Extraction of Shape Components for Classification of Textures Based on Texture Elements

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Summary
Shape representation or description is a central and challenging problem in Image Processing and Computer Vision which arises in many applications such as image classification, analysis, interpretation etc. Texture is an important spatial feature useful for identifying objects or regions of interest in an image. The present paper derives a new set of texture features, which are shape components derived from the texture elements of a 3x3 mask. The proposed texture elements extract textural information of an image with a more complete respect of texture characteristics in all the eight directions instead of only one displacement vector. The present paper evaluated five simple shape components on each of the derived patterns. The experimental results on the five groups of texture images clearly show the efficacy and simplicity of the present method.

Key words:
Shape representation, Description, Classification, Texture element, Patterns, Shape components.

1. Introduction

Texture has long been an important topic in image processing [1-19]. Generally speaking, textures can be classified into two major categories, i.e. regular and irregular [2-3]. The first is a structural approach, where regular textures like brick wall, are composed of structurally repeated similar patterns with a certain rule of placement. The traditional Fourier [4] spectrum analysis and wavelet based analysis [5] are often used to determine the primitives and placement rule. Several authors have applied these methods to texture classification and texture characterization with a certain degree of success [6-8]. The second is a statistical approach, where irregular textures like cloud or grass cannot be constructed by regularly arranged patterns. Many statistical approaches have been proposed, they use parameters to measure texture content in terms of smoothness, coarseness and regularity. Its aim is to characterize the stochastic properties of the spatial distribution of gray levels in an image. The gray tone co occurrence matrix is frequently used for such characteristics. A set of textural features derived from the co-occurrence matrix has been widely used in practice to extract textural information from digital images[8-11]. The present paper derived a set of texture features, which are shape components based on texture elements to extract textural information and classification of textures.

Study of patterns on textures is recognized as an important step in characterization and classification of textures. Textures are classified recently by various pattern methods: preprocessed images [20], long linear patterns [21], and edge direction movements [22]. Depending on the context the word pattern has many different interpretations. The biology community seems to use the word pattern without defining it. The implicit meaning generally brings to mind some kind of repeated arrangement (regular or not) and the term is often defined by examples. The word ‘texture’ also has many interpretations in the graphics community. The word texture is used in the sense of a pattern applied to the surface of an object. Intuitively, one can think of texture as visual information which gives us clues about the nature of the object, usually expressed at the object’s surface. The difference between a pattern and a texture is that, a texture involves the attachment of the pattern to the surface of an object. He and Wang have proposed the texture spectrum approach for texture analysis [23-24] based on the texture elements. The present paper utilized this basic concept for the generation of texture features in terms of shape components for classification of textures.The present paper is organized as follows. In the second section methodology is presented. In the third section we have given results and discussions. The last section gives the conclusions.

2. Methodology

In a square-raster digital image, each pixel is surrounded by eight neighboring pixels. The local texture information for a pixel can be extracted from a neighborhood of 3×3 pixels, which represents the smallest complete unit having eight directions surrounding the pixel. The present paper evaluated texture features on a 3×3 mask based on the central pixel. A neighborhood of 3x3 pixels is denoted by a set containing nine elements: P= {P0, P1 ...P8}, here P0 represents the intensity value of the central pixel and Pi

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{i=1, 2… 8}, is the intensity value of the neighboring pixel i as shown in Fig.1.

P1	P2	P3
P8	P0	P4
P7	P6	P5

Fig.1: Representation of a 3x3 neighborhood.

The present paper labels eight neighbors of a 3x3 mask using three possible ternary patterns or values {0, 1 and 2} derived from the equation-1.

$$P_i = \begin{cases} 0 & if \quad P_i < P_0 \\ 1 & if \quad P_i = P_0 \\ 2 & if \quad P_i > P_0 \end{cases} \quad \text{for i=1,2,…,8} \qquad (1)$$

where P is the obtained ternary code, Pi is the original pixel value at position i and P0 is the central pixel value. The Fig. 2(a) and 2(b) shows the gray level values of a 3×3 neighborhood and the corresponding ternary labeling called as texture element pattern(TEP).

