# SAPERA PROCESSING

## Sapera Vision Software

![TELEDYNE logo]

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# Sapera Processing
## Sapera Vision Software

# Easy-to-use, versatile software for Industrial Imaging

As the core development platform within **Teledyne DALSA's Sapera™ Vision Software** family, **Sapera Processing** includes image processing and AI tools to provide developers with the critical functionality to design, develop and deploy high-performance machine vision systems.

## Key Features

### Performance
- Cost effective packaging for machine vision applications combines powerful image-processing and analysis functions
- Delivers maximum performance using MMX, SSE and SSE2 supports both 32-bit and 64-bit Microsoft Windows® platform
- MCO: based on Intel's latest instruction set technology and supports for multi-core CPUs

### Flexibility
- Hardware independence for maximum flexibility
- High-level C++ classes and .NET™ support to simplify application development on Windows® 10 and 11 and platforms

### Scalability
- Application specific tools perform Search, 1D/2D/Barcode decoding, OCR, Color, Blob analysis, 3D Measurement and AI.
- Modular components help reduce application footprint and deployment costs
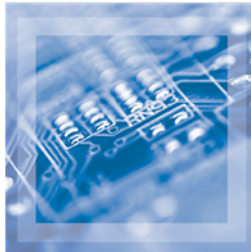
Sapera™ Processing offers quick and easy access to software functions to manage image memory and facilitate image processing and analysis tasks. Sapera Processing includes a suite of image processing tools including a highly advanced, yet cost effective, Search package that supports both area and edge-based pattern finding, a versatile Barcode tool for both 1-D and 2-D decoding, Blob Analysis capability for defect detection and Calibration tool for lens correction, a suite of 2D/3D measurement tools and an inference engine for AI models from Astrocyte.

## Sapera Processing Overview

**Image Processing and Analysis**

| Search Tool Geometric and Area | Barcode Tool | OCR | Color Tool | Measurement Tool |
|---|---|---|---|---|
| Image Processing Primitive Functions | Blob Analysis Tool | Calibration Tool | 3D Tool | AI Tool |

### IMAGE PROCESSING SDK

Sapera Processing delivers a full suite of software libraries for image processing. The Sapera Processing feature set includes program portability, functions for display management and easy-to-use example applications. Machine vision applications using Sapera Processing can be developed with unmanaged C++ and C# on Microsoft Windows® 7 and 10, (32/64-bit) platforms. These applications can be developed using Microsoft Visual Studio.

### POINT-AND-CLICK IMAGE PROCESSING EVALUATION TOOL

Sapera Architect—is a GUI based application that allows construction of sequence of operations to perform image processing tasks without writing a single line of code. Its intuitive interface allows users to gain insight into inter-relationship between various parameters by adjusting them in real-time. Sapera Architect permits users to obtain a fine balance between speed, accuracy and repeatability of the results by providing information about the execution time of a function or a sequence of operations.

# Image Processing and Analysis Libraries

Sapera Processing includes a suite of image processing tools including a highly advanced, yet cost effective, geometric Search package that supports both area and edge-based pattern finding, a versatile Barcode tool for both 1-D and 2-D decoding, Blob Analysis and Calibration tools.

## IMAGE PROCESSING PRIMITIVES

Sapera Processing provides a series of highly optimized basic image processing functions categorized in several groups including:

## FILTERS
- Generalized convolution 1-D, 2-D
- Low and high-pass filters 1-D, 2-D
- Laplacian
- Gaussian
- Compass: eight-direction edge enhancement
- Gradient: magnitude and phase
- Edge and line detection

## GEOMETRY
- Flipping: horizontal, vertical, transpose and 90-degree rotation
- Rotation by an arbitrary angle
- Translation: pan and scroll at integer or sub-pixel precision
- Zooming by image dimensions or scaling factor
- Shearing: horizontal and vertical
- Affine and perspective calibration and warping
- Polar coordinate transform

## MEASUREMENT
- Basic statistics such as histogram, pixel count, mean, variance, minimum and maximum based on the pixel values of an image
- Horizontal and vertical projections
- Histogram processing: smoothing and peak detection
- Normalized and non-normalized cross-correlation
- Sum-of-difference
- Vector difference
- Variance filter (variance computed on each pixel's neighborhood)
- Pixel sampling on a path (with sub-pixel accuracy)
- Linear and circular regression

## MORPHOLOGY
- Binary dilation, erosion, opening, closing and median on 1 or 8-bit images
- Grayscale dilation, erosion, opening, closing and median on 8 or 16-bit images
- Labeled dilation and erosion
- Outline, skeleton, thinning and thickening filters
- Conditional binary dilation
- Morphological gradient
- Rank filter
- Hit-or-miss transform
- Top-hat transform

