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A New Approach for Stone Texture Classification using Shape Features on Texton

[1] G S N Murthy, [2] Dr. Srininvasa Rao. V and [3] Dr. SVVSR Kumar. Pullela

[1] Research Scholar, Rayalaseema University, Kurnool, India.

[2] Professor and HOD, Department of CSE, V.R. Siddhartha Engineering College, Vijayawada, India.
[3] Professor and HOD, Department of CSE, Aditya College of Engineering, Surampalem, India.

Abstract

Stone texture classification can be automatically done by using stone texture image analysis. Stone texture analysis has lots of applications such as automatic recognition and classification of stone textures, defect detection of stones in stone industries, construction field. However, for existing systems it is still a challenging problem to estimate the correct stone texture class group effectively. An effective and efficient texture classification system is proposed in this paper. The proposed method extract the five shape features i.e. Axis of least inertia, Eccentricity, Rectangularity, solidity from Two valued Texton Matrix (TTM). The TTM is generated from each 2×2 sub image. Based on the feature set values the present paper derives a user defined algorithm to classify the stone texture image into one of the 4 pre-defined types i.e. Marble, Brick, Granite and Mosaic. The proposed method also tested by using the K-Nearest Neighbour Classification algorithm with the derived shape features. To prove the efficiency of the proposed method, the proposed method is tested on different stone texture image databases. The proposed method exhibits high classification rate when compared with the other existing methods.

Index Terms: Shape features, Stone texture Classification, Texton Matrix, K-NN classifier, Stone image

I. INTRODUCTION

Characterization of Textures and their classification are vital for the translation and comprehension of visual examples in genuine. Order of Texture has an assortment of planned applications in different fields [1], for example, grouping in satellite picture locales [2], in the analysis of leukemic cells in light of medicinal pictures [5], discovering absconds during modern surface assessment [3], and aspiratory ailment characterization [4]. Surface examination and characterization can be accomplished significantly utilizing measurable approach as well as basic strategy. Measurable methodologies depend on stochastic things of the spatial conveyance of dark levels in a picture. In finding the attributes, co-event network is often utilized which remove textural data from advanced pictures [6, 7]. In auxiliary approach, surface is considered as a redundancy of a few primitives.

During the time spent arrangement and portrayal of surfaces, auxiliary strategies are connected by a few creators and they made progress to a specific degree [8].

Surface portrayal and order is a critical stride in the investigation of examples in view of surface pictures. Surfaces are portrayed and grouped by various creators utilizing different example approach strategies: edge course developments [9], long straight examples [10, 11]. A few authors proposed techniques for portrayal and grouping of surfaces by utilizing pre-prepared pictures [12], Marble surface depiction [13], keeping away from of Complex Patterns [14]. Surface pictures are likewise depicted and arranged by utilizing different wavelet changes strategies in light of factual parameters [15] and primitive examples [16].

Sasi Kiran et.al [17] has proposed Wavelet construct Histogram with respect to texton designs (WHTP) in which stone surfaces are assembled into four classes and accomplished 94.56% of arrangement precision. Ravi Babu et.al [18] has proposed a strategy for order of stone surfaces into four gatherings in light of example approach on dark to-dim level preprocessed pictures which accomplished an arrangement exactness of 97.15%. Sumalatha et.al. [19] has proposed a strategy for acknowledgment of stone surfaces i.e., LBP-High-Symmetry (LBP-HS) in which designed approach is utilized for stone surface acknowledgment and accomplished 92% of exactness in acknowledgment. Sujatha. B et al [20] proposed Texton and Texture Orientation Co-event Matrix (T&TO-CM) strategy for the arrangement of surfaces and accomplished just 93% of order rate.

The main objective of the proposed system is to define a user defined classification approach for classifying the stone texture into groups and validate the efficiency based on standard classification approach like k-NN and other existing approaches. In literature, proposed approaches are used the standard classification system for classifying the stone textures that takes time for extraction of the features from stone image and also time for classification system. In some proposed approaches in literature, users defined algorithms for classifying the stone texture group but not used the standard classification algorithm. The main objective of the proposed method is to fit for both the approaches i.e. for user defined algorithm and also for standard classification algorithm. If correct features are extracted then it is fit for both standard classification and also for user define algorithm. So, the present paper concentrates on this point and develops a method for stone texture classification based on Shape features and classifying the stone textures images into four groups.

