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박사학위논문

효율적인 객체인식을 위한 코너패치 재배열 속성 기반 영상검색 시스템

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Corner patch Rearrangement feature based Image Retrieval System for efficient object recognition

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목 차

List of Figures ········· iii
List of Tables ········· vi
Abstract ········· vii

I. Introduction ········· 1
A. Background and purpose of research ········· 1
B. Related Works ········· 3
C. Content and structure of research ········· 6

II. Content-based image retrieval technique ········· 7

III. Types and characteristics of the corner detection algorithm ········· 31
A. Moravec corner detection algorithm ········· 32
B. Harris corner detection algorithm ········· 35
C. SUSAN corner detection algorithm ········· 38
D. Corner detection using line intersection ········· 41

IV. Corner rearrangement property-based proposed algorithms ········· 45
A. Existing algorithms ········· 46
B. Design of the algorithm using neighboring pixel difference value ········· 49
C. Design of the algorithm using the corner doubler array ········· 56
D. Design of the corner patch DCT rearrangement algorithm ········· 61

V. Experiments and analysis ········· 64
A. Experiments ········· 64
B. Analysis ········· 77

VI. Conclusions ········· 93

References 95

List of Figures

Fig. 2.1 Three histograms with no visual similarity by distance 11
Fig. 2.2 Cumulative histogram of the histogram given in Fig 2.4 12
Fig. 2.3 Classification of shape-based search techniques 19
Fig. 2.4 Phase of the zernike polynomials 22
Fig. 2.5 Feature extraction results 26
Fig. 3.1 Moravec operator by Type 32
Fig. 3.2 Window masking for intensity variance value 33
Fig. 3.3 Feature point division according to the distribution of eigenvalues 36
Fig. 3.4 Circular mask applied to the object in the image 38
Fig. 3.5 USAN area 39
Fig. 3.6 Four types of corners 42
Fig. 3.7 Two intersecting line segments 42
Fig. 3.8 Corner geometry 44
Fig. 3.9 Corner geometry representation 44
Fig. 4.1 Flowchart of the existing algorithms 46
Fig. 4.2 Pixel values of the corner points 47
Fig. 4.3 Corner detection in image patch histogram 48
Fig. 4.4 Histogram of corner points 48
Fig. 4.5 Corner area variance values rearrangement algorithm flowchart 49
Fig. 4.6 RGB image 51
Fig. 4.7 gray scale image 51
Fig. 4.8 Canny edge image 52
Fig. 4.9 Image after Hough transform 53
Fig. 4.10 Extracted line image 53
Fig. 4.11 Pixel values of the corner patch 54
Fig. 4.12 Corner points Image 54
Fig. 4.13 3*3 corner patch 55
Fig. 4.14 Flowchart of the algorithm using correlogram to corner point 56

Fig. 4.15 Total luminance of gray level ··· 57
Fig. 4.16 How to get the auto-correlogram ··· 59
Fig. 4.17 How to get the cross correlogram ··· 59
Fig. 4.18 Design of the corner patch DCT rearrangement algorithm ··· 61
Fig. 4.19 DCT coefficients extraction of the corner patch ··· 62
Fig. 4.20 The Rearrangement histogram of corner patch DCT coefficients ··· 63
Fig. 5.1 Comparison of the corner detectors ··· 65
Fig. 5.2 Comparison according to the corner patch size ··· 66
Fig. 5.3 Comparison according to the # of DCT coefficient ··· 66
Fig. 5.4 Experimental images ··· 68
Fig. 5.5 Query image 2.jpg ··· 68
Fig. 5.6 Similarity measurements by image number using the feature value ··· 69
Fig. 5.7 Ranking similarity measurements using the feature value ··· 70
Fig. 5.8 The image search results by the similarity values ··· 71
Fig. 5.9 Query image Q1, Q2 ··· 72
Fig. 5.10 Similar image of query image within the database ··· 73
Fig. 5.11 The image Q1, Q2 search results of corner point sum algorithm ··· 74
Fig. 5.12 The image Q1, Q2 search results of the corner neighbor pixel difference value based on the algorithm ··· 74
Fig. 5.13 The image Q1, Q2 search results of the algorithm using correlogram to corner point ··· 75
Fig. 5.14 The image Q1, Q2 search results of the corner patch DCT based algorithm ··· 76
Fig. 5.15 Query image Q1 ~ Q4 ··· 79
Fig. 5.16 Results of the existing algorithms and corner neighbor pixel differential values algorithm of Q1 and Q2 ··· 81
Fig. 5.17 Results of the existing algorithms and corner neighbor pixel differential values algorithm of Q3 and Q4 ··· 82
Fig. 5.18 Results of the algorithm using the existing algorithms and correloram of corner points of Q1 & Q2 ··· 85

Fig. 5.19 Results of the algorithm using the existing algorithms and correloram of corner points of Q3 & Q4 ········· 86
Fig. 5.20 Results of the algorithm using the existing algorithms and corner patch DCT based algorithm of Q1 & Q2 ········· 89
Fig. 5.21 Results of the algorithm using the existing algorithms and corner patch DCT based algorithm of Q3 & Q4 ········· 90

List of Tables

Table 2.1 List of the Zernike Moments ········· 22
Table 4.1 Some data of the corner points ········· 47
Table 4.2 The result of applying the correlogram ········· 60
Table 5.1 Error rate of the image ········· 71
Table 5.2 Performance analysis of existing algorithms and corner neighbor pixel value difference algorithm ········· 83
Table 5.3 Performance analysis of the algorithm using correlogram to existing algorithms and corner point ········· 88
Table 5.4 Performance analysis of the corner patch DCT based algorithm to existing algorithms and corner point ········· 92
Table 5.5 Performance analysis results of the algorithms proposed and existing algorithms ········· 92

ABSTRACT

Corner patch feature based Image Retrieval System

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현대 사회는 컴퓨터와 네트워크를 비롯한 통신 기술의 발달과 더불어 멀티미디어 기술의 비약적인 발전으로 멀티미디어 콘텐츠의 생성과 유통이 활발하게 이루어지고 있다. 최근 이런 멀티미디어 정보들이 매일 엄청난 양으로 나오고 있으며 데이터의 양 또한 과거의 텍스트 정보와 비교 할 수 없을 정도로 방대하다. 그러나 엄청난 속도로 증가하는 멀티미디어 정보 중에서 사용자가 필요로 하는 내용의 정보를 찾기 위해서는 기존의 키워드 기반의 검색은 한계에 도달한 상황이기 때문에 사용자가 원하는 정보를 콘텐츠에 기반하여 검색할 수 있는 방법이 요구되고 있다. 이것은 검색하고자 하는 영상을 질의 자료로 제시하면 자동적으로 영상의 속성이 질의 영상과 같거나 유사한 데이터베이스 내의 영상들을 오차가 적은 순서대로 출력하는 콘텐츠기반 영상검색 시스템(Content-Based Image Retrieval : CBIR)에 연구개발을 집중시켰다.

