Structural Analysis and Shape Descriptors

moments

Calculates all of the moments up to the third order of a polygon or rasterized shape.

C++: Moments `moments`(InputArray **array**, bool **binaryImage**=false)

Python: cv2.`moments`(array[, binaryImage]) → retval

C: void `cvMoments`(const CvArr* **arr**, CvMoments* **moments**, int **binary**=0)

Parameters:
- **array** – Raster image (single-channel, 8-bit or floating-point 2D array) or an array ($1 \times N$ or $N \times 1$) of 2D points (Point or Point2f).
- **binaryImage** – If it is true, all non-zero image pixels are treated as 1's. The parameter is used for images only.
- **moments** – Output moments.

The function computes moments, up to the 3rd order, of a vector shape or a rasterized shape. The results are returned in the structure Moments defined as:

```cpp
class Moments
{
public:
    Moments();
    Moments(double m00, double m10, double m01, double m20, double m11,
            double m02, double m30, double m21, double m12, double m03 );
    Moments( const CvMoments& moments );
    operator CvMoments() const;

    // spatial moments
    double  m00, m10, m01, m20, m11, m02, m30, m21, m12, m03;
    // central moments
    double  mu20, mu11, mu02, mu30, mu21, mu12, mu03;
    // central normalized moments
    double  nu20, nu11, nu02, nu30, nu21, nu12, nu03;
}
```

In case of a raster image, the spatial moments $\mathrm{Moments}{::}\mathrm{m}_{ji}$ are computed as:

$$m_{ji} = \sum_{x,y} \left(\mathrm{array}(x,y) \cdot x^j \cdot y^i \right)$$

The central moments $\mathrm{Moments}{::}\mathrm{mu}_{ji}$ are computed as:

$$mu_{ji} = \sum_{x,y} \left(\mathrm{array}(x,y) \cdot (x-\bar{x})^j \cdot (y-\bar{y})^i \right)$$

where $(\bar{x}, \bar{y})$ is the mass center:

$$\bar{x} = \frac{m_{10}}{m_{00}}, \ \bar{y} = \frac{m_{01}}{m_{00}}$$

The normalized central moments $\mathrm{Moments}{::}\mathrm{nu}_{ij}$ are computed as:

$$nu_{ji} = \frac{mu_{ji}}{m_{00}^{(i+j)/2+1}}.$$

Note: $mu_{00} = m_{00}, nu_{00} = 1 \, nu_{10} = mu_{10} = mu_{01} = mu_{10} = 0$, hence the values are not stored.

The moments of a contour are defined in the same way but computed using the Green's formula (see http://en.wikipedia.org/wiki/Green_theorem). So, due to a limited raster resolution, the moments computed for a contour are slightly different from the moments computed for the same rasterized contour.

Note: Since the contour moments are computed using Green formula, you may get seemingly odd results for contours with self-intersections, e.g. a zero area (m00) for butterfly-shaped contours.

See also: `contourArea(), arcLength()`

HuMoments

Calculates seven Hu invariants.

C++: void `HuMoments`(const Moments& **m**, OutputArray **hu**)

C++: void `HuMoments`(const Moments& **moments**, double **hu**[7])

Python: cv2.`HuMoments`(m[, hu]) → hu

C: void `cvGetHuMoments`(CvMoments* **moments**, CvHuMoments* **hu_moments**)

| Parameters: | • **moments** – Input moments computed with `moments()` . |
| | • **hu** – Output Hu invariants. |

The function calculates seven Hu invariants (introduced in [Hu62]; see also http://en.wikipedia.org/wiki/Image_moment) defined as:

$$hu[0] = \eta_{20} + \eta_{02}$$
$$hu[1] = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$
$$hu[2] = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$
$$hu[3] = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$
$$hu[4] = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$
$$hu[5] = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$$
$$hu[6] = (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$$

where η_{ji} stands for `Moments::nu`$_{ji}$.

These values are proved to be invariants to the image scale, rotation, and reflection except the seventh one, whose sign is changed by reflection. This invariance is proved with the assumption of infinite image resolution. In case of raster images, the computed Hu invariants for the original and transformed images are a bit different.

> **See also:** `matchShapes()`

connectedComponents

computes the connected components labeled image of boolean image `image` with 4 or 8 way connectivity - returns N, the total number of labels [0, N-1] where 0 represents the background label. ltype specifies the output label image type, an important consideration based on the total number of labels or alternatively the total number of pixels in the source image.

