

Assignment #2

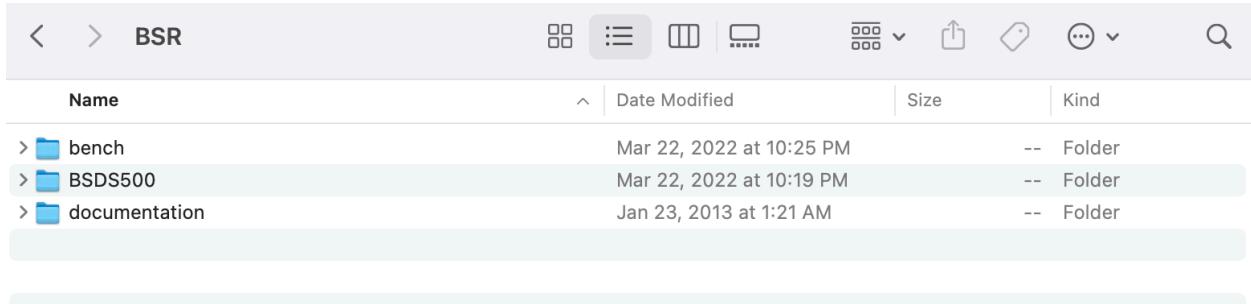
Image Segmentation

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Download the Dataset and Understand the Format:



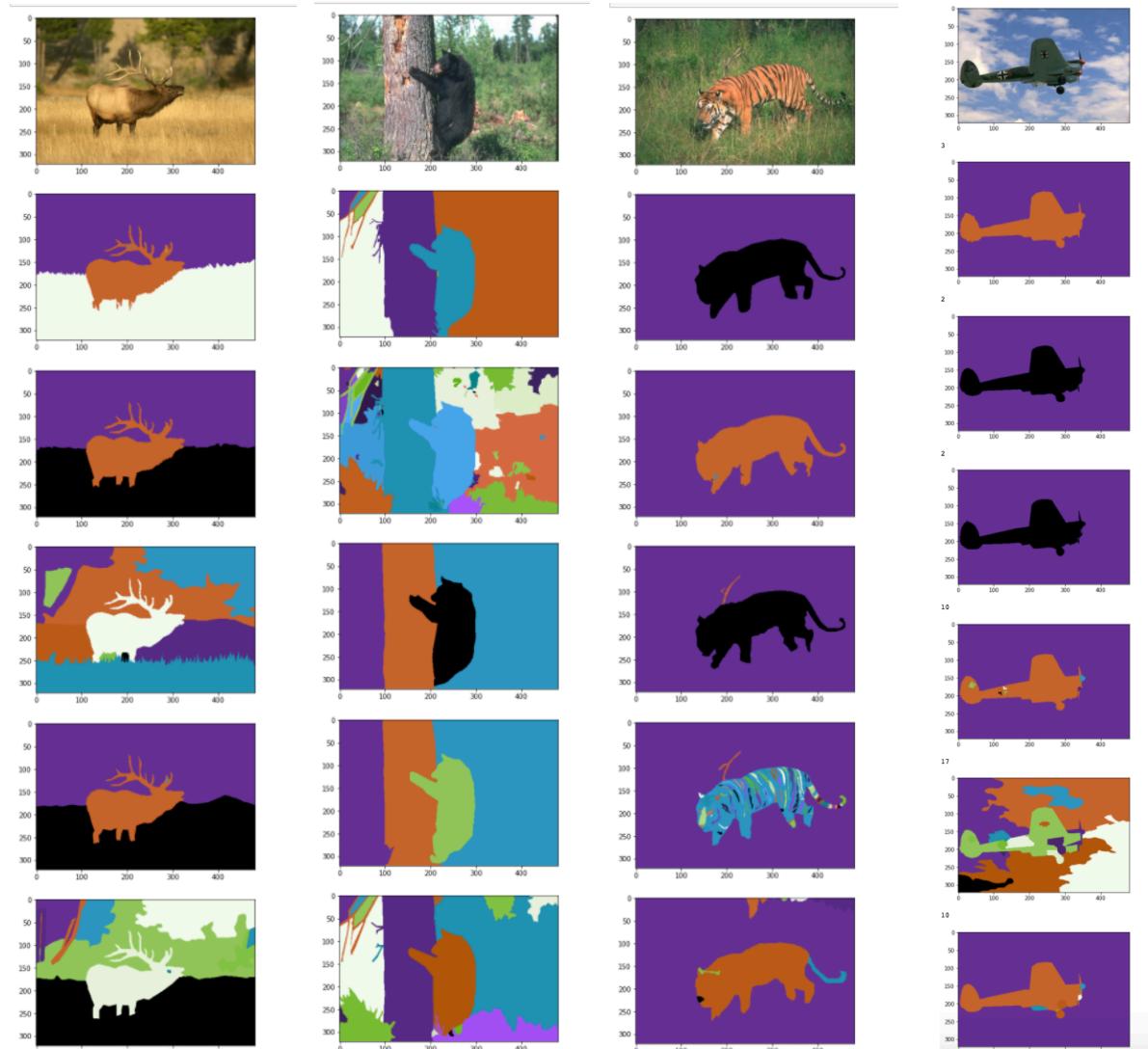
```
{'__header__': b'MATLAB 5.0 MAT-file, Platform: PCWIN, Created on: Thu Oct 29 09:24:23 2009',
 '__version__': '1.0',
 '__globals__': [],
 'groundTruth': [{'Segmentation': array([[1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1],
 ...,
 [1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1]], dtype=uint16),
 'Boundaries': array([[0, 0, 0, ..., 0, 0, 0],
 [0, 0, 0, ..., 0, 0, 0],
 ...,
 [0, 0, 0, ..., 0, 0, 0],
 [0, 0, 0, ..., 0, 0, 0], dtype=uint8)}},
 {'Segmentation': array([[1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1],
 ...,
 [1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1],
 [1, 1, 1, ..., 1, 1, 1]], dtype=uint16),
 'Boundaries': array([[0, 0, 0, ..., 0, 0, 0],
 [0, 0, 0, ..., 0, 0, 0],
 ...,
 [0, 0, 0, ..., 0, 0, 0],
 [0, 0, 0, ..., 0, 0, 0], dtype=uint8)}},
```

Visualize the image and the ground truth

segmentation:

```
def draw_ground_truth(img_path):
    img = cv2.imread(img_path)
    img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
    plt.imshow(img)
    plt.show()
    seg_path = img_path.replace("images", "groundTruth")
    seg_path = seg_path.replace("jpg", "mat")
    seg = read_mat(seg_path)
    for i in range(len(seg['groundTruth'])):
        mask = np.zeros(img.shape, np.uint8)
        # mask[seg['groundTruth'][i]['Boundaries']] = 255 # Segmentation

        for j in range(len(np.unique(seg['groundTruth'][i]['Segmentation']))):
            mask[seg['groundTruth'][i]['Segmentation'] == j, 0] = j * 100
            mask[seg['groundTruth'][i]['Segmentation'] == j, 1] = j * 50
            mask[seg['groundTruth'][i]['Segmentation'] == j, 2] = j * 150
        #print(len(np.unique(seg['groundTruth'][i]['Segmentation'])))
        plt.imshow(mask)
        plt.show()
```



Segmentation using K-means:

implementation

```
def k_means(image,k,it_max):
    C = []
    for i in range(k):
        C.append(np.array([random.randint(0, 255),random.randint(0, 255),random.randint(0, 255)]))
    C
    for x in range(it_max):
        #print("iteration, ",x)
        clusters = []
        for i in range(k):
            clusters.append([])

        for i in range(image.shape[0]):
            for j in range(image.shape[1]):
                minDis = float('inf')
                minC = -1
                for c in range(k):
                    diff = (image[i,j,:].astype('int16')-C[c].astype('int16'))
                    dis = np.dot(diff,diff)
                    if dis<minDis:
                        minDis = dis
                        minC = c
                clusters[minC].append(image[i,j,:])

        for c in range(k):
            newC = np.array([0,0,0])
            for i in range(len(clusters[c])):
                newC+=clusters[c][i]
            if len(clusters[c])!=0:
                clusters[c] = 1
            for i in range(3):
                newC[i]/=len(clusters[c])
            same = 1;
            for c1 in range(3):
                if C[c][c1]!=newC[c1]:
                    same=0
            C[c] = newC

    def draw_clusters(image,clusters):
        # print(len(clusters))
        img_clusters = []
        for c in range(len(clusters)):
            img_clusters.append([])

        mask = np.zeros(image.shape, np.uint8)
        for i in range(image.shape[0]):
            for j in range(image.shape[1]):
                minDis = float('inf')
                minC = -1
                for c in range(len(clusters)):
                    diff = (image[i,j,:].astype('int16')-clusters[c].astype('int16'))
                    dis = np.dot(diff,diff)
                    if dis<minDis:
                        minDis = dis
                        minC = c
                mask[i,j]=clusters[minC]
                img_clusters[minC].append(np.array([i,j]))
        #plt.imshow(mask)
        #plt.show()
        return mask ,img_clusters
```

evaluation

```

def evaluate_entropy(img_path,clusters):
    seg_path = img_path.replace("images", "ground_truth")
    seg_path = seg_path.replace("jpg", "mat")
    data = read_mat(seg_path)
    data = data['groundTruth']
    H_total = 0
    img_size = data[0]['Segmentation'].shape[0]*data[0]['Segmentation'].shape[1]

    for x in range(len(data)):
        ground_truth = data[x]['Segmentation']
        HC = 0
        for c in range(len(clusters)):
            nij = np.zeros(len(np.unique(ground_truth)))
            for i in range(len(clusters[c])):
                d = [clusters[c][i]]
                nij[ground_truth[d[0][0],d[0][1]]-1] += 1
            n = nij/len(clusters[c])
            HCi = 0
            for i in range(len(np.unique(ground_truth))):
                if(n[i]!=0):
                    HCi -= (n[i])* math.log2(n[i])
            #print(HCi, " ",n)
            HC += HCi*(len(clusters[c])/img_size)
        #print(HC)
        H_total += HC
    H_total /= len(data)
    return H_total

