main

April 25, 2018

#
Main: Group 10

In order to find the relationship between L(greyscale input) and A/B(layers about colors), we tried SVM, XGB and GBM.

0.1 1. Model1: SVM

0.1.1 Step1: Import packages

```
In [ ]: import cv2
        import itertools
        import numpy as np
        from scipy.cluster.vq import kmeans,vq
        from sklearn import preprocessing
        from sklearn.decomposition import PCA
        from sklearn.svm import SVC
        from sklearn.cluster import KMeans
        import matplotlib as plt
        from skimage import color
        from skimage.color import rgb2lab, lab2rgb, rgb2gray, gray2rgb
        import matplotlib.pyplot as plt
        import sys
        sys.path.append("./ImageColorization-master/colorizer/gco_python/")
        import pygco
```

0.1.2 Step2: Prepare for image processing

Here, we write some functions about feature extraction and creating color map based on training data set.

```
In [7]: # from skimage import color
        def load_image(path):
            '''
            Read in a file and separate into L*a*b* channels
            '''
            #read in original image
            img = cv2.imread(path)
            #convert to L*a*b* space and split into channels
```

```
    l, a, b = cv2.split(cv2.cvtColor(img, cv2.COLOR_RGB2LAB))
    return l, a, b

# K-means Color Space and Centroids
def quantize_kmeans(a, b,ncolors, npics):
    lengthab = len(a) / npics

#     w,h = np.shape(a)

    # reshape matrix
    pixel = np.reshape((cv2.merge((a,b))),(len(a),2)).astype(float)

    # quantization
    kmeans = KMeans(n_clusters=ncolors)
    label=kmeans.fit(pixel)
    return label.labels_.reshape(int(np.sqrt(int(lengthab))),int(np.sqrt(int(lengthab)))

# def label_to_color_map_fun(a,b,ncolors):
#     w,h = np.shape(a)
#     pixel = np.reshape((cv2.merge((a,b))),(w * h),2).astype(float)
#     centroids,_ = kmeans(pixel,ncolors)

#     color_to_label_map = {c:i for i,c in enumerate([tuple(i) for i in centroids])}
#     label_to_color_map = dict(zip(color_to_label_map.values(),color_to_label_map.key
#     return label_to_color_map

def label_to_color_map_fun(a,b,ncolors):
#     w,h = np.shape(a)
    pixel = np.reshape((cv2.merge((a,b))),(len(a),2)).astype(float)
    centroids,_ = kmeans(pixel,ncolors)

    color_to_label_map = {c:i for i,c in enumerate([tuple(i) for i in centroids])}
    label_to_color_map = dict(zip(color_to_label_map.values(),color_to_label_map.keys()
    return label_to_color_map

def feature_surf(img, pos):
    '''
    Gets the SURF descriptor of img at pos = (x,y).
    Assume img is a single channel image.
    '''
    octave2 = cv2.GaussianBlur(img, (0, 0), 1)
    octave3 = cv2.GaussianBlur(img, (0, 0), 2)
    kp = cv2.KeyPoint(pos[0], pos[1], SURF_WINDOW)
    surf = cv2.xfeatures2d.SURF_create()
    _, des1 = surf.compute(img, [kp])
    _, des2 = surf.compute(octave2, [kp])
    _, des3 = surf.compute(octave3, [kp])
    return np.concatenate((des1[0], des2[0], des3[0]))
```

```
def feature_dft(img, pos):
    xlim = (max(pos[0] - windowSize,0), min(pos[0] + windowSize,img.shape[1]))
    ylim = (max(pos[1] - windowSize,0), min(pos[1] + windowSize,img.shape[0]))
    patch = img[ylim[0]:ylim[1],xlim[0]:xlim[1]]

    l = (2*windowSize + 1)**2

    #return all zeros for now if we're at the edge
    if patch.shape[0]*patch.shape[1] != l:
        return np.zeros(l)
    return np.abs(np.fft(patch.flatten()))


def feature_position(img, pos):
    m,n = img.shape
    x_pos = pos[0]/n
    y_pos = pos[1]/m

    return np.array([x_pos, y_pos])


def get_features(img, pos):
    intensity = np.array([img[pos[1], pos[0]]])
    #position = feature_position(img, pos)
    meanvar = np.array([getMean(img, pos), getVariance(img, pos)])
    feat = np.concatenate((meanvar, feature_surf(img, pos), feature_dft(img, pos)))
    return feat


def getMean(img, pos):
    '''
    Returns mean value over a windowed region around (x,y)
    '''

    xlim = (max(pos[0] - windowSize,0), min(pos[0] + windowSize,img.shape[1]))
    ylim = (max(pos[1] - windowSize,0), min(pos[1] + windowSize,img.shape[0]))
    return np.mean(img[ylim[0]:ylim[1],xlim[0]:xlim[1]])


def getVariance(img, pos):

    xlim = (max(pos[0] - windowSize,0), min(pos[0] + windowSize,img.shape[1]))
    ylim = (max(pos[1] - windowSize,0), min(pos[1] + windowSize,img.shape[0]))

    return np.var(img[ylim[0]:ylim[1],xlim[0]:xlim[1]])/1000

# add
```

```
def get_edges(img, blur_width=3):
        img_blurred = cv2.GaussianBlur(img, (0, 0), blur_width)
        vh = cv2.Sobel(img_blurred, -1, 1, 0)
        vv = cv2.Sobel(img_blurred, -1, 0, 1)

        #vh = vh/np.max(vh)
        #vv = vv/np.max(vv)

        #v = np.sqrt(vv**2 + vh**2)

        v = 0.5*vv + 0.5*vh
#        print('max pre-normalize: %f'%np.amax(v))
        #v = v/np.amax(v)
        return v
```