C++: int `connectedComponents`(InputArray **image**, OutputArray **labels**, int **connectivity**=8, int **ltype**=CV_32S)

C++: int `connectedComponentsWithStats`(InputArray **image**, OutputArray **labels**, OutputArray **stats**, OutputArray **centroids**, int **connectivity**=8, int **ltype**=CV_32S)

Parameters:	• **image** – the image to be labeled
	• **labels** – destination labeled image
	• **connectivity** – 8 or 4 for 8-way or 4-way connectivity respectively
	• **ltype** – output image label type. Currently CV_32S and CV_16U are supported.
	• **statsv** –
	statistics output for each label, including the background label, see below for available statistics. Statistics are accessed via statsv(label, COLUMN) where available columns are defined below.
	○ **CC_STAT_LEFT** The leftmost (x) coordinate which is the inclusive start of the bounding box in the horizontal direction.
	○ **CC_STAT_TOP** The topmost (y) coordinate which is the inclusive start of the bounding box in the vertical direction.
	○ **CC_STAT_WIDTH** The horizontal size of the bounding box
	○ **CC_STAT_HEIGHT** The vertical size of the bounding box
	○ **CC_STAT_AREA** The total area (in pixels) of the connected component
	• **centroids** – floating point centroid (x,y) output for each label, including the background label

findContours

Finds contours in a binary image.

C++: void `findContours`(InputOutputArray **image**, OutputArrayOfArrays **contours**, OutputArray **hierarchy**, int **mode**, int **method**, Point **offset**=Point())

C++: void `findContours`(InputOutputArray **image**, OutputArrayOfArrays **contours**, int **mode**, int **method**, Point **offset**=Point())

Python: cv2.`findContours`(image, mode, method[, contours[, hierarchy[, offset]]]) → image, contours, hierarchy

C: int `cvFindContours`(CvArr* **image**, CvMemStorage* **storage**, CvSeq** **first_contour**, int **header_size**=sizeof(CvContour), int **mode**=CV_RETR_LIST, int **method**=CV_CHAIN_APPROX_SIMPLE, CvPoint **offset**=cvPoint(0,0))

| Parameters: | • **image** – Source, an 8-bit single-channel image. Non-zero pixels are treated as 1's. Zero pixels remain 0's, so |

the image is treated as `binary` . You can use **`compare()`** , **`inRange()`** , **`threshold()`** , **`adaptiveThreshold()`** , **`Canny()`** , and others to create a binary image out of a grayscale or color one. The function modifies the `image` while extracting the contours. If mode equals to `CV_RETR_CCOMP` or `CV_RETR_FLOODFILL`, the input can also be a 32-bit integer image of labels (`CV_32SC1`).

- **contours** – Detected contours. Each contour is stored as a vector of points.
- **hierarchy** – Optional output vector, containing information about the image topology. It has as many elements as the number of contours. For each i-th contour `contours[i]` , the elements `hierarchy[i][0]` , `hierarchy[i][1]` , `hiearchy[i][2]` , and `hiearchy[i][3]` are set to 0-based indices in `contours` of the next and previous contours at the same hierarchical level, the first child contour and the parent contour, respectively. If for the contour `i` there are no next, previous, parent, or nested contours, the corresponding elements of `hierarchy[i]` will be negative.
- **mode** –

  Contour retrieval mode (if you use Python see also a note below).

  - **CV_RETR_EXTERNAL** retrieves only the extreme outer contours. It sets `hierarchy[i][2]=hierarchy[i][3]=-1` for all the contours.
  - **CV_RETR_LIST** retrieves all of the contours without establishing any hierarchical relationships.
  - **CV_RETR_CCOMP** retrieves all of the contours and organizes them into a two-level hierarchy. At the top level, there are external boundaries of the components. At the second level, there are boundaries of the holes. If there is another contour inside a hole of a connected component, it is still put at the top level.
  - **CV_RETR_TREE** retrieves all of the contours and reconstructs a full hierarchy of nested contours. This full hierarchy is built and shown in the OpenCV `contours.c` demo.
- **method** –

  Contour approximation method (if you use Python see also a note below).

  - **CV_CHAIN_APPROX_NONE** stores absolutely all the contour points. That is, any 2 subsequent points `(x1,y1)` and `(x2,y2)` of the contour will be either horizontal, vertical or diagonal neighbors, that is, `max(abs(x1-x2),abs(y2-y1))==1`.
  - **CV_CHAIN_APPROX_SIMPLE** compresses horizontal, vertical, and diagonal segments and leaves only their end points. For example, an up-right rectangular contour is encoded with 4 points.
  - **CV_CHAIN_APPROX_TC89_L1,CV_CHAIN_APPROX_TC89_KCOS** applies one of the flavors of the Teh-Chin chain approximation algorithm. See [TehChin89] for details.
- **offset** – Optional offset by which every contour point is shifted. This is useful if the contours are extracted from the image ROI and then they should be analyzed in the whole image context.

The function retrieves contours from the binary image using the algorithm [Suzuki85]. The contours are a useful tool for shape analysis and object detection and recognition. See `squares.c` in the OpenCV sample directory.

> **Note:** Source `image` is modified by this function. Also, the function does not take into account 1-pixel border of the image (it's filled with 0's and used for neighbor analysis in the algorithm), therefore the contours touching the image border will be clipped.