본 논문에서 구현하고자 하는 영상 검색 기법은 객체의 코너점을 기반으로 한 코너 패치(patch)의 속성을 이용한 것으로 효율적이고 강인한 이미지 검색의 새로운 방법들을 제시한다. 그리고 제안한 코너 영역 분산치 재배열 알고리즘, 코너 영역의 이중재배열을 이용한 알고리즘, 코너 패치 DCT 재배열 알고리즘에 대해 코너패치 및 재배열 속성을 적용하여 분석·고찰한다.

본 논문에서 제안한 알고리즘은 먼저 영상 내 객체의 에지를 검출한 뒤, 허프 변환을 이용하여 직선을 추출한다. 그렇게 추출된 직선의 교차점을 코너점으로 하여 코너 패치를 구성한다. 첫째, 코너 영역 분산치 재배열 알고리즘은 영상에서 코너점을 추출한 후 코너점 8근방 이웃 화소와의 차분값을 추출하여 분산치를 재배열 하는 방법이

고, 둘째, 코너 영역의 이중재배열을 이용한 알고리즘은 영상에서 코너점을 추출한 후 대푯값을 이용하여 백색 레벨의 휘도총량을 계산하고, 코너 영역의 평균 레벨값과 백색 레벨 휘도 총량 사이의 코렐로그램을 적용하는 기법이며, 셋째, 코너 패치 DCT 재배열 알고리즘은 영상에서 코너점을 추출한 후 코너 패치의 DCT계수를 계산하여 DCT계수 히스토그램을 재배열하여 특징 벡터를 구성하는 기법이다. 이와 같은 기법들은 기존의 코너점 알고리즘이 가지고 있는 영상의 회전이나 확대 및 축소 등에 민감하다는 단점을 보완하였다. 그리고, 기존 알고리즘과 제안한 알고리즘의 정확한 비교를 위하여 콘텐츠기반 영상 검색에서 많이 사용되고 있는 Recall과 Precision을 성능평가 척도로 이용하였다.

본 논문에서 제안한 코너 패치 속성을 이용한 콘텐츠기반 영상 검색 방법을 기존의 코너점의 합을 이용한 알고리즘 및 코너 패치 히스토그램을 이용한 알고리즘과 성능을 비교하기 위하여 시뮬레이션을 수행하였다. 그 결과, 제안한 알고리즘들이 기존의 코너점 알고리즘보다 Recall이 최소 0.09에서 최대 0.22 높고, Precision이 최소 0.02에서 최대 0.11 높은 것으로 나타내 검색 성능이 더 좋다는 것을 확인하였다.

I. Introduction

A. Background and purpose of research

In modern society, with the development of communication technology including computer-network and the rapid development of multimedia technology, creation and distribution of multimedia contents is being actively conducted. As these results, the multimedia database has been built in many areas, and are used for various purposes. Recently, these multimedia information have come out the enormous amount daily, the amount of data is also large enough it can not be compared with past text information. Since it has been increased for a need of the method to efficiently store multimedia information and to easily search the information that we need, various methods associated therewith have been actively studied.

In particular, image search methods for finding what you want from the video database or multiple sequential images has attracted attention as a new field of image processing. Image retrieval techniques are being increasingly expanded as its range of applications such as digital libraries, real-time trading, trademark search, it may be an essential technology in upcoming information society.

Because the existing keyword-based search has been reached to a condition limit, to find the content information that the user needs in the rapidly increasing multimedia information, the way that can retrieve the user's desired information based on contents has been required[1-5].

In the initial search system, text-based retrieval system searching the image with the index of the same character by presenting characters keyword as data query, was the mainstream. In the text-based search method, a characterized word is inserted directly to content in the form of queries or comments.

Thus the inserted words is called a tag, and is used to search for content. In order to find the desired content in the text-based search methods, a specific word or phrase is entered in a query language ,and contents which contain the input query to the tag are shown in the search results.

Text-based search method is performed very quickly, since the search only by comparison of simple character is executed. This is because text-based search method, rather than to investigate the relevance of words and phrase is to perform a binary legal matching(the dichotomy match) to determine only whether the word is correctly matched [6,7]. This method, within a limited range, has the advantage of high accuracy but, for all images in the database, labor of setting a keyword that can be well represented each image is required, and when the keyword is set, it contains the personal subjectivity, so there are cases where it is not possible to set a specific keyword. In addition, I have also disadvantages that must remember the specific keywords of the image specified by the user during the search. In addition, the method also has drawbacks must remember the unique keyword for the image that the user has been given at the time of the search.

Therefore, the need for a more objective and automated retrieval systems have appeared. and when the attribute information about the image or image similar to the image you want to search, instead of the character keywords, is presented as queries, the system outputs the images similar to the query automatically was researched and developed. And these systems are called content-based image retrieval system. [8-12]

B. Related Works

Many of the related research on content-based image retrieval have been performed, since the academic conference is held on database management technology for the pictorial applications in 1979[13-15]. Kato was made a research on recognition of the people for the image even before, were also proposed a method to manage the image database through the way of the independent expression of the video in 1992[16]. As typical applications, he proposed a technique searching the image using a rough sketch as a query. Most of the early multimedia retrieval had been studied in dimension of computer vision, and was mainly a feature-based similarity search[17].

The most important factor in content-based image retrieval technique is a problem for what characteristically represent the content of image and the expressed features can be classified into three levels significantly. Firstly, image color, shape, and a texture information as a primitive features is relevant to this. Secondly, there is the information such as the recognition of the included object as a logical features. Finally, it is an abstract information, that is feel of the image, emotion, an abstract representation, such as the importance of the scene. In current image search technology, a technique of using a primitive features such as color, shape and texture as image information in large part are much studied. [1]

The color information, as one of important information constituting the image, in general, often used in the form of a histogram, it is very useful as a global information of the image [18]. Texture information, as a kind of texture information that is represented in the image, use a consistent pattern that forms each pixel gathered[19, 20]. In general, color information, texture information represents a global information, to show the local information, the advantages of each other and disadvantages are organically coupled to one another, it becomes possible to derive a higher performance [21, 22].

