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Gabor

OpenCV meets Clojure: Motivation

OpenCV is quite well known in the domain of image manipulation. It has all those secret boots you can wear and use to apply filters, resize, rotate, find shapes, remove background etc ...

In those days of neural networks, image pre-analysis is actual a fundamental step in preparing a training set.

While OpenCV is fantastic to achieve all those tasks, its also quite a pain to re-compile and make the install manually on each machine you want to run it, and I do feel this is a gigantic wall for most of the people out there who just want to use it.

|

Short Sample

Welcome to this tutorial. This is a short sample to show how to use this fantastic API to do OpenCV stuff in the browser.

```
[ns composed-pine
  (:require
    [opencv3.utils :as u]
    [opencv3.core :refer :all]))
```

```
nil
```

```
(defn load-cvt-resize-show[url]
  (-> url
        (u/mat-from-url)
        (cvt-color! COLOR_RGB2GRAY)
        (resize! (new-size 150 200))
        (u/mat-view)))
```

```
 #'composed-pine/load-cvt-resize-show
```



Interactive OpenCV Introduction

Manipulate images with clojure and opencv

```
(ns spacial-dusk
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

```
nil
```

```
(def neko
  (u/mat-from-url "https://s-media-cache-
ak0.pinimg.com/236x/10/2c/75/102c756d7e808deff666f3edf540abba.jpg" ))
(u/mat-view neko)
```



```
(def gray (new-mat))
(cvt-color neko gray COLOR_RGB2GRAY)
(u/mat-view gray)
```



```
(def small-gray-neko
  (u/resize-by gray 0.5))
(u/mat-view small-gray-neko)
```



```
(def equalized (new-mat))
(equalize-hist small-gray-neko equalized)
(u/mat-view equalized)
```

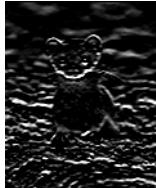


```
(def dilated (u/mat-from small-gray-neko))
(def dilation-size 2)
(def element (get-structuring-element MORPH_RECT
  (new-size (inc (* 2 dilation-size)) (inc (* 2 dilation-size)))))  

(dilate small-gray-neko dilated element)
(u/mat-view dilated)
```



```
(def sobelled (u/mat-from small-gray-neko))
(sobel small-gray-neko sobelled -1 0 1)
(u/mat-view sobelled)
```



```
(def bit_not (u/mat-from small-gray-neko)_
(bitwise-not small-gray-neko bit_not)
(u/mat-view bit_not)
```



Color Maps

This short tutorial will show you how to change the color maps of loaded pictures. A colormap is defined by a m-by-3 matrix of real numbers between 0.0 and 1.0. Each row is an RGB vector that defines one color.

This follows the story of kutsushita, the cat that likes to change color.

```
; first we import the usual namespaces.
(ns affectionate-thorns
  (:require
    [opencv3.utils :as u]
    [opencv3.colors.rgb :as color]
    [opencv3.core :refer :all]))
```

```
nil
```

Changing color space for a default color space is done through the function **apply-color-map!** from opencv3.core. The mat as well as the colormap id is passed as parameter.

Using the chaining method we can apply the BONE color map using the code below:

```
(-> "resources/images/cats/onsofa.jpg"
  imread
  (u/resize-by 0.5)
  (apply-color-map! COLORMAP_BONE)
  (u/mat-view))
```



You just saw one colormap, but a few other default color maps are available by default. The array below is a list of all the available color maps through OpenCV core.

```
(def colors-maps
[ "COLORMAP_HOT"
  "COLORMAP_HSV"
  "COLORMAP_JET"
  "COLORMAP_BONE"
  "COLORMAP_COOL"
  "COLORMAP_PINK"
  "COLORMAP_RAINBOW"
  "COLORMAP_OCEAN"
  "COLORMAP_WINTER"
  "COLORMAP_SUMMER"
  "COLORMAP_AUTUMN"
  "COLORMAP_SPRING" ])
```

```
#'affectionate-thorns/colors-maps
```

```
(defn watermark [ source text ]
  (put-text! source
  text
  (new-point 30 30) FONT_HERSHEY_PLAIN 1 (new-scalar 255 255 255) 2))

(defn change-color [ source color-map-string ]
  (->
  source
  clone
  (apply-color-map! (eval (read-string (str "opencv3.core/" color-map-string)))) 
  (watermark color-map-string)))

(defn apply-all-colormaps [ source ]
  (cons
    (-> source clone (watermark "ORIGINAL"))
    (map (partial change-color source) colors-maps))) )
```

```
#'affectionate-thorns/apply-all-colormaps
```

```
(def source
  (-> "http://sites.psu.edu/siowfa15/wp-content/uploads/sites/29639/2015/10/cat.jpg"
       (u/mat-from-url)
       (u/resize-by 0.1)))
```

```
#'affectionate-thorns/source
```

```
(def targets (apply-all-colormaps source))
(u/mat-view (vconcat! targets))
```



Defining your own color space is also possible using the function **transform!**. transform needs a matrix doing the mapping from rgb to some mapping. The first line of the matrix is the blue value, the second line is the green value, the third value is the red value.

The below matrix makes so that all red pixels are turned to green.

```
(def custom (u/matrix-to-mat [  
  [1 0 0] ; blue  
  [0 1 0] ; green  
  [0 1 0] ; red  
]))  
(-> img  
  clone  
  (transform! custom)  
  (u/mat-view ))
```



You could use the same technique to define your own sepia filter.

```
(def img (-> "resources/images/cats/onsofa.jpg" imread (u/resize-by 0.5)))  
  
(def blue-sepia (u/matrix-to-mat [  
  [0.393 0.769 0.189] ; blue  
  [0.349 0.686 0.168] ; green  
  [0.272 0.534 0.131] ; red  
]))  
(-> img  
  clone  
  (transform! blue-sepia)  
  (u/mat-view ))
```



And a regular sepia is done using a similar matrix.

```
(def sepia-2 (u/matrix-to-mat [  
  [0.131 0.534 0.272]  
  [0.168 0.686 0.349]  
  [0.189 0.769 0.393]  
]))  
(-> img  
  clone  
  (transform! sepia-2)  
  (u/mat-view ))
```



Cartoon Cats

Because we all love cats and cartoon ...