> **Note:** If you use the new Python interface then the `CV_` prefix has to be omitted in contour retrieval mode and contour approximation method parameters (for example, use `cv2.RETR_LIST` and `cv2.CHAIN_APPROX_NONE` parameters). If you use the old Python interface then these parameters have the `CV_` prefix (for example, use `cv.CV_RETR_LIST` and `cv.CV_CHAIN_APPROX_NONE`).

> **Note:**
>
> - An example using the findContour functionality can be found at opencv_source_code/samples/cpp/contours2.cpp
> - An example using findContours to clean up a background segmentation result at opencv_source_code/samples/cpp/segment_objects.cpp
> - (Python) An example using the findContour functionality can be found at opencv_source/samples/python2/contours.py
> - (Python) An example of detecting squares in an image can be found at opencv_source/samples/python2/squares.py

approxPolyDP

Approximates a polygonal curve(s) with the specified precision.

C++: void **`approxPolyDP`**(InputArray **curve**, OutputArray **approxCurve**, double **epsilon**, bool **closed**)

Python: `cv2.` **`approxPolyDP`**(curve, epsilon, closed[, approxCurve]) → approxCurve

C: CvSeq* **`cvApproxPoly`**(const void* **src_seq**, int **header_size**, CvMemStorage* **storage**, int **method**, double **eps**, int **recursive**=0)

Parameters:
- **curve** –

  Input vector of a 2D point stored in:

  - `std::vector` or `Mat` (C++ interface)
  - `Nx2` numpy array (Python interface)
  - `CvSeq` or `` `` `CvMat` (C interface)

- **approxCurve** – Result of the approximation. The type should match the type of the input curve. In case of C interface the approximated curve is stored in the memory storage and pointer to it is returned.
- **epsilon** – Parameter specifying the approximation accuracy. This is the maximum distance between the original curve and its approximation.
- **closed** – If true, the approximated curve is closed (its first and last vertices are connected). Otherwise, it is not closed.
- **header_size** – Header size of the approximated curve. Normally, `sizeof(CvContour)` is used.
- **storage** – Memory storage where the approximated curve is stored.
- **method** – Contour approximation algorithm. Only `CV_POLY_APPROX_DP` is supported.
- **recursive** – Recursion flag. If it is non-zero and `curve` is `CvSeq*`, the function `cvApproxPoly` approximates all the contours accessible from `curve` by `h_next` and `v_next` links.

The functions `approxPolyDP` approximate a curve or a polygon with another curve/polygon with less vertices so that the distance between them is less or equal to the specified precision. It uses the Douglas-Peucker algorithm http://en.wikipedia.org/wiki/Ramer-Douglas-Peucker_algorithm

See https://github.com/Itseez/opencv/tree/master/samples/cpp/contours2.cpp for the function usage model.

ApproxChains

Approximates Freeman chain(s) with a polygonal curve.

C: CvSeq* **cvApproxChains**(CvSeq* **src_seq**, CvMemStorage* **storage**, int **method**=CV_CHAIN_APPROX_SIMPLE, double **parameter**=0, int **minimal_perimeter**=0, int **recursive**=0)

Parameters:
- **src_seq** – Pointer to the approximated Freeman chain that can refer to other chains.
- **storage** – Storage location for the resulting polylines.
- **method** – Approximation method (see the description of the function `FindContours()`).
- **parameter** – Method parameter (not used now).
- **minimal_perimeter** – Approximates only those contours whose perimeters are not less than `minimal_perimeter` . Other chains are removed from the resulting structure.
- **recursive** – Recursion flag. If it is non-zero, the function approximates all chains that can be obtained from `chain` by using the `h_next` or `v_next` links. Otherwise, the single input chain is approximated.

This is a standalone contour approximation routine, not represented in the new interface. When `FindContours()` retrieves contours as Freeman chains, it calls the function to get approximated contours, represented as polygons.

arcLength

Calculates a contour perimeter or a curve length.

C++: double **arcLength**(InputArray **curve**, bool **closed**)

Python: cv2. **arcLength**(curve, closed) → retval

C: double **cvArcLength**(const void* **curve**, CvSlice **slice**=CV_WHOLE_SEQ, int **is_closed**=-1)

Parameters:
- **curve** – Input vector of 2D points, stored in `std::vector` or `Mat`.
- **closed** – Flag indicating whether the curve is closed or not.

The function computes a curve length or a closed contour perimeter.

boundingRect

Calculates the up-right bounding rectangle of a point set.

C++: Rect **boundingRect**(InputArray **points**)

Python: cv2. **boundingRect**(points) → retval

C: CvRect **cvBoundingRect**(CvArr* **points**, int **update**=0)

Parameters:
- **points** – Input 2D point set, stored in `std::vector` or `Mat`.

The function calculates and returns the minimal up-right bounding rectangle for the specified point set.

contourArea

Calculates a contour area.

