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Pattern Generation for Geometrical Objects using Morphological Transformations

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Abstract

A new approach to generate a pattern for any object of binary image is proposed. One of important compression techniques of any monochrome images without losing the information is chain code encoding principle. It is segmenting the connected component of each region at point of boundary. The boundary is located by selecting the point with coordinates and then transmitted. This continues to reach the starting point, so this way object will be segmented from monochrome images with background. This novel method first applying the morphological transformations for enhancing the image, elimination of background, and binarisation, secondly using modified chain code encoding system for segmenting the object with edges and corner detection. This method generates the pattern for each object by applying modified chain code and morphological transformations procedure which extracts the coordinates of the shapes with considerable improvement in accuracy over classical chain code. We could reconstruct the original objects from the generated pattern which shows more accurate for considerable geometrical objects.

Key words

Pattern generation, object detection, chain code, morphology, neighborhoods.

1. Introduction

The computer applications are applied into real time operation to detect an object using mathematical pattern. The mathematical pattern widely used for identify the objects based on object detection techniques such as chain code as well as geometrical shapes. It is represented in two dimensional shapes. Use of the object boundary and its features like boundary length are the one of way to describe shapes. It is directly connected to edge and line detection. Second way of describing the shape is region occupied by the object on the image plane. It is linked to the region segmentation techniques. To describe the shape includes few properties like uniqueness, completeness, Invariance under geometrical transformations, sensitivity and abstraction from detail. In identification of edges for object detection we propose a method which includes morphological transformations and chain code segmentations. The chain code depends on the start point of boundary following. An advantage of chain code is that it is translation invariant. Scale invariance can be obtained by changing the size of the sampling grid producing seldom. Modified chain codes can also be used to calculate certain boundary features. The generated pattern which can be reduced form of objects, used to operate on any platform.

A method for the line detection based on chain code detection is proposed (Guang-quan lu, 2005). The chain codes are tracked in an edge image. After the curvature estimated, the corners in chain codes can be detected, and chain codes are separated ate the corners. Chain codes of line segments are recognized, and only the chain codes which represent line segments are kept. New morphological edge detector has proposed (Neeta nain *et al*, 2006), which returns a one pixel thick m-connected binary boundary image in the regions. This is followed by our chain encoding method to detect corners on the extracted edges. The algorithm works on all types of images (i.e. binary, gray level and color images). Since the proposed methods are based on morphological operations, these are very simple, efficient and fast. Experimental results on a variety of images identified. (Vasile prejmerean and Simona Motogna, 2001) constructed a description grammar for the object under study, grammars that are used in the syntactical recognition of similar objects. The object being recognized has a corresponding description through morphological transformations that allows them to study if the description belongs to the language generated by the designed grammar. This paper presents a method for character recognition using morphological transformations, whose purpose is to obtain certain structures formed from lines and curves needed for pattern recognition. The author (Neeta Nain *et al*, 2008) addressed some aspects of analyzing the content of an image. This paper presents a new approach for corner detection using first order difference of chain codes called shape numbers. Since the proposed method is based on integer operations it is simple to implement and efficient. The extracted boundary is chain encoded using m-connectivity. In the second step we apply chain smoothing procedures to remove false corners by suppressing regular intensity changes. The final step calculates shape numbers and then abrupt changes are identified in shape numbers to detect significant corners.

Extracted of drainage networks includes generation and processing of digital elevation models (DEMs) obtained from the remotely sensed data having stereo viewing capability (B. S. Daya Sagar *et al*, 2000). The later aspect generally aims to extract terrain features such as elevation contours and channel networks. The methodology is illustrated using a transcendentally generated DEM that bears the spatially distributed regions in grey levels, assumed as the regions of topographic reliefs and the V-shaped crenulations in successive elevation contours. Generating pattern for any DEM can be minimum form of digital values on the data. The pattern can identify the boundaries of each elevation to segment the DEM. Also it can be applied for generating a channel networks within DEM which will be reduced form of information available in DEM. Image compression scheme based SVM with neural network has proposed (Gang, G and Gao, X, 2008). The content based face image retrieval using robust feature set, which may solve various retrieval activities (Baulkani.S and Ganesan.L, 2010). Likelihood-based methods for estimating rules of cellular automata aimed at the re-generation of observed regular patterns (Craiu RV and Lee TC, 2006). Under noisy data, our approach is equivalent to estimating the local map of a stochastic cellular automaton. Direct computations of the maximum likelihood estimates are possible for regular binary patterns.

