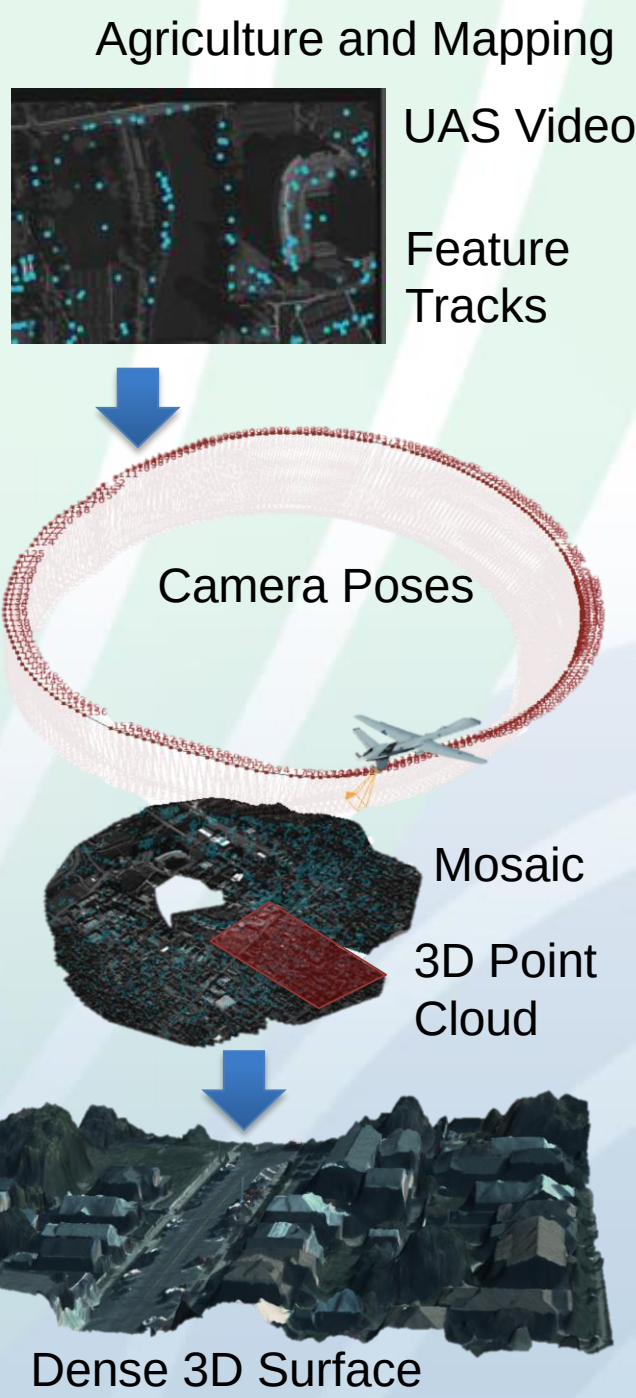
# CV Trends, Capabilities, Way Ahead



# MAP-Tk

## Motion-imagery Aerial Photogrammetry Toolkit

- Estimation of UAS **camera pose** trajectory
- Estimation of scene **3D point cloud**
- Video **stabilization** and **mosaic** construction
- **Geo-registration** with GPS or selected ground control points
- Automatic geo-registration by matching to reference imagery [planned]
- Dense **3D surface** modeling [pending public release approval]
- **Open source** with permissive BSD license https://github.com/kitware/maptk
- Highly **modular**, open framework
  - Integrates key technologies from other open source toolkits (OpenCV, VXL, Ceres, etc.)
- OpenCL (**GPU**) acceleration
- Intuitive **GUI** frontend [planned]

