Programmation Avancée

OpenCV

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(Support de Bertrand Cannelle)

OpenCV

- license BSD
  - gratuit pour la recherche et l'éducation
  - gratuit pour un usage commercial

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  - C
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  - Java

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  - Windows
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- écrit en C++
- multi-processeur

OpenCV a une structure modulaire :

core structures de bases (point, matrice...) et des fonctions de base utilisées par les autres modules

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highgui IHM

gpu module d'algorithm GPU

Conventions

- toutes les classes et fonctions sont placées dans le namespace cv::
- il faut donc utiliser cv::MaFonction

Type de données :

- 8 bit unsigned integer (uchar) CV_8U
- 8 bit signed integer (schar) CV_8S
- 16 bit unsigned integer (ushort) CV_16U
- 16 bit signed integer (short) CV_16S
- 32 bit signed integer (int) CV_32S
- 32 bit floating-point number (float) CV_32F
- 64 bit floating-point number (double) CV_64F

Type d'image multicanaux :

- 8 bit unsigned integer 1 canaux CV_8UC1 ou CV_8U
- 8 bit unsigned integer 2 canaux CV_8UC2
- 8 bit unsigned integer 3 canaux CV_8UC3
- 8 bit unsigned integer 4 canaux CV_8UC4
- 8 bit unsigned integer n canaux $CV\_MAKETYPE(CV\_8U, n)$
- (The number of bits per item)(Signed or Unsigned)(Type Prefix)C(The channel number)

```
// matrice 3x3 de float
Mat mtx(3, 3, CV_32F);
// matrice 10*1 a 2 canaux en double
Mat cmtx(10, 1, CV_64FC2);
// image 1920*1080 sur 3 canaux en unsigned char
Mat img(Size(1920, 1080), CV_8UC3);
```

Gestion des erreurs

```
 try
{
    ... // call OpenCV
}
catch( cv::Exception& e )
{
    const char* err_msg = e.what();
    std::cout << "exception caught: " << err_msg <<
   std::endl;
}
```

Structures de base

Point 2D

```
typedef cv::Point_<int> cv::Point2i;
typedef cv::Point2i cv::Point;
typedef cv::Point_<float> cv::Point2f;
typedef cv::Point_<double> cv::Point2d;

  cv::Point2f a(0.3f, 0.f), b(0.f, 0.4f);
  cv::Point2f ptA = (a + b)*2.5;
  std::cout << ptA.x << ", " << ptA.y << std::endl;
  cv::Point   ptB = (a + b)*2.5;
  std::cout << ptB.x << ", " << ptB.y << std::endl;
```

```
0.75, 1
1, 1
```

Point 3D

```
typedef cv::Point3_<int> cv::Point3i;
typedef cv::Point3_<float> cv::Point3f;
typedef cv::Point3_<double> cv::Point3d;

cv::Point3f a(0.3f, 0.f, 2.f), b(0.f, 0.4f, 4.f);
cv::Point3i ptA = (a + b)*5.f;
cout << ptA.x << ", " << ptA.y << ", " << ptA.z <<
    endl;
cv::Point3f ptB = (a + b)*5.f;
cout << ptB.x << ", " << ptB.y << ", " << ptB.z <<
    endl;
```

```
2, 2, 30
1.5, 2, 30
```

Rectangle

```
#include <iostream>
#include <cv.h>
#include <highgui.h>

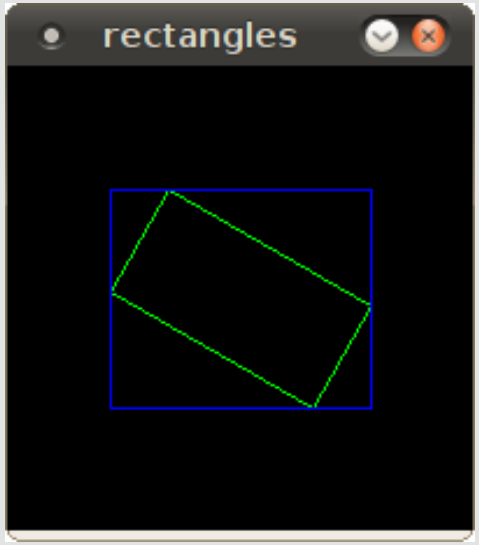
using namespace cv;
int main ( int argc, char **argv )
{
  Mat image(200, 200, CV_8UC3, Scalar(0));
  RotatedRect rRect = RotatedRect(Point2f(100,100), Size2f(100,50), 30);

  Point2f vertices[4];
  rRect.points(vertices);
  for (int i = 0; i < 4; i++)
    line(image, vertices[i], vertices[(i+1)%4], Scalar(0,255,0));

  Rect brect = rRect.boundingRect();
  rectangle(image, brect, Scalar(255,0,0));

  imshow("rectangles", image);
  waitKey(0);
  return 0;
}
```

Rectangle



Matrice

```
typedef cv::Matx<float, 1, 2> Matx12f;
typedef cv::Matx<double, 1, 2> Matx12d;

template<typename _Tp, int m, int n> class Matx
    {...};
```

- addition, soustraction... : A+B, A-B, A+s, A-s, s+A, s-A, -A
- echelle : A*alpha
- multiplication et division par element : A.mul(B), A/B, alpha/A
- multiplication: A*B
- transposition: A.t()
- inversion et pseudo-inversion
- solveur de systeme linéaire et moindre carrés


MATIS
METHODES D'ANALYSE ET DE TRAITEMENT
D'IMAGES POUR LA STEREO-RESTITUTION

Mémoire

Gestion de la mémoire

Attention

```
// Creation d'une grosse matrice
Mat A(10000, 10000, CV_64F);
// Creation d'une autre matrice mais qui pointe vers les memes donnees
Mat B = A;
```