0.1.3 Step3: Prepare for building model

```
In [ ]: def train_svm_new(files,ntrain,ncolors,prob,gamma,cost,npca):

    #dimensions of image
    l,a,b = load_image(files[0])
    m,n = l.shape
    features = []
    classes = []
    numTrainingExamples = 0
    colors_present = []
    svm = [SVC(probability=prob, gamma=gamma, C=cost) for i in range(ncolors)]
    pca = PCA(npca)

    scaler = preprocessing.MinMaxScaler()
    npics = len(files)
    kmap_a = np.array([])
    kmap_b = np.array([])
    for f in files:

        _,a,b = load_image(f)
        kmap_a = np.concatenate([kmap_a, a.flatten()])
        kmap_b = np.concatenate([kmap_b, b.flatten()])

    label=quantize_kmeans(kmap_a, kmap_b, ncolors, npics)  #get labels for files

    for ind, f in enumerate(files):
        l,a,b = load_image(f)
#         a,b = quantize_kmeans(a,b, ncolors, 1)

        for i in range(ntrain):
        #choose random pixel in training image
            x = int(np.random.uniform(n))
```

```
                y = int(np.random.uniform(m))

                features.append(get_features(l, (x,y)))
                classes.append(label[x,y,ind])
                numTrainingExamples = numTrainingExamples + 1

        # normalize columns
        features =np.array(features)
        classes = np.array(classes)


        # reduce dimensionality
        #features = pca.fit_transform(features)

        for i in range(ncolors):
            if len(np.where(classes==i)[0])>0:
                curr_class = (classes==i).astype(np.int32)
                colors_present.append(i)
                svm[i].fit(features,(classes==i).astype(np.int32))

        return colors_present,svm
```

0.1.4 Step4: Train Model

```
In [ ]: train_dir = ['./data/' + str(num).zfill(4) + '.jpg' for num in range(1,6)]
        train_dir

        ncolors = 16
        ntrain = 8000
        # (l, a, b) = load_image(img)
        prob = False
        npca = 635
        gamma = 0.1
        cost = 5.0
        colors_present,svm = train_svm_new(train_dir,
                                   ntrain = ntrain,
                                   ncolors = ncolors,
                                   prob = prob,
                                   gamma = gamma,
                                   cost = cost,
                                   npca = npca)
```

```
In [ ]: label_to_color_map = label_to_color_map_fun(a,b,ncolors)
        label_to_color_map
```

0.1.5 Step5: Graph Cut Algorithm

```
In [ ]: def graphcut(colors_present, label_to_color_map, label_costs, g, l=100):
```

```
        num_classes = len(colors_present)

        #calculate pariwise potiential costs (distance between color classes)
        pairwise_costs = np.zeros((num_classes, num_classes))
        for ii in range(num_classes):
            for jj in range(num_classes):
                c1 = np.array(label_to_color_map[ii])
                c2 = np.array(label_to_color_map[jj])
                pairwise_costs[ii,jj] = np.linalg.norm(c1-c2)

        label_costs_int32 = (100*label_costs).astype('int32')
        pairwise_costs_int32 = (l*pairwise_costs).astype('int32')
        vv_int32 = g.astype('int32')
        vh_int32 = g.astype('int32')

        #vv_int32 = (1/np.clip(self.g,0.00001,10000)).astype('int32')
        #vh_int32 = (1/np.clip(self.g,0.00001,10000)).astype('int32')

        #perform graphcut optimization
        new_labels = pygco.cut_simple_vh(label_costs_int32,
                                         pairwise_costs_int32,
                                         vv_int32, vh_int32,
                                         n_iter=10, algorithm='swap')

        #new_labels = pygco.cut_simple(label_costs_int32, pairwise_costs_int32, algorithm=

        return new_labels
```

