

# OpenCV 2.4 Cheat Sheet (C++)

The OpenCV C++ reference manual is here:

<http://docs.opencv.org>. Use **Quick Search** to find descriptions of the particular functions and classes

## Key OpenCV Classes

<a href="#">Point_</a>	Template 2D point class
<a href="#">Point3_</a>	Template 3D point class
<a href="#">Size_</a>	Template size (width, height) class
<a href="#">Vec</a>	Template short vector class
<a href="#">Matx</a>	Template small matrix class
<a href="#">Scalar</a>	4-element vector
<a href="#">Rect</a>	Rectangle
<a href="#">Range</a>	Integer value range
<a href="#">Mat</a>	2D or multi-dimensional dense array (can be used to store matrices, images, histograms, feature descriptors, voxel volumes etc.)
<a href="#">SparseMat</a>	Multi-dimensional sparse array
<a href="#">Ptr</a>	Template smart pointer class

## Matrix Basics

### Create a matrix

```
Mat image(240, 320, CV_8UC3);
```

### [Re]allocate a pre-declared matrix

```
image.create(480, 640, CV_8UC3);
```

### Create a matrix initialized with a constant

```
Mat A33(3, 3, CV_32F, Scalar(5));
```

```
Mat B33(3, 3, CV_32F); B33 = Scalar(5);
```

```
Mat C33 = Mat::ones(3, 3, CV_32F)*5.;
```

```
Mat D33 = Mat::zeros(3, 3, CV_32F) + 5.;
```

### Create a matrix initialized with specified values

```
double a = CV_PI/3;
```

```
Mat A22 = (Mat_<float>(2, 2) <<  
    cos(a), -sin(a), sin(a), cos(a));
```

```
float B22data[] = {cos(a), -sin(a), sin(a), cos(a)};
```

```
Mat B22 = Mat(2, 2, CV_32F, B22data).clone();
```

### Initialize a random matrix

```
randu(image, Scalar(0), Scalar(256)); // uniform dist
```

```
randn(image, Scalar(128), Scalar(10)); // Gaussian dist
```

### Convert matrix to/from other structures

(without copying the data)

```
Mat image_alias = image;
```

```
float* Idata=new float[480*640*3];
```

```
Mat I(480, 640, CV_32FC3, Idata);
```

```
vector<Point> iptvec(10);
```

```
Mat iP(iptvec); // iP - 10x1 CV_32SC2 matrix
```

```
IplImage* oldC0 = cvCreateImage(cvSize(320,240),16,1);
```

```
Mat newC = cvarrToMat(oldC0);
```

```
IplImage oldC1 = newC; CvMat oldC2 = newC;
```

### ... (with copying the data)

```
Mat newC2 = cvarrToMat(oldC0).clone();
```

```
vector<Point2f> ptvec = Mat_<Point2f>(iP);
```

### Access matrix elements

```
A33.at<float>(i,j) = A33.at<float>(j,i)+1;
```

```
Mat dyImage(image.size(), image.type());  
for(int y = 1; y < image.rows-1; y++) {  
    Vec3b* prevRow = image.ptr<Vec3b>(y-1);  
    Vec3b* nextRow = image.ptr<Vec3b>(y+1);  
    for(int x = 0; x < image.cols; x++)  
        for(int c = 0; c < 3; c++)  
            dyImage.at<Vec3b>(y,x)[c] =  
                saturate_cast<uchar>(  
                    nextRow[x][c] - prevRow[x][c]);  
}  
Mat_<Vec3b>::iterator it = image.begin<Vec3b>(),  
    itEnd = image.end<Vec3b>();  
for(; it != itEnd; ++it)  
    (*it)[1] ^= 255;
```