```

```

def evaluate_F_measure(img_path,clusters):
    seg_path = img_path.replace("images", "ground_truth")
    seg_path = seg_path.replace("jpg", "mat")
    data = read_mat(seg_path)
    data = data['groundTruth']
    F_total = 0
    for x in range(len(data)):
        F=0.0
        Tj = np.zeros(len(np.unique(data[x]['Segmentation'])))
        ground_truth = data[x]['Segmentation']
        h = 0
        for i in range(ground_truth.shape[0]):
            for j in range(ground_truth.shape[1]):
                Tj[ground_truth[i,j]-1] += 1
        for c in range(len(clusters)):
            nij = np.zeros(len(np.unique(ground_truth)))
            for i in range(len(clusters[c])):
                d = [clusters[c][i]]
                nij[ground_truth[d[0][0],d[0][1]]-1] += 1
            maxI = -1
            maxN = -1
            for i in range(len(nij)):
                N = nij[i]
                if N>maxN:
                    maxN = N
                    maxI = i
            prec = (maxN/len(clusters[c]))
            recall = (maxN/Tj[maxI])
            F += (2*prec*recall)/(prec+recall)
        #      print("p",prec)
        #      print("r",recall)
        F /= len(clusters)
        #print(F)
        F_total += F
    F_total /= len(data)
    return F_total

```

img 1 to 10

```
img 1 : 2018.jpg
for k = 1
best F-measure = 0.41817402595397457
best Conditional Entropy = 2.668875164911475
for k = 3
best F-measure = 0.4201914684426245
best Conditional Entropy = 2.4938847262460055
for k = 5
best F-measure = 0.378310754525291
best Conditional Entropy = 2.0887344591242067
for k = 7
best F-measure = 0.3393979215874988
best Conditional Entropy = 1.9462721466723152
for k = 9
best F-measure = 0.2680503240665534
best Conditional Entropy = 2.0212602647720432
for k = 11
best F-measure = 0.23418675478551004
best Conditional Entropy = 1.9101621872045897
img 2 : 3863.jpg
for k = 1
best F-measure = 0.832213128382361
best Conditional Entropy = 1.0172530381099023
for k = 3
best F-measure = 0.49468375501924997
best Conditional Entropy = 0.891426444030663
for k = 5
best F-measure = 0.3463132407188704
best Conditional Entropy = 0.8584133794168286
for k = 7
best F-measure = 0.377747349283209
best Conditional Entropy = 0.4880014814101141
for k = 9
best F-measure = 0.296085129384611
best Conditional Entropy = 0.5653059718949939
for k = 11
best F-measure = 0.28532069624982587
best Conditional Entropy = 0.4272954840368402
img 3 : 5896.jpg
for k = 1
best F-measure = 0.3201567765943344
best Conditional Entropy = 3.3183972723667465
for k = 3
best F-measure = 0.4572385061650035
best Conditional Entropy = 2.6468401222655507
for k = 5
best F-measure = 0.473754379244293
best Conditional Entropy = 2.526389187806233
for k = 7
best F-measure = 0.41936609418639126
best Conditional Entropy = 2.275797537246732
for k = 9
best F-measure = 0.380493664731366
best Conditional Entropy = 2.177527796046788
for k = 11
best F-measure = 0.32723769698225446
best Conditional Entropy = 2.1749614996654394
img 4 : 6046.jpg
for k = 1
best F-measure = 0.4159397397923949
best Conditional Entropy = 3.4717229609330493
for k = 3
best F-measure = 0.396331093384208
best Conditional Entropy = 3.153883050965888
for k = 5
best F-measure = 0.33396764419128216
best Conditional Entropy = 3.0794259545862785
for k = 7
best F-measure = 0.3103916739390871
best Conditional Entropy = 2.9211201069145947
for k = 9
best F-measure = 0.266251143159693
best Conditional Entropy = 2.8754440037882723
for k = 11
best F-measure = 0.2500783915423641
best Conditional Entropy = 2.756604402584575
img 5 : 8068.jpg
for k = 1
best F-measure = 0.7680284309745733
best Conditional Entropy = 1.4851404548530935
for k = 3
best F-measure = 0.6645419474061367
best Conditional Entropy = 0.9066809172242074
for k = 5
best F-measure = 0.4246622301652304
best Conditional Entropy = 1.0855657937395295
for k = 7
best F-measure = 0.3566921375536979
best Conditional Entropy = 1.0849544803004023
for k = 9
best F-measure = 0.303636196010056
best Conditional Entropy = 0.8749410236431914
for k = 11
best F-measure = 0.2786575238285985
best Conditional Entropy = 0.8586349525487716
img 6 : 10081.jpg
for k = 1
best F-measure = 0.5184620289081161
best Conditional Entropy = 2.08337013665
for k = 3
best F-measure = 0.678274172461887
best Conditional Entropy = 1.47664845936
for k = 5
best F-measure = 0.5003939857376686
best Conditional Entropy = 1.31392526782
for k = 7
best F-measure = 0.3932381812717154
best Conditional Entropy = 1.49481206575
for k = 9
best F-measure = 0.3161650544014646
best Conditional Entropy = 1.403586808536
for k = 11
best F-measure = 0.30056660507384014
best Conditional Entropy = 1.145887795797
img 7 : 14885.jpg
for k = 1
best F-measure = 0.73764312913121486
best Conditional Entropy = 1.761781687941
for k = 3
best F-measure = 0.4920146328652269
best Conditional Entropy = 1.35471188203
for k = 5
best F-measure = 0.37720782744707393
best Conditional Entropy = 1.3350426510506481
for k = 7
best F-measure = 0.2862989887302967
best Conditional Entropy = 1.3381672556650641
for k = 9
best F-measure = 0.21650132555834717
best Conditional Entropy = 1.50085187449181505
for k = 11
best F-measure = 0.19236331126823555
best Conditional Entropy = 1.45750247878846
img 8 : 14092.jpg
for k = 1
best F-measure = 0.8621404661092621
best Conditional Entropy = 1.4608774260793085
for k = 3
best F-measure = 0.4609589509538215
best Conditional Entropy = 1.3652182950441372
for k = 5
best F-measure = 0.31182170996779907
best Conditional Entropy = 1.3286011374730606
for k = 7
best F-measure = 0.2756301675117336
best Conditional Entropy = 1.3017513353937709
for k = 9
best F-measure = 0.1911554815988258
best Conditional Entropy = 1.2583078291641845
for k = 11
best F-measure = 0.19276542380475728
best Conditional Entropy = 1.2351139018046977
img 9 : 15011.jpg
for k = 1
best F-measure = 0.41886179916092814
best Conditional Entropy = 3.6356075910510675
for k = 3
best F-measure = 0.5467230830872436
best Conditional Entropy = 3.0797093172383105
for k = 5
best F-measure = 0.4190119875310304
best Conditional Entropy = 2.8488542805630633
for k = 7
best F-measure = 0.30679361622990936
best Conditional Entropy = 2.959300887376649
for k = 9
best F-measure = 0.3209141916423285
best Conditional Entropy = 2.9481994798608313
for k = 11
best F-measure = 0.3225462727735115
best Conditional Entropy = 2.858848899978252
img 10 : 15062.jpg
for k = 1
best F-measure = 0.4946735828096844
best Conditional Entropy = 2.825771784464479
for k = 3
best F-measure = 0.4680761303079599
best Conditional Entropy = 2.279996018141721
for k = 5
best F-measure = 0.3472671040021928
best Conditional Entropy = 2.5187769272617317
for k = 7
best F-measure = 0.3431760384939155
best Conditional Entropy = 2.0968416277938933
for k = 9
best F-measure = 0.2735007644944158
best Conditional Entropy = 2.28555331989721
for k = 11
best F-measure = 0.2291098849978269
best Conditional Entropy = 2.2148969624661423
```