2. Methodology

The digital color image representing of any set of objects considered as input for this study. Morphological image enhancement has been carried out for converting the given input to binary format of image, which can be used for detecting the modified chain code. The outer contour of an object detected through the morphological transformations in the binary image. The object boundary are used for detecting the modified chain code which includes the image size, starting point of an object in the image and number of similar code available with the a particular chain code and continue with the corner detection where codes changes of chain code or direction for representing each object until starting point of object. It can be continued for other objects in the same image. The pattern will represent the all the object of an image through that we are detecting the objects. For identification of an object in the image we try to use the corner points and size of the entire contours. The 8-connectivity has applied for detecting the modified chain code. The 8-connectivity of directions for each chain code are shown in the following figure 1.

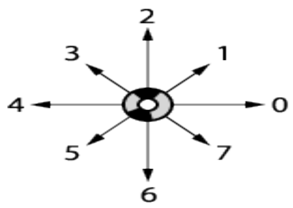


Fig 1. The chain code with direction

The following chain code direction values are identified by using above figure. The x axis represents dr (ie) row value, and y axis represents dc (ie) column value. obj (i,k) indicates the direction value for respective row and columns.

```
if ((dr == 1)&& (dc == 0))     obj(i,k) = 0;
if ((dr == 1)&& (dc == -1))    obj(i,k) = 1;
if ((dr == 0)&& (dc == -1))    obj(i,k) = 2;
if ((dr == -1)&& (dc == -1))   obj(i,k) = 3;
if ((dr == -1)&& (dc == 0))    obj(i,k) = 4;
if ((dr == -1)&& (dc == 1))    obj(i,k) = 5;
if ((dr == 0)&& (dc == 1))     obj(i,k) = 6;
if ((dr == 1)&& (dc == 1))     obj(i,k) = 7;
```

2.1 Morphological Transformation

A discrete binary image (M) that contained objects, defined as a finite subset of IR^2, was used (B.S.Daya Sagar, 2005). The geometrical properties of M, which contained objects (set) and non-objects (set compliment), were subjected to morphological functional by means of defined sub-image (or kernel) that is here termed a structuring template (S). A bounded S that possesses a designed shape that is thought of as a probe of M was used. Constraints that correspond to the four principles of the theory of mathematical morphology such as invariance under translation, compatibility on morphological transformations erosion to shrink, dilation to expand and cascade processes performed by means of structuring templates that are represented by a compact subset of Euclidean space.

0	1	0
1	1	1
0	1	0

Rhombus structuring template (S)

M and *S* are sets of Euclidean space with elements *m* and *s*, respectively; $m= (m_1 \ldots, m_n)$ and $s=(s_1 \ldots, s_n)$ being *n*-tuple elements, morphological set transformations can be performed on *M* by means of *S*. Dilation and erosion combines and subtracts, respectively, two sets using vector addition and subtraction of set elements, one coming from *M* and the other from *S*, (B.S.Daya Sagar, 2005).

$$M \oplus S = \{m : S_m \cap M\} = \bigcup_{s \in S} M_S$$
$$M \quad \Theta \quad S = \{m : S_m \subseteq M\} = \bigcap_{s \in S} M_S \qquad (1)$$

The M⊕S is for dilation and MΘS refers to erosion of M with S. The size of S can be increased as *S⊕S⊕S⊕...⊕S=Sn*, According to this multi-scale dilation and erosion is written as

$$(M \oplus S) \oplus S \oplus ... \oplus S = M \oplus S_n$$
$$(M \quad \Theta \quad S) \quad \Theta \quad S \quad \Theta ... \Theta \quad S = M \quad \Theta \quad S_n \qquad (2)$$

The erosion and dilation are utilized for image enhancement or preprocessing, which help to detect the object in an accurate manner. For a digital image representing a character or objects are identified and generate the pattern for each object of an image through morphological transformation and chain code process. The pattern generation will be the short form of image which can be reconstructed using the reverse chain code process.