- Permet de réduire la taille en mémoire

Gestion de la mémoire

Solution

```
// Creation d'une grosse matrice
Mat A(10000, 10000, CV_64F);
// Creation d'une autre matrice
Mat B = A.clone();
```

- Effectue une copie complète

Entrée / Sortie

Lire

```
cv::Mat img = cv::imread("linux_icon.png");
```

Écrire

```
// fabrique une image a 3 canaux
// 1920 colonnes et 1080 lignes.
cv::Mat img(Size(1920, 1080), CV_8UC3);
cv::imwrite("c:/toto.png", img);
```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Accesseurs


```
#include <iostream>
#include <cv.h>
#include <highgui.h>

using namespace cv;
int main ( int argc, char **argv ){
  Mat imgT = imread("linux_icon.png");
  for( int l = 0; l < imgT.rows; l++ ){
    for( int c = 0; c < imgT.cols; c++ ){
      std::cout<<c<<" "<<l<<" "<< (unsigned
    int)imgT.at<Vec3b>(l,c)[0]<<" "<<(unsigned
    int)imgT.at<Vec3b>(l,c)[1]<<" "<<(unsigned
    int)imgT.at<Vec3b>(l,c)[2]<<"\n";
    }
  }
  return 0;
}
```

Region

```
cv::Mat img = cv::imread("c:/toto.png");
cv::Rect r(10, 10, 100, 100);
cv::Mat smallImg = img(r);
```

Creation

```
cv::Mat M(5,3, cv::CV_8UC3, cv::Scalar(0,0,255));
std::cout << "M = " << std::endl << " " << M <<
    std::endl << std::endl;
```

```
cv::Mat M;
M.create(4,4, CV_8UC(2));
std::cout << "M = "<< std::endl << " "  << M <<
    std::endl << std::endl;
```

```
M =
[0, 0, 255, 0, 0, 255, 0, 0, 255;
0, 0, 255, 0, 0, 255, 0, 0, 255;
0, 0, 255, 0, 0, 255, 0, 0, 255;
0, 0, 255, 0, 0, 255, 0, 0, 255;
0, 0, 255, 0, 0, 255, 0, 0, 255]
```

Creation

```
cv::Mat E = cv::Mat::eye(4, 4, cv::CV_64F);
cout << "E = " << endl << " " << E << endl << endl;

cv::Mat O = cv::Mat::ones(2, 2, cv::CV_32F);
cout << "O = " << endl << " " << O << endl << endl;

cv::Mat Z = cv::Mat::zeros(3,3, cv::CV_8UC1);
cout << "Z = " << endl << " " << Z << endl << endl;
```

Creation

```
cv::Mat E = cv::Mat::eye(4, 4, cv::CV_64F);
cout << "E = " << endl << " " << E << endl << endl;

cv::Mat O = cv::Mat::ones(2, 2, cv::CV_32F);
cout << "O = " << endl << " " << O << endl << endl;

cv::Mat Z = cv::Mat::zeros(3,3, cv::CV_8UC1);
cout << "Z = " << endl << " " << Z << endl << endl;
```

```
E =
[1, 0, 0, 0;
0, 1, 0, 0;
0, 0, 1, 0;
0, 0, 0, 1]
```

Creation

```
cv::Mat E = cv::Mat::eye(4, 4, cv::CV_64F);
cout << "E = " << endl << " " << E << endl << endl;

cv::Mat O = cv::Mat::ones(2, 2, cv::CV_32F);
cout << "O = " << endl << " " << O << endl << endl;

cv::Mat Z = cv::Mat::zeros(3,3, cv::CV_8UC1);
cout << "Z = " << endl << " " << Z << endl << endl;
```

```
O =
[1, 1;
1, 1]
```

Creation

```
cv::Mat E = cv::Mat::eye(4, 4, cv::CV_64F);
cout << "E = " << endl << " " << E << endl << endl;

cv::Mat O = cv::Mat::ones(2, 2, cv::CV_32F);
cout << "O = " << endl << " " << O << endl << endl;

cv::Mat Z = cv::Mat::zeros(3,3, cv::CV_8UC1);
cout << "Z = " << endl << " " << Z << endl << endl;
```

```
Z =
[0, 0, 0;
 0, 0, 0;
 0, 0, 0]
```


MATIS
METHODES D'ANALYSE ET DE TRAITEMENT
D'IMAGES POUR LA STEREO-RESTITUTION

Dessin

Primitive

```
void circle(Mat& img, Point center, int radius, const Scalar& color, int thickness=1, int
      lineType=8, int shift=0);
bool clipLine(Size imgSize, Point& pt1, Point& pt2);
void ellipse(Mat& img, Point center, Size axes, double angle, double startAngle, double
      endAngle, const Scalar& color, int thickness=1, int lineType=8, int shift=0);
void ellipse2Poly(Point center, Size axes, int angle, int startAngle, int endAngle, int
      delta, vector<Point>& pts);
void fillConvexPoly(Mat& img, const Point* pts, int npts, const Scalar& color, int
      lineType=8, int shift=0);
void fillPoly(Mat& img, const Point** pts, const int* npts, int ncontours, const Scalar&
      color, int lineType=8, int shift=0, Point offset=Point());
Size getTextSize(const string& text, int fontFace, double fontScale, int thickness, int*
      baseLine);
void line(Mat& img, Point pt1, Point pt2, const Scalar& color, int thickness=1, int
      lineType=8, int shift=0);
void rectangle(Mat& img, Point pt1, Point pt2, const Scalar& color, int thickness=1, int
      lineType=8, int shift=0);
void polylines(Mat& img, const Point** pts, const int* npts, int ncontours, bool isClosed,
      const Scalar& color, int thickness=1, int lineType=8, int shift=0);
void putText(Mat& img, const string& text, Point org, int fontFace, double fontScale, Scalar
      color, int thickness=1, int lineType=8, bool bottomLeftOrigin=false);
```

