Open Source UAS Software Toolkits

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Kitware

Best known for open source toolkits and applications

Collaborative software R&D:

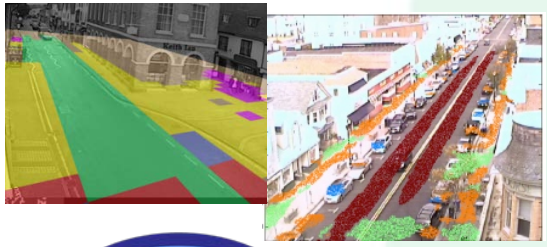
- Algorithms & Applications
- Image & Data Analysis
- Software Process & Infrastructure
- Support & Training

Supporting all sectors: Industry, Government, Academia, Commercial

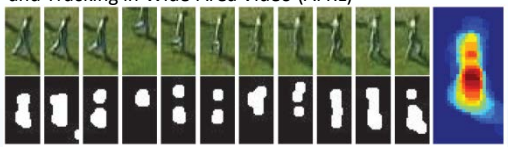
Computer Vision Projects at Kitware

- 34+ team members
- 11 PhDs
- Founded in 2007
- 34+ contracts

Object and Building Recognition by Function (DARPA)

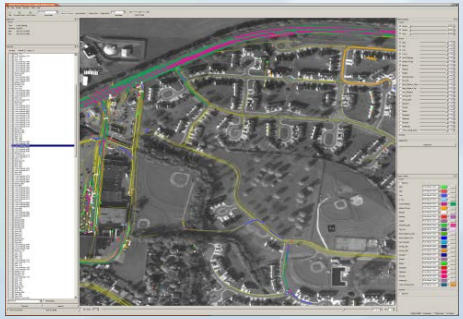


Human Activity Detection (Army RRTO, CTTSO) and Tracking in Wide-Area Video (AFRL)

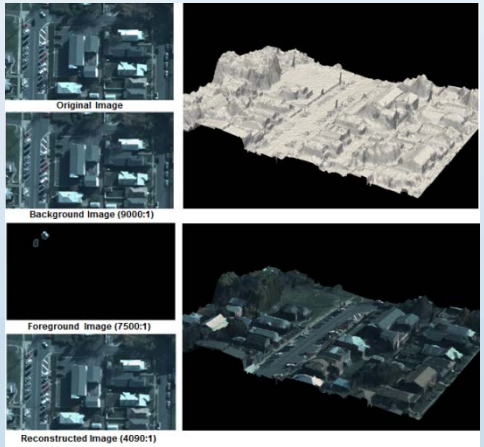


Content-based Video Retrieval by Actions (DARPA VIRAT)

Complex Event Recognition in Internet Videos (IARPA Aladdin)

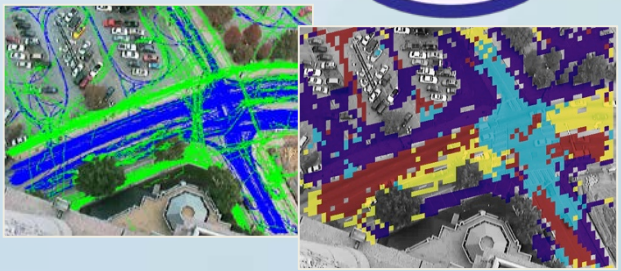


Wide-area Motion Imagery Threat Detection and Nodal Analysis (DARPA PerSEAS)

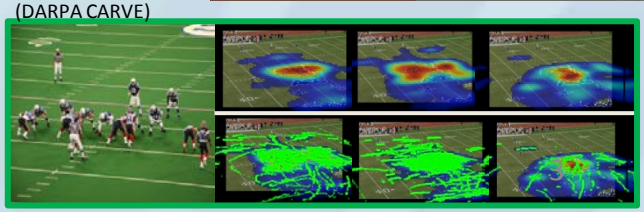


3D model-based video compression (DARPA GRID) and super-resolved 3D reconstruction (DARPA Super 3D)

Normalcy Modeling and Anomaly Detection (DARPA PANDA and PerSEAS)



Football Play Recognition (DARPA CARVE)



Changing Face of Aerial Video

$5,000,000

$1500

The increasing availability of inexpensive, capable aerial video platforms inevitably leads to an overabundance of video footage. Automated analytics are required to organize this footage and synthesize actionable information.