```
(ns opencv3.cartoon2
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

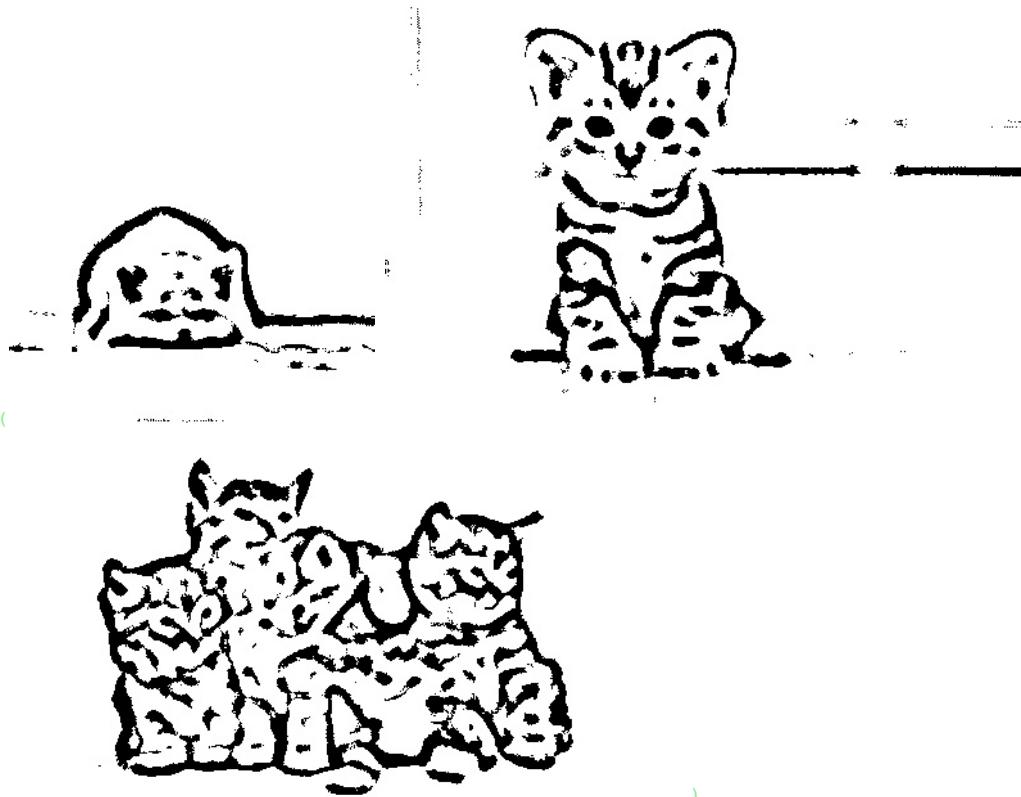
nil

```
(defn cartoon
  [buffer]
  (->
    (cvt-color! buffer COLOR_RGB2GRAY))
    (let [ c (clone buffer)]
      ; (bilateral-filter buffer c 9 9 7)
      (bilateral-filter buffer c 10 250 50)
      (-> c
        (median-blur! 7)
        (adaptive-threshold! 255 ADAPTIVE_THRESH_MEAN_C THRESH_BINARY 9 3)
        (cvt-color! COLOR_GRAY2RGB))))
```

```
(defn cartoon-me[url]
  (-> url
    u/mat-from-url
    (u/resize-by 0.5)
    cartoon
    u/mat-view))
```

#'opencv3.cartoon2/cartoon-me

```
{map
  cartoon-me
  [ "http://www.petmd.com/sites/default/files/sleepy-cat-125522297.jpg"
    "http://www.readersdigest.ca/wp-content/uploads/2011/01/4-ways-cheer-up-depressed-
cat.jpg"
    "https://hyatoky.com/wp-content/uploads/cute-cat-wallpapers-hd-1080x580.jpg"])
```



Matching triangle, and other shapes

In this recipe you learn how to match shapes with each others. Matching shapes can be used to count things automatically.

```
[ns stark-spring
  (:require
    [opencv3.utils :as u]
    [opencv3.core :refer :all]))
```

```
nil
```

```
(def t1
  (->
    "resources/white-blue-triangle.png"
    (imread)
    (u/resize-by 0.2) ))
(u/mat-view t1)
```



```
(def t2
  (->
    "resources/Sweden_road_sign_A19-1.svg.png"
    (imread)
    (u/resize-by 0.7) ))
(u/mat-view t2)
```



```
(def lower-red (new-scalar 70 20 20))
(def upper-red (new-scalar 100 255 255))
(def mask (new-mat))
(in-range (-> t2 clone (cvt-color! COLOR_RGB2HSV)) lower-red upper-red mask)
(u/mat-view mask)
```



```
(def contours (new-arraylist))
(find-contours mask contours (new-mat) RETR_LIST CHAIN_APPROX_SIMPLE)

(def indexed
  (apply hash-map (flatten (map-indexed (fn [idx itm] [idx itm]) contours ))))

(def sorted
  (into
    (sorted-map-by
      (fn [key1 key2]
        (clojure.core/compare
          (-> (get indexed key1) (.size) (.area))
          (-> (get indexed key2) (.size) (.area)))))))

(def biggest (last sorted))

#'opencv3.matchingshapes/biggest
```

```
(def output
  (new-mat (.rows mask) (.cols mask) CV_8UC3 (new-scalar 0 0 0)))
(draw-contours output contours (key biggest) (new-scalar 255 255 255) 3)
(u/mat-view output)
```



```
{def s1
  (-> t1 clone (cvt-color! COLOR_BGR2GRAY) (threshold! 210 240 1))_
(def s2
  (-> output clone (cvt-color! COLOR_BGR2GRAY) (threshold! 210 240 1)))
(match-shapes (.t s1) (.t s2) CV_CONTOURS_MATCH_I1 0)
```

```
0.001700601060277196
```

Failed to load worksheet: gorillas/04-smoothing.clj



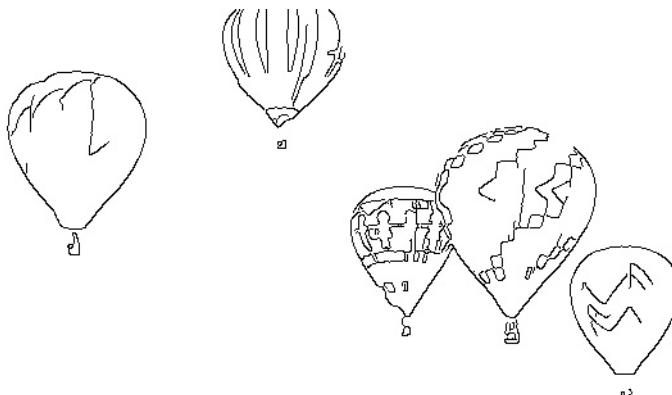
More Api Examples

We have seen very simple syntax usage, now its time to make use of those pipelines.

```
(ns opencv3.dolphin
  (:require
    [opencv3.utils :as u]
    [opencv3.core :refer :all]))
```

```
nil
```

```
(-> "http://www.v3wall.com/wallpaper/1366_768/0912/1366_768_20091223010850201138.jpg"
u/matrix-from-url
(u/resize-by 0.4)
(median-blur! 3)
(cvt-color! COLOR_BGR2GRAY)
(canny! 300.0 100.0 3 true)
(bitwise-not!)
(u/matrix-view))
```



```
(-> "resources/images/cat.jpg"
imread
(clone)
(u/resize-by 0.3)
(median-blur! 7)
(cvt-color! COLOR_BGR2GRAY)
bitwise-not!
u/matrix-view)
```

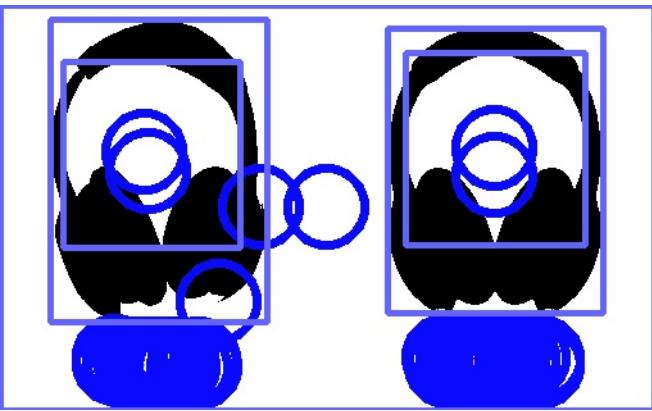


```
(def headphones (->
  "resources/morph/headphone.png"
  imread
  clone
  (cvt-color! COLOR_BGR2GRAY))

(def contours (new-arraylist))
(find-contours headphones contours (new-mat) RETR_LIST CHAIN_APPROX_SIMPLE)

(doseq [c contours]
  (if (> (contour-area c) 100)
    (let [ rect (bounding-rect c)]
      (if (> (.height rect) 28)
        (rectangle
          image-c
          (new-point (.x rect) (.y rect))
          (new-point (+ (.width rect) (.x rect)) (+ (.y rect) (.height rect)))
          (new-scalar 255 100 100)
          3))))
```

(u/mat-view image-c)



Edges

```
(ns opencv3.threshold
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))

(def neko
  (->
    "resources/images/cat.jpg"
    imread
    (u/resize-by 0.2)))
(u/mat-view neko)
```



```
(def factor 6)
(def background (new-mat))
(def work (clone neko))

(dotimes [_ factor] (pyr-down! work))
(bilateral-filter work background 9 9 7)
(dotimes [_ factor] (pyr-up! background))
(resize! background (new-size (.cols neko) (.rows neko)))
(u/mat-view background)
```



```
(def
  c
  (-> neko
    clone
    (blur! (new-size 3 3))
    (cvt-color! COLOR_BGR2GRAY)
    (canny! 300.0 100.0 3 true)
    (bitwise-not!)
    (cvt-color! COLOR_GRAY2BGR) ))
(u/mat-view c)
```



```
(let [result (new-mat) ]
  (bitwise-and background c result)
  (u/mat-view result))
```



```
(def t
  (-> neko
    clone
    (blur! (new-size 3 3))
    (cvt-color! COLOR_BGR2GRAY)
    (threshold! 150 255 THRESH_BINARY_INV)
    (cvt-color! COLOR_GRAY2BGR) )
```



Avoid Artefacts when drawing contours

You are trying to draw contours of a shape, but the original picture has some noise, and you can't get a proper contour using the standard technique.