Exemples

```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
#include <stdlib.h>
#include <stdio.h>

using namespace cv;


int main( int argc, char** argv )
{
  Mat imgI = imread("linux_icon.png");
  ellipse(imgI, Point(50,50), Size(40,40), 45, 0, 270, Scalar(255,255,0), 2, CV_AA);
  imwrite("linux_iconDe.png", imgI);
  return 0;
}
```

Exemples

```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
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}
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```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
#include <stdlib.h>
#include <stdio.h>

using namespace cv;

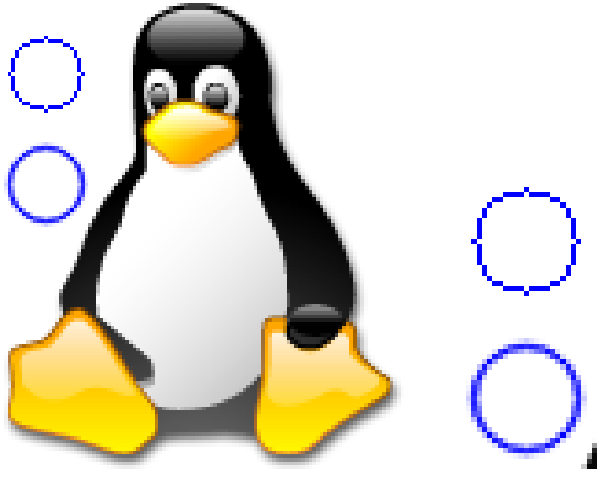

int main( int argc, char** argv )
{
  Mat imgI = imread("linux_icon.png");
  circle(imgI, Point(20,20),10, Scalar(255,0,0),1,4);
  circle(imgI, Point(20,50),10, Scalar(255,0,0),1,CV_AA);
  imwrite("linux_iconDe.png", imgI);
  return 0;
}
```

Exemples


```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
#include <stdlib.h>
#include <stdio.h>

using namespace cv;


int main( int argc, char** argv )
{
  Mat imgI = imread("linux_icon.png");
  circle(imgI, Point(20,20),10, Scalar(255,0,0),1,4);
  circle(imgI, Point(20,50),10, Scalar(255,0,0),1,CV_AA);
  imwrite("linux_iconDe.png", imgI);
  return 0;
}
```



Traitement d'image

Traitement d'image

Noyau

Filtrage

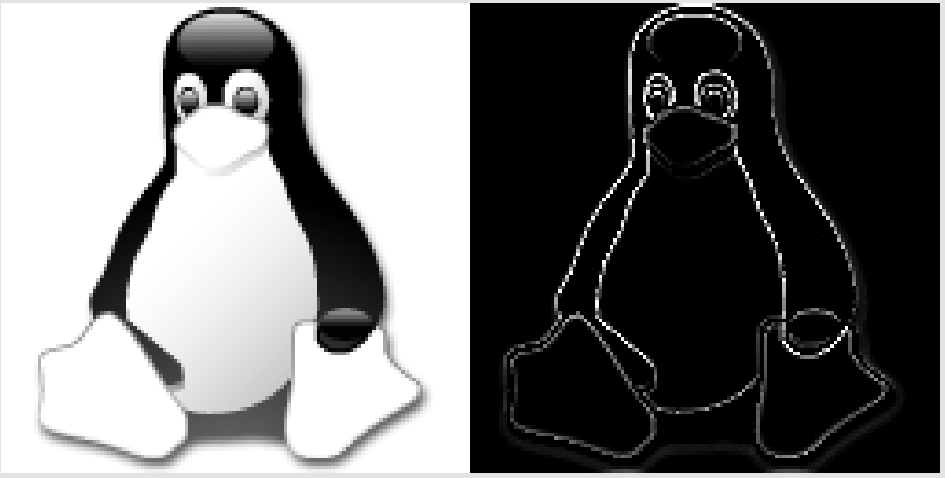
```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO ;
cv::Mat kern = (cv::Mat_<char>(3,3) <<  0, -1,  0,
                                       -1,  4, -1,
                                        0,-1,  0);

cv::filter2D(imgI, imgO, imgI.depth(), kern );
cv::imwrite("linux_iconS.png", imgO);
```

Filtrage

```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO ;
cv::Mat kern = (cv::Mat_<char>(3,3) <<  0, -1,  0,
                                       -1,  4, -1,
                                        0,-1,  0);

cv::filter2D(imgI, imgO, imgI.depth(), kern );
cv::imwrite("linux_iconS.png", imgO);
```



Traitement d'image

Morphologie

Erosion

```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO;
// MORPH_RECT - a rectangular structuring element:
// MORPH_ELLIPSE - an elliptic structuring element, that is, a filled ellipse inscribed into
      the rectangle Rect(0, 0, esize.width, 0.esize.height)
// MORPH_CROSS - a cross-shaped structuring element:

cv::Mat element = cv::getStructuringElement( MORPH_RECT,
                                             Size( 5, 3 ));

cv::erode( imgI,imgO, element );

cv::imwrite("linux_iconE.png", imgO);
```

