Keysens

Basic Vision Algorithms

Technical note

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Contents

1 Introduction

Keysens vAlgorithms are collections of functions written in C and contained in DLLs. The functions implement machine vision and data processing algorithms. ***Keysens*** software, like ***vDevelop*** and the runtimes ***vProcess***, ***RuntimeGigE***, ***RuntimeGigEUser***, etc, load several algorithms DLLs and *algorithms description files* contained in the algorithms directory, `alg`.

For building machine vision applications one makes a project with ***vDevelop***. Projects consist of several parameters for camera settings and communications with installation devices like robots, PLCs and HMIs, and the most important, an algorithms script: a list of algorithms that will be executed sequentially.

One of such algorithms library is the ***Basic Algorithms Collection***, whose files are named:

File	Description
`algorithms.dll`	The algorithms functions.
`algorithms.txt`	The algorithms description file.

This technical note briefly describes the algorithms contained in this library.

2 Basic algorithms categories

The algorithms in the *Basic Algorithms Collection* are distributed in categories:

Category	Description
Capture image	A special algorithm that starts every script. It represents the acquisition of an image.
Colour manipulation	Colour or band computations and conversions from RGB to other colour spaces like HLS, HSV, Lab, Luv, grey levels.
Geometry	Geometrical image transformations.
Grey level manipulation	Algorithms that transform the pixel values in one channel images.
Segmentation	Several colour and grey level-based segmentation algorithms.
Filtering	Algorithms that apply filters to enhance some image features.
Logical operations	Algorithm that perform bitwise operations on two labelled images. Usually the images will be binary, with labels 0 (false) or 255 (true)
Mathematical morphology	Several mathematical morphology algorithms.
Regions of interest	Algorithms that set up regions of interest that affect further processing.
Masks	Algorithms that compute masks from a raw image or from a one channel image.
Patterns	Algorithms to extract sub images to be used later as model images or patterns.
Regions	Region detection and region features algorithms.
Forms detection	Algorithms that detect forms in images, like lines, circles, corners, edges, etc.
Features manipulation	Operations on features.
Objects manipulation	Operations on objects.
Recover previous results	These algorithms recover a result from a previous algorithm, an image, regions or features, allowing to process the result in a different way.
Finish processing conditions	Algorithms that finish processing the script when some conditions happen, like when no data is detected or data represents a true or a false result.
Calibration	Check the camera alignment and calibrate the image coordinates with a world coordinates system.

Following, the algorithms in every category are described.

3 Category 'Capture image'

Capture image			
Algorithm	Input	Output	Description
IMAGE	NUL	RAW	Image acquisition.

4 Category 'Colour manipulation'

Colour manipulation			
Algorithm	**Input**	**Output**	**Description**
COLOR_STATISTICS_MASK	LBL	DAT	Compute color statistics from a previous image with and a mask.
COLOR_STATISTICS_RAW	RAW	DAT	Compute color statistics applying a colour space.
COLOR_STATISTICS_SIZES	RAW	DAT	Compute color statistics in windows of a given size.
COLOR_STATISTICS_WINDOWS	RAW	DAT	Compute color statistics in windows applying a colour space.
EXTRACT_BAND	RAW	LBL	Extract a colour band given by its number or convert an RGB image to luminance, Y.
RGB_TO_GRAY_LEVEL	RAW	RAW	Convert RGB image to grey level image.
RGB_TO_HLS	RAW	RAW	Convert RGB image to HLS colour space.
RGB_TO_HSV	RAW	RAW	Convert RGB image to HSV colour space.
RGB_TO_LAB	RAW	RAW	Convert RGB image to Lab colour space.
RGB_TO_LUV	RAW	RAW	Convert RGB image to Luv colour space.
COLOR_DIFFERENCES_MODEL	RAW	DAT	Compute differences of some colour statistics to a model.

5 Category 'Geometry'

Geometry			
Algorithm	**Input**	**Output**	**Description**
ROTATE	DAT	RAW	Rotate image.
ROTATE_LBL	DAT	LBL	Rotate image producing a one-channel image.
ZOOM	RAW	RAW	Zoom image.
ZOOM_LBL	LBL	LBL	Zoom a one-channel image.

