

Image Segmentation

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Dataset:

Data sets are images, we have 500 image. There are 200 images test set, each image has .mat file with contains its ground truths.

- Images are in jpg format, and are read as RGB image. They will be represented by a multidimensional array of dimensions : height x width x 3(for each color channel). When clustering or comparing they will be flattened to two dimension (height * width) x 3.
- Ground truths are stored in a mat file which is a matlab format, they are read as a dictionary and when accessing the data in the dictionary, we will find multiple matrices of dimensions height x width. Each matrix represents a possible ground truth, and indicates what the expected clustering output should be. Those will be used in the external measures.

Reading and showing Images:

```
## Read images, check all jpg images in path and read them.
## Return a list of images each with a matrix of height * width * 3(channels for colors).
def read_images(path):
    onlyfiles = [f[:-4] for f in.listdir(path) if isfile(join(path, f)) and f.endswith('jpg')];
    onlyfiles.sort(key=int);
    data = [];
    for file in onlyfiles:
        file = file + '.jpg';
        total_path = join(path,file);
        img = mpimg.imread(total_path);
        data.append(img);
    return onlyfiles, data;
def read_cluster_images(path):
    onlyfiles = [f[:-4] for f in.listdir(path) if isfile(join(path, f)) and f.endswith('png')];
    onlyfiles.sort(key=int);
    data = [];
    for file in onlyfiles:
        file = file + '.png';
        total_path = join(path,file);
        img = imageio.imread(total_path);
        data.append(img);
    return data;
```

```

def write_cluster_images(directory, imgs, names, k_param):
    i = 0;
    for k in k_param:
        sub_dir = join(directory, str(k));
        if not os.path.exists(sub_dir):
            os.makedirs(sub_dir);
    j = 0;
    for img in imgs[i]:
        with warnings.catch_warnings():
            warnings.simplefilter("ignore")
            rimg = img_as_uint(img);
            imageio.imwrite(join(sub_dir, names[j] + '.png'), rimg);
        j += 1;
    i += 1;
## Read ground truth from mat files.
## Only care about segmented images, throw away boundary images.
## Return a list of a list of ground truth images.
def read_ground_truth(path):
    onlyfiles = [f[-4] for f in listdir(path) if isfile(join(path, f)) and f.endswith('mat')];
    onlyfiles.sort(key=int);
    data = [];
    for file in onlyfiles:
        file = file + '.mat';
        total_path = join(path,file);
        img = loadmat(total_path);
        process_img = [];
        for k in np.squeeze(img['groundTruth']).reshape(-1):
            process_img.append(k[0][0][0]);
            ## If we want boundary images with us.
            #for c in k[0][0]:
            #    process_img.append(c);
        data.append(process_img);
    return data;

## Show image with its ground truths.
def show_img(real_data, gt_data, names, index):
    kn = 1 + len(gt_data[index]);
    n = int(math.sqrt(kn));
    mn = n;
    if (mn * n < kn):
        mn = mn + 1;
    if (mn * n < kn):
        n = n + 1;
    fig, ax = plt.subplots(n, mn, figsize=(20,20));
    fig.suptitle('Image ' + names[index], fontsize=20)
    ax[0][0].imshow(real_data[index]);
    for i in range(len(gt_data[index])):
        rem = (i + 1) % mn;
        k = int((i + 1) / mn);
        ax[k, rem].imshow(gt_data[index][i]);
    plt.show();
def show_single_img(img):
    plt.imshow(img);
    plt.show();
def show_cluster_img(real_data, kimgs, names, index, k_params):
    kn = 1 + len(kimgs);
    n = int(math.sqrt(kn));
    mn = n;
    if (mn * n < kn):
        mn = mn + 1;
    if (mn * n < kn):
        n = n + 1;
    fig, ax = plt.subplots(n, mn, figsize=(20,20));
    fig.suptitle('Image ' + names[index], fontsize=20)
    ax[0][0].imshow(real_data[index]);
    for i in range(len(kimgs)):
        rem = (i + 1) % mn;
        k = int((i + 1) / mn);
        ax[k, rem].set_title('K = ' + str(k_params[i]));
        ax[k, rem].imshow(kimgs[i][index]);
    plt.show();

```

Resize Image:

```

def resize_real_img(real_data, reduce_to, apply_gauss = False, sigma = 2):
    resize_data = []
    for img in real_data:
        gres_img = img.copy()
        res_img = np.zeros( (int(img.shape[0] * reduce_to), int(img.shape[1] * reduce_to), 3));
        if (apply_gauss):
            gres_img[:, :, 0] = gaussian_filter(img[:, :, 0], sigma=sigma);
            gres_img[:, :, 1] = gaussian_filter(img[:, :, 1], sigma=sigma);
            gres_img[:, :, 2] = gaussian_filter(img[:, :, 2], sigma=sigma);
        res_img[:, :, 0] = resize(gres_img[:, :, 0], (int(img.shape[0] * reduce_to), int(img.shape[1] * reduce_to)), mode='constant')
        res_img[:, :, 1] = resize(gres_img[:, :, 1], (int(img.shape[0] * reduce_to), int(img.shape[1] * reduce_to)), mode='constant')
        res_img[:, :, 2] = resize(gres_img[:, :, 2], (int(img.shape[0] * reduce_to), int(img.shape[1] * reduce_to)), mode='constant')
        resize_data.append(res_img);
    return resize_data;
def resize_gt_img(ground_truth, reduce_to, apply_gauss = False, sigma = 2):
    resize_data = []
    for gt in ground_truth:
        res_data_min = [];
        for img in gt:
            gimg = img;
            if (apply_gauss):
                gimg = gaussian_filter(img, sigma=sigma)
            res_img = resize(gimg, (int(img.shape[0] * reduce_to), int(img.shape[1] * reduce_to)), mode='constant');
            res_data_min.append(res_img);
        resize_data.append(res_data_min);
    return resize_data;

```

Get measures:

Calculates F-measure and conditional entropy for image I with M available ground-truth segmentations. For a clustering of K-clusters

```

import math
import numpy as np
from sklearn.metrics.cluster import contingency_matrix
def get_measures(gt_img, kimg):
    cont_mat = contingency_matrix(gt_img, kimg);
    f_measure = 0;
    cond_entropy = 0;
    for i in range(len(cont_mat[0])):
        n_i = np.sum(cont_mat[:,i]);
        n = len(gt_img);
        # f_measure_i
        temp_index = np.argmax(cont_mat[:,i]);
        prec = cont_mat[temp_index][i] / np.sum(cont_mat[:,i]);
        rec = cont_mat[temp_index][i] / np.sum(cont_mat[temp_index,:]);
        f_measure_i = (2 * prec * rec) / (prec + rec);
        f_measure += f_measure_i;
        # conditional entropy
        entropy = 0;
        for j in range(len(cont_mat)):
            percent_j = cont_mat[j][i] / np.sum(cont_mat[:,i]);
            if (percent_j != 0.0):
                entropy -= percent_j * math.log10(percent_j);
        entropy *= n_i / n;
        cond_entropy += entropy;
    f_measure /= len(cont_mat[0]);
    return f_measure, cond_entropy;

```

```

def get_scores(gts, cds, k_param):
    tf = [];
    tc = [];
    taf = [];
    tac = [];
    for k in range(len(k_param)):
        i = 0;
        f_meas = [];
        cond_entr = [];
        average_f = [];
        average_c_ent = [];
        for img in cds[k]:
            min_f = [];
            min_cent = [];
            for gt in gts[i]:
                fimg = img.reshape(-1);
                fgt = gt.reshape(-1);
                f, c = get_measures(fgt, fimg);
                min_f.append(f);
                min_cent.append(c);
            f_meas.append(min_f);
            cond_entr.append(min_cent);
            average_f.append(np.mean(min_f));
            average_c_ent.append(np.mean(min_cent));
            i += 1;
        tf.append(f_meas);
        tc.append(cond_entr);
        taf.append(average_f);
        tac.append(average_c_ent);
    return tf, tc, taf, tac;

```

Printing Statistics:

```

print('Calculating kmeans scores...');
k_f, k_c, k_af, k_ac = get_scores(real_gt, k_results, k_param);
print('Done');
print('Calculating RBF-1 scores...');
rbf1_f, rbf1_c, rbf1_af, rbf1_ac = get_scores(mod_gt, s_results[0], k_param);
print('Done');
print('Calculating RBF-10 scores...');
rbf10_f, rbf10_c, rbf10_af, rbf10_ac = get_scores(mod_gt, s_results[1], k_param);
print('Done');
print('Calculating NN-5 scores...');
nn5_f, nn5_c, nn5_af, nn5_ac = get_scores(mod_gt, s_results[2], k_param);
print('Done');

Calculating kmeans scores...
Done
Calculating RBF-1 scores...
Done
Calculating RBF-10 scores...
Done
Calculating NN-5 scores...
Done

```

```

def print_stats(method_name, af, ac, k_param):
    print(method_name + " : ");
    for i in range(len(af)):
        plt.figure(figsize=(20,10));
        plt.title(method_name + ' with k = ' + str(k_param[i]));
        plt.plot(af[i], label = 'Average F-measure');
        plt.plot(ac[i], label = 'Average Conditional Entropy');
        plt.legend();
        plt.show();
    print('With k = ', k_param[i]);
    print('Average F-measure over dataset : ', np.mean(af[i]));
    print('Average Conditional entropy over dataset : ', np.mean(ac[i]));

```

```

def show_all_stats_img(real_data, real_gt, real_cluster, names, index, method, k_param,
                      f, c, af, ac):
    print('Image ' + names[index]);
    show_img(real_data, real_gt, names, index);
    print(method, ' cluster results : ');
    show_cluster_img(real_data, real_cluster, names, index, k_param);
    for i in range(len(k_param)):
        print('Average F-measure for k = ', k_param[i], ': ', af[i][index]);
        print('Average Conditional Entropy for k = ', k_param[i], ': ', ac[i][index]);
        for j in range(len(real_gt[index])):
            print('Ground truth ', j, ':');
            print('\tF-measure for k = ', k_param[i], " is ", f[i][index][j]);
            print('\tConditional entropy for k = ', k_param[i], " is ", c[i][index][j]);
    print('-----');

def show_single_stats(real_data, real_gt, real_k, names, index, method,
                      kf, kc, kaf, kac, k_param = [3,5,7,9,11], k = 1):
    print('Image ' + names[index]);
    show_img(real_data, real_gt, names, index);
    print(method, ' cluster results : ');
    show_single_img(real_k[k][index]);
    print('Average F-measure for k = ', k_param[k], ' : ', kaf[k][index]);
    print('Average Conditional Entropy for k = ', k_param[k], ' : ', kac[k][index]);
    for j in range(len(real_gt[index])):
        print('Ground truth ', j, ':');
        print('\tF-measure for k = ', k_param[k], " is ", kf[k][index][j]);
        print('\tConditional entropy for k = ', k_param[k], " is ", kc[k][index][j]);
    print('-----');

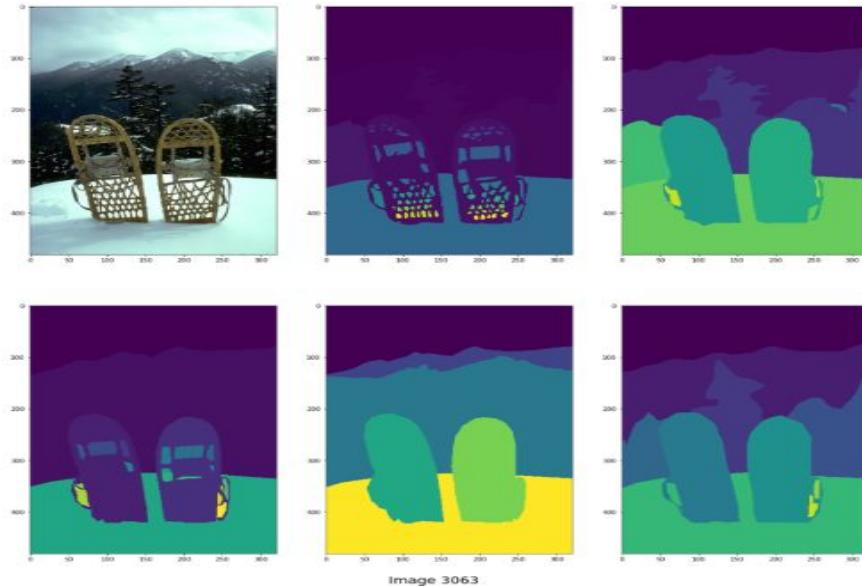
def show_compare_stats(real_data, real_gt, mod_data, mod_gt, real_k, real_n, names, index,
                      kf, kc, kaf, kac, nf, naf, nac, k_param = [3,5,7,9,11], k = 1):
    print('Image ' + names[index]);
    show_img(real_data, real_gt, names, index);
    show_img(mod_data, mod_gt, names, index);
    print('Kmeans cluster results : ');
    show_single_img(real_k[k][index]);
    print('NNS cluster results : ');
    show_single_img(real_n[k][index]);
    print('Average F-measure for k = ', k_param[k], '(kmeans): ', kaf[k][index]);
    print('Average F-measure for k = ', k_param[k], '(spectral): ', naf[k][index]);
    print('Average Conditional Entropy for k = ', k_param[k], '(kmeans): ', kac[k][index]);
    print('Average Conditional Entropy for k = ', k_param[k], '(spectral): ', nac[k][index]);
    for j in range(len(real_gt[index])):
        print('Ground truth ', j, ':');
        print('\tF-measure for k = ', k_param[k], " (kmeans) is ", kf[k][index][j]);
        print('\tF-measure for k = ', k_param[k], " (spectral) is ", nf[k][index][j]);
        print('\tConditional entropy for k = ', k_param[k], " (kmeans) is ", kc[k][index][j]);
        print('\tConditional entropy for k = ', k_param[k], " (spectral) is ", nc[k][index][j]);
    print('-----');

```

Showing an image with ground truths example:

Reading real data and its ground truths and call functions that is like utils that can be used anytime to show image and read data.

```
names, real_data = read_images('data/images/test');
real_gt = read_ground_truth('data/groundTruth/test');
show_img(real_data, real_gt, names, 0);
show_img(real_data, real_gt, names, 1);
```



Segmentation using K-means:

As shown in code below we store our results from Kmeans in order to compute it just one time, because it takes too much time.

We change do_kmeans_run boolean to choose reading from stored results or computing.

```

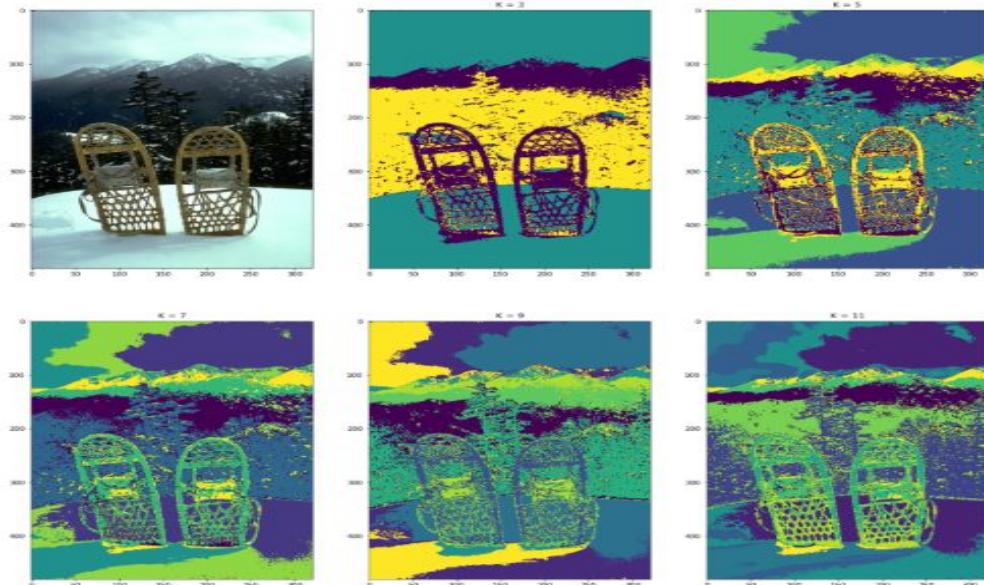
## K-Means with different k
do_kmeans_run = False;
if do_kmeans_run:
    k_param = [3,5,7,9,11];
    k_results = [];
    for k in k_param:
        min_k = [];
        i = 0;
        print('Starting with k : ', k);
        for img in real_data:
            img_u = img.reshape(-1, 3);
            kmeans = KMeans(n_clusters=k, random_state=0).fit(img_u);
            min_k.append(kmeans.labels_.reshape(img.shape[:-1]));
            i = i + 1;
            if (i % 20 == 0):
                print('Finished : ', i / 2, '%')
        k_results.append(min_k);
else:
    print('Generation bypassed, will be read from stored results...');

Generation bypassed, will be read from stored results...

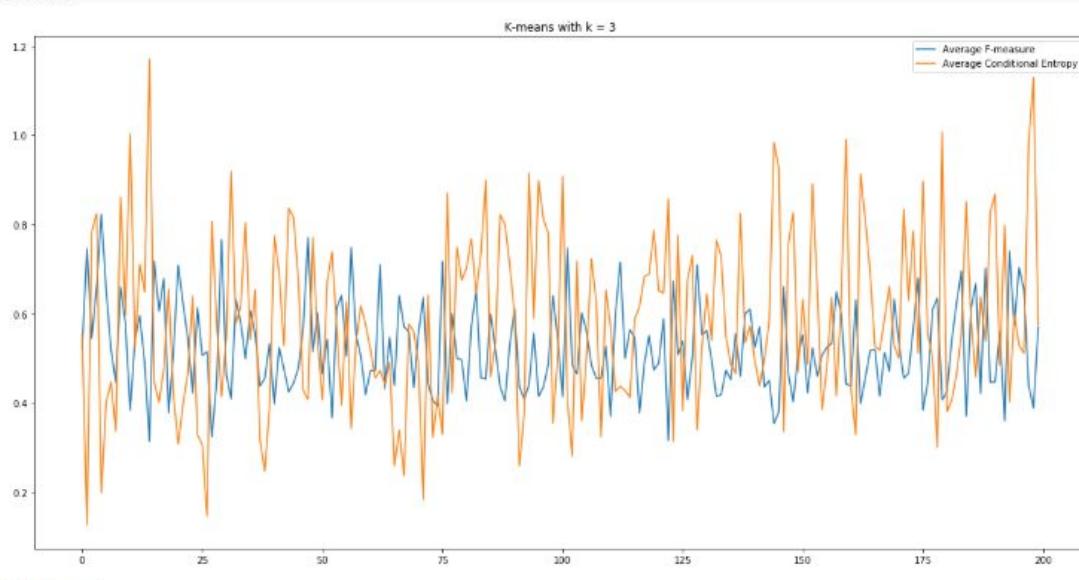
if do_kmeans_run:
    directory = 'results/kmeans'
    k_param = [3,5,7,9,11];
    write_cluster_images(directory, k_results, names, k_param);
    print('All results saved...');
else:
    print('No results to save, skip to reading');

```

Showing image example after k-means:



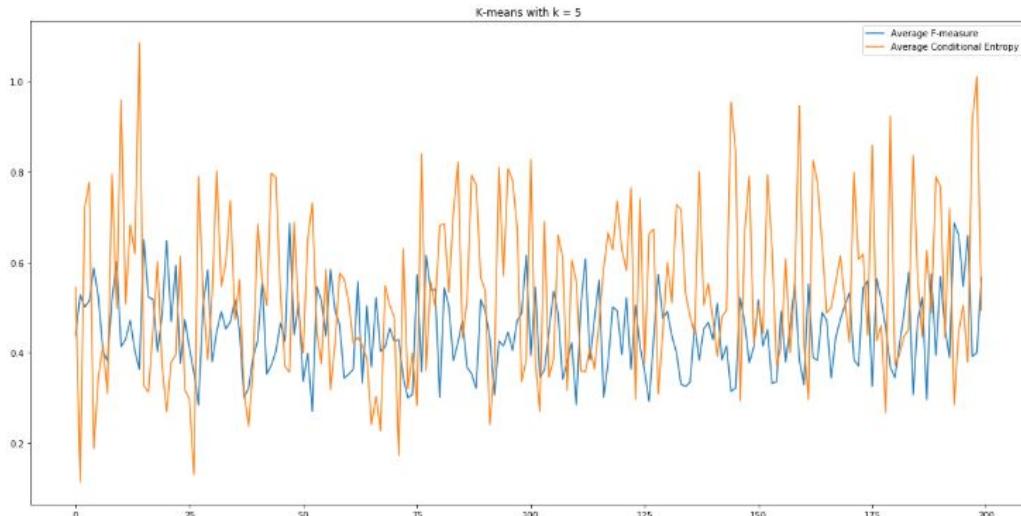
Evaluating Results of K-means:



With k = 3
 Average F-measure over dataset : 0.5238836219172895
 Average Conditional entropy over dataset : 0.5846179479157467

Average F-measure for k = 3 : 0.522287613622364

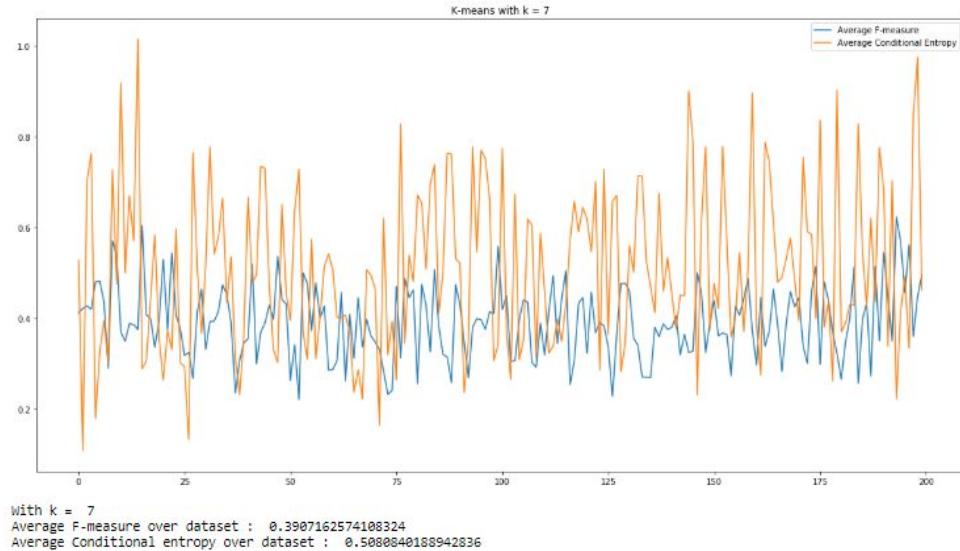
Average Conditional Entropy for k = 3 : 0.5540726862862236



With k = 5
 Average F-measure over dataset : 0.4459619913805923
 Average Conditional entropy over dataset : 0.5352544856747694

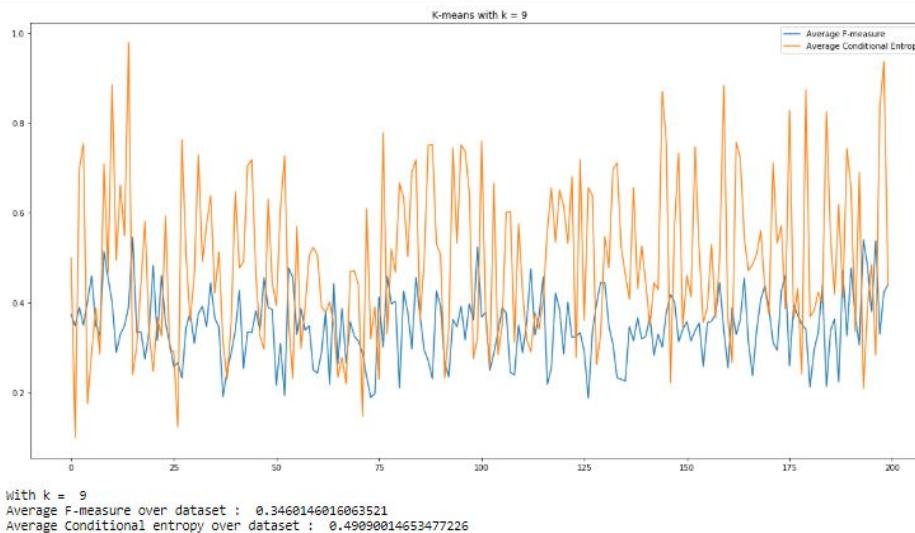
Average F-measure for k = 5 : 0.7458562346083769

Average Conditional Entropy for k = 5 : 0.1258200543953803



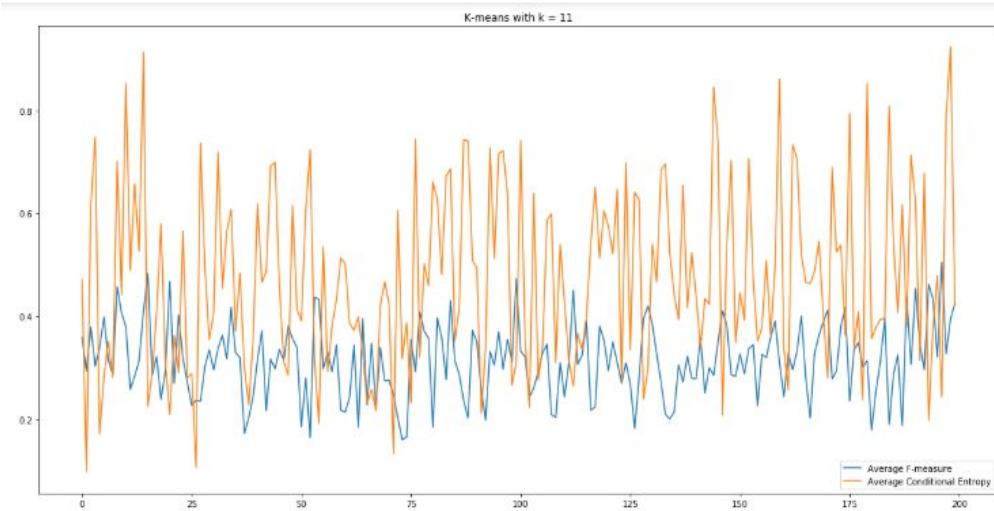
Average F-measure for k = 7 : 0.5438022605101056

Average Conditional Entropy for k = 7 : 0.7832011414072854



Average F-measure for k = 9 : 0.6595701821027584

Average Conditional Entropy for k = 9 : 0.8244446449070855



With k = 11
 Average F-measure over dataset : 0.31417965944297177
 Average Conditional entropy over dataset : 0.474304837715364

Average F-measure for k = 11 : 0.8222196690545228

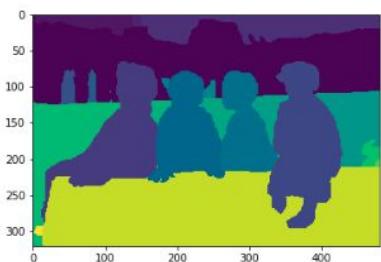
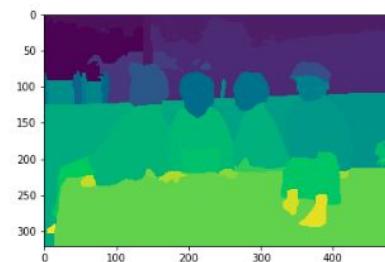
Average Conditional Entropy for k = 11 : 0.1983325712215717