## POINT-TO-POINT
- Arithmetic operations on one or two images: add, subtract, multiply, divide, absolute subtract, minimum, maximum and user-defined expression
- Logical operations on one or two images: AND, OR and XOR
- Fixed and adaptive thresholding
- Gaussian noise generation
- Lookup table transformation
- Contrast equalization manual or histogram-based
- Segmentation
- Distance map
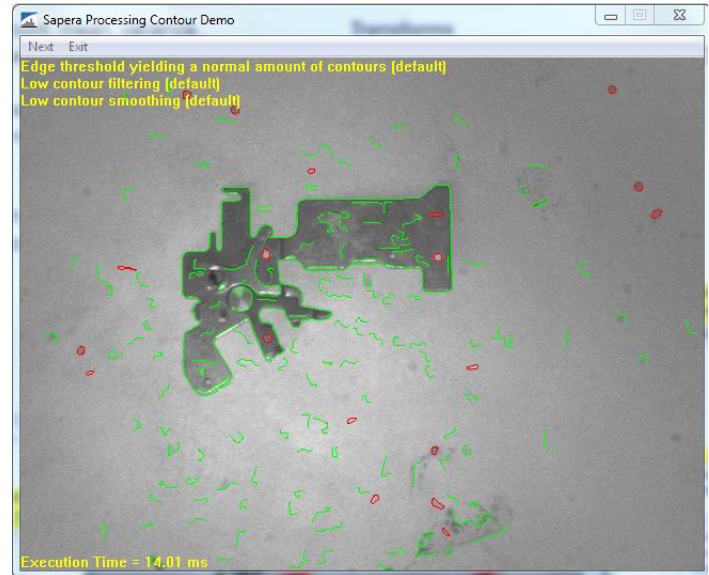




- Directional edge detection
- K-means clustering
- Local peak detection
- Region-growing
- Watershed transform
- Zero-crossing detection

## TRANSFORMS
- Spectral transforms: FFT (Fourier), DCT (Cosine), DHT (Hadamard)
- Hough transform: direct and reverse

## MISCELLANEOUS FEATURES:
- Sub-pixel edge crossing on a path
- Contour Following tool
- Frame averaging (true and recursive)

# Barcode/Decoding

Sapera Processing offers two different barcode reading algorithms. Quick Barcode is the preferred tool as it allows very high speed reading while being tolerant to noise, occlusion, and geometric distortions.

However, in cases of highly degraded conditions, Standard Barcode might be a good alternative to Quick Barcode. Standard Barcode provides more flexibility in adjusting parameters as well as providing the ability to create golden models for increased robustness.

As part of the barcode tool, Sapera Processing also offers Print Quality Grading. Grading is usually used to verify the quality of 1D and 2D marks.

## QUICK BARCODE
- Fast and robust decoding of most 1D barcode and 2D matrix code symbologies
    - 1D Symbologies: Code 11, 32, 39, 93, 128, 2 of 5 (Interleaved, Matrix, Straight, IATA, NEC Hong Kong), UPC-A/E, EAN-8/13, GS1 Databar, BC412, Pharmacode, Plessey, Telepen, Trioptic, Postal (Postnet, Planet, Intelligent Mail, Royal Mail)
    - 2D symbologies: Data matrix (ECC200), QR Code, Micro QR Code, PDF417, MicroPDF417, Composite (CC-A/B/C), Codablock F, Aztec, Han Xin, MaxiCode
- Quickly and accurately reads printed, stamped, or etched 1D/2D codes
- Reads poorly-printed, low-contrast, noisy, and warped barcodes
- Reliably reads Data Matrix and QR codes with damaged or missing finder patterns
- Decodes multiple barcodes in the same image ROI
- Resolution
    - 1D Codes: Min. distance between bars = 1.5 pixels (2.5 px for low contrast)
                     Min. bar width = 1.5 pixels (2.5 px for low contrast)
    - 2D Codes: Min. cell size = 2 × 2 pixels
                     Min. dot diameter = 2 pixels
- Two licensing options:
    - "Quick Barcode" decodes the majority of codes.
    - "Quick Barcode DPM" offers greater robustness for decoding marks etched or dot peened on plastic or metallic surfaces.

## STANDARD BARCODE
- Supports 1D and 2D industry standards (includes the majority of standards suported by Quick Barcode)
- High tolerance for noisy and poorly-illuminated images
- Asian native language and unicode output
- Includes Barcode Studio to set up barcode reading via Learning Assistant to help adjust optimal parameters
- Supports model training on Data Matrix for increased robustness handling highly-damaged images
- Two licensing options:
    - "Standard Barcode" supports a wide range of codes and options and does not require training.
    - "Advanced Barcode" offers the ability to train a Data Matrix model for increasing robustness while supporting the same codes and options as "Standard Barcode".

# OCR (Optical Character Recognition)

A highly integrated optical character recognition tool that is scale and contrast invariant, the OCR tool supports both solid and dot matrix fonts and can be trained on user fonts. Its robust recognition technique is optimized for speed and accuracy. The ability of the OCR tool to operate on significantly degraded images makes it ideal for repetitive inspection tasks performed in the pharmaceutical, electronics and semiconductor industries.