The rest of the paper is organized as follows. In section 2, proposed methodology is described and results of standard classification and derived user defined algorithm are explained in section 3. Finally, conclusions are given in section 4.

II. PROPOSED METHODOLOGY

The proposed method of stone texture classification system can be shown by using the block diagram as shown in figure 1. The Figure 1 indicates the proposed approach that mainly contains of four stages. In stage 1, change the RGB stone texture image into Gray level image using Weighted RGB conversion method. In stage 2, generate the Two-valued Texton Matrix (TTM) from gray level image. In stage 3, extract the shape features like Axis of least inertia, Rectangularity, Eccentricity, Solidity and add these features to feature vector. Based on the feature values in feature vector derive an algorithm for classifying the test stone image into one of the four pre-defined types i.e., Marble, Brick, Granite and Mosaic in the final stage.

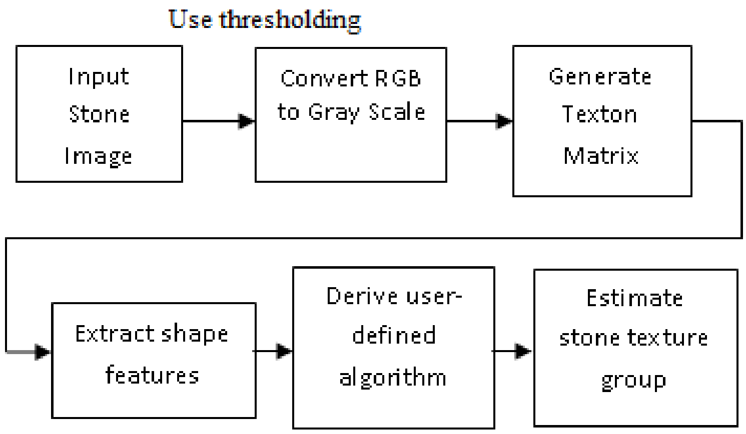

Fig. 1. Block diagram of the proposed Stone texture Classification System

A. Convert the RGB Color Image into Gray Level Image

To extract the shape features from the texton image, first need to convert the input RGB colour image into gray level image. The proposed method utilizes the Weighted RGB conversion method. Generally, the RGB image is composed by 3 dominated colours i.e. Red(R), Green(G) and Blue(B). In Weighted RGB conversion process, different weights are assigned to each colour component and these three components are utilized for converting the colour image into gray level image. The conversion process is represented by using the equation 1. The resultant image is shown in figure 2.

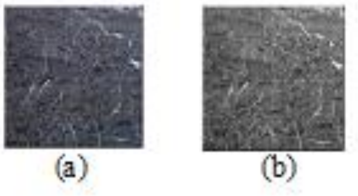

Fig. 2. Marble stone image (a) Color image (b) Resultant Grey level image

In equation 1; R, G, B are the corresponding color component values and x,y are the pixel positions.

$$Gray(x,y)=0.3*R(x,y)+0.59*G(x,y)+0.11*B(x,y) \quad (1)$$

B. Generate Two-valued Texton Matrix (TTM):

To extract the features from a stone surface picture, the present approach produce the TTM. For producing the TTM, the following technique is used. The Textons allude to the basic examples in regular pictures and in this manner form the essential components in visual view. By similarity to material science, if picture bases resemble protons, neutrons and electrons, then textons resemble molecules [21, 22]. The textons can speak to pixel connections in a wide range of routes with in a sub picture or sub window picture components, for example, shape, nearby circulation introduction, spatial conveyance, design and so on.., utilizing textons and which is fundamental for picture surface examination.

Textons [23, 24] are considered as basic examples, which are situated in a sub picture or sub window. The textons are characterized as an arrangement of blobs or developing examples sharing a typical property everywhere throughout the picture [23, 24, 30]. As texton may shape different picture components, to characterize an exact and precise stone surface arrangement, the present review consider all the texton designs framed in a 2×2 window. A few issues exist related with texton estimate, tonal distinction between the extent of neighboring pixels, texton classifications, extension of textons in one introduction, lengthened components of textons with jittered in introduction. By this, occasionally a fine or coarse or a conspicuous shape may come about or a pre-mindful segregation is diminished or texton inclinations at the surface limits might be expanded.