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Video Analytics

Answer Fundamental Questions

What Can I see?

- How does it change over time?
- How big is it?
- Where is it?

What is Happening?

- Is anything moving?
- Where does it go?
- When does it get someplace interesting?

What is the Value?

- Data to Decisions
- Automation
- Improves Exploitation of Data
- Increases Data Analysis Efficiency
- Improves Performance

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Open Source Building Blocks

OpenCV

Libxml2

ØMQ

vtk

Qt

boost
C++ LIBRARIES

zlib

Leptonica

PROJ.4

GDAL

http://logging.apache.org
Logging Services™

PostGIS
Spatial PostgreSQL

CMake

PostgreSQL

SQLite

GEOS
Geometry
Engine
Open
Source

GeoTIFF

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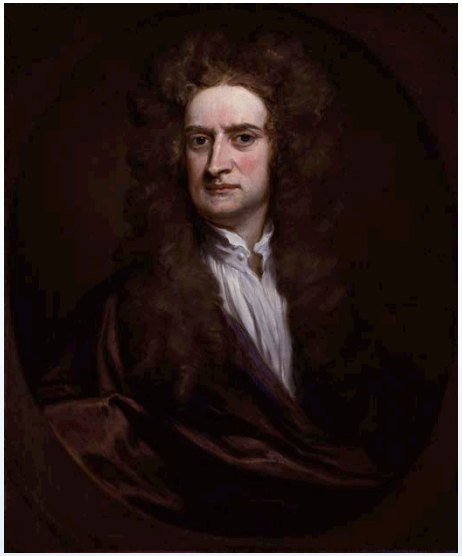
Open Source Use Challenges

- Complex and idiosyncratic software build processes across many tools
- OS package managers have their own agenda
  - What is current?
  - What is important?
  - What is available?
- Platform requirements

Why Open Source?



"If I have seen further, it is by standing on the shoulders of giants." – Isaac Newton

"I often compare open source to science. To where science took this whole notion of developing ideas in the open and improving on other peoples' ideas and making it into what science is today and the incredible advances that we have had. And I compare that to witchcraft and alchemy, where openness was something you didn't do."
- Linus Torvalds, Linux Creator

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KWIVER Toolkit

Kitware Image and Video Exploitation and Retrieval Toolkit

An Open Source, production-quality video exploitation system

- Engage the community: academic, industry, government
- Avoid expensive software duplication and redundancy, speed time to solution
- Leverage the “many eyes” of the community to improve quality, stability and utility
- Bridge the gaps between research code → production software, initial feasibility → operational evaluation
- Create a true open-source community for cooperative, distributed development based upon available Open Source toolkits
- Scale down to a single researcher’s desktop and up to multi-node clusters