0.1.6 Step6: Colorize

```
In [ ]: def colorize(colors_present,label_to_color_map, img, svm, skip=4, SAVE_OUTPUTS = False)
        '''
        -- colorizes a grayscale image, using the set of SVMs defined by train().

        Returns:
        -- ndarray(m,n,3): a mxn pixel RGB image
        '''
        scaler = preprocessing.MinMaxScaler()
        m,n = img.shape

        num_classified = 0
        _,raw_output_a,raw_output_b = cv2.split(cv2.cvtColor(cv2.merge((img, img, img)),
                                                             cv2.COLOR_RGB2LAB))

    #     raw_output_a,_,raw_output_b = cv2.split(cv2.cvtColor(cv2.merge((img, img, img)),
    #                                                          cv2.COLOR_RGB2HLS))
    #     _,raw_output_a,raw_output_b = cv2.split(cv2.cvtColor(cv2.merge((img, img, img)),
        #default a and b for a grayscale image
```

```
    output_a = np.zeros(raw_output_a.shape)
    output_b = np.zeros(raw_output_b.shape)

    num_classes = len(colors_present)
    label_costs = np.zeros((m,n,num_classes))

    g = np.zeros(raw_output_a.shape)

    count=0
    for x in np.arange(0,n,skip):
        for y in np.arange(0,m,skip):

            feat = get_features(img, (x,y)).reshape(1,-1)
#             feat = scaler.fit_transform(get_features(img, (x,y)).reshape(-1,1).resha
#             feat = scaler.fit_transform(np.array(tmp).reshape(-1,1),y= np.array([0,1
#             print(len(feat))

            #print "Size, Pre-PCA"
            #print np.shape(feat)
#             pca = PCA(npca)
#             feat = pca.fit_transform(feat)
            #print "size, Post-PCA"
            #print np.shape(feat)

            #sys.stdout.write('\rcolorizing: %3.3f%%'%(np.min([100, 100*count*skip**2/
            #sys.stdout.flush()
            count += 1

            # Hard-but-correct way to get g
            # self.g[y-int(skip/2):y+int(skip/2)+1,x-int(skip/2):x+int(skip/2)+1] = se

            #get margins to estimate confidence for each class
            for i in range(num_classes):
                cost = -1*svm[colors_present[i]].decision_function(feat)[0]
                label_costs[y-int(skip/2):y+int(skip/2)+1,x-int(skip/2):x+int(skip/2)+
    #edges = self.get_edges(img)
    #self.g = np.sqrt(edges[0]**2 + edges[1]**2)
    g = get_edges(img)
    #self.g = np.log10(self.g)

    if SAVE_OUTPUTS:
        #dump to pickle
        print('saving to dump.dat')
        fid = open('dump.dat', 'wb')
        pickle.dump({'S': label_costs, 'g': g, 'cmap': label_to_color_map,
                     'colors': colors_present}, fid)
        fid.close()
```