C++: double **contourArea**(InputArray **contour**, bool **oriented**=false)

Python: cv2.**contourArea**(contour[, oriented]) → retval

C: double **cvContourArea**(const CvArr* **contour**, CvSlice **slice**=CV_WHOLE_SEQ, int **oriented**=0)

> **Parameters:** • **contour** – Input vector of 2D points (contour vertices), stored in std::vector or Mat.
> • **oriented** – Oriented area flag. If it is true, the function returns a signed area value, depending on the contour orientation (clockwise or counter-clockwise). Using this feature you can determine orientation of a contour by taking the sign of an area. By default, the parameter is false, which means that the absolute value is returned.

The function computes a contour area. Similarly to **moments()**, the area is computed using the Green formula. Thus, the returned area and the number of non-zero pixels, if you draw the contour using **drawContours()** or **fillPoly()**, can be different. Also, the function will most certainly give a wrong results for contours with self-intersections.

Example:

```
vector<Point> contour;
contour.push_back(Point2f(0, 0));
contour.push_back(Point2f(10, 0));
contour.push_back(Point2f(10, 10));
contour.push_back(Point2f(5, 4));

double area0 = contourArea(contour);
vector<Point> approx;
approxPolyDP(contour, approx, 5, true);
double area1 = contourArea(approx);

cout << "area0 =" << area0 << endl <<
        "area1 =" << area1 << endl <<
        "approx poly vertices" << approx.size() << endl;
```

convexHull

Finds the convex hull of a point set.

C++: void **convexHull**(InputArray **points**, OutputArray **hull**, bool **clockwise**=false, bool **returnPoints**=true)

Python: cv2.**convexHull**(points[, hull[, clockwise[, returnPoints]]]) → hull

C: CvSeq* **cvConvexHull2**(const CvArr* **input**, void* **hull_storage**=NULL, int **orientation**=CV_CLOCKWISE, int **return_points**=0)

> **Parameters:** • **points** – Input 2D point set, stored in std::vector or Mat.
> • **hull** – Output convex hull. It is either an integer vector of indices or vector of points. In the first case, the hull elements are 0-based indices of the convex hull points in the original array (since the set of convex hull points is a subset of the original point set). In the second case, hull elements are the convex hull points themselves.
> • **hull_storage** – Output memory storage in the old API (cvConvexHull2 returns a sequence containing the convex hull points or their indices).
> • **clockwise** – Orientation flag. If it is true, the output convex hull is oriented clockwise. Otherwise, it is oriented counter-clockwise. The assumed coordinate system has its X axis pointing to the right, and its Y axis pointing upwards.
> • **orientation** – Convex hull orientation parameter in the old API, CV_CLOCKWISE or CV_COUNTERCLOCKWISE.
> • **returnPoints** – Operation flag. In case of a matrix, when the flag is true, the function returns convex hull points. Otherwise, it returns indices of the convex hull points. When the output array is std::vector, the flag is ignored, and the output depends on the type of the vector: std::vector<int> implies returnPoints=true, std::vector<Point> implies returnPoints=false.

The functions find the convex hull of a 2D point set using the Sklansky's algorithm [Sklansky82] that has *O(N logN)* complexity in the current implementation. See the OpenCV sample convexhull.cpp that demonstrates the usage of different function variants.

> **Note:**
>
> • An example using the convexHull functionality can be found at opencv_source_code/samples/cpp/convexhull.cpp

convexityDefects

Finds the convexity defects of a contour.

C++: void **convexityDefects**(InputArray **contour**, InputArray **convexhull**, OutputArray **convexityDefects**)

Python: cv2.**convexityDefects**(contour, convexhull[, convexityDefects]) → convexityDefects

C: CvSeq* **cvConvexityDefects**(const CvArr* **contour**, const CvArr* **convexhull**, CvMemStorage* **storage**=NULL)

> **Parameters:** • **contour** – Input contour.

- **convexhull** – Convex hull obtained using `convexHull()` that should contain indices of the contour points that make the hull.
- **convexityDefects** – The output vector of convexity defects. In C++ and the new Python/Java interface each convexity defect is represented as 4-element integer vector (a.k.a. `cv::Vec4i`): `(start_index, end_index, farthest_pt_index, fixpt_depth)`, where indices are 0-based indices in the original contour of the convexity defect beginning, end and the farthest point, and `fixpt_depth` is fixed-point approximation (with 8 fractional bits) of the distance between the farthest contour point and the hull. That is, to get the floating-point value of the depth will be `fixpt_depth/256.0`. In C interface convexity defect is represented by `CvConvexityDefect` structure - see below.
- **storage** – Container for the output sequence of convexity defects. If it is NULL, the contour or hull (in that order) storage is used.