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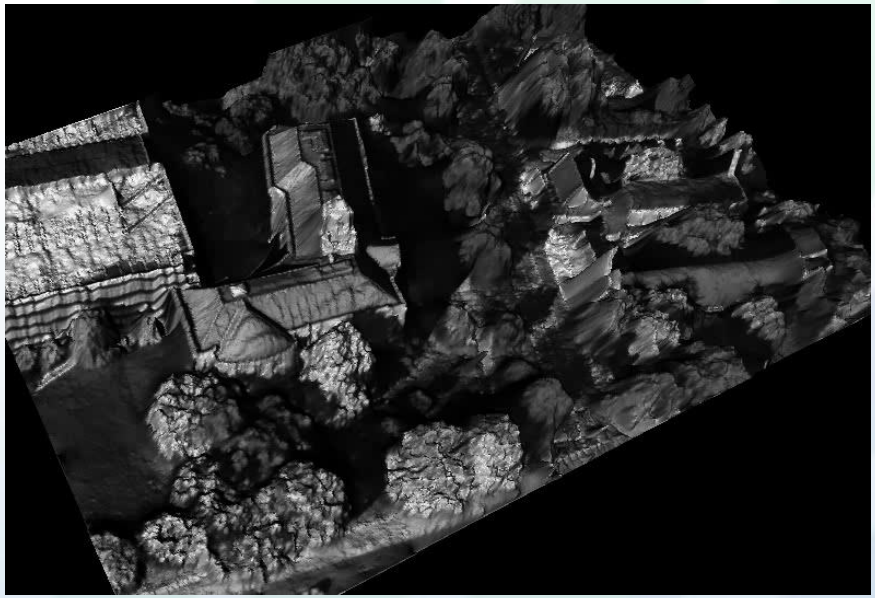
# 3D Reconstruction of Vegetation

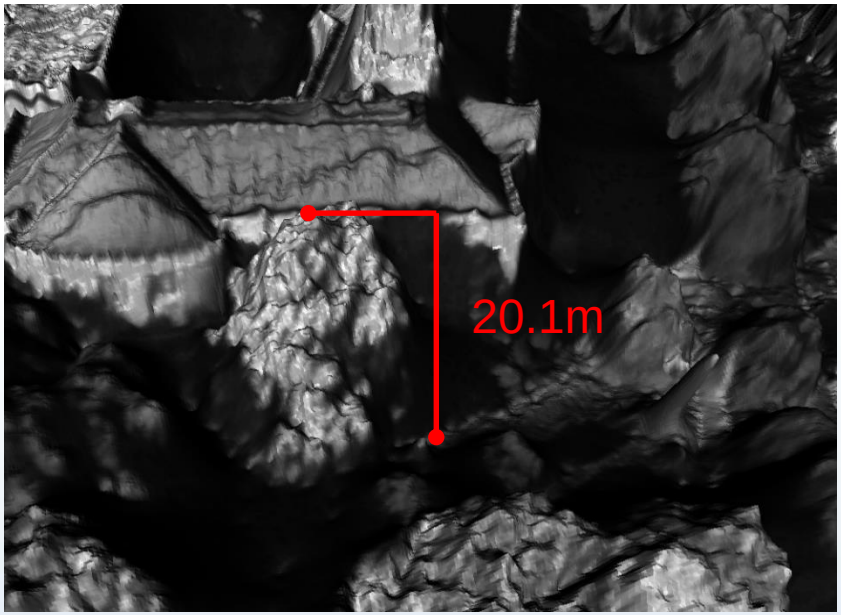
Input imagery (stabilized for display)

Dense 3D reconstruction



- Produce a dense depth map using two or more images with associated calibrated cameras (example above is 9 images).
- Variational optimization technique can reconstruct fine detailed structures such as vegetation.