Searching method utilizing the shape, rather than applied to common image, is generally applied in practice for a particular application [23, 24]. To use the shape directly as a preprocessing step, it is needed to segmentation process. Because these split operation is one of the very difficult areas, it is difficult to ensure reliable retrieval performance. These search techniques, important to separate the objects in the image, show a good performance in a case where the contour of the object is relatively clear.[25] When the outline of the object is determined, the shape of object can be represented by information such as area, eccentricity (major axis and minor axis ratio), circularity(similarity of a circle having the same area), the center of the shape signature (object sequence of the distance between the suburb), the curvature (a measure of the degree of the contour rotates) and the fractal dimension (degree of self-similarity). The search technology using the type information, chain code [26], me and Mike moment [27-29], invariant moment [26] [30], proposed a technique that uses such as feature parameters Fourier descriptors [26] has been that has been. Among them, a corner of the detection is an important feature of the video image processing and computer vision is to analyze the distribution of how the brightness of detecting the corner position of the corner at the gray levels of the image using a circular mask method was by using a method to be crossed by using the straight line direction of the contour lines have been studied. [31]

Zuniga and Haralick is, taking into account the continuous change in the inclination in the direction of the rate of change of the pixels in each point and surrounding a range, proposed a method of extracting a corner [32] Kichen and Rosenfeld, the local slope width by using the degree of variation of constant slope value the degree of curvature of the contour line by, were proposed method to extract the corner. [33] Moravec may analyze the contrast value in all directions of each pixel, has proposed a method of detecting a point with the greatest change width in the corner. [34] Harris and Stephens, by using the contour information of the image, proposed a method for detecting the corner by using the cross-correlation method. [35] Trajkovic and Hedley is, in all directions from each pixel by analyzing the changes in the brightness of the image, to extract the corner. [36] Smith and Brady detecting the corners through the comparison of the brightness is also known as the SUSAN corner detection method. [37] In addition to such corner extraction process, by dividing the contour map of the image locally, analyzes the curvature information is determined in the corner when the distribution method and the contrast for detecting the corners have the type of curvature by using a method of detecting in a [38-41] symmetric analysis , a number of methods have been studied from a method of extracting a corner [42-44].

Search method utilizing the characteristics of these basic video, the 2000s it has been generated by some other features further use the methods of these things have been developed in the international standard called MPEG-7 organized [45, 46]. In order to improve the retrieval performance, and develop new features, were also made studies of the method of measuring the similarity between these extracted features. Beretti is based on the graph matching method, proposed an algorithm of a new similarity measure, Cooper was proposed a method for measuring the new similarity utilizing same time the time information and the pixel information [47, 48]. Also, in tough so also to deformation such as conversion and partial deletion of difficult was size of the traditional feature-based approach is resolved, the Lindberg that feature point-based methods have been proposed for feature size step (characteristic scale level) by establishing a theory called, for each feature point, so as to automatically assign a corresponding size, are based role other size invariant algorithm [49]. Since, as an element for determining the stage of the size, LoG (Laplacian of Gaussian) have been provided by Mikolajczyk and Schmid, actually showed very good performance in [50]. In addition to this, Lowe is by using the DoG (Difference of Gaussian), establishes the algorithm can be configured the steps of similar size, are utilized in many fields [51]. However, the algorithm of these feature points based size unchanged, because the reproducibility is not fully ensured in order to extract actual feature points, which requires a lot of additional operations. The Nevertheless, the conventional description, to maintain the toughness of serious deformation was difficult to resolve, have been made continuously studied.

C. Content and structure of research

Image retrieval method to be implemented in this paper utilizes the attribute of corner patches based on the corner points of the object, for providing a new method of efficient and robust image search.

Image retrieval techniques to be implemented in this paper are that methods using the properties of the corner patch based on the corner points of an object, I propose a new method for efficient and robust image retrieval.

After detecting the edge of the object within the image, I extract a straight line using a Hough transformation. A corner patches is formed by defining the intersection of the straight line extracted in that way as a corner point. Using configured patches rearranged in three ways, after configuring the feature vectors, I measured the similarity between images in the database. Finally, it was utilized as the Recall and Precision, which has been widely used in content-based image retrieval for an accurate comparison between the proposed algorithm and existing algorithms.

The proposed method in this paper, content-based image retrieval method using the rearranged corner patch property, was simulated by using the MATLAB7.8 to prove that it is better than the conventional algorithm using corner patches histogram and using the sum of the corner points.

The proposed method is, for all the images that were used in the experiment, were able to verify that each of the image search is performed more accurately than the conventional method. In Section II for its, I describe the content-based image retrieval method, in Section III, describe corner detector, and in the Section IV, describe the proposed image search algorithm. I demonstrate the image retrieval performance through the simulation in Section V, and conclude in Section VI.

II. Content-based image retrieval technique

Content-based image retrieval technique, it is classified by either use any type of features to represent the characteristics of the image, as the feature is being used, primitive features, logical features and abstract features. In this study, we consider color, only the primitive features of shape and texture. In this chapter, it is decided to examine the existing search methods based on the information of the color, the shape and texture.

1. Retrieval method using color information

Index of color information base is a very important way in search of the video database. Compared with the other information of the video, characteristics of the colors, which have the most important low-level information to build the index of the image. The color information may be used to be hardly affected by the complexity of the noise and other background, and calculates the statistics receive less movement of the object in the image, the influence on the change of such rotation. Swain and Ballard proposed search method of a color called histogram intersection. In this method, after a color histogram for each image and compared by obtaining a distance in a way that taking the intersection between the histograms.

This method, for simplicity in calculation and information representation, have been conveniently used in many situations, when the illumination is changed, it has the disadvantage of poor performance.[15] Funt and Finlayson in order to solve these problems, announced Swain method has been extended to develop an algorithm called certain color index. This method, by comparing the histogram of the color ratio, to perform the search.[18]

The paper such Funt, the proposed algorithm is constant in lighting, but falls a little performance than Swain method, when illumination changes, performance showed greatly improved. In addition, a method of using the cumulative histogram to reinforce the drawbacks of histogram intersection methods such Stricker, and presented a method of comparing the similarity by representing the color information by using the moments of each color channel. [19] One such Mehtre has developed a distance of methods and standard color table method for comparison of color.[18] method as is, as a feature, using the average values of one-dimensional histograms of the three color components. The distance between both feature vectors are used to indicate the degree of similarity between both characteristics. The standard color table method, one set of reference color is first defined in the color table. Each color pixel in the image is defined to the closest color of the color representation. Histogram of the pixels with the newly assigned colors are used as a color feature of the image.

However, the method of using the color histogram has the following disadvantages.[20] First, the histogram requires a quantization to reduce the dimensionality. A typical 24-bit color images, to generate 224 the bin, this requires a storage capacity of a minimum 2MB. Therefore, it is necessary to quantization to reduce the number of bin, this due to the loss of color information takes place, also, how much of the quantization process is optimal, it is necessary to perform a quantization of the extent to which there are no rules. Second, the histogram color space that is created can have a significant effect on the results, also, to determine the method and the quantization accuracy of the quantization.

For example, it is a uniform quantization in the RGB space, but can be usefully employed, the distribution of each color component is uniform. However, in Mensell or LUV space, the uniform quantization is insufficient. Third, the use of color histograms, it is difficult to consider the exclusion of color. Depending on the degree of quantization, because the bin color changes that indicate, it is difficult to find the bin indicating the color to be excluded, and if the colors and different color to be excluded. Finally, the histogram extracts only the overall color information of the image. In other words, it also has the drawback of not being used any spatial information.