The function finds all convexity defects of the input contour and returns a sequence of the `CvConvexityDefect` structures, where `CvConvexityDetect` is defined as:

```
struct CvConvexityDefect
{
    CvPoint* start; // point of the contour where the defect begins
    CvPoint* end; // point of the contour where the defect ends
    CvPoint* depth_point; // the farthest from the convex hull point within the defect
    float depth; // distance between the farthest point and the convex hull
};
```

The figure below displays convexity defects of a hand contour:
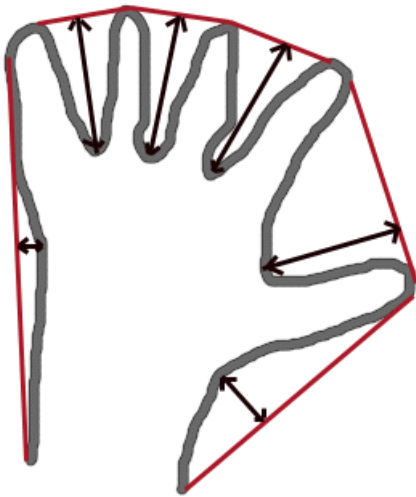
fitEllipse

Fits an ellipse around a set of 2D points.

C++: RotatedRect `fitEllipse`(InputArray **points**)

Python: cv2. `fitEllipse`(points) → retval

C: CvBox2D `cvFitEllipse2`(const CvArr* **points**)

    Parameters: • **points** –

        Input 2D point set, stored in:

        ◦ `std::vector<>` or Mat (C++ interface)
        ◦ `CvSeq*` or `CvMat*` (C interface)
        ◦ Nx2 numpy array (Python interface)

The function calculates the ellipse that fits (in a least-squares sense) a set of 2D points best of all. It returns the rotated rectangle in which the ellipse is inscribed. The algorithm [Fitzgibbon95] is used. Developer should keep in mind that it is possible that the returned ellipse/rotatedRect data contains negative indices, due to the data points being close to the border of the containing Mat element.

> **Note:**
>
> - An example using the fitEllipse technique can be found at opencv_source_code/samples/cpp/fitellipse.cpp

fitLine

Fits a line to a 2D or 3D point set.

C++: void `fitLine`(InputArray **points**, OutputArray **line**, int **distType**, double **param**, double **reps**, double **aeps**)

Python: cv2. `fitLine`(points, distType, param, reps, aeps[, line]) → line

C: void `cvFitLine`(const CvArr* **points**, int **dist_type**, double **param**, double **reps**, double **aeps**, float* **line**)

Parameters:
- **points** – Input vector of 2D or 3D points, stored in std::vector<> or Mat.
- **line** – Output line parameters. In case of 2D fitting, it should be a vector of 4 elements (like Vec4f) - (vx, vy, x0, y0), where (vx, vy) is a normalized vector collinear to the line and (x0, y0) is a point on the line. In case of 3D fitting, it should be a vector of 6 elements (like Vec6f) - (vx, vy, vz, x0, y0, z0), where (vx, vy, vz) is a normalized vector collinear to the line and (x0, y0, z0) is a point on the line.
- **distType** – Distance used by the M-estimator (see the discussion below).
- **param** – Numerical parameter (C) for some types of distances. If it is 0, an optimal value is chosen.
- **reps** – Sufficient accuracy for the radius (distance between the coordinate origin and the line).
- **aeps** – Sufficient accuracy for the angle. 0.01 would be a good default value for reps and aeps.

The function `fitLine` fits a line to a 2D or 3D point set by minimizing $\sum_i \rho(r_i)$ where r_i is a distance between the ith point, the line and $\rho(r)$ is a distance function, one of the following:

- distType=CV_DIST_L2

$$\rho(r) = r^2/2 \quad \text{(the simplest and the fastest least-squares method)}$$

- distType=CV_DIST_L1

$$\rho(r) = r$$

- distType=CV_DIST_L12

$$\rho(r) = 2 \cdot (\sqrt{1 + \frac{r^2}{2}} - 1)$$

- distType=CV_DIST_FAIR

$$\rho(r) = C^2 \cdot \left(\frac{r}{C} - \log\left(1 + \frac{r}{C}\right) \right) \quad \text{where} \quad C = 1.3998$$

- distType=CV_DIST_WELSCH

$$\rho(r) = \frac{C^2}{2} \cdot \left(1 - \exp\left(-\left(\frac{r}{C}\right)^2 \right) \right) \quad \text{where} \quad C = 2.9846$$

- distType=CV_DIST_HUBER

$$\rho(r) = \begin{cases} r^2/2 & \text{if } r < C \\ C \cdot (r - C/2) & \text{otherwise} \end{cases} \quad \text{where} \quad C = 1.345$$

The algorithm is based on the M-estimator (http://en.wikipedia.org/wiki/M-estimator) technique that iteratively fits the line using the weighted least-squares algorithm. After each iteration the weights w_i are adjusted to be inversely proportional to $\rho(r_i)$.

isContourConvex

Tests a contour convexity.