6 Category 'Grey level manipulation'

Grey level manipulation			
Algorithm	**Input**	**Output**	**Description**
ADD_LABELS	NUL	DAT	Add labels from a previous labelled image.
COMPENSATE_LATERAL_LIGHT	RAW	RAW	Enhance intensity with a parabolic function, apply to 3-channel images.
COMPENSATE_LATERAL_LIGHT_LBL	LBL	LBL	Enhance intensity with a parabolic function, apply to 1-channel images.
EQUALIZE	RAW	RAW	Equalize the histogram of the input image.
INVERT	LBL	LBL	Invert labels or grey levels.
LABELS_COUNT	LBL	DAT	Count pixels with specified label or grey level.
SCALE_SHIFT	RAW	RAW	Scale and shift the image, apply to 3-channel images.
SCALE_SHIFT_LBL	LBL	LBL	Scale and shift the image, apply to 1-channel images.
SELECT_LABEL	LBL	LBL	Select the specified label or grey level.

7 Category 'Segmentation'

Segmentation			
Algorithm	Input	Output	Description
COLOR_SEGMENTATION_MODEL	**RAW**	**LBL**	**Segmentation inside a mask using a colour model.**
COLOR_SEGMENTATION_STATS	**RAW**	**LBL**	**Segmentation inside a mask using colour statistics.**
COLOR_SEGMENTATION_TABLE	**RAW**	**LBL**	**Segmentation inside a mask using a colour model and a LUT.**
SEGMENT_COLUMNS	**LBL**	**LBL**	**Segmentation by columns.**
SEGMENT_HISTOGRAM	**RAW**	**LBL**	**Band extraction and segmentation by histograms with windows inside a mask.**
SEGMENT_HISTOGRAM_AUTO	**RAW**	**LBL**	**Segmentation by histograms with windows inside a mask. Auto background dark/light detection.**
SEGMENT_HISTOGRAM_LBL	**LBL**	**LBL**	**Segmentation by histograms with windows inside a mask.**
SEGMENT_OTSU	**RAW**	**LBL**	**Band extraction and segmentation by Otsu threshold with windows inside a mask.**
SEGMENT_OTSU_LBL	**LBL**	**LBL**	**Segmentation by Otsu threshold with windows inside a mask.**
SEGMENT_ROWS	**LBL**	**LBL**	**Segmentation by rows.**
SEGMENT_SOBEL	**LBL**	**LBL**	**Segmentation of bright and dark zones usually extracted from a Sobel filter.**
THRESHOLD	**RAW**	**RAW**	**Threshold a one channel image.**
THRESHOLD_BORDERS	**RAW**	**RAW**	**Threshold image by rows starting from the image limits.**
THRESHOLD_COLOR	**RAW**	**RAW**	**Threshold an image colour setting values below the threshold to zero.**

8 Category 'Filtering'

Image manipulation			
Algorithm	Input	Output	Description
SMOOTH	**RAW**	**RAW**	**Smooth image with mean or Gaussian filter.**
FILTER	**LBL**	**LBL**	**Filter an image applying a convolution kernel.**
LAPLACE	**LBL**	**LBL**	**Apply a Laplace mask to estimate the second derivatives.**
SOBEL	**LBL**	**LBL**	**Apply a Sobel mask to estimate the gradient.**

9 Category 'Logical operations'

Logical operations			
Algorithm	Input	Output	Description
AND	**LBL**	**LBL**	**Logical AND with a previous image.**
NOT	**LBL**	**LBL**	**Logical NOT this image.**
OR	**LBL**	**LBL**	**Logical OR with a previous image.**
XOR	**LBL**	**LBL**	**Logical XOR with a previous image.**

10 Category 'Mathematical morphology'

Mathematical morphology			
Algorithm	**Input**	**Output**	**Description**
APERTURE	**LBL**	**LBL**	Morphological aperture.
CLOSING	**LBL**	**LBL**	Morphological closing.
DILATE	**LBL**	**LBL**	Morphological dilation.
ERODE	**LBL**	**LBL**	Morphological erosion.
FILL	**LBL**	**LBL**	Fill rows or columns.
FORM_FILTER	**LBL**	**LBL**	Form filter.
FORM_FILTER_2	**LBL**	**LBL**	Form filter with two levels.
HIT_FILTER	**LBL**	**LBL**	Marks pixels where the a pattern of labels fits the image.

