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Adaptation of matlab K-means clustering function to create Color Image Features

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Abstract
K_means method is commonly used for color image clustering, and it can be used also for color image features creation, these features can be used later on as an image signature which refers to the image in any application, such image recognition or image retrieval system.
Using clusters or within_cluster sums created by K_means method is not correct because the values of these sets change from time (run) to time. So a modification was added to this method, by proposing a new method.
The proposed method will be implemented, the clusters for each image will be created, also the within_cluster sums will be created and it will be shown that each of these data sets can be used as an image features to create an image signature.

Keywords: K_means, histogram, cluster, features, WCS

1. Introduction

Digital color image is a huge in size data media and it is usually represented by a huge 3D matrix, the first dimension of this matrix refers to the red colors pixels, the second refers to the green colors pixels, while the third dimension refers to the blue colors pixels [1, 2, 3]. Many applications require image matching and identifying to make a certain decisions [4, 5], so using a huge 3D matrix for decision making will cause a big trouble and efforts.
To reduce the number of elements to be manipulated in order to make a decision, we can use the image histogram which gives us detailed features of the color image; these features can be used instead of directly using the image pixels [6-48].
Color image histogram [8] is a three column matrix, each row contains 256 elements, and each element value points to the repetition of the color in the associated color channel.
Using the image histogram we can reduce the elements to be processed in order to make a decision to 768 (256 elements for each color). Figure 1 shows an example of color image and its histogram, while figure 2 shows the colors distribution.

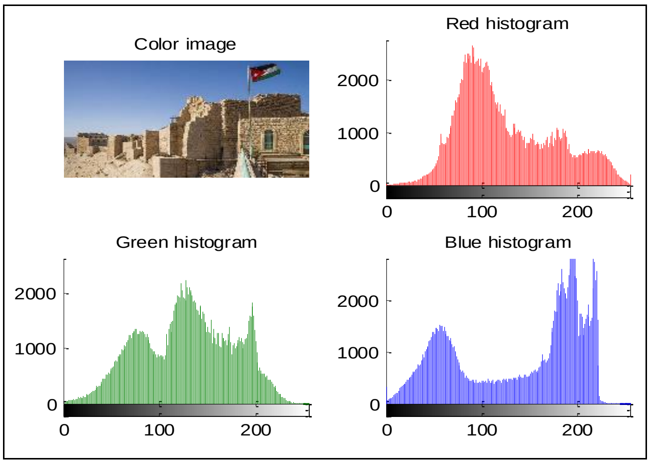


Fig 1: Color image and histograms

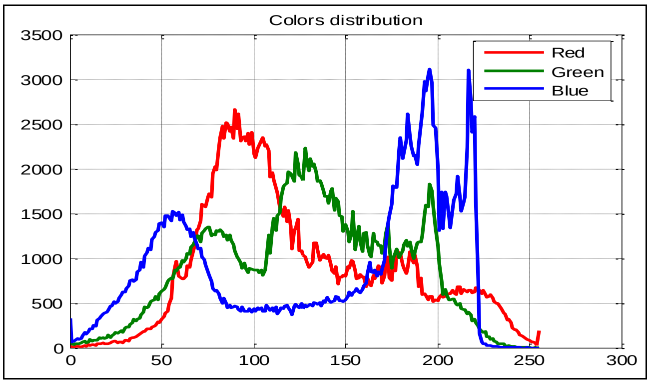


Fig 2: Colors distribution for the image in fig.1

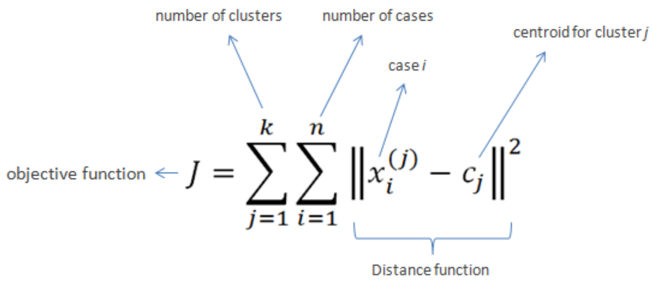
Many authors introduced many methods to create features for any color image [9, 10], theses features were used as signature to retrieve or identify color images, these features were also passed to artificial neural networks which were built as a color image recognition tools based on the extracted color image features [11, 12].
In this research paper we will focus on matlab k_means function, update this function and use the updated algorithm to create a unique features for any given color image.
The images shown in figure 3 were used to manipulate features extraction methods

