Dedicated to machine vision software development

VISION fOr VISION specializes in the development of software for machine vision applications. We create standard and custom vision algorithms, tune them for best performance, adapt them you your platforms and can assemble complete solutions that suit your needs.

If you couldn't find an off-the-shelf package to address your vision problem, this is where VISION fOr VISION can help you by providing consultancy, doing research & development and writing efficient code for you.

We enjoy twenty years of active development of image processing algorithms and machine vision products. Our mission is to help you expand your business in connection to computer vision by providing tailor-made software.

Example projects

- Fast blob analysis for real-time particle detection
- Steel coil 3D inspection for planarity
- Registration of point clouds from range images
- Remote measurement of building vibrations
- Car plate detection and recognition
- Barcode and 2D code readers on mobile phones
- Location of rotated text on a display
- Stereoscopic map analysis for people detection
- Morphing of bitmap and vector images
- Redesign of special barcodes for improved performance

Why would you need us?

Since 2007, VISION fOr VISION helps vision integrators and OEMs achieve optimized results in a cost-effective way. We are responsive and willing to help.

Successful vision projects depend on the quality of the input images, itself relying on the system setup, lighting, optics, cameras and their proper adjustment. This takes good electromechanical integration skills.

On the other hand, they require a good mastering of the numerous image processing and machine learning techniques. Very often, the specificities of the problem need to be exploited, there is no size-fits-all solution. Every new case may require non-standard approaches.

Nothing replaces practice and experience. Trust a well-trained team able to judge at a glance the feasibility of a problem and to suggest an adequate processing pipeline, tailor-made from scratch or from existing resources.

Software libraries

Simple problems can be addressed with configurable, GUI-based software. But practitioners are well aware that in more complex cases, nothing beats traditional programming in terms of flexibility. An alternative is provided by open-source software, from which several image processing packages are available.

Anyway, these are not focused on machine vision applications and are filled with black-box functions, to be taken "as-are". VISION fOr VISION develops and extends **mViz**, a large set of functions designed with machine vision applications in mind. Having full mastery of our code basis, we are in the best position to advise about usage, troubleshoot if needed, or augment the product when needed.

OEM versions of mViz, as well as source code are available on request.

mViz, comprehensive machine vision libraries

For processing, analysis, inspection, guidance and identification

Compatible with the C++, C++.NET, C# and Visual Basic 32/64 bits environments

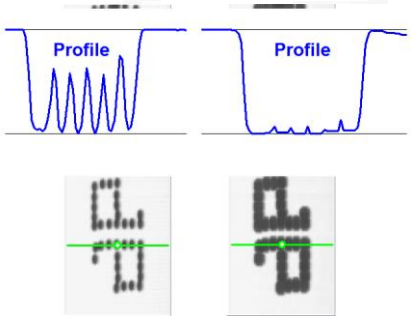
Windows / Linux OSes, x86-64 / *ARM architectures*

mViz is not just "another image processing package". We want full customer satisfaction and we know that the learning curve for a first project can be costly. This is why free consultancy hours are included to help you establish a proof of concept very quickly and at a low risk.

mViz supplies all required functions for processing as well as integration in a user-application with no dependencies and with all needed graphical support. mViz is completely open to coexist with other software and image acquisition means.

mViz covers a broad range of functionality useful in classical machine vision applications as well as specialized OEM projects. mViz is licensed by separate modules or in bundles, run-times per machine, with an attractive pricing scheme. Feature enhancements, porting and special adaptations are possible on request.

Image Processing



The processing functions are used to prepare the image by reducing unwanted nuisances such as noise or blur, or enhance some properties such as connexity of characters, contrast… They usually turn images into other images.

This function set comprises point-to-point operations such as pixel arithmetic, lookup table transforms or shading correction. It also handles geometric transforms like deskewing or size normalization.

Point-to-point arithmetic & logic, grayscale & color transforms, shading correction, convolutions, grayscale morphology, segmentation, geometric transforms, polar unwarping and much more

```
        // Sample code

        // Rotate 30°, scale +20% around the center, with interpolation
        Geometry::Rotate(XY(320, 240), XY(320, 240), 30, 1.2, Source,
Rotated, true);

        // Two points shading correction with Black and White reference
        Operator::Correct(Black, White, Source, Corrected, 0, 255);
```

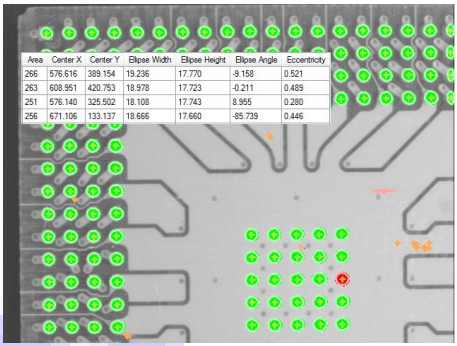
Typical running times

(In milliseconds, 640x480 images, Core i7 @ 3.4 GHz and Core i9 @ 3.5 GHz)

Addition of two images	0.022	0.015
Pixel-wise maximum of two images	0.022	0.012
Pixel-wise greater-or-equal comparison	0.024	0.016
Automatic binarization	0.590	0.520
Two-point shading correction	0.710	0.630
Sobel magnitude	0.150	0.150
Prewitt magnitude	0.150	0.140
Binomial low-pass (3x3)	0.099	0.120
Uniform low-pass (25x25)	1.200	1.100
Sharpening filter (3x3)	0.120	0.120
Uniform high-pass (25x25)	1.300	1.000
User-defined convolution (3x3)	6.000	5.500
User-defined convolution (5x5)	11.000	9.200
Gaussian filter (15x15)	4.300	3.000
Bilateral filter (5x5)	14.00	11.00
Morphological dilation (3x3 square)	0.040	0.096
Morphological opening (7x7 diamond)	0.340	0.600
Morphological top-hat (5x5 octagon)	0.240	0.480
Median filter (7x7)	6.300	5.600
Downsampling (2:1)	0.830	0.660
Upsampling (1:2)	3.100	2.500
Rotation (nearest neighbor)	0.410	0.320
Rotation (bilinear)	1.200	1.200
Polar unwarping (bilinear)	2.600	2.100

Image Analysis

The analysis functions extract condensed information from images or regions in order to characterize and classify 1D or 2D features.



They encompass histogram analysis, straight or curved profile extraction, and blob analysis. When numerical values are obtained, they can be used to compare objects to known references and discriminate between them.