## FEATURES:
- User trainable font set
- Supports solid and dot-matrix fonts including italic fonts
- Tolerates non-linear background variations
- Supports training of touching characters
- Two algorithms: binary-based (speed), greyscale-based (tolerant to extreme noise).
- Resolution level adjustment (robustness versus speed)
- Rotation, scale and aspect ratio invariance.
- Multi-string support (reads more than one string of characters in single execution).
- Support of Asian characters (output in Unicode mode).
- Adjustable effort level
- Alphabetical font sorting
- Automatic string detection
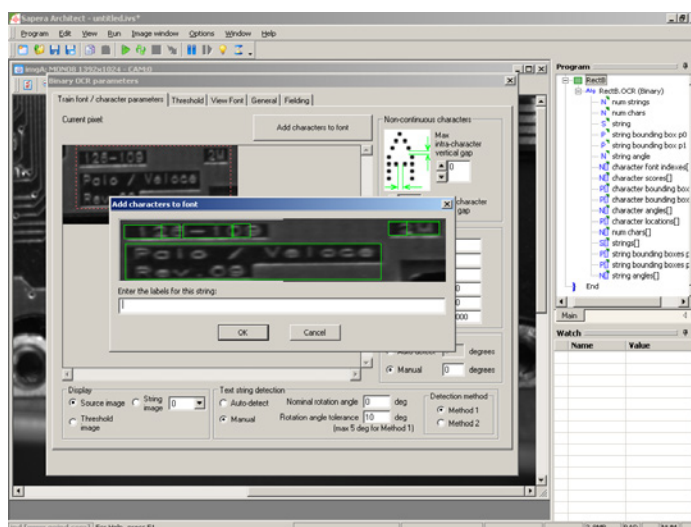


*Sapera OCR Tool support user trainable fonts.*
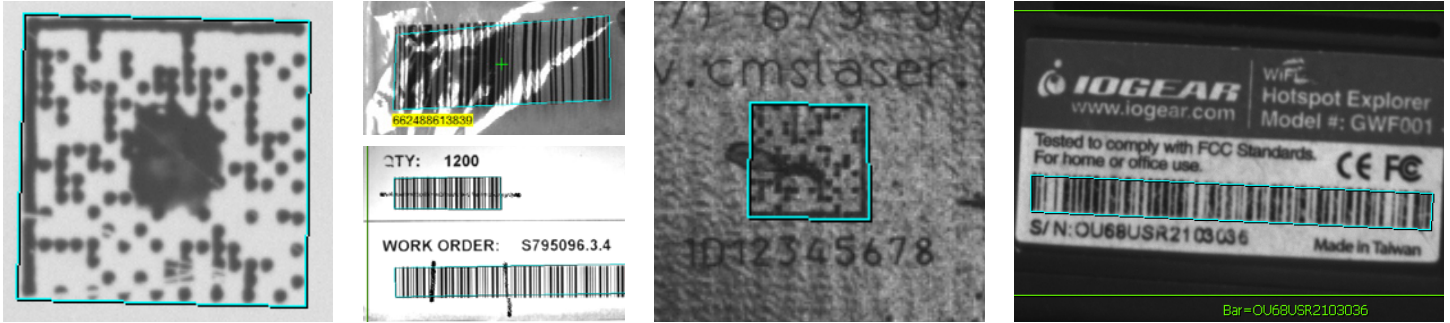
*Barcodes (left to right): damaged, warped, damaged, worn, and poor contrast.*

# Search (Pattern Finding Tool)

A crucial performance component of Sapera Processing is a highly advanced Search tool that quickly and accurately recognizes multiple objects and patterns, regardless of orientation and scale. This high-level image analysis tool can locate arbitrary user-specified
models in a target image at very high speeds at resolutions of up to 1/50th of a pixel. Designed to work under poor and uneven lighting conditions, the Search tool's fast, robust and accurate algorithms are well suited for demanding alignment applications in semiconductor and electronics manufacturing.

### EDGE-BASED ALGORITHM FEATURES:
• Algorithm based on object contours
• Rotation, scale and contrast independent
• Tolerant to extensive occlusion
• Great for contrast reversal
• Great for overlapping and touching objects
• User-selectable model contours
• Position accuracy up to 1/50th pixel
• Angle accuracy up to 1/80th degree

### AREA-BASED ALGORITHM FEATURES:
• Algorithm based on normalized cross-correlation (NCC)
• Extremely fast when no rotation and scale is involved
• Tolerant to extreme noise
• Position accuracy up to 1/25th pixel
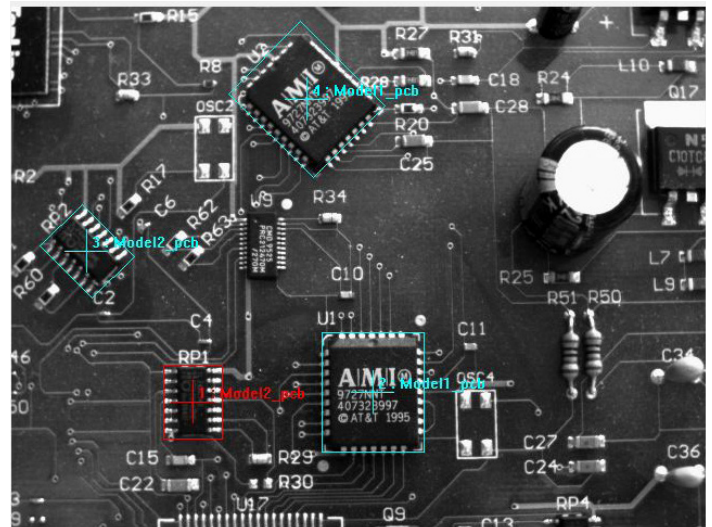