To address these issues, the present paper used six texton sorts which are shaped on a 2×2 window as appeared in figure 3(a). In figure 3(a), the four pixels of a 2×2 lattice are signified as V1, V2, V3 and V4. On the off chance that two pixels are highlighted in dim shade of same pixel esteem then the window frames a texton and comparing texton design dim levels set to paired esteem one ‘1’ generally remain pixel qualities are set to zero ‘0’. The six texton sorts meant as TP1, TP2, TP3, TP4, TP5 and TP6 are appeared in figure 3(b) to 3(g). The component adjusted in proposed technique for texton identification is represented in figure 4.

In figure 4(b) the first 2×2 window has two texton patterns so that window values are replaced with ones, second 2×2 window does not have any texton patterns so that those values are replaced with zeros and third 2×2 window have one texton pattern and those values are replaced with one and remaining two values are replaced with zeros. This procedure is continued in each 2X2 sub window of fig 4(b) which resulted in fig 4(d)

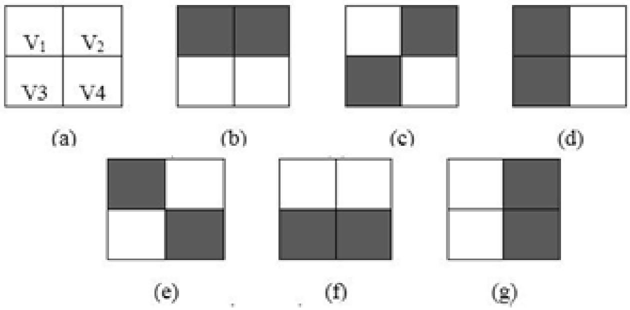

Fig. 3. Texton Patterns (a) 2×2 sub window b) TP1 c) TP2 d) TP3 e) TP4 f) TP5 g) TP6

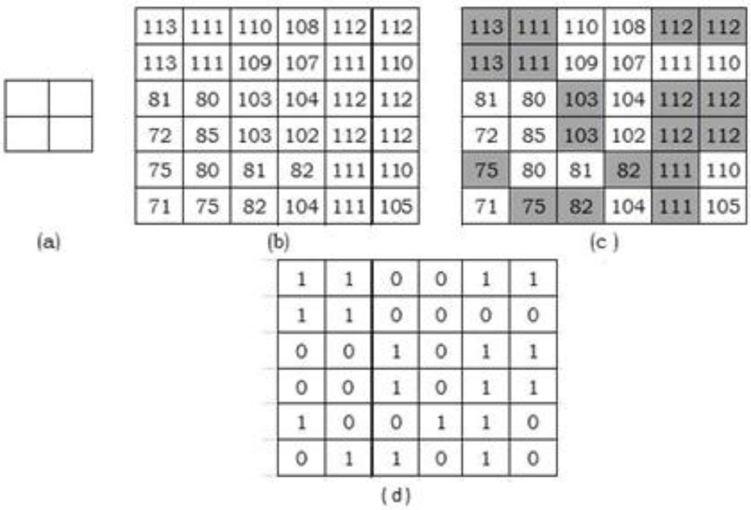

Fig. 4. Working Mechanism of the Two Valued texton Matrix (a) 2X2 block (b) Sample 6X6 gray level matrix (c) texton identified location shaded with gray colour in 4(b) (d) resultant Two valued Texton Matrix.

C. Extract the shape features from TTM

Once the TTM is generated, the shape features can be extracted. The shape features give more information about the surface of the stone. The present paper uses the shape features only because of patterns on stone texture surface is different from one group to other stone texture group. These different types of patterns are identified by using shape features. The shape features used in the present approach is Axis of Least Inertia, Eccentricity, Rectangularity, and Solidity. Based on these shape features, the group of the stone texture can be identified.

III. RESULTS AND DISCUSSION

To test the proposed method, among numerous available stone texture databases around the globe, four of them are considered which incorporates huge set of images. The stone texture images are collected from VisTex, Mayang, Paul Bourke and Google colour texture databases. VisTex database [25] is to provide texture images that are representative of real world conditions.

The proposed method used brick, stone and tiles (mosaic) from VisTex database textures and it contains 678 images. The Mayang dataset [26] is consists of 59 texture classes, but the present study uses 4 texture group which has 152 in each class totally 612 images are considered in the present study. The Paul Bourke colour textures [27] is composed of 100 texture classes, but the present study uses 4 texture group which has 208 in each class totally 832 images are considered in the present study. From the Google database, the present paper uses 400 stone texture images 100 per each class. Totally, the present paper uses 2522 texture images for analysis. The Vistex and Mayang dataset contains stone textures with 256×256 pixels however the size of the Paul Bourke colour textures are 746×538 pixels.