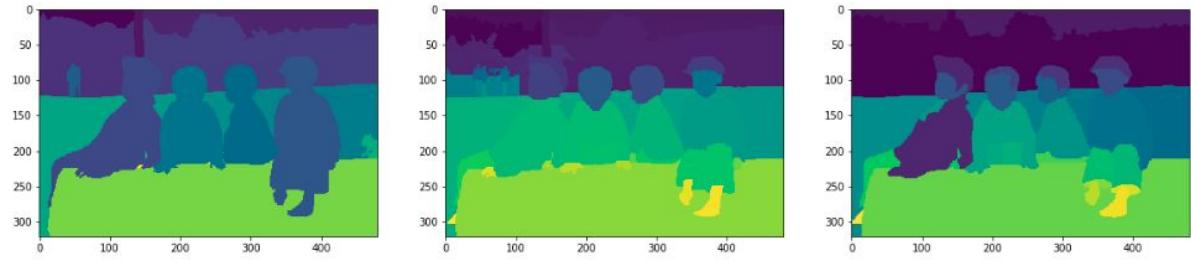
Example of a full detailed image output:

As we can see as we increase number of clusters (k) more info appears and shapes of childrens

Image 15011

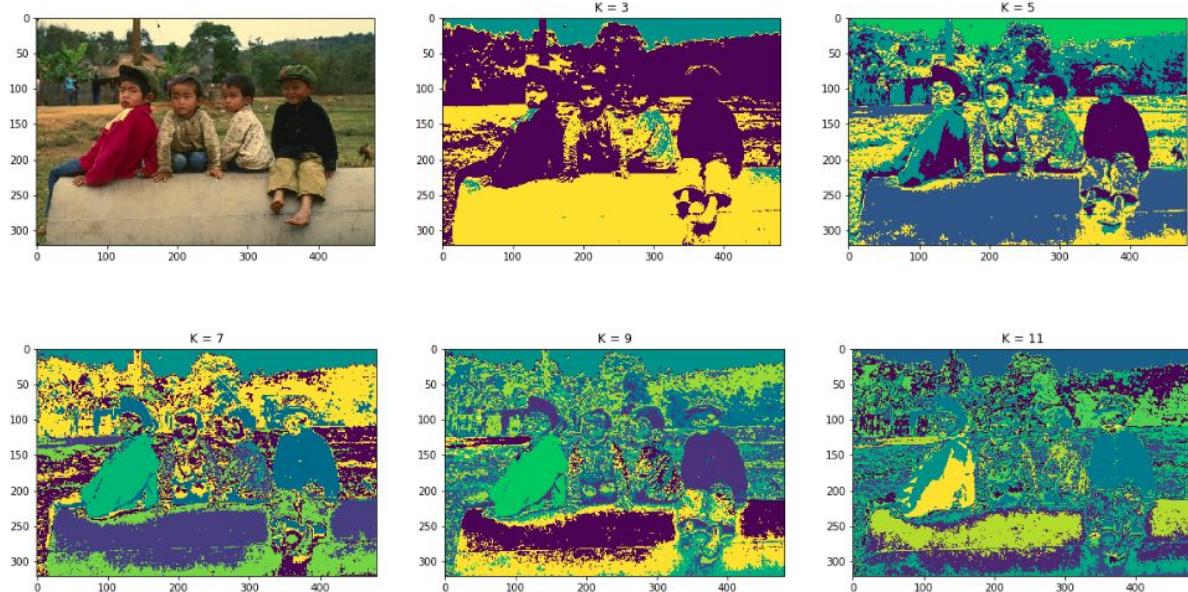
Image 15011





K-means cluster results :

Image 15011



Average F-measure for k = 3 : 0.6591956795696032

Average Conditional Entropy for k = 3 : 0.8613728668969298

Ground truth 0 :

F-measure for k = 3 is 0.6413659546176559

Conditional entropy for k = 3 is 0.9693654351875991

Ground truth 1 :

F-measure for k = 3 is 0.6809309669451018

Conditional entropy for k = 3 is 0.7398959387162769

Ground truth 2 :

F-measure for k = 3 is 0.6337085916830109

Conditional entropy for k = 3 is 0.7933575250611524

Ground truth 3 :

F-measure for k = 3 is 0.64426097492144

Conditional entropy for k = 3 is 0.9742179878226016

Ground truth 4 :

F-measure for k = 3 is 0.6957119096808072

Conditional entropy for k = 3 is 0.8300274476970186

Average F-measure for k = 5 : 0.518050729822219

Average Conditional Entropy for k = 5 : 0.7949524362053169

Ground truth 0 :

F-measure for k = 5 is 0.5155248295725579

Conditional entropy for k = 5 is 0.8975543293849789

Ground truth 1 :

F-measure for k = 5 is 0.5171291131034493

Conditional entropy for k = 5 is 0.6817979035821997

Ground truth 2 :

F-measure for k = 5 is 0.5150900632611644

Conditional entropy for k = 5 is 0.7338174701435392

Ground truth 3 :

F-measure for k = 5 is 0.5150417961583871

Conditional entropy for k = 5 is 0.9021659573767623

Ground truth 4 :

F-measure for k = 5 is 0.527467847015536

Conditional entropy for k = 5 is 0.7594265205391046

Average F-measure for k = 7 : 0.5705852513412285

Average Conditional Entropy for k = 7 : 0.7274954444289351

Ground truth 0 :

F-measure for k = 7 is 0.5842636625457047

Conditional entropy for k = 7 is 0.8224417102410386

Ground truth 1 :

F-measure for k = 7 is 0.5545398016831983

Conditional entropy for k = 7 is 0.6226569116788756

Ground truth 2 :

F-measure for k = 7 is 0.5497727768259081

Conditional entropy for k = 7 is 0.6746800332057732

Ground truth 3 :

F-measure for k = 7 is 0.5861070033418205

Conditional entropy for k = 7 is 0.8254754466608742

Ground truth 4 :

F-measure for k = 7 is 0.5782430123095111

Conditional entropy for k = 7 is 0.6922231203581138

Average F-measure for k = 9 : 0.5137626484095309

Average Conditional Entropy for k = 9 : 0.7084957036274766

Ground truth 0 :

F-measure for k = 9 is 0.523823671761576

Conditional entropy for k = 9 is 0.7999790025697965

Ground truth 1 :

F-measure for k = 9 is 0.5009953142903929

Conditional entropy for k = 9 is 0.6072417934737879

Ground truth 2 :

F-measure for k = 9 is 0.48843867142307423

Conditional entropy for k = 9 is 0.6587841579677941

Ground truth 3 :

F-measure for k = 9 is 0.5250072846656821

Conditional entropy for k = 9 is 0.8036982831474138

Ground truth 4 :

F-measure for k = 9 is 0.5305482999069292

Conditional entropy for k = 9 is 0.6727752809785909

Average F-measure for k = 11 : 0.45839743914638265

Average Conditional Entropy for k = 11 : 0.7015613137871934

Ground truth 0 :

F-measure for k = 11 is 0.4773104698172332

Conditional entropy for k = 11 is 0.7912701508141562

Ground truth 1 :

F-measure for k = 11 is 0.4383963135182114

Conditional entropy for k = 11 is 0.6019426696763049

Ground truth 2 :

F-measure for k = 11 is 0.42787371213496717

Conditional entropy for k = 11 is 0.6532247510941954

Ground truth 3 :

F-measure for k = 11 is 0.4793269874319627

Conditional entropy for k = 11 is 0.7950530184199388

Ground truth 4 :

F-measure for k = 11 is 0.4690797128295383

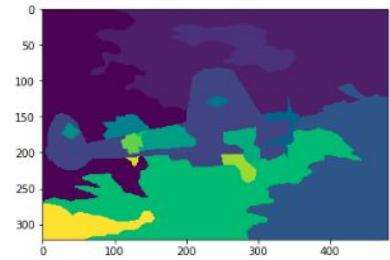
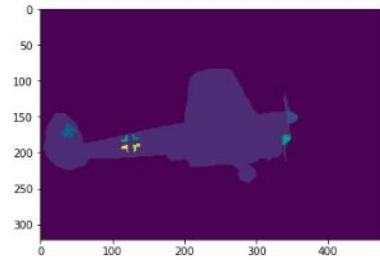
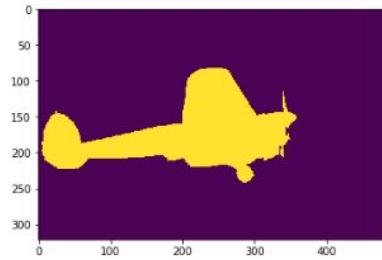
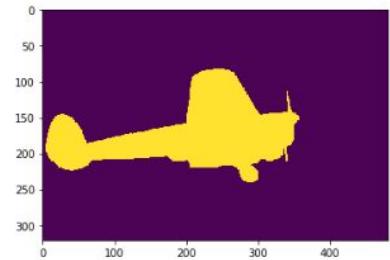
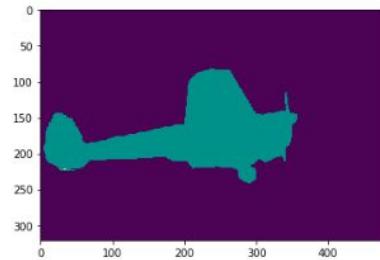
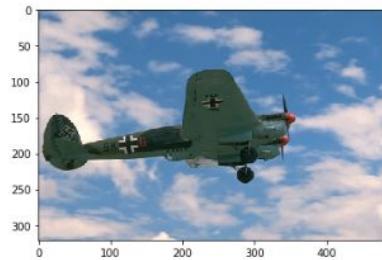
Conditional entropy for k = 11 is 0.6663159789313718

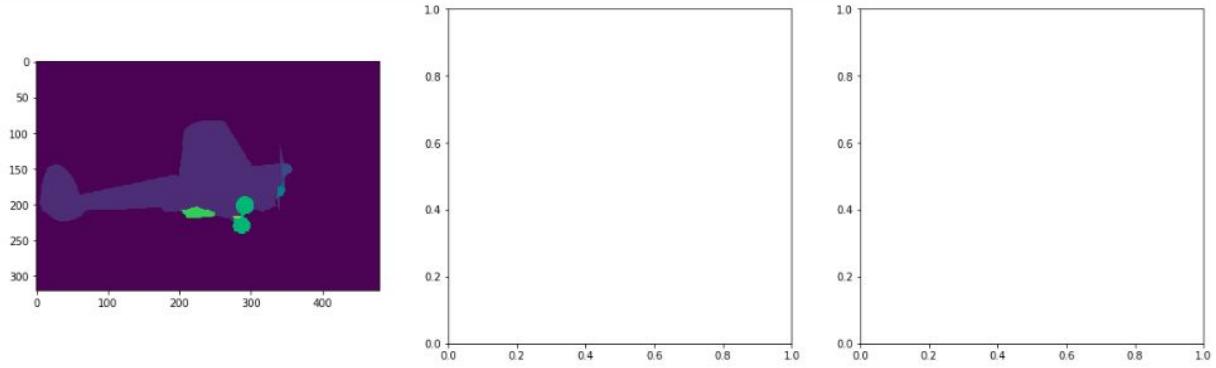
Good, Bad images for each configuration:

We can see in $K = 3$ pixels are divided into 3 clusters so similar pixels are in the same cluster so we can see the plane and sky with some clouds so this image is the best one as we see in results, clouds and plane and sky are separated into clusters.

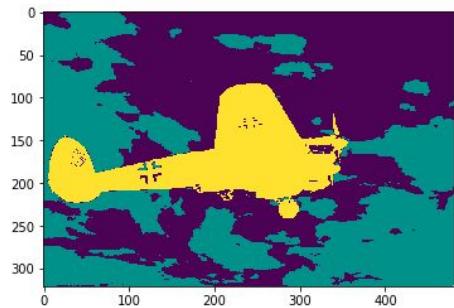
K-means with $k = 3$
Good image :
Image 3063

Image 3063





Kmeans cluster results :



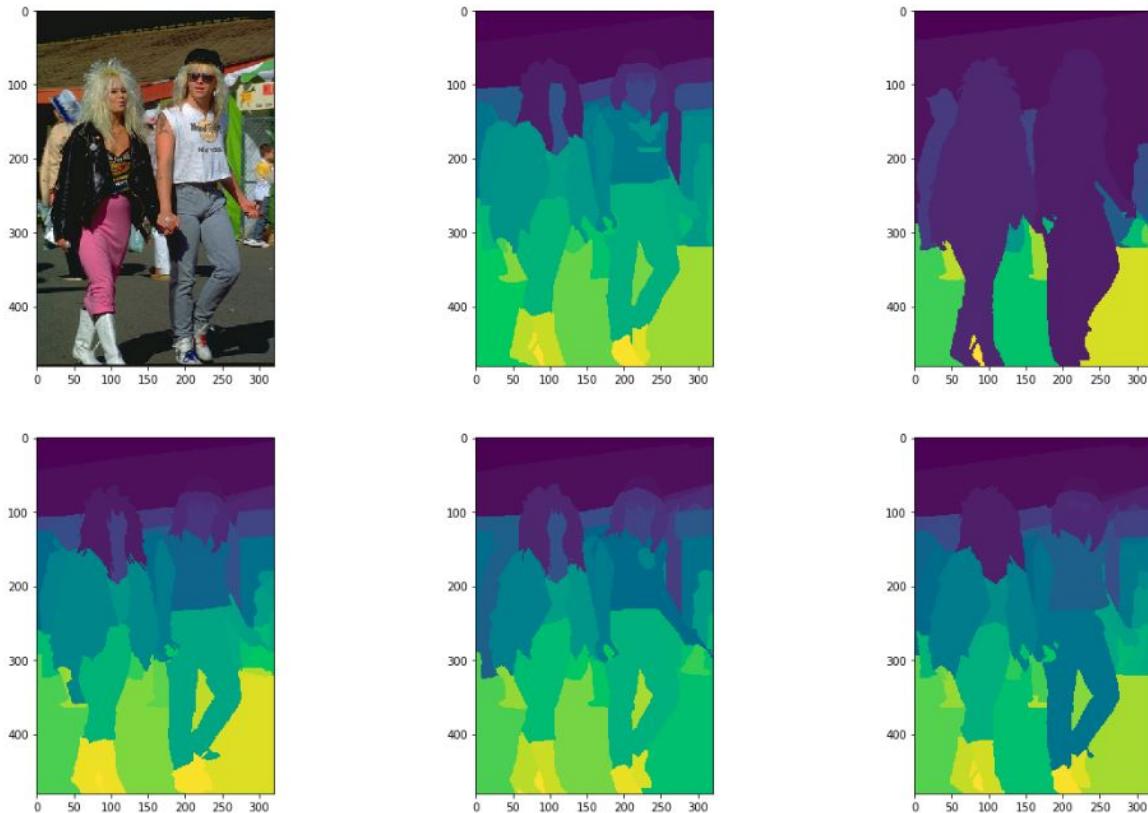
```

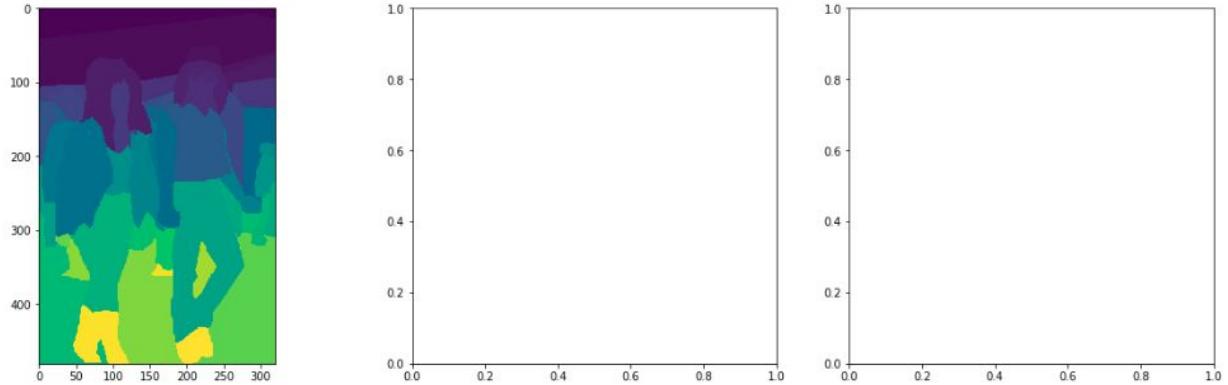
Average F-measure for k = 3 : 0.7458562346083769
Average Conditional Entropy for k = 3 : 0.1258200543953803
Ground truth 0 :
    F-measure for k = 3 is 0.759627613277318
    Conditional entropy for k = 3 is 0.02940025033028021
Ground truth 1 :
    F-measure for k = 3 is 0.759832775625949
    Conditional entropy for k = 3 is 0.028819037137061482
Ground truth 2 :
    F-measure for k = 3 is 0.7611138457169647
    Conditional entropy for k = 3 is 0.027052445694611377
Ground truth 3 :
    F-measure for k = 3 is 0.7594123643195619
    Conditional entropy for k = 3 is 0.038485173663867216
Ground truth 4 :
    F-measure for k = 3 is 0.678463468377764
    Conditional entropy for k = 3 is 0.5848438434182255
Ground truth 5 :
    F-measure for k = 3 is 0.756687340332704
    Conditional entropy for k = 3 is 0.04631957612823602
-----
```

We can see below the worst image for $k = 3$ as this image has many colours and it's no way to be clear in 3 clusters, As we see certain cluster takes the dark colors in image and other two cluster take the rest of colours.

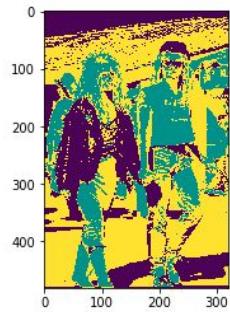
Bad image :
Image 23050

Image 23050





Kmeans cluster results :



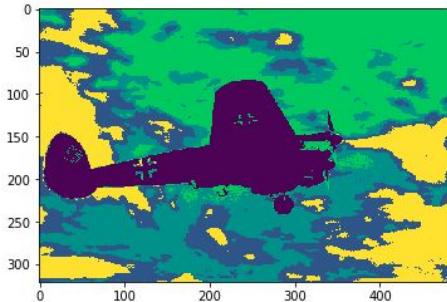
```

Average F-measure for k = 3 : 0.3135398743282311
Average Conditional Entropy for k = 3 : 1.1700251871608527
Ground truth 0 :
    F-measure for k = 3 is 0.29080854085797664
    Conditional entropy for k = 3 is 1.2635816322142215
Ground truth 1 :
    F-measure for k = 3 is 0.3951873298908552
    Conditional entropy for k = 3 is 0.8238076172646398
Ground truth 2 :
    F-measure for k = 3 is 0.31456534871000613
    Conditional entropy for k = 3 is 1.2299906611916436
Ground truth 3 :
    F-measure for k = 3 is 0.2930967880783992
    Conditional entropy for k = 3 is 1.2272907112187532
Ground truth 4 :
    F-measure for k = 3 is 0.2993301410042017
    Conditional entropy for k = 3 is 1.2137863504518838
Ground truth 5 :
    F-measure for k = 3 is 0.2882510974279477
    Conditional entropy for k = 3 is 1.261694150623975
-----
K-means with k = 5
Good image :
Image 3063

```

Moving with the best image we can have, now we have 5 clusters so there is some details can appear as pixels can be divided in a way better, as we can see there is a details of plane that start to appear and the sky also.

Kmeans cluster results :



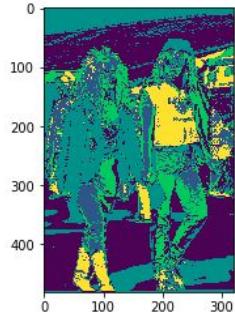
```

Average F-measure for k = 5 : 0.5278724826619564
Average Conditional Entropy for k = 5 : 0.11236830436078325
Ground truth 0 :
    F-measure for k = 5 is 0.5082131971929392
    Conditional entropy for k = 5 is 0.030636706164696804
Ground truth 1 :
    F-measure for k = 5 is 0.5083208508517241
    Conditional entropy for k = 5 is 0.03014058190438688
Ground truth 2 :
    F-measure for k = 5 is 0.509092143632641
    Conditional entropy for k = 5 is 0.028146837872640166
Ground truth 3 :
    F-measure for k = 5 is 0.508045925918287
    Conditional entropy for k = 5 is 0.03953018197008024
Ground truth 4 :
    F-measure for k = 5 is 0.626865119793456
    Conditional entropy for k = 5 is 0.4986839508079111
Ground truth 5 :
    F-measure for k = 5 is 0.5066976585826912
    Conditional entropy for k = 5 is 0.047071567444984315
-----
```

Bad image :
Image 23050

Moving with the bad image we have, having 5 cluster is not enough to show details, but there is some details that can be recognized as the boots and two shapes of people appear however we need more clusters for more details.

Kmeans cluster results :

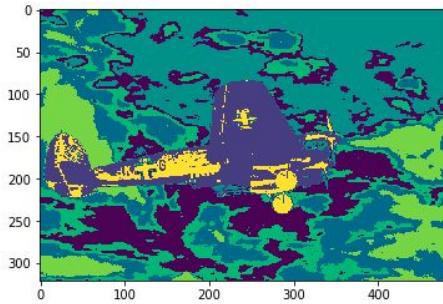


```
Average F-measure for k = 5 : 0.3620262223732071
Average Conditional Entropy for k = 5 : 1.08574998261763
Ground truth 0 :
    F-measure for k = 5 is 0.3677801218622269
    Conditional entropy for k = 5 is 1.1695718651844775
Ground truth 1 :
    F-measure for k = 5 is 0.3398134537215178
    Conditional entropy for k = 5 is 0.7778699782708861
Ground truth 2 :
    F-measure for k = 5 is 0.3775953783071394
    Conditional entropy for k = 5 is 1.137301796885199
Ground truth 3 :
    F-measure for k = 5 is 0.3580488386214718
    Conditional entropy for k = 5 is 1.1370001805118601
Ground truth 4 :
    F-measure for k = 5 is 0.36685511211035726
    Conditional entropy for k = 5 is 1.1202878441291617
Ground truth 5 :
    F-measure for k = 5 is 0.3620644296165293
    Conditional entropy for k = 5 is 1.172468230724196
```

```
K-means with k = 7
Good image :
Image 3063
```

Here we go with the good image more details appears on plane and shapes of clouds as similar pixels are getting in one cluster.

Kmeans cluster results :



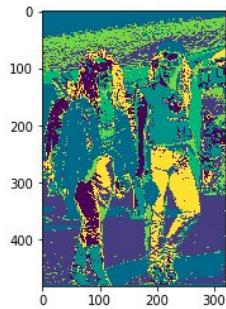
```

Average F-measure for k = 7 : 0.4210277506603835
Average Conditional Entropy for k = 7 : 0.10735006299725607
Ground truth 0 :
    F-measure for k = 7 is 0.404523015404418
    Conditional entropy for k = 7 is 0.02897277406925779
Ground truth 1 :
    F-measure for k = 7 is 0.4046384121271983
    Conditional entropy for k = 7 is 0.02832319634642707
Ground truth 2 :
    F-measure for k = 7 is 0.40561905228835854
    Conditional entropy for k = 7 is 0.026429120673706362
Ground truth 3 :
    F-measure for k = 7 is 0.4052107228200038
    Conditional entropy for k = 7 is 0.03758857491233731
Ground truth 4 :
    F-measure for k = 7 is 0.5028337352043335
    Conditional entropy for k = 7 is 0.48003346288098125
Ground truth 5 :
    F-measure for k = 7 is 0.4033415661179891
    Conditional entropy for k = 7 is 0.042753249100826604
-----
```

Bad image :
Image 23050

For the bad image still info not that good, we need more details, too many pixels that are different in same cluster.

Kmeans cluster results :



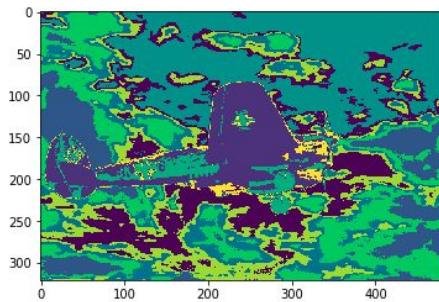
```

Average F-measure for k = 7 : 0.374589709424702
Average Conditional Entropy for k = 7 : 1.0154148208957523
Ground truth 0 :
    F-measure for k = 7 is 0.3904357169338728
    Conditional entropy for k = 7 is 1.0883775010095387
Ground truth 1 :
    F-measure for k = 7 is 0.30160581812060716
    Conditional entropy for k = 7 is 0.7438828564010952
Ground truth 2 :
    F-measure for k = 7 is 0.3944636950062052
    Conditional entropy for k = 7 is 1.0552438537594768
Ground truth 3 :
    F-measure for k = 7 is 0.3856388326103048
    Conditional entropy for k = 7 is 1.0602367506451775
Ground truth 4 :
    F-measure for k = 7 is 0.38640988506292817
    Conditional entropy for k = 7 is 1.050623593111886
Ground truth 5 :
    F-measure for k = 7 is 0.388984308814294
    Conditional entropy for k = 7 is 1.0941243704473407
-----
K-means with k = 9
Good image :
Image 3063

```

We can see here the shape of the plane clearly and the wheels with different color than the plane body, we can see also the clouds clearer than at k = 7.

Kmeans cluster results :



```

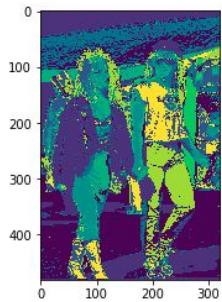
Average F-measure for k = 9 : 0.34696822426409346
Average Conditional Entropy for k = 9 : 0.09818743202302303
Ground truth 0 :
    F-measure for k = 9 is 0.33204215685603916
    Conditional entropy for k = 9 is 0.019877295674754873
Ground truth 1 :
    F-measure for k = 9 is 0.3322257854857996
    Conditional entropy for k = 9 is 0.019253782867376404
Ground truth 2 :
    F-measure for k = 9 is 0.3326203927559708
    Conditional entropy for k = 9 is 0.017929438839074583
Ground truth 3 :
    F-measure for k = 9 is 0.3317762934468903
    Conditional entropy for k = 9 is 0.028546843618798237
Ground truth 4 :
    F-measure for k = 9 is 0.42380669248893
    Conditional entropy for k = 9 is 0.47063422606914657
Ground truth 5 :
    F-measure for k = 9 is 0.3293380245509309
    Conditional entropy for k = 9 is 0.0328830050689876
-----

```

Bad image :
Image 23050

Bad image is slightly become clearer than other k's but still pixels of different colours are in same cluster.we can see shapes of two women and one of them is wearing a jacket with has a colour different than the boots.

Kmeans cluster results :



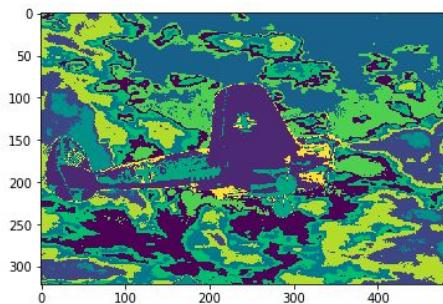
```

Average F-measure for k = 9 : 0.38988544074378323
Average Conditional Entropy for k = 9 : 0.9782619756804566
Ground truth 0 :
    F-measure for k = 9 is 0.4083880715207952
    Conditional entropy for k = 9 is 1.0466107504540934
Ground truth 1 :
    F-measure for k = 9 is 0.254616236269321
    Conditional entropy for k = 9 is 0.7250032735551236
Ground truth 2 :
    F-measure for k = 9 is 0.4279642385958273
    Conditional entropy for k = 9 is 1.0134378010844125
Ground truth 3 :
    F-measure for k = 9 is 0.4136772379384816
    Conditional entropy for k = 9 is 1.0192628342685437
Ground truth 4 :
    F-measure for k = 9 is 0.41929906643491804
    Conditional entropy for k = 9 is 1.0118951863718544
Ground truth 5 :
    F-measure for k = 9 is 0.415367793703356
    Conditional entropy for k = 9 is 1.0533620083487119
-----
K-means with k = 11
Good image :
Image 3063

```

Here we can see more details, a badge on the plane and some clouds have the same colour of plane body which is grey. Similar pixels are together.