*Sapera Search Tool supports rotation independent, simultaneous multiple target detection.*

# Calibration

Calibration tool provides functions to compensate for geometrical distortions caused by camera lens, camera positioning or any other kind of arbitrary image distortion.
• Correction of perspective, radial (barrel or pin-cushion), combined or arbitrary distortions
• Automated calibration:
• Supported targets: checkerboard, grid of lines or dots, and randomly distributed points
• Fully automated detection of target shading (black/white or white/black), rotation, scaling, grid size and cell spacing
• Optional assisted calibration by specifying approximate target description
• Manual calibration: provide exact image and world grids
• Restoration of full image, single point or vector of points
• Forward (image to world) or reverse (world to image) restoration
• Different restoration modes to adjust speed versus accuracy

# Color Tool

Sapera Processing features an advanced color tool for machine vision that delivers speed, accuracy and flexibility to applications that require color inspection. Ideal for sorting, verification and inspection in food, packaging, print, textile and electronics inspection, this powerful tool supports multiple color spaces such as HSI, CIELAB, RGB, and YUV and can perform color classification in native color space. With built-in support for color calibration, user trainable color classifier, Delat-E measurement and lookup table operations, the Sapera Processing Color tool augments the performance of Sapera Processing image processing and analysis libraries.
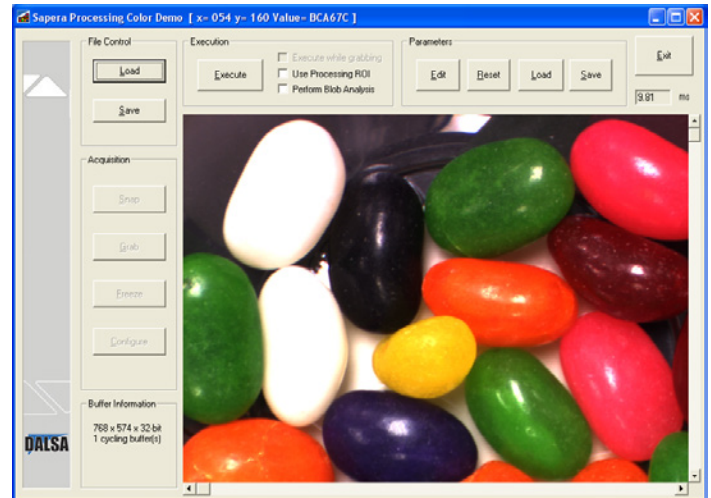