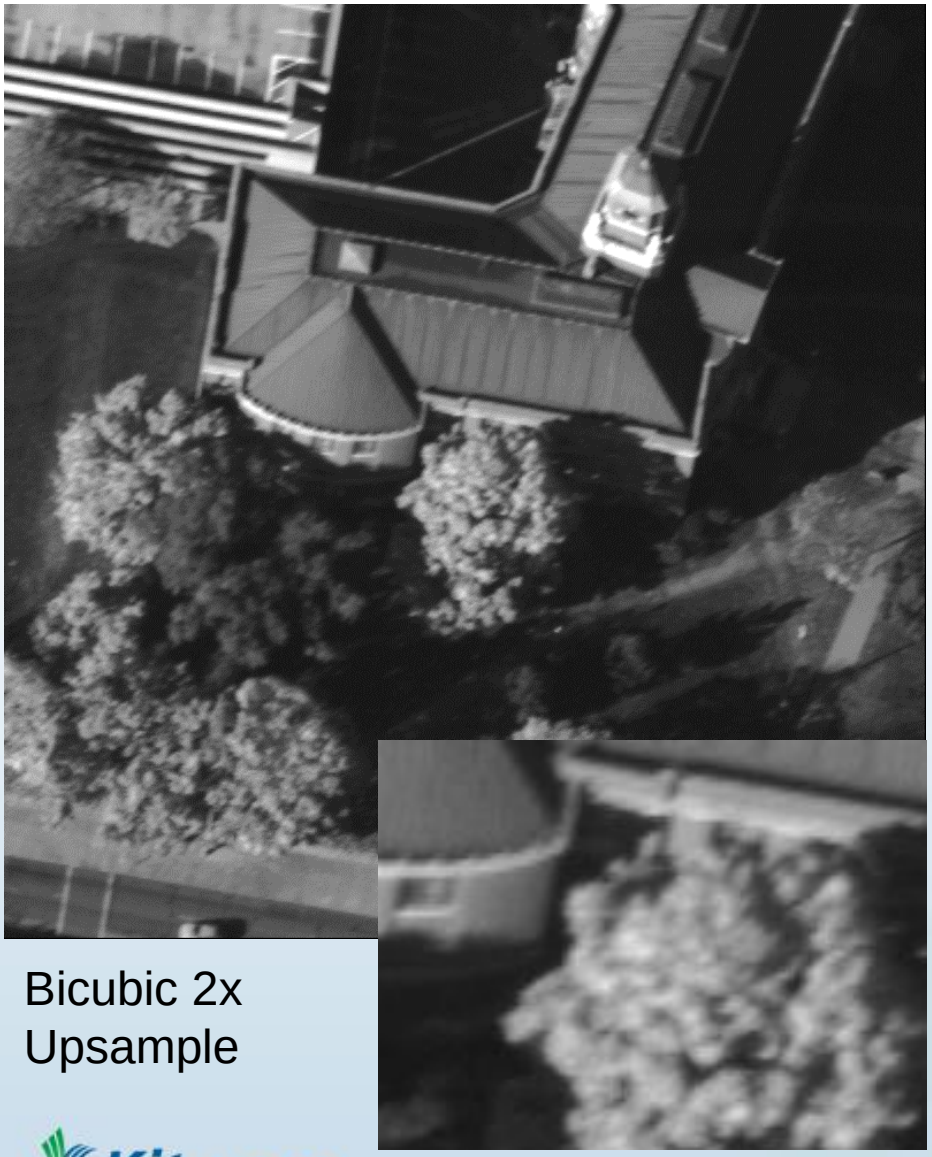
# Mensuration with 3D models



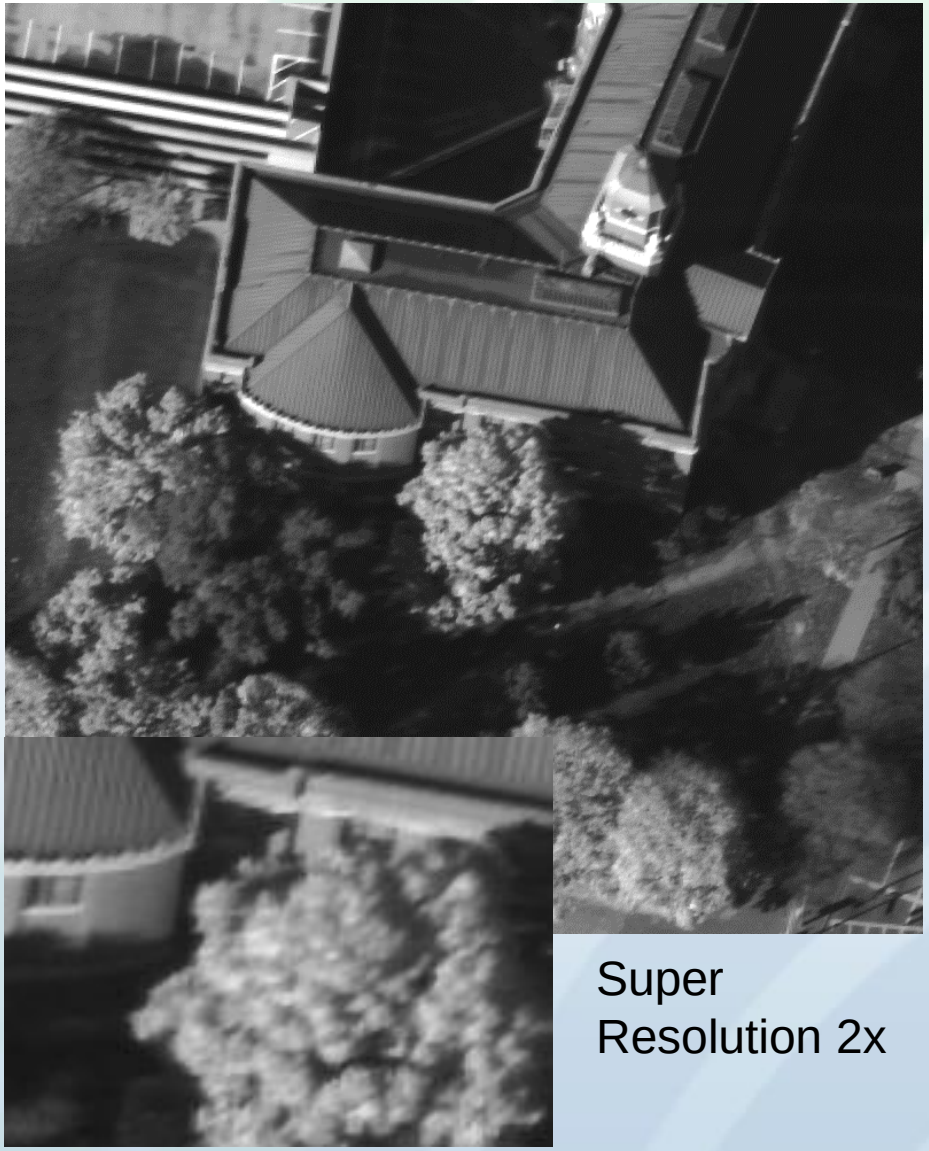

- What is the average height of my crop in Acre A?
- What is the difference in average height from Acre A/B?
- I need to know when my crop has reached a certain height.
- When should I harvest?

- Using geo-referenced cameras in a dense 3D reconstruction permits accurate mensuration