11 Category 'Regions of interest'

Regions of interest			
Algorithm	**Input**	**Output**	**Description**
REGION_OF_INTEREST	**RAW**	**RAW**	Set a region of interest (ROI).
REGION_OF_INTEREST_LBL	**LBL**	**LBL**	Set a new ROI from the extension of the non-zero values in the input labelled image.
REGION_OF_INTEREST_NEW	**RAW**	**RAW**	Apply a new ROI to the previous image.
REGION_OF_INTEREST_NEW_LBL	**LBL**	**LBL**	Apply a new ROI to the previous image.
REGION_OF_INTEREST_NEW_DAT	**DAT**	**DAT**	Set a new ROI.
REGION_OF_INTEREST_FROM_POINT	**DAT**	**DAT**	Set a new ROI from a point.
REGION_OF_INTEREST_OFFSET	**RAW**	**RAW**	Apply a new ROI to the previous image.
REGION_OF_INTEREST_OFFSET_LBL	**LBL**	**LBL**	Apply a new ROI to the previous image.
REGION_OF_INTEREST_WIDTH	**RAW**	**RAW**	Apply a new ROI to the previous image getting a copy.
REGION_OF_INTEREST_WIDTH_LBL	**LBL**	**LBL**	Apply a new ROI to the previous image getting a copy.
REGION_OF_INTEREST_HEIGHT	**RAW**	**RAW**	Apply a new ROI to the previous image getting a copy.
REGION_OF_INTEREST_HEIGHT_LBL	**LBL**	**LBL**	Apply a new ROI to the previous image getting a copy.
REGION_OF_INTEREST_MASK	**LBL**	**RAW**	Apply a mask to a former image to obtain a masked image and set a new region of interest (ROI).

12 Category 'Masks'

Masks			
Algorithm	Input	Output	Description
MASK_EXTENSION	RAW	DAT	Find mask extension as non-(0,0,0) values.
MASK_EXTENSION_LBL	LBL	DAT	Find mask extension as non-zero values.
MASK_IMAGE	RAW	RAW	Apply a mask to the input image from a former labelled image.
MASK_IMAGE_LBL	LBL	LBL	Apply a mask to the input image from a former labelled image.
MASK_REGIONS	RAW	RAW	Find regions in a previous image and mask the input image with the good ones.
MASK_REGIONS_LBL	LBL	LBL	Find regions in a previous image and mask the input image with the good ones.

13 Category 'Patterns'

Models and patterns			
Algorithm	Input	Output	Description
MODEL	DAT	DAT	Subimage that bounds all input regions.
PATTERN_TO_IMAGE	RAW	RAW	Full-size image from a pattern image.

14 Category 'Regions'

Regions			
Algorithm	Input	Output	Description
FILL_REGIONS	LBL	REG	Fill regions in a labelled image.
REGIONS	LBL	REG	Regions detection.
REGIONS_INTERNAL	LBL	REG	Internal regions detection.
REGIONS_CENTERS	REG	DAT	Centres of the regions.
REGIONS_COLOR_CLASSIFICATION	REG	DAT	Classification of input regions using colour statistics.
REGIONS_DRAW	REG	RAW	Draw regions over an image.
REGIONS_EXTENSION	REG	DAT	Extension of each region.
REGIONS_FEATURES	REG	DAT	Features including Hu moments.
REGIONS_FILLED_PERCENTAGES	LBL	DAT	Filled percentages in regions.
REGIONS_FILTER	LBL	REG	Regions detection bigger than the specified area, length and compactness.
REGIONS_FILTER_LBL	LBL	LBL	Take out regions of small area, length or compactness.
REGIONS_HOUGH_LINES	REG	DAT	Compute lines from contours by Hough transform.
REGIONS_LOCATION	REG	DAT	Location of regions.
REGIONS_LOCATION_HOUGH	REG	DAT	Compute location of regions with orientation by Hough transform.
REGIONS_SIGNATURE	REG	DAT	Signature function of each region.
REGIONS_SIGNATURE_ORIENTATION	REG	DAT	Centres and orientation to models using signature functions.
REGIONS_TOTALS	REG	DAT	Filters regions, outputs number of regions, total length, area and compactness.
REGIONS_TOTALS_LBL	LBL	LBL	Filters regions, outputs number of regions, total length, area and compactness.

15 Category 'Forms detection'

Forms detection			
Algorithm	**Input**	**Output**	**Description**
COLUMNS_ROWS_SIGNALS	**LBL**	**DAT**	**Compute two signals counting object pixels in rows and columns.**
CORNERS	**LBL**	**LBL**	**Corner detection using Harris approach.**
DARK_TO_BRIGHT	**LBL**	**LBL**	**Marks pixels where transitions from dark to bright occur.**
EDGES	**LBL**	**LBL**	**Edge detection with Canny approach.**
EXTERNAL_EDGES	**LBL**	**LBL**	**External edges of regions in a labelled image.**
HOUGH_LINES	**LBL**	**DAT**	**Lines detection from edges.**
HOUGH_LINES_I	**LBL**	**DAT**	**Lines detection from edges, improved method.**
HOUGH_CIRCLES	**LBL**	**DAT**	**Circles detection from edges.**
LINES_INTERSECTIONS	**DAT**	**DAT**	**Points of intersection between consecutive lines.**
LINES_ORIENTATIONS	**DAT**	**DAT**	**Lines orientations from (rho,theta).**