**Sapera Processing Color Demo**
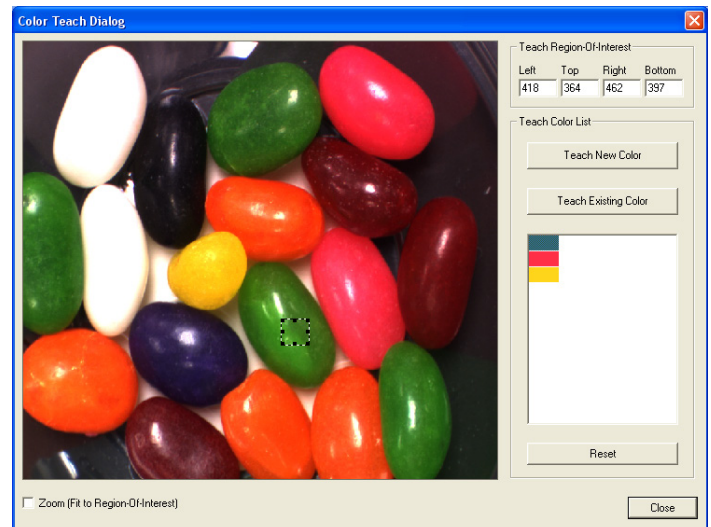


**Training**
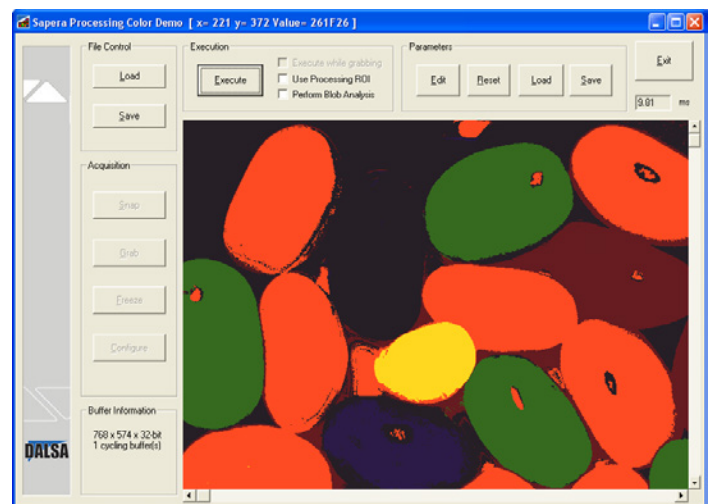


**Classification**

# Blob Analysis

Blob analysis allows for the separating (segmenting) of objects in a scene from the background and then computes a series of geometric and grayscale features. Blob analysis is ideal for defect detection in the electronic and semiconductor industries.
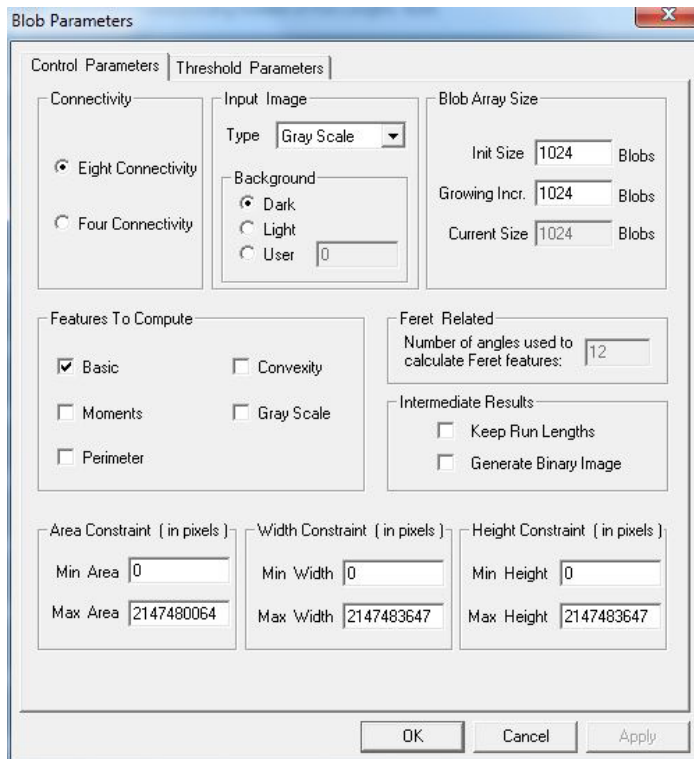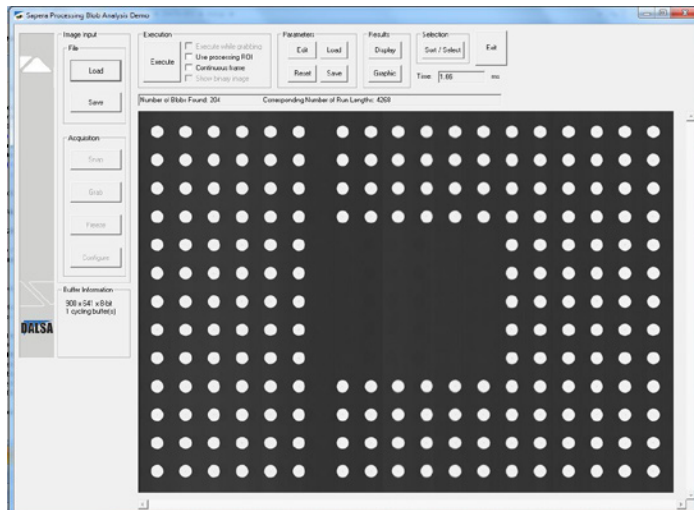