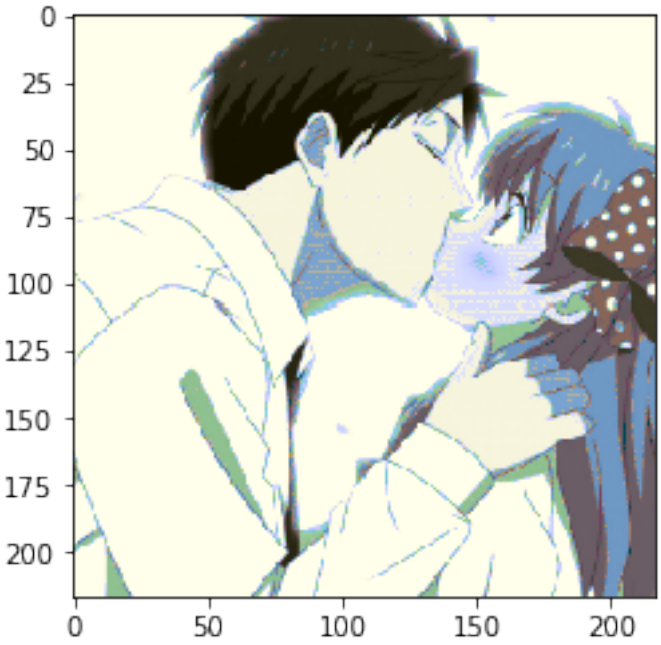
```
    # postprocess using graphcut optimization
#     output_labels = graphcut(label_costs, l=graphcut_lambda)
    output_labels = graphcut(colors_present, label_to_color_map, label_costs, g, l=100)



    for i in range(m):
        for j in range(n):

            a,b = label_to_color_map[colors_present[output_labels[i,j]]]

            output_a[i,j] = a
            output_b[i,j] = b

    output_img = cv2.cvtColor(cv2.merge(( img,np.uint8(output_a), np.uint8(output_b)))

    return output_img, g, output_labels
```

0.1.7 Step7: Show the test image

```
In [ ]: # img_file = cv2.imread(img)
        # img_file = load_image(img)[0]
        # get_edges(img_file)
        # img_test = './Train/test.jpg'
        img_test = './data/0003.jpg'
        # l a b
        img_test_file = load_image(img_test)
        # img_test_file = cv2.imread(img_test)
        color_tmp = colorize(colors_present,label_to_color_map, img = img_test_file[0], svm = s

In [ ]: plt.imshow(color_tmp[0])
        plt.show()
        plt.imsave('color_tmp.jpg',color_tmp[0])
        # plt.imshow(load_image_gray(img_test)[0])
        # plt.show()
```

According to the result, we could see that svm did not perform well on cartoon images.

```
In [15]: import matplotlib.pyplot as plt
         import cv2
         img_test = 'C:/Users/rolco/Desktop/car.png'
         img_test_file = cv2.imread(img_test)
         plt.imshow(img_test_file)

Out[15]: <matplotlib.image.AxesImage at 0x194bcafed30>
```



0.2 2.Model2: Xgboost

Since svm did not perform well on predicting the color labels of a and b, we tried to built xgboost to find the relationship between grey layer and color labels. What's more, we extracted more features(hog and daisy) rather than L only from grey layer in this model.

0.2.1 Step1: Import Packages

```
In [ ]: import cv2
        import itertools
        import numpy as np
        from scipy.cluster.vq import kmeans,vq
        from sklearn import preprocessing
        from sklearn.decomposition import PCA
        from sklearn.svm import SVC
        from sklearn.cluster import KMeans
        import operator
        from functools import reduce
        import xgboost as xgb
        import matplotlib.pyplot as plt
        import os
        from PIL import Image
        from skimage.feature import hog, daisy
```

0.2.2 Step2: Prepare for image processing

```
In [ ]: # from skimage import color
        def load_image(path):
            '''
            Read in a file and separate into L*a*b* channels
            '''
            #read in original image
            img = cv2.imread(path)
            l, a, b = cv2.split(cv2.cvtColor(img, cv2.COLOR_RGB2LAB))
        #     a, l, b = cv2.split(cv2.cvtColor(img, cv2.COLOR_RGB2HLS))


            return l, a, b

        def quantize_kmeans(a, b,ncolors, npics):
            lengthab = len(a) / npics

            # reshape matrix
            pixel = np.reshape((cv2.merge((a,b))),(len(a),2)).astype(float)

            # quantization
            kmeans = KMeans(n_clusters=ncolors)
            label=kmeans.fit(pixel)
            return label.labels_

        def label_to_color_map_fun(a,b,ncolors):
            w,h = np.shape(a)
            pixel = np.reshape((cv2.merge((a,b))),(w * h,2)).astype(float)
            centroids,_ = kmeans(pixel,ncolors)
            color_to_label_map = {c:i for i,c in enumerate([tuple(i) for i in centroids])}
            label_to_color_map = dict(zip(color_to_label_map.values(),color_to_label_map.keys()
            return label_to_color_map

        def get_feature(file):
            test_color = Image.open(file,'r')
            test_color = test_color.convert('L') #makes it greyscale
            test_gray = np.asarray(test_color.getdata(),dtype=np.float64).reshape((test_color.s
            test_gray = np.asarray(test_gray,dtype=np.uint8) #if values still in range 0-255!
            test_gray = Image.fromarray(test_gray,mode='L')

            # l(256,256)
            l, a, b = load_image(file)
            w,h = np.shape(a)
            # hog(256,256)
            fd, hog_image = hog(test_gray, orientations=8, pixels_per_cell=(16, 16),
                                cells_per_block=(1, 1), visualise=True)
            # daisy(256,256,3)
```

```
        descs, descs_img = daisy(test_gray, step=180, radius=58, rings=2, histograms=6,
                                 orientations=8, visualize=True)
        feature = np.zeros((256*256,5))
        feature[:,0] = hog_image.reshape(1,256*256)[0]
        feature[:,1] = descs_img[:,:,0].reshape(1,256*256)[0]
        feature[:,2] = descs_img[:,:,1].reshape(1,256*256)[0]
        feature[:,3] = descs_img[:,:,2].reshape(1,256*256)[0]
        feature[:,4] = l.reshape(1,256*256)[0]

        return(feature)
```