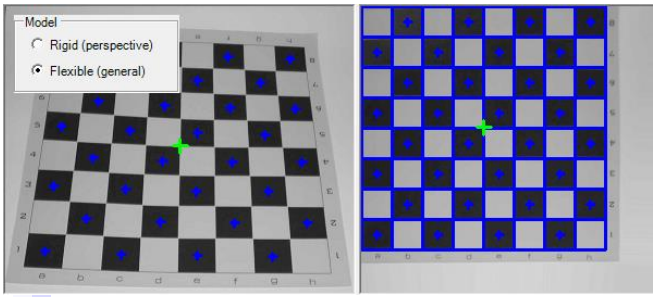
Profile processing, histogram statistics, blob analysis, region masking, contouring, shape fitting, shape features and more

```
// Get the trimmed gray-level mean with 10% trimming
double Mean= Histogram::TrimmedMean(0.1, Source);

// Accumulate the histogram of the first (largest) blob
Blobs.PixelHistogram(0, Source, Histo);
```

Typical running times

Cumulate 16 rows	0.008	0.0090
Trace a blob contour	0.020	0.0230
Compute a contour area	0.001	0.0020
Fill a contour	0.089	0.1000
Mean of an image	0.070	0.260
Entropy of an image	0.190	0.170
Compute the image histogram	0.190	0.160
Variance of the histogram	<0.001	<0.001
Skewness of the histogram	<0.001	<0.001
Best threshold from an histogram	0.0020	0.0010
Segment an image (200 blobs)	0.160	0.130
Evaluate the gray-level averages (200 blobs)	<0.001	<0.001
Evaluate the gray-level maxima (200 blobs)	<0.001	<0.001
Evaluate the ellipse of inertia (200 blobs)	0.007	0.006
Evaluate the Feret box (200 blobs)	0.002	0.001
Sort blobs by area (200 blobs)	0.004	0.005
Compute a blob histogram	0.130	<0.001

Image Calibration



An image is said to be calibrated when a mapping has been established between the pixel coordinates and some real-world coordinate system established on the observed surface.

The image calibration set provides support to accurately compute the direct and inverse matching from a number of "anchor points", and to deal with perspective distortion as well as optical deformations.

Scaling, Isometry, Affinity, Perspective & Distortion Transforms

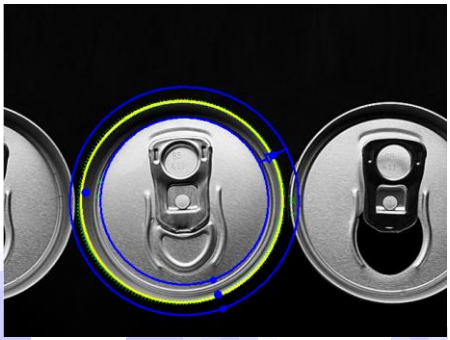
```
// Adjust the perspective from source to calibrated points
Model.Append(XY(RawX, RawY), XY(GridX, GridY));
Model.Fit(Perspective);

// Undistort the source image, without bilinear interpolation
Model.Register(Source, Calibrated, false);
```

Typical running times

Affine calibration (nearest neighbor)	0.420	0.350
Affine calibration (bilinear)	1.200	1.000
Perspective calibration (bilinear)	4.600	3.300
Distortion calibration (bilinear)	4.800	4.500
Full calibration (bilinear)	5.900	5.200

Edge Gauging

The edges of objects usually correspond to sharp transitions in the intensities in the image.



Gauging enables very accurate measurements of edges in order to determine positions, distances, sizes, angles…

This function set is specialized in profile analysis (peak detection) and fitting of straight / circular lines. It performs robust selection of the relevant edge points.

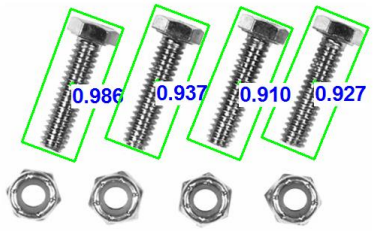
Automatic edge detection, outlier rejection, point model fitting, robust sub-pixel measurement, lines, arcs, circles, rectangles

```
// Place a straight line measurement gauge
Gauge.Beg= XY(139, 88); Gauge.End= XY(343, 87);

// Fit the line and get the angle
Gauge.Detect(Source, BestStep);
double Angle= Gauge.FittedAngle;
```

Typical running times

Detect edges along a profile (100 pixels)	<0.001	0.001
Fit a straight edge (21 profiles)	0.006	0.017
Fit a circular edge (63 profiles)	0.039	0.058

Pattern Matching



Pattern matching, also called template matching, is an excellent approach to locate known objects in an image. It works by providing a sample image of the item to be located and then searching for similar shapes in the target image.

The pattern matching tool of mViz supports translation, rotation and scaling and tolerates linear changes in light intensity. It is based on the well-known normalized correlation score.

Model training, sub-pixel location, rotation & scaling, multiple instances

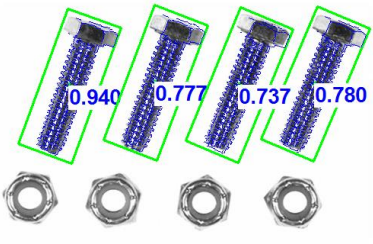
```
// Train the pattern from a region of interest
Source.Window(41, 170, 219, 194);
Template.Train(Source);

// NGC search in the whole image with a rotation tolerance
Template.MinAngle= -30; Template.MaxAngle= 30;
Template.Find(Source);
```

Typical running times

Search (160x160 template)	0.170	1.200
Search ±30° rotation (160x160)	1.600	3.400
Search ±30° rotation, ±10% scaling (160x160)	5.700	9.900

Geometric Matching

By contrast to standard pattern matching, the geometric finder uses edge information rather than area information. This provides better robustness to occlusion, clutter, blur, non-linear intensity changes.



The geometric and standard pattern matching tools share a common API and can easily be traded for one another.

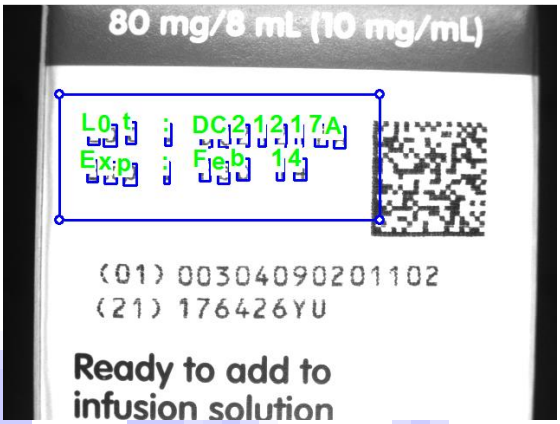
Model training, sub-pixel location, full rotation & scaling, multiple instances, outline-based recognition

```
// Train the pattern from a region of interest
Source.Window(41, 170, 219, 194);
Template.Train(Source);

// Geometric search in the whole image with a rotation tolerance
Template.MinAngle= -30; Template.MaxAngle= 30;
Template.Find(Source, true);
```

Typical running times

Search (160x160 template)	0.250	0.580
Search ±30° rotation (160x160)	0.910	2.400
Search ±30° rotation, ±10% scaling (160x160)	3.400	5.800

Character Reading



Many industrial applications require part identification. One of the ways to distinguish object is by printing a human-readable serial number on the surface or on a stickled label.