Edges and corners are region of interest to generate the pattern and reconstruct. So initially we identified the coordinates of starting edges of objects and then the direction and length of movement of the object will recorded, which produce the actual pattern of objects in the image. This will be used for reconstruction process. The location of objects is the first identification using morphological transformation then the direction and number pixels will be continued. The binary form of images first utilized for object detection and pattern generation, we also applied color image by convert to binary form then generate pattern. In both cases the reconstruction process gives significance results.

2.2 Pattern Generation with Modified Chain code

The pattern of modified chain code is as follows:

[isr, isc, nor, osr, osc, recurrence of (frequency of indices, indices)]

isr – image size row value; isc – image size column value; nor – number of objects in region of interest; osr – object starting row; osc – object starting column; recurrence of frequency which appears in objects for each direction and respective directions.

For example *[512, 512, 7, 30, 40, (25, 0, 12, 6, 25, 4, 12, 2)]*

It is a given modified chain code represented for *512 x 512* image and the rectangle object is identified at 30, 40 and 25 pixels in 0 direction, 12 pixels in 6 direction, 25 pixels in 4 direction, 12 pixels in 2 direction. So it represents a rectangle. This modified chain code will be useful to detect the object and reconstruct the original objects. By having objection location and image size in the same code will be useful for many other applications on the objects. The following Figure 2 shows the steps and the process of object detection using morphological transformations and modified chain code (Walid Shahab *et al*, 2009, Jayendra Barua and Sachin Chirgaiya, 2013, Salem, M., A. *et al* , 2005, D. N. Besekar and R. J. Ramteke, 2011)