0.2.3 Step 3: Prepare for model

```
In [ ]: def train_xgb(files,ncolors,num_class, npics):

        kmap_a=np.array([])
        kmap_b=np.array([])
        for f in files:
            _,a,b = load_image(f)
            kmap_a = np.concatenate([kmap_a, a.flatten()])
            kmap_b = np.concatenate([kmap_b, b.flatten()])
        w,h = np.shape(a)
        label=quantize_kmeans(kmap_a, kmap_b, ncolors, npics)

        pixel=[]
        for f in files:
            l, a, b = load_image(f)
            this_pixel = l.reshape(1,w*h).tolist()
            pixel.append(this_pixel[0])

        pixel = reduce(operator.add, pixel)

        pixel_mat = np.array(pixel).reshape(npics*w*h,1)

        dtrain = xgb.DMatrix(pixel_mat, label=label)
        param = {'max_depth':10, 'eta':0.1, 'silent':1, 'objective':'multi:softmax', 'num_
        num_round = 10
        print('Begin xgb training')
        bst = xgb.train(param, dtrain, num_round)
        return bst

    def train_xgb_fea(files,ncolors,num_class, npics):

        kmap_a=np.array([])
        kmap_b=np.array([])


        for f in files:
```

```
            _,a,b = load_image(f)
            kmap_a = np.concatenate([kmap_a, a.flatten()])
            kmap_b = np.concatenate([kmap_b, b.flatten()])

        label=quantize_kmeans(kmap_a, kmap_b, ncolors, npics)
        w,h = np.shape(a)

        pixel_feature = np.zeros(shape=(w*h*npics,1))



        for ind,f in enumerate(files):
            feature = get_feature(f)
            pixel_feature[(w*h*ind):(w*h*(ind+1)),:] = feature

    #     pixel_mat = np.array(pixel).reshape(npics*256*256,1)

        dtrain = xgb.DMatrix(pixel_feature, label=label)
        param = {'max_depth':10, 'eta':0.1, 'silent':1, 'objective':'multi:softmax', 'num_
        num_round = 10
        print('Begin xgb training')
        bst = xgb.train(param, dtrain, num_round)
        return bst

    def test_xgb_fea(file,xgb_model):

        pixel_feature = get_feature(file)

        dtest=xgb.DMatrix(pixel_feature)
        preds = xgb_fit.predict(dtest)

        return preds
```