A KWIVER Enabled System

Video Analytics System or Application

MAP-Tk	VIBRANT	ViVIA

VITAL

Fletch

boost C++ LIBRARIES

PostgreSQL

OpenCV

GDAL

PostGIS Spatial PostgreSQL

GEOS Geometry Engine Open Source

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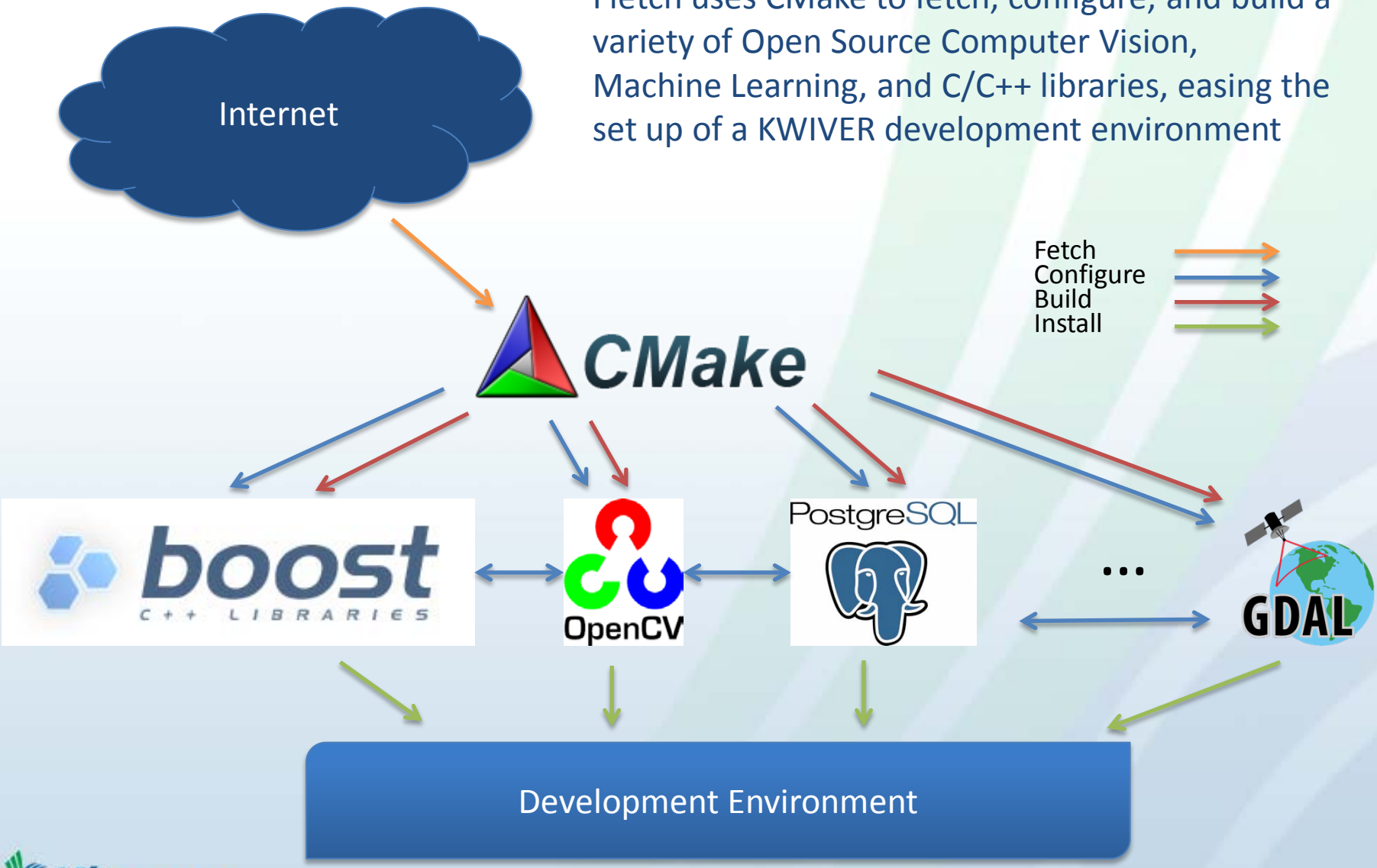
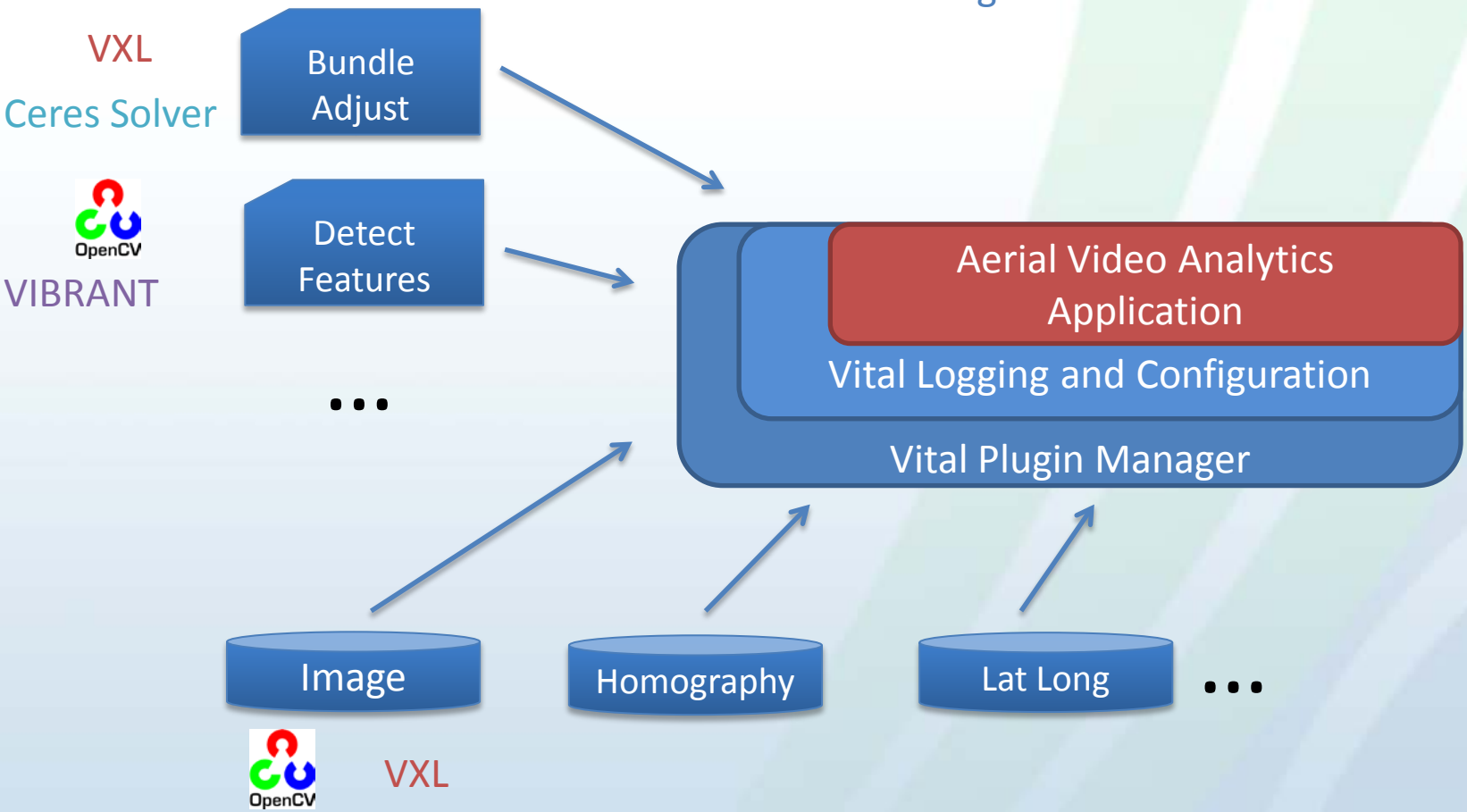
Fletch – A Computer Vision Tool Chest