## Matrix Manipulations: Copying, Shuffling, Part Access

<a href="#">src.copyTo(dst)</a>	Copy matrix to another one
<a href="#">src.convertTo(dst,type,scale,shift)</a>	Scale and convert to another datatype
<a href="#">m.clone()</a>	Make deep copy of a matrix
<a href="#">m.reshape(nch,nrows)</a>	Change matrix dimensions and/or number of channels without copying data
<a href="#">m.row(i), m.col(i)</a>	Take a matrix row/column
<a href="#">m.rowRange(Range(i1,i2))</a>	Take a matrix row/column span
<a href="#">m.colRange(Range(j1,j2))</a>	
<a href="#">m.diag(i)</a>	Take a matrix diagonal
<a href="#">m(Range(i1,i2),Range(j1,j2))</a>	Take a submatrix
<a href="#">m(roi)</a>	
<a href="#">m.repeat(ny,nx)</a>	Make a bigger matrix from a smaller one
<a href="#">flip(src,dst,dir)</a>	Reverse the order of matrix rows and/or columns
<a href="#">split(...)</a>	Split multi-channel matrix into separate channels
<a href="#">merge(...)</a>	Make a multi-channel matrix out of the separate channels
<a href="#">mixChannels(...)</a>	Generalized form of split() and merge()
<a href="#">randShuffle(...)</a>	Randomly shuffle matrix elements

### Example 1. Smooth image ROI in-place

```
Mat imgroi = image(Rect(10, 20, 100, 100));  
GaussianBlur(imgroi, imgroi, Size(5, 5), 1.2, 1.2);
```

### Example 2. Somewhere in a linear algebra algorithm

```
m.row(i) += m.row(j)*alpha;
```

### Example 3. Copy image ROI to another image with conversion

```
Rect r(1, 1, 10, 20);  
Mat dstroi = dst(Rect(0,10,r.width,r.height));  
src(r).convertTo(dstroi, dstroi.type(), 1, 0);
```

## Simple Matrix Operations

OpenCV implements most common arithmetical, logical and other matrix operations, such as

- [add\(\)](#), [subtract\(\)](#), [multiply\(\)](#), [divide\(\)](#), [absdiff\(\)](#), [bitwise\\_and\(\)](#), [bitwise\\_or\(\)](#), [bitwise\\_xor\(\)](#), [max\(\)](#), [min\(\)](#), [compare\(\)](#)  
– correspondingly, addition, subtraction, element-wise multiplication ... comparison of two matrices or a matrix and a scalar.

Example. [Alpha compositing](#) function:

```
void alphaCompose(const Mat& rgba1,  
    const Mat& rgba2, Mat& rgba_dest)  
{  
    Mat a1(rgba1.size(), rgba1.type(), r1);  
    Mat a2(rgba2.size(), rgba2.type());  
    int mixch[]={3, 0, 3, 1, 3, 2, 3, 3};  
    mixChannels(&rgba1, 1, &a1, 1, mixch, 4);  
    mixChannels(&rgba2, 1, &a2, 1, mixch, 4);  
    subtract(Scalar::all(255), a1, r1);  
    bitwise_or(a1, Scalar(0,0,0,255), a1);  
    bitwise_or(a2, Scalar(0,0,0,255), a2);  
    multiply(a2, r1, a2, 1./255);  
    multiply(a1, rgba1, a1, 1./255);  
    multiply(a2, rgba2, a2, 1./255);  
    add(a1, a2, rgba_dest);  
}
```

- [sum\(\)](#), [mean\(\)](#), [meanStdDev\(\)](#), [norm\(\)](#), [countNonZero\(\)](#), [minMaxLoc\(\)](#),  
– various statistics of matrix elements.
- [exp\(\)](#), [log\(\)](#), [pow\(\)](#), [sqrt\(\)](#), [cartToPolar\(\)](#), [polarToCart\(\)](#)  
– the classical math functions.
- [scaleAdd\(\)](#), [transpose\(\)](#), [gemm\(\)](#), [invert\(\)](#), [solve\(\)](#), [determinant\(\)](#), [trace\(\)](#), [eigen\(\)](#), [SVD](#),  
– the algebraic functions + SVD class.
- [dft\(\)](#), [idft\(\)](#), [dct\(\)](#), [idct\(\)](#),  
– discrete Fourier and cosine transformations

For some operations a more convenient [algebraic notation](#) can be used, for example:

```
Mat delta = (J.t()*J + lambda*  
    Mat::eye(J.cols, J.cols, J.type()))  
    .inv(CV_SVD)*(J.t()*err);
```

implements the core of Levenberg-Marquardt optimization algorithm.