In this paper, from the video retrieval method using color information, the cumulative histogram method such as the histogram intersection method and Stricker typical Swain, analyzing the method of using moments of the color channels in detail.

a. Histogram intersection

For color images in a way that Swain proposed, by using a large number of amount of information compared to the brightness image, after creating a three-dimensional histogram using the statistical properties of the image, and the model on the histogram space it is an algorithm that attempts to match the input image. This algorithm is simple, I have rotation of the applied easy object, move, and how much of the magnitude of the change, and the advantage to work aggressively to such changes in the angle at the time of image acquisition. [15]

This method was utilized complementary axis obtained from R, G, B (Red, Green, Blue)such as expression(2-1) as a color space.

$$\begin{aligned} rg &= R - G \\ by &= 2B - R - G \\ wb &= R + G + B \end{aligned} \tag{2-1}$$

To determine the color histogram of the image, in order to divide the three-axis section, here, because the axis wb of the century is sensitive to such length and brightness change from the light source, more the interval to reduce the impact was big. rg, by is divided into 16 segments, wb is the histogram is divided into eight intervals, has a total of $2048(16 \times 16 \times 8)$ groups. Color histogram of the second image the histogram is required, are compared by histogram intersection method. when given two image I, M of n groups, histogram intersection is defined by the equation (2-2).

$$\sum_{j=1}^{n} \min(I_j, M_j) \tag{2-2}$$

In result of the above formula, it shows the number of pixels that have the same color value in both of the video. The results, the value is changed according to the size of the image is used by normalizing the equation (2-3).

$$H(I, M) = \frac{\sum_{j=1}^{n} \min(I_j, M_j)}{\sum_{j=1}^{n} M_j} \tag{2-3}$$

If two images are identical, the result is a one and if two images' color is completely different, to become a zero. This method implementation is simple and shows a relatively good performance, but it is not only sensitive to changes in lighting but also it has a problem in that it was the comparison considering independently each group without considering the visual similarity between different groups at all.

b. Method using the cumulative histogram

Stricker such presented a method using a cumulative histogram is improved histogram intersection method of Swain. [19] As shown in Figure 2.1, the number of pixels is to have a personal three histograms of N, the more distance L1 that is being used to measure the degree of similarity between normal histogram If you use to calculate the distance as equation (2-4).

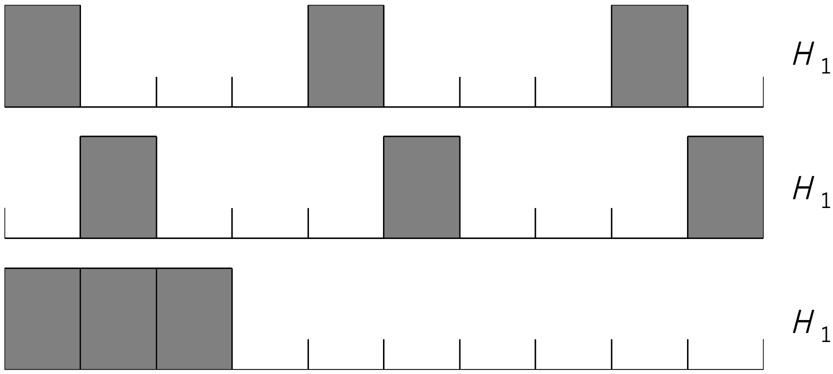


Fig. 2.1 Three histograms with no visual similarity by distance

$$L_1 = d_{L_1}(H, I) = \sum_{i=1}^{n} |h_{cl} - i_{cl}|$$
$$d_{L_1}(H_1, H_2) = 2N > d_{L_1}(H_1, H_3) = d_{L_1}(H_2, H_3) = 1.33N \qquad (2\text{-}4)$$

Looking at the histogram of Figure 2.1, but H_1 and H_2 are more similar, it can be seen that the actual computation results are displayed differently. Therefore, Stricker was defined $\widetilde{H}(M) = (\widetilde{h_{c1}}, \widetilde{h_{c2}}, \cdots, \widetilde{h_{cn}})$ is the cumulative histogram of the color histogram $H(M)$. Here it is $\widetilde{h_{cj}} = \sum_{c_i \le c_j} h_{ci}$. When obtaining the cumulative histogram to the histogram of Figure 2.1 are shown in Figure 2.2. By using the distance L of the re-accumulated histogram, and to measure the degree of similarity, is the same as the equation (2-5).

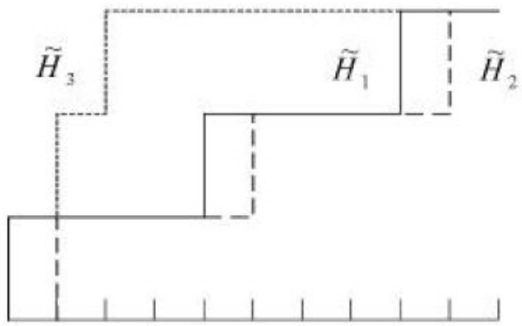


그림 2.2 Cumulative histogram of the histogram given in Fig 2.1

$$d_{L_1}(\widetilde{H}_2, \widetilde{H}_3) = 4N > d_{L_1}(\widetilde{H}_1, \widetilde{H}_3) = 3N > d_{L_1}(\widetilde{H}_1, \widetilde{H}_2) = N \tag{2-5}$$

Looking at the above results, it can be seen that to show better results than the method utilizing the existing histogram. In other words, using the cumulative histogram, even if Similar colors by the noise belong to other groups, it can be known to be reflected in the extent when measuring the similarity, when configuring the histogram.

c. Techniques Using Color Moment

Color histogram and the cumulative histogram, when applied to the search, it is necessary to quantization in the course of an index, to find the optimum quantization process is very difficult. Therefore, a method that does not depend on the parameters in the process of indexing has been needed, and those in which one of them is to use the characteristics of the color distribution. Stricker such as features of color distribution for color retrieval, and proposed a method of utilizing the moments of each color channel.[19]

If you look at the method using the color moments, this method, the probability distribution is based on the fact that it may be described uniquely by its central moment's. The color distribution of the image, that is, a color histogram is interpreted as a probability distribution, therefore, the color distribution may be represented by moment. Here, as an index for the color information, and utilizing 1,2,3-order central moments of each color channel. If the j-th value of the color channels of a pixel p_{ij} from the i-th image, the index related to the channel is calculated by the equation (2-6).

$$E_i = \frac{1}{N}\sum_{j=1}^{N} p_{ij}$$

$$\sigma_i = (\frac{1}{N}\sum_{j=1}^{N}(p_{ij} - E_i)^2)^{\frac{1}{2}} \tag{2-6}$$

$$s_i = (\frac{1}{N}\sum_{j=1}^{N}(p_{ij} - E_i)^3)^{\frac{1}{3}}$$

Here, N is the total number of image pixels.

two images I, H with r color channels, and each color information of an index E_i, F_i, σ_i, ζ_i and s_i, t_t, the color similarity of both images is obtained by the equation (2-7).

$$d_{mom}(H, I) = \sum_{i=1}^{r}(w_{i1}|E_i - F_i| + w_{i2}|\sigma_i - \zeta_i| + w_{i3}|s_i - t_i| \tag{2-7}$$

Here, $w_{kl} \geq 0 \, (1 \leq l, k \leq 3)$ is a coefficient defined by the user. By adjusting the coefficients, it is possible to determine the similarity function to suit the application environment.