63	28	40
88	**40**	35
67	40	21

(a)

2	0	1
2		0
2	1	0

(b)

Fig. 2(a) Sample Gray level Neighborhood 2(b) labeling of texture element.

On the texture element representation of a 3x3 mask the present study evaluated texture features which represents the shape component. The present paper derived five different shape components named as Diamond Texture Element Pattern(DTEP-I), Corner Texture Element Pattern(CTEP-I), Left Texture Element Pattern(LTEP-I), Right Texture Element Pattern(RTEP-I) and Blob Texture Element Pattern(BTEP-I), where 'I' ranges from 0 to 2. That is DTEP-0 means the diamond shape component formed with texture element values 0. Each shape components can be represented in 3-ways by using the ternary representation of texture element which is shown in Fig.3.

	0	
0		0
	0	

(a)

	1	
1		1
	1	

(b)

	2	
2		2
	2	

(c)

Fig.3. (a) Representation of DTEP-I.

0		0
0		0

(a)

1		1
1		1

(b)

2		2
2		2

(c)

Fig.3. (b) Representation of CTEP-I.

0		
0		
0	0	

(a)

1		
1		
1	1	

(b)

2		
2		
2	2	

(c)

Fig.3. (c) Representation of LTEP-I.

	0	0
		0
		0

(a)

	1	1
		1
		1

(b)

	2	2
		2
		2

(c)

Fig.3. (d) Representation of RTEP-I.

0	0	0
0		0
0	0	0

(a)

1	1	1
1		1
1	1	1

(b)

2	2	2
2		2
2	2	2

(c)

Fig.3. (e) Representation of BTEP-I.

For the classification of textures the frequency of occurrence of each shape component with different patterns is counted using the Algorithm 1. One can enumerate large number of shape components using TEP's 0, 1 and 2. The novelty of the present work is, it uses only five different types of shape components using TEP's 0, 1 and 2.

Algorithm 1: Classification of textures based on shape components with different TEP.
begin

1. Read the original texture images TK, where K=1 to n with dimension N×M.
2. Convert each 3x3 mask of the gray level texture image into a ternary texture element image.
   The gray level texture image Tk is assigned a ternary value 0, 1 or 2 in the following way
   for u=1:3
       for v =1:3
           if Tk(u,v) > Tk(2,2)