**TOOL FEATURES:**

- Supports 1-bit, 8-bit, 16-bit, binary or grayscale input
- Supports infinite frame size when using line scan cameras
- Supports hardware accelerated blob analysis operations
- Spatial and grayscale blob features include:
  - Blob centroid, area, and perimeter length
  - Bounding box location and size, number of holes
  - Best-fitting oriented ellipse with axes lengths
  - Blob roundness and elongation
  - Convex area and solidity (ratio of net area to convex area)
  - Feret diameters, bounding box location, size and orientation
  - External and internal perimeter points, filled area
  - Minimum, maximum, standard deviation of all pixels
  - Gray scale centroid
  - Sorting and blob selection based on calculated feature
  - Robust automatic threshold algorithms
  - Optional output of RLE (Run-Length-Encoding) for user-defined feature calculations
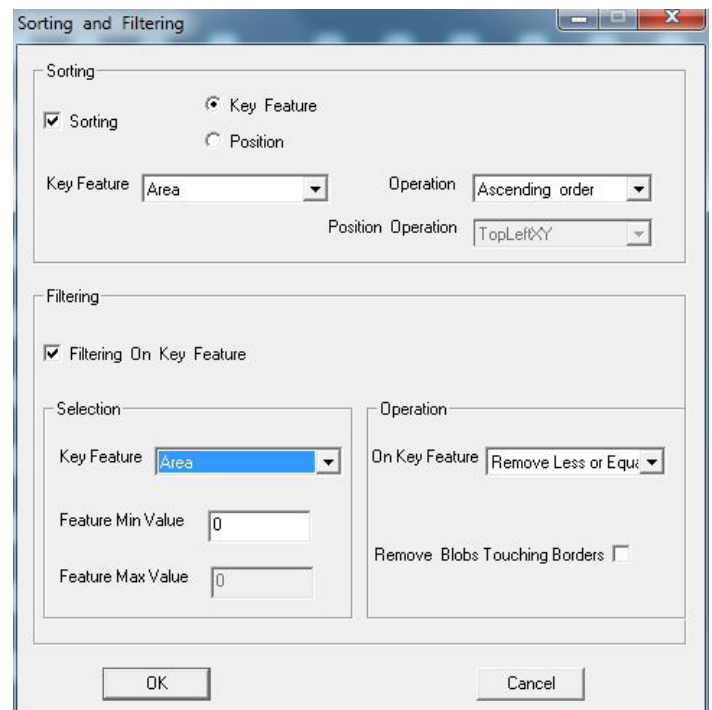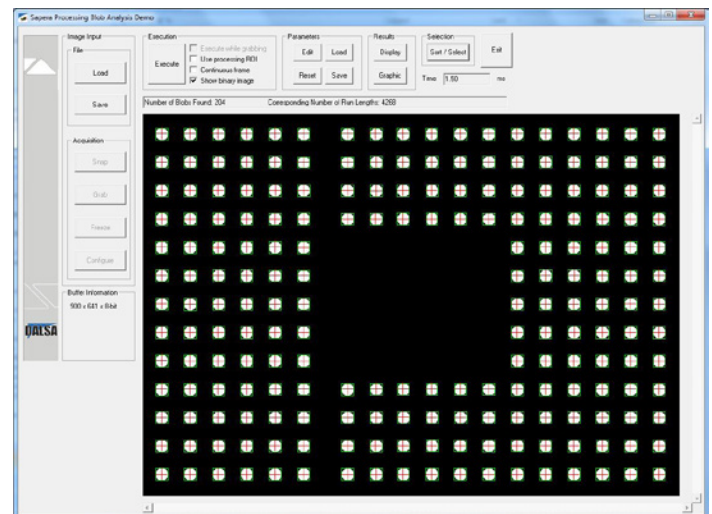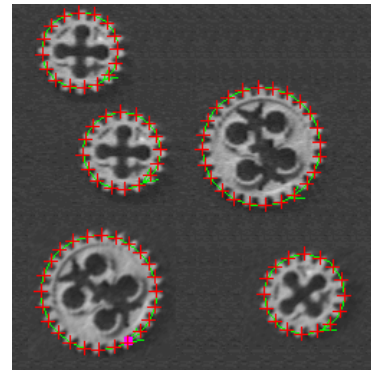
# Measurement Tool

## KEY FEATURES:
- Highly optimized execution
- Automatic simultaneous multiple measurements
- Sub-pixel Accuracy
- Measurement statistics for distances and angles.
- Built-in calibration tools ensure accurate real-world measurements
- Extensive set of markers include single or multiple points, lines, arcs and circles
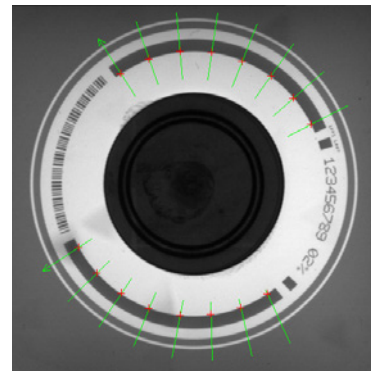
Sapera Processing's Measurement Tool is a video metrology tool for machine vision inspection applications including positioning, identification, and guidance. The measurement tool features a wide selection of image markers to facilitate multiple simultaneous measurements from one or more selected paths including point, line, polyline, arc, circle, spoke, and many more. The highly accurate results are computed with sub-pixel accuracy and can be combined with Sapera Processing's calibration tool to obtain consistent and accurate measurements.
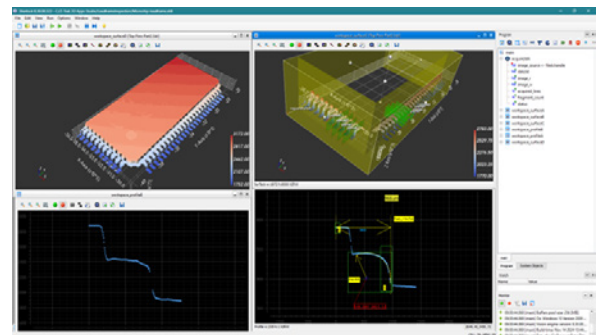
## SPECIFICATIONS:
- **Image acquisition**
  - Supports 8, 10, 12-bit images
  - Supports area and line-scan cameras

- **Accuracy**
  - Sub-pixel accuracy
  - Corrects for lens, perspective and arbitrary distortion

- **Measurements**
  - Distance
  - Radii
  - Diameter
  - Angle
  - Width
  - Intersections
  - Circularity
  - Straightness
  - Markers:
  - Point, Line, Polyline, Arc, Circle, Rake, Spoke, Bullseye

# 3D Tool

The 3D Tool is a suite of 3D processing/analysis functions specifically designed for Teledyne's Z-Trak laser profilers. This internal library forms the foundation of the **Z-Trak 3D Apps Studio**. For more details, please visit:
www.teledynevisionsolutions.com/z-trak-3d-apps-studio

If you need direct access to the 3D Tool at the Sapera Processing API level, please contact Teledyne Sales.