img 11 to 20

```

img 11 : 16004.jpg
for k = 1
best F-measure = 0.319114244287724
best Conditional Entropy = 3.7449983086180465
for k = 3
best F-measure = 0.3000830850699817
best Conditional Entropy = 3.561866071853475
for k = 5
best F-measure = 0.2960681870954727
best Conditional Entropy = 3.403286652956199
for k = 7
best F-measure = 0.28346610587565707
best Conditional Entropy = 3.317407608811373
for k = 9
best F-measure = 0.2581576100907039
best Conditional Entropy = 3.244738210550466
for k = 11
best F-measure = 0.2518933207702375
best Conditional Entropy = 3.2130919365880297
img 12 : 16068.jpg
for k = 1
best F-measure = 0.6228358257107712
best Conditional Entropy = 2.1380267190357007
for k = 3
best F-measure = 0.41595931969579825
best Conditional Entropy = 1.9635321927094305
for k = 5
best F-measure = 0.36110050944197414
best Conditional Entropy = 1.8559894019092383
for k = 7
best F-measure = 0.2960875314033295
best Conditional Entropy = 1.7940607571373912
for k = 9
best F-measure = 0.2425794307313509
best Conditional Entropy = 1.8325599039646026
for k = 11
best F-measure = 0.23665478903876072
best Conditional Entropy = 1.7416514349032999
img 13 : 17067.jpg
for k = 1
best F-measure = 0.37720398896147095
best Conditional Entropy = 3.0808738128837647
for k = 3
best F-measure = 0.456294177237399
best Conditional Entropy = 2.64066778899503
for k = 5
best F-measure = 0.436413225263376
best Conditional Entropy = 2.4371932945761436
for k = 7
best F-measure = 0.24811552727745897
best Conditional Entropy = 2.591011365583217
for k = 9
best F-measure = 0.2543906628906909
best Conditional Entropy = 2.631251269606063
for k = 11

/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:27: Ru
value encountered in double_scalars
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:17: Ru
value encountered in true_divide

best F-measure = 0.20980676789278632
best Conditional Entropy = 2.422479233035414
img 14 : 20069.jpg
for k = 1
best F-measure = 0.5169164311289837
best Conditional Entropy = 2.82417759308607
for k = 3
best F-measure = 0.43508449936359886
best Conditional Entropy = 2.431905492598195
for k = 5
best F-measure = 0.34834975175741795
best Conditional Entropy = 2.4562631962003745
for k = 7
best F-measure = 0.27121980423667486
best Conditional Entropy = 2.538447966108757
for k = 9
best F-measure = 0.24449992297287693
best Conditional Entropy = 2.284407458603553
for k = 11
best F-measure = 0.22413755145977046
best Conditional Entropy = 2.2062006962061624

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```

img 15 : 23050.jpg
for k = 1
best F-measure = 0.23607472153841233
best Conditional Entropy = 4.446856054856073
for k = 3
best F-measure = 0.2914796481006731
best Conditional Entropy = 4.096490487039346
for k = 5
best F-measure = 0.357380064158318433
best Conditional Entropy = 3.744820342938313
for k = 7
best F-measure = 0.29676390073408154
best Conditional Entropy = 3.7568974817614396
for k = 9
best F-measure = 0.33795354905079744
best Conditional Entropy = 3.4525666889360935
for k = 11
best F-measure = 0.32215501563625243
best Conditional Entropy = 3.471277808522744
img 16 : 28083.jpg
for k = 1
best F-measure = 0.5982117192344448
best Conditional Entropy = 2.3924986964877806
for k = 3
best F-measure = 0.505464428459331
best Conditional Entropy = 1.986789513324773
for k = 5
best F-measure = 0.39124183174871435
best Conditional Entropy = 1.8997570172180094
for k = 7
best F-measure = 0.40383930882783287
best Conditional Entropy = 1.56643929044973
for k = 9
best F-measure = 0.3615124879109656
best Conditional Entropy = 1.5472086502284619
for k = 11
best F-measure = 0.30042656120832795
best Conditional Entropy = 1.4843118279310035
img 17 : 29030.jpg
for k = 1
best F-measure = 0.7233010195943059
best Conditional Entropy = 1.829648945571174
for k = 3
best F-measure = 0.6211257797897428
best Conditional Entropy = 1.4046850030619265
for k = 5
best F-measure = 0.4405435081752696
best Conditional Entropy = 1.347519274022
for k = 7
best F-measure = 0.35913619645845435
best Conditional Entropy = 1.2112295002081
for k = 9
best F-measure = 0.2771663247788527
best Conditional Entropy = 1.345201590454
for k = 11
best F-measure = 0.23889590593795906
best Conditional Entropy = 1.282744969657:
img 18 : 33044.jpg
for k = 1
best F-measure = 0.5786827965172348
best Conditional Entropy = 2.2298042801961
for k = 3
best F-measure = 0.4479339807065525
best Conditional Entropy = 1.9561476171331
for k = 5
best F-measure = 0.3252703036536583
best Conditional Entropy = 1.9054795399883108
for k = 7
best F-measure = 0.32053267758042214
best Conditional Entropy = 1.7179804803190524
for k = 9
best F-measure = 0.2413913159473649
best Conditional Entropy = 1.8150171630721068
for k = 11
best F-measure = 0.17513110313998473
best Conditional Entropy = 1.8634348724060712
----- data_set average -----
for k = 1 , average F-measure = 0.516269579632995
1 , average Conditional Entropy = 2.672192535052777
for k = 3 , average F-measure = 0.4367177991418084
3 , average Conditional Entropy = 2.3615661711954696
for k = 5 , average F-measure = 0.37750591057433885
5 , average Conditional Entropy = 2.239016241717953
for k = 7 , average F-measure = 0.31518888895558532
7 , average Conditional Entropy = 2.170888638615787
for k = 9 , average F-measure = 0.2758146080077079
9 , average Conditional Entropy = 2.133786728431476
for k = 11 , average F-measure = 0.24269900455584534
11 , average Conditional Entropy = 2.0848083449157055

```

img 21 to 30

```

img 21 : 36046.jpg
for k = 1
best F-measure = 0.6094629078951755
best Conditional Entropy = 2.265420312334868
for k = 3
best F-measure = 0.717735763300755
best Conditional Entropy = 1.1381106934393852
for k = 5
best F-measure = 0.5942518615802417
best Conditional Entropy = 1.3624662839416966
for k = 7
best F-measure = 0.4453587393815052
best Conditional Entropy = 1.22331198795372
for k = 9
best F-measure = 0.40168999862577106
best Conditional Entropy = 1.2808733272844697
for k = 11
best F-measure = 0.3408129052087088
best Conditional Entropy = 1.1969999269879914
img 22 : 41006.jpg
for k = 1
best F-measure = 0.5802300038609804
best Conditional Entropy = 1.8818238038656318
for k = 3
best F-measure = 0.5361920483232617
best Conditional Entropy = 1.3540031147657687
for k = 5
best F-measure = 0.3633158478316604
best Conditional Entropy = 1.3016411027897494
for k = 7
best F-measure = 0.3098561699607787
best Conditional Entropy = 1.119987206888791
for k = 9
best F-measure = 0.21171540579929077
best Conditional Entropy = 1.6788450978632625
for k = 11
best F-measure = 0.1977595625309264
best Conditional Entropy = 1.2710410893969804
img 23 : 41029.jpg
for k = 1
best F-measure = 0.5720943596797091
best Conditional Entropy = 2.049004030299056
for k = 3
best F-measure = 0.4670484785966123
best Conditional Entropy = 1.7804280269408086
for k = 5
best F-measure = 0.40546225178338186
best Conditional Entropy = 1.595650913853004
for k = 7
best F-measure = 0.33210439611316633
best Conditional Entropy = 1.6144965347211644
for k = 9
best F-measure = 0.275902122239619
best Conditional Entropy = 1.5511825951472484
for k = 11
best F-measure = 0.255989763924811
best Conditional Entropy = 1.509856995211457
img 24 : 41085.jpg
for k = 1
best F-measure = 0.5105365466118752
best Conditional Entropy = 2.44838601041802
for k = 3
best F-measure = 0.3873334423661065
best Conditional Entropy = 2.26518424376752
for k = 5
best F-measure = 0.30097364912080473
best Conditional Entropy = 2.189738976157761
for k = 7
best F-measure = 0.2954140906071442
best Conditional Entropy = 2.144601420845985
for k = 9
best F-measure = 0.2102855932168447
best Conditional Entropy = 2.104268080325037
for k = 11
best F-measure = 0.19951158913568856
best Conditional Entropy = 2.082716271984691
img 25 : 41096.jpg
for k = 1
best F-measure = 0.5804563760760818
best Conditional Entropy = 1.606840785499526
for k = 3
best F-measure = 0.5863747252837416
best Conditional Entropy = 1.099514978544956
for k = 5
best F-measure = 0.4001124058014487
best Conditional Entropy = 1.1540434853460977
for k = 7
best F-measure = 0.31097276656588385
best Conditional Entropy = 1.0492004812867577
for k = 9
best F-measure = 0.27213182046609025
best Conditional Entropy = 1.030164605454157
for k = 11
best F-measure = 0.22959907787368472
best Conditional Entropy = 0.9089168428528359

img 26 : 43033.jpg
for k = 1
best F-measure = 0.76754087220335
best Conditional Entropy = 1.23499268804736
for k = 3
best F-measure = 0.5455571886256864
best Conditional Entropy = 1.0291338394248053
for k = 5
best F-measure = 0.39500719840737153
best Conditional Entropy = 1.0023471512518576
for k = 7
best F-measure = 0.31000709943191584
best Conditional Entropy = 0.987457423066825
for k = 9
best F-measure = 0.25284316342737995
best Conditional Entropy = 0.967275450781268
for k = 11
best F-measure = 0.21740606510512
best Conditional Entropy = 0.9854680726153487
img 27 : 43051.jpg
for k = 1
best F-measure = 0.9035421455167636
best Conditional Entropy = 0.717027881712697
for k = 3
best F-measure = 0.48850286627179285
best Conditional Entropy = 0.5164878905559915
for k = 5
best F-measure = 0.369533902372555
best Conditional Entropy = 0.5226113810473203
for k = 7
best F-measure = 0.27621394752842965
best Conditional Entropy = 0.49889270286481724
for k = 9
best F-measure = 0.20740750854426912
best Conditional Entropy = 0.45374724941868516
for k = 11
best F-measure = 0.18111759582294093
best Conditional Entropy = 0.47857833005725486
img 28 : 45000.jpg
for k = 1
best F-measure = 0.48360674683308444
best Conditional Entropy = 2.894761824558669
for k = 3
best F-measure = 0.3554654579416362
best Conditional Entropy = 2.689266730558516
for k = 5
best F-measure = 0.32119695523267255
best Conditional Entropy = 2.612642936963929
for k = 7
best F-measure = 0.27498862388640215
best Conditional Entropy = 2.561522595244269
for k = 9
best F-measure = 0.25686648737009665
best Conditional Entropy = 2.48132915570812
for k = 11
best F-measure = 0.2347864338202196
best Conditional Entropy = 2.3926797537224034
img 29 : 48017.jpg
for k = 1
best F-measure = 0.5280863401924363
best Conditional Entropy = 2.298941367630281
for k = 3
best F-measure = 0.3844903569949838
best Conditional Entropy = 2.182051710808378
for k = 5
best F-measure = 0.4050988503799521
best Conditional Entropy = 1.9743885728442934
for k = 7
best F-measure = 0.3466468237162106
best Conditional Entropy = 1.929848270755739
for k = 9
best F-measure = 0.2780323898021791
best Conditional Entropy = 1.983183499802472
for k = 11
best F-measure = 0.27649934528977665
best Conditional Entropy = 1.7944181655785951
img 30 : 48025.jpg
for k = 1
best F-measure = 0.7174177547514361
best Conditional Entropy = 2.092387656773029
for k = 3
best F-measure = 0.41540461871157497
best Conditional Entropy = 1.9411397737205491
for k = 5
best F-measure = 0.34747186171663084
best Conditional Entropy = 1.753193514294810
for k = 7
best F-measure = 0.26458239963921804
best Conditional Entropy = 1.6894990205344365
for k = 9
best F-measure = 0.2317907023124365
best Conditional Entropy = 1.6338558105694538
for k = 11
best F-measure = 0.21651060817616816
best Conditional Entropy = 1.669579618435885