As the texture surface rotates, only the central part of the image captures the same portion of the surface. For this reason, the central part of the rotated images is retained which is calculated by (min(W,H)/2) where W and H are the width and height of the original images. This gives an image size of 256×256 pixels. Some of the images from different data bases are shown in figure 5. The feature set values of the each stone texture category is listed out in tables 1 to 4. Based on these feature set values, the tested image is classified by using standard classification algorithm and also based on user defined algorithm.

Fig. 5. Sample stone texture images of various databases, 16 from each class

TABLE 1: FEATURE SET VALUES FOR BRICKS TEXTURES EXTRACTED FROM TTM

Sno	Image Name	Axis of least inertia	Solidity	Eccentricity	Rectangularity
1	brick001	0.02015	32.3015	0.3002	0.279
2	brick002	0.02043	24.2708	0.3213	0.319
3	brick003	0.02024	28.318	0.3321	0.342
4	brick004	0.02006	32.3334	0.3209	0.32
5	brick005	0.02043	23.2511	0.3232	0.323
6	brick006	0.02043	24.2708	0.3213	0.319
7	brick007	0.02015	31.3136	0.3223	0.323
8	brick008	0.01997	34.329	0.3126	0.304
9	brick009	0.02043	24.3027	0.345	0.367
10	brick010	0.02024	27.2983	0.3339	0.345
11	brick011	0.02043	24.2708	0.3213	0.319
12	brick012	0.02015	32.3015	0.3002	0.279
13	brick013	0.02024	28.2862	0.31	0.297
14	brick014	0.02024	28.2862	0.31	0.297

15	brick015	0.02034	27.2664	0.3116	0.3
16	brick016	0.02034	27.2664	0.3119	0.301
17	brick017	0.02006	34.3092	0.3138	0.306
18	brick018	0.02043	24.2708	0.3213	0.319
19	brick019	0.02006	34.2971	0.2929	0.265
20	brick020	0.01997	34.329	0.3126	0.304

TABLE 2: FEATURE SET VALUES FOR MARBLE TEXTURES EXTRACTED FROM TTM

Sno	Image Name	Axis of least inertia	Solidity	Eccentricity	Rectangularity
1	Marble.001	0.01104	38.2862	0.3083	0.294
2	Marble.002	0.00884	40.3322	0.2822	0.244
3	Marble.003	0.00608	40.3322	0.2817	0.243
4	Marble.004	0.00966	36.2401	0.3108	0.297
5	Marble.005	0.00911	36.3015	0.2982	0.275
6	Marble.006	0.00939	44.2708	0.3026	0.282
7	Marble.007	0.00856	47.3431	0.2704	0.222
8	Marble.008	0.00884	40.3322	0.2822	0.244
9	Marble.009	0.00911	41.2817	0.2996	0.277
10	Marble.010	0.00874	41.352	0.2973	0.274
11	Marble.011	0.00773	68.4397	0.2576	0.2
12	Marble.012	0.00939	44.2708	0.286	0.249
13	Marble.013	0.00856	45.3673	0.29	0.26
14	Marble.014	0.00902	35.2971	0.2909	0.261
15	Marble.015	0.00847	48.3948	0.2859	0.253
16	Marble.016	0.0093	37.2664	0.3096	0.296
17	Marble.017	0.00838	50.3706	0.2814	0.244
18	Marble.018	0.0092	38.2862	0.308	0.293
19	Marble.019	0.00838	51.3904	0.2805	0.243
20	Marble.020	0.00902	36.2971	0.2912	0.261