The character reading set serves two purposes: either to be able to read the content of the marking (OCR), or to verify that a given content has been properly printed (OCV). mViz uses user pre-trained fonts for the most accurate recognition. A priori information on the text layout can be used to further increase reliability.

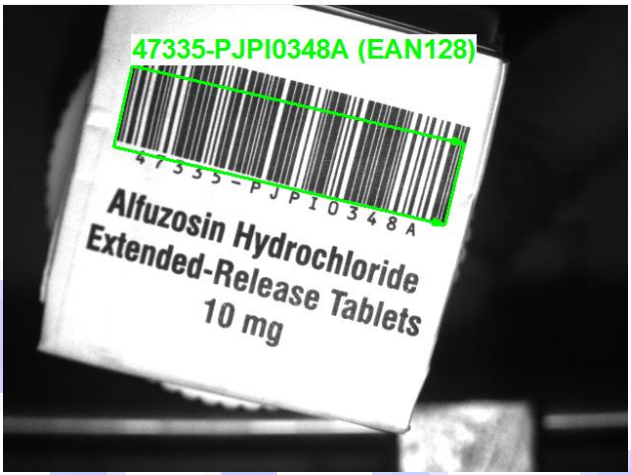
Font training, predefined fonts, deskewing, auto-segmentation, printed character recognition & verification

```
// Load the pre-recorded font from a file
OCR.Read("Fonts\\OCR-B.fnt");

// Perform the recognition from a region of interest
Source.Window(41, 170, 219, 194);
OCR.CharsRead(Source);
char* String= OCR.AsciiString;
```

Typical running times

Read characters (among 54 in font)	0.700	0.900
Read characters (adaptive threshold)	1.900	2.000

Bar Code Reading & Verification



A well-known alternative to printed characters are the barcodes. They come in numerous flavors and allow storing a number of digits and/or alphabetic characters. Depending on the type, the payload ranges from a few digits to a few tens of characters.

Verification is made according to ISO standards.

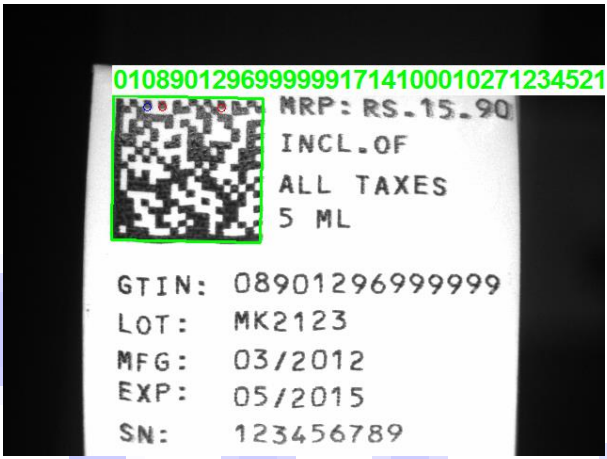
Automatic multiple code location, recognition and decoding, fully scale and rotation invariant, EAN/UPC, GS1 Databar, Code 39, Code 93, Codabar, (color) Pharmacode… symbologies, code quality verification

```
// Find the Pharmacode from the whole image
Barcode.DetectPharmacode= true;
bool Success= Barcode.Decode(Source);

// Read the decided string
char* String= Barcode.AsciiString;
```

Typical running times

Read a EAN128 code	0.670	1.200
Read a EAN128 code (Auto direction)	2.300	1.200

Dot Code Reading & Verification



Another alternative to printed characters appeared more recently and is known as dot codes or 2D codes. They encode more information in the same space by allowing variations in two dimensions rather than one. To ensure data integrity, they also embed error detection and correction mean.

Verification is made according to ISO standards.

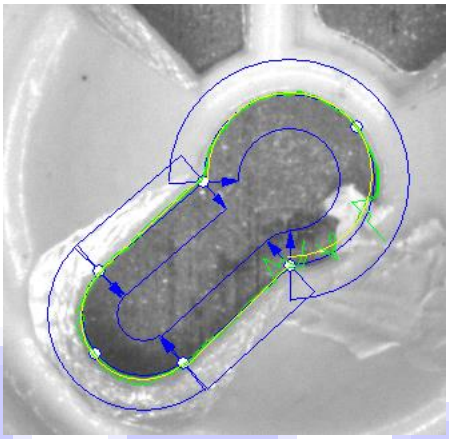
Automatic code location, recognition and decoding, scale and rotation invariant, Data Matrix, Aztec Code, QR, PDF417… symbologies

```
// Find the Data Matrix code from the whole image
bool Success= DataMatrix.Decode(Source);

// Read the decided string
char* String= DataMatrix.AsciiString;
```

Typical running times

Read a Data Matrix code	4.600	2.800
Read a QR code	2.500	2.000

Shape Inspection



Many part inspection tasks work by comparing the part under scrutiny to a reference shape. Deviations from it form protrusions or intrusions which you want to detect.

The "Snake" device allows you to define shapes of arbitrary complexity and perform comparisons over the image.

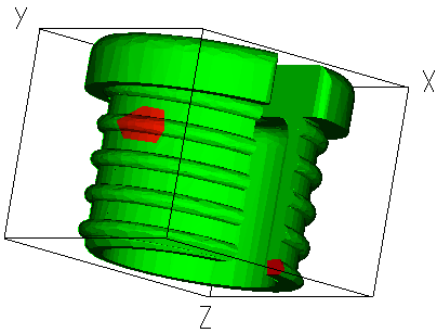
Shapes made of straight line, circular arcs, elliptic arcs, splines, of arbitrary complexity. Detection of protrusion, intrusions or width anomalies, graphical and programmatic defect reports, guidance for parameter setting.

```
// Load the Snake description
Inspector.Read("Snake.sng");

// Look for defects along the edges of the ribbon
Inspector.InspectRibbon(Src);
```

Typical running times

Inspect edges	4.600	2.800
Inspect width	2.500	2.000

3D Inspection



3D cameras open a new world of possibilities by adding the Z dimensions to describe the shapes. Different technologies are available to obtain point clouds or depth maps that capture the spatial geometry of the objects.