C++: bool `isContourConvex`(InputArray **contour**)

Python: cv2. `isContourConvex`(contour) → retval

C: int `cvCheckContourConvexity`(const CvArr* **contour**)

Parameters:
- **contour** –

    Input vector of 2D points, stored in:

    - std::vector<> or Mat (C++ interface)
    - CvSeq* or CvMat* (C interface)
    - Nx2 numpy array (Python interface)

The function tests whether the input contour is convex or not. The contour must be simple, that is, without self-intersections. Otherwise, the function output is undefined.

minAreaRect

Finds a rotated rectangle of the minimum area enclosing the input 2D point set.

C++: RotatedRect **minAreaRect**(InputArray **points**)

Python: cv2.**minAreaRect**(points) → retval

C: CvBox2D **cvMinAreaRect2**(const CvArr* **points**, CvMemStorage* **storage**=NULL)

> **Parameters:** • **points** –
>
> > Input vector of 2D points, stored in:
> >
> > ○ std::vector<> or Mat (C++ interface)
> > ○ CvSeq* or CvMat* (C interface)
> > ○ Nx2 numpy array (Python interface)

The function calculates and returns the minimum-area bounding rectangle (possibly rotated) for a specified point set. See the OpenCV sample minarea.cpp . Developer should keep in mind that the returned rotatedRect can contain negative indices when data is close the the containing Mat element boundary.

boxPoints

Finds the four vertices of a rotated rect. Useful to draw the rotated rectangle.

C++: void **boxPoints**(RotatedRect **box**, OutputArray **points**)

Python: cv2.**boxPoints**(box[, points]) → points

C: void **cvBoxPoints**(CvBox2D **box**, CvPoint2D32f **pt**[4])

> **Parameters:** • **box** – The input rotated rectangle. It may be the output of .. ocv:function:: minAreaRect.
> > • **points** – The output array of four vertices of rectangles.

The function finds the four vertices of a rotated rectangle. This function is useful to draw the rectangle. In C++, instead of using this function, you can directly use box.points() method. Please visit the tutorial on bounding rectangle for more information.

minEnclosingTriangle

Finds a triangle of minimum area enclosing a 2D point set and returns its area.

**C++:** double **minEnclosingTriangle**(InputArray **points**, OutputArray **triangle**)

Python: cv2.**minEnclosingTriangle**(points[, triangle]) → retval, triangle

> **Parameters:** • **points** –
>
> > Input vector of 2D points with depth CV_32S or CV_32F, stored in:
> >
> > ○ std::vector<> or Mat (C++ interface)
> > ○ Nx2 numpy array (Python interface)
> > • **triangle** – Output vector of three 2D points defining the vertices of the triangle. The depth of the OutputArray must be CV_32F.

The function finds a triangle of minimum area enclosing the given set of 2D points and returns its area. The output for a given 2D point set is shown in the image below. 2D points are depicted in *red* and the enclosing triangle in *yellow*.
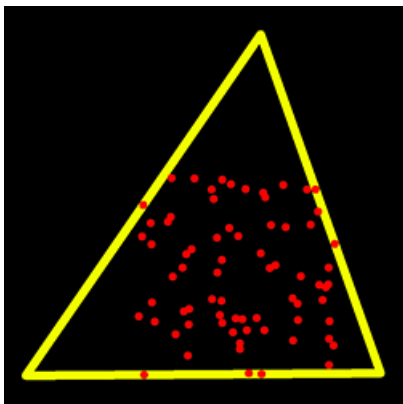
The implementation of the algorithm is based on O'Rourke's [ORourke86] and Klee and Laskowski's [KleeLaskowski85] papers. O'Rourke provides a $\theta(n)$ algorithm for finding the minimal enclosing triangle of a 2D convex polygon with n vertices. Since the **minEnclosingTriangle()** function takes a 2D point set as input an additional preprocessing step of computing the convex hull of the 2D point set is required. The complexity of the **convexHull()** function is $O(n\log(n))$ which is higher than $\theta(n)$. Thus the overall complexity of the function is $O(n\log(n))$.

minEnclosingCircle

Finds a circle of the minimum area enclosing a 2D point set.

C++: void **minEnclosingCircle**(InputArray **points**, Point2f& **center**, float& **radius**)

Python: cv2. **minEnclosingCircle**(points) → center, radius

C: int **cvMinEnclosingCircle**(const CvArr* **points**, CvPoint2D32f* **center**, float* **radius**)

    Parameters: • **points** –

        Input vector of 2D points, stored in:

- std::vector<> or Mat (C++ interface)
- CvSeq* or CvMat* (C interface)
- Nx2 numpy array (Python interface)
- **center** – Output center of the circle.
- **radius** – Output radius of the circle.

The function finds the minimal enclosing circle of a 2D point set using an iterative algorithm. See the OpenCV sample minarea.cpp .

matchShapes

Compares two shapes.