TABLE 3: FEATURE SET VALUES FOR GRANITE TEXTURES EXTRACTED FROM TTM

Sno	Image Name	Axis of least inertia	Solidity	Eccentricity	Rectangularity
1	Granite.001	0.02015	38.3015	0.326	0.292
2	Granite.002	0.01942	52.3783	0.2887	0.225
3	Granite.003	0.02024	37.2862	0.3364	0.311
4	Granite.004	0.01988	39.3443	0.3284	0.299
5	Granite.005	0.01988	40.3322	0.3088	0.26
6	Granite.006	0.01951	50.3387	0.2908	0.228
7	Granite.007	0.01923	55.4057	0.2989	0.247
8	Granite.008	0.02015	35.9798	0.326	0.292
9	Granite.009	0.01942	51.3904	0.3053	0.258
10	Granite.010	0.01942	51.3904	0.3053	0.258
11	Granite.011	0.01896	63.4364	0.2871	0.226
12	Granite.012	0.01978	43.3278	0.3028	0.249
13	Granite.013	0.01932	54.864	0.2981	0.245
14	Granite.014	0.01923	55.4057	0.2989	0.247
15	Granite.015	0.01978	40.3641	0.327	0.297
16	Granite.016	0.01932	54.3859	0.2999	0.248
17	Granite.017	0.01997	36.3487	0.3362	0.314
18	Granite.018	0.01932	54.3859	0.2999	0.248
19	Granite.019	0.02061	35.6274	0.3289	0.293
20	Granite.020	0.0196	47.3753	0.3122	0.27

TABLE 4: FEATURE SET VALUES FOR MOSAIC TEXTURES EXTRACTED FROM TTM

Sno	Image Name	Axis of least inertia	Solidity	Eccentricity	Rectangularity
1	mosaic.001	0.01163	38.3334	0.3189	0.316
2	mosaic.002	0.0113	48.3629	0.3171	0.315
3	mosaic.003	0.01162	36.3169	0.323	0.325
4	mosaic.004	0.01155	57.4134	0.3217	0.326
5	mosaic.005	0.0116	44.3794	0.3262	0.333

6	mosaic.006	0.01167	44.2708	0.336	0.349
7	mosaic.007	0.01163	37.3334	0.3356	0.349
8	mosaic.008	0.0153	59.4211	0.3188	0.321
9	mosaic.009	0.01159	47.375	0.337	0.355
10	mosaic.010	0.01163	36.5956	0.3268	0.332
11	mosaic.011	0.0197	43.3597	0.3367	0.318
12	mosaic.012	0.0198	43.3278	0.3495	0.383
13	mosaic.013	0.0196	47.3431	0.3427	0.371
14	mosaic.014	0.0199	39.3443	0.3417	0.366
15	mosaic.015	0.0202	38.2862	0.333	0.344
16	mosaic.016	0.0195	49.3508	0.3493	0.365
17	mosaic.017	0.0198	41.3201	0.3361	0.355
18	mosaic.018	0.0199	39.3443	0.345	0.333
19	mosaic.019	0.02	37.3366	0.3458	0.373
20	mosaic.020	0.0189	67.9298	0.3306	0.315

A. By using standard classification algorithm

In this paper, for testing the proposed strategy, k-Nearest Neighbor Classifier (KNNC) is utilized for grouping reason. All investigations are completed on a PC machine with i5 processor 2.6 GHz CPU and 4 GB RAM memory under MatLab 10.0. In implementing the classification 60% of the data is taken as test data and remaining 40% of stone textures are utilized for testing i.e. 1514 stone textures are utilized for generation of classifier and 1008 pictures are utilized for testing. The classification rate of the proposed strategy based on k-NN Classifier are represented in table 5 w.r.to different stone textures.

TABLE 5: PERCENTAGE OF CLASSIFICATION WHEN K-NNC ALGORITHM IS APPLIED

Texture Group	Classification Rate of considered Stone texture Databases				Overall %
	VisTex	Mayang	Google	PaulBourke	
Bricks	95.75	95.59	95.83	96.18	95.84
Marble	95.79	96.17	95.91	95.87	95.94
Granite	95.84	95.59	96.13	96.18	95.94
Mosaic	95.73	95.85	96.37	95.13	95.77

B. By using User defined classification Algorithm

Based on the extracted feature set values, the present paper derives a user defined algorithm called Shape feature based classification algorithm. The input for the proposed algorithm is feature set values and the output of the algorithm is one of the four stone texture groups, the detailed Shape feature based classification algorithm is shown in Algorithm 1. The classification results of proposed method when user defined algorithm are applied and results are listed out in table 6.