0.2.4 Step4: Train Model

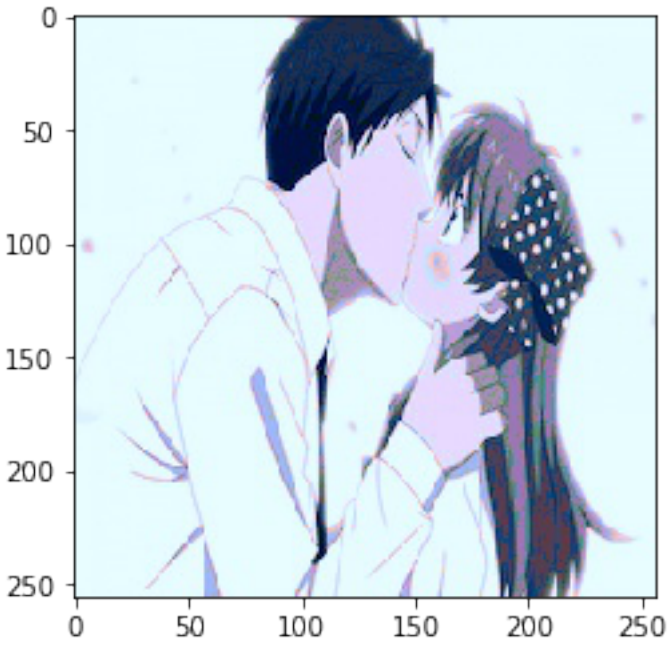
```
In [ ]: #load images
        folder_dir = './girl/'
        train_dir = []

        for filename in os.listdir(folder_dir):
            if filename.startswith('.') or \
            filename.startswith('predict') or \
            filename.startswith('gray'):
                continue
            train_dir.append(folder_dir + filename)

        # train_dir = ['WechatIMG1667.jpeg']
```

```
In [ ]: ncolors = 16
        kmap_a=np.array([])
        kmap_b=np.array([])
        for f in train_dir:
            _,a,b = load_image(f)
            kmap_a = np.concatenate([kmap_a, a.flatten()])
            kmap_b = np.concatenate([kmap_b, b.flatten()])
        h,w = np.shape(a)

In [ ]: npics = len(train_dir) # number of train image
        kmap_a = kmap_a.reshape(npics*w*h,1)
        kmap_b = kmap_b.reshape(npics*w*h,1)
        label_to_color_map = label_to_color_map_fun(kmap_a,kmap_b,ncolors)
        print(len(label_to_color_map))
        ncolors = len(label_to_color_map) # update ncolors

In [ ]: xgb_fit = train_xgb_fea(train_dir,ncolors,ncolors,npics)
```

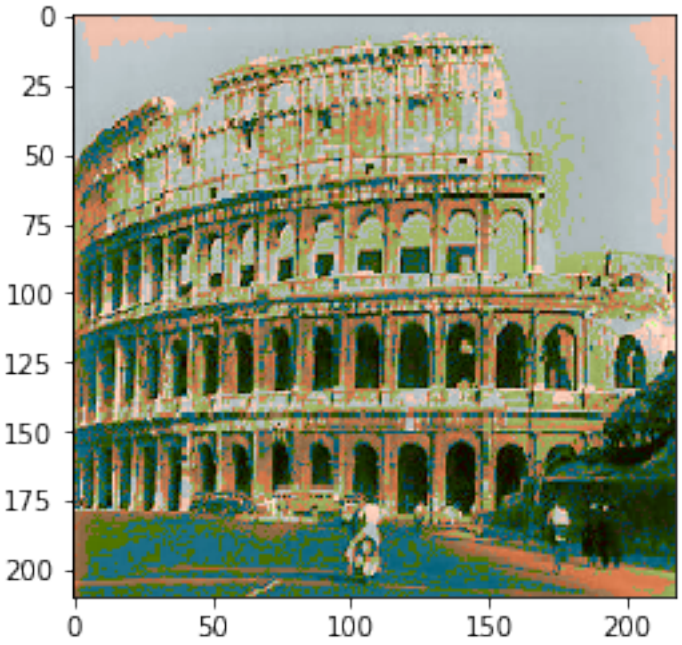
0.2.5 Step5: Colorize new test image

```
In [ ]: test_img = './girl/gray/WechatIMG1286_gray.jpg'
        preds = test_xgb_fea(test_img, xgb_fit)

In [ ]: def pred2color(test_img,preds,label_to_color_map,ncolors=16, saveimg = False, savename
            l_test, a_test, b_test = load_image(test_img)
            preds = preds.reshape(h,w)
            print(w,h)
            colors_present = [i for i in range(ncolors)]
            output_a = np.zeros((h,w))
            output_b = np.zeros((h,w))
            output_l = l_test.reshape((h,w))
            for i in range(h):
                for j in range(w):
                    a,b = label_to_color_map[colors_present[int(preds[i,j])]]
                    output_a[i,j] = a
                    output_b[i,j] = b
            print(output_a.shape,output_b.shape,output_l.shape)
            output_img = cv2.cvtColor(cv2.merge(( np.uint8(output_l), np.uint8(output_a), np.u
                                      cv2.COLOR_LAB2RGB)
            if saveimg == True:
                plt.imsave('./girl/predict/' + savename,output_img)
            return(output_img)

In [ ]: output_img = pred2color(test_img,preds,label_to_color_map,ncolors=ncolors,
                               saveimg = False, savename = 'wenzhu.jpg')
        plt.imshow(output_img)
        # cv2.imwrite('savename.jpg', output_img )
        # plt.imsave('./girl/predict/output_img_gile12.jpg',output_img)
```

In [33]:
```
img_test = 'C:/Users/rolco/Desktop/result3.jpg'
img_test_file = plt.imread(img_test)
plt.imshow(img_test_file)
plt.show()
```



In [35]:
```
img_test = 'C:/Users/rolco/Desktop/ghost.png'
img_test_file = plt.imread(img_test)
plt.imshow(img_test_file)
plt.show()
```



Here we could see that xgboost performed well on colorizing cartoon. However, for architectures, it does not so well. So we tried to build GBM model as our next model.