Kmeans cluster results :



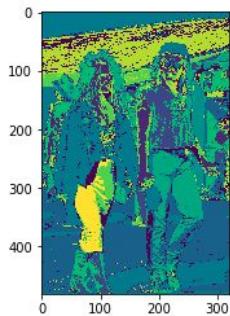
```

Average F-measure for k = 11 : 0.2938708912698143
Average Conditional Entropy for k = 11 : 0.09829085010190013
Ground truth 0 :
    F-measure for k = 11 is 0.27682937363257437
    Conditional entropy for k = 11 is 0.020355520175669033
Ground truth 1 :
    F-measure for k = 11 is 0.2769967899483437
    Conditional entropy for k = 11 is 0.019646333156651694
Ground truth 2 :
    F-measure for k = 11 is 0.27730627824002074
    Conditional entropy for k = 11 is 0.01838910810992753
Ground truth 3 :
    F-measure for k = 11 is 0.2766133715652481
    Conditional entropy for k = 11 is 0.028993938289220453
Ground truth 4 :
    F-measure for k = 11 is 0.38072891619015137
    Conditional entropy for k = 11 is 0.4689553913958286
Ground truth 5 :
    F-measure for k = 11 is 0.2747506180425478
    Conditional entropy for k = 11 is 0.03340480948410339
-----
```

Bad image :
Image 23050

Below still not clear, dark colours and grey are in one cluster many details are lost here this appears when we calculate the conditional entropy which is nearly 1

Kmeans cluster results :



Average F-measure for k = 11 : 0.40963877187451864
Average Conditional Entropy for k = 11 : 0.912783355407329
Ground truth 0 :
 F-measure for k = 11 is 0.43404520351370574
 Conditional entropy for k = 11 is 0.9760527990518113
Ground truth 1 :
 F-measure for k = 11 is 0.25514200376650203
 Conditional entropy for k = 11 is 0.6810042838249424
Ground truth 2 :
 F-measure for k = 11 is 0.4530216685444533
 Conditional entropy for k = 11 is 0.9447103480065889
Ground truth 3 :
 F-measure for k = 11 is 0.4363277438292759
 Conditional entropy for k = 11 is 0.950118744872379
Ground truth 4 :
 F-measure for k = 11 is 0.44224386881413724
 Conditional entropy for k = 11 is 0.9405394435268607
Ground truth 5 :
 F-measure for k = 11 is 0.43705214277903753
 Conditional entropy for k = 11 is 0.9842745131613918

Normalized-Cut Segmentation:

We resized images into 20% of its original size to overcome memory problems.

The same as k-means segmentations we store results however we need more memory to get all set so we tested about 26 only.

```

## Spectral clustering with different k
do_spectral_clustering = False;
k_param = [3,5,7,9,11];
s_results = [[[] for i in range(len(k_param))] for j in range(3)];
if do_spectral_clustering:
    index = 0;
    for img in mod_data:
        i = 0;
        img_u = img.reshape(-1, 3);
        ## Following https://scikit-Learn.org/stable/modules/generated/sklearn.cluster.SpectralClustering.html
        ## RBF kernel -> np.exp(-gamma * d(X,X) ** 2) where d(X,X) is euclidean distance.
        spectCluster = SpectralClustering(n_clusters=11, random_state=0, affinity='rbf', gamma = 1);
        rbf_1_aff = spectCluster.fit(img_u).affinity_matrix_;
        spectCluster = SpectralClustering(n_clusters=11, random_state=0, affinity='rbf', gamma = 10);
        rbf_10_aff = spectCluster.fit(img_u).affinity_matrix_;
        spectCluster = SpectralClustering(n_clusters=11, random_state=0, affinity='nearest_neighbors', n_neighbors = 5);
        nn_5_aff = spectCluster.fit(img_u).affinity_matrix_;
        for k in k_param:
            spectCluster = SpectralClustering(n_clusters=k, random_state=0, affinity='precomputed');
            clustering = spectCluster.fit(rbf_1_aff);
            s_results[0][i].append(clustering.labels_.reshape(img.shape[:-1]).copy());
            clustering = spectCluster.fit(rbf_10_aff);
            s_results[1][i].append(clustering.labels_.reshape(img.shape[:-1]).copy());
            clustering = spectCluster.fit(nn_5_aff);
            s_results[2][i].append(clustering.labels_.reshape(img.shape[:-1]).copy());
            i = i + 1;
        index += 1;
        if (index % 20 == 0):
            print('Finished : ', index / 2, '%');
else:
    print('Generation bypassed, will be read from stored results...');

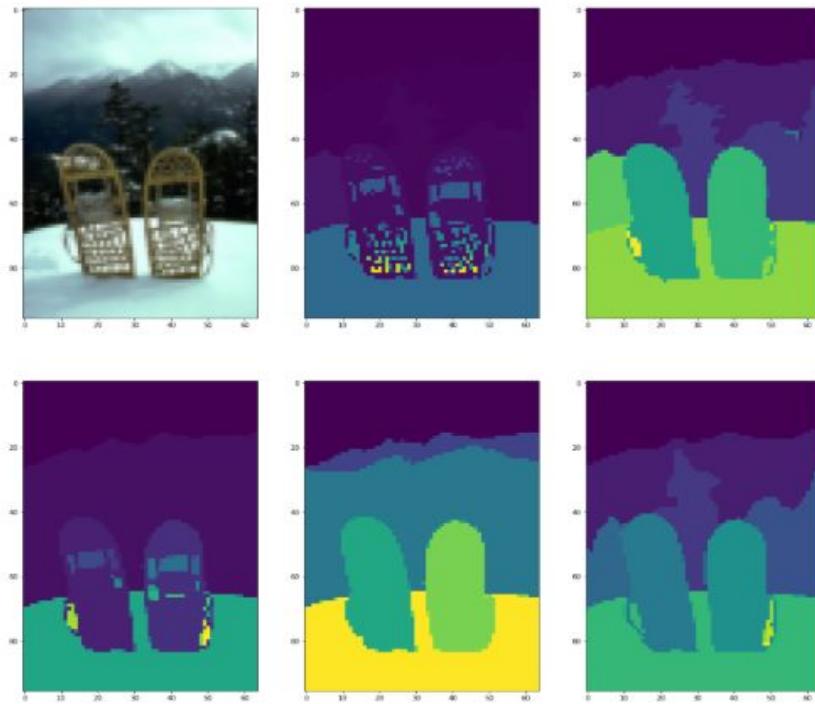
Generation bypassed, will be read from stored results...

if do_spectral_clustering:
    k_param = [3,5,7,9,11];
    directory = 'results/spectral/rbf_1';
    write_cluster_images(directory, s_results[0], names, k_param);
    directory = 'results/spectral/rbf_10';
    write_cluster_images(directory, s_results[1], names, k_param);
    directory = 'results/spectral/nn_5';
    write_cluster_images(directory, s_results[2], names, k_param);
    print('All results saved...');
else:
    print('No results to save, skip to reading');

    directory = 'results/spectral/rbf_1';
    k_param = [3,5,7,9,11];
    s_results = [[] for j in range(3)];
    for k in k_param:
        sub_dir = join(directory, str(k));
        if not os.path.exists(sub_dir):
            os.makedirs(sub_dir);
        lk = read_cluster_images(sub_dir);
        s_results[0].append(lk);
    directory = 'results/spectral/rbf_10';
    k_param = [3,5,7,9,11];
    for k in k_param:
        sub_dir = join(directory, str(k));
        if not os.path.exists(sub_dir):
            os.makedirs(sub_dir);
        lk = read_cluster_images(sub_dir);
        s_results[1].append(lk);
    directory = 'results/spectral/nn_5';
    k_param = [3,5,7,9,11];
    for k in k_param:
        sub_dir = join(directory, str(k));
        if not os.path.exists(sub_dir):
            os.makedirs(sub_dir);
        lk = read_cluster_images(sub_dir);
        s_results[2].append(lk);
    print('RBF with gamma = 1');
    show_cluster_img(mod_data, s_results[0], names, 0, k_param);
    print('RBF with gamma = 10');
    show_cluster_img(mod_data, s_results[1], names, 0, k_param);
    print('Nearest Neighbours with n = 5');
    show_cluster_img(mod_data, s_results[2], names, 0, k_param);

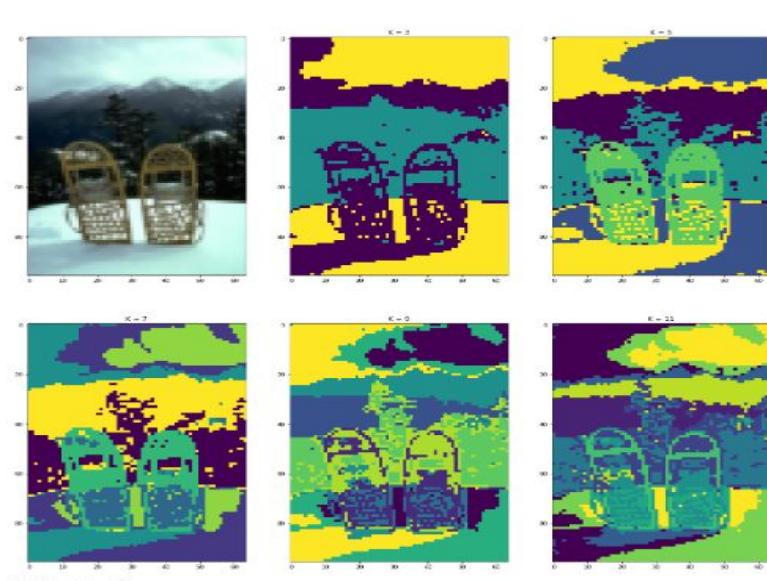
```

After resizing image we decided to show it with its ground truths to know the difference between it and original, we can see it isn't clear enough:

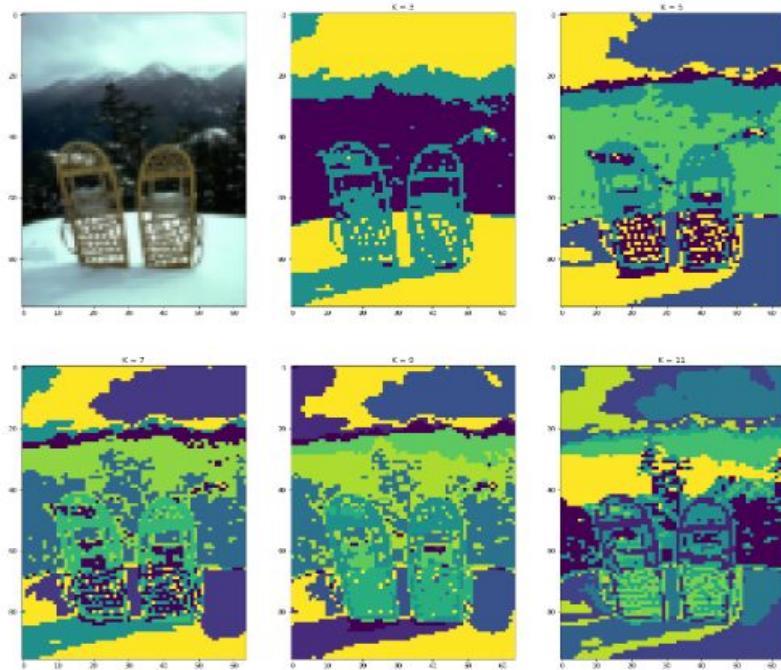


Showing image example after normalized-cut:

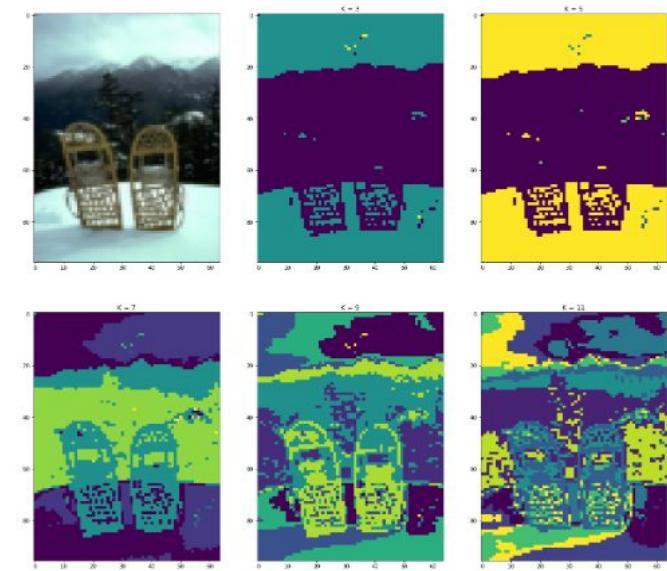
- RBF with gamma = 1:



- RBF with gamma = 10:

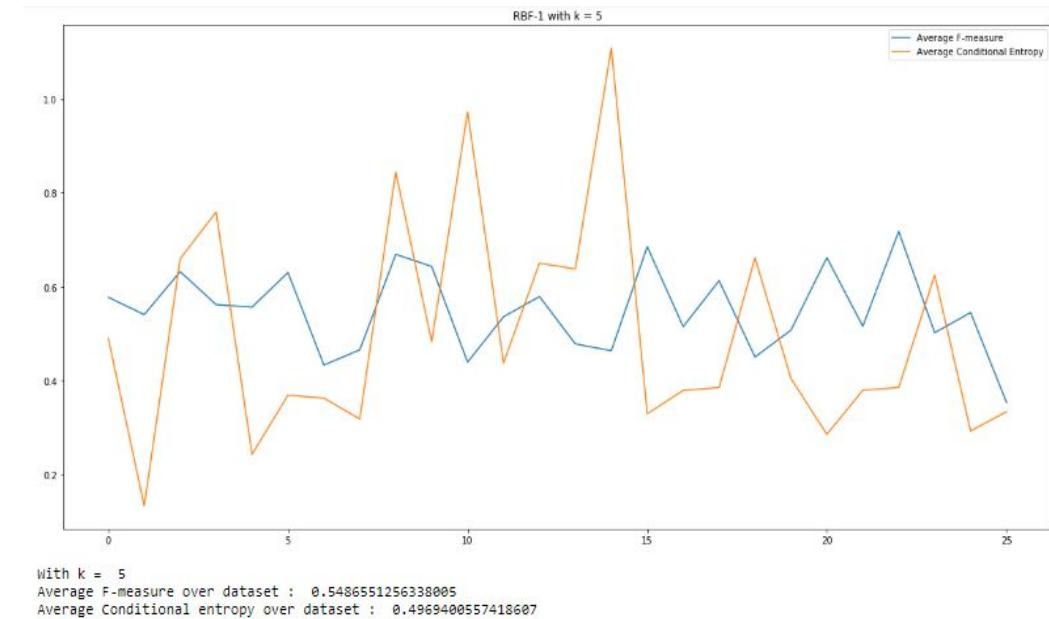
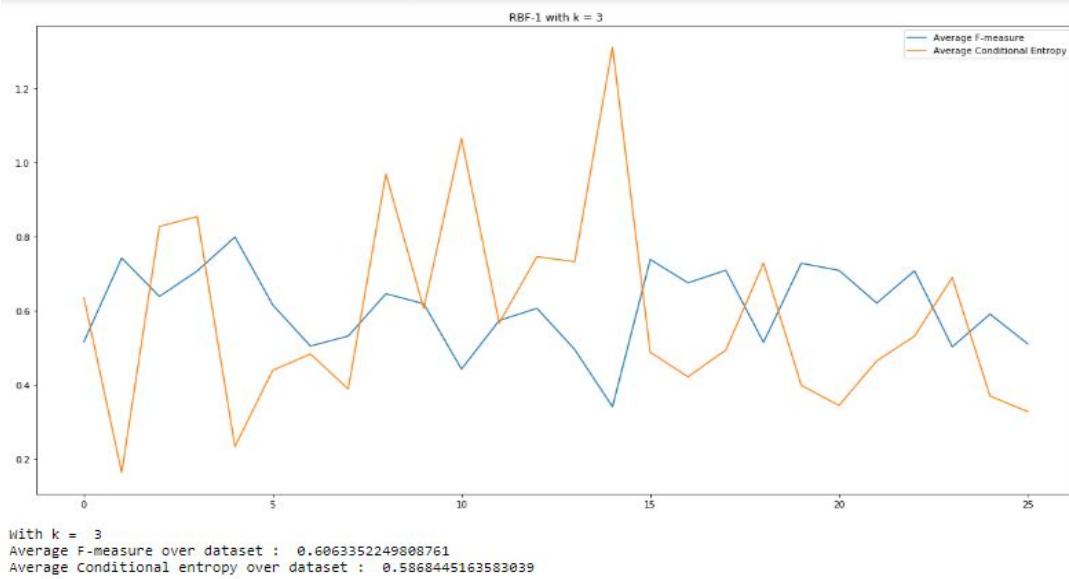


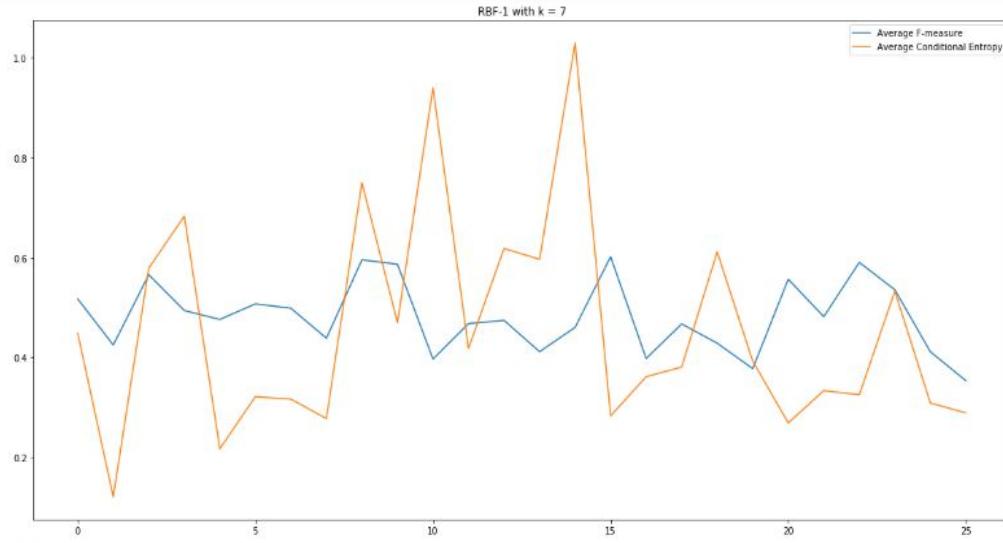
- **5-Nearest Neighbours:**



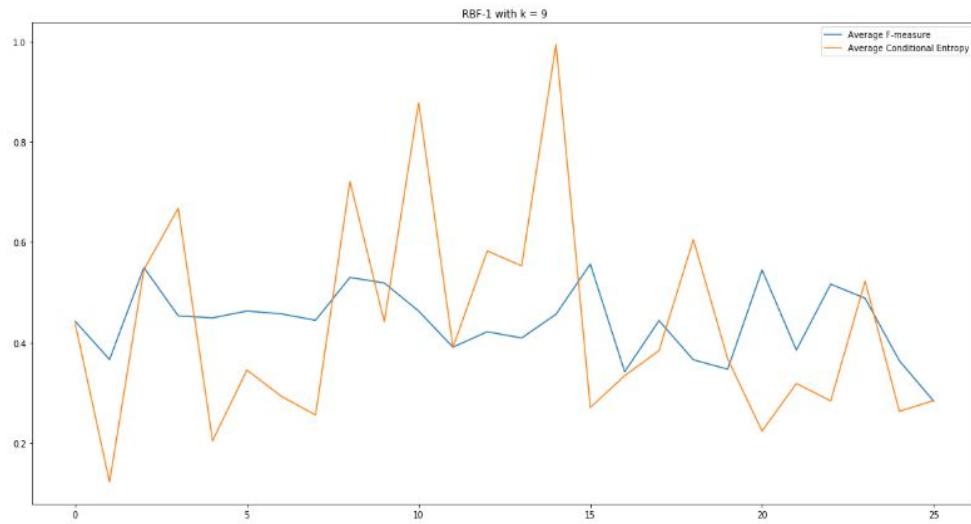
Evaluating Results of Normalized-Cut:

- RBF with gamma = 1:

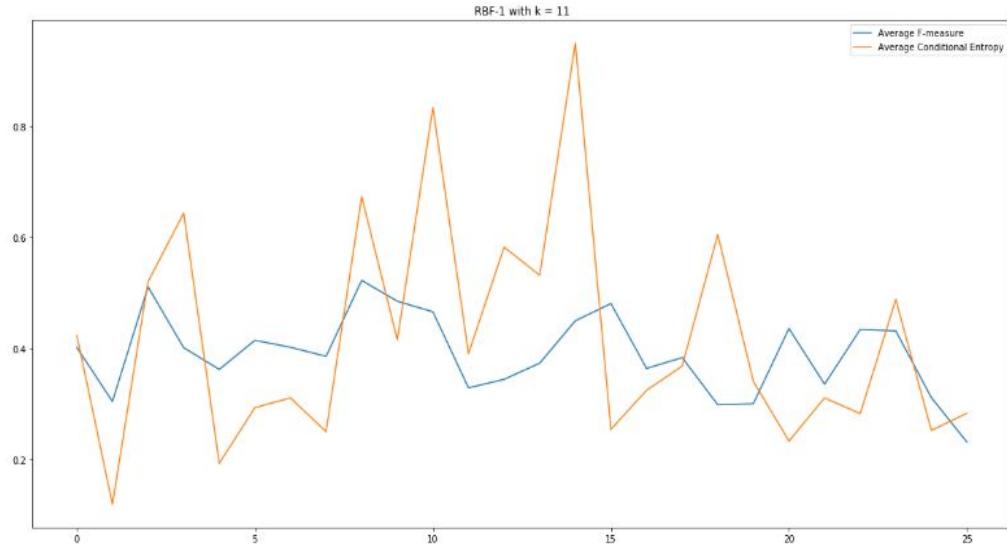




With k = 7
 Average F-measure over dataset : 0.48142818856462966
 Average Conditional entropy over dataset : 0.4567263494555573

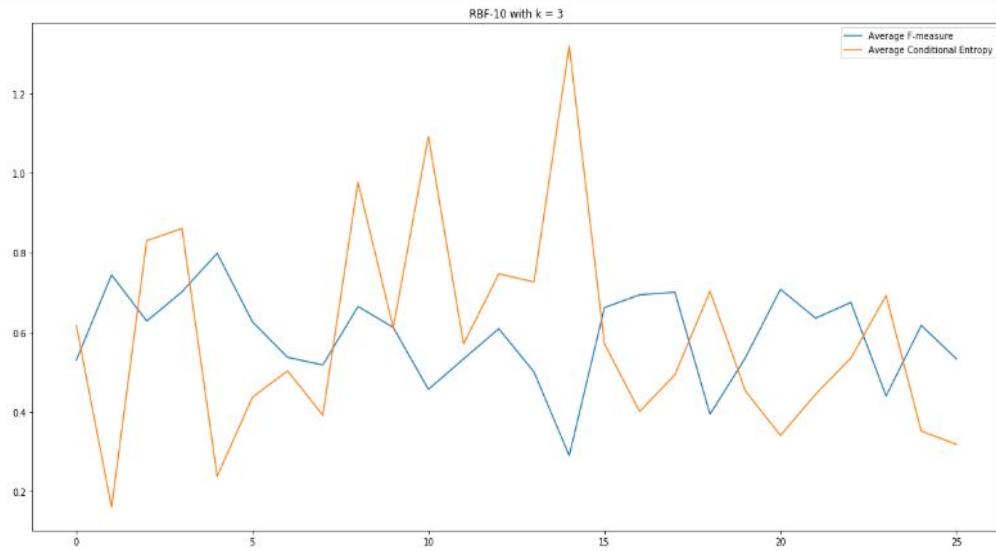


With k = 9
 Average F-measure over dataset : 0.4401474199154429
 Average Conditional entropy over dataset : 0.4339186319575847

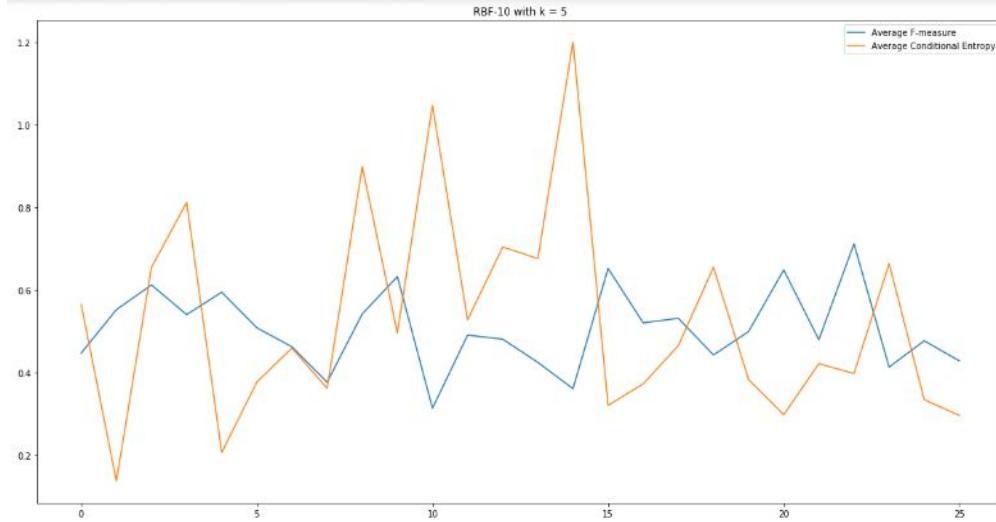


With k = 11
 Average F-measure over dataset : 0.3910861298877703
 Average Conditional entropy over dataset : 0.41857908360272117

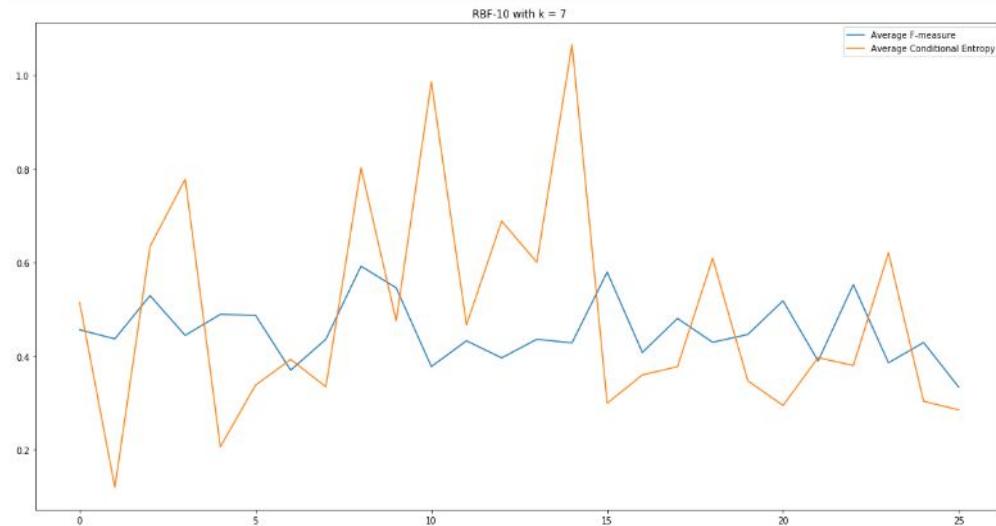
- RBF with gamma = 10:



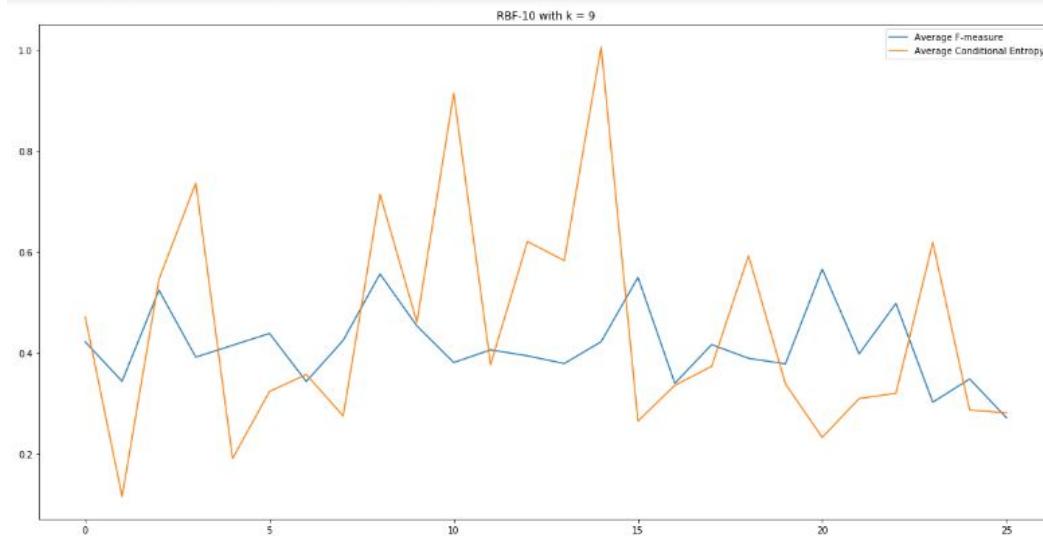
With k = 3
 Average F-measure over dataset : 0.5903317602319089
 Average Conditional entropy over dataset : 0.5919304051661961



With k = 5
Average F-measure over dataset : 0.5049686447375181
Average Conditional entropy over dataset : 0.5276177998053576



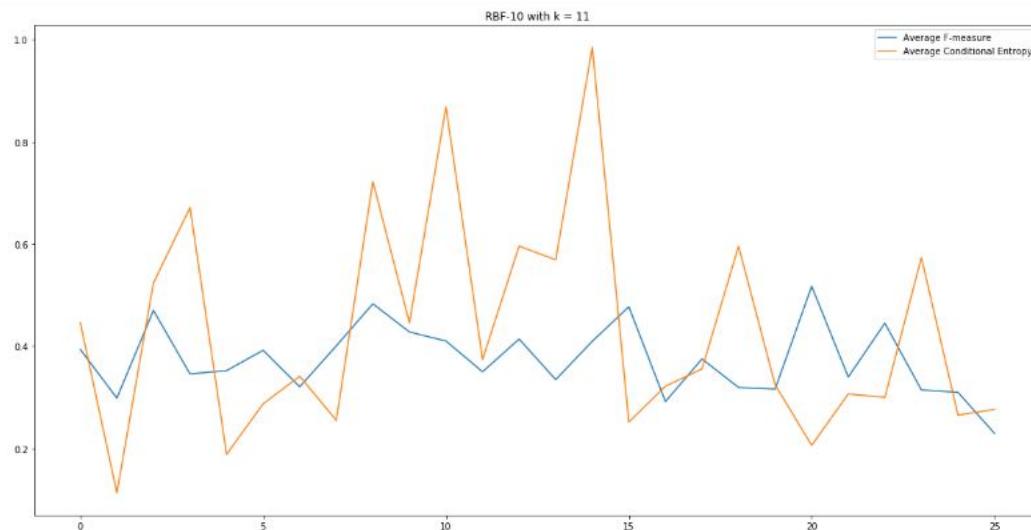
With k = 7
Average F-measure over dataset : 0.4544768975438173
Average Conditional entropy over dataset : 0.4877386754157436



With k = 9

Average F-measure over dataset : 0.4136457905972207

Average Conditional entropy over dataset : 0.4480288317306474

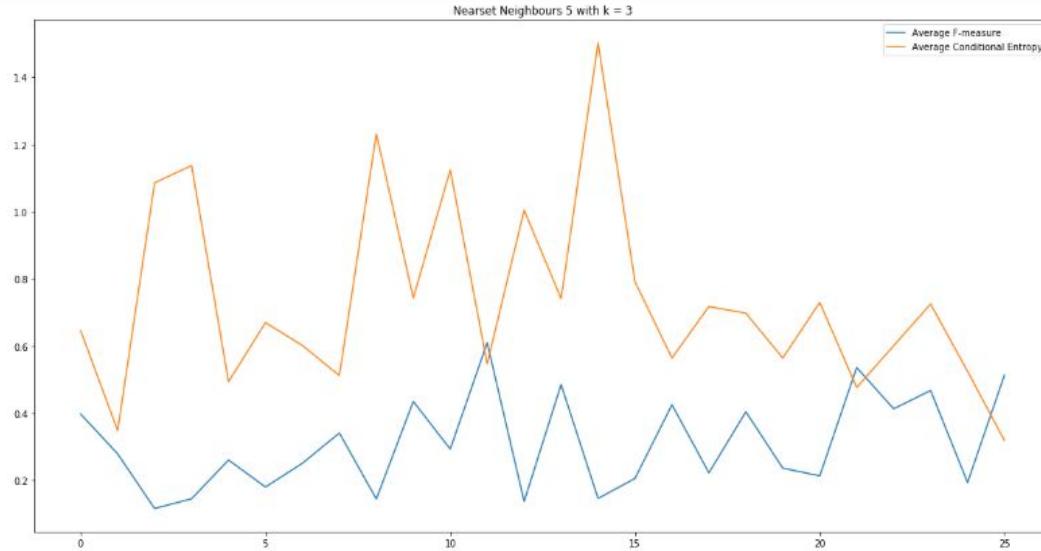


With k = 11

Average F-measure over dataset : 0.37442452792753195

Average Conditional entropy over dataset : 0.42917414859917274

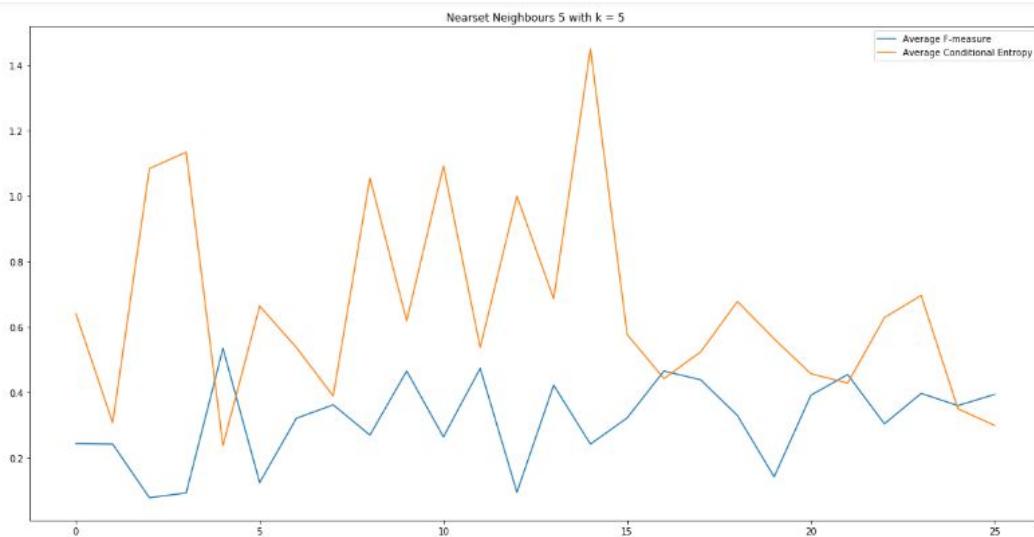
- 5-NN:



With k = 3

Average F-measure over dataset : 0.3101765227304779

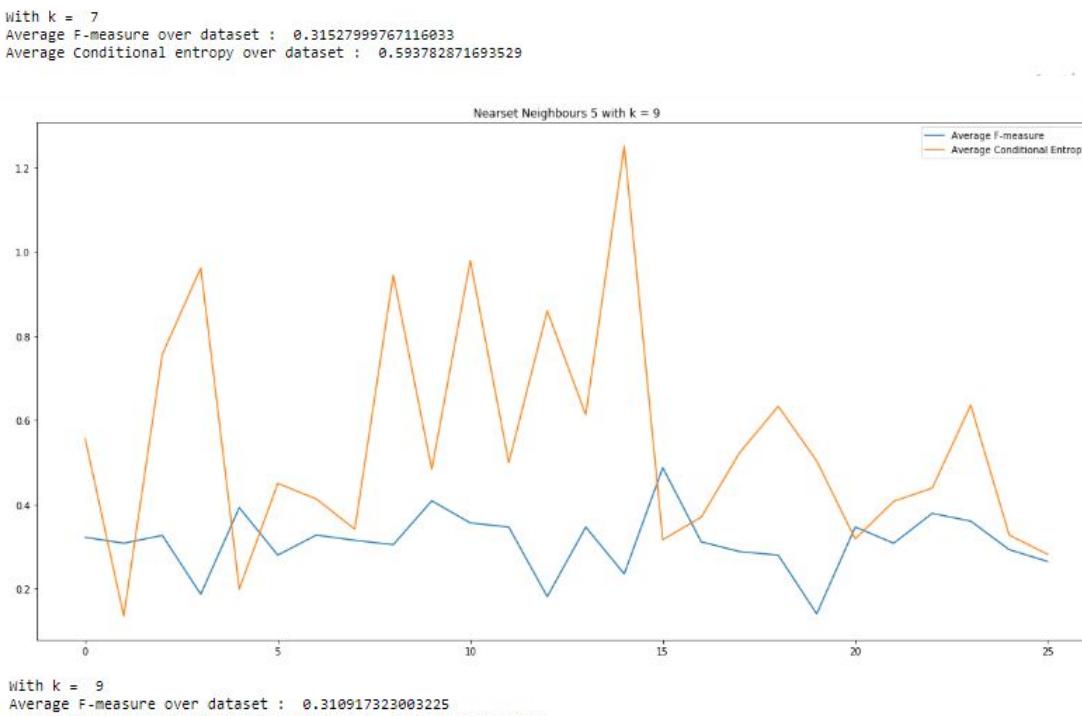
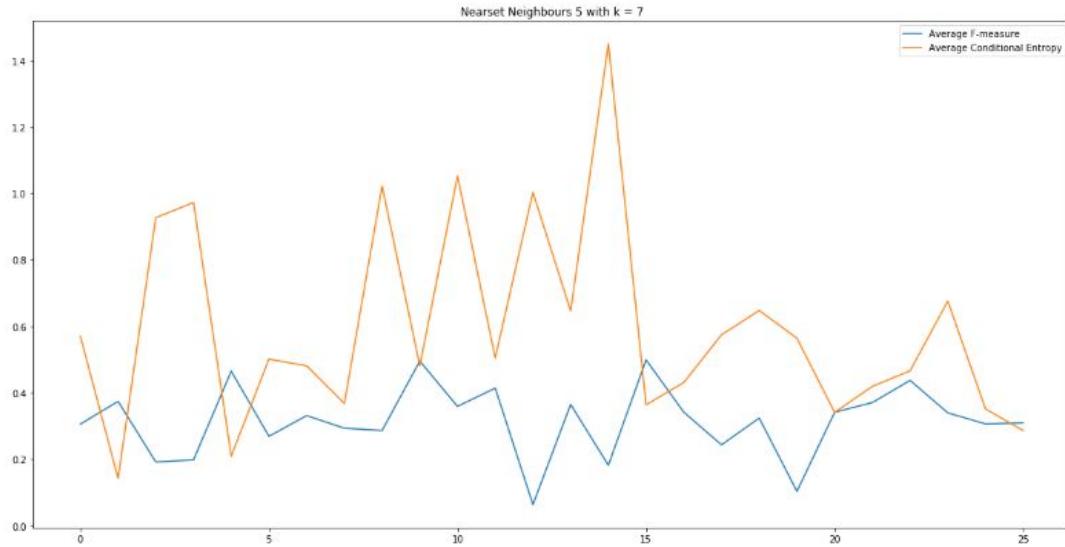
Average Conditional entropy over dataset : 0.7345149219420334

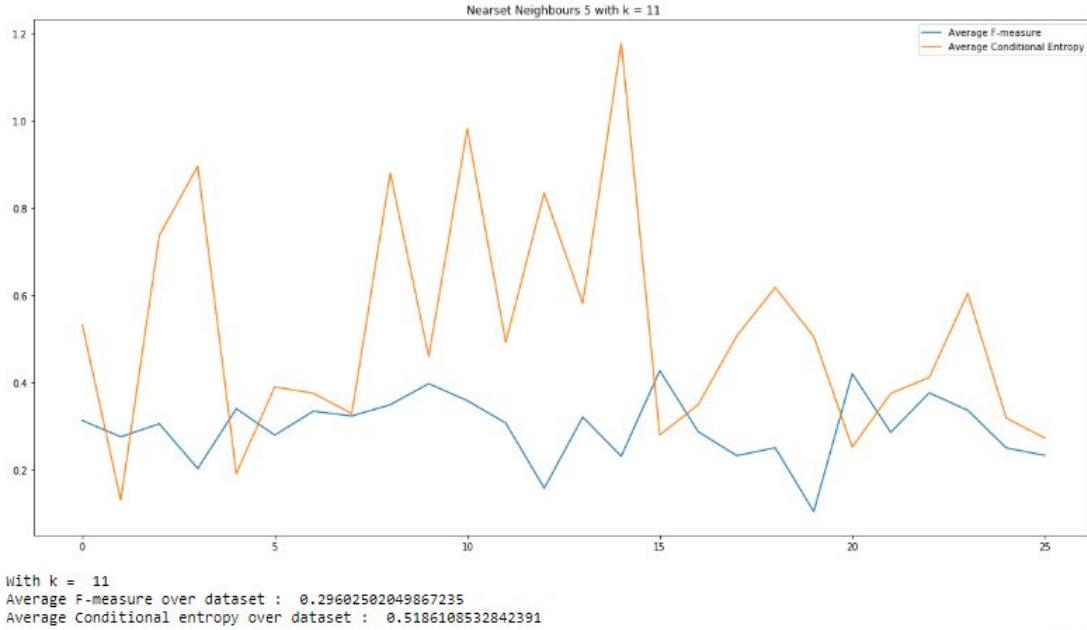


With k = 5

Average F-measure over dataset : 0.31694122576799094

Average Conditional entropy over dataset : 0.6575000859593177





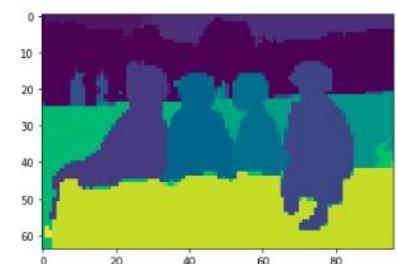
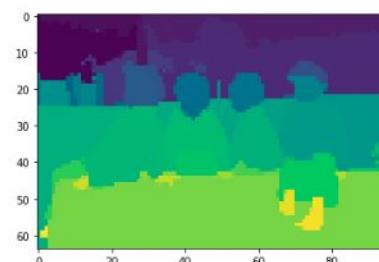
Example of a full detailed image output:

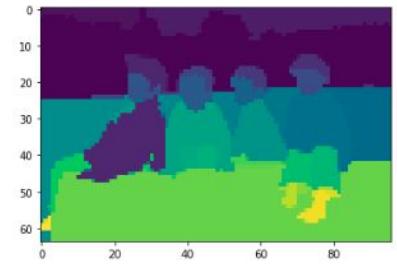
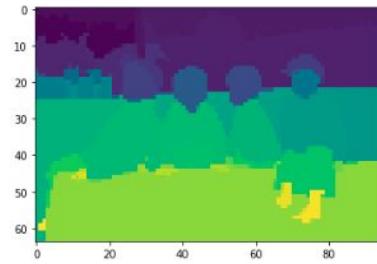
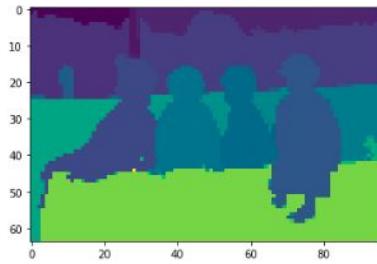
- RBF-1

As we can see as we increase number of clusters (k) more details appears and shapes of childrens

Image 15011

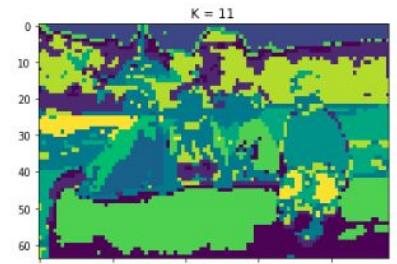
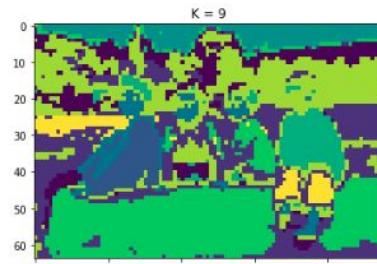
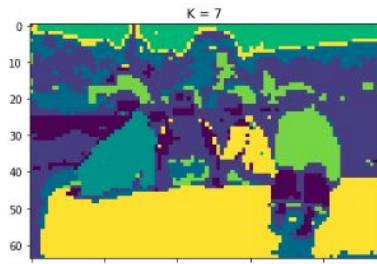
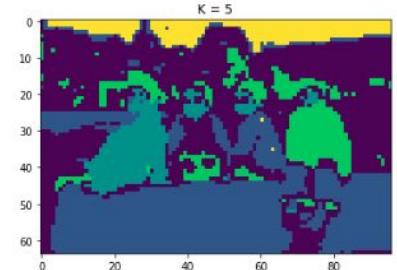
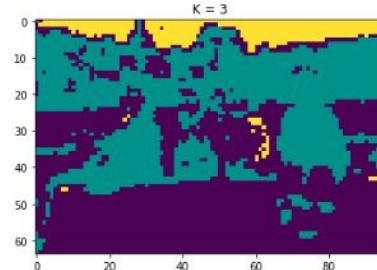
Image 15011





RBF-1 cluster results :

Image 15011



Average F-measure for k = 3 : 0.6450774401713837

Average Conditional Entropy for k = 3 : 0.9684298503042921

Ground truth 0 :

F-measure for k = 3 is 0.6372458107947302

Conditional entropy for k = 3 is 1.0926744639993105

Ground truth 1 :

F-measure for k = 3 is 0.6797340392313123

Conditional entropy for k = 3 is 0.8148610881723987

Ground truth 2 :

F-measure for k = 3 is 0.5779543281236308

Conditional entropy for k = 3 is 0.9434129747957876

Ground truth 3 :

F-measure for k = 3 is 0.6403781899876292

Conditional entropy for k = 3 is 1.0798838752620343

Ground truth 4 :

F-measure for k = 3 is 0.6900748327196163

Conditional entropy for k = 3 is 0.911316849291929

```

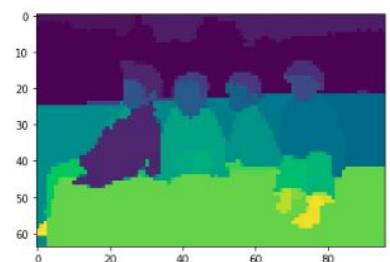
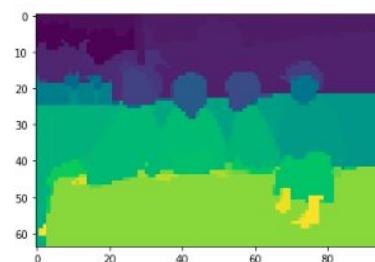
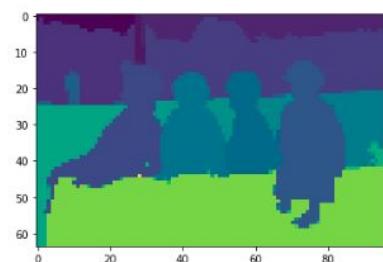
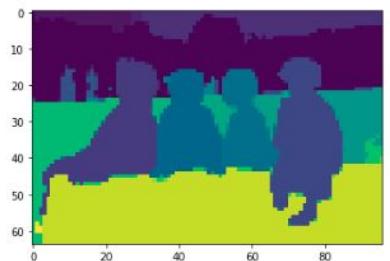
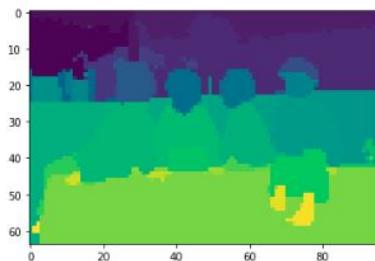
Average F-measure for k = 5 : 0.6689273232408836
Average Conditional Entropy for k = 5 : 0.8445903873193386
Ground truth 0 :
    F-measure for k = 5 is 0.6597857957506423
    Conditional entropy for k = 5 is 0.9603084778177687
Ground truth 1 :
    F-measure for k = 5 is 0.6895220427495994
    Conditional entropy for k = 5 is 0.7071802149620334
Ground truth 2 :
    F-measure for k = 5 is 0.6292049476208694
    Conditional entropy for k = 5 is 0.8354324211254909
Ground truth 3 :
    F-measure for k = 5 is 0.6476197647511184
    Conditional entropy for k = 5 is 0.9431328092403808
Ground truth 4 :
    F-measure for k = 5 is 0.7185040653321881
    Conditional entropy for k = 5 is 0.7768980134510192
-----
Average F-measure for k = 7 : 0.5952552785130868
Average Conditional Entropy for k = 7 : 0.7499121407841998
Ground truth 0 :
    F-measure for k = 7 is 0.5944510748799078
    Conditional entropy for k = 7 is 0.8609003627058561
Ground truth 1 :
    F-measure for k = 7 is 0.596977717763029
    Conditional entropy for k = 7 is 0.6212998778665244
Ground truth 2 :
    F-measure for k = 7 is 0.5505248810961609
    Conditional entropy for k = 7 is 0.7483102968754147
Ground truth 3 :
    F-measure for k = 7 is 0.5902769115899628
    Conditional entropy for k = 7 is 0.8373411479095128
Ground truth 4 :
    F-measure for k = 7 is 0.6440458072363736
    Conditional entropy for k = 7 is 0.6817090185636909
-----
Average F-measure for k = 9 : 0.5297369668618466
Average Conditional Entropy for k = 9 : 0.7218892649772455
Ground truth 0 :
    F-measure for k = 9 is 0.5440443346676295
    Conditional entropy for k = 9 is 0.8202425255389942
Ground truth 1 :
    F-measure for k = 9 is 0.5192847235578627
    Conditional entropy for k = 9 is 0.6005532719371804
Ground truth 2 :
    F-measure for k = 9 is 0.4975831688280212
    Conditional entropy for k = 9 is 0.730805798046492
Ground truth 3 :
    F-measure for k = 9 is 0.5238123958146305
    Conditional entropy for k = 9 is 0.8037314892507409
Ground truth 4 :
    F-measure for k = 9 is 0.5639602114410892
    Conditional entropy for k = 9 is 0.6541132401128201
-----
Average F-measure for k = 11 : 0.5229599071441579
Average Conditional Entropy for k = 11 : 0.6738613153868848
Ground truth 0 :
    F-measure for k = 11 is 0.5344903063678103
    Conditional entropy for k = 11 is 0.7711793564437082
Ground truth 1 :
    F-measure for k = 11 is 0.5119729935513105
    Conditional entropy for k = 11 is 0.5573990598487916
Ground truth 2 :
    F-measure for k = 11 is 0.4841873926360724
    Conditional entropy for k = 11 is 0.6833144467016298
Ground truth 3 :
    F-measure for k = 11 is 0.527911660002287
    Conditional entropy for k = 11 is 0.7492814686094829
Ground truth 4 :
    F-measure for k = 11 is 0.5562371831633091
    Conditional entropy for k = 11 is 0.6081322453308113
-----
```

- RBF-10

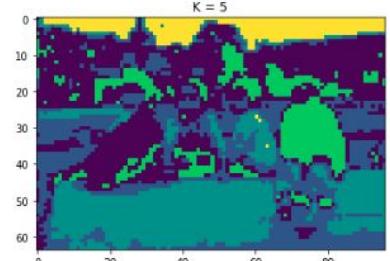
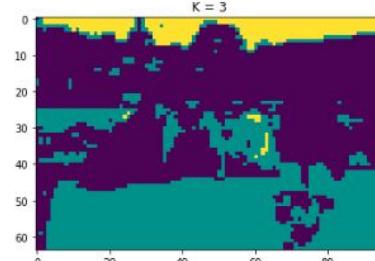
The same as in RBF-1 more details appear as we add more cluster.

