

# OpenCV 2.1 Cheat Sheet (C++)

The OpenCV C++ reference manual is here:

<http://opencv.willowgarage.com/documentation/cpp/>.

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="#">Scalar</a>    | 4-element vector                                   |
| <a href="#">Rect</a>      | Rectangle                                          |
| <a href="#">Range</a>     | Integer value range                                |
| <a href="#">Mat</a>       | 2D dense array (used as both a matrix or an image) |
| <a href="#">MatND</a>     | Multi-dimensional dense array                      |
| <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(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
```

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

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

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

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

```
Mat image_copy = image.clone();
```

```
Mat P(10, 1, CV_32FC2, Scalar(1, 1));
```

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

### 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

[src.copyTo\(dst\)](#) Copy matrix to another one

[src.convertTo\(dst,type,scale,shift\)](#) Scale and convert to another datatype

[m.clone\(\)](#) Make deep copy of a matrix

[m.reshape\(nch,nrows\)](#) Change matrix dimensions and/or number of channels without copying data

[m.row\(i\), m.col\(i\)](#) Take a matrix row/column

[m.rowRange\(Range\(i1,i2\)\)](#) Take a matrix row/column span

[m.colRange\(Range\(j1,j2\)\)](#)

[m.diag\(i\)](#) Take a matrix diagonal

[m\(Range\(i1,i2\),Range\(j1,j2\)\)](#), Take a submatrix

[m\(roi\)](#)

[m.repeat\(ny,nx\)](#) Make a bigger matrix from a smaller one

[flip\(src,dst,dir\)](#) Reverse the order of matrix rows and/or columns

[split\(...\)](#) Split multi-channel matrix into separate channels

[merge\(...\)](#) Make a multi-channel matrix out of the separate channels

[mixChannels\(...\)](#) Generalized form of split() and merge()

[randShuffle\(...\)](#) Randomly shuffle matrix elements

## 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), ra1;
```

```
    Mat a2(rgba2.size(), rgba2.type);  
    int mixch[]={3, 0, 3, 1, 3, 2, 3, 3};  
    mixChannels(&rgba1, &a1, mixch, 4);  
    mixChannels(&rgba2, &a2, mixch, 4);  
    subtract(Scalar::all(255), a1, ra1);  
    bitwise_or(a1, Scalar(0,0,0,255), a1);  
    bitwise_or(a2, Scalar(0,0,0,255), a2);  
    multiply(a2, ra1, 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

[filter2D\(\)](#) Non-separable linear filter

[sepFilter2D\(\)](#) Separable linear filter

[boxFilter\(\)](#), [GaussianBlur\(\)](#), [medianBlur\(\)](#), [bilateralFilter\(\)](#) Smooth the image with one of the linear or non-linear filters

[Sobel\(\)](#), [Scharr\(\)](#) Compute the spatial image derivatives

[Laplacian\(\)](#) compute Laplacian:  $\Delta I = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$

[erode\(\)](#), [dilate\(\)](#) Erode or dilate the image

Example. Filter image in-place with a 3x3 high-pass filter

(preserve negative responses by shifting the result by 128):

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

## Geometrical Transformations

|                                |                                              |
|--------------------------------|----------------------------------------------|
| <code>resize()</code>          | Resize image                                 |
| <code>getRectSubPix()</code>   | Extract an image patch                       |
| <code>warpAffine()</code>      | Warp image affinely                          |
| <code>warpPerspective()</code> | Warp image perspectively                     |
| <code>remap()</code>           | Generic image warping                        |
| <code>convertMaps()</code>     | 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

|                                                                |                                                                                                                             |
|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| <code>cvtColor()</code>                                        | Convert image from one color space to another                                                                               |
| <code>threshold()</code> ,<br><code>adaptiveThreshold()</code> | Convert grayscale image to binary image using a fixed or a variable threshold                                               |
| <code>floodFill()</code>                                       | Find a connected component using region growing algorithm                                                                   |
| <code>integral()</code>                                        | Compute integral image                                                                                                      |
| <code>distanceTransform()</code>                               | build distance map or discrete Voronoi diagram for a binary image.                                                          |
| <code>watershed()</code> ,<br><code>grabCut()</code>           | marker-based image segmentation algorithms. See the samples <a href="#">watershed.cpp</a> and <a href="#">grabcut.cpp</a> . |

## Histograms

|                                |                                         |
|--------------------------------|-----------------------------------------|
| <code>calcHist()</code>        | Compute image(s) histogram              |
| <code>calcBackProject()</code> | Back-project the histogram              |
| <code>equalizeHist()</code>    | Normalize image brightness and contrast |
| <code>compareHist()</code>     | Compare two histograms                  |

Example. Compute Hue-Saturation histogram of an image:

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

## Contours

See [contours.cpp](#) and [squares.c](#) 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)

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

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

## Camera Calibration, Pose Estimation and Depth Estimation

|                                        |                                                                                    |
|----------------------------------------|------------------------------------------------------------------------------------|
| <code>calibrateCamera()</code>         | Calibrate camera from several views of a calibration pattern.                      |
| <code>findChessboardCorners()</code>   | Find feature points on the checkerboard calibration pattern.                       |
| <code>solvePnP()</code>                | Find the object pose from the known projections of its feature points.             |
| <code>stereoCalibrate()</code>         | Calibrate stereo camera.                                                           |
| <code>stereoRectify()</code>           | Compute the rectification transforms for a calibrated stereo camera.               |
| <code>initUndistortRectifyMap()</code> | Compute rectification map (for <code>remap()</code> ) for each stereo camera head. |
| <code>StereoBM, StereoSGBM</code>      | The stereo correspondence engines to be run on rectified stereo pairs.             |
| <code>reprojectImageTo3D()</code>      | Convert disparity map to 3D point cloud.                                           |
| <code>findHomography()</code>          | 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

|                                |                                                                                                                                                                                                         |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>matchTemplate</code>     | Compute proximity map for given template.                                                                                                                                                               |
| <code>CascadeClassifier</code> | 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 <a href="#">facetedect.cpp</a>       |
| <code>HOGDescriptor</code>     | N. Dalal's object detector using Histogram-of-Oriented-Gradients (HOG) features. Suits for detecting people, cars and other objects with well-defined silhouettes. See <a href="#">peopledetect.cpp</a> |