This allows to detect anomalies otherwise invisible, and to locate the objects with a 3D pose, for guidance or position control.

Point clouds, meshes or range images. Location of single or multiple instances. Merging of partial scans. Global measurements of size, area, volume… Alignment for robot guidance. Surface comparison. Graphical and quantitative difference reporting.

```
// Load the Snake description
Inspector.Read("Snake.cli");

// Align the template on the subject
Inspector.Match(Src);

// Detect discrepancies
Inspector.Compare(Src);

// Quantify discrepancies
Inspector.Area(AllSelected);
```

Typical running times

Match template	4.603	3.240
Compare to template	0.520	0.421

Utilities

mViz uses the programming paradigm, which means that you integrate function calls in your own application program, using your favorite framework and programming language, among C++, C++/CLI, C# and Visual Basic.

mViz supplies a rapid prototyping tool named mViz+, that lets you try the functions in a very interactive way, and build processing chains without any programming. Next, mViz+ will deliver the required source code in the desired language, ready for plugging to your application.

Interactive processing on your images. Instant visualization of the parameter changes. Rapid prototyping. Code snippet generation.

In addition, mViz includes handy utilities specialized in

- OCR cases, training and testing of fonts.
- 2D code reading optimization.
- Snake tool interactive drawing and setup.
- 3D model inspection setup.
- License management.