## Image Processing

### Filtering

<a href="#">filter2D()</a>	Non-separable linear filter
<a href="#">sepFilter2D()</a>	Separable linear filter
<a href="#">boxFilter()</a> , <a href="#">GaussianBlur()</a> , <a href="#">medianBlur()</a> , <a href="#">bilateralFilter()</a>	Smooth the image with one of the linear or non-linear filters
<a href="#">Sobel()</a> , <a href="#">Scharr()</a>	Compute the spatial image derivatives
<a href="#">Laplacian()</a>	compute Laplacian: $\Delta I = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$
<a href="#">erode()</a> , <a href="#">dilate()</a>	Morphological operations

Example. Filter image in-place with a 3x3 high-pass kernel (preserve negative responses by shifting the result by 128):

```
filter2D(image, image, image.depth(), (Mat_<float>(3,3)«
-1, -1, -1, -1, 9, -1, -1, -1, -1), Point(1,1), 128);
```

## Geometrical Transformations

**resize()** Resize image  
**getRectSubPix()** Extract an image patch  
**warpAffine()** Warp image affinely  
**warpPerspective()** Warp image perspectively  
**remap()** Generic image warping  
**convertMaps()** Optimize maps for a faster remap() execution

Example. Decimate image by factor of  $\sqrt{2}$ :

```
Mat dst; resize(src, dst, Size(), 1./sqrt(2), 1./sqrt(2));
```

## Various Image Transformations

**cvtColor()** Convert image from one color space to another  
**threshold()** Convert grayscale image to binary image using a fixed or a variable threshold  
**adaptiveThreshold()** Find a connected component using region growing algorithm  
**floodFill()** Compute integral image  
**integral()** build distance map or discrete Voronoi diagram for a binary image.  
**distanceTransform()** marker-based image segmentation algorithms. See the samples [watershed.cpp](#) and [grabcut.cpp](#).

## Histograms

**calcHist()** Compute image(s) histogram  
**calcBackProject()** Back-project the histogram  
**equalizeHist()** Normalize image brightness and contrast  
**compareHist()** Compare two histograms

Example. Compute Hue-Saturation histogram of an image:

```
Mat hsv, H;
cvtColor(image, hsv, CV_BGR2HSV);
int planes[]={0, 1}, hsize[] = {32, 32};
calcHist(&hsv, 1, planes, Mat(), H, 2, hsize, 0);
```

## Contours

See [contours2.cpp](#) and [squares.cpp](#) samples on what are the contours and how to use them.

## Data I/O

[XML/YAML storages](#) are collections (possibly nested) of scalar values, structures and heterogeneous lists.

### Writing data to YAML (or XML)

```
// Type of the file is determined from the extension
```

```
FileStorage fs("test.yml", FileStorage::WRITE);
fs < "i" < 5 < "r" < 3.1 < "str" < "ABCDEFGH";
fs < "mtx" < Mat::eye(3,3,CV_32F);
fs < "mylist" < [" < CV_PI < "1+1" <
"{:" < "month" < 12 < "day" < 31 < "year"
< 1969 < "]" < "]"];
fs < "mystruct" < [{" < "x" < 1 < "y" < 2 <
"width" < 100 < "height" < 200 < "lbp" < "[:";
const uchar arr[] = {0, 1, 1, 0, 1, 1, 0, 1};
fs.writeRaw("u", arr, (int)(sizeof(arr)/sizeof(arr[0])));
fs < "]" < "]"];
```

*Scalars (integers, floating-point numbers, text strings), matrices, STL vectors of scalars and some other types can be written to the file storages using < operator*