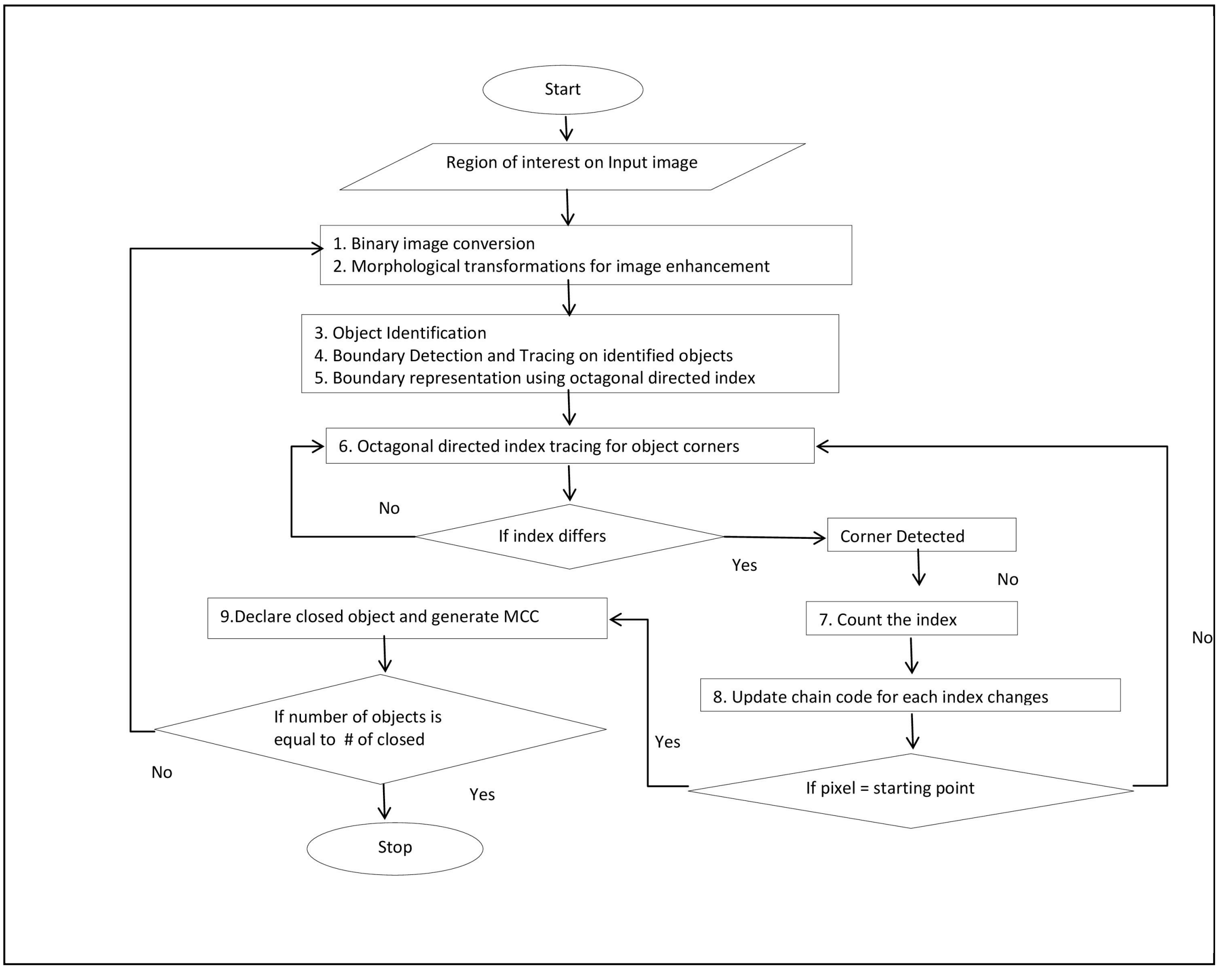


Fig 2 . Flowchart to generate a pattern for any geometrical objects using morphological transmissions and chain code

The area of detected object is computed by identifying the number of pixels in the object boundary Area calculations done by using a number of pixels in the object contour. Each line of the object is having continuous code with its length. By considering the length it is possible to find the area.

For example the area of rectangle will be multiplication of length and width pixels. The perimeter can be measured by vertical or horizontal line as 1 and diagonal as 1.414. The perimeter (Walid Shahab *et al*, 2009) of an object is calculated by number of pixels multiplied by

1 or 1.414 using horizontal or diagonal respectively. For example a small circle has 4 horizontal and 4 vertical pixels which could be multiplied by 1 and 8 diagonal direction pixel which could be multiplied by 1.414. So Perimeter of small circle is 8 * 1 + 8 * 1.4.14 = 19.312. Another example in small triangle has 3 horizontal and vertical pixels which could be multiplied 1 and 4 diagonal direction pixels which could be multiplied by 1.414. So perimeter calculation of small triangle is 4 * 1 + 4 * 1.4.14 = 9.656.

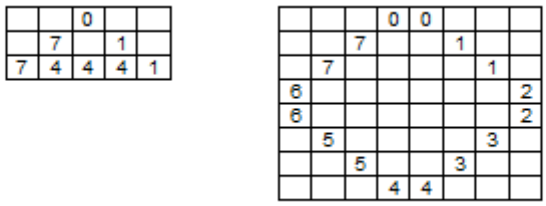


Fig 3 (a) Triangle (b) Circle for calculation of perimeter

The directions of the boundary can be identified from successive values of chain codes, for example if the successive values (0,2), (2,0), (6,0), (0,6), (1,3), (3,1), (2,4), (4,2), (5,7), (7,5), (1,7), (7,1), (4,6), (6,4), (3,5), (5,3) are generating 90^o for the boundary of objects. In the similar manner for the angle 45^o can be from the pair of successive values (+1 or -1) of the chain code. The rectangle shape can be generated by using 90^o on the corner pixels of the objects. Similarly for square (without starting point) also have 3 corners with perpendicular angles which can represents the above shown successive chain code formats. If the chain code does have change, it means that no change in direction which will continue with same angle.