TABLE 6: PERCENTAGE OF CLASSIFICATION WHEN USER DEFINED ALGORITHM IS APPLIED

Texture Group	Classification Rate of considered Stone texture Databases				Overall %
	VisTex	Mayang	Google	PaulBourke	
Bricks	96.17	95.12	96.43	96.13	95.96
Marble	96.29	95.08	96.13	96.75	96.06
Granite	96.31	96.36	96.31	96.16	96.29
Mosaic	96.69	96.21	95.37	96.71	96.25

Algorithm 1: Estimation of texture group of a stone texture using Shape features

START

if Solidity is less than 35 then

print" Test image class is treated as Brick Class "

else

if Solidity is greater than 35 and Axis of least inertia is less than or equal to 0.01104 then

print" Test image class is treated as Marble class "

else

if Solidity is greater than 35 and Axis of least inertia is greater than 0.01104 and Rectangularity is less than or equal to 0.314 then

print" Test image is treated as Granite Class "

else

if Eccentricity is greater than 0.3171 and Rectangularity is greater than or equal to 0.314 then

print" Test image is treated as Mosaic class "

otherwise

print " unknown texture class"

END

From the above two approaches the k-NNC technique has shown slightly less classification rate and also its time complexity is more. The user defined classification approach has shown slightly higher classification rate with less time complexity. So from the above results it can be observed that the user defined approach is most suitable than standard classification (k-NNC). The accuracy of classification of the both the approaches w.rto different stone texture groups are shown in figure 6.

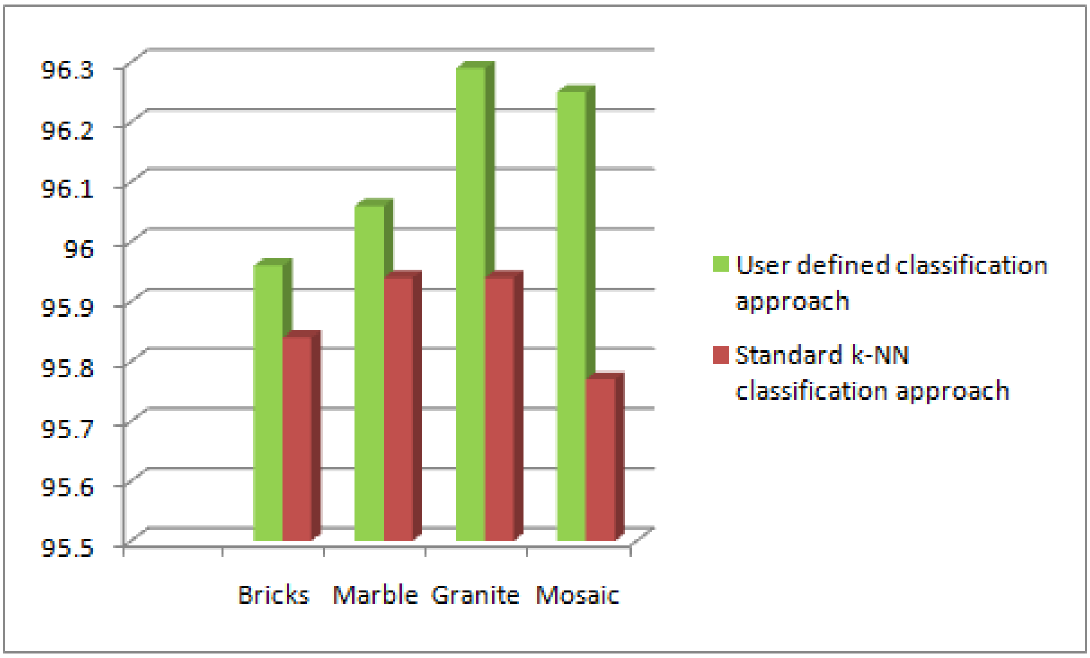

Fig. 6. Classification rate of the user defined and standard k-NN classification algorithms

C. Comparison of the Proposed Method With Other Existing Methods

To assess the productivity, the proposed strategy is compared with other stone surface order procedures [17, 28, 29]. The technique proposed by J. S. Kiran et.al [17] characterizes stone surface pictures utilizing wavelet based texton design histogram and texton include development technique into four classes. This approach textons are distinguished on 2×2 window after wavelets are connected. The proposed strategy is likewise contrasted and Syntactic Pattern on 3D technique [28] which depends on the event of deliberate examples and grouped stone surfaces into four classifications. The technique proposed by Ravi babu et.al [29] likewise orders the stone surfaces into four classes in view of the components removed by textons. The characterization rate of proposed strategy and other existing strategies are recorded in table 7 from which it is evident that, the proposed technique has hinted at a high order rate than the other existing techniques. The graphical representation of the rate mean arrangement of the proposed and other existing strategies is appeared in figure 7.