Fletch uses CMake to fetch, configure, and build a variety of Open Source Computer Vision, Machine Learning, and C/C++ libraries, easing the set up of a KWIVER development environment



VITAL

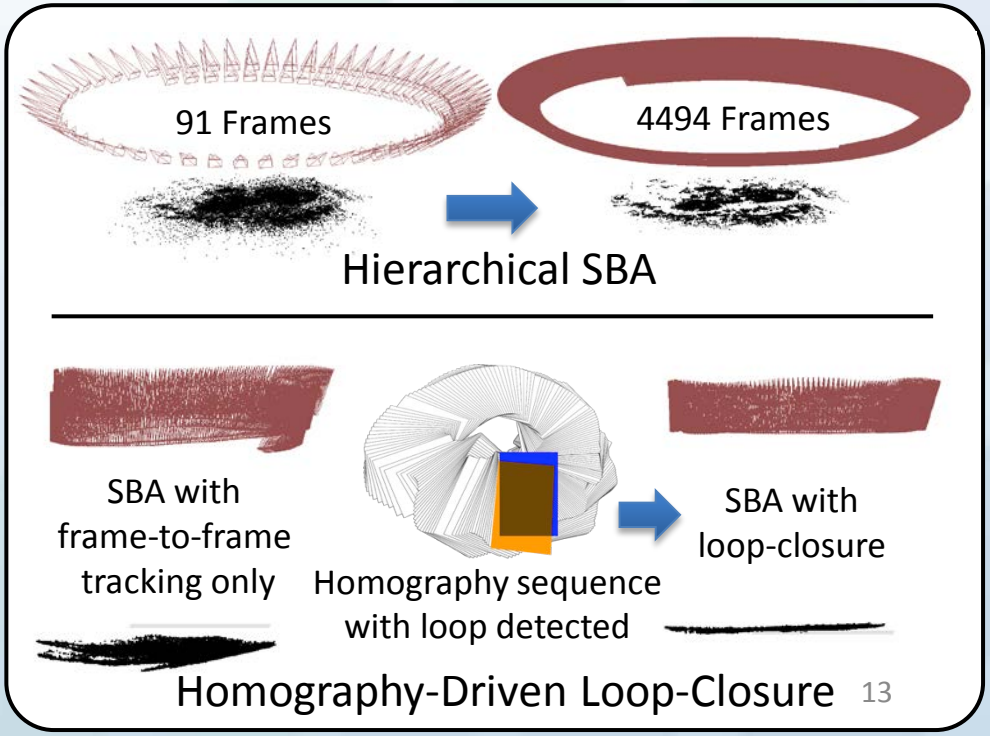
Provides abstractions for algorithms and data types along with core services such as logging and configuration to help build cohesive systems. Many choices can be configured at *runtime*.