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                img(u,v) = 2
            elseif  Tk(u,v) == Tk(2,2)
                    img(u,v) = 1
             else
                    img(u,v) = 0
        end
     end
  end
```

3. Represent the given shape patterns Pij on 3×3 mask elements, where i =1 to 5 are shape components and j=1 to 3 represent texture element patterns 0, 1, and 2.
4. Compute frequency occurrence (FPi) of each shape pattern Pij .
5. Compute the number of occurrence of each shape pattern (NSPi j, i=1 to 5 and j=1 to 3) for each category of the texture Tk.

end

3. Results and Discussions

To evaluate a good classification and recognition based on the shape components of texture elements, the present paper initially computed the frequency occurrences of each shape component with each TEP. The novelty of the present scheme is, it classifies the given set of textures without any distance function, and that, it reduces the time complexity. For the classification purpose the present paper considers 5 groups of textures namely brick, fabric, marble, mosaic and granite each with six textures of 256 x 256 resolutions as shown in Fig 4, 5, 6, 7 and 8 respectively. These texture image groups are collected mainly from the Vistex album and other standard albums. Based on Algorithm-1 the frequency of occurrence of each shape component using different texture element pattern for each group of textures is evaluated and represented in Table 1, 2, 3, 4 and 5 for brick, fabric, granite, marble and mosaic textures respectively.

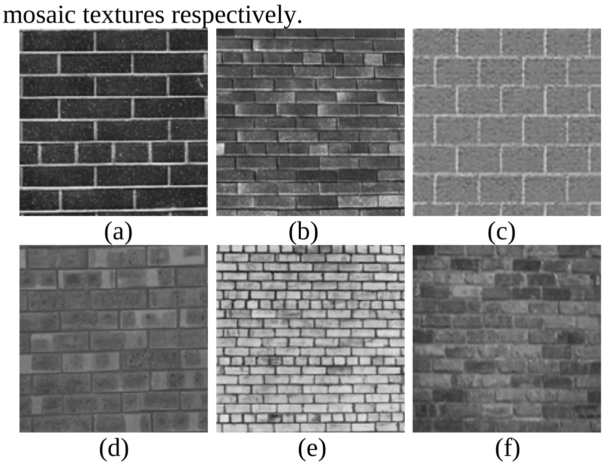

Figure 4. Original images of six brick textures from (a)-(f).

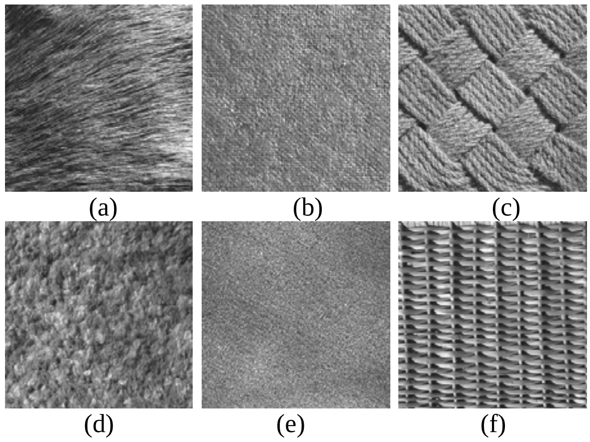

Figure 5. Original images of six fabric textures from (a)-(f).

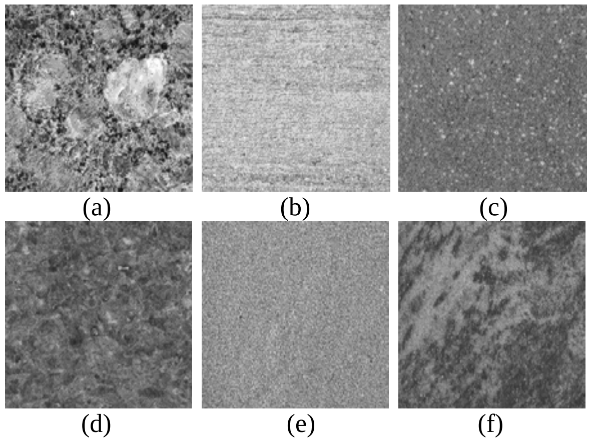

Figure 6. Original images of six granite textures from (a)-(f).

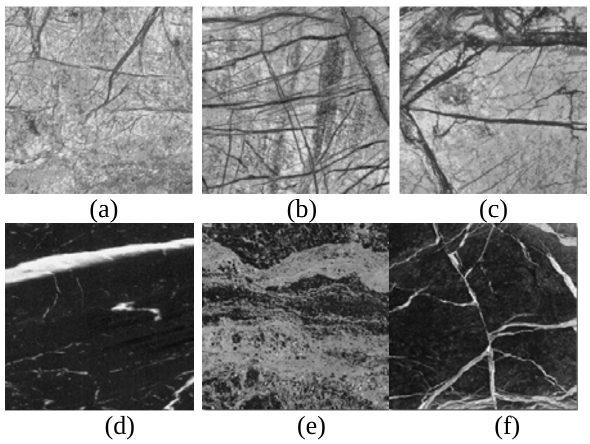

Figure 7. Original images of six marble textures from (a)-(f).

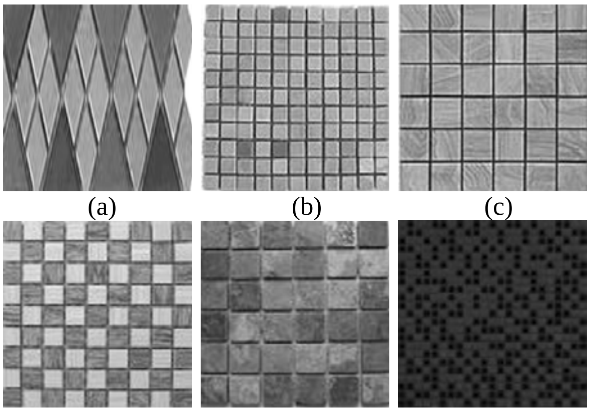

Figure 8. Original images of six mosaic textures from (a)-(f).

Table 1. Frequency of occurrence of each shape component of brick textures using TEP.

Image	Diamond			Corners			Left - L			Right - L			Blob		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Brick1	963	31	828	1180	2	1117	1108	1	1096	1180	0	1043	609	0	463
Brick2	1027	27	823	1365	1	1126	1193	1	1000	1198	1	950	587	0	451
Brick3	335	22	329	363	6	365	718	23	788	857	12	792	91	3	92
Brick4	502	20	497	870	2	901	939	11	967	934	16	958	311	0	346
Brick5	692	36	642	965	1	1071	1103	1	989	1045	3	1040	413	0	403
Brick6	373	32	378	430	22	456	658	45	686	753	45	724	121	5	109
Average	649	28	583	862	6	839	953	14	921	995	13	918	355	8	311