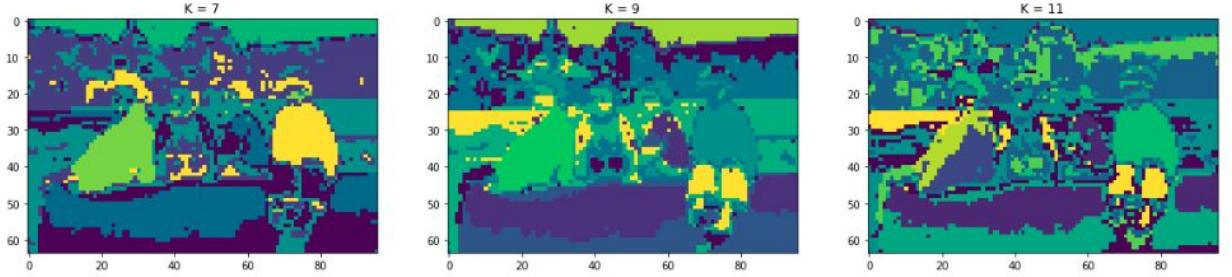
Image 15011

Image 15011



RBF-10 cluster results :





```

Average F-measure for k = 3 : 0.6648389713329574
Average Conditional Entropy for k = 3 : 0.9766491206643917
Ground truth 0 :
    F-measure for k = 3 is 0.6145117860490806
    Conditional entropy for k = 3 is 1.1661716799724864
Ground truth 1 :
    F-measure for k = 3 is 0.7118264022746942
    Conditional entropy for k = 3 is 0.8012333865051344
Ground truth 2 :
    F-measure for k = 3 is 0.6068725404658369
    Conditional entropy for k = 3 is 0.9322986350938659
Ground truth 3 :
    F-measure for k = 3 is 0.6680515420482435
    Conditional entropy for k = 3 is 1.0813376730249025
Ground truth 4 :
    F-measure for k = 3 is 0.7229325858269324
    Conditional entropy for k = 3 is 0.9022042287255693
-----
Average F-measure for k = 5 : 0.5414147777258743
Average Conditional Entropy for k = 5 : 0.8990178338823391
Ground truth 0 :
    F-measure for k = 5 is 0.5089950912212537
    Conditional entropy for k = 5 is 1.0734945818615977
Ground truth 1 :
    F-measure for k = 5 is 0.5832251013041951
    Conditional entropy for k = 5 is 0.7402397810421103
Ground truth 2 :
    F-measure for k = 5 is 0.5170793893012124
    Conditional entropy for k = 5 is 0.8715498817022798
Ground truth 3 :
    F-measure for k = 5 is 0.49704068171197247
    Conditional entropy for k = 5 is 0.9904684715144629
Ground truth 4 :
    F-measure for k = 5 is 0.6007336250907378
    Conditional entropy for k = 5 is 0.8193364532912446
-----
Average F-measure for k = 7 : 0.5922227889495345
Average Conditional Entropy for k = 7 : 0.8027416210487488
Ground truth 0 :
    F-measure for k = 7 is 0.5873270639046029
    Conditional entropy for k = 7 is 0.9675746889518186
Ground truth 1 :
    F-measure for k = 7 is 0.5992471736495613
    Conditional entropy for k = 7 is 0.6553437702058312
Ground truth 2 :
    F-measure for k = 7 is 0.5567405594999105
    Conditional entropy for k = 7 is 0.7867479790916072
Ground truth 3 :
    F-measure for k = 7 is 0.5894474568795652
    Conditional entropy for k = 7 is 0.8845464914681018
Ground truth 4 :
    F-measure for k = 7 is 0.628351690814033
    Conditional entropy for k = 7 is 0.7194951755263849
-----
```

```

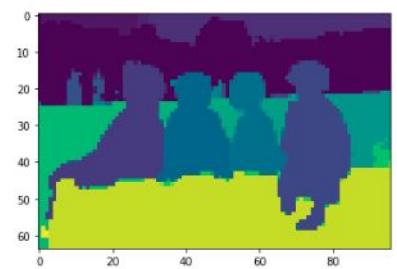
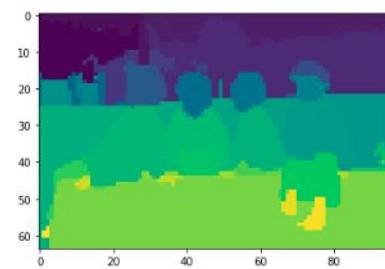
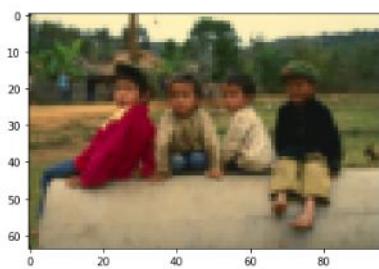
Average F-measure for k = 9 : 0.556548100657796
Average Conditional Entropy for k = 9 : 0.7147398151779336
Ground truth 0 :
    F-measure for k = 9 is 0.5605072116912451
    Conditional entropy for k = 9 is 0.8729594547235522
Ground truth 1 :
    F-measure for k = 9 is 0.5470114714907997
    Conditional entropy for k = 9 is 0.5747038332594465
Ground truth 2 :
    F-measure for k = 9 is 0.5113645950357113
    Conditional entropy for k = 9 is 0.7052509381923642
Ground truth 3 :
    F-measure for k = 9 is 0.5623292100955961
    Conditional entropy for k = 9 is 0.7878716836786208
Ground truth 4 :
    F-measure for k = 9 is 0.6015280149756282
    Conditional entropy for k = 9 is 0.6329131660356848
-----
Average F-measure for k = 11 : 0.482859913889062
Average Conditional Entropy for k = 11 : 0.7220017495439921
Ground truth 0 :
    F-measure for k = 11 is 0.49619344576803714
    Conditional entropy for k = 11 is 0.8804841364125051
Ground truth 1 :
    F-measure for k = 11 is 0.4635580038442265
    Conditional entropy for k = 11 is 0.5838169702484727
Ground truth 2 :
    F-measure for k = 11 is 0.4430173450367942
    Conditional entropy for k = 11 is 0.7115776051891489
Ground truth 3 :
    F-measure for k = 11 is 0.49293155224966595
    Conditional entropy for k = 11 is 0.7942838418559918
Ground truth 4 :
    F-measure for k = 11 is 0.5185992225465864
    Conditional entropy for k = 11 is 0.6398461940138426
-----
```

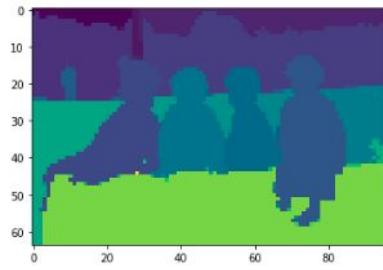
- NN-5

In NN-5 we can see that it depends on neighbours so pixels have more similarity
bs in same cluster which is not good and not bad, it depends on images.

Image 15011

Image 15011





NN-5 cluster results :

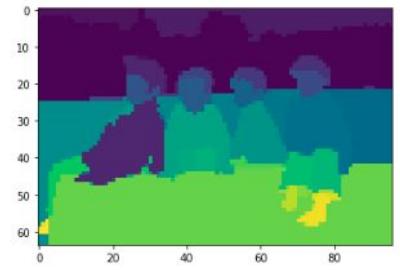
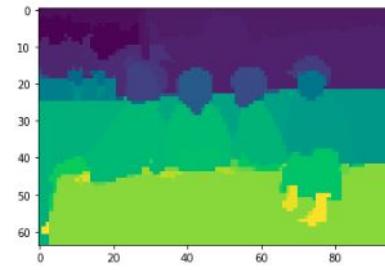
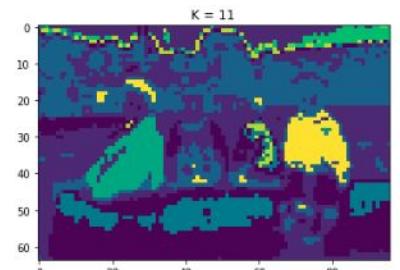
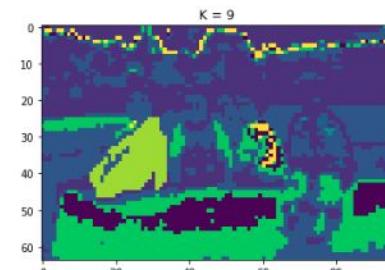
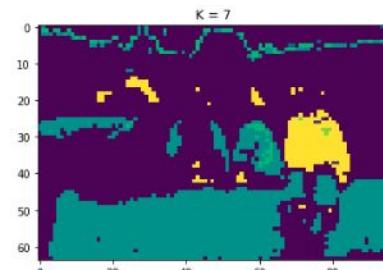
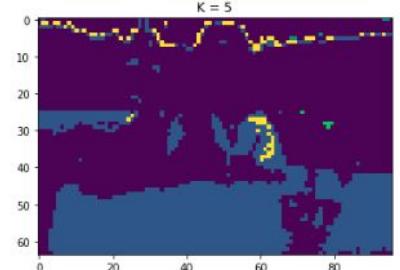
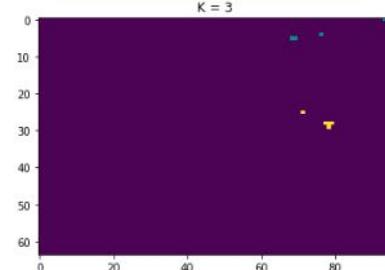


Image 15011



Average F-measure for k = 3 : 0.14521177298642504

Average Conditional Entropy for k = 3 : 1.2308934405176264

Ground truth 0 :

F-measure for k = 3 is 0.13113649878055866

Conditional entropy for k = 3 is 1.4349487340734774

Ground truth 1 :

F-measure for k = 3 is 0.1529987783593729

Conditional entropy for k = 3 is 1.0361183126506033

Ground truth 2 :

F-measure for k = 3 is 0.11808649916666851

Conditional entropy for k = 3 is 1.1636410578027965

Ground truth 3 :

F-measure for k = 3 is 0.16331977699719633

Conditional entropy for k = 3 is 1.3491881634707257

Ground truth 4 :

F-measure for k = 3 is 0.16051731162832886

Conditional entropy for k = 3 is 1.17057093459053

```

Average F-measure for k = 5 : 0.27002614436191374
Average Conditional Entropy for k = 5 : 1.0565068538972084
Ground truth 0 :
    F-measure for k = 5 is 0.24976856242940002
    Conditional entropy for k = 5 is 1.2498743526070086
Ground truth 1 :
    F-measure for k = 5 is 0.2894131840963231
    Conditional entropy for k = 5 is 0.8779482149467429
Ground truth 2 :
    F-measure for k = 5 is 0.2308073589052258
    Conditional entropy for k = 5 is 1.0065035764027563
Ground truth 3 :
    F-measure for k = 5 is 0.27863094046109094
    Conditional entropy for k = 5 is 1.1648605966071686
Ground truth 4 :
    F-measure for k = 5 is 0.30151067591752884
    Conditional entropy for k = 5 is 0.9833475289223661
-----
Average F-measure for k = 7 : 0.28589581425242444
Average Conditional Entropy for k = 7 : 1.0214701154348174
Ground truth 0 :
    F-measure for k = 7 is 0.2830466244818171
    Conditional entropy for k = 7 is 1.207401609459321
Ground truth 1 :
    F-measure for k = 7 is 0.28490476060268477
    Conditional entropy for k = 7 is 0.8519886266048997
Ground truth 2 :
    F-measure for k = 7 is 0.24377599892652402
    Conditional entropy for k = 7 is 0.9811039236242605
Ground truth 3 :
    F-measure for k = 7 is 0.28145589683028677
    Conditional entropy for k = 7 is 1.1213727535805442
Ground truth 4 :
    F-measure for k = 7 is 0.3362957904208096
    Conditional entropy for k = 7 is 0.9454836639050622
-----
Average F-measure for k = 9 : 0.30409465559873256
Average Conditional Entropy for k = 9 : 0.9445286388574214
Ground truth 0 :
    F-measure for k = 9 is 0.3054373606696127
    Conditional entropy for k = 9 is 1.122835504646072
Ground truth 1 :
    F-measure for k = 9 is 0.29546133399510754
    Conditional entropy for k = 9 is 0.7811404054399369
Ground truth 2 :
    F-measure for k = 9 is 0.2724931728240482
    Conditional entropy for k = 9 is 0.9082745505044807
Ground truth 3 :
    F-measure for k = 9 is 0.3261707369488945
    Conditional entropy for k = 9 is 1.0381789253330846
Ground truth 4 :
    F-measure for k = 9 is 0.32091067355599984
    Conditional entropy for k = 9 is 0.8722138083635324
-----
Average F-measure for k = 11 : 0.3490860626083144
Average Conditional Entropy for k = 11 : 0.88053818226553
Ground truth 0 :
    F-measure for k = 11 is 0.3529371172648404
    Conditional entropy for k = 11 is 1.0525971718430729
Ground truth 1 :
    F-measure for k = 11 is 0.3370577201590094
    Conditional entropy for k = 11 is 0.7275947272089416
Ground truth 2 :
    F-measure for k = 11 is 0.3128003535055862
    Conditional entropy for k = 11 is 0.8557420185938166
Ground truth 3 :
    F-measure for k = 11 is 0.35804343427543145
    Conditional entropy for k = 11 is 0.9660306200238056
Ground truth 4 :
    F-measure for k = 11 is 0.3845916878367042
    Conditional entropy for k = 11 is 0.8007263736580136
-----
```

Good,Bad outputs for each configuration

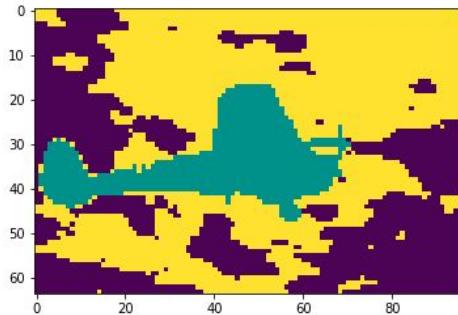
- RBF-1

- The printing of k-means with $k = 3$ is a type, those are results of rbf with the indicated k .
- As we go for higher k 's conditional entropy decreases.

K-means with $k = 3$
 Good image :
 Image 3063

The best image is the same for K-means, for $k = 3$ it appears the three clusters have plane and sky with clouds.

RBF-1 cluster results :

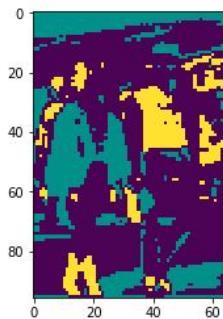


```
Average F-measure for k = 3 : 0.741622707316392
Average Conditional Entropy for k = 3 : 0.16215567020062713
Ground truth 0 :
    F-measure for k = 3 is 0.7595071899843835
    Conditional entropy for k = 3 is 0.05036777585059553
Ground truth 1 :
    F-measure for k = 3 is 0.7580817037838452
    Conditional entropy for k = 3 is 0.05272171077583822
Ground truth 2 :
    F-measure for k = 3 is 0.7589115008038211
    Conditional entropy for k = 3 is 0.05532195807810388
Ground truth 3 :
    F-measure for k = 3 is 0.7553007053301147
    Conditional entropy for k = 3 is 0.06599798990283623
Ground truth 4 :
    F-measure for k = 3 is 0.6651017212274611
    Conditional entropy for k = 3 is 0.6779240379579539
Ground truth 5 :
    F-measure for k = 3 is 0.7528334227687258
    Conditional entropy for k = 3 is 0.07060054863843496
```

Bad image :
 Image 23050

Bad image is the same as k-means also, 3 clusters are not enough to show details.

RBF-1 cluster results :



```

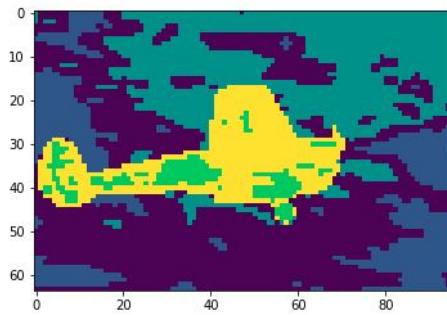
Average F-measure for k = 3 : 0.3398939872112348
Average Conditional Entropy for k = 3 : 1.3113893777226175
Ground truth 0 :
    F-measure for k = 3 is 0.2854941558691784
    Conditional entropy for k = 3 is 1.3944646536879057
Ground truth 1 :
    F-measure for k = 3 is 0.3319912428543938
    Conditional entropy for k = 3 is 0.946012232407388
Ground truth 2 :
    F-measure for k = 3 is 0.35477981635109224
    Conditional entropy for k = 3 is 1.3950185248664018
Ground truth 3 :
    F-measure for k = 3 is 0.3500641625798861
    Conditional entropy for k = 3 is 1.3611977227626375
Ground truth 4 :
    F-measure for k = 3 is 0.3659758335500878
    Conditional entropy for k = 3 is 1.3573833317207253
Ground truth 5 :
    F-measure for k = 3 is 0.3510587120627706
    Conditional entropy for k = 3 is 1.414259800890647
-----
```

```

K-means with k = 5
Good image :
Image 3063
```

Below we can see more details in plane body and sky, this is image is the best for showing as deep details can appear with k = 5.

RBF-1 cluster results :



```

Average F-measure for k = 5 : 0.5402533290376257
Average Conditional Entropy for k = 5 : 0.13200482308618014
Ground truth 0 :
    F-measure for k = 5 is 0.5365783158084332
    Conditional entropy for k = 5 is 0.033025024487932486
Ground truth 1 :
    F-measure for k = 5 is 0.5374706184941703
    Conditional entropy for k = 5 is 0.031210835036285776
Ground truth 2 :
    F-measure for k = 5 is 0.5365988012639107
    Conditional entropy for k = 5 is 0.035577043128062855
Ground truth 3 :
    F-measure for k = 5 is 0.5329857807754557
    Conditional entropy for k = 5 is 0.05066405359667983
Ground truth 4 :
    F-measure for k = 5 is 0.5708878069008936
    Conditional entropy for k = 5 is 0.5877821047000236
Ground truth 5 :
    F-measure for k = 5 is 0.5269986509828907
    Conditional entropy for k = 5 is 0.05376987756809627
-----

```

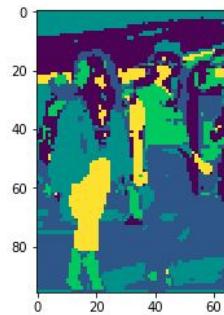
```

Bad image :
Image 23050

```

Below we can see that nothing is clear, clusters can't divide pixels in a good way.

RBF-1 cluster results :



```

Average F-measure for k = 5 : 0.4631930179166317
Average Conditional Entropy for k = 5 : 1.1096845411792517
Ground truth 0 :
    F-measure for k = 5 is 0.44692438496057363
    Conditional entropy for k = 5 is 1.166888759367995
Ground truth 1 :
    F-measure for k = 5 is 0.3950519532608851
    Conditional entropy for k = 5 is 0.8315541267513448
Ground truth 2 :
    F-measure for k = 5 is 0.4934294584634401
    Conditional entropy for k = 5 is 1.1679232039812348
Ground truth 3 :
    F-measure for k = 5 is 0.49243961195976504
    Conditional entropy for k = 5 is 1.1437167061460312
Ground truth 4 :
    F-measure for k = 5 is 0.5004053737252615
    Conditional entropy for k = 5 is 1.1513199930656717
Ground truth 5 :
    F-measure for k = 5 is 0.45090732512986464
    Conditional entropy for k = 5 is 1.1967044577632333
-----

```

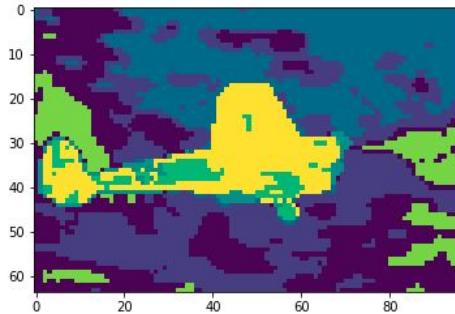
```

K-means with k = 7
Good image :
Image 3063

```

Below we can see more and more details, plane wheels and shapes of clouds.
Similar pixels are together.

RBF-1 cluster results :



```

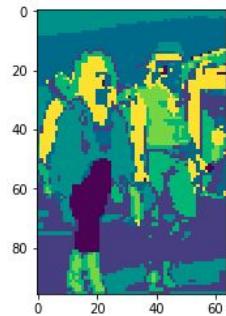
Average F-measure for k = 7 : 0.42506748804540506
Average Conditional Entropy for k = 7 : 0.12161321241064695
Ground truth 0 :
    F-measure for k = 7 is 0.41003198382224937
    Conditional entropy for k = 7 is 0.028410255041942237
Ground truth 1 :
    F-measure for k = 7 is 0.4100150248812122
    Conditional entropy for k = 7 is 0.028754821020436697
Ground truth 2 :
    F-measure for k = 7 is 0.40933042301606204
    Conditional entropy for k = 7 is 0.031011561408051024
Ground truth 3 :
    F-measure for k = 7 is 0.4041532362278365
    Conditional entropy for k = 7 is 0.04354672565150748
Ground truth 4 :
    F-measure for k = 7 is 0.5172912580991786
    Conditional entropy for k = 7 is 0.5551928352317738
Ground truth 5 :
    F-measure for k = 7 is 0.39958300222589166
    Conditional entropy for k = 7 is 0.04276307611017047
-----
```

```

Bad image :
Image 23050
```

Below we can start see similar pixels are getting together however there is a wide range, different colours are in the same cluster.

RBF-1 cluster results :



```

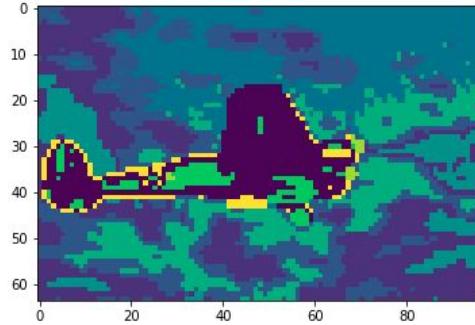
Average F-measure for k = 7 : 0.46021052858876704
Average Conditional Entropy for k = 7 : 1.0290050969808695
Ground truth 0 :
    F-measure for k = 7 is 0.4647932448451354
    Conditional entropy for k = 7 is 1.0815546389875854
Ground truth 1 :
    F-measure for k = 7 is 0.3378779400284146
    Conditional entropy for k = 7 is 0.7728297854378341
Ground truth 2 :
    F-measure for k = 7 is 0.5006143249597613
    Conditional entropy for k = 7 is 1.0845691158563924
Ground truth 3 :
    F-measure for k = 7 is 0.49242303851112185
    Conditional entropy for k = 7 is 1.0622591338305352
Ground truth 4 :
    F-measure for k = 7 is 0.5046451170834838
    Conditional entropy for k = 7 is 1.0623092222178676
Ground truth 5 :
    F-measure for k = 7 is 0.4609095061046852
    Conditional entropy for k = 7 is 1.1105086855550028
-----
```

```

K-means with k = 9
Good image :
Image 3063
```

Below we can see a more detailed image, the shape of plane appears, similar pixels are in same cluster.

RBF-1 cluster results :



```

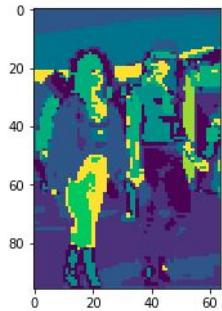
Average F-measure for k = 9 : 0.36568268907436136
Average Conditional Entropy for k = 9 : 0.1211210995036046
Ground truth 0 :
    F-measure for k = 9 is 0.3260289582902563
    Conditional entropy for k = 9 is 0.030046714873625115
Ground truth 1 :
    F-measure for k = 9 is 0.3265536190362
    Conditional entropy for k = 9 is 0.030558620073238126
Ground truth 2 :
    F-measure for k = 9 is 0.3258793588941116
    Conditional entropy for k = 9 is 0.033085294096089526
Ground truth 3 :
    F-measure for k = 9 is 0.3715651867938463
    Conditional entropy for k = 9 is 0.04465447274545337
Ground truth 4 :
    F-measure for k = 9 is 0.4711657171700146
    Conditional entropy for k = 9 is 0.543823970393909
Ground truth 5 :
    F-measure for k = 9 is 0.3729032942617394
    Conditional entropy for k = 9 is 0.044557524839312565
-----
```

```

Bad image :
Image 23050
```

Below we start see shape and more details however some different pixels are still in same cluster.

RBF-1 cluster results :



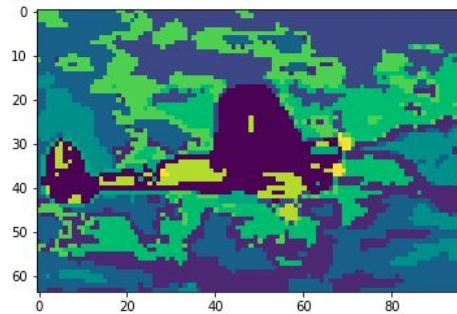
```

Average F-measure for k = 9 : 0.4562212926311943
Average Conditional Entropy for k = 9 : 0.995661633269964
Ground truth 0 :
    F-measure for k = 9 is 0.4592662068510633
    Conditional entropy for k = 9 is 1.0471001131648672
Ground truth 1 :
    F-measure for k = 9 is 0.28646630188216793
    Conditional entropy for k = 9 is 0.7532287679036596
Ground truth 2 :
    F-measure for k = 9 is 0.5112993341459021
    Conditional entropy for k = 9 is 1.048504480474352
Ground truth 3 :
    F-measure for k = 9 is 0.49920336531098614
    Conditional entropy for k = 9 is 1.023849415500956
Ground truth 4 :
    F-measure for k = 9 is 0.511751730940293
    Conditional entropy for k = 9 is 1.028181058210893
Ground truth 5 :
    F-measure for k = 9 is 0.46934081665675387
    Conditional entropy for k = 9 is 1.0731059643650558
-----
K-means with k = 11
Good image :
Image 3063

```

We can see the good image in a detailed clusters, each cluster have the most similar pixels.

RBF-1 cluster results :



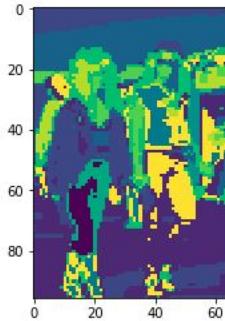
```

Average F-measure for k = 11 : 0.30477256683865134
Average Conditional Entropy for k = 11 : 0.11936161542153327
Ground truth 0 :
    F-measure for k = 11 is 0.27135326599617793
    Conditional entropy for k = 11 is 0.03358861833532303
Ground truth 1 :
    F-measure for k = 11 is 0.2717897555602367
    Conditional entropy for k = 11 is 0.0338298277583719
Ground truth 2 :
    F-measure for k = 11 is 0.27197522783577877
    Conditional entropy for k = 11 is 0.03455961157602596
Ground truth 3 :
    F-measure for k = 11 is 0.30869996277710576
    Conditional entropy for k = 11 is 0.047317525067225794
Ground truth 4 :
    F-measure for k = 11 is 0.39407233931004854
    Conditional entropy for k = 11 is 0.521523836027547
Ground truth 5 :
    F-measure for k = 11 is 0.31074484955256043
    Conditional entropy for k = 11 is 0.04535027376470581
-----
Bad image :
Image 23050

```

Below we can see some similar pixels in the same cluster, however it's not clear.

RBF-1 cluster results :



```

Average F-measure for k = 11 : 0.4501493487281138
Average Conditional Entropy for k = 11 : 0.9506285508394927
Ground truth 0 :
    F-measure for k = 11 is 0.4658551784296463
    Conditional entropy for k = 11 is 0.9970667685575303
Ground truth 1 :
    F-measure for k = 11 is 0.27021846182073644
    Conditional entropy for k = 11 is 0.7258510510088186
Ground truth 2 :
    F-measure for k = 11 is 0.5102033448430408
    Conditional entropy for k = 11 is 1.001927376531489
Ground truth 3 :
    F-measure for k = 11 is 0.496535782219499
    Conditional entropy for k = 11 is 0.9772744251204178
Ground truth 4 :
    F-measure for k = 11 is 0.4938555530888202
    Conditional entropy for k = 11 is 0.9746143734372057
Ground truth 5 :
    F-measure for k = 11 is 0.46422777196694026
    Conditional entropy for k = 11 is 1.0270373103814945
-----
```

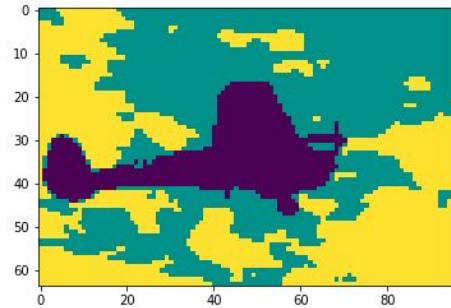
- RBF-10

```

RBF-10 with k = 3
Good image :
Image 3063
```

The best image is the same for RBF-1, plane and sky with clouds have similar colours so can be divided into few number of cluster.