MAP-Tk

Motion-imagery Aerial Photogrammetry Toolkit

- Open source with permissive BSD license https://github.com/kitware/maptk
- Highly modular, open framework
- OpenCL (GPU) accelerated feature detector and descriptor option.
- Optimized for aerial video processing
  - Frame-to-frame homography guided feature tracking
  - Homography guided loop-closure
- Recovery from bad frames during tracking
- Temporally hierarchical bundle adjustment
- Estimate shared, but unknown, intrinsics



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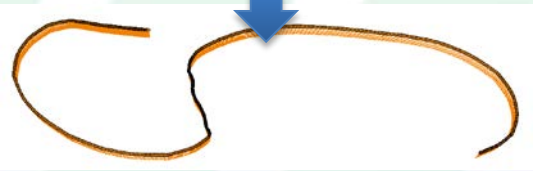
MAP-Tk 3D From Video

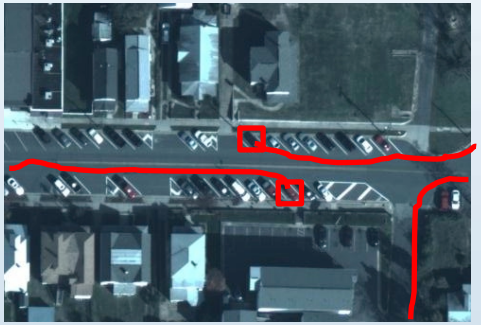
- Various applications depend on camera pose
  - GPS/intertial sensors are not always available or accurate enough for 3D image analysis
  - Sparse bundle adjustment (SBA) provides accurate pose from images
- Existing open source SBA packages focus on unordered collections of images and are very slow for video
- We can do much better by exploiting temporal continuity at all stages of processing
- Designed **MAP-Tk** to address these issues

Aerial Video (WAMI & FMV)



Sparse Bundle Adjustment
(MAP-Tk)

3D Surface Modeling
(DARPA Super 3D / GRID)



Moving Target Tracking
(VIRAT / AFRL SentinelHawk / AFRL E2AT / etc.)

Video Compression with 3D Models
(DARPA WAVC / GRID)

3D Super Resolution
(DARPA Super 3D)

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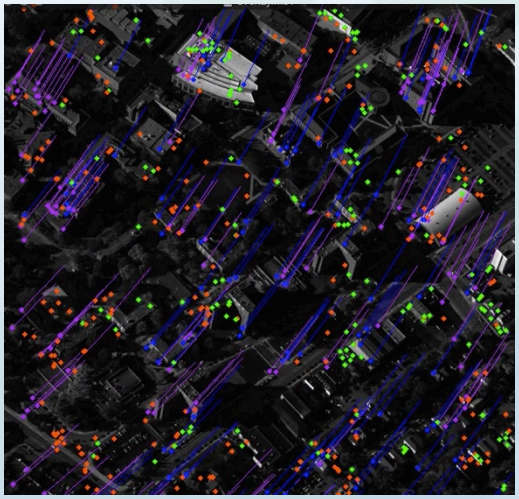
Using MAP-TK

```
...
# Algorithm to use for 'descriptor_extractor'.
# Must be one of the following options:
#   - ocv
feature_tracker:core:descriptor_extractor:type = ocv

# Algorithm to use for 'feature_detector'.
# Must be one of the following options:
#   - ocv
feature_tracker:core:feature_detector:type = ocv

# Algorithm to use for 'feature_matcher'.
# Must be one of the following options:
#   - homography_guided
#   - ocv
#   - vxl_constrained
feature_tracker:core:feature_matcher:type = vxl_constrained

# Algorithm to use for 'loop_closer'.
# Must be one of the following options:
#   - bad_frames_only :: Attempts short-term loop closure ...
#   - multi_method :: Iteratively run multiple loop closure ...
#   - vxl_homography_guided
feature_tracker:core:loop_closer:type = vxl_homography_guided

# Algorithm to use for 'feature_tracker'.
# Must be one of the following options:
#   - core
feature_tracker:type = core
```

```
maptk_track_features -o my_tracker.conf
```

```
maptk_analyze_tracks -c my_analyze.conf
```