### Reading the data back

```
// Type of the file is determined from the content
FileStorage fs("test.yml", FileStorage::READ);
int i1 = (int)fs["i"]; double r1 = (double)fs["r"];
string str1 = (string)fs["str"];
Mat M; fs["mtx"] > M;
FileNode t1 = fs["mylist"];
CV_Assert(t1.type() == FileNode::SEQ && t1.size() == 3);
double t10 = (double)t1[0]; string t11 = (string)t1[1];
int m = (int)t1[2]["month"], d = (int)t1[2]["day"];
int year = (int)t1[2]["year"];
FileNode tm = fs["mystruct"];
Rect r; r.x = (int)tm["x"], r.y = (int)tm["y"];
r.width = (int)tm["width"], r.height = (int)tm["height"];
int lbp_val = 0;
FileNodeIterator it = tm["lbp"].begin();
for(int k = 0; k < 8; k++, ++it)
    lbp_val |= ((int)*it) < k;
```

*Scalars are read using the corresponding FileNode's cast operators. Matrices and some other types are read using > operator. Lists can be read using FileNodeIterator's.*

### Writing and reading raster images

```
imwrite("myimage.jpg", image);
Mat image_color_copy = imread("myimage.jpg", 1);
Mat image_grayscale_copy = imread("myimage.jpg", 0);
```

*The functions can read/write images in the following formats: BMP (.bmp), JPEG (.jpg, .jpeg), TIFF (.tif, .tiff), PNG (.png), PBM/PGM/PPM (.p?m), Sun Raster (.sr), JPEG 2000 (.jp2). Every format supports 8-bit, 1- or 3-channel images. Some formats (PNG, JPEG 2000) support 16 bits per channel.*

### Reading video from a file or from a camera

```
VideoCapture cap;
if(argc > 1) cap.open(string(argv[1])); else cap.open(0);
Mat frame; namedWindow("video", 1);
for(;;) {
    cap > frame; if(!frame.data) break;
    imshow("video", frame); if(waitKey(30) >= 0) break;
}
```

## Simple GUI (highgui module)

**namedWindow(winname, flags)** Create named highgui window  
**destroyWindow(winname)** Destroy the specified window  
**imshow(winname, mtx)** Show image in the window  
**waitKey(delay)** Wait for a key press during the specified time interval (or forever). Process events while waiting. *Do not forget to call this function several times a second in your code.*  
**createTrackbar(...)** Add trackbar (slider) to the specified window  
**setMouseCallback(...)** Set the callback on mouse clicks and movements in the specified window

See [camshiftdemo.cpp](#) and other [OpenCV samples](#) on how to use the GUI functions.

## Camera Calibration, Pose Estimation and Depth Estimation

**calibrateCamera()** Calibrate camera from several views of a calibration pattern.  
**findChessboardCorners()** Find feature points on the checkerboard calibration pattern.  
**solvePnP()** Find the object pose from the known projections of its feature points.  
**stereoCalibrate()** Calibrate stereo camera.  
**stereoRectify()** Compute the rectification transforms for a calibrated stereo camera.  
**initUndistortRectifyMap()** Compute rectification map (for [remap\(\)](#)) for each stereo camera head.  
**StereoBM, StereoSGBM** The stereo correspondence engines to be run on rectified stereo pairs.  
**reprojectImageTo3D()** Convert disparity map to 3D point cloud.  
**findHomography()** Find best-fit perspective transformation between two 2D point sets.

To calibrate a camera, you can use [calibration.cpp](#) or [stereo\\_calib.cpp](#) samples. To get the disparity maps and the point clouds, use [stereo\\_match.cpp](#) sample.

## Object Detection

**matchTemplate** Compute proximity map for given template.  
**CascadeClassifier** Viola's Cascade of Boosted classifiers using Haar or LBP features. Suits for detecting faces, facial features and some other objects without diverse textures. See [facedetect.cpp](#)  
**HOGDescriptor** N. Dalal's object detector using Histogram-of-Gradient (HOG) features. Suits for detecting people, cars and other objects with well-defined silhouettes. See [peopledetect.cpp](#)