Here we present a technique of smoothing the picture to remove unwanted artefacts on the mat used for detection. The smoothing is done by looping many on the picture with a blur, erode, dilate sequence so that hard edges naturally disappears.

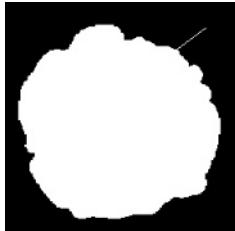
```
[ns balmy-beach
  (:require
    [opencv3.utils :as u]
    [opencv3.core :refer :all]))]

nil
```

We start by loading the picture of the shape we would like to mark the contours of. The picture is slightly big for this book so we resize it a bit.

```
(def img
  (->
    "resources/morph/u9phq.png"
    imread
    (u/resize-by 0.8)))

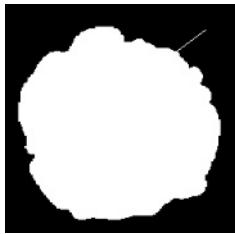
(u/mat-view img)
```



Most of the detection algorithms work on 1 channel pictures, so let's convert the picture to gray using **cvt-color!** on a clone of the original picture.

```
(def gray
  (->
    img
    (clone)
    (cvt-color! COLOR_BGR2GRAY)))

(u/mat-view img)
```



Naively using find-contours and draw-contours

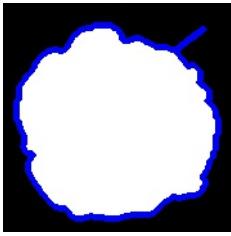
So we have the work picture ready now, let's naively use **find-contours** and **draw-contours** and see how it goes.

```
(def contours-1 (new-arraylist))

(find-contours gray contours-1 (new-mat) RETR_CCOMP CHAIN_APPROX_SIMPLE)

(def conv-1 (clone img))
(draw-contours conv-1 contours-1 0 (new-scalar 255 0 0) 3)

(u/mat-view conv-1)
```



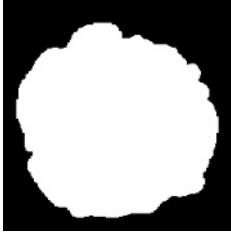
Hmm ... there is that weird artefact on the top right of the picture which is pretty annoying, and not really the interesting part of the picture. What should we do ?

Erode and Dilate to smooth the shape

```
(def k 1)
(def blur-factor 1)
(def mask (new-mat))

(dotimes[ i k]
  (-> gray
    ;(median-blur! blur-factor)
    (erode! mask)
    ;(median-blur! blur-factor)
    (dilate! mask)))

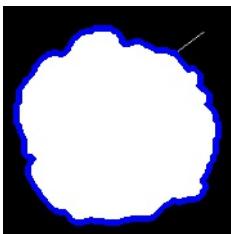
(u/mat-view gray)
```



```
(def contours-2 (new-arraylist))
(find-contours gray contours-2 (new-mat) RETR_CCOMP CHAIN_APPROX_SIMPLE)

(def conv-2 (clone img))
(draw-contours conv-2 contours-2 0 (new-scalar 255 0 0) 3)

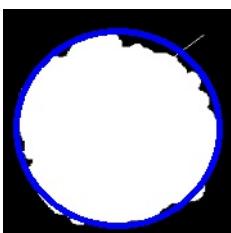
(u/mat-view conv-2)
```



approximate with an ellipse in the bounded box

```
(def boxed
  (clone img))
(def b-box
  (bounding-rect (first contours-2)))
(def center
  (u/middle-of-two-points (.br b-box) (.tl b-box)))
(def r-rect
  (new-rotatedrect center (.size b-box) 1 ))
(ellipse boxed r-rect (new-scalar 255 0 0) 3)

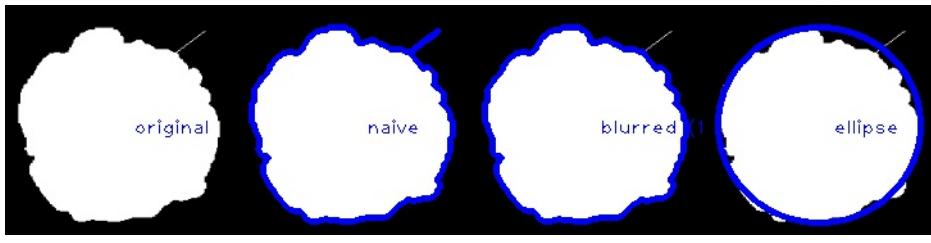
(u/mat-view boxed)
```



Summary

```
(annotate img "original")
(annotate conv-1 "naive")
(annotate conv-2 (str "blurred (" k")"))
(annotate boxed "ellipse")

(u/mat-view (hconcat! [img conv-1 conv-2 boxed]))
```



Mastering masking

```
(ns tasteless-lagoon
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

```
nil
```

read the original picture

```
(def rose
  (-> "resources/matching/rose_flower.jpg"
       imread
       (u/resize-by 0.15)))
(u/mat-view rose)
```



convert the color space to HSV

```
(def hsv
  (-> rose clone (cvt-color! COLOR_BGR2HSV)))
(u/mat-view hsv)
```



filter on red and create a mask from that filtering

```
(def lower-red (new-scalar 0 70 70))
(def upper-red (new-scalar 10 255 255))
(def mask (new-mat))
(in-range hsv lower-red upper-red mask)
(u/mat-view mask)
```



pick up pixels from the original pictures that are selected by the mask

```
(def res (new-mat))
(bitwise-and! rose res mask)
(u/mat-view res)
```



adjust luminosity of the pixels selected by the mask

```
; change the color by using convert-to and  
; apply original*alpha + beta on each pixel  
(def res2 (new-mat))  
(convert-to res res2 -1 1 100)  
(u/mat-view res2)
```



```
; copy the updated picture (which is the masked portion)  
; to the original (a clone of)  
(def cl (clone rose))  
(copy-to res2 cl mask)  
(u/mat-view cl)
```



copy something completely different using the mask

```
(def cl2  
  (imread "resources/inside-a-hot-air-balloon.jpg"))  
(def cl3  
  (clone rose))  
  
(resize! cl2 (new-size (cols mask) (rows mask)))  
(u/mat-view cl2)
```



```
(copy-to cl2 cl3 mask)  
(u/mat-view cl3)
```



Modifying only part of a picture

This recipe shows how to use `submat` to create a ROI, region of interest, that is only part of the main picture. A `submat` shares the same underlying pixels as the original picture, thus any modification on the `submat` will also modify the original picture.

So why would you want to use a `submat` then ? The main reason is that it is easier to work with.