- Camera calibration (both exterior orientation and camera intrinsics) computed from raw input imagery.
- Camera calibration into geo-referenced coordinate system through GPS measurement or geo-reference control points.

# Super Resolution of Vegetation



Bicubic 2x Upsample



Super Resolution 2x

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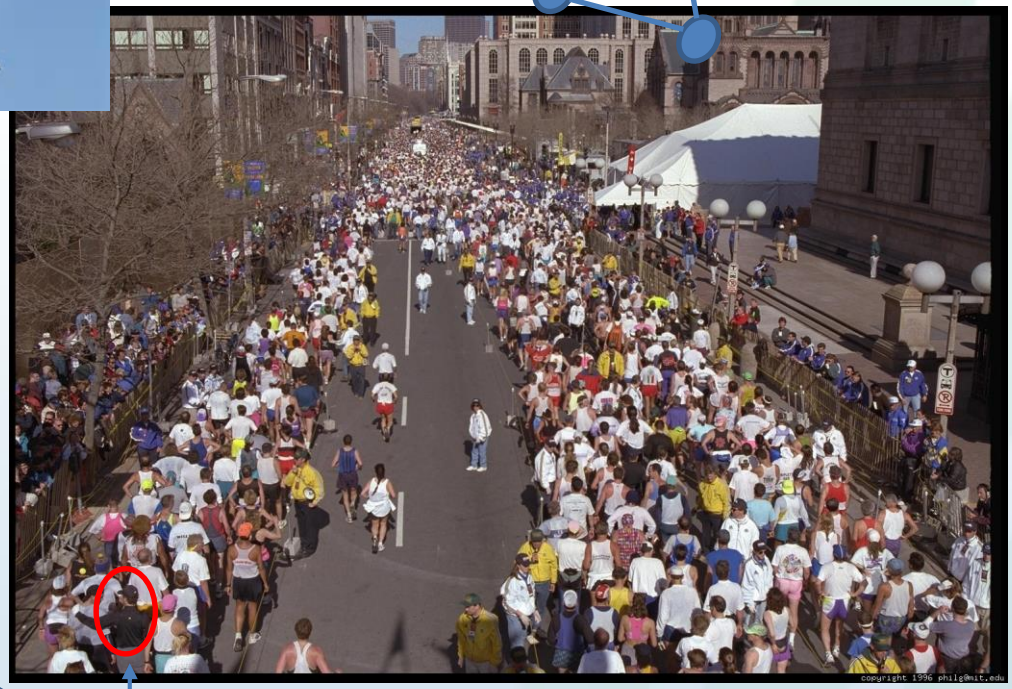
# Managing the Safety of Public Events: A Multi-Int Endeavor