RBF-10 cluster results :



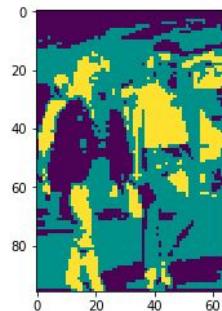
```

Average F-measure for k = 3 : 0.7442253271146613
Average Conditional Entropy for k = 3 : 0.16076838370387198
Ground truth 0 :
    F-measure for k = 3 is 0.7605980422828574
    Conditional entropy for k = 3 is 0.05054923644129965
Ground truth 1 :
    F-measure for k = 3 is 0.7591605135557984
    Conditional entropy for k = 3 is 0.05297230598608328
Ground truth 2 :
    F-measure for k = 3 is 0.7607376677359201
    Conditional entropy for k = 3 is 0.05522935704289748
Ground truth 3 :
    F-measure for k = 3 is 0.7578837355904403
    Conditional entropy for k = 3 is 0.06593496851757122
Ground truth 4 :
    F-measure for k = 3 is 0.6727301567127734
    Conditional entropy for k = 3 is 0.6683203347170064
Ground truth 5 :
    F-measure for k = 3 is 0.7542418468101779
    Conditional entropy for k = 3 is 0.07160409951837386
-----
Bad image :
Image 23050

```

Bad image is the same as RBF-1, This image have many colours and can't be clustered into three clusters to get nice details and this appears below.

RBF-10 cluster results :



```

Average F-measure for k = 3 : 0.2902757209605254
Average Conditional Entropy for k = 3 : 1.3192939148080582
Ground truth 0 :
    F-measure for k = 3 is 0.23704685362796699
    Conditional entropy for k = 3 is 1.3983030632935378
Ground truth 1 :
    F-measure for k = 3 is 0.3409023068646195
    Conditional entropy for k = 3 is 0.9366056468919554
Ground truth 2 :
    F-measure for k = 3 is 0.2877499256446347
    Conditional entropy for k = 3 is 1.3958893319836647
Ground truth 3 :
    F-measure for k = 3 is 0.2868966461973532
    Conditional entropy for k = 3 is 1.3661680867816397
Ground truth 4 :
    F-measure for k = 3 is 0.3045715652067278
    Conditional entropy for k = 3 is 1.3647648703197979
Ground truth 5 :
    F-measure for k = 3 is 0.28448702822185035
    Conditional entropy for k = 3 is 1.454032489577754
-----

```

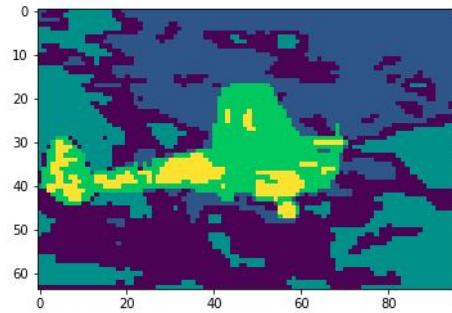
```

RBF-10 with k = 5
Good image :
Image 3063

```

Moving with the good image to k = 5, details of plane increases, and clouds start to have a shape.

RBF-10 cluster results :



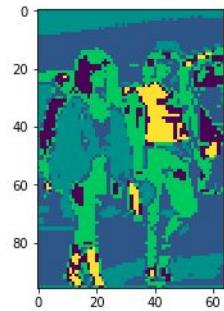
```

Average F-measure for k = 5 : 0.5518598590771994
Average Conditional Entropy for k = 5 : 0.1365587539211646
Ground truth 0 :
    F-measure for k = 5 is 0.5452335265096411
    Conditional entropy for k = 5 is 0.0388223600719774
Ground truth 1 :
    F-measure for k = 5 is 0.5444628932515906
    Conditional entropy for k = 5 is 0.039697600701101544
Ground truth 2 :
    F-measure for k = 5 is 0.5455483570162805
    Conditional entropy for k = 5 is 0.042364670925381376
Ground truth 3 :
    F-measure for k = 5 is 0.5438667143447824
    Conditional entropy for k = 5 is 0.05391885480318652
Ground truth 4 :
    F-measure for k = 5 is 0.5919976715346393
    Conditional entropy for k = 5 is 0.5880327246388845
Ground truth 5 :
    F-measure for k = 5 is 0.540049991806262
    Conditional entropy for k = 5 is 0.05651631238645628
-----
Bad image :
Image 23050

```

Moving with the bad image at $k = 5$, still no details appear, it seems similar pixels are in different clusters.

RBF-10 cluster results :



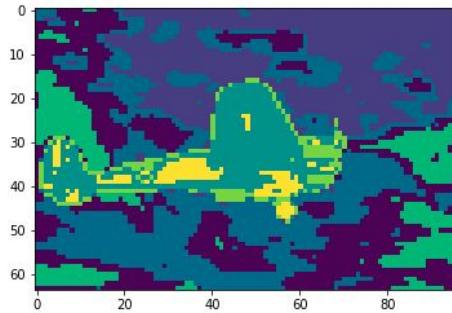
```

Average F-measure for k = 5 : 0.36020211681744785
Average Conditional Entropy for k = 5 : 1.2006797600048487
Ground truth 0 :
    F-measure for k = 5 is 0.32274422667086033
    Conditional entropy for k = 5 is 1.2693076825104546
Ground truth 1 :
    F-measure for k = 5 is 0.3300177019169215
    Conditional entropy for k = 5 is 0.8573000901760798
Ground truth 2 :
    F-measure for k = 5 is 0.3726549902644157
    Conditional entropy for k = 5 is 1.2695844410473973
Ground truth 3 :
    F-measure for k = 5 is 0.37751254999908024
    Conditional entropy for k = 5 is 1.2393434528303497
Ground truth 4 :
    F-measure for k = 5 is 0.3927631608918233
    Conditional entropy for k = 5 is 1.2342600536745008
Ground truth 5 :
    F-measure for k = 5 is 0.3655200711615859
    Conditional entropy for k = 5 is 1.3342828397903097
-----
RBF-10 with k = 7
Good image :
Image 3063

```

Moving with good image to k = 7, shape of plane and badge start to appear and clouds are in shapes. Similar pixels are together.

RBF-10 cluster results :



```

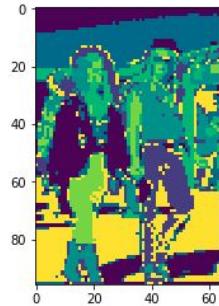
Average F-measure for k = 7 : 0.43705400726941224
Average Conditional Entropy for k = 7 : 0.11990575272660708
Ground truth 0 :
    F-measure for k = 7 is 0.4184707551541748
    Conditional entropy for k = 7 is 0.027864863862344276
Ground truth 1 :
    F-measure for k = 7 is 0.41925738060433954
    Conditional entropy for k = 7 is 0.02838613813356312
Ground truth 2 :
    F-measure for k = 7 is 0.4181228997428247
    Conditional entropy for k = 7 is 0.030459452155592825
Ground truth 3 :
    F-measure for k = 7 is 0.41582928069047587
    Conditional entropy for k = 7 is 0.04410628053769072
Ground truth 4 :
    F-measure for k = 7 is 0.539869268680551
    Conditional entropy for k = 7 is 0.5437110345983949
Ground truth 5 :
    F-measure for k = 7 is 0.41077445874410745
    Conditional entropy for k = 7 is 0.04490674707205669
-----

```

Bad image :
Image 23050

Moving with the bad image, the ground pixels are in same cluster but seems this cluster include different pixels too.

RBF-10 cluster results :



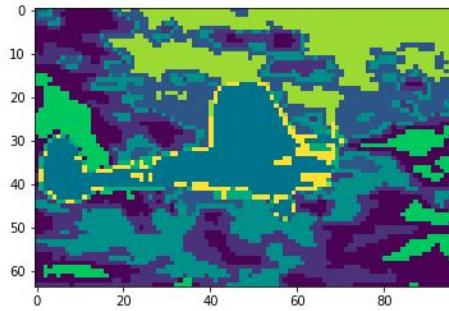
```

Average F-measure for k = 7 : 0.42853235521686245
Average Conditional Entropy for k = 7 : 1.065266372078071
Ground truth 0 :
    F-measure for k = 7 is 0.4275055176436534
    Conditional entropy for k = 7 is 1.117781347840898
Ground truth 1 :
    F-measure for k = 7 is 0.34808080483936127
    Conditional entropy for k = 7 is 0.7888237620409034
Ground truth 2 :
    F-measure for k = 7 is 0.4619937243710095
    Conditional entropy for k = 7 is 1.1118670322614397
Ground truth 3 :
    F-measure for k = 7 is 0.4549603481381269
    Conditional entropy for k = 7 is 1.0906721237427088
Ground truth 4 :
    F-measure for k = 7 is 0.45965699110512187
    Conditional entropy for k = 7 is 1.0962197917646899
Ground truth 5 :
    F-measure for k = 7 is 0.41899674520390173
    Conditional entropy for k = 7 is 1.1862341748177865
-----
RBF-10 with k = 9
Good image :
Image 3063

```

Moving with good image to k = 9 we can see the shape of plane the different layer of clouds. Conditional entropy is going done.

RBF-10 cluster results :



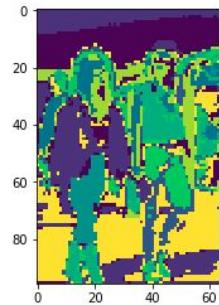
```

Average F-measure for k = 9 : 0.3439005796827242
Average Conditional Entropy for k = 9 : 0.11551707231420381
Ground truth 0 :
    F-measure for k = 9 is 0.3281049564119283
    Conditional entropy for k = 9 is 0.02432826060864112
Ground truth 1 :
    F-measure for k = 9 is 0.32922931933070615
    Conditional entropy for k = 9 is 0.02314168563658646
Ground truth 2 :
    F-measure for k = 9 is 0.3267704706067072
    Conditional entropy for k = 9 is 0.026352007255418832
Ground truth 3 :
    F-measure for k = 9 is 0.3239285996300355
    Conditional entropy for k = 9 is 0.039157854536174826
Ground truth 4 :
    F-measure for k = 9 is 0.434007547331761
    Conditional entropy for k = 9 is 0.5363861448995144
Ground truth 5 :
    F-measure for k = 9 is 0.3213625847852071
    Conditional entropy for k = 9 is 0.043736480948887255
-----
Bad image :
Image 23050

```

Moving with bad image to k = 9, the same as k = 7 nothing is new, cluster containing different pixels not similar only.

RBF-10 cluster results :



```

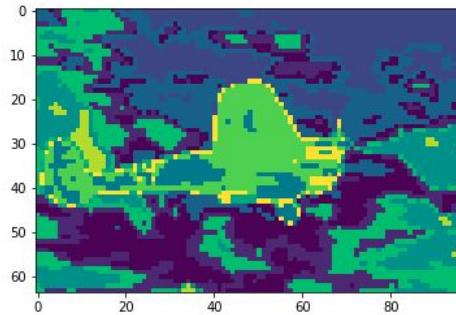
Average F-measure for k = 9 : 0.42221793877059954
Average Conditional Entropy for k = 9 : 1.0064320098350872
Ground truth 0 :
    F-measure for k = 9 is 0.43395303321063106
    Conditional entropy for k = 9 is 1.0514980349464875
Ground truth 1 :
    F-measure for k = 9 is 0.3062808084283424
    Conditional entropy for k = 9 is 0.7543784892572849
Ground truth 2 :
    F-measure for k = 9 is 0.46529955161027875
    Conditional entropy for k = 9 is 1.0488372022274353
Ground truth 3 :
    F-measure for k = 9 is 0.4542145802289191
    Conditional entropy for k = 9 is 1.030224708838234
Ground truth 4 :
    F-measure for k = 9 is 0.4507270869850366
    Conditional entropy for k = 9 is 1.034675536971264
Ground truth 5 :
    F-measure for k = 9 is 0.4228325721603893
    Conditional entropy for k = 9 is 1.1189780867698171
-----
```

```

RBF-10 with k = 11
Good image :
Image 3063
```

At k = 11 we can see the plane and its wheels and shape, and sky with clouds more below the plane and blue sky on upper. Conditional entropy is nearly 0.1

RBF-10 cluster results :



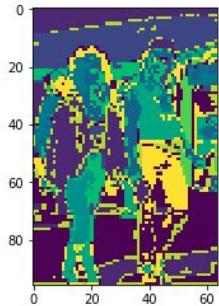
```

Average F-measure for k = 11 : 0.29832813967423893
Average Conditional Entropy for k = 11 : 0.11287337362119015
Ground truth 0 :
    F-measure for k = 11 is 0.28407444248739944
    Conditional entropy for k = 11 is 0.02470746859653397
Ground truth 1 :
    F-measure for k = 11 is 0.28495574818126856
    Conditional entropy for k = 11 is 0.023115423153111662
Ground truth 2 :
    F-measure for k = 11 is 0.28353770323034894
    Conditional entropy for k = 11 is 0.026973356178645866
Ground truth 3 :
    F-measure for k = 11 is 0.27853048783864426
    Conditional entropy for k = 11 is 0.04026735069704038
Ground truth 4 :
    F-measure for k = 11 is 0.3819145328475484
    Conditional entropy for k = 11 is 0.5206318549176391
Ground truth 5 :
    F-measure for k = 11 is 0.2769559234602238
    Conditional entropy for k = 11 is 0.041544788184169915
-----
Bad image :
Image 23050

```

At k = 11 conditional entropy is still 0.98, some shapes can be seen but still details are not clear.

RBF-10 cluster results :



```

Average F-measure for k = 11 : 0.4095899525127223
Average Conditional Entropy for k = 11 : 0.9847509310055743
Ground truth 0 :
    F-measure for k = 11 is 0.42082716458591185
    Conditional entropy for k = 11 is 1.0307146790002941
Ground truth 1 :
    F-measure for k = 11 is 0.24237276590488543
    Conditional entropy for k = 11 is 0.742496601181527
Ground truth 2 :
    F-measure for k = 11 is 0.46848239235363726
    Conditional entropy for k = 11 is 1.0236590462320354
Ground truth 3 :
    F-measure for k = 11 is 0.4551810783328351
    Conditional entropy for k = 11 is 1.0046808076780527
Ground truth 4 :
    F-measure for k = 11 is 0.45668867562181864
    Conditional entropy for k = 11 is 1.0112301993637063
Ground truth 5 :
    F-measure for k = 11 is 0.4139876382772453
    Conditional entropy for k = 11 is 1.0957242525778308
-----

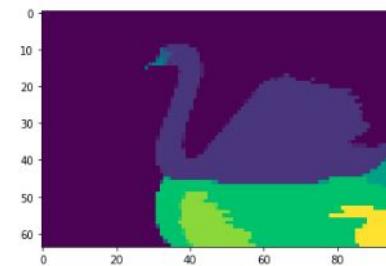
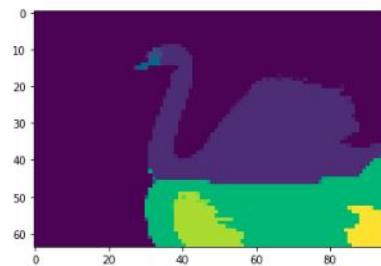
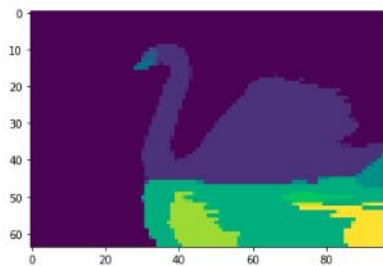
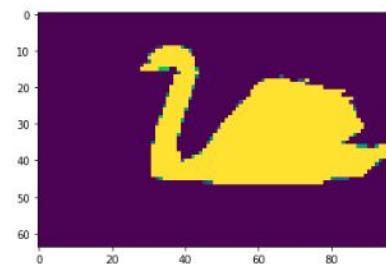
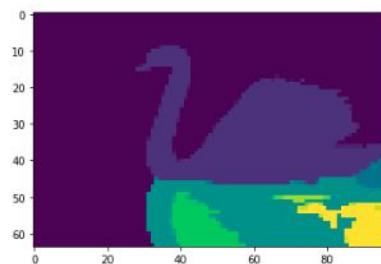
```

- NN-5

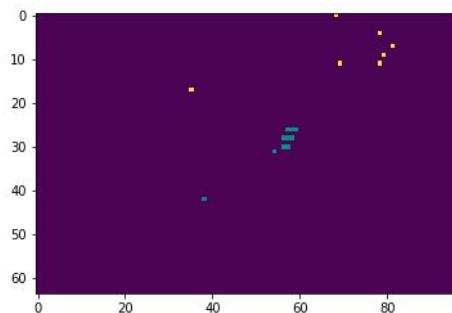
The good image here is a swan in lake, however we can see here in k=3 nothing can be detected in image this because neighbours of pixel in lake is colour of lake so it's a dominant cluster.

NN-5 with k = 3
Good image :
Image 8068

Image 8068



NN-5 cluster results :

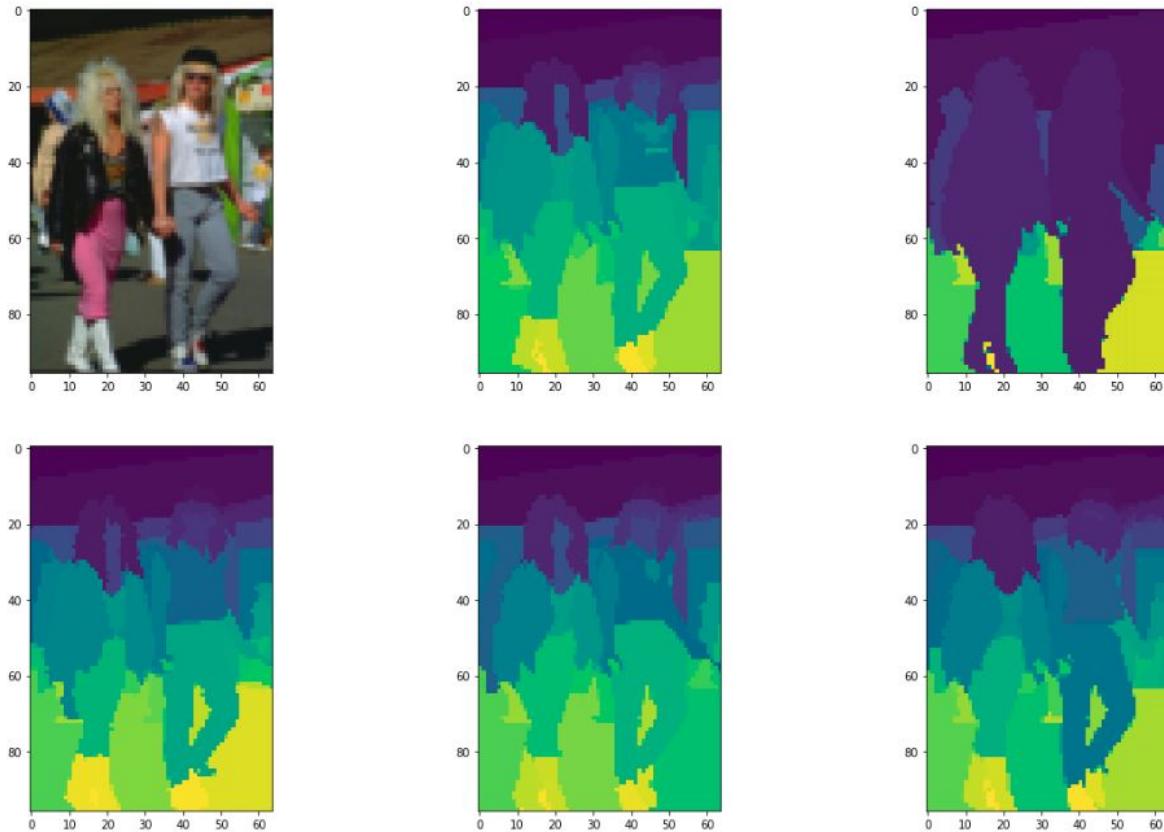


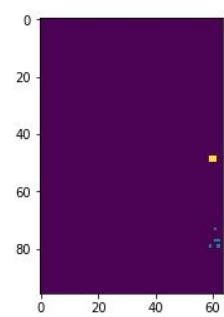
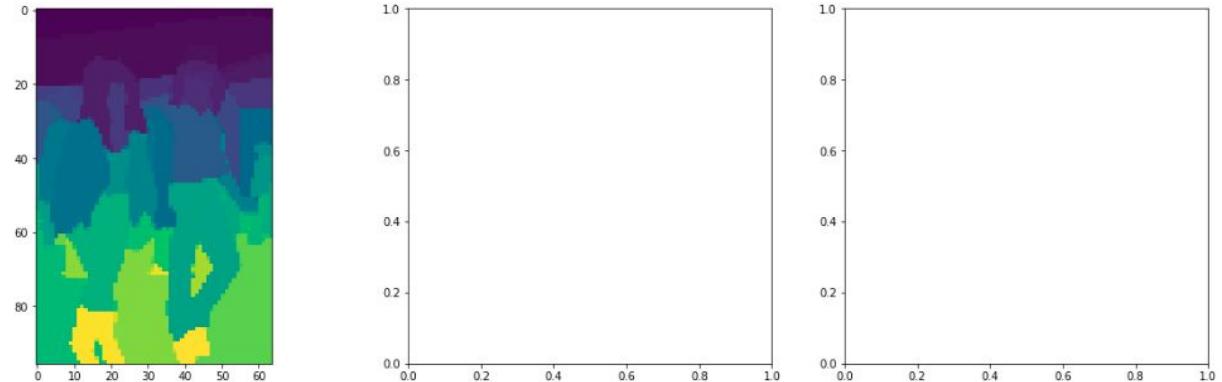
```
Average F-measure for k = 3 : 0.7983219219787805
Average Conditional Entropy for k = 3 : 0.2324317007452871
Ground truth 0 :
    F-measure for k = 3 is 0.834305560518599
    Conditional entropy for k = 3 is 0.27037248978291395
Ground truth 1 :
    F-measure for k = 3 is 0.6660038552144817
    Conditional entropy for k = 3 is 0.09817469801463688
Ground truth 2 :
    F-measure for k = 3 is 0.8302651156421366
    Conditional entropy for k = 3 is 0.2771172860526774
Ground truth 3 :
    F-measure for k = 3 is 0.8260040966400348
    Conditional entropy for k = 3 is 0.2572162225128568
Ground truth 4 :
    F-measure for k = 3 is 0.8350309818786507
    Conditional entropy for k = 3 is 0.2592778073633504
-----
```

Bad image is still as K-means, nearly all image in one cluster at k = 3, conditional entropy is 1.325

Bad image :
Image 23050

Image 23050





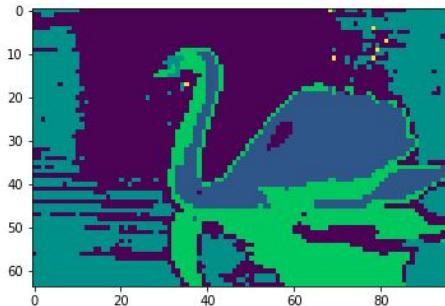
```

Average F-measure for k = 3 : 0.3398939872112348
Average Conditional Entropy for k = 3 : 1.325347374818103
Ground truth 0 :
    F-measure for k = 3 is 0.2854941558691784
    Conditional entropy for k = 3 is 1.4017090027785126
Ground truth 1 :
    F-measure for k = 3 is 0.3319912428543938
    Conditional entropy for k = 3 is 0.9472590213203781
Ground truth 2 :
    F-measure for k = 3 is 0.35477981635109224
    Conditional entropy for k = 3 is 1.4061957704868082
Ground truth 3 :
    F-measure for k = 3 is 0.3500641625798861
    Conditional entropy for k = 3 is 1.3666048135147428
Ground truth 4 :
    F-measure for k = 3 is 0.3659758335500878
    Conditional entropy for k = 3 is 1.3686583696227805
Ground truth 5 :
    F-measure for k = 3 is 0.3510587120627706
    Conditional entropy for k = 3 is 1.4616572711853957
-----
```

NN-5 with k = 5
Good image :
Image 8068

At k = 5 we nearly get the shape of swan and it's image in lake which is great.

NN-5 cluster results :



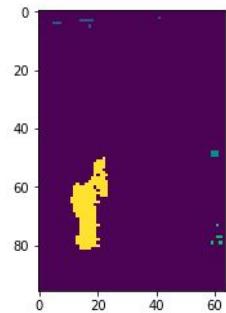
```

Average F-measure for k = 5 : 0.5562224683094776
Average Conditional Entropy for k = 5 : 0.24216470863971643
Ground truth 0 :
    F-measure for k = 5 is 0.5803938345100321
    Conditional entropy for k = 5 is 0.28553188352868647
Ground truth 1 :
    F-measure for k = 5 is 0.47929215640713824
    Conditional entropy for k = 5 is 0.09487789338031286
Ground truth 2 :
    F-measure for k = 5 is 0.5765339659408422
    Conditional entropy for k = 5 is 0.2886486505914461
Ground truth 3 :
    F-measure for k = 5 is 0.5687487770043639
    Conditional entropy for k = 5 is 0.2692662124402191
Ground truth 4 :
    F-measure for k = 5 is 0.5761436076850115
    Conditional entropy for k = 5 is 0.2724989032579175
-----
```

Bad image :
Image 23050

For bad image at k = 5 still nothing appears, conditional entropy is 1.12

NN-5 cluster results :



```

Average F-measure for k = 5 : 0.4610484162884551
Average Conditional Entropy for k = 5 : 1.123472721201774
Ground truth 0 :
    F-measure for k = 5 is 0.44692438496057363
    Conditional entropy for k = 5 is 1.1739899810686376
Ground truth 1 :
    F-measure for k = 5 is 0.3950519532608851
    Conditional entropy for k = 5 is 0.8326907197102713
Ground truth 2 :
    F-measure for k = 5 is 0.4934294584634401
    Conditional entropy for k = 5 is 1.178842985229122
Ground truth 3 :
    F-measure for k = 5 is 0.49243961195976504
    Conditional entropy for k = 5 is 1.149074163270541
Ground truth 4 :
    F-measure for k = 5 is 0.5004053737252615
    Conditional entropy for k = 5 is 1.1626459295077667
Ground truth 5 :
    F-measure for k = 5 is 0.4380397153608051
    Conditional entropy for k = 5 is 1.2435925484243076
-----

```

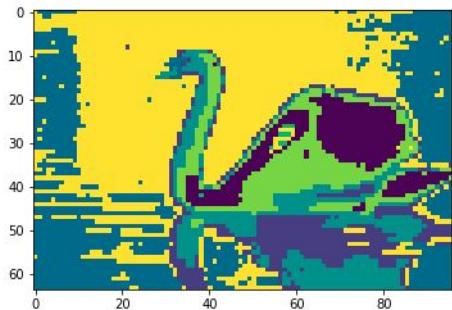
```

NN-5 with k = 7
Good image :
Image 8068

```

At k = 7 we can see the wave of water and details of swan, similar pixels are getting closer to each other in same cluster and more details appear.

NN-5 cluster results :



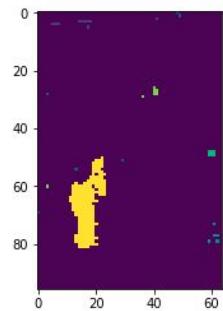
```

Average F-measure for k = 7 : 0.4761110656508266
Average Conditional Entropy for k = 7 : 0.21762430583989306
Ground truth 0 :
    F-measure for k = 7 is 0.4963766402899423
    Conditional entropy for k = 7 is 0.2577351421021493
Ground truth 1 :
    F-measure for k = 7 is 0.4023628456550317
    Conditional entropy for k = 7 is 0.08435108401828818
Ground truth 2 :
    F-measure for k = 7 is 0.49561347608543194
    Conditional entropy for k = 7 is 0.25999908377950653
Ground truth 3 :
    F-measure for k = 7 is 0.48974866012852447
    Conditional entropy for k = 7 is 0.24251206411313234
Ground truth 4 :
    F-measure for k = 7 is 0.4964537060952026
    Conditional entropy for k = 7 is 0.2435241551863889
-----
```

Bad image :
Image 23050

Still in Bad image can't recognize something good, this due to the different of pixels in this image.