The shape can be recognized by using the number of corner positions, for example if the number of corners is zero, it mean that the object will be line. If the number of corners is two, then the object has two lines. For 3 corners position, the shape can be triangle. In similar manner 4 corners position including the starting point can produce square or rectangle. The shape square or rectangle can be identified by using the number of length and width pixels. The pattern which we generated using size of image, object starting pixel, number of similar direction pixels, direction code, and etc. The object can be detected by applying the reconstruct from the generated pattern of morphological transformations.

We proposed an algorithm for generating a pattern for region of interest. A set of various image classes has been used. Here images were various objects with colored, Rabbit, and skeleton. The proposed algorithm converts the region of interest into binary form then with the use of morphological transformations such as opening, closing, thinning, pruning, hit or miss, erosion and dilations, the image enhancement are processed for betterment of the object detection. The morphological transformations are combined for the purpose of preprocessing on the region of interest. Results of morphological transformations used for generating the pattern with the use of modified chain code. The pattern includes the size of image, number of objects in the region of interest, starting position of object in the region of interest with row and columns, number of frequency of direction code with 8-connectivity neighborhoods, direction code, continue with next direction frequency and direction until the starting position of the object. After generating the pattern, we try to reconstruct the object using generated pattern which yields the original object structure.The steps involved in the pattern generation are as follows:

- Binary image conversion
- Morphological transformations for image enhancement or preprocessing
- Object Identification
- Boundary Detection and Tracing on identified objects
- Boundary representation using octagonal directed
- Octagonal directed index tracing for object corners; count the index
- Update Chain Code for each index changes
- Declare closed object and Generate pattern with MCC
- Reconstruct using generated pattern

The patterns which we generate from the object identified in the region of interest including the direction of object which can be derived by identifying the corners in boundary. While tracing boundary if we reach the starting point of the object, it is a closed object.

2.3 Reconstruction Procedure

The reconstruction of an object from the generated pattern, confirms the unique pattern for any input object in the region of interest with below given procedure.

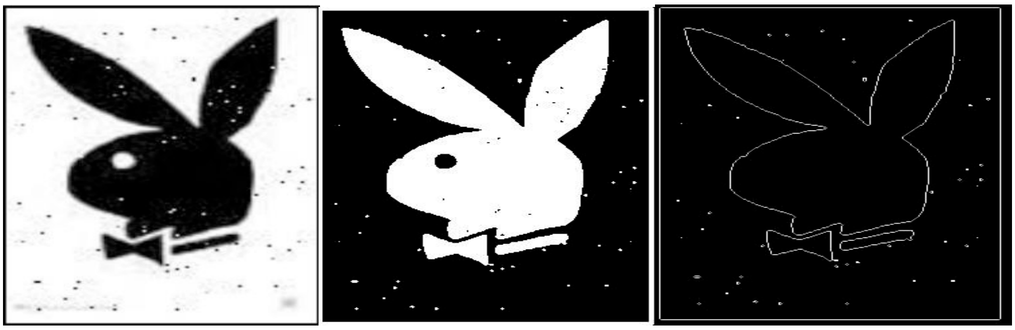
```
Begin
{
fetch(generated code)
        for i = 1:size(prd1,1)
              k = 1;
          sp(i,k) = prd1(i,1);
          k = k+1;
          sp(i,k) = prd1(i,2);
          k = k+1;
          pn = prd1(i,3);
          count = 1;
         for j = 4:size(prd1,2)
            if(pn==prd1(i,j))
               count = count +1;
             else
               sp(i,k) = count;
               k = k+1;
               sp(i,k) = pn;
               k = k+1;
               pn = prd1(i,j);
               count = 1;
            end
         end
        end
```

```
save sp;
 %code generation
 code(1) = imgr;
 code(2) = imgc;
 code(3) = no_obj;
 kk = 4;
 for i = 1:size(sp,1)
    for j = 1:size(sp,2)-1
       if ( (sp(i,j) ==0) && (sp(i,j+1) == 0))
          % no action
       else
          code(kk) = sp(i,j);
          kk = kk+1;
       end
    end
 end  }
```