```

img 31 to 40

```
img 31 : 49024.jpg
for k = 1
best F-measure = 0.49216089547836717
best Conditional Entropy = 2.210446498355079
for k = 3
best F-measure = 0.46256319780571137
best Conditional Entropy = 1.858969888280967
for k = 5
best F-measure = 0.3672914599917387
best Conditional Entropy = 1.6680476868689378
for k = 7
best F-measure = 0.3312276002985638
best Conditional Entropy = 1.56751014972801
for k = 9
best F-measure = 0.29930075632877295
best Conditional Entropy = 1.469082773694486
for k = 11
best F-measure = 0.2686814947124586
best Conditional Entropy = 1.4561090449146181
img 32 : 51084.jpg
for k = 1
best F-measure = 0.39407932465072826
best Conditional Entropy = 3.71061399860375
for k = 3
best F-measure = 0.48235472621405384
best Conditional Entropy = 3.145106758867309
for k = 5
best F-measure = 0.30914379876528203
best Conditional Entropy = 3.286784020676431
for k = 7
best F-measure = 0.32371853836243886
best Conditional Entropy = 3.037448773945684
for k = 9
best F-measure = 0.25520546102918396
best Conditional Entropy = 3.052263147886213
for k = 11
best F-measure = 0.20395413998725792
best Conditional Entropy = 3.0453682068715793
img 33 : 61084.jpg
for k = 1
best F-measure = 0.5897108232691377
best Conditional Entropy = 2.7351669739008295
for k = 3
best F-measure = 0.5491803253235763
best Conditional Entropy = 2.192437340840844
for k = 5
best F-measure = 0.33787798148546337
best Conditional Entropy = 2.3286278571231227
for k = 7
best F-measure = 0.3108041139428609
best Conditional Entropy = 2.33512280282832
for k = 9
best F-measure = 0.2459726928839112
best Conditional Entropy = 2.346145233894036
for k = 11
best F-measure = 0.20231408389033883
best Conditional Entropy = 2.2170251896665407
img 34 : 64061.jpg
for k = 1
best F-measure = 0.52397042184118
best Conditional Entropy = 2.8210936367039547
for k = 3
best F-measure = 0.5417787677026228
best Conditional Entropy = 2.1988750653577407
for k = 5
best F-measure = 0.36568616893282924
best Conditional Entropy = 2.1548463276634444
for k = 7
best F-measure = 0.34263528783173236
best Conditional Entropy = 2.0959197854948744
for k = 9
best F-measure = 0.20316132507994387
best Conditional Entropy = 2.0810489969103814
for k = 11
best F-measure = 0.25509712789098826
best Conditional Entropy = 2.0404687880679426
img 35 : 65084.jpg
for k = 1
best F-measure = 0.39599249947313486
best Conditional Entropy = 3.43714139788325
for k = 3
best F-measure = 0.4386829549661253
best Conditional Entropy = 3.0130663227329
for k = 5
best F-measure = 0.38512335246661805
best Conditional Entropy = 2.7224412428281775
for k = 7
best F-measure = 0.3303298508388286
best Conditional Entropy = 2.6542817186768213
for k = 9
best F-measure = 0.30144835428292715
best Conditional Entropy = 2.55327553356315
for k = 11
best F-measure = 0.2542135670504539
best Conditional Entropy = 2.493895601966256
best Conditional Entropy = 2.493895601966256
img 36 : 69008.jpg
for k = 1
best F-measure = 0.4888197540627611
best Conditional Entropy = 2.425023587235919
for k = 3
best F-measure = 0.6224650792144456
best Conditional Entropy = 1.7856525951080022
for k = 5
best F-measure = 0.38233375742668174
best Conditional Entropy = 1.972667605112914
for k = 7
best F-measure = 0.38920863235668496
best Conditional Entropy = 1.6629233806343684
for k = 9
best F-measure = 0.29152671852002377
best Conditional Entropy = 1.8112896968849903
for k = 11
best F-measure = 0.24232338481351992
best Conditional Entropy = 1.8198901982317754
img 37 : 69007.jpg
for k = 1
best F-measure = 0.5488102643274694
best Conditional Entropy = 2.8487648770137137
for k = 3
best F-measure = 0.5815987897207292
best Conditional Entropy = 2.0289881953137447
for k = 5
best F-measure = 0.42794476409546666
best Conditional Entropy = 1.993900252171435
for k = 7
best F-measure = 0.3501599404589732
best Conditional Entropy = 2.08720071527258
for k = 9
best F-measure = 0.29885752805162674
best Conditional Entropy = 1.971725872583912
for k = 11
best F-measure = 0.2536179506225362
best Conditional Entropy = 1.9578846797851601
img 38 : 69007.jpg
for k = 1
best F-measure = 0.8205523451345753
best Conditional Entropy = 1.0790393484677936
for k = 3
best F-measure = 0.4470956786548327
best Conditional Entropy = 1.0648920333856136
for k = 5
best F-measure = 0.309975539693388
best Conditional Entropy = 1.0611628098450654
for k = 7
best F-measure = 0.2567821864982665
best Conditional Entropy = 1.0257425788584302
for k = 9
best F-measure = 0.20733944517656938
best Conditional Entropy = 1.0113327112838433
for k = 11
best F-measure = 0.17559309408350887
best Conditional Entropy = 1.0010971174469385
img 39 : 70011.jpg
for k = 1
best F-measure = 0.8916562261066833
best Conditional Entropy = 0.922177292366375
for k = 3
best F-measure = 0.45661341499304225
best Conditional Entropy = 0.8130348115329129
for k = 5
best F-measure = 0.32078700669507151
best Conditional Entropy = 0.794762865763419
for k = 7
best F-measure = 0.30390732849856467
best Conditional Entropy = 0.7709761725505175
for k = 9
best F-measure = 0.24513415526881013
best Conditional Entropy = 0.7721704299342126
for k = 11
best F-measure = 0.20756019763189287
best Conditional Entropy = 0.7584159870888443
img 40 : 70009.jpg
for k = 1
best F-measure = 0.6900334438698764
best Conditional Entropy = 1.53143286392208482
for k = 3
best F-measure = 0.5102359248364551
best Conditional Entropy = 1.3591997549171744
for k = 5
best F-measure = 0.3535312253232148
best Conditional Entropy = 1.3405135653166902
for k = 7
best F-measure = 0.2759346494866379
best Conditional Entropy = 1.3373932033505345
for k = 9
best F-measure = 0.23587194027266747
best Conditional Entropy = 1.34894863148834
for k = 11
best F-measure = 0.19098133550158383
best Conditional Entropy = 1.3265346228417136
data_set average
for k = 1 , average F-measure = 0.5835785998212508
1 , average Conditional Entropy = 2.3720899575394383
for k = 3 , average F-measure = 0.5092568859431595
3 , average Conditional Entropy = 1.9460227663358
for k = 5 , average F-measure = 0.3558794967047348
5 , average Conditional Entropy = 1.932369423336964
for k = 7 , average F-measure = 0.3214708120573551
7 , average Conditional Entropy = 1.857457006578493
for k = 9 , average F-measure = 0.2682818368734437
9 , average Conditional Entropy = 1.84172830309930086
for k = 11 , average F-measure = 0.22465163761845375
11 , average Conditional Entropy = 1.8116689356881366
```