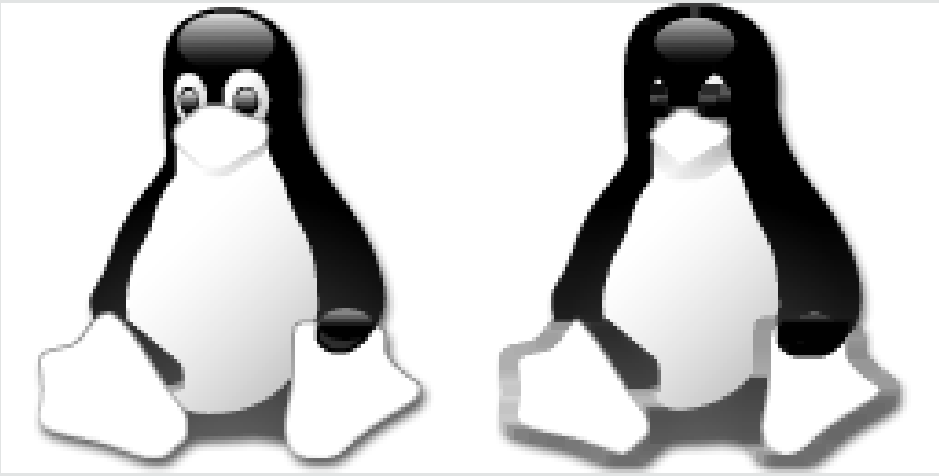
Erosion

```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO;
// MORPH_RECT - a rectangular structuring element:
// MORPH_ELLIPSE - an elliptic structuring element, that is, a filled ellipse inscribed into
      the rectangle Rect(0, 0, esize.width, 0.esize.height)
// MORPH_CROSS - a cross-shaped structuring element:

cv::Mat element = cv::getStructuringElement( MORPH_RECT,
                                             Size( 5, 3 ));

cv::erode( imgI,imgO, element );

cv::imwrite("linux_iconE.png", imgO);
```



Dilatation

```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO;
// MORPH_RECT
// MORPH_ELLIPSE
// MORPH_CROSS

cv::Mat element = cv::getStructuringElement( MORPH_RECT,
                                             Size( 5, 3 ));

cv::dilate( imgI,imgO, element );

cv::imwrite("linux_iconD.png", imgO);
```

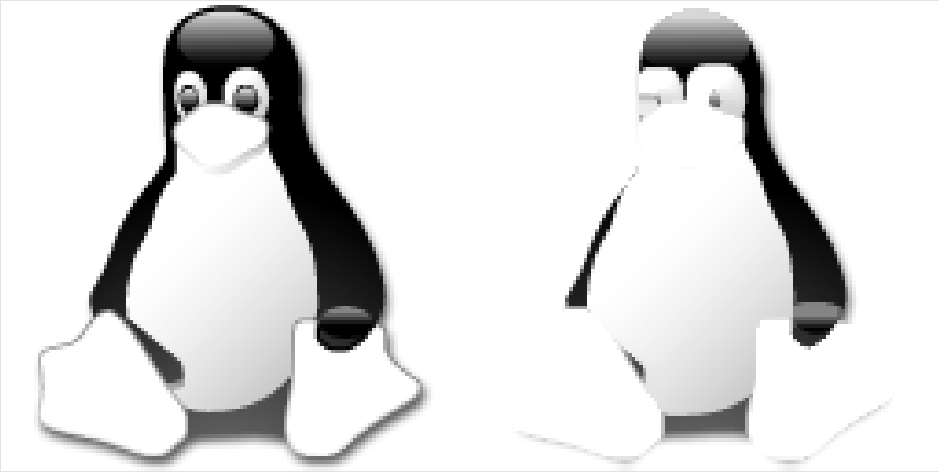
Dilatation

```
cv::Mat imgI = cv::imread("linux_iconG.png");
cv::Mat imgO;
// MORPH_RECT
// MORPH_ELLIPSE
// MORPH_CROSS

cv::Mat element = cv::getStructuringElement( MORPH_RECT,
                                             Size( 5, 3 ));

cv::dilate( imgI,imgO, element );

cv::imwrite("linux_iconD.png", imgO);
```



Traitement d'image

Couleurs

Attention

Une image couleurs est par défaut ouverte en BGR, c'est à dire que le canal 0 est le bleu, le 1 est le vert et le 2 le rouge !

```
#include <iostream>
#include <cv.h>
#include <highgui.h>

using namespace cv;
int main ( int argc, char **argv ){
  Mat imgT = imread("linux_icon.png");
  for( int l = 0; l < imgT.rows; l++ ){
    for( int c = 0; c < imgT.cols; c++ ){
      std::cout<<c<<" "<<l<<" "<< (unsigned
    int)imgT.at<Vec3b>(l,c)[0]<<" "<<(unsigned
    int)imgT.at<Vec3b>(l,c)[1]<<" "<<(unsigned
    int)imgT.at<Vec3b>(l,c)[2]<<"\n";
    }
  }
  return 0;
}
```