```
(ns homeless-crater
  (:require
    [opencv3.core :refer :all]
    [opencv3.colors.rgb :as rgb]
    [opencv3.utils :as u]))
```

```
nil
```

blur only part of the picture

```
(def rose
  (->
    "resources/matching/rose_flower.jpg"
    imread
    (u/resize-by 0.25)))

(def rose-1
  (-> rose clone))
(def sub
  (submat rose-1 (new-rect 50 25 150 150)))
(median-blur! sub 9)

(u/mat-view rose-1)
```



```
(def sub2
  (submat (-> rose clone) (new-rect 100 100 50 50)))

(u/mat-view sub2)
```



turn picture to grey except part

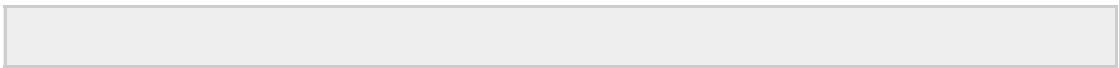
```
(def rose-2 (-> rose clone))

(def gray
  (->
    rose
    clone
    (cvt-color! COLOR_BGR2GRAY)
    (cvt-color! COLOR_GRAY2BGR) ))

(def rects [
  (new-rect 50 50 100 150)
  (new-rect 200 100 100 100)])

(doseq [ r rects ]
  (let [ s (submat rose-2 r) mask (new-mat)]
    (copy-to s (submat gray r) mask)))

(u/mat-view gray)
```



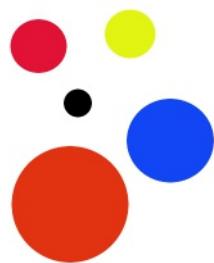
Find shapes with hough circles

This tutorial shows how to find shape with a given color within an image.

```
(ns combative-atoll
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

nil

```
(def bgr-image
  (-> "resources/detect/circles.jpg" imread (u/resize-by 0.5) ))
(u/mat-view bgr-image)
```

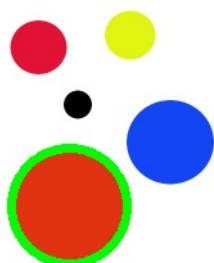


```
(def ogr-image
  (-> bgr-image
    (clone)
    (median-blur! 3)
    (cvt-color! COLOR_BGR2HSV)
    (in-range! (new-scalar 0 100 100) (new-scalar 10 255 255))
    (gaussian-blur! (new-size 9 9) 2 2)))
(u/mat-view ogr-image)
```



Let's find the circles using the **hough-circles** function from opencv core.

```
(def circles (new-mat)
  (hough-circles ogr-image circles CV_HOUGH_GRADIENT 1 (/ (.rows bgr-image) 8) 100 20 0 0)
  (dotimes [i (.cols circles)]
    (let [ circle (.get circles 0 i) x (nth circle 0) y (nth circle 1) r (nth circle 2) p
      (new-point x y)]
      (opencv3.core/circle bgr-image p (int r) (new-scalar 0 255 0) 5)))
  (u/mat-view bgr-image))
```



Change the exposure (the contrast) of a picture

Changing the exposure of a picture is rather easy and done simply using the function **convert-to**.

```
ns inquisitive-pond
(:require
 [opencv3.utils :as u]
 [opencv3.core :refer :all]))

(def org
 (-> "resources/images/cat.jpg" imread (u/resize-by 0.2)))

(u/mat-view org)
```



Making the image darker

```
(->
org
clone
(convert-to! -1 0.4 0)
(u/mat-view))
```



Making the image brighter

```
(->
org
clone
(convert-to! -1 2 0)
(u/mat-view))
```



```
(def img3 (new-mat))
(add-weighted img1 0.2 img2 0.8 1 img3)
(u/mat-view img3)
```



Using hough techniques to find lines and circles

Here we learn how to use opencv's hough lines

```
(ns opencv3.hough
  (:require
    [opencv3.utils :as u]
    [opencv3.colors.rgb :as color]
    [opencv3.core :refer :all]))
```

```
nil
```

Let's load the target image, and convert it to gray with a bit of blur, so that canny can work on it.

```
(def parking (-> "resources/images/lines/parking.png" imread (u/resize-by 0.3)))
(u/mat-view parking)
```

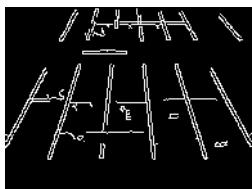


```
(def gray      (-> parking clone (cvt-color! COLOR_BGR2GRAY) (gaussian-blur! (new-size 3
3) 0 ) ))
(u/mat-view gray)
```



Edges detection is done using canny.

```
(def edges      (-> gray clone (canny! 50 150 )))
(u/mat-view edges)
```



Let's setup the parameters for the hough lines detection.

```
(def rho 1) ; distance resolution in pixels of the Hough grid
(def theta (/ Math/PI 180)) ; angular resolution in radians of the Hough grid
(def min-intersections 15) ; minimum number of votes (intersections in Hough grid cell)
(def min-line-length 50) ; minimum number of pixels making up a line
(def max-line-gap 20) ; maximum gap in pixels between connectable line segments

(def lines (new-mat))
(ugh-lines-p edges lines rho theta min-intersections min-line-length max-line-gap)
```

```
nil
```

Now that we have the lines, let's draw them on a clone of the original picture.

```
(def result (clone parking))
(dotimes [ i (.rows lines)]
(let [ val (.get lines i 0)]
(line result
  (new-point (nth val 0) (nth val 1))
  (new-point (nth val 2) (nth val 3))
  color/teal
  2)))
```

```
(u/mat-view result)
```



Finally, output all the intermediate images used in this guide. Let's not forget that hconcat and vconcat need all the pictures to be in the same format, in our case, the same number of channels. We convert back gray and edges with the proper number of channels.

```
(u/mat-view (hconcat! [  
  parking  
  (-> gray clone (cvt-color! COLOR_GRAY2RGB))  
  (-> edges clone (cvt-color! COLOR_GRAY2RGB))  
  result] ))
```



Finding only pockets on a pool table

```
(def pool  
  (->  
    "https://raw.githubusercontent.com/badlogic/opencv-fun/master/data/topdown-6.jpg"  
    u/mat-from-url  
    (u/resize-by 0.5)))  
(u/mat-view pool)
```



```
(def gray (-> pool clone (cvt-color! COLOR_BGR2GRAY)))  
(def minRadius 14)  
(def maxRadius 18)  
(def circles (new-mat))  
(hough-circles gray circles CV_HOUGH_GRADIENT 1 minRadius 120 10 minRadius maxRadius)
```

```
nil
```

```
(def output (clone pool))  
(dotimes [i (.cols circles)]  
  (let [ circle (.get circles 0 i) x (nth circle 0) y (nth circle 1) r (nth circle 2) p  
        (new-point x y)]  
    (opencv3.core/circle output p (int r) color/red-2 1)))  
(u/mat-view output)
```