This method has the advantage that can be shown by using the index of the small number of color image information, shows the results of the above method using a histogram on the performance. However, since the information is also not used for the correlation between the color channels, is limited in its performance.

2. Techniques Using Texture Feature

Texture refers to the characteristics of regional areas that shows a pseudo regularity particular pattern. Method for searching on the basis of the similarity of these texture features, not be applied to various situations of the image are colored, such as the (eg, the sky and the sea, or leaves, grass, etc.) can be conveniently used to distinguish between areas. Although various techniques have been proposed to calculate the similarity of the texture information, a number of ways to perform the search by comparing the second-order statistics are computed from the image stored as the quality of the material. In this way, coarseness, directionality, regularity, and by utilizing such linearity and roughness, and represent the texture information [16] 1996 Liu and Picard is periodic, such as by using a directional and randomness, was calculated texture information [21-22].

How to use the Gabor filter by Manjun ath and Ma in a different way such as [23], and a method [24] utilizing the fractal like Kaplan. And like 1999 Manjunath is a bar provided the texture extracted texture technicians using Garbor filters, in order to complement the drawbacks of this texture technology, such as 2001 Carkacioglu is based on second order statistics of the autocorrelation coefficients and SASI (Statistical Analysis of Structural Information) texture engineers have been proposed, ongoing studies are underway.[10]

a. Definition of texture feature and image retrieval

(1) coarseness - coarse vs. fine

coarseness is the most basic texture information, it shows the fineness of a regular pattern to be repeated. Process of calculating the coarseness Video $f(x, y)$ are as follows.

Step 1. For all pixels in the image, the power of two sizes, namely, Obtain an average for the pixels in the range of $1\times1,\ 2\times2,\ \cdots,\ 32\times32$. The average size in the (x, y) position of the range of $2^k \times 2^k$ is as equation (2-8).

$$A_k(x, y) = \sum_{i=x-2^{k-1}}^{x+2^{k-1}-1} \sum_{j=y-2^{k-1}}^{y+2^{k-1}-1} f(i, j)/2^{2k} \qquad (2\text{-}8)$$

Step 2. For each position, Calculate the difference between the average value in the vertical and horizontal direction. For example, the difference in the horizontal direction can be calculated by the equation (2-9).

$$E_{k,h}(x, y) = \left|A_k(x+2^{k-1}, y) - A_k(x-2^{k-1}, y)\right| \qquad (2\text{-}9)$$

Step 3. For each location, Determine the best size that satisfies the conditions of the following equation (2-10).

$$S_{best}(x, y) = 2^k \qquad (2\text{-}10)$$

Here, k is a value that maximizes the E from the vertical or horizontal direction. That is,

$$E_k = E_{\max} = \max(E_1, E_2, \cdots, E_L)$$

Step 4. Averaging the S_{best} in order to get the coarseness F_{crs}.

$$F_{crs} = \frac{1}{m \times n} \sum_{i}^{m} \sum_{j}^{n} S_{best}(i,j) \tag{2-11}$$

Here, m, n is the effective width and height of the video during the coarseness calculation.

(2) Contrast - high contrast vs. low contrast

Represents the degree of contrast of the pixels of the pattern in the image, it can be obtained by the following method.

First, Calculate the kurtosis α_4 as in equation (2-12). in order to take into account the distribution degree of white and black in the image.

$$\alpha_4 = \frac{\mu_4}{\sigma^2} \tag{2-12}$$

Here, μ_4 is a fourth order moment of the average, σ^2 is the variance. In consideration of the dynamic range of the pixel values in the image, the contrast is defined by the equation (2-13).

$$F_{con} = \frac{\sigma}{(\alpha_4)^n} \tag{2-13}$$

(3) Directional

Represents the degree of the pattern of direction is obtained by using the orientation histogram for each edge. That is, values obtained by using the Sobel operator in the vertical and horizontal directions, when the $\triangle_H$, $\triangle_V$,

$$|\triangle G| = (|\triangle_H| + |\triangle_V|)/2$$
$$\theta = \tan^{-1}(\triangle_V/\triangle_H) + \frac{\pi}{2} \tag{2-14}$$

are obtained. $|\triangle G|$ is quantized for a constant threshold or more pixels, it makes a histogram such as equation (2-15)

$$H_D(k) = N_\theta(k)/\sum_{i=0}^{n-1} N_\theta(i), \qquad k = 0, 1, 2, \cdots, n-1 \tag{2-15}$$

Here, $N_\theta(k)$ is that of a point that satisfies the condition of $|\triangle G| \ge t,\ (2k-1)\pi/2n \le \theta < (2k+1)/2n$. In view of the sharpness of the peak of the $H_D(k)$, to calculate the orientation as shown in equation (2-16).

$$F_{dir} = 1 - r \cdot n_p \sum_{p}^{n_p} \sum_{\phi \in w_p} (\phi - \phi_p)^2 \cdot H_D(\phi) \tag{2-16}$$

Here, n_p : The number of peaks

ϕ_p : pth peak position of the H_D

w_p : Range of pth peak

r : The normalization factor for the quantization level of the ϕ

ϕ : Quantized direction value

(4) Linearity

Linearity refers to the degree of the pattern that consists of a line. When the direction of one of the edge direction and its surrounding edge is similar, I considered the group of such edge and line. To determine the linearity, but must first configure a direction co-occurrence matrix $P_{Dd}(i,j)$, the elements of the matrix, both the edge another edge pixel with respect to the pair has a direction code i of in other of the edge pixels have the j direction code, I show the frequency when the distance of each other are separated by D. The formula for the linearity by using the co-occurrence matrix of these $n \times n$ size is as equation (2-17).

$$F_{lin} = \sum_{i}^{n}\sum_{j}^{n} P_{Dd}(i,j)\cos\left[(i-j)\frac{2\pi}{n}\right] / \sum_{i}^{n}\sum_{j}^{n} P_{Dd}(i,j) \qquad (2\text{-}17)$$

(5) Regularity

I shows the degree of regularity of the texture characteristics of the image. Tamura is assumed but irregular when a change in the characteristics of the texture across the entire image, thus, by dividing the image, extracts the characteristics of the texture of the divided portions, considering the changes of the characteristics. Expression that defines the regularity, is as equation (2-18).

$$F_{reg} = 1 - r(\sigma_{crs} + \sigma_{con} + \sigma_{dir} + \sigma_{lin}) \qquad (2\text{-}18)$$

Here, r is the normalization factor, the σ_{xxx} is the standard deviation of each texture features $Fxxx$.