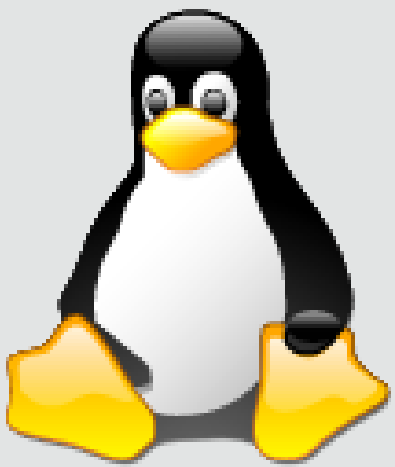
Conversion de couleur

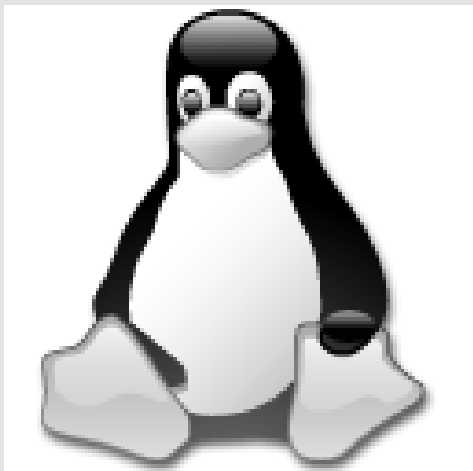
- RGB $->$ gris (CV_RGB2GRAY)
- RGB HSV (CV_BGR2HSV...)
- BGR XYZ (CV_BGR2XYZ...)
- BGR2YCrCb (CV_BGR2YCrCb...)
- BGR2HLS (CV_BGR2HLS...)
- BGR2Lab (CV_BGR2Lab...)
- BGR2Luv (CV_BGR2Luv...)
- BayerBG2BGR (...)

```
#include <cv.h>
#include <highgui.h>
using namespace cv;
int main( int argc, char** argv )
{
  Mat src, hsv;
  src=imread("linux_icon.png");
  cvtColor(src, hsv, CV_BGR2GRAY);
  imwrite("linux_iconG.png",hsv);
  return 0;
}
```

Conversion de couleur

```
#include <cv.h>
#include <highgui.h>
using namespace cv;
int main( int argc, char** argv )
{
  Mat src, hsv;
  src=imread("linux_icon.png");
  cvtColor(src, hsv, CV_BGR2GRAY);
  imwrite("linux_iconG.png",hsv);
  return 0;
}
```





Traitement d'image

Seuillage

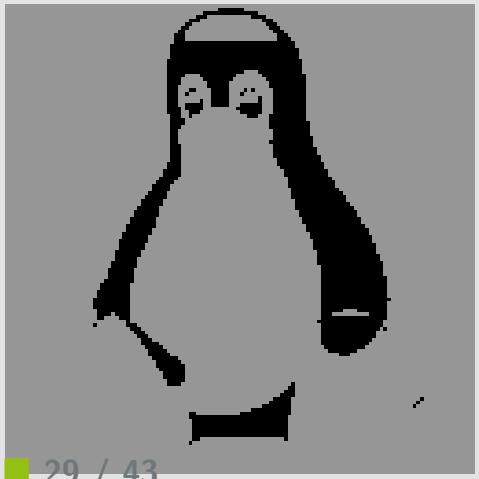
Seuillage automatique

- THRESH_BINARY

```
#include <cv.h>
#include <highgui.h>
#include <iostream>

using namespace cv;

int main( int argc, char** argv )
{
  Mat src = imread( "linux_icon.png" );
  Mat dst;
  threshold(src,dst, 100, 150, THRESH_BINARY);
  imwrite( "linux_icon_.png" ,dst);
 return 0;
}
```



Seuillage automatique

- THRESH_BINARY
- THRESH_BINARY_INV

```
#include <cv.h>
#include <highgui.h>
#include <iostream>

using namespace cv;

int main( int argc, char** argv )
{
  Mat src = imread( "linux_icon.png" );
  Mat dst;
  threshold(src,dst, 100, 150, THRESH_BINARY);
  imwrite( "linux_icon_.png" ,dst);
 return 0;
}
```

Seuillage automatique

- THRESH_BINARY
- THRESH_BINARY_INV
- THRESH_TRUNC

```
#include <cv.h>
#include <highgui.h>
#include <iostream>

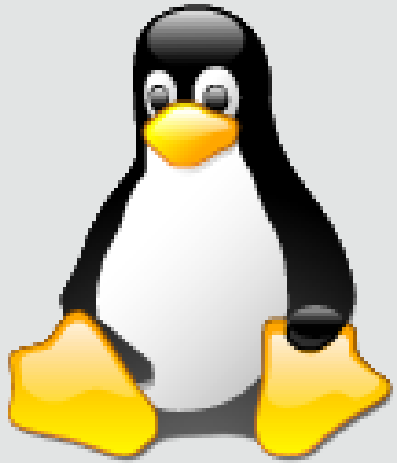
using namespace cv;

int main( int argc, char** argv )
{
  Mat src = imread( "linux_icon.png" );
  Mat dst;
  threshold(src,dst, 100, 150, THRESH_BINARY);
  imwrite( "linux_icon_.png" ,dst);
 return 0;
}
```


MATIS
METHODES D'ANALYSE ET DE TRAITEMENT
D'IMAGES POUR LA STEREO-RESTITUTION

IHM

Visualiser une Image



Visualiser une Image

```
#include <iostream>
#include <cv.h>
#include <highgui.h>

using namespace cv;
int main ( int argc, char **argv )
{
  Mat img = cv::imread("./linux_icon.png");
  imshow("Mon image", img);
  waitKey();
  return 0;
}
```