One pixel thick boundary have been created by using the pattern while reconstruct, where we confirm the accuracy.

3. Results and discussion

Our proposed algorithm is applied in various data sets. In the first example we used the rabbit structure Fig 4.a as a region of interest, on the first stage which yields a binary format with image enhancement by applying the morphological transformations in Fig 4.b Binary form of rabbit structure used for pattern generation by adopting modified chain codes with 8-connectivity neighborhoods.

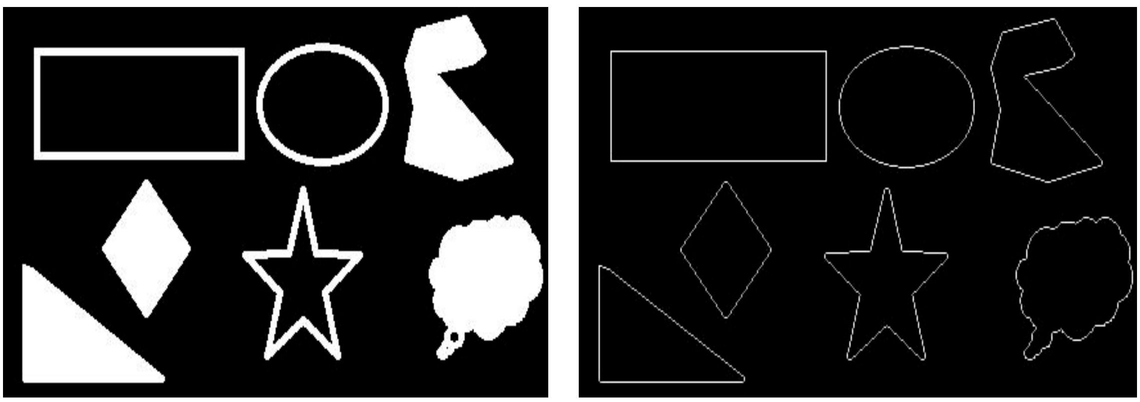


(a) **(b)** **(c)**

Fig 4 (a). Region of Interest on Rabbit object (b). Binary form of objects in Rabbit for generating pattern. (c). Reconstructed object from generated pattern

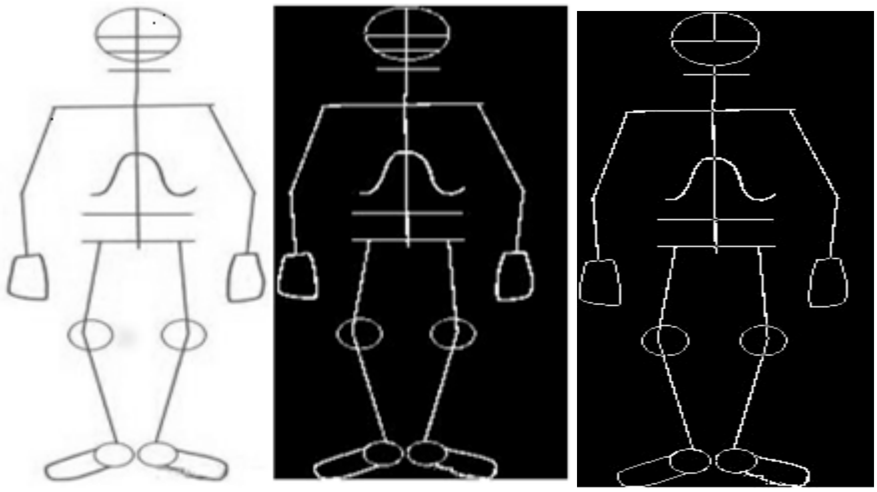
From the generated pattern we try to trace the corners and create the structure using the values represented in the pattern, which is very accurate to original object Fig.4.c. The contour of pattern is produced in the binary form by applying reverse form of MCC.

