



SightLine
APPLICATIONS

EAN-Video Processing Algorithms

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⚠ CAUTION: Alerts to a potential hazard that may result in personal injury, or an unsafe practice that causes damage to the equipment if not avoided.

ⓘ IMPORTANT: Identifies crucial information that is important to setup and configuration procedures.

📄 *Used to emphasize points or reminds the user of something. Supplementary information that aids in the use or understanding of the equipment or subject that is not critical to system use.*



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1 Software Library Functions

The Video Processing Library is the foundation of all of SightLine Application's OEM products. The firmware is designed to run on SightLine hardware platforms and are licensable for use on a customer's Texas Instrument (TI) DSP based hardware platform.

Video Stabilization and Object Tracking	<p>Removes the jitter (shake) from a video source by its environment or by being on an unstable or moving platform. This vibration or movement can cause the video to appear blurry, specifically at high zoom. The SightLine firmware removes the blur caused by motion and provides a higher quality and stable video output for the operator.</p> <p>Object tracking allows the operator to manually designate an object of interest (a target) in the frame/scene. Once designated, it tracks the object and provides coordinates back to the camera gimbal control, which keeps the object in the field of view.</p>
Moving Object Detection	<p>Identification of objects moving against the background of a frame provides situational cues important to system operators that helps them initiate object tracking. It also assists the performance of the object tracking functions.</p>
Video Enhancement	<p>Enhancement functions improve the quality of the image to optimize the system operator experience. Functions include de-noising, contrast enhancement, sharpening, adding false color, and facilitating digital zoom.</p>
Video Compression	<p>Video compression enables system uses of video over Ethernet by using industry standard compression techniques (h.264 or MJPEG).</p>
Multi-Camera Management	<p>Functions are provided to support multi-camera systems that are common. Picture in Picture displays, stitched images, and blended display are some of the functions available to system operators.</p>

 See the following sections for more detailed information on each of these functions.



2 Video Stabilization and Object Tracking

2.1 Video Stabilization

Video stabilization utilizes an estimate of frame-to-frame registration to calculate the adjustment of each frame of video necessary to closely match the previous frame, which compensates for rapid camera movements.

SightLine firmware is engineered for security, commercial and industrial applications for off-the-shelf camera systems that do not provide stabilization. Tunable parameters adjust how rapidly the stabilization adapts back to center, enabling an operator to trade off good stabilization with camera steering lag introduced by stabilization.

The SLA-LIB's video stabilization and object tracking algorithm is a two-step process consisting of frame-to-frame registration followed by target tracking. The registration and tracking algorithms are shown at a high level in [Figure 1](#) and [Figure 2](#).

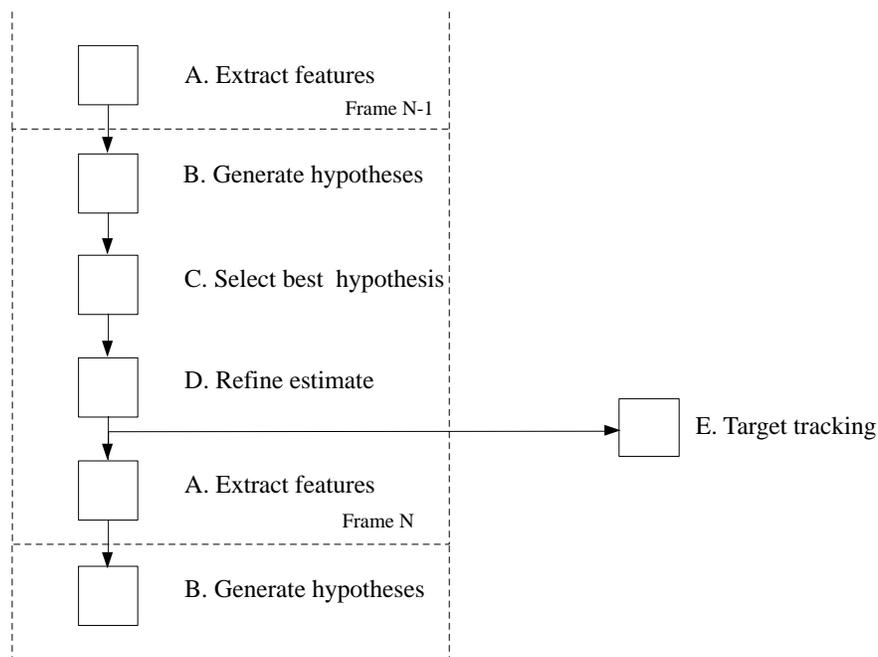


Figure 1: Frame-to-Frame Registration and Tracking Steps

Image registration estimates a frame-to-frame transformation between each video frame and the previous frame by maximizing correlation between control points.