(6) Coarseness

Based on visual psychological experiments, in order to consider the effect of coarseness and contrast is the most important element in the texture features to define the rough by the equation (2-19).

$$F_{rgh} = F_{crs} + F_{con} \qquad (2\text{-}19)$$

Characteristics of texture as described above, it has been used in systems such as current QBIC, extracts all part or six of the above features to texture characteristics of the image, mutually compare it to between the video makes it possible video search of texture information base.

3. Retrieval techniques using the shape feature

For the shape of the object, visually it has a wide variety of information of the video type information-based search approach, since it is a difficult form of information to implement the best representation of the object, the search of content-based system is the most important part. Type representation techniques are divided into two large categories, as shown in Figure 2.3.[25] One is an outline-based approach, the other is a region-based approach. Profile-based approach is based on the contours of objects in the image, a method of extracting features, chain code, Fourier description, UNL, the Fourier characteristics of the contour of an object radius, such as method using a feature point, various technique exists. Area-based approach, beginning as a method of extracting the geometric features of the object region, area, growth rate, Euler number, invariant moment, Zernike Moments with Zernike polynomial, there are many ways .

In this study, a method using the orientation histogram of the edge, such as Jain is a typical form-based search method[26], I was using the method[27] and regional differential invariant values using the I and microphone moment I examine how to. [28-29]

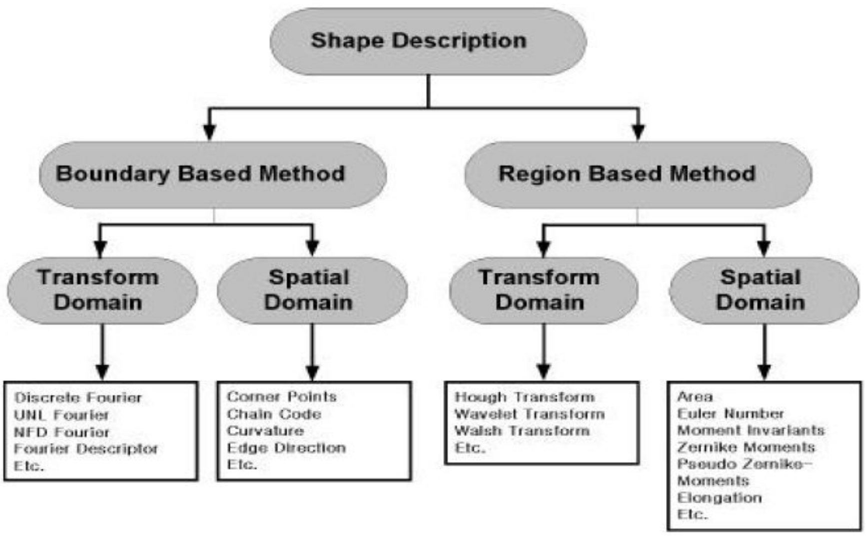


Fig. 2.3 Classification of shape-based search techniques

a. Method using direction histogram of edge

It was used the edge direction histogram of the object in the image as the shape information in the method proposed by Jain. That is, after determining the edge direction histogram, using the histogram intersection method, and compared the histogram of each image.[26]

First, by using the Canny edge operation[30], to detect the position of the edge, it is possible to obtain the direction information of the edge to determine the direction of the gradient from the position of the edge. The variation in the horizontal direction of the horizontal pixel (m,n) is a $g_h(m,n)$, and when the variation in the vertical direction $g_v(m,n)$, the direction can be calculated using equation (2-20).

$$\theta = \tan^{-1}\frac{g_v(m,n)}{g_h(m,n)} \tag{2-20}$$

After creating a histogram by using the direction obtained in the case edge position, using the histogram intersection equation (2-3) in the previous section, to compare the degree of similarity. However, to a histogram of the edge direction, the moving image has the disadvantage that changes is immutable scale and rotation. Therefore, Jain is utilizing methods such as those described below. Scale of the problem, by using the total number of edges in the video, by normalizing a histogram, can be solved. However, the change in rotation is slightly harder than that of the scale. When an object is rotated, in a direction histogram of the edge, so that movement occurs. However, the following problem occurs. That is, if the group of edge direction histogram is divided at an angle of 45 °, 30 °, 40 ° of the edge will be included in the same group. However, if the rotation of 10 ° takes place, by belonging to different groups, a histogram of another form it will be created from the original histogram. To solve these problems, have been performed smoothing operation of the histogram. However, it is also made to smooth the histogram, and because it has a rapid in the rotation does not apply disadvantage, the change of the movement scale, but out somewhat better results, and shows the results change of the rotation is not good.

b. Method using Zernike moments

Zernike Moments can be derived from the complex Zernike polynomial to form a complete orthogonal set inside the unit circle, the study of recognition of the image by using the Zernike Moments were proposed by Khontanzad.[27] set of Zernike polynomials can be expressed as in equation (2-21).

$$V_{nm}(x,y) = V_{nm}(\rho,\theta) = R_{nm}(\rho)\exp(jm\theta) \tag{2-21}$$

Here,

n : 0 and a positive integer

m : Integer satisfying the condition $|m| \le n$, $n-|m| = even$

ρ, θ : Distance to the center and angle of the counter-clockwise

$R_{nm}(\rho)$: Radial polynomial

$$R_{nm}(\rho) = \sum_{s=0}^{n-|m|} (-1)^s \frac{(n-s)!}{s!\left(\frac{n+|m|}{2}-s\right)!\left(\frac{n-|m|}{2}-s\right)!}\rho^{n-2s} \tag{2-22}$$

Figure 2.4 shows the phase of the Zernike polynomial in accordance with the repetition factor, from this it can know that the Zernike Moments has a symmetry information of the object. That is, when the size of the m-th order of the corresponding maximum moment, the inside of the object circle, has the form of m-order symmetry.

n-th order of the digital video $f(x,y)$, Zernike Moments of repetition factor m is defined similarly to regular moments as equation (2-23) using a Zernike polynomial.

$$A_{nm} = \frac{n+1}{\pi} \sum_x \sum_y f(x,y) V_{nm}^*(x,y), \qquad 여기서\ x^2+y^2 \le 1 \tag{2-23}$$

List of Zernike Moments are generated in response to orders, are shown in Table 2.1. By comparing the thus extracted moment for each image, it is possible to compare the form of a similarity between the images.