Table 2. Frequency of occurrence of each shape component of fabric textures using TEP.

Image	Diamond			Corners			Left -L			Right - L			Blob		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Fabric1	898	0	853	1271	0	1295	1211	0	1173	1146	0	1148	550	0	528
Fabric2	718	0	689	1119	0	1155	1244	0	1198	1249	0	1222	516	0	456
Fabric3	884	0	845	994	0	1045	1206	0	1179	1163	0	1183	473	0	512
Fabric4	648	0	578	869	0	785	1259	0	1432	1538	0	1206	369	0	319
Fabric5	1032	0	1053	1226	0	1181	1336	0	1290	1331	0	1307	637	0	621
Fabric6	1065	0	1237	2570	0	2883	2242	0	2173	1912	0	2431	655	0	815
Average	874	0	876	1342	0	1391	1416	0	1408	1390	0	1416	533	0	542

Table 3. Frequency of occurrence of each shape component of marble textures using TEP.

Image	Diamond			Corners			Left -L			Right - L			Blob		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Marble1	670	12	744	987	1	990	1256	1	1260	1272	3	1252	445	0	470
Marble2	574	10	615	856	1	889	1142	1	1102	1114	4	1122	375	0	405
Marble3	647	15	653	845	3	876	1148	7	1145	1146	6	1128	397	2	375
Marble4	573	14	702	856	1	1030	1071	1	1117	1029	3	1126	372	0	456
Marble5	584	16	555	873	0	840	1148	0	1167	1157	0	1133	388	0	372
Marble6	448	19	479	694	1	745	1028	2	1003	1026	7	1028	295	0	314
Average	583	14	625	852	1	895	1132	2	1132	1124	4	1132	379	0	399

Table 4. Frequency of occurrence of each shape component of mosaic textures using TEP.

Image	Diamond			Corners			Left -L			Right - L			Blob		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Mosaic1	60	38	56	1006	31	1070	1276	84	1129	1102	96	1297	51	24	48
Mosaic2	122	12	136	556	0	653	954	3	1084	1010	2	1005	117	0	123
Mosaic3	85	14	109	469	1	503	784	13	878	880	9	834	73	0	97
Mosaic4	80	12	90	428	2	472	770	11	906	862	6	819	70	0	78
Mosaic5	56	16	50	290	3	267	751	14	734	754	12	703	48	2	41
Mosaic6	23	10	23	150	5	106	487	33	870	767	22	585	18	3	21
Average	71	17	77	483	7	512	837	26	934	896	25	874	63	5	68

Table 5. Frequency of occurrence of each shape component of granite textures using TEP.

Image	Diamond			Corners			Left -L			Right - L			Blob		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Granite1	634	0	634	880	0	900	1207	0	1281	1235	0	1285	408	0	382
Granite2	663	0	744	1049	0	1080	1208	0	1341	1224	0	1241	461	0	501
Granite3	725	0	723	960	1	1070	1321	1	1298	1218	2	1327	435	0	461
Granite4	537	0	540	848	0	825	1165	1	1173	1211	0	1168	354	0	370
Granite5	695	0	711	1042	0	1094	1301	0	1328	1355	0	1300	469	0	473
Granite6	598	0	688	1037	0	1024	1324	0	1388	1358	0	1364	396	0	431
Average	642	0	673	969	0	999	1254	0	1302	1267	0	1281	421	0	436

The present study utilized 1-Dimensional and 2-Dimensional analysis or plots based on the frequency count of shape components using TEP's for the classification purpose.

3.1 Classification based on 1-D survey of shape components using TEP's