2D Filters

```
(ns voiceless-drylands
  (:require
    [opencv3.utils :as u]
    [opencv3.core :refer :all]))
```

```
nil
```

```
(def neko
  (-> "resources/images/cat.jpg"
       imread
       (u/resize-by 0.2)))
```

```
#'voiceless-drylands/neko
```

prewitt-horizontal

```
(defn apply-my-filter
  ([ mat my-filter]
   (apply-my-filter mat my-filter false))
  ([ mat my-filter invert]
   (->
    mat
    clone
    (cvt-color! COLOR_RGB2GRAY)
    (filter-2-d! -1 (u/matrix-to-mat my-filter))
    ((fn [x] (if invert (bitwise-not! x) x))
     (u/mat-view )))))
  (apply-my-filter neko
    [ [-1 -1 -1]
      [ 0 0 0]
      [ 1 1 1]] true))
```



prewitt-vertical

```
(->
 neko
 clone
 (cvt-color! COLOR_RGB2GRAY)
 (filter-2-d! -1 (u/matrix-to-mat
  [ [-1 0 1]
    [-1 0 1]
    [-1 0 1]]))
 (u/mat-view ))
```



```
; sobel vertical-matrix
(->
  (imread "resources/images/cat.jpg")
  (cvt-color! COLOR_RGB2GRAY)
  (filter-2-d! -1 (u/matrix-to-mat
    [ [-1 0 1]
```

```

[ -2 0 2 ]
[ -1 0 1]]))
(imwrite "output/cat3.png"))

; sobel horizontal
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ -1 -2 -1]
[ 0 0 0]
[ 1 2 1]]))
(imwrite "output/cat3.png"))

; kirsch east
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ -3 -3 -3]
[ -3 0 -3]
[ 5 5 5]]))
(imwrite "output/cat3.png"))

; kirch southwest
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ 5 5 -3]
[ 5 0 -3]
[ -3 -3 -3]]))
(imwrite "output/cat3.png"))

; robinson north
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ -1 0 1]
[ -2 0 2]
[ -1 0 1]]))
(imwrite "output/cat3.png"))

; robinson east
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ -1 -2 -1]
[ 0 0 0]
[ 1 2 1]]))
(imwrite "output/cat3.png"))

; laplacian negative
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ 0 -1 0]
[ -1 4 -1]
[ 0 -1 0]]))
(imwrite "output/cat3.png"))

; laplacian positive
(->
(imread "resources/images/cat.jpg")
(cvt-color! COLOR_RGB2GRAY)
(filter-2-d! -1 (u/matrix-to-mat
[ [ 0 1 0]
[ 1 4 1]
[ 0 1 0]]))
(imwrite "output/cat3.png"))

```

Akaze

Find an image inside another image.

```
(ns wandering-moss
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u])
  (:import
    [org.opencv.features2d Features2d DescriptorExtractor DescriptorMatcher
     FeatureDetector]))
(def detector (FeatureDetector/create FeatureDetector/AKAZE))
(def extractor (DescriptorExtractor/create DescriptorExtractor/AKAZE))
```

```
#'wandering-moss/extractor
```

```
(def original (-> "resources/images/cat.jpg" imread (u/resize-by 0.3)))
(def mat1 (clone original))
(def points1 (new-matofkeypoint))
(.detect detector mat1 points1)

(def show-keypoints1 (new-mat))
(Features2d/drawKeypoints mat1 points1 show-keypoints1 (new-scalar 255 0 0) 0)
(u/mat-view show-keypoints1)
```



```
(def desc1 (new-mat))
(.compute extractor mat1 points1 desc1)
(u/mat-view desc1)
```

```
(def mat2 (-> "resources/images/cat_face.jpg" imread (u/resize-by 0.3)))
(def points2 (new-matofkeypoint))
(.detect detector mat2 points2)

(def show-keypoints2 (new-mat))
(Features2d/drawKeypoints mat2 points2 show-keypoints2 (new-scalar 255 0 0) 0)
(u/mat-view show-keypoints2)

(def desc2 (new-mat))
(.compute extractor mat2 points2 desc2)
```

```
nil
```

```
(def matcher
  (DescriptorMatcher/create DescriptorMatcher/BRUTEFORCE_HAMMINGLUT)`)
(def matches
  (new-matofdmatch))
(.match matcher desc1 desc2 matches)

(defn best-n-dmatches2 [dmatches]
  (new-matofdmatch
    (into-array org.opencv.core.DMatch
      (filter #(< (.distance %) 10) (.toArray dmatches)))))

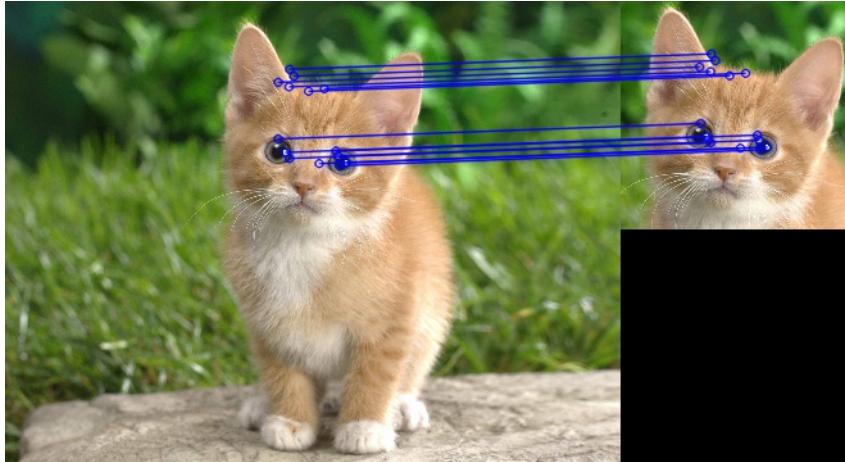
(defn draw-matches [_mat1 _points1 _mat2 _points2 _matches draw-method]
  (let[ _mat (new-mat (* 2 (.rows _mat1)) (* 2 (.cols _mat1)) (.type _mat1))
       _sorted-matches (best-n-dmatches2 _matches)]
    (Features2d/drawMatches
      _mat1
      _points1
      _mat2
      _points2
```

```
_sorted-matches
  _mat
  (new-scalar 255 0 0)
  (new-scalar 0 0 255)
  (new-matofbyte)
  draw-method)
  _mat))

(defn is-a-match [dmatches]
  (> (count (filter #((< (.distance %) 10) (.toArray dmatches)))) 0))

; (is-a-match matches)

(u/mat-view
  (draw-matches mat1 points1 mat2 points2 matches Features2d/NOT_DRAW_SINGLE_POINTS))
```



Reading business cards

You are trying to highlight specific region of a business card to send it to an OCR...

The default find contours just makes you crazy .. and you are not sure you want to play with OpenCV anymore ... this recipe is for you.

```
(ns sunset-firefly
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

```
nil
```

Start by reading the bizcard as an image.

```
(def original
  (-> "resources/images/bizcard.png"
       imread
       (u/resize-by 0.3)))
(u/mat-view original)
```

Let's naively find out what the contours are and draw them on a copy of the original.

```
(def contours
  (new-arraylist))

(find-contours
  (-> original clone (cvt-color! COLOR_RGB2GRAY))
  contours
  (new-mat)
  RETR_LIST CHAIN_APPROX_SIMPLE)

(def result
  (-> original clone))

(doseq [c contours]
  (let [ rect (bounding-rect c)]
    (do
      (rectangle result
        (new-point (.x rect) (.y rect))
        (new-point (+ (.width rect) (.x rect)) (+ (.y rect) (.height rect)))
        (new-scalar 0 0 0)
        1)
      )))

(u/mat-view result)
```

Hmm .. that did not work whatsoever. There are so many contours that it just feels like you are drawing the letters

themselves with rectangles ... let's try something else. We will blur the image before apply a binary threshold, and then dilate the result just a bit.

```
(def work
  (-> original
    clone
    (cvt-color! COLOR_RGB2GRAY)
    (gaussian-blur! (new-size 17 17) 50)
    (threshold! -1 255 (+ THRESH_BINARY_INV THRESH_OTSU))
    (dilate! (get-structuring-element MORPH_RECT (new-size 2 2)))))

(u/mat-view work)
```

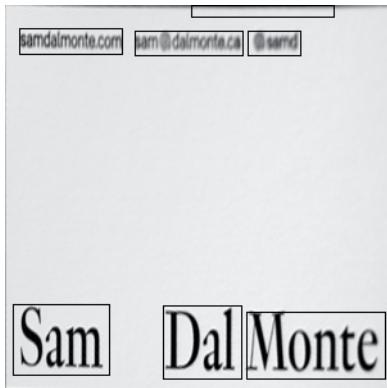


Then go back and find those contours again.