C++: double **matchShapes**(InputArray **contour1**, InputArray **contour2**, int **method**, double **parameter**)

Python: cv2. **matchShapes**(contour1, contour2, method, parameter) → retval

C: double **cvMatchShapes**(const void* **object1**, const void* **object2**, int **method**, double **parameter**=0)

    Parameters: • **object1** – First contour or grayscale image.
- **object2** – Second contour or grayscale image.
- **method** – Comparison method: CV_CONTOURS_MATCH_I1 , CV_CONTOURS_MATCH_I2 or CV_CONTOURS_MATCH_I3 (see the details below).
- **parameter** – Method-specific parameter (not supported now).

The function compares two shapes. All three implemented methods use the Hu invariants (see **HuMoments()**) as follows (A denotes object1,:math:*B* denotes object2):

- method=CV_CONTOURS_MATCH_I1

$$I_1(A, B) = \sum_{i=1...7} \left| \frac{1}{m_i^A} - \frac{1}{m_i^B} \right|$$

- method=CV_CONTOURS_MATCH_I2

$$I_2(A, B) = \sum_{i=1...7} \left| m_i^A - m_i^B \right|$$

- method=CV_CONTOURS_MATCH_I3

$$I_3(A, B) = \max_{i=1...7} \frac{\left| m_i^A - m_i^B \right|}{\left| m_i^A \right|}$$

where

$$m_i^A = \text{sign}(h_i^A) \cdot \log h_i^A$$
$$m_i^B = \text{sign}(h_i^B) \cdot \log h_i^B$$

and h_i^A, h_i^B are the Hu moments of A and B , respectively.

pointPolygonTest

Performs a point-in-contour test.

C++: double **pointPolygonTest**(InputArray **contour**, Point2f **pt**, bool **measureDist**)

Python: cv2. **pointPolygonTest**(contour, pt, measureDist) → retval

C: double **cvPointPolygonTest**(const CvArr* **contour**, CvPoint2D32f **pt**, int **measure_dist**)

Parameters:
- **contour** – Input contour.
- **pt** – Point tested against the contour.
- **measureDist** – If true, the function estimates the signed distance from the point to the nearest contour edge. Otherwise, the function only checks if the point is inside a contour or not.

The function determines whether the point is inside a contour, outside, or lies on an edge (or coincides with a vertex). It returns positive (inside), negative (outside), or zero (on an edge) value, correspondingly. When `measureDist=false`, the return value is +1, -1, and 0, respectively. Otherwise, the return value is a signed distance between the point and the nearest contour edge.

See below a sample output of the function where each image pixel is tested against the contour.
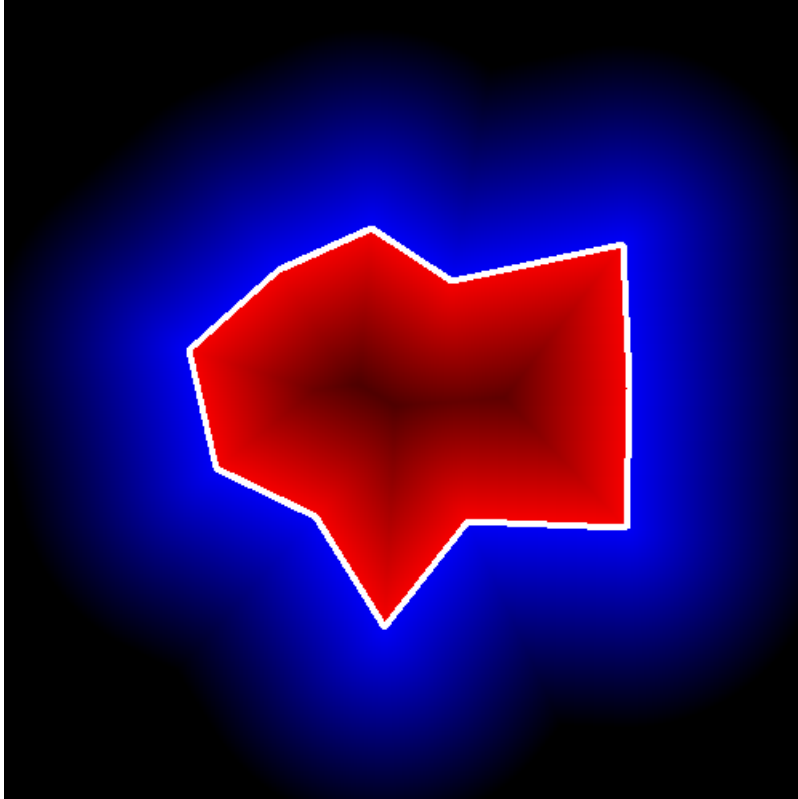
[Fitzgibbon95]   Andrew W. Fitzgibbon, R.B.Fisher. *A Buyer's Guide to Conic Fitting*. Proc.5th British Machine Vision Conference, Birmingham, pp. 513-522, 1995.

[Hu62]
            M. Hu. *Visual Pattern Recognition by Moment Invariants*, IRE Transactions on Information Theory, 8:2, pp. 179-187, 1962.