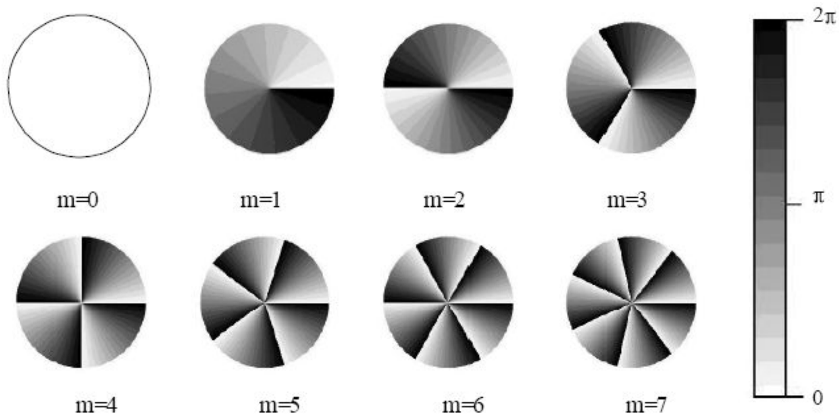


Fig. 2.4 Phase of the Zernike polynomials

Table 2.1 List of the Zernike Moments

Order (n)	Moments	Order (n)	Moments
0	A_{00}	7	A_{71}, A_{73}, A_{75}, A_{77}
1	A_{11}	8	A_{80}, A_{82}, A_{84}, A_{86}, A_{88}
2	A_{20}, A_{22}	9	A_{91}, A_{93}, A_{95}, A_{97}, A_{99}
3	A_{31}, A_{33}	10	$A_{10,0}$, $A_{10,2}$, $A_{10,4}$, $A_{10,8}$, $A_{10,10}$
4	A_{40}, A_{42}, A_{44}	11	$A_{11,1}$, $A_{11,3}$, $A_{11,5}$, $A_{11,7}$, $A_{11,9}$, $A_{11,11}$
5	A_{51}, A_{53}, A_{55}	12	$A_{12,0}$, $A_{12,2}$, $A_{12,4}$, $A_{12,6}$, $A_{12,8}$, $A_{12,10}$, $A_{12,12}$
6	A_{60}, A_{62}, A_{64}, A_{66}	13	$A_{13,1}$, $A_{13,3}$, $A_{13,5}$, $A_{13,7}$, $A_{13,9}$, $A_{13,11}$, $A_{13,13}$

For Zernike Moments, the magnitude of the moment due to rotation invariant, is characterized in that the reconstruction of images from them. To apply the Zernike

Moments should always without full course of movement the size. In other words, you will need to adjust as object in the image is located in the interior of the area $x^2 + y^2 \le 1$. Zernike Moments is a complete orthogonal set, using the Zernike Moments, it is possible to restore the original video, the geometric deformation of the image (move, rotate, scale) the whole very strong image to changes in the illumination there is an advantage that the shape information can be effectively express. However, it is very sensitive to image degradation, more pixel values of the internal video have weakness being ignored.

c. Method using the regional differential invariant value

Portion that includes a lot of information in the video, that is, the change is large portions were separately extracted and used to detect the local features of the part. Therefore, it defines an inter-rest point as a feature point in the image, the seek differential invariant values for the characteristic points, to obtain the regional characteristics, and compares the feature points with similar regional features between the images makes it possible to measure the similarity.

(1) Interest point

Interest point is a place where the video signal is changed in two dimensions, the corner point, T intersections, such as where the texture changes rapidly corresponds to this. Interest point rotation, move, scale, image degradation, changes in illumination, are also geometrically stable and changes in perspective, to have a high amount of information is effectively utilized for image retrieval.[31-33]

Performance of interest point, are dependent on the performance of the detector, the performance of the detector, showing the reproducibility representing repetitive detection results to changes in the various images, the entropy of the random variable, that is, the separation of information amount is the comparative reference. Existing detector, Moravec, Harris, Heitge, Forstner, Horaud, has been devised by such Cottie, Harris detector is the most outstanding was found in terms of double recurrent and amount of information.[32]

Harris detector obtains a matrix associated with the autocorrelation function, to detect the inter-point list of the eigenvalues is an important curvature of the autocorrelation function matrix to scale. Harris detector is a detector to improve the problems of the Moravec detector.

Moravec detector, based on the century change amount of the image when moving the Windows image region in different directions, to classify regions of the image.

$$E_{x,y} = \sum_u \sum_v W_{u,v} (I_{u+x,v+y} - I_{u,v})^2 \tag{2-24}$$

Here, w : Unit perpendicular to the window

x, y : movement, u, v : Window area

If the intensity of the image in a window, such as roughly similar, intensity of the amount of change in the video is small. If the window is applied to the edge component, when moving along the edge component is intensity change in image is small, when moved in the vertical direction, variation is large. Area where the window area corresponding to the inter-point list such as a corner point, intensity amount of change in video, is always larger.

Moravec detector, the minimum value of the amount of change in the displacement is equal to or greater than a threshold, if it is the maximum value of the area, to determine a interest point.

Harris detector, improved the three problems of the Moravec detector. For Moravec detector was sensitive to noise using the unit orthogonal windows, Harris you use the Gaussian window is circular, solves the noise problem, the movement of the window is performed for each 45 °, change in the amount of results to solve the problem of anisotropy, considering movement in all directions to apply the analytic expansion, in order to improve detection performance, we used the eigenvalue of the autocorrelation function matrix.

$$E_{x,y} = \sum_u \sum_v W_{u,v}(I_{u+x,v+y} - I_{u,v})^2 = \sum_u \sum_v W_{u,v}(xX + yY + O(x^2, y^2))^2 \tag{2-25}$$

Variation of image intensity in the small movement of the window area is the same as the equation (2-26).

$$E(x,y) = Ax^2 + 2Cxy + By^2 = (x, y)M(x, y)^T \tag{2-26}$$

Here, $M = \begin{bmatrix} A & C \\ C & B \end{bmatrix}$

$W_{u,v} = \exp\{-(u^2+v^2)/2\sigma^2\}$

$X = I \otimes (-1, 0, 1) = \partial I / \partial x$

$Y = I \otimes (-1, 0, 1)^T = \partial I / \partial y$

$A = X^2 \otimes W$

$B = Y^2 \otimes W$

$C = (X\ Y) \otimes W$

M is invariant to rotation, and a home position when x, y change a measure of the distribution. Eigenvalues of M, so α, β is proportional to the critical curvature of the autocorrelation function, to classify the regions of the video based on it. If the two different values is smaller, the window area to have almost the same pixel values, one of the unique value is greater One window area smaller is true edge component, a unique value all large window area, are corresponding to the inter Wrest Point.

Eigenvalue of the auto-correlation function matrix has properties such as the following equations.

$$Tr(M) = \alpha + \beta = A + B \tag{2-27}$$

$$Det(M) = \alpha\beta = AB - C^2 \tag{2-28}$$

$$R = Det - kTr^2 \tag{2-29}$$

Response function R is a function of A, B, C, k value is an arbitrary small positive. R value is positive sleep interlist point the R value as an index, a negative edge region, determines a region with similar pixel values smaller.[32]

Figure 2.5 shows the results of extracting the feature points using the Harris corner point detector for video.