UAS Aerial Surveillance/Tracking

Information Collection and Analytics All Tie Together

Social Media



Archived Computing & Storage

Agency 1

State System

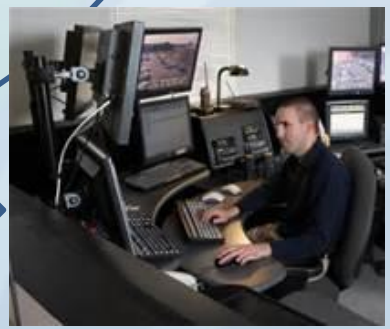
Cloud

Regional System

Agency 2

*Where is the person in the black shirt?*
*What are they doing?*

*Dispatch…Can you assist?*
*Potential threat identified.*



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***Where is there a big crowd?***
***Where are people moving quickly (scattering)?***

# Kitware 3D Reconstruction of Urban Scenes

- 3D models can be extracted directly from aerial video itself and perfectly align to the video.
- Aids video analysis tasks


Estimated Digital Surface Model (DSM) Rendered as a Texture-mapped Mesh

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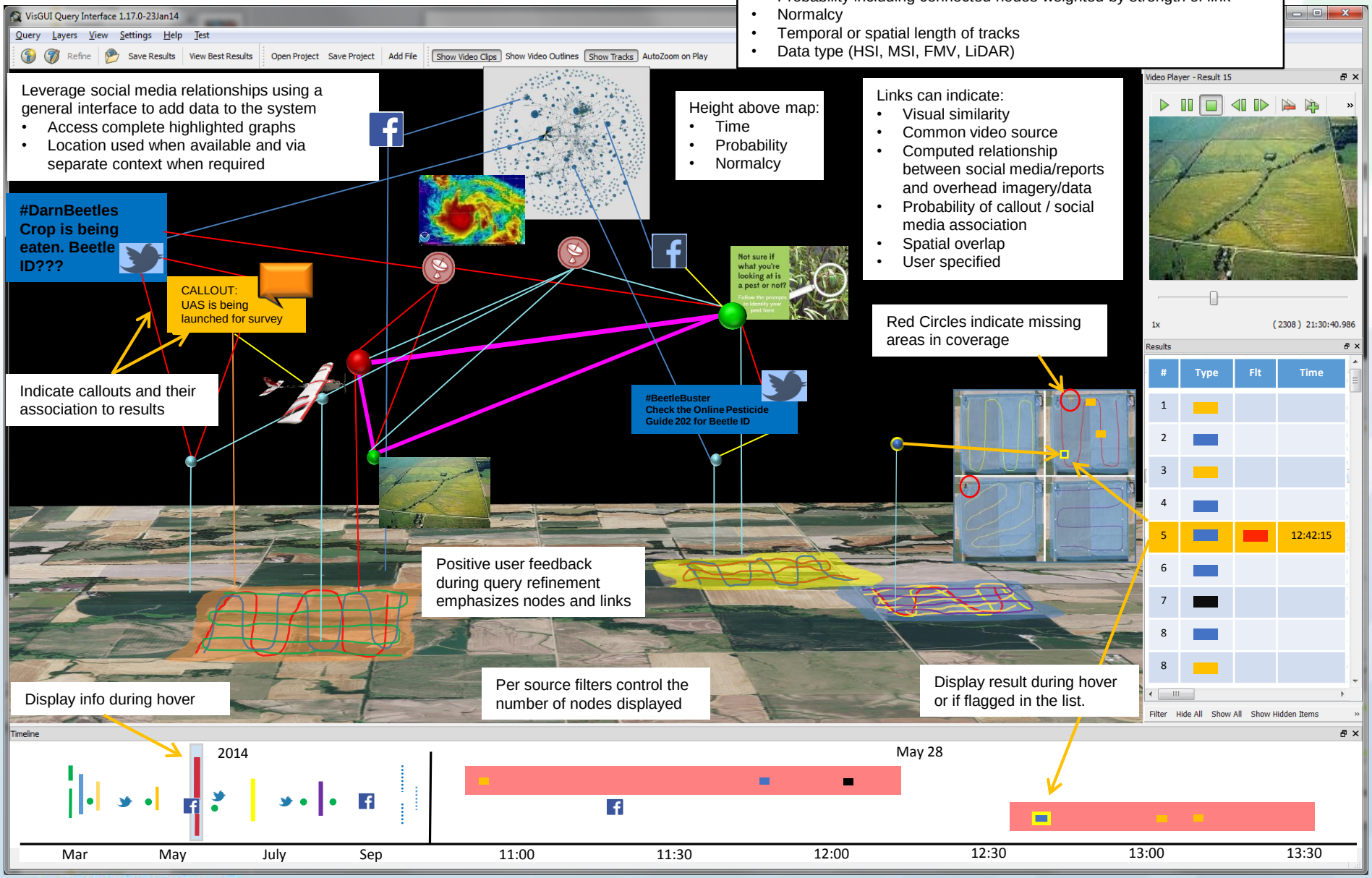
# Graphical Map-Multi-Media Exploration Agriculture