Fig 3: Sample color covering images used in features extractraction

2. Matlab K_means function

K_means Matlab function works [13, 14] using the following algorithm:

1) Split the data into k clusters where k is predefined.
2) Select k points at random as cluster centers.
3) Assign objects to their closest cluster center according to the Euclidean distance function [15, 16].



$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2$$

4) Calculate the centroid or mean of all objects in each cluster.
5) Repeat steps 2, 3 and 4 until the same points are assigned to each cluster in consecutive rounds.

Worked example

Suppose we have the following data set with 19 data items:
15,15,16,19,19,20,20,21,22,28,35,40,41,42,43,44,60,61,65

This data set is to be clustered into 2 clusters using the following initial values:

$$k = 2$$
$$c_1 = 16$$
$$c_2 = 22$$

$$Distance\ 1 = |x_i - c_1|$$

$$Distance\ 2 = |x_i - c_2|$$

Processing phase 1

$$c_1 = 15.33$$
$$c_2 = 36.25$$

x_i	c_1	c_2	Distance 1	Distance 2	Nearest Cluster	New Centroid
15	16	22	1	7	1	**15.33**
15	16	22	1	7	1	
16	16	22	0	6	1	
19	16	22	9	3	2	**36.25**
19	16	22	9	3	2	
20	16	22	16	2	2	
20	16	22	16	2	2	
21	16	22	25	1	2	
22	16	22	36	0	2	
28	16	22	12	6	2	
35	16	22	19	13	2	
40	16	22	24	18	2	
41	16	22	25	19	2	
42	16	22	26	20	2	
43	16	22	27	21	2	
44	16	22	28	22	2	
60	16	22	44	38	2	
61	16	22	45	39	2	
65	16	22	49	43	2	

Processing phase 2

$c_1 = 18.56$

$c_2 = 45.90$

x_i	c_1	c_2	Distance 1	Distance 2	Nearest Cluster	New Centroid
15	15.33	36.25	0.33	21.25	1	**18.56**
15	15.33	36.25	0.33	21.25	1	
16	15.33	36.25	0.67	20.25	1	
19	15.33	36.25	3.67	17.25	1	
19	15.33	36.25	3.67	17.25	1	
20	15.33	36.25	4.67	16.25	1	
20	15.33	36.25	4.67	16.25	1	
21	15.33	36.25	5.67	15.25	1	
22	15.33	36.25	6.67	14.25	1	
28	15.33	36.25	12.67	8.25	2	**45.9**
35	15.33	36.25	19.67	1.25	2	
40	15.33	36.25	24.67	3.75	2	
41	15.33	36.25	25.67	4.75	2	
42	15.33	36.25	26.67	5.75	2	
43	15.33	36.25	27.67	6.75	2	
44	15.33	36.25	28.67	7.75	2	
60	15.33	36.25	44.67	23.75	2	
61	15.33	36.25	45.67	24.75	2	
65	15.33	36.25	49.67	28.75	2	