```
(def contours
  (new-arraylist))
(find-contours work contours (new-mat) RETR_LIST CHAIN_APPROX_SIMPLE)

(def result
  (clone original))

(doseq [c contours]
  (let [ rect (bounding-rect c)]
    (rectangle result
      (new-point (.x rect) (.y rect))
      (new-point (+ (.width rect) (.x rect)) (+ (.y rect) (.height rect)))
      (new-scalar 0 0 0)
    1
  )))
(u/mat-view result )
```



Almost there ... let's get rid of the small artefact at the top of the business card, by selecting contours with a bounding box bigger than a given size, here 15.

```
(def result
  (clone original))

(doseq [c (filter #(> (.height (bounding-rect %)) 15) contours)]
  (let [ rect (bounding-rect c)]
    (rectangle
      result
      (new-point (.x rect) (.y rect))
      (new-point (+ (.width rect) (.x rect)) (+ (.y rect) (.height rect)))
      (new-scalar 0 0 0)
    1
  )))
(u/mat-view result)
```

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Sam DalMonte

Failed to load worksheet: gorillas/13-blurdetect.clj



Tennis Ball

This tutorial proposes options to find a tennis ball in a picture using two different techniques. This will also play with parameters, to show how to avoid finding false positive, i.e objects that are nowhere near the one we are looking for.

First, let's load the image that will be the base for our image finding exercice.

```
ns divine-briars
(:require
[opencv3.utils :as u]
[opencv3.colors.rgb :as color]
[opencv3.core :refer :all]))
```

```
nil
```

```
(def img (-> "http://i.imgur.com/uONRu60.jpg" (u/mat-from-url) (u/resize-by 0.5)))
(u/mat-view img)
```



Using Hough Circles

```
(def hsv (-> img clone (cvt-color! COLOR_RGB2HSV)))
(def thresh-image (new-mat))
(in-range hsv (new-scalar 50 100 0) (new-scalar 95 255 255) thresh-image)
; the ball is here
(u/mat-view thresh-image)
```



```
(let[ circles (new-mat) output (clone img) minRadius 25 maxRadius 40 ]
(hough-circles thresh-image circles CV_HOUGH_GRADIENT 1 minRadius 120 15 minRadius
maxRadius)
(dotimes [i (.cols circles)]
(let [ circle (.get circles 0 i) x (nth circle 0) y (nth circle 1) r (nth circle 2) p
(new-point x y)]
(opencv3.core/circle output p (int r) color/plum 2)))
; the ball is detected
(u/mat-view output))
```



Method2: Using Find Contours

Find object with find contours gives less chance to parameters, the **find-contours** function from core does pretty much all for us.

```
(let[ hsv (-> img clone (cvt-color! COLOR_RGB2HSV))
      thresh-image (new-mat)
      contours (new-arraylist)
      output (clone img)]
  (in-range hsv
             (new-scalar 50 100 0)
             (new-scalar 95 255 255)
             thresh-image)

  (find-contours
   thresh-image
   contours
   (new-mat) ; mask
   RETR_LIST
   CHAIN_APPROX_SIMPLE)

  (dotimes [ci (.size contours)]
    (if (> (contour-area (.get contours ci)) 100 )
        (draw-contours output contours ci color/plum FILLED)))
  (u/mat-view output))
```



Pencil Sketch

<http://www.askaswiss.com/2016/01/how-to-create-pencil-sketch-opencv-python.html>

Using OpenCV and Python, an RGB color image can be converted into a pencil sketch in four simple steps:

- Convert the RGB color image to grayscale.
- Invert the grayscale image to get a negative.
- Apply a Gaussian blur to the negative from step 2.
- Blend the grayscale image from step 1 with the blurred negative from step 3 using a color dodge.

Load the picture that will be sketched

```
[ns opencv3.cartoon2
 (:require
  [opencv3.core :refer :all]
  [opencv3.utils :as u]))

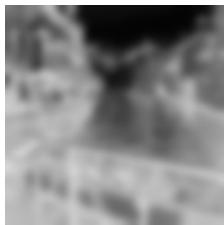
(def img
  (-> "https://cdn.theculturetrip.com/wp-content/uploads/2016/01/canals2.jpg"
       u/mat-from-url
       (u/resize-by 0.10)))
(u/mat-view img)
```



```
(def gray (-> img clone (cvt-color! COLOR_BGR2GRAY)))
(u/mat-view gray)

(def inverted
  (-> gray clone (bitwise-not!)))
(u/mat-view inverted)

(def gaussed
  (-> inverted clone (gaussian-blur! (new-size 21 21) 0.0 0.0)))
(u/mat-view gaussed)
```



```
(defn dodge-v2! [img_ mask]
  (let [ output (clone img_) ]
    (divide img_ (bitwise-not! (-> mask clone)) output 256.0)
    output))

(u/mat-view (dodge-v2! gray gaussed))
```



```
(defn burn-v2! [ image mask]
  (bitwise-not! (dodge-v2! image mask)))
(u/mat-view (burn-v2! gray gaussed))
```

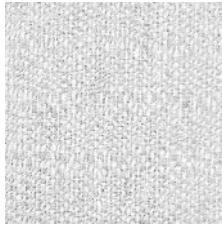


Apply a Canvas effect

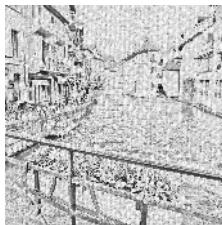
Now that the main picture has been turned to a crayon styled art form, it would be nice to lay this out on a canvas looking mat.

This is done using the **multiply** function from OpenCV core.

```
(def canvas (imread "resources/canvas.jpg" 0))
(resize! canvas (new-size (.cols gray) (.rows gray)))
(u/mat-view canvas)
```



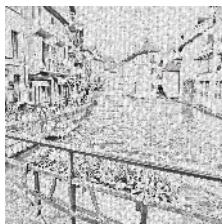
```
(def output (new-mat))
(multiply (dodge-v2! gray gaussed) canvas output (/ 1 256.0))
(u/mat-view output)
```



Let's make a function out of the above, so we can apply a few different canvas and see the output and effect of each of them.

```
(defn apply-canvas! [ sketch canvas ]
  (let [ output (new-mat)
        (resize! canvas (new-size (.cols sketch) (.rows sketch)))
        (multiply (-> sketch clone (cvt-color! COLOR_GRAY2RGB)) canvas output (/ 1 256.0))
        output ])
  #'opencv3.cartoon2/apply-canvas!
```

```
(def sketch (dodge-v2! gray gaussed))
(def canvas (imread "resources/canvas.jpg"))
(u/mat-view (apply-canvas! sketch canvas))
```



```
(def canvas (imread "resources/canvas/oldcanvas.jpg"))
(u/mat-view (apply-canvas! sketch canvas))
```



```
(def canvas (imread "resources/canvas/dottedcanvas.jpg"))
(u/mat-view (apply-canvas! sketch canvas))
```



```
(u/mat-view (apply-canvas! sketch (imread "resources/canvas/oldcanvastexture.jpg")))
```



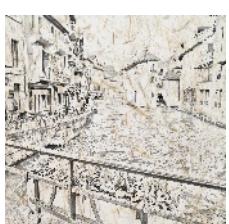
```
(u/mat-view (apply-canvas! sketch (imread "resources/canvas/vintage-old-brown-canvas-
texture.jpg")))
```



```
(u/mat-view (apply-canvas! sketch (imread "resources/canvas/grunge-parchment-background-
canvas.jpg")))
```



```
(u/mat-view (apply-canvas! sketch (imread "resources/canvas/japanese_paper.jpg")))
```



Landscape Art Adventures

```
(ns opencv3.cartoon
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
```