image 41 to 50

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img 41 : 71076.jpg
for k = 1
best F-measure = 0.6497727941017307
best Conditional Entropy = 2.744482939881631
for k = 3
best F-measure = 0.3865049345499624
best Conditional Entropy = 2.587906840091904
for k = 5
best F-measure = 0.4343907995877147
best Conditional Entropy = 2.3986156763029457
for k = 7
best F-measure = 0.3375494682832788
best Conditional Entropy = 2.291106363869728
for k = 9
best F-measure = 0.32871885943531765
best Conditional Entropy = 2.147784771046621
for k = 11
best F-measure = 0.2880377854376114
best Conditional Entropy = 2.139855463576536
img 42 : 71699.jpg
for k = 1
best F-measure = 0.4286554143696146
best Conditional Entropy = 2.936459314541252
for k = 3
best F-measure = 0.53202388630683
best Conditional Entropy = 2.318240119231335
for k = 5
best F-measure = 0.49482650488814727
best Conditional Entropy = 2.021643867022506
for k = 7
best F-measure = 0.36238413607850595
best Conditional Entropy = 2.0773449337008507
for k = 9
best F-measure = 0.3298283260056033
best Conditional Entropy = 1.9109688569856864
for k = 11
best F-measure = 0.30481661309905267
best Conditional Entropy = 1.8846430551188245
img 43 : 77862.jpg
for k = 1
best F-measure = 0.642269697875139
best Conditional Entropy = 2.095063605961007
for k = 3
best F-measure = 0.40603428583973804
best Conditional Entropy = 1.9692951788366675
for k = 5
best F-measure = 0.3174467543131416
best Conditional Entropy = 1.9046742358166298
for k = 7
best F-measure = 0.25099686566244817
best Conditional Entropy = 1.893850084935856
for k = 9
best F-measure = 0.2063995134916558
best Conditional Entropy = 1.8311376219451867
for k = 11
best F-measure = 0.1778141569181694
best Conditional Entropy = 1.843583875900542
img 44 : 78098.jpg
for k = 1
best F-measure = 0.5125490482078056
best Conditional Entropy = 3.1033802312691194
for k = 3
best F-measure = 0.420892664224945225
best Conditional Entropy = 2.8840976391545306
for k = 5
best F-measure = 0.3283877820029683
best Conditional Entropy = 2.7148550841780197
for k = 7
best F-measure = 0.2646031215595067
best Conditional Entropy = 2.814430651645104
for k = 9
best F-measure = 0.254963797729855
best Conditional Entropy = 2.7126823424815907
for k = 11
best F-measure = 0.23483535518972742
best Conditional Entropy = 2.646622869677257
img 45 : 79873.jpg
for k = 1
best F-measure = 0.442653367804761155
best Conditional Entropy = 3.075041107053773
for k = 3
best F-measure = 0.3888445897435102
best Conditional Entropy = 2.8456515014736574
for k = 5
best F-measure = 0.371140985857188
best Conditional Entropy = 2.739559791694244
for k = 7
best F-measure = 0.26961211271412067
best Conditional Entropy = 2.8031791190219595
for k = 9
best F-measure = 0.23324411887327196
best Conditional Entropy = 2.770712373018604
for k = 11
best F-measure = 0.2471137793191458
best Conditional Entropy = 2.58087298587229655

```