Processing phase 3

$c_1 = 19.50$

$c_2 = 47.89$

x_i	c_1	c_2	Distance 1	Distance 2	Nearest Cluster	New Centroid
15	18.56	45.9	3.56	30.9	1	**19.50**
15	18.56	45.9	3.56	30.9	1	
16	18.56	45.9	2.56	29.9	1	
19	18.56	45.9	0.44	26.9	1	
19	18.56	45.9	0.44	26.9	1	
20	18.56	45.9	1.44	25.9	1	
20	18.56	45.9	1.44	25.9	1	
21	18.56	45.9	2.44	24.9	1	
22	18.56	45.9	3.44	23.9	1	
28	18.56	45.9	9.44	17.9	1	
35	18.56	45.9	16.44	10.9	2	**47.89**
40	18.56	45.9	21.44	5.9	2	
41	18.56	45.9	22.44	4.9	2	
42	18.56	45.9	23.44	3.9	2	
43	18.56	45.9	24.44	2.9	2	
44	18.56	45.9	25.44	1.9	2	
60	18.56	45.9	41.44	14.1	2	
61	18.56	45.9	42.44	15.1	2	
65	18.56	45.9	46.44	19.1	2	

Processing phase 4

$c_1 = 19.50$

$c_2 = 47.89$

x_i	c_1	c_2	Distance 1	Distance 2	Nearest Cluster	New Centroid
15	19.5	47.89	4.50	32.89	1	19.50
15	19.5	47.89	4.50	32.89	1	
16	19.5	47.89	3.50	31.89	1	
19	19.5	47.89	0.50	28.89	1	
19	19.5	47.89	0.50	28.89	1	
20	19.5	47.89	0.50	27.89	1	
20	19.5	47.89	0.50	27.89	1	
21	19.5	47.89	1.50	26.89	1	
22	19.5	47.89	2.50	25.89	1	
28	19.5	47.89	8.50	19.89	1	
35	19.5	47.89	15.50	12.89	2	47.89
40	19.5	47.89	20.50	7.89	2	
41	19.5	47.89	21.50	6.89	2	
42	19.5	47.89	22.50	5.89	2	
43	19.5	47.89	23.50	4.89	2	
44	19.5	47.89	24.50	3.89	2	
60	19.5	47.89	40.50	12.11	2	
61	19.5	47.89	41.50	13.11	2	
65	19.5	47.89	45.50	17.11	2	

No change between processing phases 3 and 4 has been noted. By using clustering, 2 clusters have been identified 15-28 and 35-65.

Implementation using digital color images

We took im3.jpg and applied K_means matlab function, dividing the image into 4 clusters, table 1 shows the results of this clustering by running the function several times:

From the obtained results in table 1 we can see that the clusters vary from run to run so the cluster values here cannot be used as features to identify the image because they are not unique.

Table 1: 4 clusters for im1.jpg

Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
78	150	150	76	199	36	209	29	87	204
199	96	97	127	78	141	150	130	205	89
29	209	40	198	29	204	39	199	140	36
130	40	209	27	130	90	96	79	33	140

Table 2: Within-cluster sums

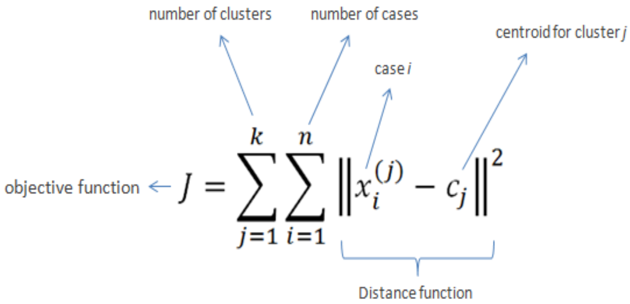
Clusters	within-cluster sums									
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
1	111	111	111	111	111	111	111	111	111	111
2	236	242	239	241	242	242	239	239	232	236
3	350	349	365	367	347	351	354	365	367	351
4	491	498	491	490	471	437	428	435	493	432
5	497	583	631	626	522	498	619	623	635	524
6	836	646	604	789	834	747	752	812	758	613
7	787	843	741	669	748	945	945	643	911	816
8	777	866	1183	1072	943	1168	1032	1182	822	1146
9	954	1245	1147	1158	1092	1114	1137	1218	1073	1072
10	1417	1440	849	1467	1342	1064	948	1128	1118	1018
11	1375	1358	960	1392	1822	1409	1298	1395	1052	1472
12	1651	1747	1511	1754	1892	1337	1526	1582	1805	1237
13	1491	1455	1208	1605	1453	1556	1450	1943	1564	1866
14	1594	1900	2173	1834	1827	1768	1729	1739	1841	1788
15	1423	2068	2228	1753	2066	2235	1990	2263	1539	1935
16	2193	2043	2095	2104	2101	1851	1346	2115	2192	2185