Visualiser une Image

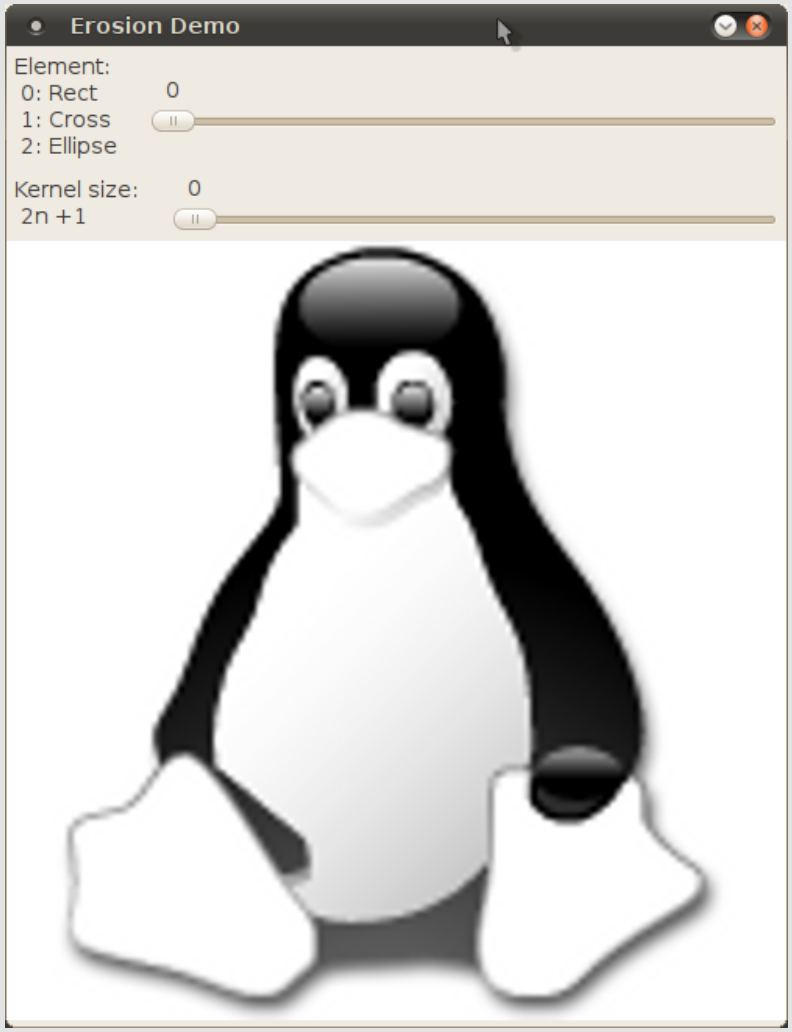
Ajouter une trackbar


```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
#include <stdlib.h>
#include <stdio.h>
using namespace cv;
Mat src, erosion_dst;
int erosion_elem = 0;int erosion_size = 0;

void Erosion( int, void* )
{
  int erosion_type;
  if( erosion_elem == 0 ){ erosion_type = MORPH_RECT; }
  else if( erosion_elem == 1 ){ erosion_type = MORPH_CROSS; }
  else if( erosion_elem == 2) { erosion_type = MORPH_ELLIPSE; }
  Mat element = getStructuringElement( erosion_type,Size( 2*erosion_size + 1,
      2*erosion_size+1 ),Point( erosion_size, erosion_size ) );
  erode( src, erosion_dst, element );
  imshow( "Erosion Demo", erosion_dst );
}

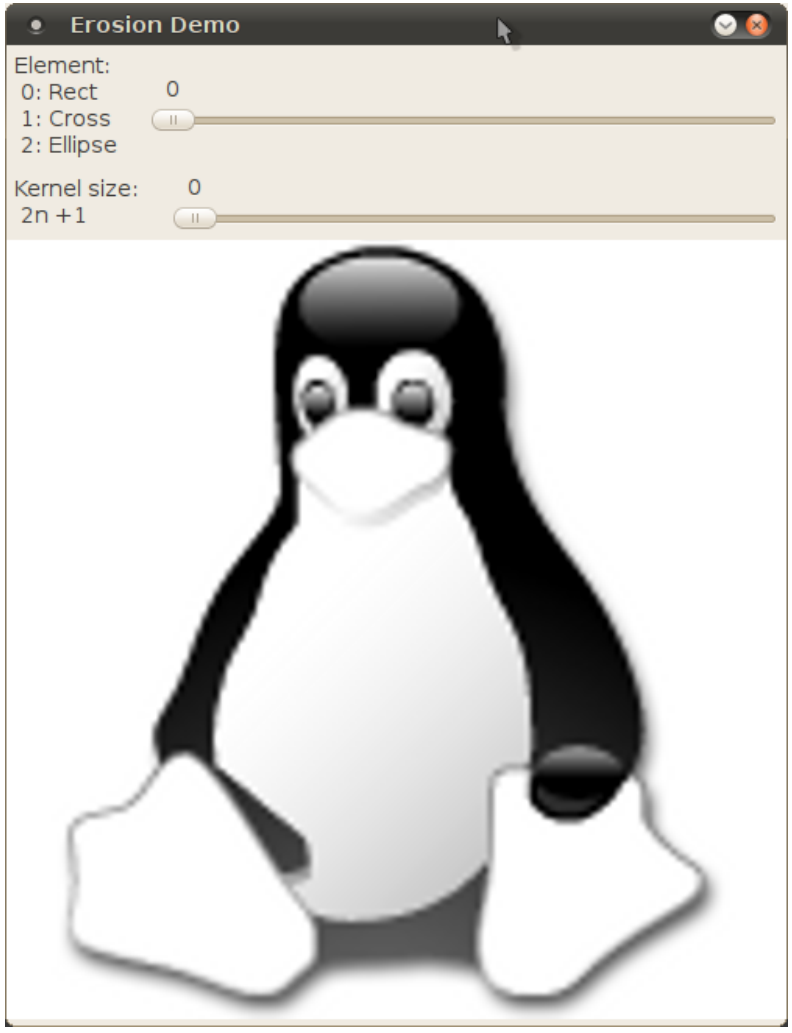
int main( int argc, char** argv )
{
  src = imread( "linux_iconGG.png" );
  if( !src.data ) return -1;
  namedWindow( "Erosion Demo", CV_WINDOW_AUTOSIZE );
  createTrackbar( "Element:\n 0: Rect \n 1: Cross \n 2: Ellipse", "Erosion
      Demo",&erosion_elem, 2,Erosion );
  createTrackbar( "Kernel size:\n 2n +1", "Erosion Demo",&erosion_size, 21, Erosion );
  Erosion( 0, 0 );
  waitKey(0);
  return 0;
}
```