0.3 3.Model3: GBM

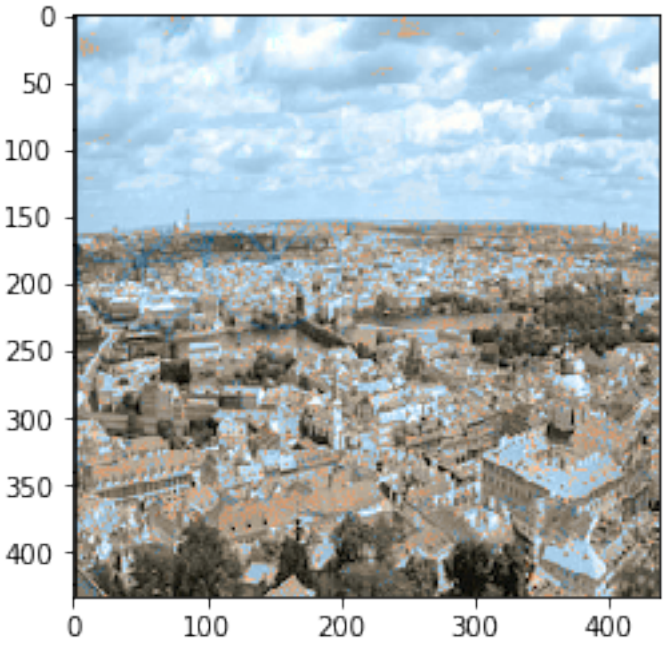
```
In [ ]: import numpy as np
        import pandas as pd
        import skimage
        import matplotlib.pyplot as plt
        import cv2
        from PIL import Image
        from skimage.feature import hog
        from skimage.feature import daisy
        from sklearn.model_selection import train_test_split
        from sklearn.ensemble import GradientBoostingClassifier

        # import train_label, train_image, test_image
        label999 = pd.read_csv('/Users/yuexuanhuang/Documents/GitHub/Spring2018-Project5-grp_10
        train_color = Image.open('/Users/yuexuanhuang/Documents/GitHub/Spring2018-Project5-grp_
        label = label999
        test_color = Image.open('/Users/yuexuanhuang/Documents/GitHub/Spring2018-Project5-grp_1

        # train model, predict, output
        def colorme(train_color, train_label, test_color):

            train_color = train_color.convert('L') #makes it greyscale
```

```
train_gray = np.asarray(train_color.getdata(),dtype=np.float64).reshape((train_colo
train_gray = np.asarray(train_gray,dtype=np.uint8) #if values still in range 0-255
train_gray = Image.fromarray(train_gray,mode='L')
# train_gray.save('/Users/yuexuanhuang/Desktop/Proj_5/alpha2/gray/gray%s.png'%000)

test_color = test_color.convert('L') #makes it greyscale
test_gray = np.asarray(test_color.getdata(),dtype=np.float64).reshape((test_color.s
test_gray = np.asarray(test_gray,dtype=np.uint8) #if values still in range 0-255!
test_gray = Image.fromarray(test_gray,mode='L')
# test_gray.save('/Users/yuexuanhuang/Desktop/Proj_5/alpha2/gray/gray%s.png'%001)

# hog(256,256)
fd, hog_image = hog(train_gray, orientations=8, pixels_per_cell=(16, 16),
                    cells_per_block=(1, 1), visualise=True)

# daisy(256,256,3)
descs, descs_img = daisy(train_gray, step=180, radius=58, rings=2, histograms=6,
                         orientations=8, visualize=True)

train = pd.DataFrame(np.matrix(np.full((65536, 5), np.inf)))
train.columns = ['label', 'hog', 'daisy1', 'daisy2', 'daisy3']
for i in range(5):
    if i == 0:
        collect = train_label
        for j in range(256):
            for k in range(256):
                train.iloc[k+j*256, i] = collect.iloc[k,j]

    if i == 1:
        collect = np.matrix(hog_image)
        for j in range(256):
            for k in range(256):
                train.iloc[k+j*256, i] = collect[k,j]

    if i == 2:
        collect = np.matrix(descs_img[:,:,0])
        for j in range(256):
            for k in range(256):
                train.iloc[k+j*256, i] = collect[k,j]

    if i == 3:
        collect = np.matrix(descs_img[:,:,1])
        for j in range(256):
            for k in range(256):
                train.iloc[k+j*256, i] = collect[k,j]

    if i == 4:
        collect = np.matrix(descs_img[:,:,2])
```

```
        for j in range(256):
            for k in range(256):
                train.iloc[k+j*256, i] = collect[k,j]

train_features, test_features, train_labels, test_labels = train_test_split(train.
clf = GradientBoostingClassifier()
clf.fit(train_features, train_labels)