```

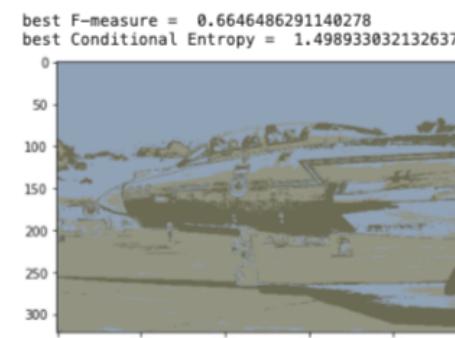
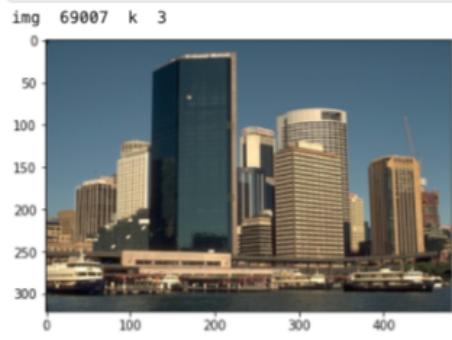
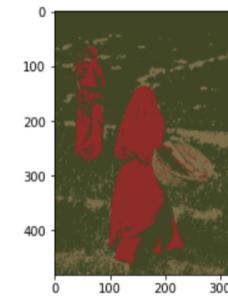
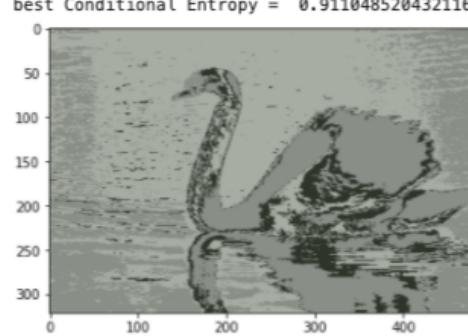
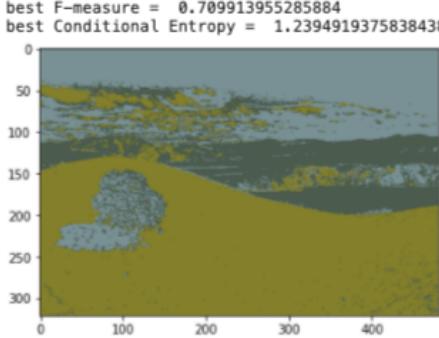
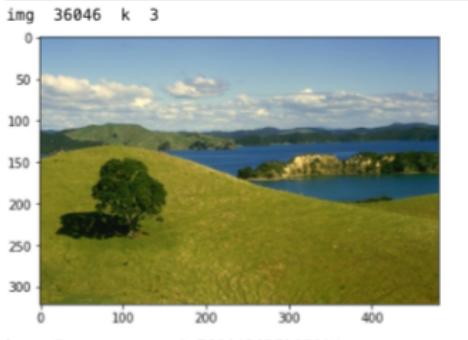
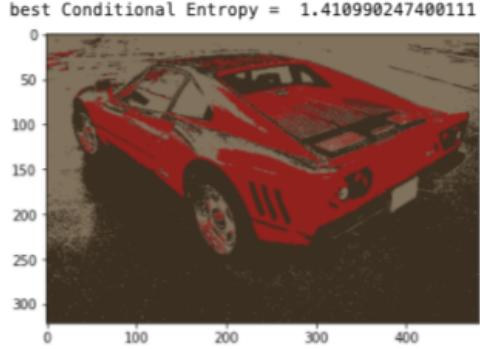
img 46 : 80085.jpg
for k = 1
best F-measure = 0.6631336888130734
best Conditional Entropy = 2.7532822044197514
for k = 3
best F-measure = 0.463984427964721
best Conditional Entropy = 2.1556479275997433
for k = 5
best F-measure = 0.47246755492445497
best Conditional Entropy = 1.801024892998855
for k = 7
best F-measure = 0.38698005115435924
best Conditional Entropy = 1.77325343729178
for k = 9
best F-measure = 0.34562766819674756
best Conditional Entropy = 1.6803792219846897
for k = 11
best F-measure = 0.3161537841998199
best Conditional Entropy = 1.613121397263264
img 47 : 80090.jpg
for k = 1
best F-measure = 0.7466895442010891
best Conditional Entropy = 1.9350974158923802
for k = 3
best F-measure = 0.5927351169591858
best Conditional Entropy = 1.3699704015185794
for k = 5
best F-measure = 0.4947241086294149
best Conditional Entropy = 1.1621442664568748
for k = 7
best F-measure = 0.41025013539248883
best Conditional Entropy = 1.1348367398567756
for k = 9
best F-measure = 0.3746206827472265
best Conditional Entropy = 1.074458589440489
for k = 11
best F-measure = 0.2930095832192937
best Conditional Entropy = 1.1057717971952907
img 48 : 81066.jpg
for k = 1
best F-measure = 0.65508535463637964
best Conditional Entropy = 2.2426556738491845
for k = 3
best F-measure = 0.5653025822130042
best Conditional Entropy = 1.7612915094573842
for k = 5
best F-measure = 0.518618942468456
best Conditional Entropy = 1.3333511308438737
for k = 7
best F-measure = 0.36765828210249313
best Conditional Entropy = 1.3765797639307764
for k = 9
best F-measure = 0.3440857363136424
best Conditional Entropy = 1.289197610839997
for k = 11
best F-measure = 0.2993953241144443
best Conditional Entropy = 1.3132998303899832
img 49 : 81098.jpg
for k = 1
best F-measure = 0.402543104465533
best Conditional Entropy = 3.2222388934651343
for k = 3
best F-measure = 0.4848781122176257
best Conditional Entropy = 2.565541373446578
for k = 5
best F-measure = 0.396032493958071
best Conditional Entropy = 2.661798865504725
for k = 7
best F-measure = 0.3439550684321276
best Conditional Entropy = 2.565428938449418
for k = 9
best F-measure = 0.2785603511211011
best Conditional Entropy = 2.4958629988606175
for k = 11
best F-measure = 0.29297883538391234
best Conditional Entropy = 2.3995632839333725
img 50 : 81095.jpg
for k = 1
best F-measure = 0.5475373118095639
best Conditional Entropy = 2.558227581910537
for k = 3
best F-measure = 0.586317196054236
best Conditional Entropy = 1.7950398246056587
for k = 5
best F-measure = 0.45896901635448695
best Conditional Entropy = 1.8292897940818151
for k = 7
best F-measure = 0.35152786038491357
best Conditional Entropy = 1.776163476518636
for k = 9
best F-measure = 0.3006203248687695
best Conditional Entropy = 1.7494633981204342
for k = 11
best F-measure = 0.2497182992485466
best Conditional Entropy = 1.686545514412467

```

dataset average:

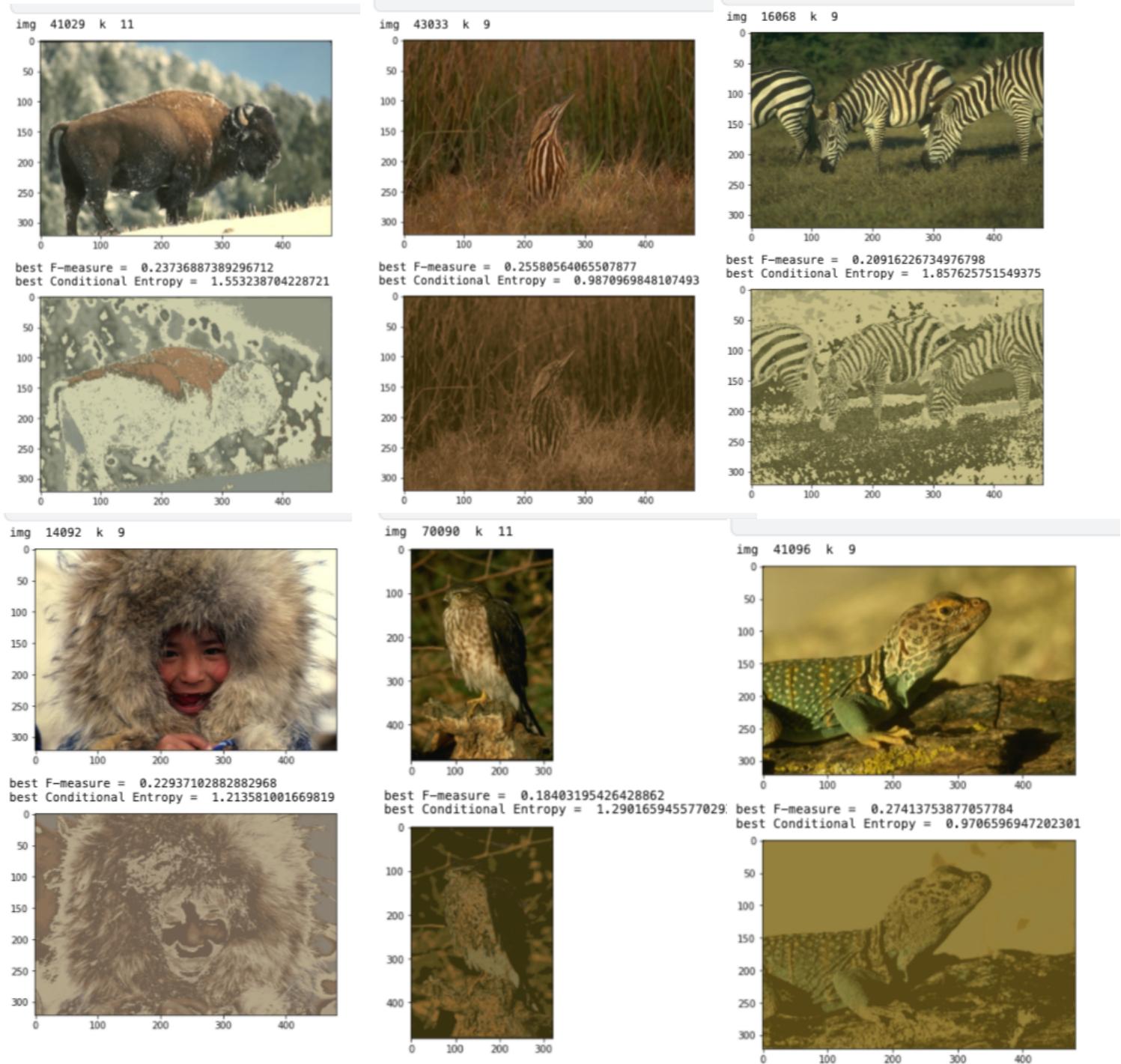
```
for k = 3 , average F-measure = 0.4850071456074095
      3 , average Conditional Entropy = 2.0194513005755392
for k = 5 , average F-measure = 0.38855973474569117
      5 , average Conditional Entropy = 1.932862751101096