Visualiser une Image



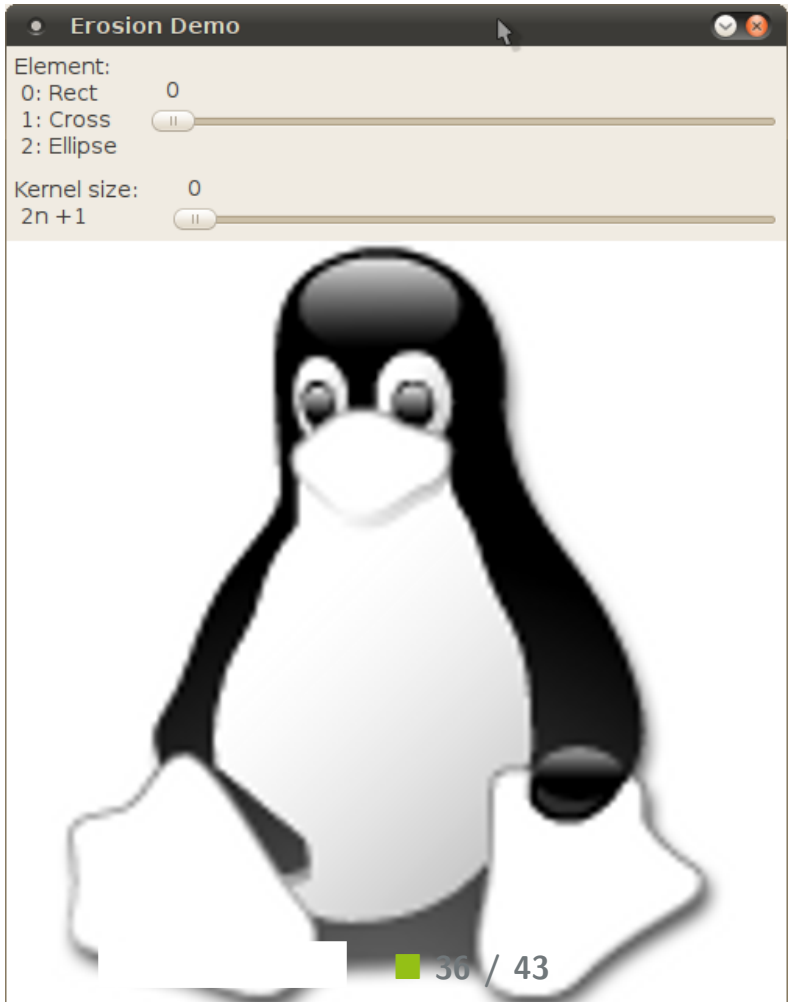
Ajouter une trackbar

```
namedWindow( "Erosion Demo", CV_WINDOW_AUTOSIZE );
```



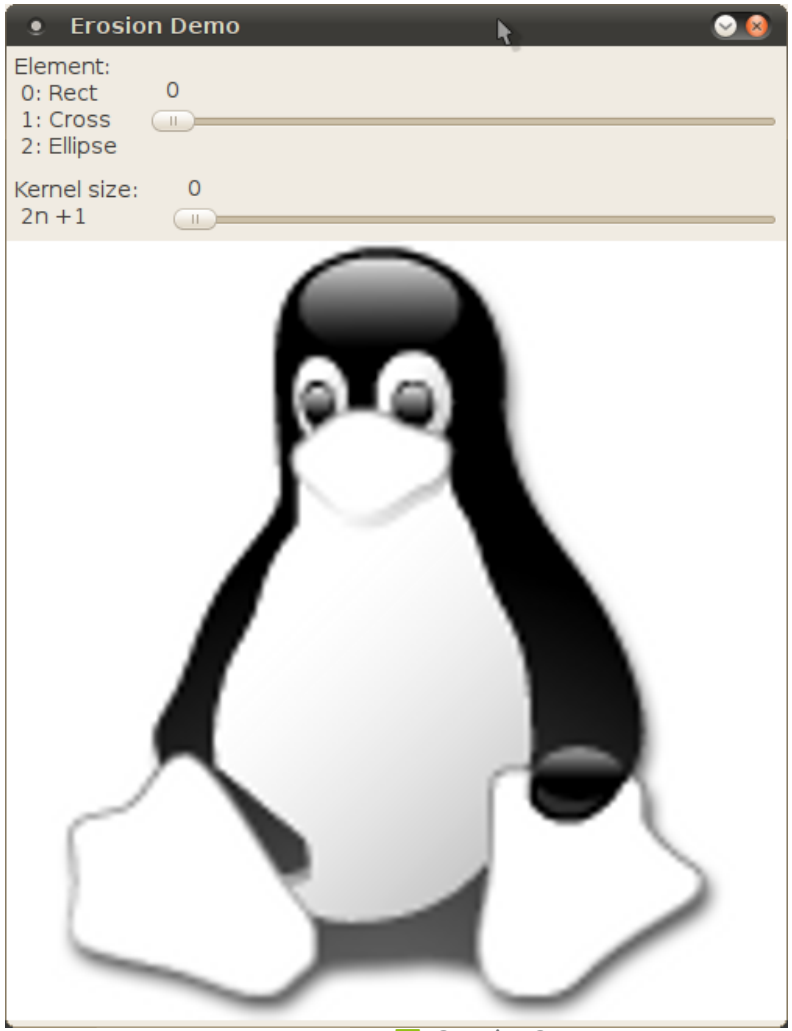
Ajouter une trackbar

```
createTrackbar( "Element:\n 0: Rect \n 1: Cross \n
    2: Ellipse", "Erosion Demo",&erosion_elem,
    2,Erosion );
```