API Overview

```
// Image, 2D Pixel Array
class Image
{
  void Read; (x2)
  void Write; (x2)

  // Sizing
  void Set; (x2)

  // Window of Interest
  void Window; (x3)
  ReadOnly<int> X, Y, Width, Height;
  bool HasWindow;

  // Pixel Data
  bool PixelGray1;
  void PixelGray1;
  GrayPixel& PixelGray;
  Gray16Pixel& PixelGray16;
  Gray32Pixel& PixelGray32;
  Gradient& PixelGrad;
  RgbPixel& PixelRgb;
  RgbaPixel& PixelRgba;
  ReadOnly<byte*> Buffer;
  ReadOnly<int> Pitch;

  // Graphics
  void Draw; (x3)
  void DrawWindow;
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  void Drag;
  XY Center;

  // Storage
  ReadOnly<enum PixelTypes> Type;
  ReadOnly<int> StoreWidth, StoreHeight;
};


// Image Sequence Reading
class Source
{
  // Access
  void Append; (x2)
  void OpenSequenceFile; (x2)
  void OpenCamera;
  void Close;
  ReadOnly<SourceMode> Mode;

  // Frame Reading
  ReadOnly<int> FrameCount;
  ReadOnly<double> FrameRate;
  int FrameIndex;
  bool Grab;
  double Exposure;
  double Gain;

  // Frame Transfer
  void CopyToClipboard;
  void PasteFromClipboard;

  // Data Transfer
  void CopyToClipboard;

  // I/O
  bool Input;
  void Output;
};


// Profile, 1D Data Container
class Profile
{
  // Sizing
  void Set; (x2)
  void Clear;
  void Append; (x3)

  // Sample
  void RowGet;
  void RowAdd;
  void RowVariance;
  void RowMaximize;
  void RowMinimize;
  void RowRange;
  void ColumnGet;
  void ColumnAdd;
  void ColumnVariance;
  void ColumnMaximize;
  void ColumnMinimize;
  void ColumnRange;
  void LineGet;
  void LineAdd;
  void LineVariance;
  void LineMaximize;
  void LineMinimize;
  void LineRange;
  void CurveGet;

  // Interval of Interest
  void Window; (x2)
  ReadOnly<int> I, Length;
  bool HasWindow;

  // Statistics
  int Quantile;
  int Median;
  double Mean;
  double TrimmedMean;
  void Range;
  double Variance;

  // Filter
  void GaussLowPass;
  void BoxLowPass;
  void GaussHighPass;
```

```
  void BoxHighPass;
  void Integrate;
  void Derive;

  // Analyze
  void EdgeDetect;

  // Define LUT
  void GainOffset;
  void Threshold;
  void BiThreshold;
  void Quantize;
  void Logarithm;
  void Gamma;
  void PseudoColor;

  // Sample Data
  Gray32Pixel& Sample; (x2)
  ReadOnly<int*> Buffer;
  ReadOnly<int> Pitch;

  // Graphics
  void Plot;
  char* ToAsciiString;

  // Storage
  ReadOnly<enum PixelTypes> Type;
  ReadOnly<int> Scale;
  ReadOnly<int> StoreLength;
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void SetWindow;
  int X, Y, Width, Height;
  XY Beg, End;
  int XCol, YRow, Breadth;
  bool IsSum;
  enum DraggingHandles Direction;
  void Draw;
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  void Drag;
};


// Path, Arc/Line Curve Container
class ArcPath
{
  // Path Data
  void Clear;
  void Append; (x2)
  ArcSite& Vertex;

  // Graphics
  void Draw;
  enum DraggingHandles HitHandle;
  int ClosestHandle;
  ReadOnly<enum DraggingHandles> Handle;
  ReadOnly<int> HitIndex;
  void Drag;

  // Storage
  ReadOnly<int> Length;
  bool Closed;
};


// Path, Curve Container
class Path
{
  // Path Data
  void Clear;
  void Append; (x2)
  void PolygonToRaster;
  int ClosestTo;
  Site& Vertex;

  // Contouring
  void Follow;

  // Processing
  void Smooth;
  bool LineFit;
  bool CircleFit;
  bool EllipseFit;

  // Analysis
  void Box;
  void Rectangle;
  void Circle;
  void ConvexHull;
  int Area;
  double Perimeter
  void Center;
  bool FilledCenter;
  bool FilledEllipse;
  int Mass;
  bool Centroid;
  double LineDeviation;
  double CircleDeviation;
  void GrayHistogram;
  void Vectorize; (x2)

  // Graphics
  void Draw;
  enum DraggingHandles HitHandle;
  int ClosestHandle;
  ReadOnly<enum DraggingHandles> Handle;
  ReadOnly<int> HitIndex;
  bool PointInPath;
  bool Overlapping;
  void Drag;
  void Insert;
  void Delete;
  char* ToAsciiString;

  // Storage
  ReadOnly<int> Length;
  Site* Buffer;
  bool Closed;
};
```

```
// Poly, Polygonal Chain or Polygon
Container
class Poly
{
  // Poly Data
  void Clear;
  void Append; (x2)
  int ClosestTo;
  XY& Vertex;

  // Processing
  void Smooth;
  bool LineFit;
  bool CircleFit;
  bool EllipseFit;

  // Analysis
  void Box;
  void Rectangle;
  void Circle;
  void ConvexHull;
  double Area;
  double Perimeter;
  void Center;
  double LineDeviation;
  double CircleDeviation;

  // Graphics
  void Draw;
  int ClosestHandle;
  ReadOnly<enum DraggingHandles> Handle;
  ReadOnly<int> HitIndex;
  bool PointInPolygon;
  bool Overlapping;
  void Drag;
  void Insert;
  void Delete;

  // Storage
  ReadOnly<int> Length;
  XY* Buffer;
  bool Closed;
  void Read; (x2)
  void Write; (x2)
};


// Pixel-to-pixel Arithmetic
class Operator
{
  // Copy
  void Copy; (x4)

  // Color
  void Invert;
  void Convert;
  void DeBayer;
  void ColorsLighten;
  void ColorsSaturate;
  void ColorsHueSet;

  // Image Arithmetic
  void Add; (x2)
  void Subtract; (x3)
  void Multiply; (x2)
  void Divide; (x3)
  void Maximize; (x4)

  void Blend;

  // Compare
  void EqualTest; (x2)
  void GreaterTest; (x3)
  void GreaterEqualTest; (x3)

  // Bitwise
  void And; (x2)
  void Or; (x2)
  void Xor; (x2)

  // Binarize
  int Binarize; (x6)

  // Correct Shading
  void AddCorrect; (x2)
  void MultiplyCorrect; (x2)
  void Correct; (x2)

  // Scale Grays
  void GainOffset;