*Multiple measurements on circular path.*



*Multiple Measurements using Partial Spoke.*
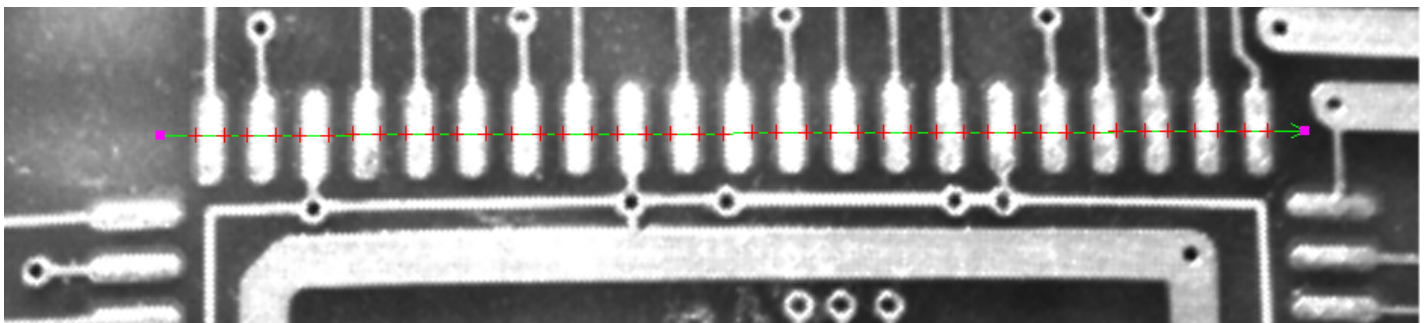




*Multiple Measurements across a line path.*

# AI Tool

Sapera Processing includes a series of classes to perform AI inference on models generated by Astrocyte™ (available only with Sapera AI license).



- Performs inference on video input based on the loaded model. Inference consists in executing an AI model (i.e. a trained neural network) to a stream of input images in order to produce results such class names, bounding boxes, labeled images, etc.
- Allows loading a model file exported from the Astrocyte™ AI training tool.
- Supports the following AI architectures:

## CLASSIFICATION

Classification is a generic classifier for identifying the class of an image. It is used in applications where multiple class identification is required. For example, it can be used to identify several classes of defects in industrial inspection. It can also train in the field using continual learning.

## ANOMALY DETECTION
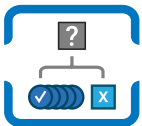
Anomaly detection is a binary classifier (good/bad) trained on "good" images only. It is used in defect inspection where simply finding defects is sufficient (no need to classify defects). It is also useful on imbalanced datasets where many "good" images and a few "bad" images are available. It does not require manual graphical annotations, making it very practical on large datasets.

## OBJECT DETECTION

Object detection is an all-in-one localizer and classifier. It finds the location and the orientation of an object in an image and classifies the object. orientation of objects is important. For example, it can be used to provide the location and class of defects in industrial inspection.

## SEGMENTATION

A pixel-wise classifier, segmentation associates each image pixel with a class. Connected pixels of the same class create identifiable regions in the image. Segmentation is used in applications where the size and/or shape of objects are required. For example, it can be used to provide location, class, and shape of defects in industrial inspection.