Green: new tracks
Blue: active tracks
Purple: terminating tracks
Orange: untracked features

VIBRANT

Motion Detection and Tracking Libraries

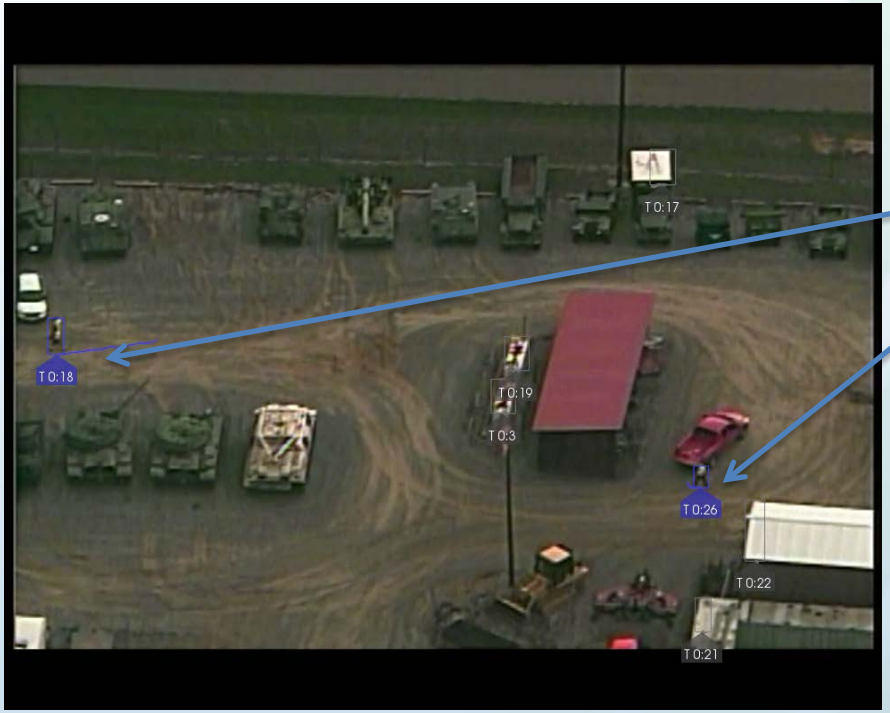
Stabilized video to account for platform motion

Refined geo-registration of pixels based on metadata and stabilization

Geo-registered object tracks

Tracks soft-assigned to known object classes

Stabilization → Geo-registration → Tracking → Track classification



Person Tracks

Developed as part of DARPA projects as the basis for automatic motion based video analytics.

- Patterns of Life
- Event and Activity Detection
- Querying and Alerting

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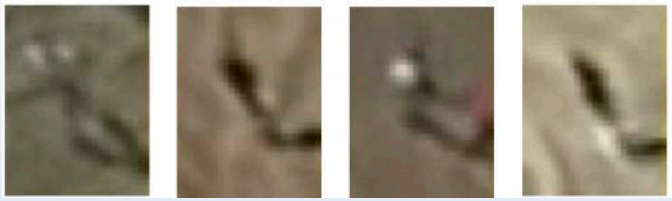
VIBRANT Challenges