[KleeLaskowski85]   Klee, V. and Laskowski, M.C., *Finding the smallest triangles containing a given convex polygon*, Journal of Algorithms, vol. 6, no. 3, pp. 359-375 (1985)

[ORourke86]   O'Rourke, J., Aggarwal, A., Maddila, S., and Baldwin, M., *An optimal algorithm for finding minimal enclosing triangles*, Journal of Algorithms, vol. 7, no. 2, pp. 258-269 (1986)

[Sklansky82]   Sklansky, J., *Finding the Convex Hull of a Simple Polygon*. PRL 1 $number, pp 79-83 (1982)

[Suzuki85]   Suzuki, S. and Abe, K., *Topological Structural Analysis of Digitized Binary Images by Border Following*. CVGIP 30 1, pp 32-46 (1985)

[TehChin89]   Teh, C.H. and Chin, R.T., *On the Detection of Dominant Points on Digital Curve*. PAMI 11 8, pp 859-872 (1989)

rotatedRectangleIntersection

Finds out if there is any intersection between two rotated rectangles. If there is then the vertices of the interesecting region are returned as well.

C++: int **rotatedRectangleIntersection**(const RotatedRect& **rect1**, const RotatedRect& **rect2**, OutputArray **intersectingRegion**)

Python: cv2. **rotatedRectangleIntersection**(rect1, rect2) → retval, intersectingRegion

Parameters:
- **rect1** – First rectangle
- **rect2** – Second rectangle
- **intersectingRegion** – The output array of the verticies of the intersecting region. It returns at most 8 vertices. Stored as `std::vector<cv::Point2f>` or `cv::Mat` as Mx1 of type CV_32FC2.
- **pointCount** – The number of vertices.

The following values are returned by the function:

- INTERSECT_NONE=0 - No intersection
- INTERSECT_PARTIAL=1 - There is a partial intersection

- INTERSECT_FULL=2 - One of the rectangle is fully enclosed in the other

Below are some examples of intersection configurations. The hatched pattern indicates the intersecting region and the red vertices are returned by the function.
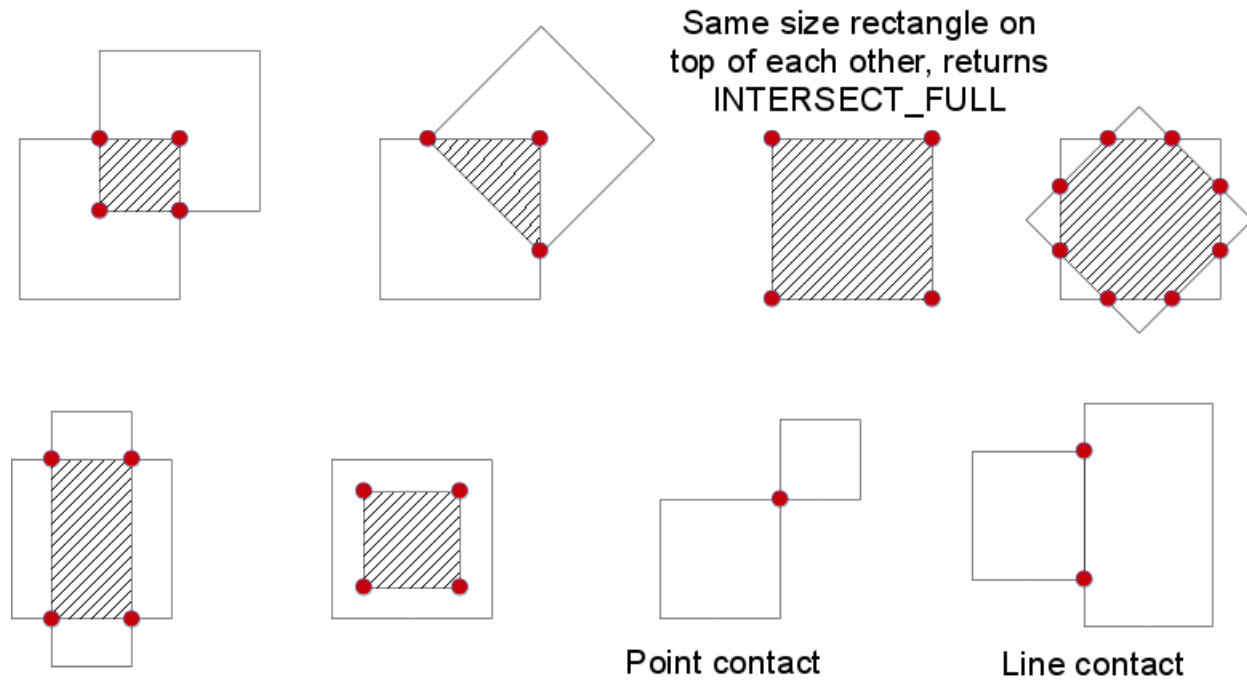
Help and Feedback

You did not find what you were looking for?

- Ask a question on the **Q&A forum**.
- If you think something is missing or wrong in the documentation, please file a **bug report**.