In the second example Fig.5, we considered various object in the region of interest, which are producing the challenging results on different structures.



(a) (b)

Fig 5(a). Binary form of objects in multi objects for generating patterns (b). Reconstructed objects from generated pattern



(a) **(b)** **(c)**

Fig 6 (a). Region of structure of skeleton (b) Binary skeleton for generating patterns (c). Reconstructed structure from generated pattern

Fig. 6.a is a skeleton where we introduced our algorithm to verify the competent of our method. The skeleton yields efficient results through our procedure. Pattern for rabbit image is as follows

[268, 363, 40, 4, 9, 250,7,349,1,250,3,348, 5]

The size of rabbit image is 268, 363, there are 40 objects in the rabbit image. The first object starts at (4, 9) which have 250 pixels in direction 7, 349 pixels in direction 1, 250 pixels in the direction 3, and 348 pixels in the direction of 5. The other 39 objects are similarly represented in the pattern. The pattern for multi-image region is as follows

[432,249,7,21,163,110,7,71,5,109,3]

The size of multi object image is (432, 249) and 7 objects are identified in the image and its starting position presented in table 1. The first triangle object starts at (21,163) which have 110 pixels in direction 7, 71 pixels in direction 5 and 109 pixels in the direction 3. Other 6 objects are starts in following location of the image which are similarly represented in the pattern.

Table 1 Location of objects presented in Fig. 5. (a)

	Row	**Column**
Object 1	10	30
Object 2	30	30
Object 3	111	116
Object 4	27	249
Object 5	115	238
Object 6	10	363
Object 7	133	388

The pattern for skeleton image [fig 6a)] is as follows

[356,158,1,2,65,12,7,5,3,20,1,20,8,6,6.]

The size of skeleton image is 356, 158, only one object in the image. The object starts at (2,65) which have 12 pixels in direction 7, 5 pixels in direction 3, 20 pixels in direction 1, 20 pixels in direction 8 and 6 pixels in the direction 6 and so on.

3.1 Comparative Study

The comparison of 2D modified chain code method (2D-MCC) described by Walid *et al* (2009) and corner detection method by (Anjan *et al* 2011) with our method are given below (Table 2).

- 2D-MCC method has some problem while we reconstruct some images but our method more accurate, which is not greater than 0.5% significance for various complicated structures.
- Corner detection method by (Anjan *et al*, (2011) has only considered the some specific structures which does not included the smooth corners, but in our method includes various natural objects

Table 2: Comparative study on reconstruction accuracy

Methods	**Reconstruction accuracy**	**Object considered**	**Time for pattern**
2D-MCC	20 to 57% Accuracy with different shapes in 1D chain code	Valid for shapes composed of triangular, rectangular and hexagonal cells	88%
Chain code by Anjan	Binary image with sharp corners given accuracy and not discussed with smooth corners	Chain code are used for connected sequence of straight line segments	90%
Our method (Pattern Generation)	It is achieved significance of 99.05% for various structures	The digital color image representing of any set of objects with various structures and natural images	90%

4. Conclusion

Pattern generation is an important process to make compressed information of images. In this paper proposed and implemented code generation yields pattern which could represent as well as reconstruction of the given original image. This result is obtained through morphological transformation and 8- connectivity chain code. The result shows that the original image and reconstructed with an ignorable difference, which has not greater than 0.5% significance for various structures of objects used in this research. However the geometrical objects also extracted using this code generation. This algorithm could be improved by introducing the corner detection techniques with 2D modified chain codes and one-dimensional grammar-based codes.

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