```
nil
```

```
(def img
  (-> "https://cdn.theculturetrip.com/wp-content/uploads/2016/01/canals2.jpg"
       u/mat-from-url
       (u/resize-by 0.2)))
(u/mat-view img)
```

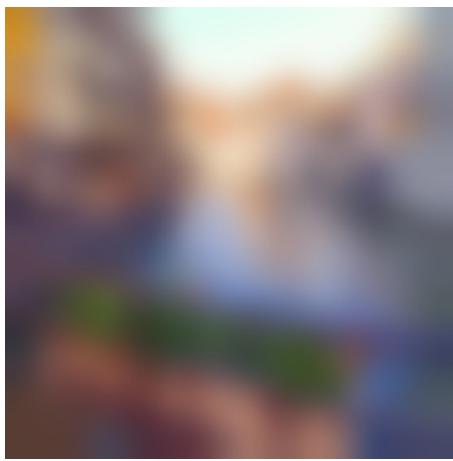


smoothing the picture using a bilateral filter

```
(def factor 4)
(def output (new-mat))
(def work (clone img))

(dotimes [_ factor] (pyr-down! work))
(bilateral-filter work output 9 9 7)
(dotimes [_ factor] (pyr-up! output))

(u/mat-view output)
```



detect and enhance edges

- Reduce noise using a median filter
- Create an edge mask using adaptive thresholding

```
(def edge
  (-> img
       clone
       (resize! (new-size (.cols output) (.rows output)))
       (cvt-color! COLOR_RGB2GRAY)
       (median-blur! 7)
       (adaptive-threshold! 255 ADAPTIVE_THRESH_MEAN_C THRESH_BINARY 9 7)
       (cvt-color! COLOR_GRAY2RGB))
  (u/mat-view edge))
```



Combine color image with edge mask

```
(let [result (new-mat)]
  (bitwise-and output edge result)
  (u/mat-view result))
```

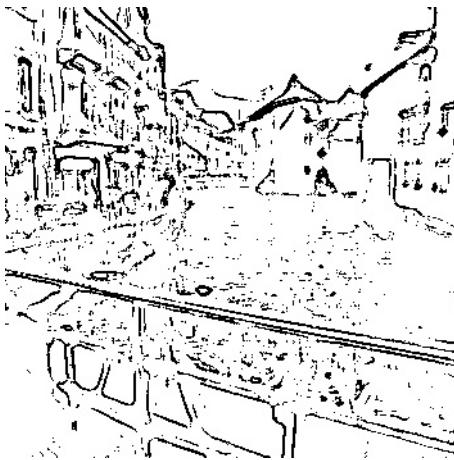


Playing with contours

Of course you can play with the contours size and numbers. The adaptive-threshold! does that with its last two parameters.

The **edges-thickness** parameter controls how thick the contours will be, and the **edges-number** controls how many of them should be drawn.

```
(def edges-thickness 5)
(def edges-number 5)
(def edge
  (-> img
    clone
    (resize! (new-size (.cols output) (.rows output)))
    (cvt-color! COLOR_RGB2GRAY)
    (median-blur! 7)
    (adaptive-threshold! 255 ADAPTIVE_THRESH_MEAN_C THRESH_BINARY edges-thickness edges-number)
    (cvt-color! COLOR_GRAY2RGB)))
  (u/mat-view edge))
```



```
(let [result (new-mat)
     (bitwise-and output edge result)
     (u/mat-view result))
```



turning all this in functions

```
(defn smoothing!
  [img factor filter-size filter-value]
  (let [work (clone img) output (new-mat)]
    (dotimes [_ factor] (pyr-down! work))
    (bilateral-filter work output filter-size filter-size filter-value)
    (dotimes [_ factor] (pyr-up! output)))
  (resize! output (new-size (.cols img) (.rows img)))))

(defn edges!
  [img e1 e2 e3]
  (-> img
       clone
       (cvt-color! COLOR_RGB2GRAY)
       (median-blur! e1)
       (adaptive-threshold! 255 ADAPTIVE_THRESH_MEAN_C THRESH_BINARY e2 e3)
       (cvt-color! COLOR_GRAY2RGB)))

(defn cartoonize!
  [img s1 s2 s3 e1 e2 e3]
  (let [output (smoothing! img s1 s2 s3) edge (edges! img e1 e2 e3)]
    (bitwise-and output edge output)
    output))
```

```
#'opencv3.cartoon3/cartoonize!
```

```
(->
 "resources/landscape/landscape-nature-sky-blue.jpg"
 imread
 (u/resize-by 0.2)
 (cartoonize! 6 9 7 7 9 11)
 (u/resize-by 0.5)
 (u/mat-view ))
```



```
(->
  "resources/landscape/amazing-beautiful-beauty-blue.jpg"
  imread
  (cartoonize! 5 9 7 7 7 5)
  (u/resize-by 0.25)
  (u/mat-view))
```



```
(->
  "resources/landscape/amazing-beautiful-beauty-blue.jpg"
  imread
  (u/resize-by 0.25)
  (cartoonize! 5 9 7 7 7 5)
  (u/mat-view))
```



Finding and drawing contours

Finding object by their shape is one of the key reason people usually comes to OpenCV.

```
(ns lush-storm
  (:require
    [opencv3.utils :as u]
    [opencv3.colors.html :as color]
    [opencv3.core :refer :all]))
```

```
nil
```

Finding contour of headphone and drawing rectangles ...

```
(def headphones
  (imread "resources/morph/headphone.png"))

(def image-c
  (clone headphones))
```

```
#'lush-storm/image-c
```

```
(def contours
  (new-arraylist))

(find-contours
  (-> headphones clone (cvt-color! COLOR_BGR2GRAY))
  contours
  (new-mat)
  RETR_TREE CHAIN_APPROX_SIMPLE)
```

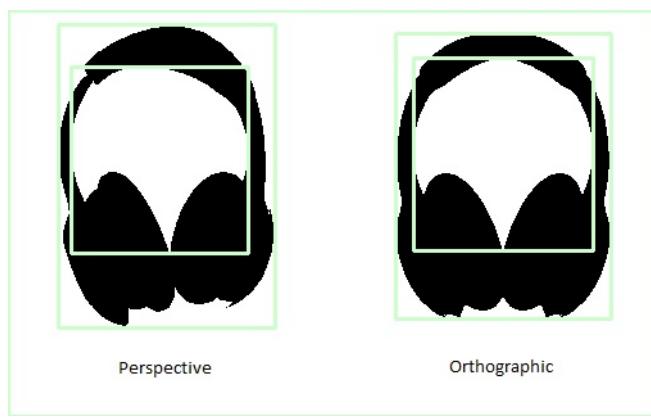
```
nil
```

```
(def interesting-contours
  (filter
    #(and (> (contour-area %) 100) (> (.height (bounding-rect %)) 28))
    contours))
```

```
#'lush-storm/interesting-contours
```

```
(doseq [c interesting-contours]
  (let [ rect (bounding-rect c)]
    (rectangle
      image-c
      (new-point (.x rect) (.y rect))
      (new-point (+ (.width rect) (.x rect)) (+ (.y rect) (.height rect)))
      (color/->scalar "#ccffcc")
      2)))

(u/mat-view image-c)
```



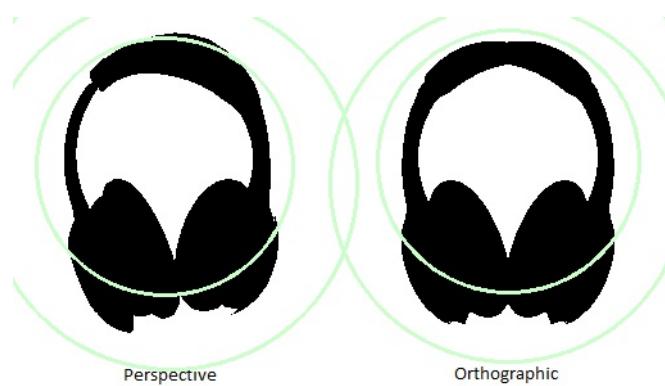
Using core draw-contours to ... draw the contours