  void Equalize; (x2)
  void Normalize;
  void Transform;
  int GrayDepth;

  // Profile Arithmetic
  void Copy;
  void Add; (x2)
  void Subtract; (x3)
  void Multiply; (x2)
  void Divide; (x3)
  void Maximize; (x4)
};


// Linear Filtering
class Kernel
{
  // Gradient Filters
  static void Gradient;
  static void GradientSum;
  static void GradientX;
  static void GradientY;
  static void Sobel;
  static void SobelSum;
  static void SobelX;
  static void SobelY;
  static void Prewitt;
  static void PrewittSum;
  static void PrewittX;
  static void PrewittY;
  static void Canny;
  static void CannyPhase;
```

```
  static void CorrelatedGradient;
  static void BoxDeviation;

  // Low-pass Filters
  static void Smooth;
  static void Smooth8;
  static void Binomial;
  static void Binomial5;
  static void Binomial7;
  static void Binomial9;
  static void BoxLowPass;
  static void GaussLowPass;
  static void Bilateral;

  // High-pass Filters
  static void Sharpen4;
  static void Sharpen8;
  static void Unsharp;
  static void BoxHighPass;

  // Cornerness
  static void Cornerness;

  // Storage
  ReadOnly<int> Width, Height;

  // General Convolution
  void Set;
  double& Coefficient;
  enum GrayClipping Clip;
  double Offset;
  void Normalize;
  void Convolve;
};

// Morphological Filtering
class Morpho
{
  // Structel
  void Set;
  void Box;
  void Square;
  void Octagon;
  void Diamond;
  void Horizontal;
  void Vertical;
  ReadOnly<int> Width, Height, Diagonal;

  // Filtering
  void Dilate;
  void Erode;
  void Open;
  void Close;
  void WhiteHat;
  void BlackHat;
  void Gradient;
  void MidRange;
  void PseudoMedian;
  void Contrast;
  void Median;
  void Rank;
  int BinaryThin;
  int BinaryThick;

  // Segmentation
  static void Isophotes;
  static int Watershed; (x2)
  static void RegionalMaxima; (x2)
  static void GraphSegment;
  static void AverageRegions;
  static void Distance;
  static void KillConnect;
};

// Image Statistics
class Histogram:
{
  // Frequency Data
  int& Bin;
  void ClearBins;

  // Compute
  void Compute; (x3)
  void Cumulate;

  // Statistics
  int Count; (x2)
  double Mean; (x4)
  int Median; (x2)
  int Mode; (x2)
  double TrimmedMean; (x2)
  void Range; (x4)
  double Variance; (x4)
  void Covariance;
  double MedianAbsoluteDeviation; (x2)
  int Quantile; (x2)
  double Skewness; (x2)
  double Kurtosis; (x2)
  double Entropy; (x2)
  int BestThreshold; (x2)
  int EntropyThreshold; (x2)
  int IsodataThreshold; (x2)

  // Filter
  void GaussLowPass;
  void BoxLowPass;
  void GaussHighPass;
  void BoxHighPass;
  void Integrate;
  void Derive;

  // Image Quality
  double Noise;
  void ShowNoise;
  void Saturation;
  void ShowSaturation;

  // Compare Images
  int CountDifferences;
  double SumAbsoluteDifferences;
  double SumSquaredDifferences;
  double NormalizedCorrelation;
```

```
  void Normalize;
  void ShowDifferences;

  // Graphics
  void Plot;
  char* ToAsciiString;
};


// Geometric Transformations
class Geometry
{
  void Read; (x2)
  void Write; (x2)

  // Simple Transforms
  void Flip;
  void Mirror;
  void Turn;
  void DownSample;
  void UpSample;

  // Linear Transforms
  void Rotate; (x2)
  void Skew;
  void Affine;

  // Polar Transform
  void Unwind;

  // Tabulated Transform
  void Transform;

  // Simple Calibration
  void SimpleCalibration; (x2)
  ReadOnly<double> ScaleToPixel;
  ReadOnly<double> ScaleFromPixel;

  // Calibration
  void CalibrateTarget;
  XY Calibrate;
  XY Decalibrate;

  // Image Correction
  void Undistort;

  // Registration
  ReadOnly<RegistrationModels> Model;
  void PureScaling;
  void ModelFit;
  XY Register;
  void Register;
  XY ReverseRegister;
  void ReverseRegister;

  // Anchor Points
  void Clear;
  void Append;
  ReadOnly<int> NumAnchors;
  XY& Src;
  XY& Dst;

  // Storage
  void Read; (x2)
  void Write; (x2)

// Graphics
  void DrawAnchors;
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  ReadOnly<int> AnchorIndex;
  void Drag; (x2)
};


// Pyramid, fine-to-coarse
representation
class Pyramid
{
  // Building
  void Build;

  // Access by Level
  ReadOnly<int> NumLevels;
  Image& Bitmap;
  Image& Bitmap;

  // Rescaling
  static void Double;
  static void Halve;

  // Tile Statistics
  static void TileMean;
  static void TileMidRange;
  static void TileDeviation;
  static void TileRange;

  // Graphics
  static bool TileWindow;
  Site DrawingOffset; (x2)
  void Draw; (x2)
};


class FeatureTable
{
  // Sizing
  void ClearFeatures;
  void ClearSamples;
  int AppendIntFeature;
  int AppendFloatFeature;
  int AppendSample;
  ReadOnly<int> NumFeatures;
  ReadOnly<int> NumSamples;

  // Sample Data
  enum PixelTypes& Type;
  int& IntFeature;
  float& FloatFeature;

  // Selection by Features
  bool IsSelected;
  void SampleSelect;
```

```
  void SamplesSelect; (x2)
  ReadOnly<int> NumSelectedSamples;

  // Sorting by Features
  int SamplesFirst;
  void SamplesSort;
};
```

```
class Region
{
  ReadOnly<int> Width, Height;

  // Sizing
  void Clear;
  void Append;
  Limits Box;

  // Generate
  int Binarize;
  void Binarize;
  int Binarize;

  // Add a Region
  void BlobAppend;
  void PathAppend;
  void QuadAppend;

  // Region Arithmetic
  void Invert;
  void Unite;
  void Intersect;
  void Subtract;

  // Region Reshaping