for k = 7 , average F-measure = 0.32573966496507206
      7 , average Conditional Entropy = 1.8703096659761687
for k = 9 , average F-measure = 0.2773801230402625
      9 , average Conditional Entropy = 1.8466744452223136
for k = 11 , average F-measure = 0.24684948186118644
      11 , average Conditional Entropy = 1.7898532141496784
```

good cases:



good cases are images of objects with color different than their background's colors or objects of only one color which is better with smaller k.

bad cases



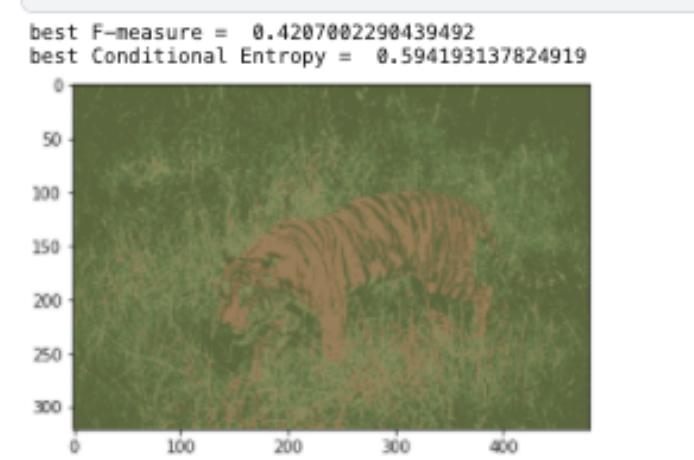
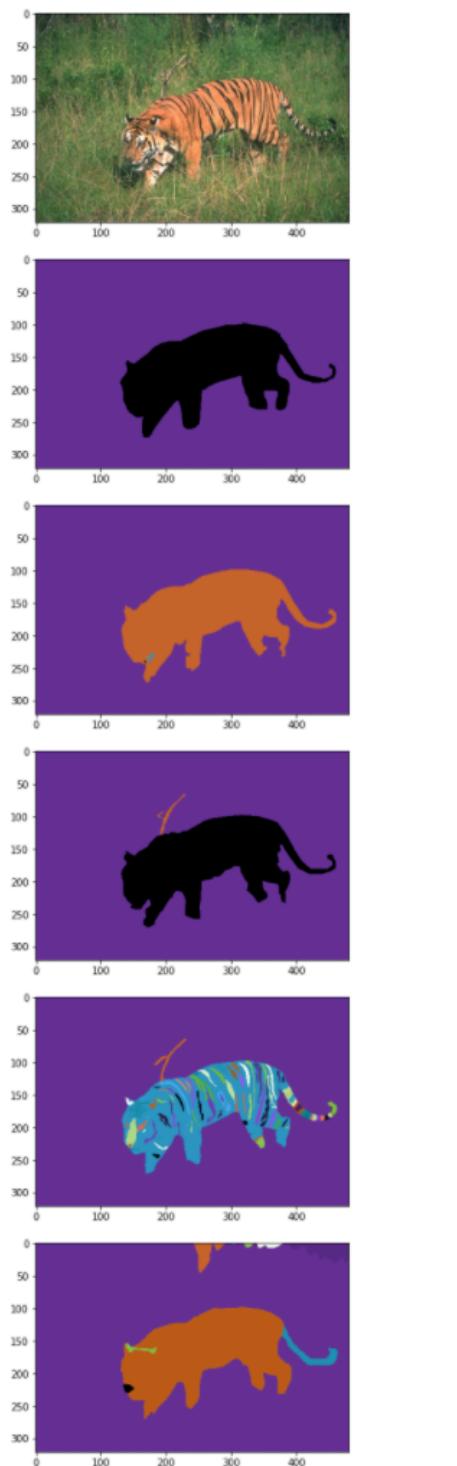
bad cases are images with objects of colors similar to background's colors or objects of that consist of distinct different colors like zebras which is worse with large k.

Big Picture:

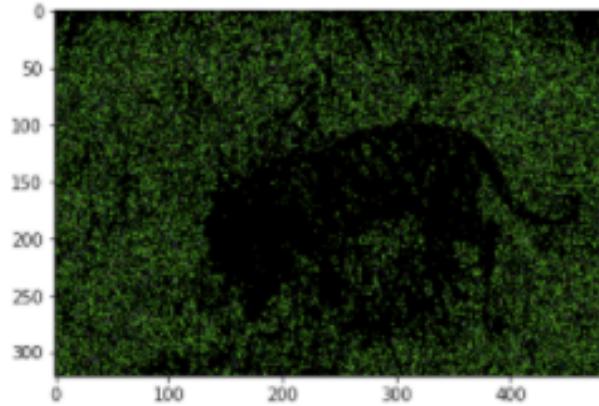
img 1:

ground truth

k means



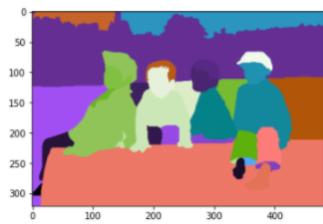
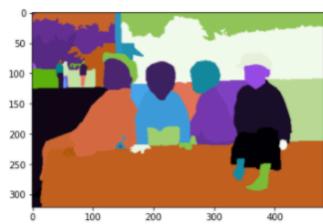
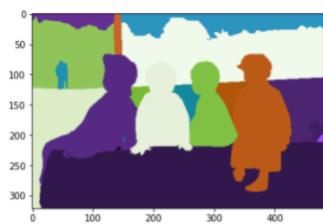
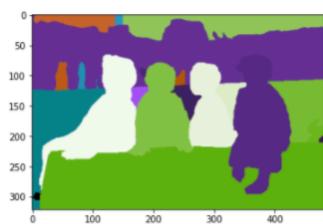
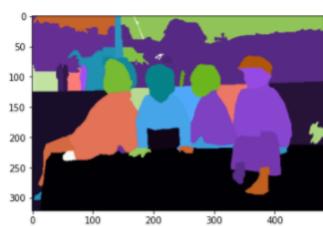
normalized cut



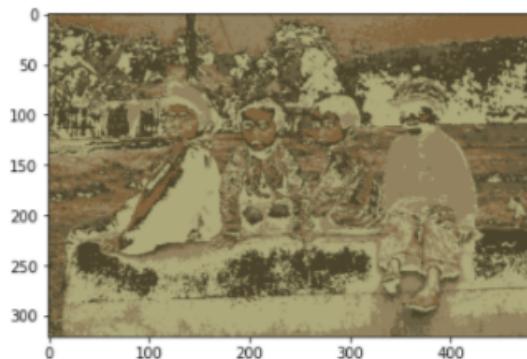
img 2:

ground truth

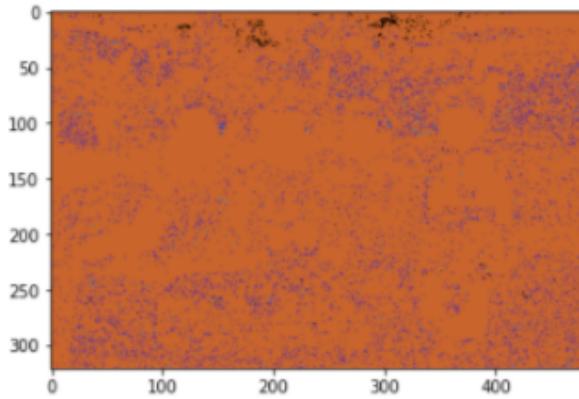
k means



best F-measure = 0.4508152658393706
best Conditional Entropy = 3.0351029532173084

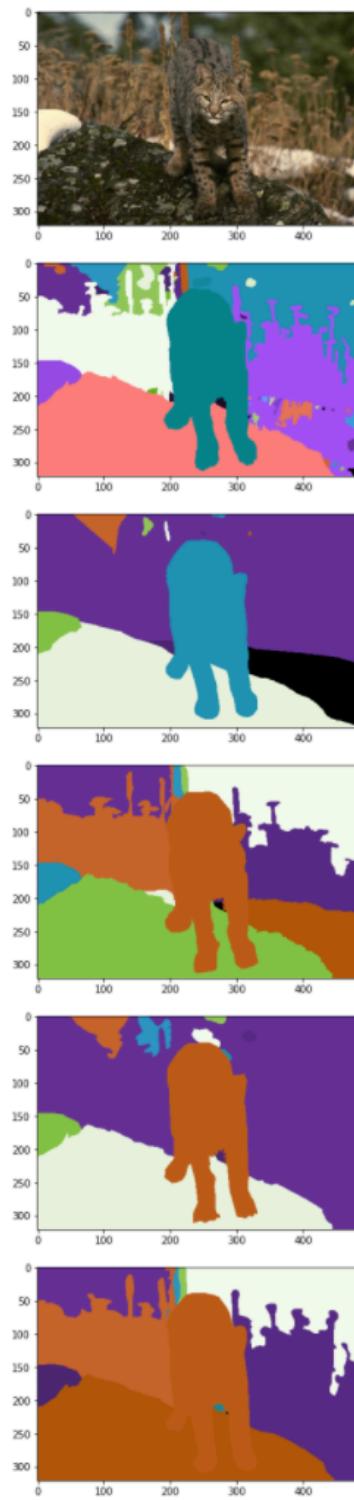


normalized cut



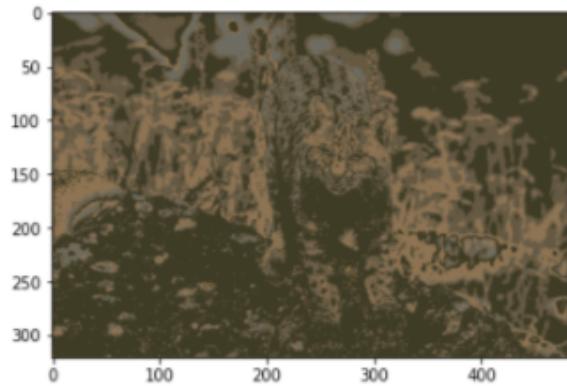
img 3:

ground truth

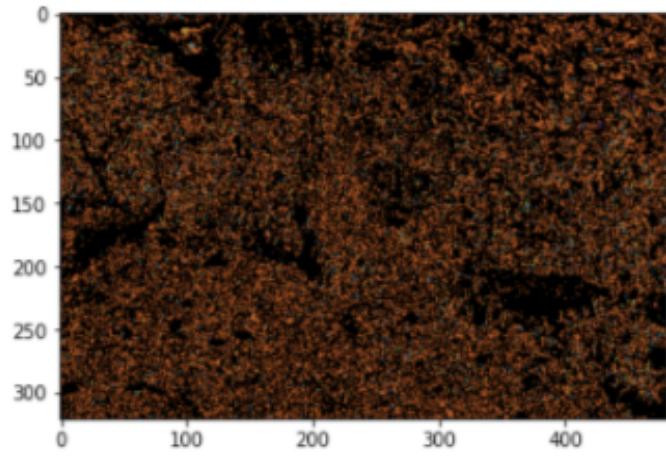


k means

best F-measure = 0.2974444046319518
best Conditional Entropy = 2.2037929206121847

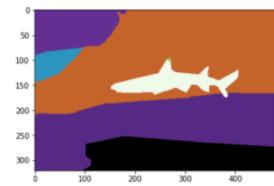
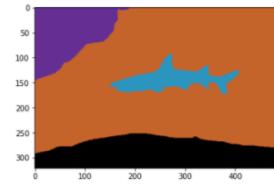
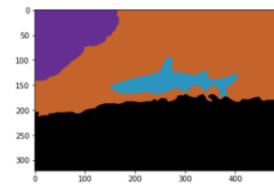
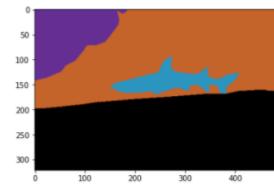


normalized cut



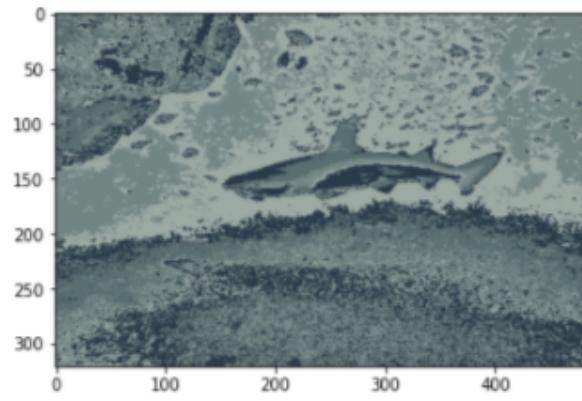
img 4:

ground truth

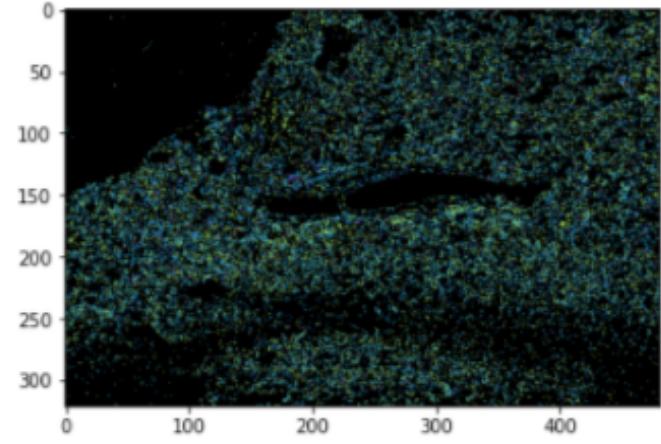


k means

best F-measure = 0.36124947594539336
best Conditional Entropy = 1.3058567747142198



normalized cut



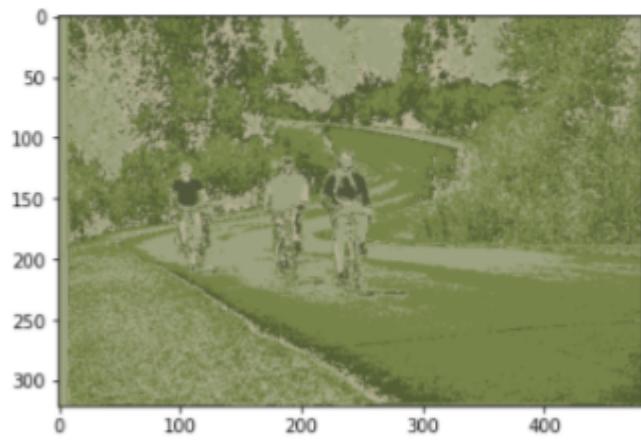
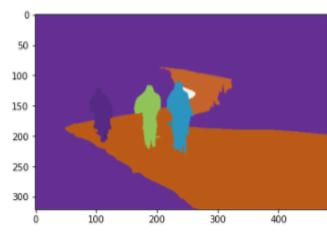
img 5:

ground truth

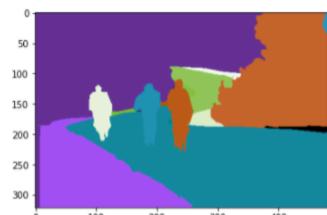
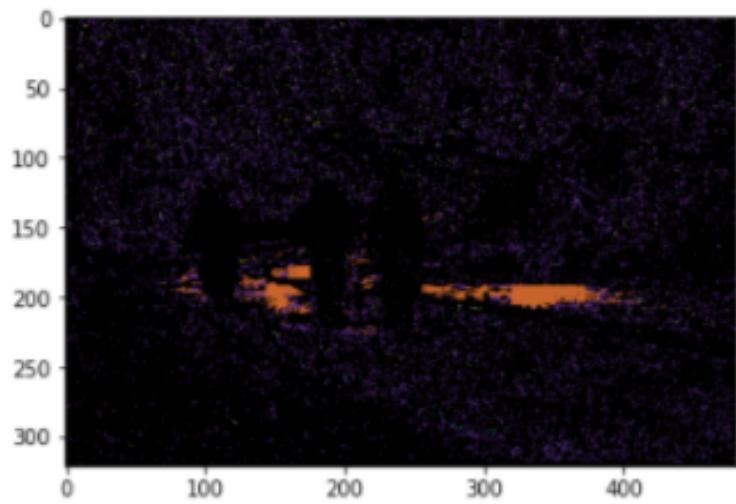
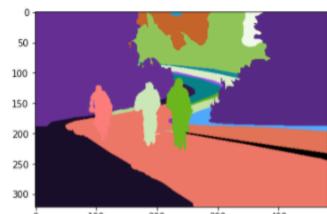
k means



best F-measure = 0.3940808975651745
best Conditional Entropy = 1.9934006776914717



normalized cut



K means vs ground truth:

results vary depending on the original image if the original image have distinct colors for background and the objects in it the k means give very good results while if background have similar color to objects in the image or if the image it is self have distinct colors k means give bad results

Normalized-cut vs ground truth:

results of normalized-cut is very different than ground truth it's results is much worse than k means, normalized-cut is not suited for finding ground truth clusters in images.

K means vs Normalized-cut:

results of k means is much better than normalized-cut as k means better cluster all pixels after passing through all of them , while normalized-cut only look for nearest 5 pixels which for a image with over of 150000 pixels is not the best solution or way to cluster pixels.

Extra:

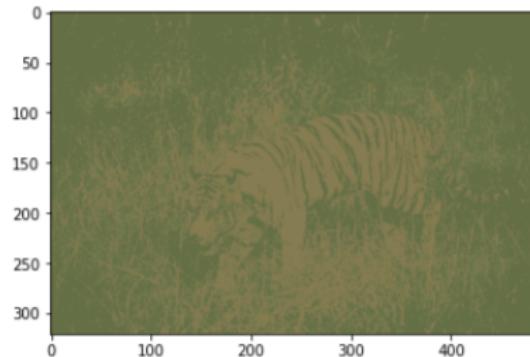
```
img_with_spatial = np.empty((img.shape[0],img.shape[1],5))
for i in range(img.shape[0]):
    for j in range(img.shape[1]):
        img_with_spatial[i,j,:]=[img[i,j,0],img[i,j,1],img[i,j,2],i,j]
img_with_spatial= img_with_spatial.astype('int16')
```