Ajouter une trackbar

```
createTrackbar( "Kernel size:\n 2n +1", "Erosion
    Demo",&erosion_size, 21, Erosion );
```

Visualiser plusieurs images

```
#include "opencv2/imgproc/imgproc.hpp"
#include "opencv2/highgui/highgui.hpp"
#include "highgui.h"
#include <stdlib.h>
#include <stdio.h>

using namespace cv;


int main( int argc, char** argv )
{
  Mat srcA=imread( "linux_icon.png" );
  Mat srcB=imread( "linux_iconG.png" );

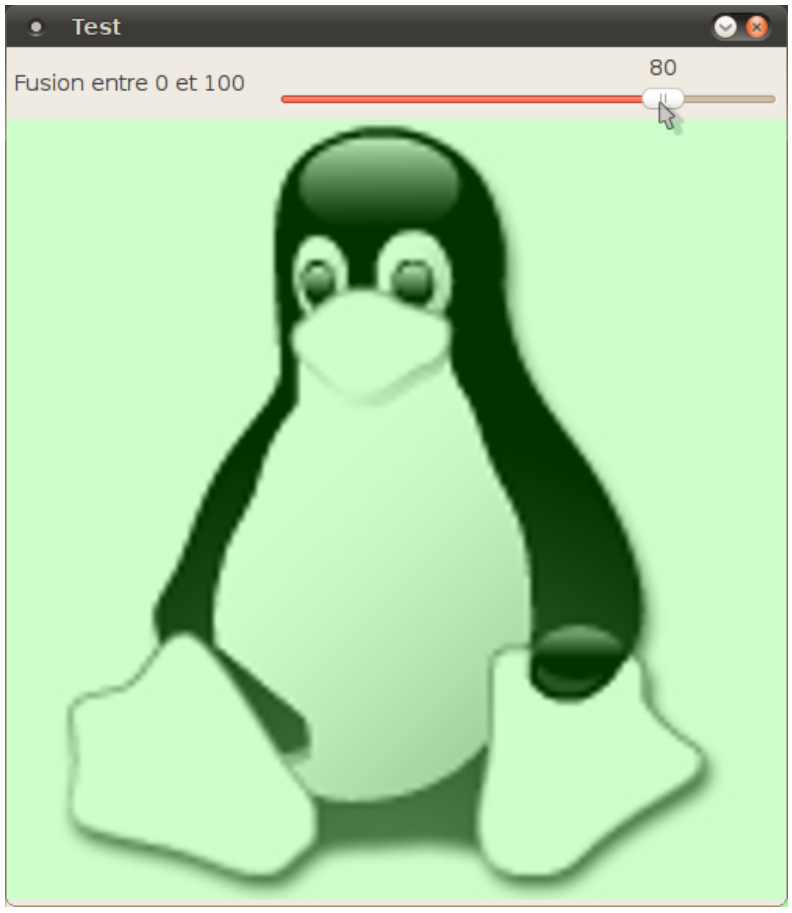
  /// Create windows
  namedWindow( "Image A", CV_WINDOW_AUTOSIZE );
  namedWindow( "Image B", CV_WINDOW_AUTOSIZE );
  cvMoveWindow( "Image A", 0, 0 );
  cvMoveWindow( "Image B", srcA.cols+50, 0 );
  imshow( "Image A", srcA );
  imshow( "Image B", srcB );
  waitKey(0);
  return 0;
}
```

Visualiser plusieurs images

```
#include <cv.h>
#include <highgui.h>
#include <iostream>
using namespace cv;
Mat src1, src2, dst;
int fusion;
void Fusion( int , void* )
{
  double alpha=fusion/100.0;
  double beta = ( 1.0 - alpha );
  addWeighted( src1, alpha, src2, beta, 0.0, dst);
  imshow( "Test", dst );
}

int main( int argc, char** argv )
{
  fusion=50;
  src1 = imread("linux_iconGG.png");
  src2 = imread("vert.png");
  if( !src1.data ) { printf("Error loading src1 \n"); return -1; }
  if( !src2.data ) { printf("Error loading src2 \n"); return -1; }

  namedWindow("Test", 1);
  createTrackbar(  "Fusion entre 0 et 100","Test",&fusion, 100,Fusion );
  Fusion(0,0);
  waitKey(0);
  return 0;
}
```




MATIS
METHODES D'ANALYSE ET DE TRAITEMENT
D'IMAGES POUR LA STEREO-RESTITUTION

CMake

Pour utiliser OpenCV dans un projet c++, on peut utiliser CMake. Voici un exemple de fichier CMakeLists :

CMakeLists.txt

```
PROJECT( helloworld_proj )
FIND_PACKAGE( OpenCV REQUIRED )
ADD_EXECUTABLE( helloworld main.cpp )
TARGET_LINK_LIBRARIES( helloworld ${OpenCV_LIBS} )
```

Voici un exemple de fichier main.cpp :

main.cpp

```
#include <cv.h>
#include <highgui.h>
#include <iostream>
using namespace cv;
Mat src1, src2, dst;
int fusion;
void Fusion( int , void* )
{
  double alpha=fusion/100.0;
  double beta = ( 1.0 - alpha );
  addWeighted( src1, alpha, src2, beta, 0.0, dst);
  imshow( "Test", dst );
}

int main( int argc, char** argv )
{
  fusion=50;
  src1 = imread("linux_iconGG.png");
  src2 = imread("vert.png");
  if( !src1.data ) { printf("Error loading src1 \n"); return -1; }
  if( !src2.data ) { printf("Error loading src2 \n"); return -1; }

  namedWindow("Test", 1);
  createTrackbar(  "Fusion entre 0 et 100","Test",&fusion, 100,Fusion );
  Fusion(0,0);
  waitKey(0);
  return 0;
}
```