From the frequency of occurrences of shape components on TEP's of Tables 1 to 5, it is clearly evident that the fabric and granite textures can be classified easily based on the frequency of occurrences of DTEP-1 which results a zero count for these two groups of textures as shown in Table 2 and Table 5. The classification using 1-D survey based on DTEP-1 is shown in the form of flowchart in Fig.9. That is from the 1-D survey of shape components based on TEP the following two classes are found from the considered five groups of textures.

Class-1 :{ Fabric, Granite}

Class-2 :{ Brick, Marble and Mosaic}

Further classification that is individual classification of class-1 and class-2 textures is not possible by the proposed 1-D survey of shape components using TEP. From the above 1-D survey it is clearly evident that only DTEP-1 resulted a good classification and all other four shape components failed in classification of textures.

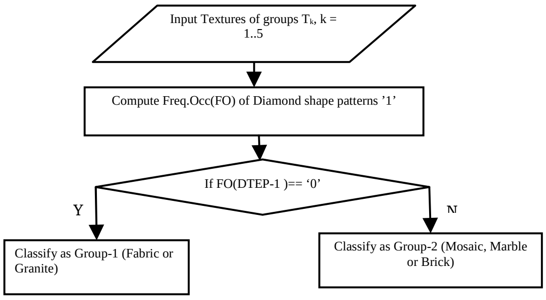

Fig.9. Classification based on 1-D analysis of shape components on TEP.

3.2 Classification of textures based on 2-D plots of shape components using TEP's

The present paper also classified the texture groups based on the 2-D analysis on the shape components using TEP's which are represented in the form of graphs. By this mechanism one can have one shape component frequency count on X-axis and the other on Y-axis. There can be a total of 14 classification graphs that represent DTEP-0 on X- axis and other shape components on Y-axis. By removing duplication the total number of such graphs for classification of texture based on the 2-D analysis on the proposed five shape components with TEP's 0, 1 and 2 is given by the equation-2.

$$T_g = \frac{n(n+1)}{2} \tag{2}$$

Where Tg is total number of different graphs, n is ((S x P) – 1), where S represents the total number of shape components and P the number of TEP's. This leads to an exhaustive study. To overcome this present approach plotted the following graphs as shown in Fig.10, Fig.11, Fig.12, Fig.13 and Fig.14. The above graphs reveal the same factor that mosaic textures are plotted as one group or in a region and other texture groups (fabric, granite, brick and marble) are plotted entirely on the other region. Thus a good classification system is built based on the 2-D plots of shape components using texture element for mosaic textures. From the 2-D survey of shape components based on TEP's the following two classes are found from the considered five groups of textures.

Class-1: {Mosaic}

Class-2: {Fabric, Granite, Brick and Marble}