To perform registration of one frame to the next:

- A) A set of features are identified and extracted from the current frame. These features are selected based on their local contrast to ensure that they will be robustly identified in the next frame.
- B) Using a subset of these features, the next frame is examined. A set of candidate hypotheses with quantized parameters (transformations in Δx , Δy , $\Delta \theta$, and Δscale) are generated based on the degree of similarity (correlation) between the transformed subset of features and the image data in the next frame at the corresponding location.



- C) Each hypothesis is then evaluated using the complete set of extracted features to select the best matching transformation.
- D) The transformation parameters are interpolated to achieve a non-quantized estimate of the true transformation. The estimated transformation is used for several purposes (described below) including:
- Scene Steering
 - Stabilization
 - Object Tracking with small gate
 - Moving Target Detection
 - Denoising

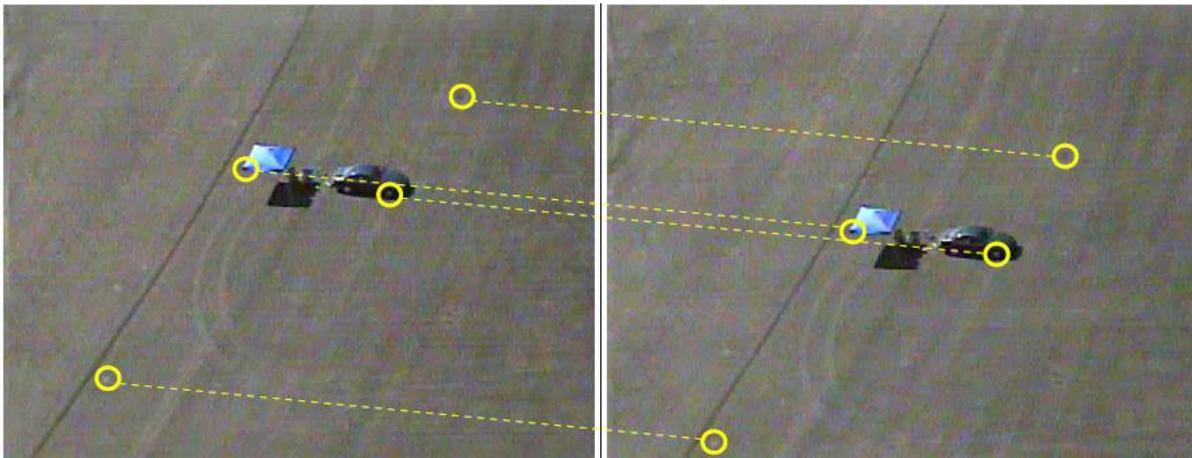


Figure 2: Matching Features Between Frame N-1 and Frame N

2.2 Object Tracking

Allows an operator to designate a region of interest on the active video as a target. The system uses that region of pixels as a template and attempts to locate the template on subsequent frames of video.

Object Tracking uses the frame-to-frame transformation in conjunction with the object's estimated velocity and previous position to estimate the position of the object in the current frame. Correlation-based template matching of long term features is used to locate the object position in the current frame.

Use of the registration transformation improves tracking speed and robustness by allowing the correlation search gate to be small. This means that the object is only sought in a narrow zone around where it is expected to be located.

The registration template also permits the estimation of object velocity (in camera pixel coordinates). This estimate is used to reacquire lost tracking lock when an object is temporarily obscured, e.g., when a vehicle drives past a tree that blocks the vehicle from view.

2.3 Scene Steering

Scene steering is the process of steering the camera system to hold the scene still in the camera. This operation is enabled by the calculated registration transformation, which is an output from the SightLine system.



3 Moving Object Detection

3.1 MTD Moving Target Detection

MTD subtracts the current frame from the forward-transformed previous frame (or from the n th-previous frame).

Processed differences between these frames, indicating the presence of moving objects, are collected and examined.

Blobs of moving pixels that exist for several frames are determined to be valid objects. The correlation-based object tracker then engages to follow them. These autonomously designated targets can be selected by an operator. They can also be manually designated as a target.



Figure 3: MTD Moving Target Detection

3.2 MTD Motion Assist

MTD utilizes the same underlying information collected by Moving Target Detection.

Autonomously-designated targets are used to improve tracking of operator-designated objects.

When tracking of an operator-designated object fails, the system looks for an autonomously-designated target in the immediate vicinity and uses this target as a replacement for the failed track.