```
def k_means_spatial(image,k,it_max):
    C = []
    for i in range(k):
        C.append(np.array([random.randint(0, 255),random.randint(0, 255),random.randint(0, 255),
                           random.randint(0, image.shape[0]),random.randint(0, image.shape[1])]))
    for x in range(it_max):
        print("iteration, ",x)
        clusters = []
        for i in range(k):
            clusters.append([])

        for i in range(image.shape[0]):
            for j in range(image.shape[1]):
                minDis = float('inf')
                minC = -1
                for c in range(k):
                    diff = (image[i,j,:].astype('int16')-C[c].astype('int16'))
                    dis = np.dot(diff,diff)
                    if dis<minDis:
                        minDis = dis
                        minC = c
                clusters[minC].append(image[i,j,:])
        for c in range(k):
            newC = np.array([0,0,0,0,0])
            for i in range(len(clusters[c])):
                newC+=clusters[c][i]
            for i in range(5):
                newC[i]/=len(clusters[c])
            same = 1;
            for c1 in range(5):
                if C[c][c1]!= newC[c1]:
                    same=0
            C[c] = newC
        if same:
            return C
    return C
```

img 1:

```
best F-measure =  0.28627489074649154  
best Conditional Entropy =  0.6730994359035227
```



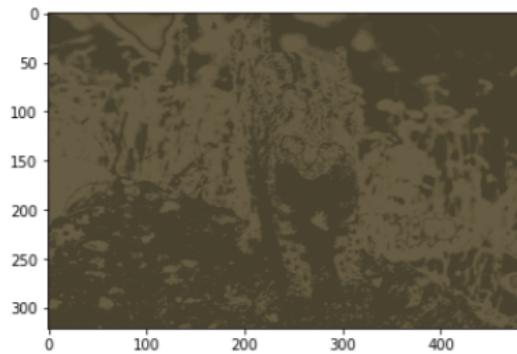
img 2:

```
best F-measure =  0.45049969909228615  
best Conditional Entropy =  3.0018347184755325
```



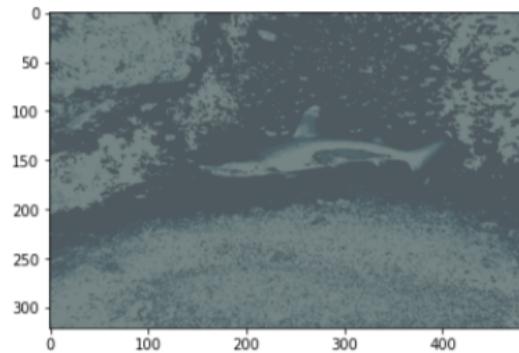
img 3:

```
best F-measure =  0.29909913183639725  
best Conditional Entropy =  2.171960616038142
```



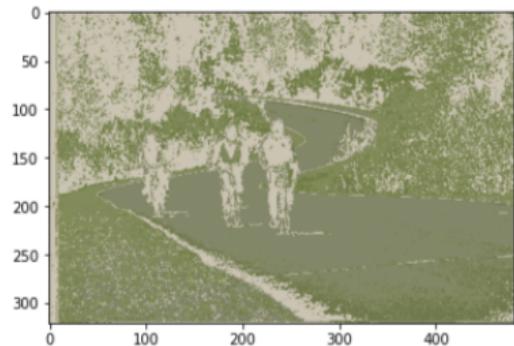
img 4:

```
best F-measure = 0.40319521228863664
best Conditional Entropy = 1.084614065301541
```



img 5:

```
best F-measure = 0.4246344438503787
best Conditional Entropy = 1.8828102907187407
```



results with spatial layout are a bit better than results without spatial layout.