```
(def image-d (clone headphones))

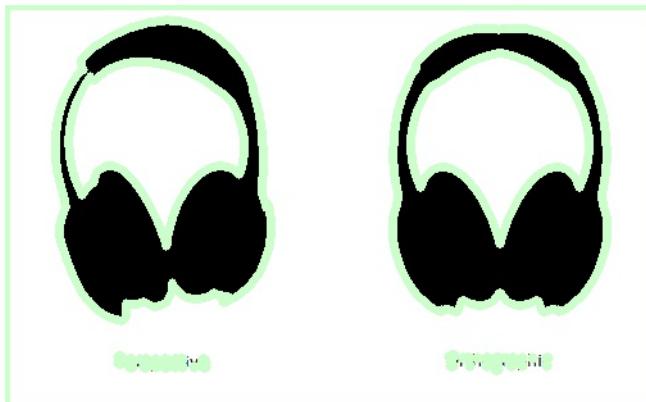
(doseq [c interesting-contours]
  (let [ rect (bounding-rect c) center (u/center-of-rect rect) ]
    (circle image-d
      center
      (u/distance-of-two-points center (.tl rect))
      (color/->scalar "#ccffcc"))))
```

2)))

(u/mat-view image-d)



```
(def image-c (clone headphones))
(dotimes [ci (.size contours)]
  (draw-contours
    image-c
    contours
    ci
    (color/->scalar "#ccffcc")
    2))
(u/mat-view image-c)
```



Simple Foreground Background Diff

Here we have a background picture and we would like to discover new objects on top of this background.

We will use the simple opencv3.core function **absdiff** and then apply a simple and large **threshold** to pick up all the new objects.

The reference clojure code file can be found here: [bgdiff.clj](#)

Let's see first what our background looks like.

```
(ns scenic-iceberg
  (:require
    [opencv3.core :refer :all]
    [opencv3.utils :as u]))
(def bg (-> "resources/images/bgdiff/header.png" imread (u/resize-by 0.5)))
(u/mat-view bg)
```



Then put our hand in front of that background.

```
(def fg (-> "resources/images/bgdiff/front.png" imread (u/resize-by 0.5)))
(u/mat-view fg)
```



The **absdiff** function from OpenCV core is used, and we can directly see the output.

```
(def output (new-mat))
(absdiff bg fg output)
(u/mat-view output)
```



```
; diff in color
(def fg-1
  (-> output
    clone
    (threshold! 10 255 1)))
(u/mat-view fg-1)
```



You can then use a very permissive threshold to find out relevant shapes.

```
; diff in gray
(def fg-2
  (-> output
    clone
    (cvt-color! COLOR_RGB2GRAY)
    (threshold! 10 255 1)))
(u/mat-view fg-2)
```



Move a shape to the center of the scene

Say you have a shape inside a picture, and you want to move it somewhere else inside the same picture.

```
(ns unwavering-briars
  (:require
    [opencv3.utils :as u]
    [opencv3.colors.html :refer :all]
    [opencv3.core :refer :all]))
```

```
nil
```

The plan is defined as follow:

- load the picture, and add a quick border to get it to show properly here.
- go into HSV color space to be able to select only the object we want use a color range
- create a mask

```
(def img
  (-> "resources/morph/cjy6M.jpg"
       imread
       (u/resize-by 0.4)
       (copy-make-border! 1 1 1 1
                          BORDER_CONSTANT
                          (->scalar "#aabbcc"))))

(u/mat-view img)
```



+

```
(def hsv
  (-> img clone (cvt-color! COLOR_BGR2HSV)))
(u/mat-view hsv)
```



thresh hold on yellow in hsv space

```
(def mask-on-yellow (new-mat))
(in-range hsv (new-scalar 20 100 100) (new-scalar 40 255 255) mask-on-yellow)

(u/mat-view mask-on-yellow)
```



find contours, and select first 1, (actually only one)

```
(def contours (new-arraylist))
(find-contours mask-on-yellow contours (new-mat) RETR_EXTERNAL CHAIN_APPROX_SIMPLE)
```

```
(count contours)
```

```
1
```

```
(def background-color (->scalar "#000000"))
; mask type CV_8UC1 is important !!
(def mask (new-mat (rows img) (cols img) CV_8UC1 background-color))
(u/mat-view mask)
```



Here we draw the one contour we have found, using the FILLED setting of draw-contours.

```
(draw-contours mask contours 0 (new-scalar 255.0) FILLED)
(u/mat-view mask)
```



```
(def box
  (bounding-rect (first contours)))
(def item
  (submat img box))
(u/mat-view item)
```



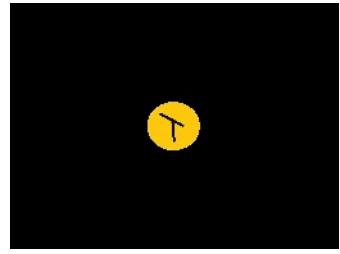
```
(def segmented-item
  (new-mat (rows item) (cols item) CV_8UC3 background-color))
(copy-to item segmented-item (submat mask box) )
(u/mat-view segmented-item)
```



```
(def center
  (new-point (/ (.cols img) 2) (/ (.rows img) 2)))
(def center-box
  (new-rect
    (- (.x center) (/ (-width box) 2))
    (- (.y center) (/ (-height box) 2))
    (.width box)
    (.height box)))
(def result (u/mat-from img))
(set-to result (->scalar "#000000"))
```

```
#object[org.opencv.core.Mat 0x2e48b2d3 "Mat [ 192*256*CV_8UC3, isCont=true, isSubmat=false,
nativeObj=0x7fecf585f7a0, dataAddr=0x158eba040 ]"]
```

```
(def final (submat result center-box))
(copy-to segmented-item final (new-mat))
(u/mat-view result)
```



Gabor

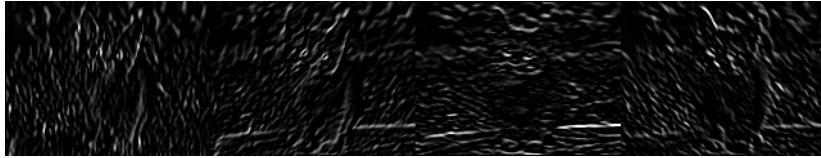
```
[ns divine-dawn
  (:require [opencv3.core :refer :all] [opencv3.utils :as u]))
; http://rondelion.blogspot.jp/2014/04/opencv-java-api-gabor-filter.html

(def height 10)
(def width 10)
(def sigma 1.4)
(def lambda 4)
(def gamma 1.0)
(def psiDeg 0)
(defn psi (* psiDeg (/ Math/PI 180)))
(def img (-> "resources/images/cat.jpg" imread (u/resize-by 0.1) (cvt-color!
COLOR_RGB2GRAY)))

(defn kernel-by-theta [ thetaDeg ]
  (get-gabor-kernel (new-size width height) sigma (* thetaDeg (/ Math/PI 180)) lambda
gamma))

#'divine-dawn/kernel-by-theta
```

```
(defn apply-gabor [ img angle]
  (->
    img
    clone
    (filter-2-d! (.type img) (kernel-by-theta angle))))
(u/mat-view
  (hconcat! (into [] (map #(apply-gabor img %) [0 45 90 135])))))
```



```
(defn apply-gabor-inv [ img angle]
  (-> img
    (apply-gabor angle)
    bitwise-not!))

(u/mat-view
  (hconcat! (into [] (map #(apply-gabor-inv img %) [0 45 90 135])))))
```