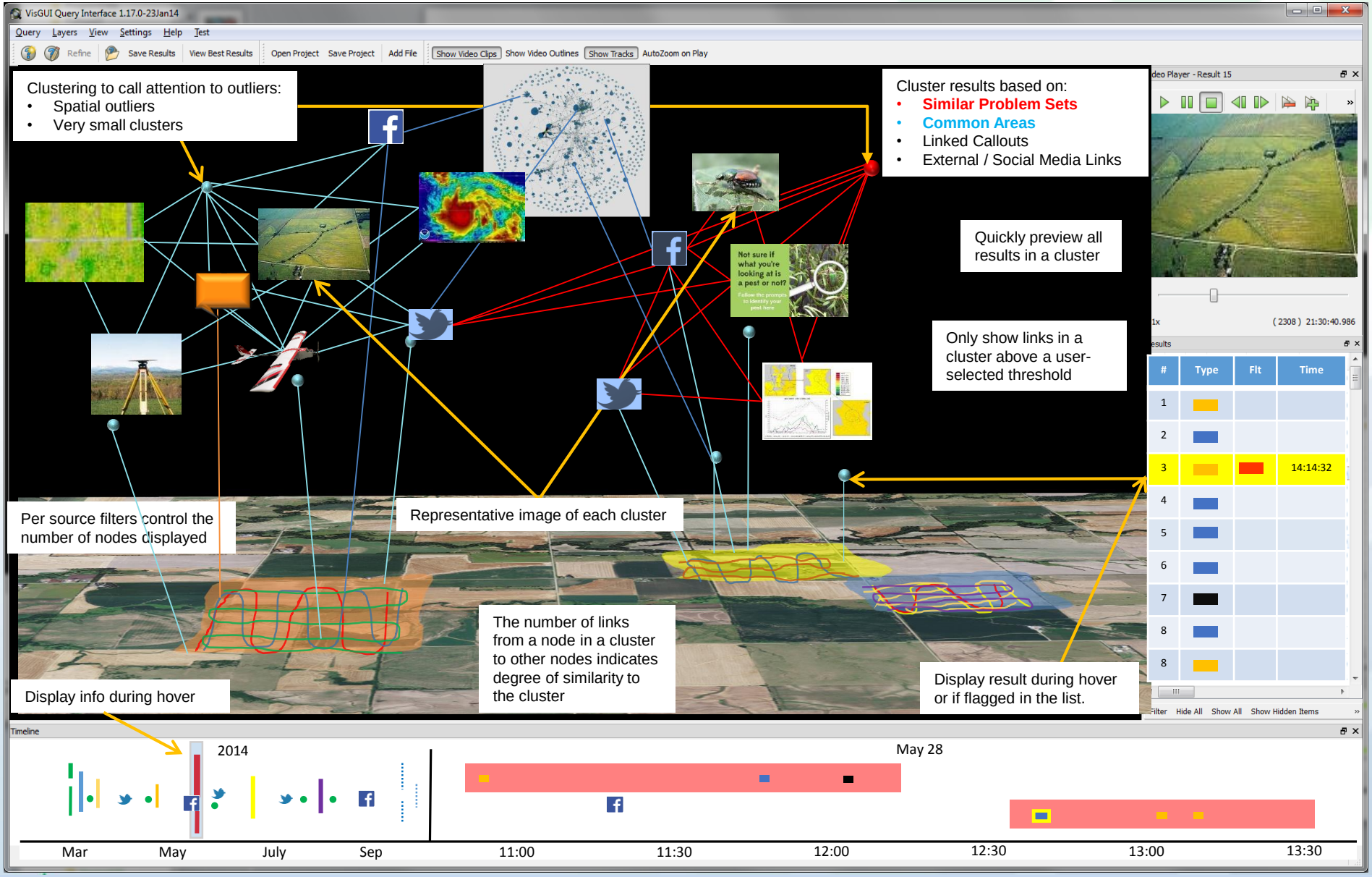
Node size and color options:
- Probability
- Probability including connected nodes weighted by strength of link
- Normalcy
- Temporal or spatial length of tracks
- Data type (HSI, MSI, FMV, LiDAR)