# label_predict = clf.predict(test_features)
# np.mean(label_predict == test_labels)

# test
# hog(256,256)
fd, hog_image = hog(test_gray, orientations=8, pixels_per_cell=(16, 16),
                    cells_per_block=(1, 1), visualise=True)

# daisy(256,256,3)
descs, descs_img = daisy(test_gray, step=180, radius=58, rings=2, histograms=6,
                         orientations=8, visualize=True)

test = pd.DataFrame(np.matrix(np.full((65536, 4), np.inf)))
test.columns = ['hog', 'daisy1', 'daisy2', 'daisy3']
for i in range(4):
    if i == 0:
        collect = np.matrix(hog_image)
        for j in range(256):
            for k in range(256):
                test.iloc[k+j*256, i] = collect[k,j]

    if i == 1:
        collect = np.matrix(descs_img[:,:,0])
        for j in range(256):
            for k in range(256):
                test.iloc[k+j*256, i] = collect[k,j]

    if i == 2:
        collect = np.matrix(descs_img[:,:,1])
        for j in range(256):
            for k in range(256):
                test.iloc[k+j*256, i] = collect[k,j]

    if i == 3:
        collect = np.matrix(descs_img[:,:,2])
        for j in range(256):
            for k in range(256):
                test.iloc[k+j*256, i] = collect[k,j]

test_predict = clf.predict(test)
test_label = pd.DataFrame(np.matrix(np.full((256, 256), np.inf)))
```

```
            for i in range(256):
                for j in range(256):
                    test_label.iloc[j,i] = test_predict[j+i*256]

            return test_label

        # get the test_label
        t_label = colorme(train_color = train_color, train_label = label, test_color = test_co

        # import the image we need to colorize
        test_color = test_color.convert('L') #makes it greyscale
        test_gray = np.asarray(test_color.getdata(),dtype=np.float64).reshape((test_color.size
        test_gray = np.asarray(test_gray,dtype=np.uint8) #if values still in range 0-255!
        test_gray = Image.fromarray(test_gray,mode='L')
        test_gray.save('/Users/yuexuanhuang/Documents/GitHub/Spring2018-Project5-grp_10/output/

        img = cv2.imread('/Users/yuexuanhuang/Documents/GitHub/Spring2018-Project5-grp_10/data/
        # img = cv2.resize(img, (256, 256))
        l, a, b = cv2.split(cv2.cvtColor(img, cv2.COLOR_RGB2LAB))
        Lab_l = np.matrix(l)

        # define colorize function
        def show(standard, t_label, Lab_l):
            Lab_a = np.matrix(np.full((256, 256), np.inf))
            Lab_b = np.matrix(np.full((256, 256), np.inf))
            for i in range(256):
                for j in range(256):
                    Lab_a[i,j] = standard[np.int(t_label.iloc[i,j])][0]
                    Lab_b[i,j] = standard[np.int(t_label.iloc[i,j])][1]

            ar = np.zeros((256,256,3))
            ar[:,:,0] = Lab_l / 2.55
            ar[:,:,1] = Lab_a
            ar[:,:,2] = Lab_b
            rgb = skimage.color.lab2rgb(ar)
            return rgb

        # show the colorful picture
        plt.imshow(show(standard, t_label, Lab_l))
```

In [36]:
```
img_test = 'C:/Users/rolco/Desktop/arch.png'
img_test_file = plt.imread(img_test)
plt.imshow(img_test_file)
plt.show()
```



In [40]:
```
img_test = 'C:/Users/rolco/Desktop/color2.png'
img_test_file = plt.imread(img_test)
plt.imshow(img_test_file)
plt.show()
```