Human Appearance in Low Resolution Videos

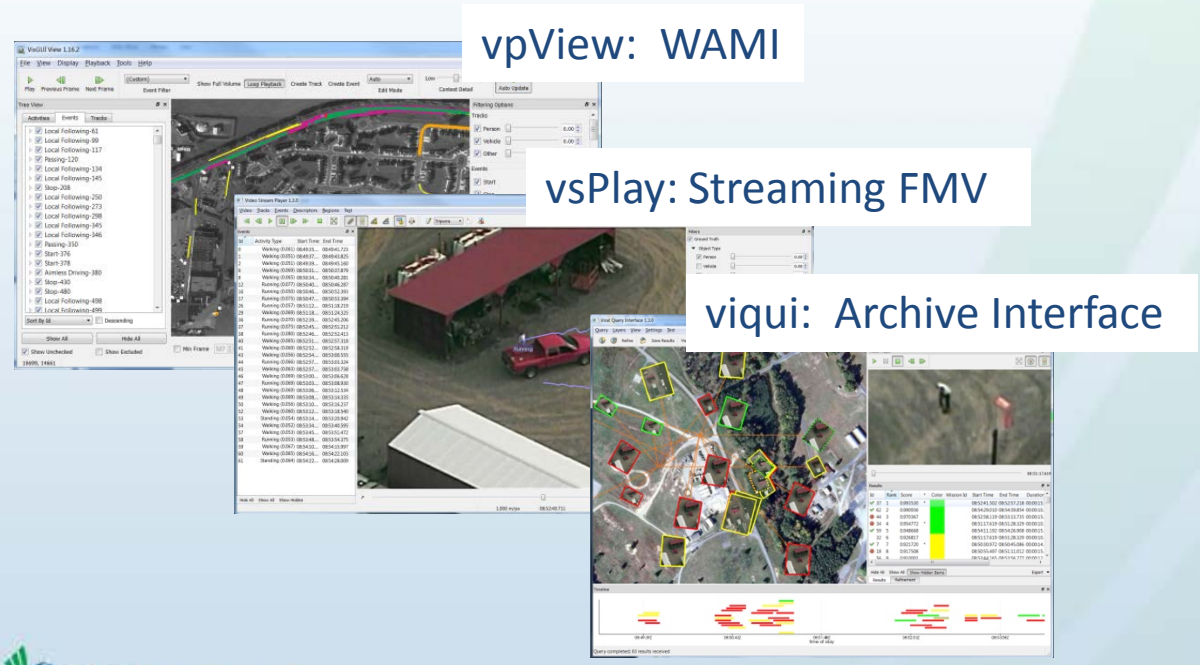


Vehicle and person detection and classification in low resolution full motion and stationary videos.

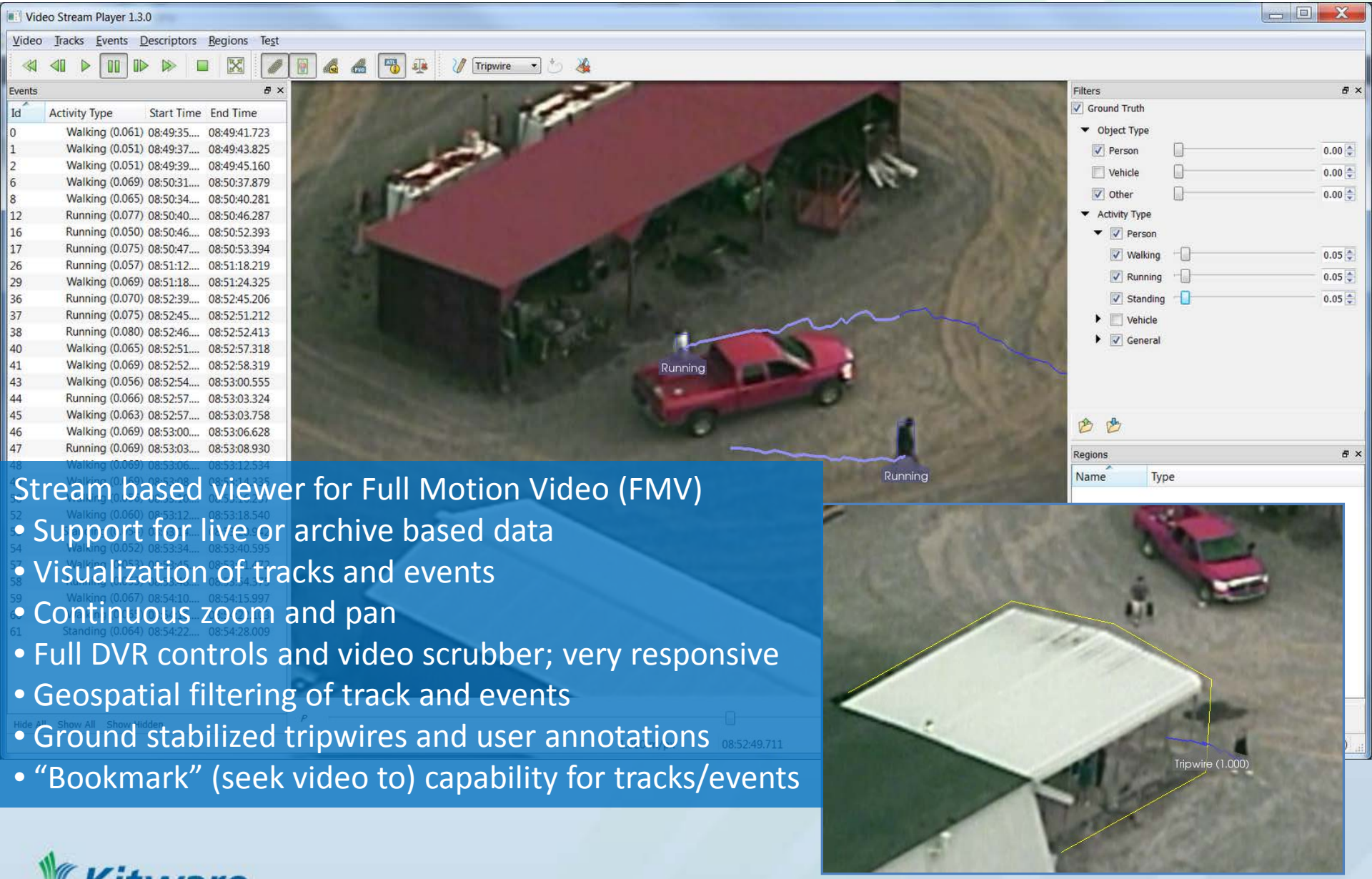
VIVIA – An Open Source GUI Toolkit for Video Exploitation Visualization