NN-5 cluster results :



```

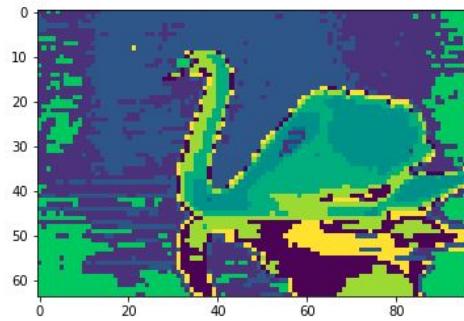
Average F-measure for k = 7 : 0.4592441514541701
Average Conditional Entropy for k = 7 : 1.0427138087248988
Ground truth 0 :
    F-measure for k = 7 is 0.4647932448451354
    Conditional entropy for k = 7 is 1.08908825293678
Ground truth 1 :
    F-measure for k = 7 is 0.3378779400284146
    Conditional entropy for k = 7 is 0.7740517365472279
Ground truth 2 :
    F-measure for k = 7 is 0.5006143249597613
    Conditional entropy for k = 7 is 1.0954100603749006
Ground truth 3 :
    F-measure for k = 7 is 0.49242303851112185
    Conditional entropy for k = 7 is 1.067298741860373
Ground truth 4 :
    F-measure for k = 7 is 0.5046451170834838
    Conditional entropy for k = 7 is 1.073056837902542
Ground truth 5 :
    F-measure for k = 7 is 0.4551112432971033
    Conditional entropy for k = 7 is 1.1573772227275685
-----
```

```

NN-5 with k = 9
Good image :
Image 8068
```

More and more details appear at k = 9, conditional entropy reaches 0.2, details of image of swan is appeared.

NN-5 cluster results :



```

Average F-measure for k = 9 : 0.4489777109149906
Average Conditional Entropy for k = 9 : 0.20349316788246719
Ground truth 0 :
    F-measure for k = 9 is 0.41753540817410373
    Conditional entropy for k = 9 is 0.24231346355689615
Ground truth 1 :
    F-measure for k = 9 is 0.31552081456432
    Conditional entropy for k = 9 is 0.07694247275454164
Ground truth 2 :
    F-measure for k = 9 is 0.5251353623169878
    Conditional entropy for k = 9 is 0.24359974727895656
Ground truth 3 :
    F-measure for k = 9 is 0.4987946077131194
    Conditional entropy for k = 9 is 0.22596796746272044
Ground truth 4 :
    F-measure for k = 9 is 0.4879023618064222
    Conditional entropy for k = 9 is 0.22864218835922112
-----

```

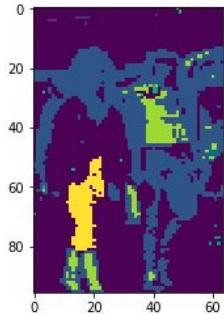
```

Bad image :
Image 23050

```

At k = 9 in Bad image we can see two shapes wearing clothes with different colours but there is no good details also, conditional entropy reaches 1.

NN-5 cluster results :



```

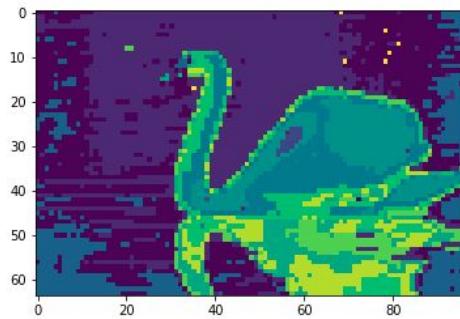
Average F-measure for k = 9 : 0.45538073335296786
Average Conditional Entropy for k = 9 : 1.009196028820958
Ground truth 0 :
    F-measure for k = 9 is 0.4592662068510633
    Conditional entropy for k = 9 is 1.0542616432860623
Ground truth 1 :
    F-measure for k = 9 is 0.28646630188216793
    Conditional entropy for k = 9 is 0.7544507190130537
Ground truth 2 :
    F-measure for k = 9 is 0.5112993341459021
    Conditional entropy for k = 9 is 1.0593274286304428
Ground truth 3 :
    F-measure for k = 9 is 0.49920336531098614
    Conditional entropy for k = 9 is 1.02876496286791
Ground truth 4 :
    F-measure for k = 9 is 0.511751730940293
    Conditional entropy for k = 9 is 1.0386704191021021
Ground truth 5 :
    F-measure for k = 9 is 0.464297460987395
    Conditional entropy for k = 9 is 1.1197010000261785
-----
```

```

NN-5 with k = 11
Good image :
Image 8068
```

Finally at $k = 11$ we can differentiate between the nose and head of swan, more details appears and conditional entropy reaches 0.19 , also the lake has more details which is great.

NN-5 cluster results :



```

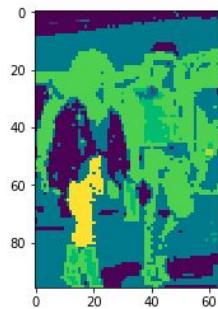
Average F-measure for k = 11 : 0.3625013146290005
Average Conditional Entropy for k = 11 : 0.19324856531747855
Ground truth 0 :
    F-measure for k = 11 is 0.33095338768506327
    Conditional entropy for k = 11 is 0.22706493604731123
Ground truth 1 :
    F-measure for k = 11 is 0.25596884725347024
    Conditional entropy for k = 11 is 0.07827339233922702
Ground truth 2 :
    F-measure for k = 11 is 0.4143569431062852
    Conditional entropy for k = 11 is 0.22962224605561382
Ground truth 3 :
    F-measure for k = 11 is 0.41116923144384115
    Conditional entropy for k = 11 is 0.21493159702828366
Ground truth 4 :
    F-measure for k = 11 is 0.40005816365634284
    Conditional entropy for k = 11 is 0.216350655116957
-----
```

```

Bad image :
Image 23050
```

At $k = 11$ still different pixels are in the same clusters as the neighbours are different from each other so usually each pixel is in a cluster where neighbours are not similar, conditional entropy reaches 0.96

NN-5 cluster results :



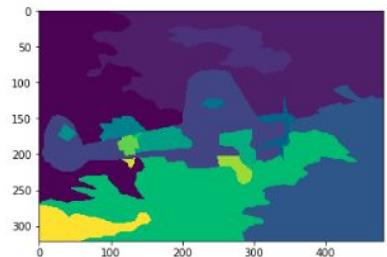
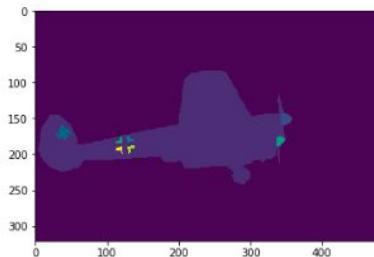
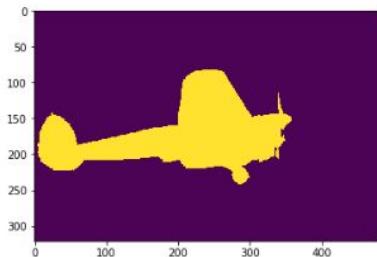
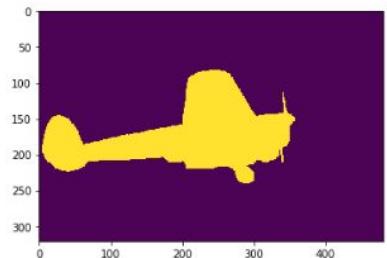
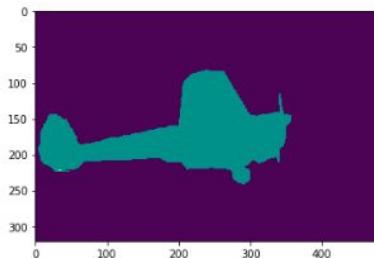
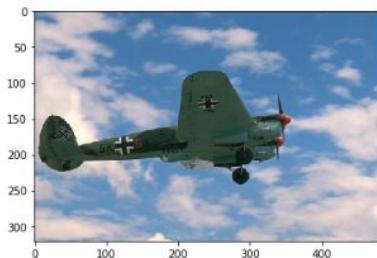
Average F-measure for k = 11 : 0.4495140650739622
Average Conditional Entropy for k = 11 : 0.9640349186509148
Ground truth 0 :
 F-measure for k = 11 is 0.4658551784296463
 Conditional entropy for k = 11 is 1.0040904088101494
Ground truth 1 :
 F-measure for k = 11 is 0.27021846182073644
 Conditional entropy for k = 11 is 0.7270730021182126
Ground truth 2 :
 F-measure for k = 11 is 0.5102033448430408
 Conditional entropy for k = 11 is 1.0123642762668967
Ground truth 3 :
 F-measure for k = 11 is 0.496535782219499
 Conditional entropy for k = 11 is 0.9822951596856769
Ground truth 4 :
 F-measure for k = 11 is 0.4938555530888202
 Conditional entropy for k = 11 is 0.9848921686143645
Ground truth 5 :
 F-measure for k = 11 is 0.46041607004203083
 Conditional entropy for k = 11 is 1.0734944964101896

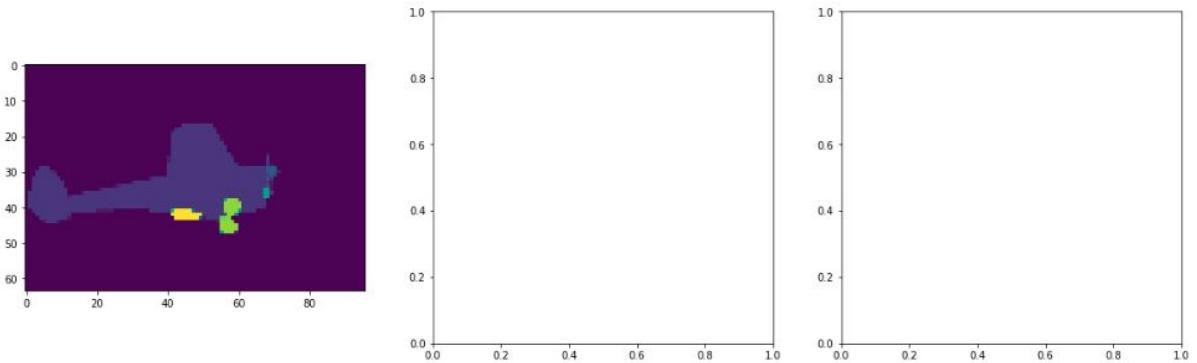
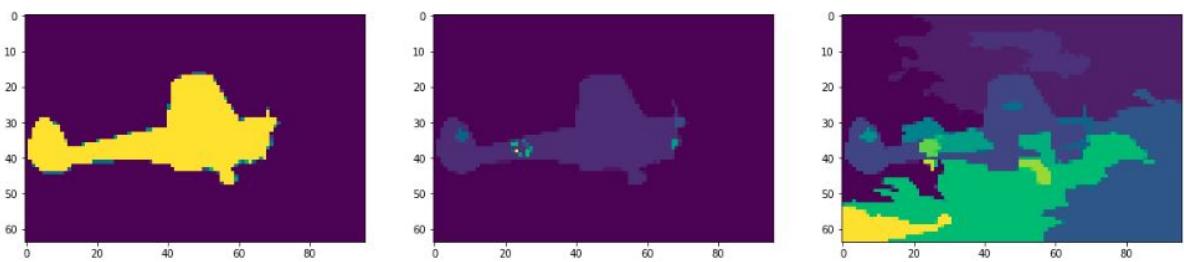
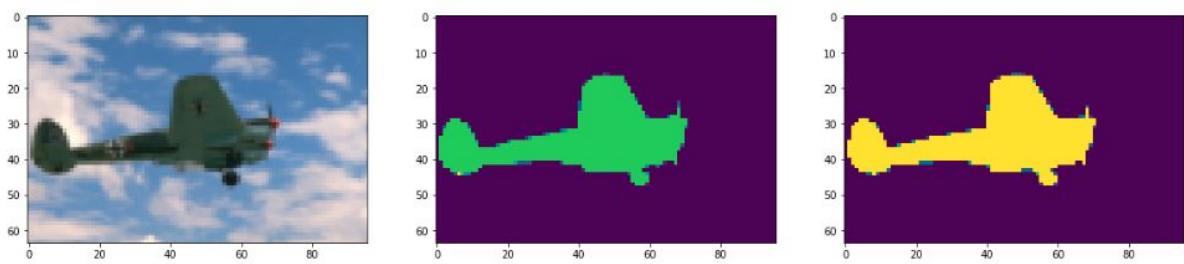
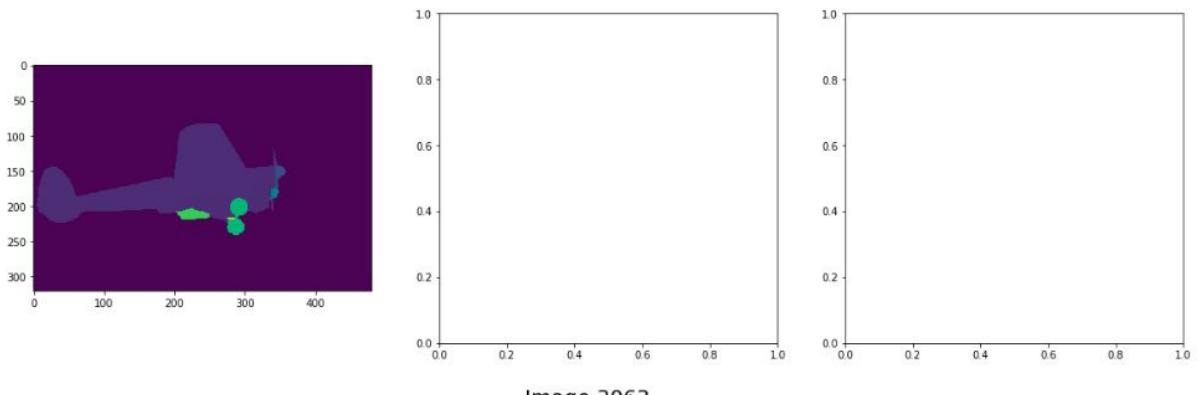
Five image comparisons

```
compare_indices = [1,4,16,7,24];
for j in compare_indices:
    show_compare_stats(real_data, real_gt, mod_data, mod_gt, k_results, s_results[2], names, j,
                        k_f, k_c, k_af, k_ac, nn5_f, nn5_c, nn5_af, nn5_ac);
```

Image 3063

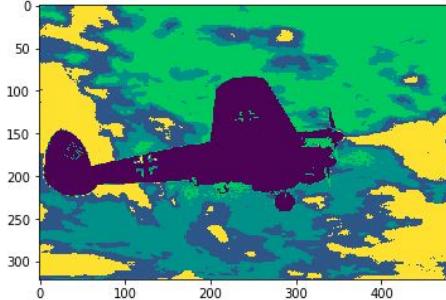
Image 3063



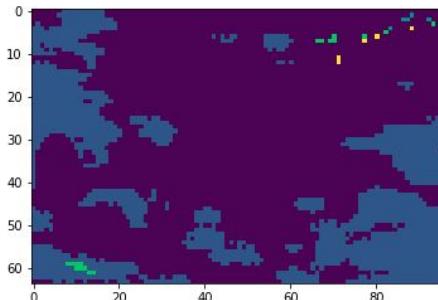


We can see in this two images that K-means is better than 5-NN in clustering this image as neighbours in images contains nearly similar pixels may be clustered in one cluster which is not that good, conditional entropy of k-means is lower than 5-NN.

Kmeans cluster results :



NN5 cluster results :



```

Average F-measure for k = 5 (kmeans): 0.5278724826619564
Average F-measure for k = 5 (spectral): 0.24256726166491263
Average Conditional Entropy for k = 5 (kmeans): 0.11236830436078325
Average Conditional Entropy for k = 5 (spectral): 0.3077968496922339
Ground truth 0 :
    F-measure for k = 5 (kmeans) is 0.5082131971929392
    F-measure for k = 5 (spectral) is 0.24403180607849456
    Conditional entropy for k = 5 (kmeans) is 0.030636706164696804
    Conditional entropy for k = 5 (spectral) is 0.1909727478762505
Ground truth 1 :
    F-measure for k = 5 (kmeans) is 0.5083208508517241
    F-measure for k = 5 (spectral) is 0.24393649824987723
    Conditional entropy for k = 5 (kmeans) is 0.03014058190438688
    Conditional entropy for k = 5 (spectral) is 0.19171686999685741
Ground truth 2 :
    F-measure for k = 5 (kmeans) is 0.509092143632641
    F-measure for k = 5 (spectral) is 0.2440844600817577
    Conditional entropy for k = 5 (kmeans) is 0.028146837872640166
    Conditional entropy for k = 5 (spectral) is 0.19696896365272337
Ground truth 3 :
    F-measure for k = 5 (kmeans) is 0.508045925918287
    F-measure for k = 5 (spectral) is 0.24420340914743416
    Conditional entropy for k = 5 (kmeans) is 0.03953018197008024
    Conditional entropy for k = 5 (spectral) is 0.20968020472619578
Ground truth 4 :
    F-measure for k = 5 (kmeans) is 0.626865119793456
    F-measure for k = 5 (spectral) is 0.2349558768146231
    Conditional entropy for k = 5 (kmeans) is 0.4986839508079111
    Conditional entropy for k = 5 (spectral) is 0.8408574546121236
Ground truth 5 :
    F-measure for k = 5 (kmeans) is 0.5066976585826912
    F-measure for k = 5 (spectral) is 0.24419151961728908
    Conditional entropy for k = 5 (kmeans) is 0.047071567444984315
    Conditional entropy for k = 5 (spectral) is 0.2165848572892528
-----
```

Image 8068

Image 8068

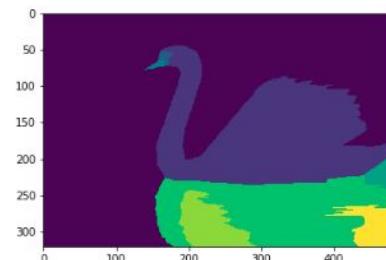
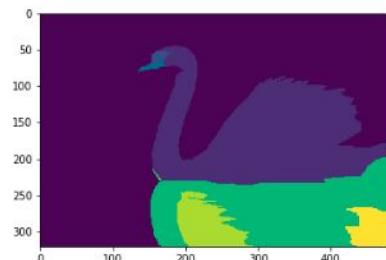
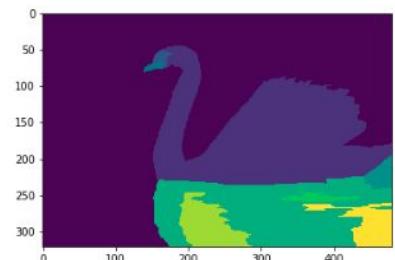
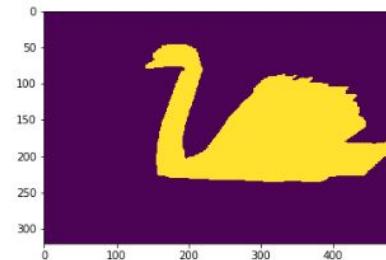
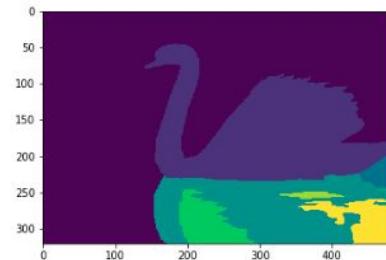
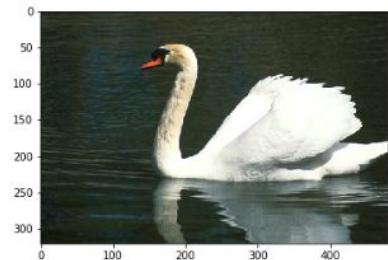
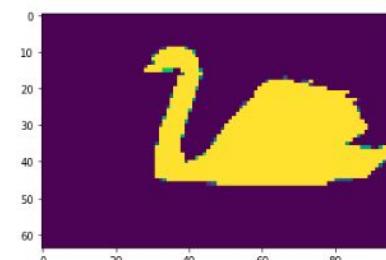
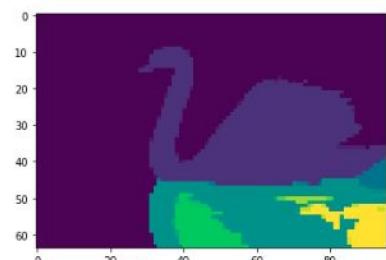
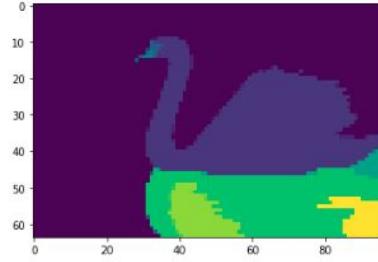
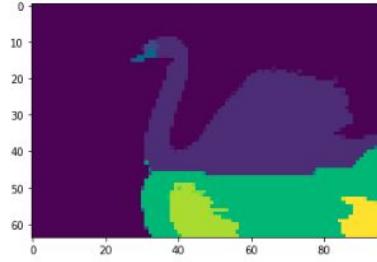
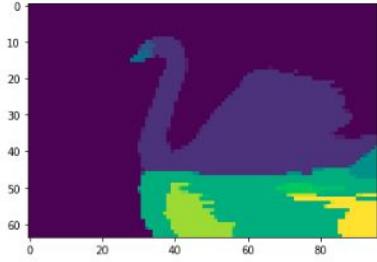


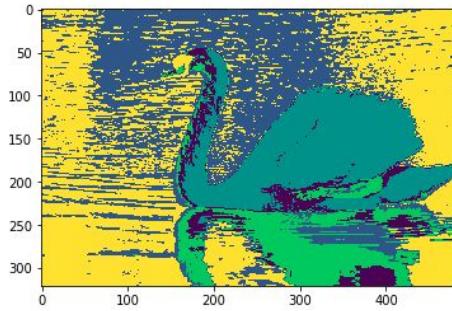
Image 8068



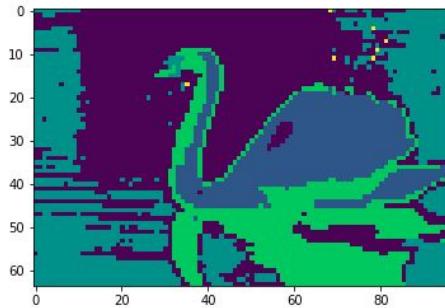
We can see in this two swan images that K-means is better than 5-NN in clustering this image however the swan in 5-NN looks clustered nice but k-means is more details



Kmeans cluster results :



NN5 cluster results :

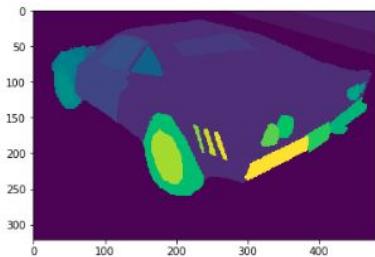
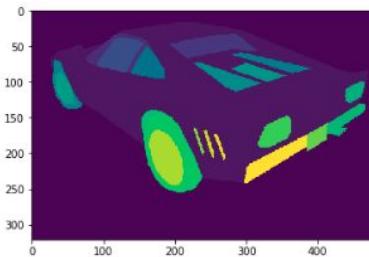
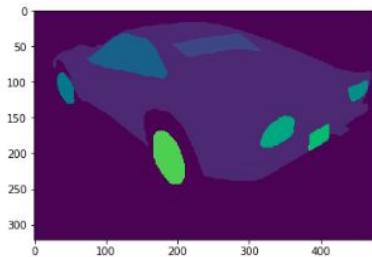
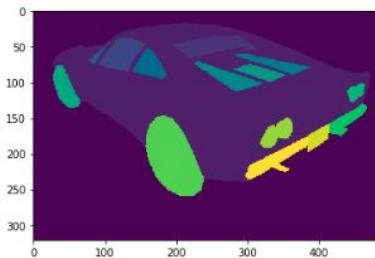
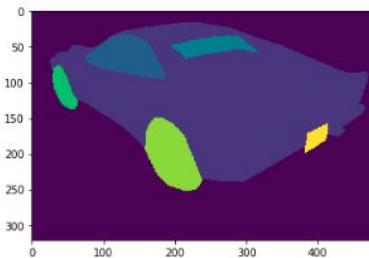