- One class per architecture with functions to access specific types of results.
- Access to detailed model properties.
- Generate heatmaps at runtime for finding location and shape of objects
- Continual learning (also known as Lifelong Learning) in classification. Allows learning from a few extra image samples at runtime to add new classes or improve accuracy on existing classes.
- Object Detection with angle (also known as rotated bounding boxes)
- Automatic internal pre-processing and post-processing for adapting to input images of various size and format.
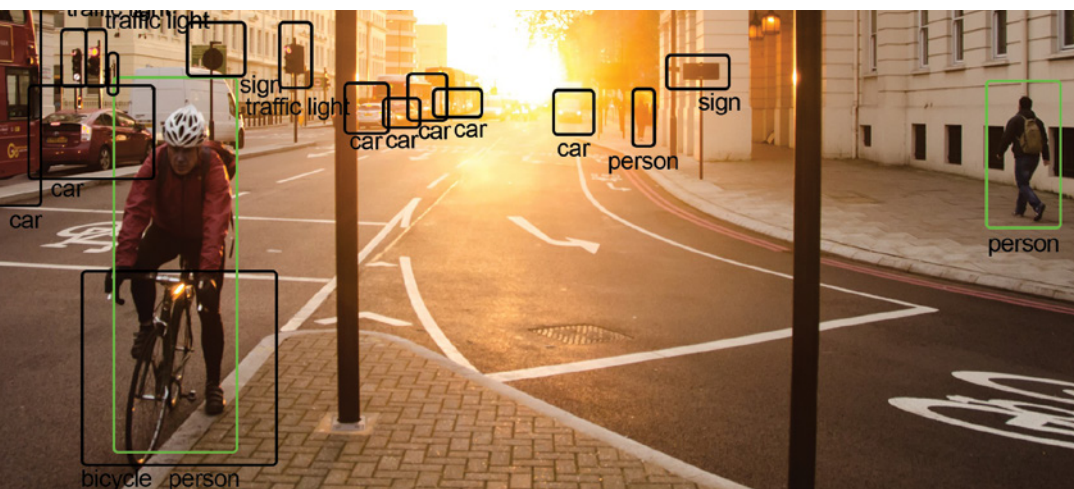- Selection of execution on GPU or CPU.
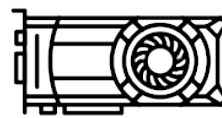


- Integrates well with other tools such as blob analysis for combining AI with traditional image processing for a complete solution.

# Sapera Processing
## Part of a Software Development Kit

**TELEDYNE**

Our latest Sapera™ Vision Software suite delivers a new AI module, giving you the ability to train neural networks with multiple deep learning architectures. Building on Sapera's field proven image acquisition, control, processing and analysis functions, it empowers you to to design, develop and deploy high-performance machine vision applications.

The Sapera AI SDK contains essential core development modules plus AI runtimes and a dedicated training application (Astrocyte) with a highly flexible graphical user interface that allows you to easily use your own images to build and train models to use at runtime.

**Sapera Vision Software Suite**

- Sapera LT
- Sapera Processing
- Astrocyte™

# Sapera™ LT
## Acquisition and Control Libraries

Sapera LT is an image acquisition and control SDK for Teledyne DALSA'S cameras and frame grabbers. Sapera LT supports image acquisition from devices based on standards including 2D/3D GigE Vision™, CameraLink® and CameraLink HS™. Free with Teledyne DALSA Hardware. Includes CamExpert GUI for configuring cameras.

# Sapera Processing
## Image Processing and AI Libraries

The core development platform includes over 400 image processing primitive and industrial strength image analysis tools such as pattern finding, 1D and 2D barcode and OCR tools for part identification and detection, color processing tool, separation and measurement applications, blob analysis tool and inspection metrology tool for real-world 2D/3D dimensional measurements, and new Artificial intelligence (AI) inference based on models imported from our Astrocyte training tool.

# Astrocyte™
## AI Training Graphical Tool

Astrocyte is an application based on artificial intelligence dedicated to training neural networks on 2D images for various applications. Through a highly flexible graphical user interface users can bring in their own image samples and train neural networks to perform classification, object detection, segmentation and noise reduction. Astrocyte allows visualizing and interpreting models for performance/accuracy as well as exporting these models to files for later use at runtime with Sapera Processing.
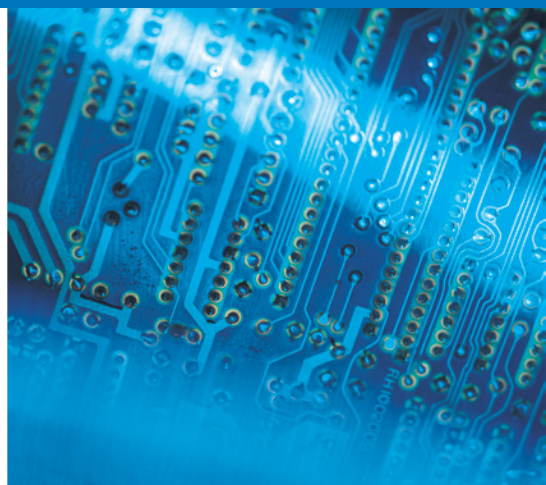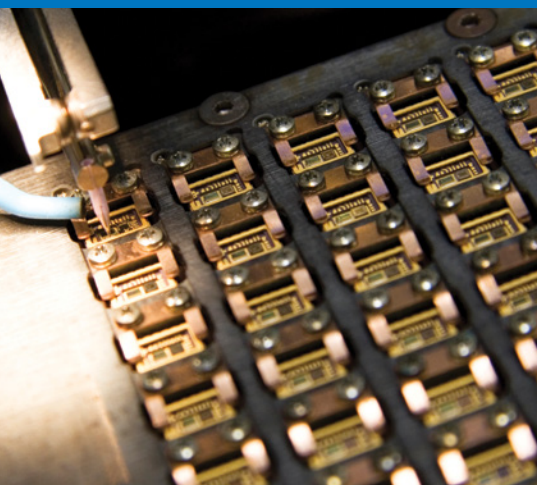
# WE ARE...
# EVERYWHERE
# YOU LOOK

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