  void Convexify;
  void ConvexHull;

  // Filling
  void Fill; (x3)
  static void SeedFill;

  // Outlining
  void Follow;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  ReadOnly<int> NumRuns;
  void Run;
  void Draw;
};


// Blob Analyser
class Blobs:
{
  // Segment Image
  ReadOnly<int> NumBlobs;
```

```
int Segment; (x5)

// Segment in Mask
int Segment; (x5)

// Binary Blob Features
int Area;
double WorldArea;
int FilledArea;
int ConvexArea;
void Box;
void WorldBox;
void TiltedBox;
bool Border;
void Center;
void Ellipse;
void FeretBox;
void DiametralBox;
int Perimeter;
enum RangeMode WindowBlob;

// Weighted Blob Features
double Average;
double Deviation;
int Median;
int Minimum;
int Maximum;
int Mass;
bool Centroid;
bool Ellipsoid;

// Non-scalar Features
void PixelHistogram;
void Outline;
void ConvexHull;

// Evaluate Features
void Evaluate;

// Select by Feature
void ByFeatureSelect; (x2)
void BorderSelect;
void BoxInWindowSelect;
void BlobInWindowSelect;
ReadOnly<int> NumSelectedBlobs;

// Sort by Feature
int ByFeatureFirst;
void ByFeatureSort;

// Transform Blobs
void Convexify;

// Features Data
enum Features AppendUserFeature;
enum PixelTypes Type;
wchar_t* UnicodeName;
bool IsComputed;
int& IntFeature;
float& FloatFeature;
int StraightIndex;
void ClearBlobs;
```

```
  // Features Distribution
  double FeatureAverage;
  double FeatureDeviation;
  double FeatureMinimum;
  double FeatureMaximum;
  double FeatureQuantile;
  double FeatureCovariance;
  double FeatureMode;

  // Graphics
  void DrawBlob;
  void DrawBox;
  void DrawTiltedBox;
  void DrawCenter;
  void DrawEllipse;
  void DrawHull;
  void DrawCentroid;
  void DrawEllipsoid;
  void DrawFeretBox;
  void DrawDiametralBox;
  void DrawOutline;
  int HitBlob;
  int HitBlobIndex;
  void ToImage;
  enum Features WhichFeature;
};


// Point Edge Detector
class EdgePoint
{
  // Location
  void Locate;
  XY From, To;
  ReadOnly<int> XMin, YMin, XMax, YMax;

  // Measurement
  int Breadth;
  int Smoothing;
  int Noise;
  int MinimumSlope;
  int MinimumStep;
  int MinimumSpan;
  enum Polarities Polarity;
  bool SplitPeaks;
  bool Detect; (x2)

  // Detection Results
  int NumPoints;
  Edge FittedEdge;
  XY FittedPoint;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void SetWindow; (x2)
  void Draw; (x2)
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  int HandleOctant;
  void Drag;
};


// Linear Edge Detector
class EdgeLine:
{
  // Location
  void Locate;
  XY Beg, End;
  double Width;

  // Measurement
  double Density;
  double Clearance;
  bool Oblique;
  FittingSide Fitting;
  bool Detect; (x2)
  ReadOnly<int> NumSamples;
  int SampleIndex;
  XY FittedPoint;

  // Fit
  XY FittedBeg;
  XY FittedEnd;
  ReadOnly<double> FittedAngle;
  ReadOnly<int> NumDetectedPoints;
  ReadOnly<double> Deviation;
  ReadOnly<int> NumFittedPoints;
  ReadOnly<double> RobustDeviation;
  void Realign;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw; (x2)
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  int HandleOctant;
  void Drag;
};


// Curved Edge Detector
class EdgeArc:
{
  // Location
  void Locate; (x2)
  XY Beg, Mid, End;
  double Width;
  XY Center;
  ReadOnly<double> Radius;

  // Measurement
  double Density;
  double Clearance;
  bool Oblique;
  bool Circle;
  bool Detect; (x2)
```

```
  ReadOnly<int> NumSamples;
  int SampleIndex;
  XY FittedPoint;

  // Fit
  XY FittedCenter;
  ReadOnly<double> FittedRadius;
  ReadOnly<int> NumDetectedPoints;
  ReadOnly<double> Deviation;
  ReadOnly<int> NumFittedPoints;
  ReadOnly<double> RobustDeviation;
  void Realign;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw; (x2)
  enum DraggingHandles HitHandle;
  enum DraggingHandles Handle;
  int HandleOctant;
  void Drag;
};

// Rectangular Edge Detector
class EdgeRectangle:
{
  // Location
  void Locate;
  XY Size;
  ReadOnly<double> Angle;
  double Width;

  // Measurement
  double Density;
  double Clearance;
  bool Oblique;
  bool FourSides;
  bool Detect; (x2)
  ReadOnly<int> NumSamples;
  int SampleIndex;
  XY FittedPoint;

  // Fit
  XY FittedMiddle;
  XY FittedSize;
  ReadOnly<double> FittedAngle;
  ReadOnly<double> Deviation;
  ReadOnly<double> RobustDeviation;
  int NumDetectedPoints;
  int NumFittedPoints;
  void Realign;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw; (x2)
  enum DraggingHandles HitHandle;
  enum DraggingHandles Handle;
  int HandleOctant;
  void Drag; (x2)
};

// Segmented Edge Map Container
class EdgeMap
{
  // Raster Map
  void GradientVector;
  int GradientMaxima;
  int StrongEdges;
  void StepEdges;

  // Vector Map
  int Follow;
  void IsoCurves;
  int Vectorize;
  ReadOnly<int> NumPaths;

  // Graphics
  void Draw;
  int ClosestTo;
  void Clear;

  // Vertex/Arc/Path Data
  int NumVertexes;
  Site& Vertex;
  int NumArcs;
  ArcSite& Arc;
};

// General Purpose Classifier
class Classifier
{
  void Read; (x2)
  void Write; (x2)

  // Features Management
  void AppendFeature;
  ReadOnly<int> NumFeatures;
  PixelTypes Type;
  wchar_t* Name;
  void ClearFeatures;

  // Samples Management
  void AppendSample;
  ReadOnly<int> NumSamples;
  void ClearSamples;

  // Value Access
  bool& Bool;
  GrayPixel& Gray;
  Gray16Pixel& Gray16;
  RgbPixel& Rgb;
  int& Int;
  float& Float;
  double& Dble;
```