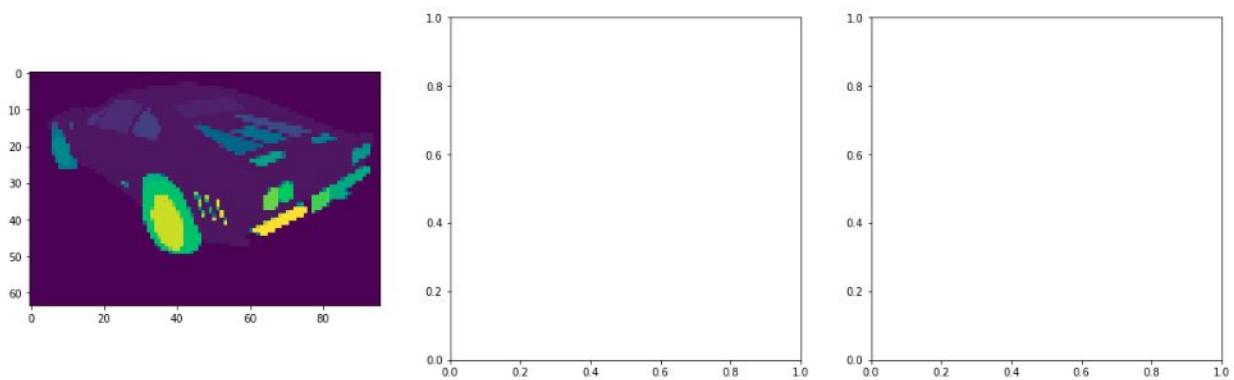
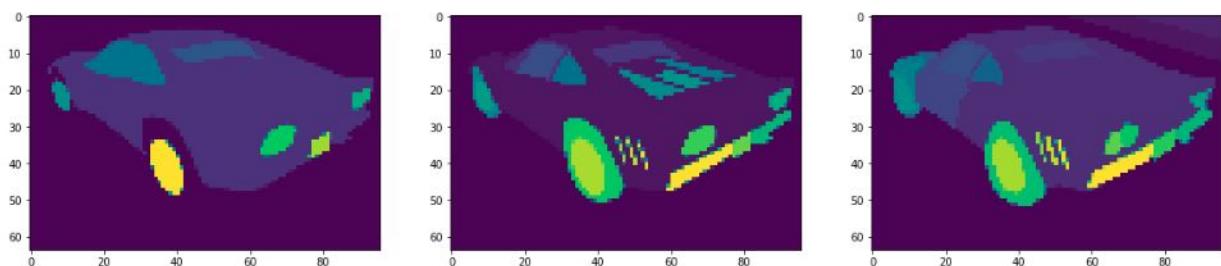
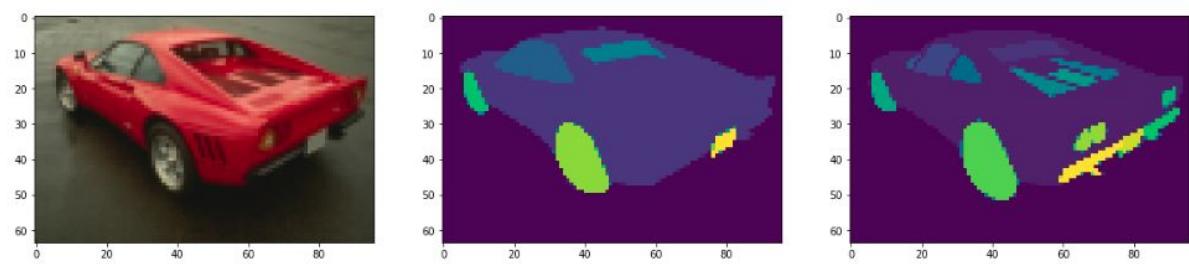
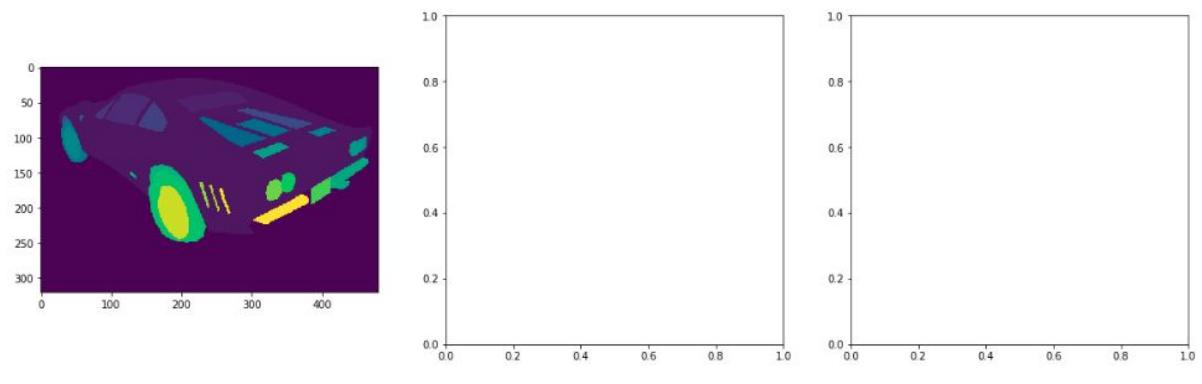
```

Average F-measure for k = 5 (kmeans): 0.586603274955023
Average F-measure for k = 5 (spectral): 0.5348983725355492
Average Conditional Entropy for k = 5 (kmeans): 0.18698137542263144
Average Conditional Entropy for k = 5 (spectral): 0.23830205777077965
Ground truth 0 :
    F-measure for k = 5 (kmeans) is 0.6119991218783591
    F-measure for k = 5 (spectral) is 0.5589670724301758
    Conditional entropy for k = 5 (kmeans) is 0.2230880298179643
    Conditional entropy for k = 5 (spectral) is 0.27866867424257763
Ground truth 1 :
    F-measure for k = 5 (kmeans) is 0.49086885665221036
    F-measure for k = 5 (spectral) is 0.448419998916747
    Conditional entropy for k = 5 (kmeans) is 0.0626980764303986
    Conditional entropy for k = 5 (spectral) is 0.1038091498056426
Ground truth 2 :
    F-measure for k = 5 (kmeans) is 0.6127022105656724
    F-measure for k = 5 (spectral) is 0.5571237052489566
    Conditional entropy for k = 5 (kmeans) is 0.2243393111961904
    Conditional entropy for k = 5 (spectral) is 0.27977477996164934
Ground truth 3 :
    F-measure for k = 5 (kmeans) is 0.60418098056098
    F-measure for k = 5 (spectral) is 0.5515816501221528
    Conditional entropy for k = 5 (kmeans) is 0.21505632040391134
    Conditional entropy for k = 5 (spectral) is 0.2642025444752698
Ground truth 4 :
    F-measure for k = 5 (kmeans) is 0.613265205117893
    F-measure for k = 5 (spectral) is 0.5583994359597139
    Conditional entropy for k = 5 (kmeans) is 0.20972513926469258
    Conditional entropy for k = 5 (spectral) is 0.2650551403687588
-----
```

Image 29030

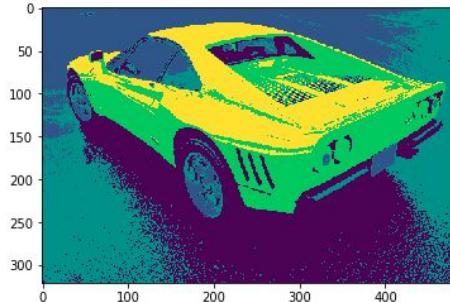
Image 29030



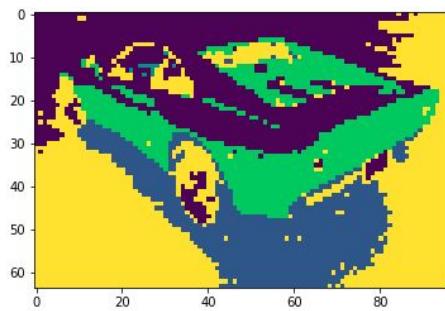


We can see in this two Cars images that K-means is also better than 5-NN in clustering this image however the care in 5-NN looks clustered nice but k-means has more details, entropy of k-means cluster is lower than that of 5-NN

Kmeans cluster results :



NN5 cluster results :



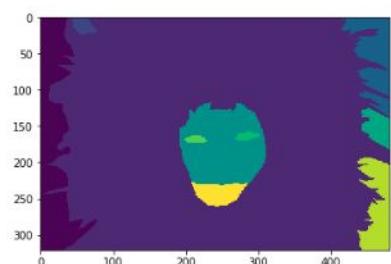
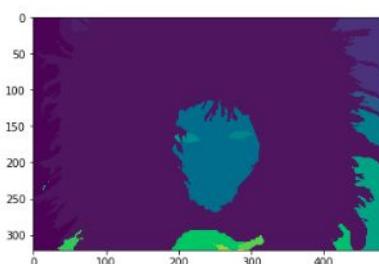
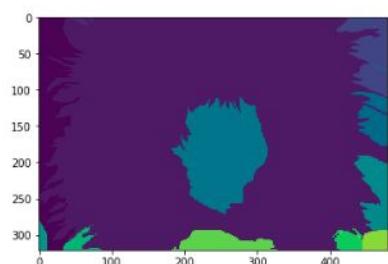
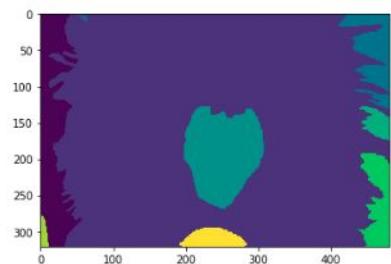
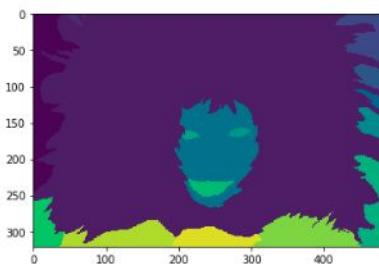
```

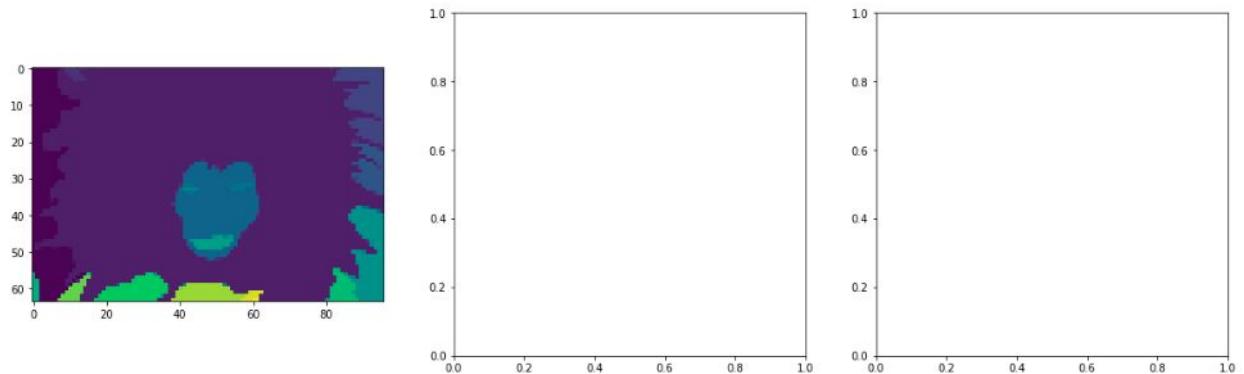
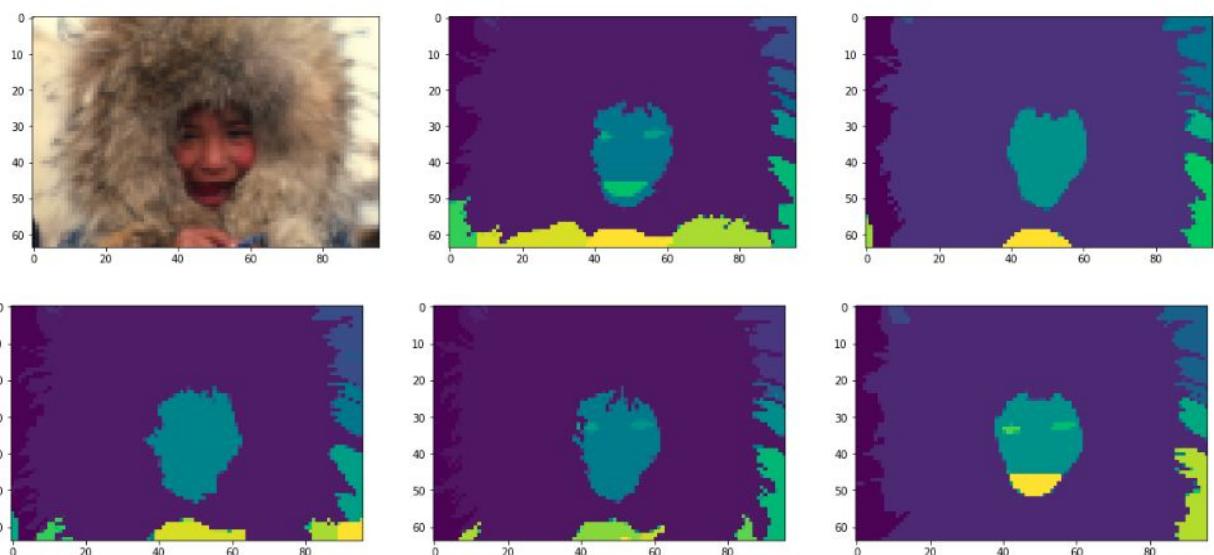
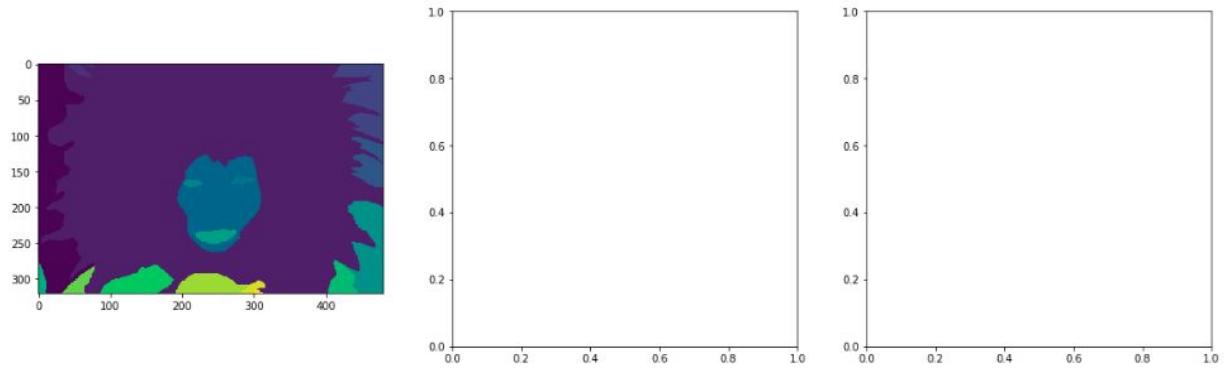
Average F-measure for k = 5 (kmeans): 0.5222910554879302
Average F-measure for k = 5 (spectral): 0.46585760307969637
Average Conditional Entropy for k = 5 (kmeans): 0.3118227110966724
Average Conditional Entropy for k = 5 (spectral): 0.4426800596982688
Ground truth 0 :
    F-measure for k = 5 (kmeans) is 0.5228367677893091
    F-measure for k = 5 (spectral) is 0.45572036507872615
    Conditional entropy for k = 5 (kmeans) is 0.22780050005620398
    Conditional entropy for k = 5 (spectral) is 0.34072733325783766
Ground truth 1 :
    F-measure for k = 5 (kmeans) is 0.5228650108513321
    F-measure for k = 5 (spectral) is 0.4736845995106752
    Conditional entropy for k = 5 (kmeans) is 0.3128345743998162
    Conditional entropy for k = 5 (spectral) is 0.4345939500756679
Ground truth 2 :
    F-measure for k = 5 (kmeans) is 0.5247737914224037
    F-measure for k = 5 (spectral) is 0.45583578205127695
    Conditional entropy for k = 5 (kmeans) is 0.21636922612998413
    Conditional entropy for k = 5 (spectral) is 0.3358016231863398
Ground truth 3 :
    F-measure for k = 5 (kmeans) is 0.530374163393508
    F-measure for k = 5 (spectral) is 0.46890490787032324
    Conditional entropy for k = 5 (kmeans) is 0.33988351990598686
    Conditional entropy for k = 5 (spectral) is 0.48892802244770217
Ground truth 4 :
    F-measure for k = 5 (kmeans) is 0.5090391293299017
    F-measure for k = 5 (spectral) is 0.46674582288402355
    Conditional entropy for k = 5 (kmeans) is 0.43639637120684627
    Conditional entropy for k = 5 (spectral) is 0.572558399764286
Ground truth 5 :
    F-measure for k = 5 (kmeans) is 0.5238574701411268
    F-measure for k = 5 (spectral) is 0.47425414108315345
    Conditional entropy for k = 5 (kmeans) is 0.3376520748811973
    Conditional entropy for k = 5 (spectral) is 0.48347102945777953
-----
```

Image 14092



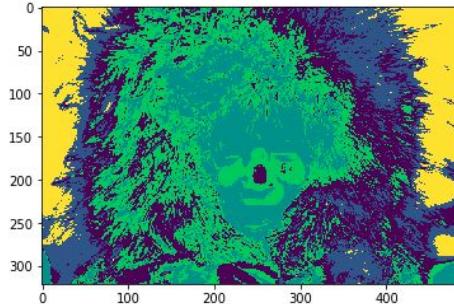
Image 14092



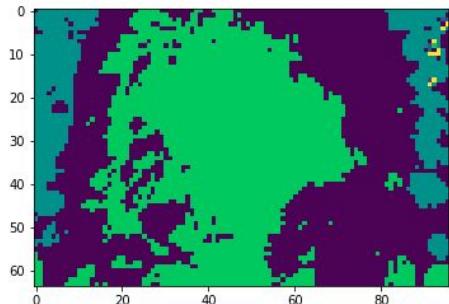


Again We can see in this image that K-means is better than 5-NN in clustering this image. We can see the face of the child while in 5-NN is not recognized, conditional entropy in k-means is lower than that of 5-NN.

Kmeans cluster results :



NN5 cluster results :



```

Average F-measure for k = 5 (kmeans): 0.3805055662791401
Average F-measure for k = 5 (spectral): 0.362594523587314
Average Conditional Entropy for k = 5 (kmeans): 0.3094976128358439
Average Conditional Entropy for k = 5 (spectral): 0.3897266094531047
Ground truth 0 :
    F-measure for k = 5 (kmeans) is 0.3083057104433832
    F-measure for k = 5 (spectral) is 0.29852963538268373
    Conditional entropy for k = 5 (kmeans) is 0.371735625629482
    Conditional entropy for k = 5 (spectral) is 0.4573442125160751
Ground truth 1 :
    F-measure for k = 5 (kmeans) is 0.3959333380349375
    F-measure for k = 5 (spectral) is 0.37667922138375476
    Conditional entropy for k = 5 (kmeans) is 0.255866350833133
    Conditional entropy for k = 5 (spectral) is 0.3197702385958674
Ground truth 2 :
    F-measure for k = 5 (kmeans) is 0.3964232879790083
    F-measure for k = 5 (spectral) is 0.37736170880872577
    Conditional entropy for k = 5 (kmeans) is 0.30346906389508654
    Conditional entropy for k = 5 (spectral) is 0.38754555643598776
Ground truth 3 :
    F-measure for k = 5 (kmeans) is 0.392419253266907
    F-measure for k = 5 (spectral) is 0.372895169372044
    Conditional entropy for k = 5 (kmeans) is 0.2956818148589057
    Conditional entropy for k = 5 (spectral) is 0.39643937221303793
Ground truth 4 :
    F-measure for k = 5 (kmeans) is 0.39470372270278425
    F-measure for k = 5 (spectral) is 0.37459567967176455
    Conditional entropy for k = 5 (kmeans) is 0.2672770043588025
    Conditional entropy for k = 5 (spectral) is 0.3373658159859709
Ground truth 5 :
    F-measure for k = 5 (kmeans) is 0.3952480852478205
    F-measure for k = 5 (spectral) is 0.3755057269049108
    Conditional entropy for k = 5 (kmeans) is 0.3629558174396536
    Conditional entropy for k = 5 (spectral) is 0.4398944609716894
-----
```

Image 41096

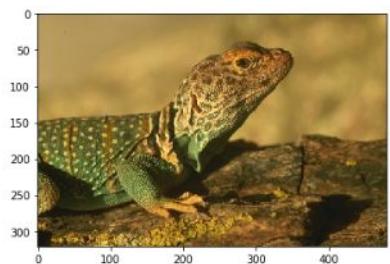
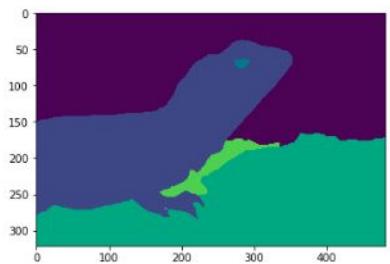
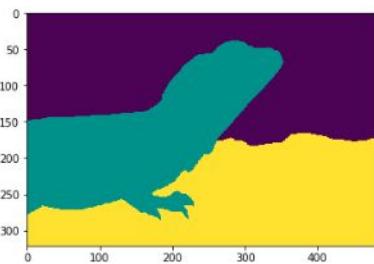
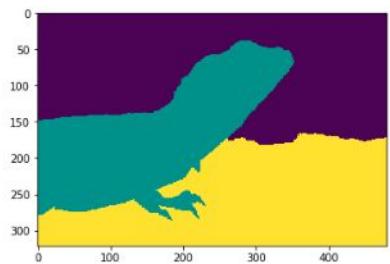
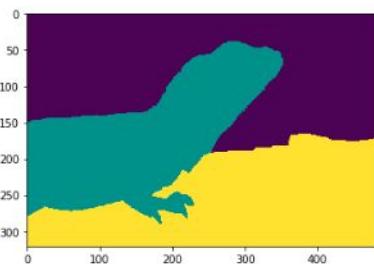
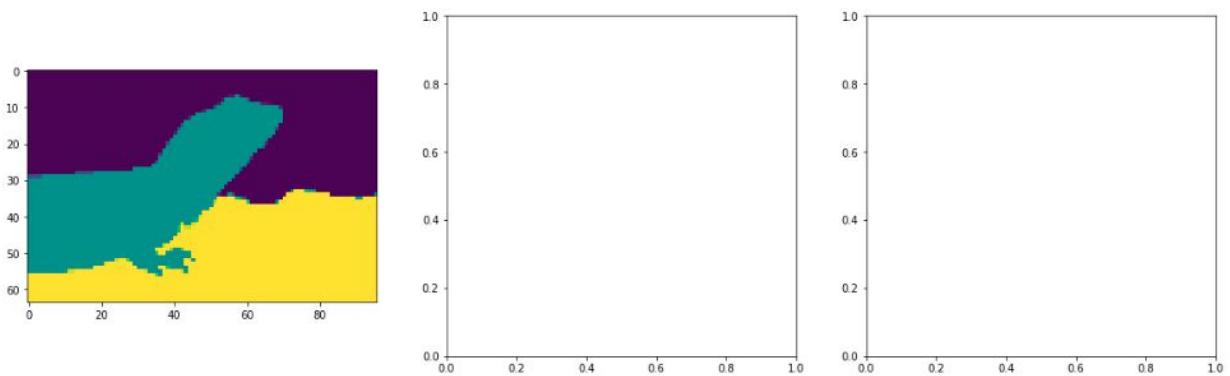
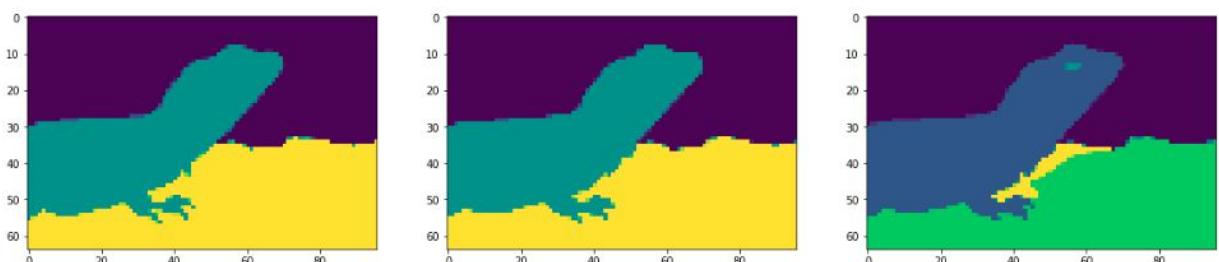
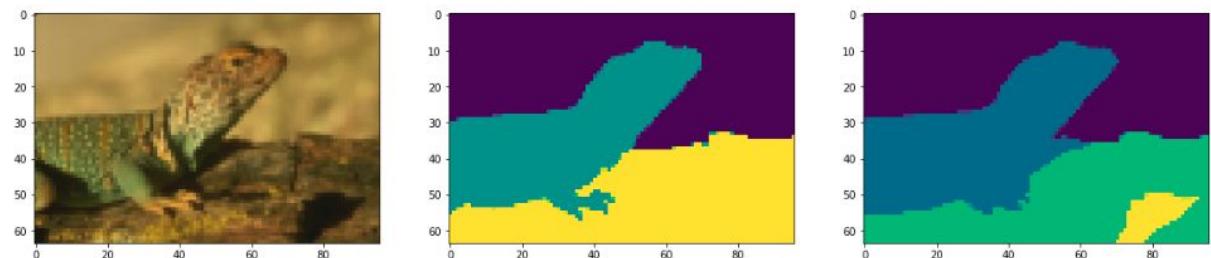
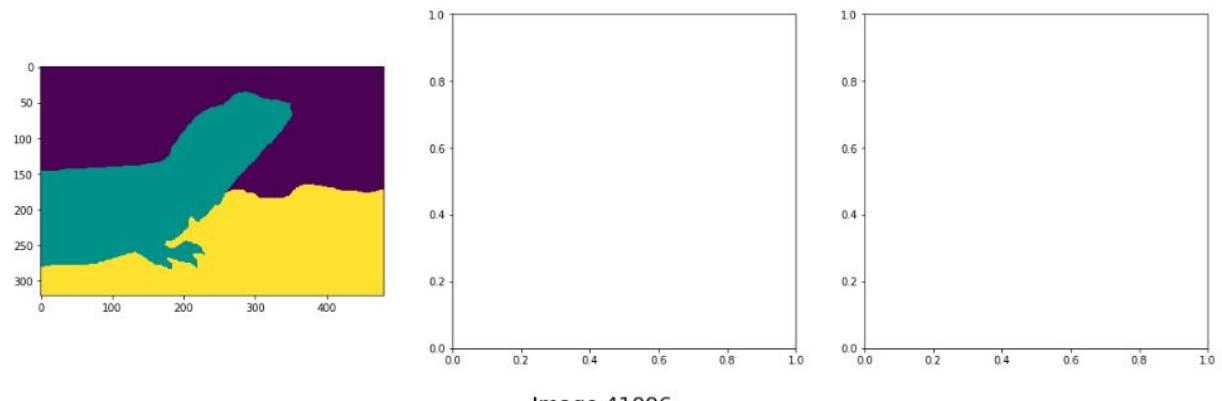


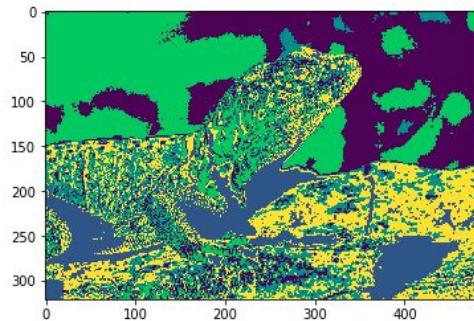
Image 41096



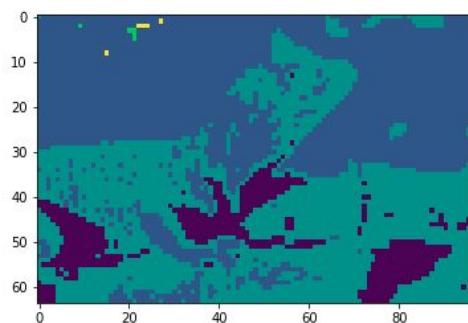


Finally in this image that K-means is also better than 5-NN in clustering this image. We can see the face of the reptile while in 5-NN is not that clear, conditional entropy in k-means is lower than that of 5-NN.

Kmeans cluster results :



NN5 cluster results :



```
Average F-measure for k = 5 (kmeans): 0.473007620672232
Average F-measure for k = 5 (spectral): 0.3602856255337307
Average Conditional Entropy for k = 5 (kmeans): 0.3173270056205031
Average Conditional Entropy for k = 5 (spectral): 0.35036728622212515
Ground truth 0 :
    F-measure for k = 5 (kmeans) is 0.4693905910232532
    F-measure for k = 5 (spectral) is 0.3590286717380521
    Conditional entropy for k = 5 (kmeans) is 0.31591402540668273
    Conditional entropy for k = 5 (spectral) is 0.345964129771553
Ground truth 1 :
    F-measure for k = 5 (kmeans) is 0.4848015472891271
    F-measure for k = 5 (spectral) is 0.3640559972534184
    Conditional entropy for k = 5 (kmeans) is 0.3316405277768581
    Conditional entropy for k = 5 (spectral) is 0.356077708892395
Ground truth 2 :
    F-measure for k = 5 (kmeans) is 0.47444460308987796
    F-measure for k = 5 (spectral) is 0.36462453309194587
    Conditional entropy for k = 5 (kmeans) is 0.3062384943969869
    Conditional entropy for k = 5 (spectral) is 0.345297535677493
Ground truth 3 :
    F-measure for k = 5 (kmeans) is 0.4730519831888106
    F-measure for k = 5 (spectral) is 0.3629070386859472
    Conditional entropy for k = 5 (kmeans) is 0.30686338292730225
    Conditional entropy for k = 5 (spectral) is 0.3383904073466131
Ground truth 4 :
    F-measure for k = 5 (kmeans) is 0.46601888030017413
    F-measure for k = 5 (spectral) is 0.3526027576613625
    Conditional entropy for k = 5 (kmeans) is 0.333106783060611
    Conditional entropy for k = 5 (spectral) is 0.37145658669484516
Ground truth 5 :
    F-measure for k = 5 (kmeans) is 0.4703381191421488
    F-measure for k = 5 (spectral) is 0.358494754771658
    Conditional entropy for k = 5 (kmeans) is 0.31019882015457767
    Conditional entropy for k = 5 (spectral) is 0.3450173489498515
```