Figure 4: MTD Motion Assist

3.3 MTI Moving Target Indication

MTI is similar to MTD but is used to locate moving objects down to a few pixels in size. MTI uses a higher order registration transformation match that finds a precise frame-to-frame fit in scenarios where the camera is moving. This requires more processing bandwidth, but allows the system to find smaller and slower moving objects.



4 Video Enhancement

Video Enhancement is a collection of several well-known algorithms that work together to improve output video.

4.1 Denoising

Denoising performs registered frame-averaging to reduce sensor noise. Averaging multiple frames of video will tend to reduce the amplitude of noise in the output image by a factor of the square root of n , when n frames are averaged. However, if there is frame-to-frame motion the output image exhibits motion-induced blur. Transforming the n frames forward to match the current frame eliminates this blur and permits noise reduction even in the presence of camera motion.

4.2 Edge Sharpening

Edge sharpening applies a small linear filter to the image that enhances the visibility of edges and small details in an image. Since it tends to emphasize sensor noise it is often used in conjunction with Denoising.

4.3 Contrast Enhancement

Contrast Enhancement is any method that increases the contrast of low contrast regions of an image and preserves contrast in other areas. SightLine uses two algorithms that provide contrast enhancement:

- Local Area Processing (LAP) is a large linear filter that emphasizes small features and dampens slightly large features. It is similar to edge sharpening but utilizes a larger convolution kernel. Its behavior is to perform local contrast enhancement, and results in imagery similar to that achieved by CLAHE.
- Contrast Limited Adaptive Histogram Equalization (CLAHE) increases the contrast of low-contrast regions of an image or video without adversely affecting the contrast of high-contrast regions.



Figure 5: CLAHE

- False Color is a method commonly used by infrared camera manufacturers. The grayscale intensity of the input image is passed through one of several operator-selectable lookup tables to provide color information to augment the color input. For example, the intensity range (black/gray/white) may be mapped to the color spectrum (red/yellow/violet), or to any other sequence of colors.
- Digital Zoom is a method to allow the operator to zoom into the input image. It uses a bilinear interpolation algorithm.



5 Video Compression

SightLine offers H.264 and MJPEG encoding formats to stream the compressed video streams over an Ethernet connection. H.264 encoded video is delivered as elementary stream within an MPEG-2 Transport Stream (TS). Handling of KLV metadata is generated in accordance with MISB standards 0102.10, 0601.7, 0603.2, 0604.3, and 0903.3. KLV metadata is also delivered as an elementary stream with the MPEG2 TS.

6 Multi Camera Management

6.1 Picture-in-Picture (PiP)

PiP displays a smaller secondary video feed superimposed in the corner of the primary video feed. This feature is used in some televisions when selecting channels. Other multi-channel display modes include:

- 2-up: Displays two video feeds of $\frac{1}{2}$ normal size in a side-by-side configuration
- 4-up: Displays four video feeds of $\frac{1}{2}$ normal side in grid configuration

6.2 Panoramic Stitching

Panoramic Stitching is similar to the 2-up display mode. It supports a user-configurable overlap between the two input feeds. The two feeds are displayed side-by-side. The overlapping region is blended to reduce the visibility of the seam between the two video feeds. This is achieved using alpha blending where the alpha term varies from 0.0 to 1.0 along the width of the overlapping region.

The digital zoom feature described in Contrast Enhancement allows the operator to visualize a rectangle within the virtual double-width video feed.

6.3 Image Blending

Image Blending allows the operator to control blending between two video inputs with a single global alpha parameter. This is equivalent to the standard [alpha blending](#) computer graphics technique with the alpha term (SRC_A) taking a constant (operator-defined) value for the entire image. The parameter allows various mixing between the two input images: alpha=0.0 implies only input image 1, alpha=1.0 implies only input image 2, and alpha=0.5 implies an 50/50 average of the two images.

The following additional variations use lookup tables and are intended at blending imagery from visible and infrared cameras:

- Thermal Blend applies blending – alpha term is set to select 80% of the visible and 20% of the infrared – to the luminance channel and creates color by applying a false-color lookup table to the infrared data. This creates an output stream that predominantly shows the visible input with colored highlights indicating hot objects in the infrared input stream.
- Night Blend uses a lookup table to threshold the visible input and utilizes the result as the per-pixel alpha term for alpha blending. This creates an output stream that shows the infrared input with bright highlights indicating bright regions of the visible input. At night these bright regions correspond to street lights, headlights, etc. and are superimposed on the otherwise unchanged infrared input.



7 Questions and Additional Support

If you require additional support, please contact [Technical Support](#). Additional support, documentation and Engineering Application Notes (EANs) can be found on the Support pages of the SightLine Applications [website](#).