This factor clearly indicates the need and advantage of 2-D graphs. However the present study suggests that it is not necessary to plot all graphs to classify mosaic textures. One can plot the frequency occurrence of DTEP-0 on X-axis and DTEP-2 on Y-axis for a clear classification of mosaic textures as shown in Fig.10. Thus it reveals that a good classification can be resulted by diamond shape components based on TEP's on a 3x3 mask and one need not necessarily count the other four shape components for classification of textures. Further classification that is individual classification of class-2 is not possible by the proposed 2-D survey of shape components using TEP's.

Table 6. Percentage of occurrence on each shape components with all patterns.

Texture	Percentage's of				
	DTEP	CTEP	LTEP	RTEP	BTEP
Brick	16.90	22.90	25.33	25.83	9.04
Fabric	15.64	24.42	25.24	25.08	9.61
Marble	14.77	21.13	27.40	27.31	9.40
Mosaic	3.38	20.47	36.72	36.66	2.77
Granite	14.23	21.29	27.65	27.56	9.27
Average	12.98	22.04	28.47	28.49	8.02

The present study also analyzed the percentage of occurrence factor of each shape component with all patterns and it is represented in the Table 6. The Table 6 reveals that CTEP, LTEP and RTEP shape components have dominant grouping in brick, fabric, marble and granite texture images but fail in classification. The DTEP which is having moderate percentage, resulted as a good texture feature for classification. The BTEP shows the least percentage of shape component and failed in classification.

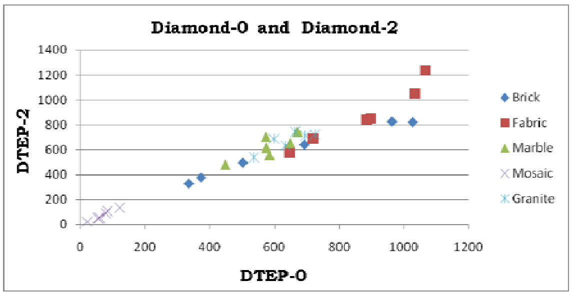

Fig.10. Graph between DTEP-0 and DTEP-2 for all textures.

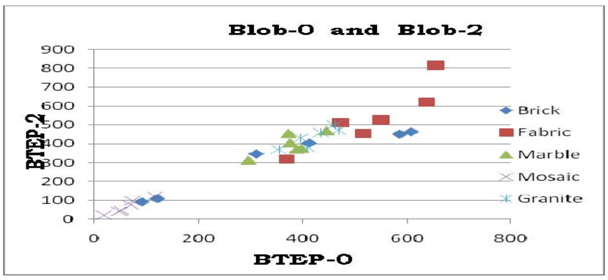

Fig.11. Graph between BTEP-0 and BTEP-2 for all textures.

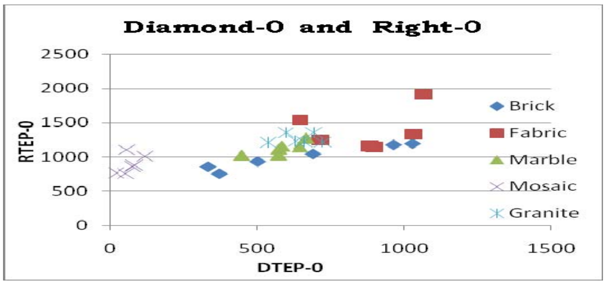

Fig.12. Graph between DTEP-0 and RTEP-0 for all textures.

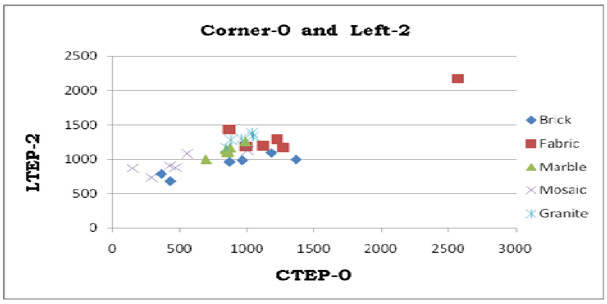

Fig.13. Graph between CTEP-0 and LTEP-2 for all textures.

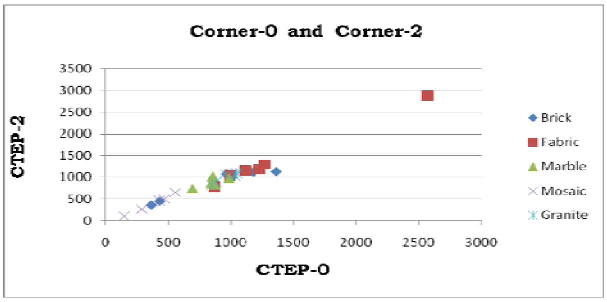

Fig.14. Graph between CTEP-0 and CTEP-2 for all textures.

4. CONCLUSIONS

The present study created a new direction for classification of textures based on texture features derived from shape components on different patterns of texture elements. By investigating texture classification using different shape components the present study concludes that diamond shape component contains more classification information than other shape components. Based on the experimental results of one dimensional and two dimensional analysis the present paper concludes that one need not consider the other texture features such as CTEP, LTEP, RTEP and BTEP for classification purpose, since these shape components contains least textural features. The present paper also investigated that any stone texture contains 79% of occurrence of CTEP, LTEP and RTEP shape components compared to DTEP with 13% and BTEP with 8% of occurrence.

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