TABLE 7: CLASSIFICATION RATE OF THE PROPOSED SHAPE FEATURE BASED METHOD WITH OTHER EXISTING METHODS

Database	Syntactic Pattern on 3D Method	Wavelet based Histogram on Texton Patterns	Texton Feature Detection	Proposed Method
Google	93.29	93.15	95.56	96.06
Mayang	92.53	92.87	94.15	95.74
Paul Bourke	93.3	93.82	95.27	96.13
VisTex	93.59	93.28	94.97	96.07

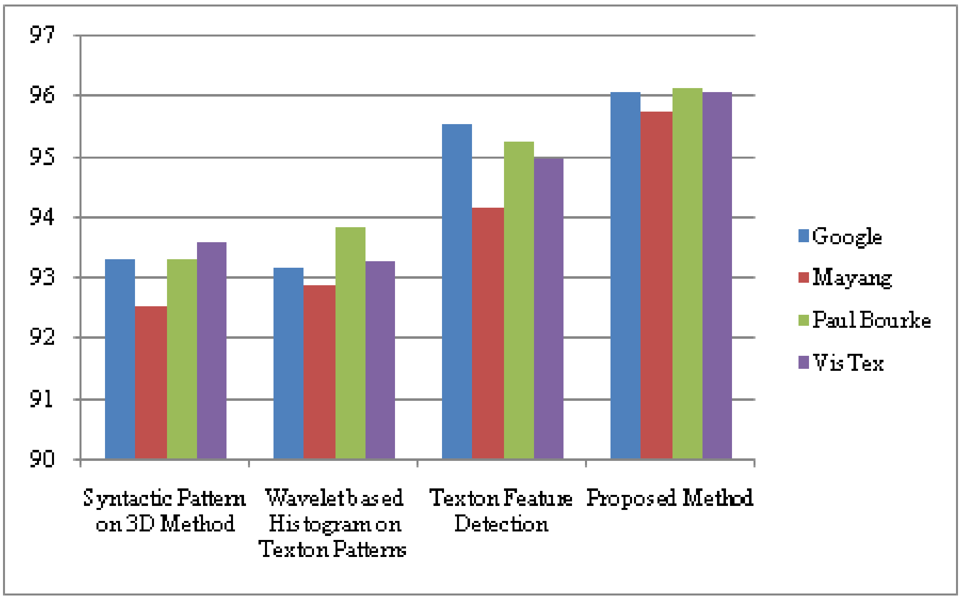

Fig.7. Comparison Chart of the proposed system with other existing methods

IV. CONCLUSION AND FUTURE SCOPE

The proposed method drastically reduced the computational time because of simple procedure is applied for each and every step of the proposed method. The proposed method is tested in two approaches. In the first approach KNNC is used for classifying the stone textures into 4 categories. The overall classification efficiency of the proposed method is 95.87% when k-NNC applied. In the second approach an user defined stone texture classification algorithm is proposed based on shaped features on Two valued Texton Matrix and achieved an overall classification accuracy of 96.14%. The efficiency of the proposed method is high compared to other existing methods in classifying the stone texture into four categories. The proposed method exhibits high average rate of classification when compared to the existing methods.

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ABOUT THE AUTHORS :

G S N Murthy has completed his MCA from Andhra University, Waltair, India in 1996 and M. Tech. (Computer Science & Engineering) from Acharya Nagarjuna University, Nagarjuna Nagar, India in 2010. He is pursuing his Ph.D.(CS) (Part-time) from Rayalaseema University, Kurnool, India and working as an Assistant Professor in the department of CSE, Aditya College of Engineering, Surampalem, Andhra Pradesh, India. His areas of interest include Data Mining and Image Processing.

Dr. Srinivasa Rao V working as a Professor and Head of the Department of Computer Science Engineering at V.R. Siddhartha Engineering College, Vijayawada, India. He is having more than 25 years of experience at various levels. He completed his Ph.D.(CSE) from Berhampur University, Orissa, India. His areas of interest include Bio-Informatics, Data Mining and Image Processing.

Dr. S V V S R Kumar. Pullela is working as a Professor and Head of the Department, Department of Computer Science & Engineering, Aditya College of Engineering, Surampalem, Andhra Pradesh, India.. He completed his Ph.D(CSE) from Acharya Nagarjuna University, Nagarjuna Nagar, India. He is having more than 17 years of experience. His areas of interest include Data Mining and Image Processing.