From the results obtained in table 2 we can see also the values of the sums are vary and they are subject to change from one run to another, hence we cannot use any of them as a features for image identification.

3. The proposed method

The proposed method is based K_means matlab function with some modification, Here in the proposed method we adjust the process of cluster initialization to use a fix number instead of using random number, this number may be the maximum gray level (255) or the cluster number, and to do clustering using this method we have to apply the following steps:

1) Get the color image
2) Reshape the 3D color matrix to 2D matrix
3) Calculate image histogram to be used as a data set for clustering.
4) Split the data into *k* clusters where *k* is predefined.
5) Select *k* points using fix number or 255 as cluster centers.
6) Assign objects to their closest cluster center according to the *Euclidean distance* function [15, 16].



$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2$$

7) Calculate the centroid or mean of all objects in each cluster.
8) Repeat steps 5, 6 and 7 until the same points are assigned to each cluster in consecutive rounds.

Below is a matlab function to implement this method:

```
function [clusters, result_image, clusterized_image] = ZJ_Clustering(im,  k)
[cc1 cc2 cc3]=size(im);
im=reshape(im,cc1*cc3,cc2);
%histogram calculation
img_hist = zeros(256,1);
hist_value = zeros(256,1);
for i=1:256
    img_hist(i)=sum(sum(im==(i-1)));
end;
for i=1:256
    hist_value(i)=i-1;
end;
%cluster initialization
cluster = zeros(k,1);
cluster_count = zeros(k,1);
for i=1:k
        cluster(i)=uint8(i*255);
 end;
old = zeros(k,1);
while (sum(sum(abs(old-cluster))) >k)
    old = cluster;
    closest_cluster = zeros(256,1);
    min_distance = uint8(zeros(256,1));
    min_distance = abs(hist_value-cluster(1));
    %calculate the minimum distance to a cluster
    for i=2:k
        min_distance =min(min_distance,  abs(hist_value-cluster(i)));
    end;
    %calculate the closest cluster
    for i=1:k
        closest_cluster(min_distance==(abs(hist_value-cluster(i)))) = i;
    end;
    %calculate the cluster count
    for i=1:k
        cluster_count(i) = sum(img_hist .*(closest_cluster==i));
    end;
```

```
        for i=1:k
            if (cluster_count(i) == 0)
                cluster(i) = uint8(i*255);
            else
    cluster(i) = uint8(sum(img_hist(closest_cluster==i).
    *hist_value(closest_cluster==i))/cluster_count(i));
            end;
        end;
    end;
    imresult=uint8(zeros(size(im)));
    for i=1:256
        imresult(im==(i-1))=cluster(closest_cluster(i));
    end;
    clustersresult=uint8(zeros(size(im)));
    for i=1:256
        clustersresult(im==(i-1))=closest_cluster(i);
    end;
    clusters = cluster;
    result_image = imresult;
    clusterized_image = clustersresult;
    end
```

This function was implemented using image 1.jpg; figure 4 shows the original image, while figure 5 shows the clustered image:

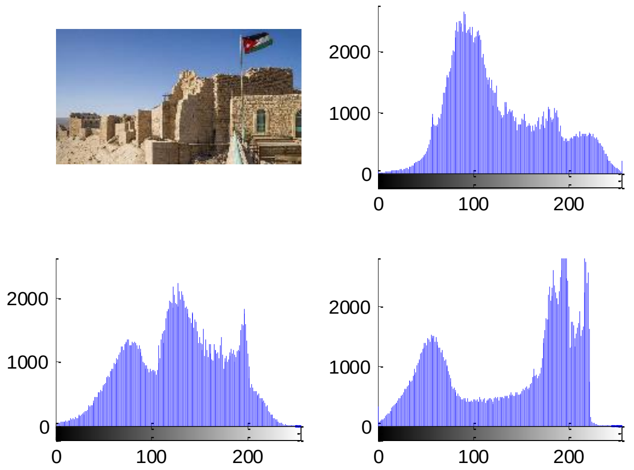


Fig 4: Original image

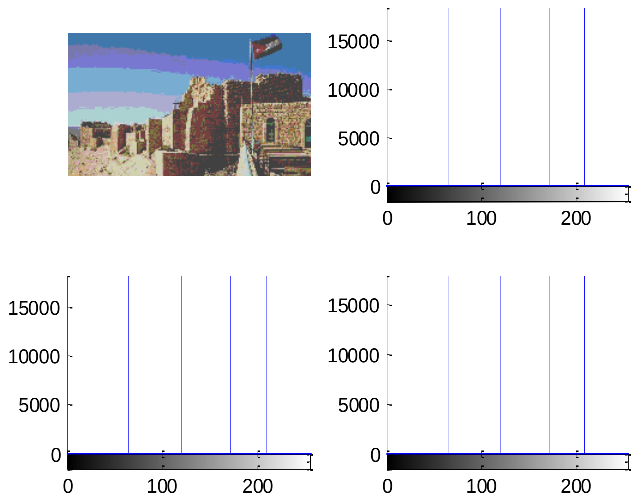


Fig 5: Clustered image (4 clusters)

This image was taken and treated by the above function; table 3 shows the clusters after each running:

Table 3: 4 clusters using the proposed method

Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
209	209	209	209	209	209	209	209	209	209
172	172	172	172	172	172	172	172	172	172
120	120	120	120	120	120	120	120	120	120
65	65	65	65	65	65	65	65	65	65

From table 3 we can see that the clusters remain the same without any changes, so we can use them as an image features, table 4 shows the 4 clusters for different color images:

Table 4: 4 clusters as an image features (identifier)

Image	Clusters			
1	209	172	120	65
2	239	165	107	41
3	209	150	96	40
4	223	157	89	22
5	207	143	95	46
6	233	157	99	6
7	218	166	97	33
8	242	193	124	58
9	237	170	104	41
10	233	163	136	96
11	238	162	88	21
12	249	189	138	44

Also we can use within-cluster sum as an image identifier, because each within-cluster sum for each image is a unique set as show in the obtained results show in table 5.

Table 5: WCS for different color images

Clusters	Wcs1	Wcs2	Wcs3	Wcs4	Wcs5	Wcs6	Wcs7	Wcs8	Wcs9	Wcs10	Wcs11	Wcs12
1	131	128	111	88	97	115	111	137	121	136	89	144
2	70	273	241	200	222	235	277	292	265	349	223	292
3	95	420	365	333	356	363	340	443	416	476	327	443
4	566	552	495	491	491	495	514	617	552	628	509	620
5	704	756	632	613	641	710	714	791	688	831	631	875
6	886	886	832	805	810	937	839	976	848	1044	811	1130
7	1106	1146	949	1025	982	1168	1065	1211	1106	1273	946	1385
8	1292	1408	1178	1152	1175	1440	1291	1424	1319	1521	1140	1643

4. Conclusion

K_means method using K_means matlab function was investigated; it was shown that in this method the clusters or the within_cluster sums cannot be used as a color image features set to identify the image.

The K_means was modified and a new method based on K_means was proposed tested and implemented, it was shown that the obtained clusters or the obtained within_cluster sum can be used to identify or retrieve the image, because each set of them are unique for a given image, so each of them can be used as key to identify the color image.

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