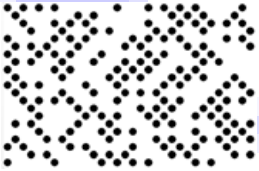
```
  // Training
  void TrainClusters;
  void TrainNeighbors;
  double ClusterCenter;
  double ClusterCovariance;

  // Matching
  Metrics Mode;
  int SlowNearestNeighbor; (x3)
  int NearestNeighbor; (x3)
  int NearestCenter;
  int NearestCluster;

  // Performance Assessment
  double InterDistance;
  int CrossValidateClusters;
  int CrossValidateNeighbors;

  // Text Input/Output
  char* ToAsciiString;
  wchar_t* ToUnicodeString;
  void FromAsciiString;
  void FromUnicodeString;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void PlotY; (x2)
  void PlotXY; (x2)

  // Clipboard
  void CopyToClipboard;
  void PasteFromClipboard;
};


// Template Location
class Locator
{
  void Read; (x2)
  void Write; (x2)

  // Training
  void Train; (x3)
  ReadOnly<int> MaxAreaDepths;
  ReadOnly<int> MaxEdgesDepths;
  Image& TemplateImage;
  Image& MaskImage;
  void TrainStringTemplate;

  // Searching
  int MaxLocations;
  double MinScore;
  double MinAngle, MaxAngle;
  double MinScale, MaxScale;
  bool Edges;
  int Symmetry;
  double MaxOverlap;
  int MaxDepths, StopDepth;
  void Find;
  ReadOnly<int> NumLocations;

  // Found Locations
  void Clear;
  Pose& Location; (x2)
  XY Register;

  // Normalization
  void Register;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw;
  void DrawModel;
  void Corners;
  void EdgePoints;
  enum DraggingHandles HitHandle;
  ReadOnly<enum DraggingHandles> Handle;
  ReadOnly<int> LocationIndex;
};


// Shape Recognition
class ShapeMatcher
{
  // Training
  void Train; (x2)
  void TrainBlob;
  ReadOnly<int> NumTrained;
  void Clear;

  // Recognition
  double MaxSimilarity;
  double MinAngle, MaxAngle; (x2)
  int Recognize;
  void RecognizeBlobs;
  ReadOnly<Pose> Location;
  ReadOnly<int> Class;

  // Registration
  void Register;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void DrawTrained;
  void DrawMatched;
  int HitTrained;
  ReadOnly<int> HitIndex;
  void DeleteHit;
};


// Optical Character Reader
class CharReader:
{
```

```
  void Read; (x2)
  void Write; (x2)

  // Character Segmentation
  void CharsSegment;
  int Quadrant;
  bool LocalThreshold;
  int Threshold;
  bool WhiteOnBlack;
  int CharWidth, CharHeight;
  bool GuessSize;
  bool KeepRatio;
  bool RepairBroken;
  int Dotted;
  int Masking;
  bool AlignChars;
  bool EvenlySpaceChars;
  int MaxTouching;
  int SplitRows;
  bool VariableWidth;
  double GapFraction;
  double DotFraction;
  ReadOnly<int> NumChars;
  wchar_t Separator;
  void PresetCharBoxes;
  void PresetCharBox;

  // Training
  FontCharImage& FontChar;
  int FontWidth, FontHeight;
  void FontCharInsert; (x2)
  void FontStringInsert; (x2)
  void FontCharDelete;
  ReadOnly<int> NumFontChars;
  void LayoutTrain;
  void LayoutReset;
  ReadOnly<int> NumLayoutChars;
  ReadOnly<int> NumLayoutStrings;

  // Reading
  void CharsDecode;
  void CharsRead; (x2)
  double MinimumScore;
  bool UseSafeScores;
  bool DiscardBadScores;
  void Filter; (x2)
  int JitterX, JitterY;
  ReadOnly<char*> AsciiFilter;
  ReadOnly<wchar_t*> UnicodeFilter;
  bool InsertSpaces;
  bool InsertNewlines;
  double MinAngle, MaxAngle;
  ReadOnly<char*> AsciiString;
  ReadOnly<wchar_t*> UnicodeString;
  ReadOnly<double> AverageScore;
  ReadOnly<double> AverageContrast;
  double CharScore;
  double CharContrast;
  int MatchingFontChar;
  int CharTrueWidth;
  LayoutModes LayoutMode;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw;
  bool GetBoxes;
  void DrawLayout;
  bool GetLayoutBoxes;
  void DrawFontChars;
  enum DraggingHandles HitChar;
  int CharIndex;
  enum DraggingHandles HitFontChar;
  ReadOnly<enum DraggingHandles> Handle;
  int FontCharIndex;
  void CharThumbnail;
  bool New;
};


// Barcode Reading
class Code1DReader
{
  // Decoding
  bool Decode;
  bool DetectEAN128;
  bool DetectEAN13;
  bool DetectEAN8;
  bool DetectUPCA;
  bool DetectUPCE;
  bool Detect2of5;
  bool Detect39;
  bool Detect39Extended;
  bool Detect93;
  bool DetectCodabar;
  bool DetectDatabar;
  bool DetectDatabarLimited;
  bool DetectPharmacode;
  int Density;
  int Noise;
  int Step;
  bool Reverse;
  bool CheckQuietZone;
  int MinimumBars;
  bool SymbologyIdentifier;

  // Decoding Results
  ReadOnly<int> NumDecoded;
  void Choose;
  void Choose;
  ReadOnly<char*> AsciiString;
  ReadOnly<wchar_t*> UnicodeString;
  ReadOnly<enum Symbologies> Symbology;
  ReadOnly<bool> ValidCRC;
  ReadOnly<bool> ReadFNC1;
  ReadOnly<bool> ReaderProgramming;
  ReadOnly<bool> Append;

  // Quality Indicators
  bool CheckQuality;
  ReadOnly<char> AsciiGrade;
  ReadOnly<wchar_t> UnicodeGrade;
  ReadOnly<char*> AsciiProfileGrades;
```

```
  ReadOnly<wchar_t*>
UnicodeProfileGrades;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Color Training
  void ColorTrain;
  int RgbTolerance;
  ReadOnly<bool> ValidColors;
  ReadOnly<int> NumColorBars;

  // Graphics
  void Draw;
  ReadOnly<int> X, Y, Width, Height;
  ReadOnly<double> Angle;
  void ColorReset;
  RgbPixel BarColor;
};

// Dot Code Reading
class Code2DReader
{
  // Properties
  enum CodePolarities EnabledPolarities;
  enum CodeViews EnabledViews;
  ReadOnly<Sizes> Size;
  bool DetectDataMatrix;
  bool DetectQR;
  bool DetectDotCode;
  int InkingCorrection;
  bool AdaptiveThreshold;
  int Threshold;
  int StartLevel;
  bool AccurateEdges;
  bool SymbologyIdentifier;

  // Decoding
  int MaxDecoded;
  bool Decode;

  // Decoding Results
  ReadOnly<int> NumDecoded;
  void Choose;
  void Choose;

  ReadOnly<char*> AsciiString;
  ReadOnly<wchar_t*> UnicodeString;
  ReadOnly<Symbologies> Symbology;
  ReadOnly<int> StringLength;
  ReadOnly<enum CodePolarities>
Polarity;
  ReadOnly<enum CodeViews> View;
  ReadOnly<float> CellSize;
  ReadOnly<bool> ReadFNC1;
  ReadOnly<bool> ReaderProgramming;
  ReadOnly<int> SymbolPosition;
  ReadOnly<int> SymbolTotal;
  ReadOnly<int> ParityData;

  // Quality ISO / IEC 15415
  bool CheckQuality;
  ReadOnly<char*> AsciiGrades;
  ReadOnly<wchar_t*> UnicodeGrades;
  ReadOnly<float> SymbolContrast;
  ReadOnly<float> ContrastUniformity;
  ReadOnly<float> AxialNonUniformity;
  ReadOnly<float> GridNonUniformity;
  ReadOnly<float> UnusedError;
  ReadOnly<float> PrintGrowthHorizontal;
  ReadOnly<float> PrintGrowthVertical;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Graphics
  void Draw;
  ReadOnly<int> X, Y, Width, Height;
  ReadOnly<double> Angle;
  XY Corner;
  float PrintGrowthNominal;
  float PrintGrowthMinimum;
  float PrintGrowthMaximum;
};

class SnakeGauge
{
  // Inspection
  int Density;
  int Thickness;
  int MinStep, MinSlope, MaxSpan, Noise;
  Polarities Polarity, Polarity2;
  int Selection, Selection2;
  double NominalWidth;
  double MaxDeviation;
  bool RMS;
  bool AssessEdges;
  void InspectEdges;
  void InspectRibbon;

  // Inspection results
  ReadOnly<int> NumSections;
  SectionType Type;
  int NumProfiles;
  double Intrusions;
  double Protrusions;
  double Deviation;
  void SectionSegment;
  void SectionArc;
  bool EdgePoint;
  bool RibbonPoint;

  // Sampling
  void Sample;

  // Storage
  void Read; (x2)
  void Write; (x2)

  // Axis edition
```

```
  void ClosestTo;
  void Drag;

  // Graphics
  static bool PreciseDrawing;
  void Draw;
  void DrawEdge;
  void DrawRibbon;
  void DrawFit;

// Unstructured set of 3D points, or
mesh
class PointCloud
{
  // Point/face storage
  void Clear;
  void AppendPoint;
  fXYZ& fPoint;
  void AppendFace;
  void AppendPoints;
  void AppendMesh;

  // Measurement
  void MinMax (x2);
  dXYZ Centroid;
  void Ellipsoid;
  double Length;
  double Area;
  double Volume;

  // Point/face selection
  void SelectAll;
  void ByPathSelect;

  // Transformation
  void Triangulate();
  void Move(dXYZ XForm[4]);

  // File storage
  void FromRangeImage;
  void Read (x2);
  void Write (x2);

  // Graphics
  XYZ NoFrame;
  void Draw (x2);
};


class CloudInspector
{
  // Matching
  double Inliers;
  int MaxIterations;
  void Match;
  int MaxLocations;
  void Find;

  // Found Locations
  ReadOnly<int> NumLocations;
  Pose3& Location;

  // Comparison
  void Compare;

  // File storage
  void Read (x2)
;
  void Write (x2);
};


// Graphics
class Graph
{
  // Display
  void*& DrawTo;
  double Zoom;
  void Offset;
  void Offset;
  double Resolution;
  int TextSize;
  void* DrawToDefault;
  void DrawToImage;
  void ReleaseImage;

  // Graphics Attributes
  DotColor, LineColor, FillColor,
TextColor;
  void TextOrigin;
  ReadOnly<char*> TextFont;
  void SetTextFont;
  bool AutoColor;
  bool SmoothZoom;

  // Graphics Primitives
  void Dot; (x3)
  void Cross; (x3)
  void Line; (x3)
  void Box; (x2)
  void Circle; (x2)
  void Arc; (x2)
  void Ellipse; (x2)
  void Text; (x6)
  void Handle; (x3)
  void Distance; (x6)
  void Angle; (x2)
  RgbPixel Color;
  void EraseWindow;
  void ZoomToWindow;
};


// Global Parameters
class Status
{
  // Error Processing
  enum ErrorCodes& Error;
  char* AsciiError;
  wchar_t* UnicodeError;
  char* AsciiFunction;
  wchar_t* UnicodeFunction;
```

```
void IgnoreError;
void ThrowError;
void ShowError;
void PrintError;
void AssertError;
void ErrorBehavior;
Callback ErrorCallback;
void* ErrorContext;

// Angle Unit
double AngleUnit;
double FromDegrees;
double ToDegrees;
double FromRadians;
double ToRadians;

// Timing
void StartWatch;
int ReadWatch;
void Wait;

// Keypress
int Key;

// Versioning
wchar_t* UnicodeVersion;
char* AsciiVersion;

// Multithreading
void AttachThRead; (x2)
void ReleaseThRead; (x2)
void EnterSection;
void LeaveSection;

// Data Storage
bool License;

// Miscellaneous
int JpegQuality;
};
```



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