Multiple Months and Farms

Multiple Flights for Multiple Farms in One Day

# Multi-Media Exploration Clustering




Multiple Months and Farms

Multiple Flights for Multiple Farms in One Day

# Open Source Image and Video Analytics Toolkit

**Image Ingest**

Aerial Cameras

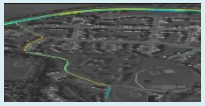
**Pixel Stabilization & Localization**

- Image Stabilization
- Geolocalization

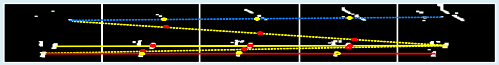
**Tracking**

Track Update

Track Linking



Track Initialization



**Object Identification**

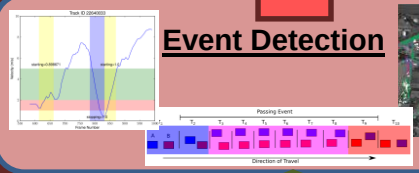
Stationary

Moving

**Behavior Recognition**

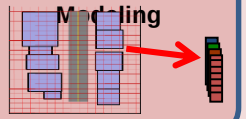
Activity Recognition

Event Detection

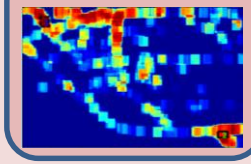


**Normalcy & Anomaly**

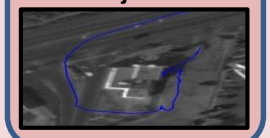
Probabilistic Modeling



Locations



Objects



**Functional Analysis**

Buildings

Scene Elements

Objects

**Geometry**

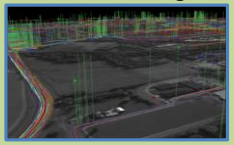
3D Reconstruction

Super Resolution

**Visualization & User Interface**

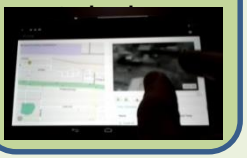
Viewer

3D Browsing



HTML5

Thin client



Information Vis

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Kitware Image and Video Exploitation and Retrieval (KWIVER) toolkit: http://www.kwiver.org/

# OS and CV: Big Benefits

- Collaborative software for the global community
- Compliments and adds value to traditional methods
  - "Data to Decisions"
- CV Methods can be applied to multiple domains

Analyze, Identify, and Deliver more accurate info to make intelligent decisions in the UAS Community