16 Category 'Features manipulation'

Features manipulation			
Algorithm	**Input**	**Output**	**Description**
FEATURES_ADD	**DAT**	**DAT**	**Add selected feature values and count objects.**
FEATURES_AND_OR	**DAT**	**DAT**	**And/or logical operations on features.**
FEATURES_COMBINE	**DAT**	**DAT**	**Combine data columns from previous algorithms.**
FEATURES_DELETE	**DAT**	**DAT**	**Delete features.**
FEATURES_DIFFERENCES_ MODEL	**DAT**	**DAT**	**Features differences to a data mdoel.**
FEATURES_FILTER	**DAT**	**DAT**	**Filter features.**
FEATURES_SCALE_OFFSET	**DAT**	**DAT**	**Add an offset and scale the features.**
FEATURES_SELECTION	**DAT**	**DAT**	**Select features.**
FEATURES_SORT	**DAT**	**DAT**	**Sort features.**
FEATURES_STATISTICS	**DAT**	**DAT**	**Statisrics from features.**
FEATURES_THRESHOLD	**DAT**	**DAT**	**Threshold features above or below a value.**
FEATURES_THRESHOLD_2	**DAT**	**DAT**	**Threshold features above and below two values.**
RESULTS_ACCUMULATE	**DAT**	**DAT**	**Accumulate feature values to the global results resource.**
RESUTS_STATISTICS	**DAT**	**DAT**	**Compute feature values statistics for the global results resource.**

17 Category 'Objects manipulation'

Objects manipulation			
Algorithm	**Input**	**Output**	**Description**
OBJECTS_COMBINE	DAT	DAT	Combine data rows from previous algorithms.
OBJECTS_COUNT	DAT	DAT	Count objects, number data rows.
OBJECTS_COUNT_WITH_THRESHOLD	DAT	DAT	Count objects with a feature above and below a threshold.
OBJECTS_REMOVE	DAT	DAT	Remove objects from a previous result.
OBJECTS_SELECTION	DAT	DAT	Select objects, copy the indicated rows.
OBJECTS_THRESHOLD	DAT	DAT	Threshold objects with a feature above or below a value.

18 Category 'Recover previous results'

Recover previous results			
Algorithm	**Input**	**Output**	**Description**
RECOVER_DATA	NUL	DAT	Recover data from a previous algorithm.
RECOVER_LBL	NUL	LBL	Recover a previous labelled image.
RECOVER_LBL_MASKED	NUL	LBL	Recover a previous labelled image and mask it.
RECOVER_RAW	NUL	RAW	Recover a previous raw image.
RECOVER_RAW_MASKED	NUL	RAW	Recover a previous raw image and mask it.
RECOVER_REG	NUL	REG	Recover regions from a previous algorithm.

19 Category 'Finish processing conditions'

Finish processing conditions			
Algorithm	**Input**	**Output**	**Description**
END_NO_DATA	DAT	DAT	Finish processing the script if there is no data on input.
END_ON_DATA	DAT	DAT	Finish processing the script if there is any input data.
END_ON_TRUE	DAT	DAT	Finish processing the script if there is no data on input or the first value is true (different from 0.0).
END_ON_FALSE	DAT	DAT	Finish processing the script if there is no data on input or the first value is false (0.0).
END_SEND_ACC_NO_DATA	DAT	DAT	End script and send accumulated results if there is no input data.
END_SEND_ACC_ON_DATA	DAT	DAT	End script and send accumulated results if there is any input data.
END_SEND_ACC_ON_TRUE	DAT	DAT	End script and send accumulated results if there is no input data or the first value is true (different from 0.0).
END_SEND_ACC_ON_FALSE	DAT	DAT	End script and send accumulated results if there is no input data or the first value is false (0.0).

20 Category 'Calibration'

Calibration			
Algorithm	Input	Output	Description
CALIBRATION	**DAT**	**DAT**	Calibrate the (row,column) measurements to provide measurements in mm in an external coordinate system.
FRAME_POINTS	**DAT**	**DAT**	Detect the frame points in due order starting from the upper-left point and going clockwise.
FRAME_SETUP	**DAT**	**DAT**	Provide measurements to help to align the camera horizontally and vertically to the imaged area.
PIXEL_SIZE	**DAT**	**DAT**	Calibrate the pixel size in millimeters per pixel.
SAVE_DATA	**DAT**	**DAT**	Saves data to a model data file.

21 Comments

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