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

- Human Activity Detection (Army RRTO, CTTSO) and Tracking in Wide-Area Video (AFRL)
- Object and Building Recognition by Function (DARPA)
- Detection & Tracking
- Recognition by Function
- Images & Video
- 3D Extraction and Compression
- Content-based Retrieval
- Event & Activity Recognition
- Anomaly Detection
- Normalcy Modeling and Anomaly Detection (DARPA PANDA and PerSEAS)
- Wide-area Motion Imagery Threat Detection and Nodal Analysis (DARPA PerSEAS)
- Football Play Recognition (DARPA CARVE)

- Content-based Video Retrieval by Actions (DARPA VIRAT)
- Complex Event Recognition in Internet Videos (IARPA Aladdin)

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

- 3D model-based video compression (DARPA GRID) and super-resolved 3D reconstruction (DARPA Super 3D)
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.
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
Open Source Building Blocks
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
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

Kitware
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](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

91 Frames → 4494 Frames
Hierarchical SBA

SBA with frame-to-frame tracking only
Homography sequence with loop detected
SBA with loop-closure

Homography-Driven Loop-Closure
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

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

Aerial Video (WAMI & FMV)

Sparse Bundle Adjustment (MAP-Tk)

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

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

3D Super Resolution (DARPA Super 3D)
Using MAP-TK

```plaintext
# 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
```

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

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

Human Appearance in Low Resolution Videos
VIVIA – An Open Source GUI Toolkit for Video Exploitation Visualization

Suite of tools built on a shared toolkit
- Derived from The Visualization Toolkit (VTK)
  - 2D and 3D computer graphics
  - Information visualization
- GUI’s written using Qt
  - Cross-platform support

vpView: WAMI
vsPlay: Streaming FMV
viqui: Archive Interface
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
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
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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