Suite of tools built on a shared toolkit

- Derived form The Visualization Toolkit (VTK)
  - 2D and 3D computer graphics
  - Information visualization
- GUI's written using Qt
  - Cross-platform support



VsPlay



Stream based viewer for Full Motion Video (FMV)

- Support for live or archive based data
- Visualization of tracks and events
- Continuous zoom and pan
- Full DVR controls and video scrubber; very responsive
- Geospatial filtering of track and events
- Ground stabilized tripwires and user annotations
- “Bookmark” (seek video to) capability for tracks/events

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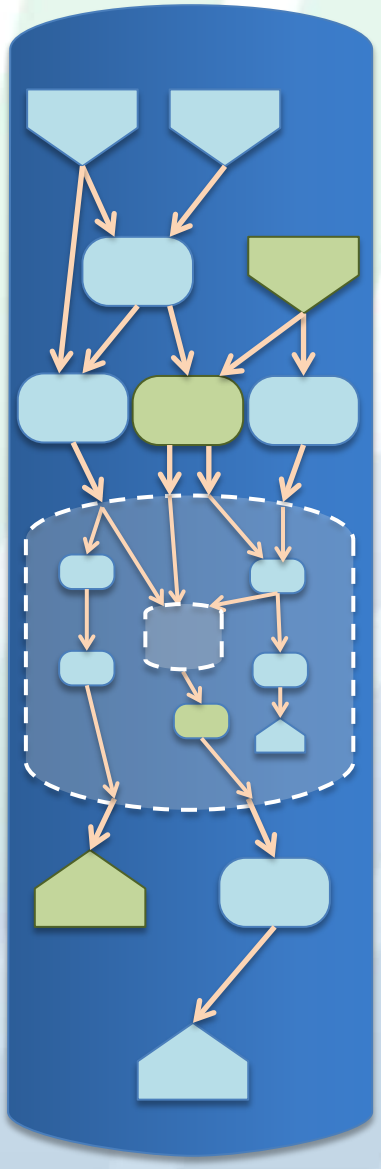
SproKit – A Framework for Streaming Data Processing

- Chains individual processing elements
- Executes a constructed pipeline on streaming data (e.g. video)
- Manages data dependencies, flow, and synchronization
- Distributes and balances processing load over CPU cores
- Provides dynamic construction/configuration via configuration files
- Allows reuse of preconfigured clusters of processes
- Supports algorithms written in C++ and Python
- Extends to custom processes, data types, and schedulers via plugins



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KWIVER & Open Source UAS Toolkits

- Open Source projects, including KWIVER, are the rising tide that raises all boats
- KWIVER can help manage the wide range of available tools and build them into useful video analytics solutions
- KWIVER Components such as MAP-Tk and VIBRANT leverage other Open Source toolkits to provide useful, new capabilities

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