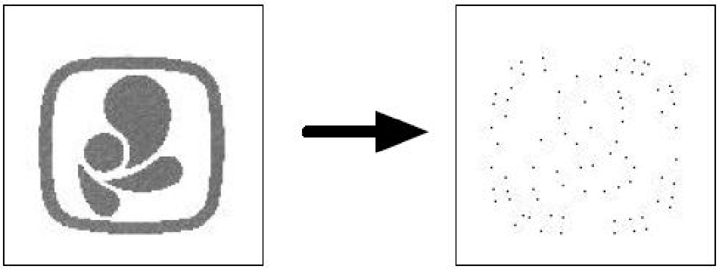


Fig. 2.5 Feature extraction results

(2) Feature vector extraction of differential invariant value of the feature points

Rotation of the feature points extracted from the image, move, invariant differential value vector, which can be applied to even a strong image retrieval variation size can be calculated as follows. Calculation of the differential invariant value, if the small size of the noise circle image is added, comparing the differential value of the image to the original image and the noise is added, are very different. Even when small noise is added, if high frequency noise is included, the differential value is quite different, as the differential value of the higher order terms becomes more images.

When the original signal is an $f(x)$, and the signal noise is added with $h(x)$,

$$h(x) = f(x) + \epsilon \sin(wx) \tag{2-30}$$

$$h(x)' = f(x)' + w \cdot \epsilon \sin(wx) \tag{2-31}$$

$$h(x)'' = f(x)'' + w^2 \cdot \epsilon \sin(wx) \tag{2-32}$$

For high frequency noise, since the w value is very large, $h(x)'$ and $f(x)'$ are very different, but what would be different because the derivative of the higher order terms. Therefore, it is necessary to smooth the signals prior to differentiating the original signal. Using a Gaussian function G with a smoothing function, and executes the following derivative obtained by removing noise from the original signal. In addition, differential operation and convolution, so commutative law is satisfied, it can be expressed by the equation (2-33).

$$\partial_i(G * F) = G * \partial_i F = \partial_i G * F \tag{2-33}$$

The simplest way to stabilize the derivative calculation is intended to be convolution images to those obtained by differentiating the Gaussian function is a smoothing function.[28]

When Gaussian function $G(x,\sigma)$, it is a differential value $G_{i_1, i_2, \cdots, i_p}(x,\sigma)$ of the Gaussian function

$$G(x,\sigma) = \frac{1}{\left(\sqrt{2\pi\sigma^2}\right)^D} \exp\left(-\frac{x^2}{2\sigma^2}\right) \tag{2-34}$$

$$G_{i_1, i_2, \cdots, i_p}(x,\sigma) = \frac{\partial^D}{\partial i_1, \partial i_2, \cdots, \partial i_D} G(x,\sigma) \tag{2-35}$$

Here, a $x = (x_1, x_2, \cdots, x_D)$ $(D=2$ in the picture), σ in the Gaussian function determine the degree of smoothing. It can be viewed as a vector to calculate the differential value to N-order, this was represented by a vector is first referred to as the local jet by Koenderink.[28]

The characteristics of local Windows image around the feature point of the image can be represented by a set of differential Cheadle. Stable can be obtained by convolution of the Gaussian derivative value and the local image window when obtaining the differential value, the set of these differential values of the local jet. [28] The Windows image of the region is set to I, when there is a given size, N-order local jets from an arbitrary point $x=(x_1, x_2)$ is the same as the equation (2-36).

$$J^N[I](x,\sigma)=\left\{L_{i_1, i_2, \cdots, i_n}(x,\sigma)|(x,\sigma)\in I*R^+; n=0,1,2,\cdots,N\right\} \tag{2-36}$$

σ corresponds to the magnitude of the Gaussian function, if the size of the image changes, it is important to used to apply to the search image.

Calculated from the differential value invariant local jets, it is possible to represent video signals to these feature vectors. Feature vectors, maintaining a strong distinctive value in some variations. If the differential value invariant vector DI in consideration to the secondary differential term expressed by Einstein and manner as the orthogonal coordinate system, it is as the formula (2-37).

$$DI=[0,\cdots,4]=\begin{bmatrix} L \\ L_iL_i \\ L_iL_{ij}L_i \\ L_{ii} \\ L_{ij}L_{ji} \end{bmatrix}=\begin{bmatrix} L \\ L_xL_x+L_yL_y \\ L_{xx}L_xL_x+2L_{xy}L_xL_y+L_{yy}L_yL_y \\ L_{xx}+L_{yy} \\ L_{xx}L_{xx}+2L_{xy}L_{yx}+L_{yy}L_{yy} \end{bmatrix} \tag{2-37}$$

L_i is an element of the local jet that is the display. In other words, L is a component that was convolution the Windows image and the Gaussian function of the region. By modifying the size of the Gaussian function to be applied to images of other sizes can be used to determine the differential value vector unchanged.

If the video is a two-dimensional vector $x=(x,y)$, the subscript x,y in L_{xy} corresponds to each of the partial derivative in the x,y direction. The Einstein and subscripts in the manner i is a sum of the differential variables. L_i and L_{ij} of formula (2-38), can be expressed as (2-39).

$$L_i = \sum_i L_i = L_x + L_y \tag{2-38}$$

$$L_{ij} = \sum_i \sum_j L_{ij} = L_{xx} + L_{xy} + L_{yx} + L_{yy} \tag{2-39}$$

If the differential value invariant vector DI in the case of considering the derivative of the cubic term is represented by Einstein and methods are the same as the equation (2-40).

$$DI[5 \dots 8] = \begin{bmatrix} \epsilon_{ij}(L_{jkl}L_iL_kL_i - L_{jkk}L_iL_iL_l) \\ (L_{iij}L_jL_kL_k - L_{ijk}L_iL_jL_k) \\ -\epsilon_{ij}L_{jkl}L_iL_kL_l \\ L_{ijk}L_iL_jL_k \end{bmatrix} \tag{2-40}$$

$$(\text{단},\ \epsilon_{12} = -\epsilon_{12},\ \epsilon_{11} = -\epsilon_{22} = 0)$$

When to simplify the equation representing the differentiated value invariant vector DI in the orthogonal coordinate system are as in equation (2-41).

$$\begin{aligned} DI[5] &= L_{xxx}L_yL_yL_y - L_{yyy}L_xL_xL_x + 3L_{xyy}L_xL_yL_y \\ DI[6] &= L_{xxx}L_xL_yL_y - L_{yyy}L_xL_xL_y + L_{xxy}L_y(L_yL_y - 2L_xL_x) + L_{xyy}L_x(L_xL_x - 2L_yL_y) \\ DI[7] &= L_{xxx}L_xL_xL_y - L_{yyy}L_xL_yL_x + L_{xxy}L_x(2L_yL_y - L_xL_x) + L_{xyy}L_y(L_yL_y - 2L_xL_x) \\ DI[8] &= L_{xxx}L_xL_xL_x + L_{yyy}L_yL_yL_y + 3L_xL_y(L_{xxy}L_x + L_{xyy}L_y) \end{aligned} \tag{2-41}$$

After extracting the feature points using the Harris corner point extraction in the video as described above, when the calculated differential invariant values for each of the feature points, comparison of the similarity between each image, each is performed by comparing the distance between the feature points. If the distance between the feature vector differential invariant value between the feature points being compared does not exceed the predetermined threshold, both feature points and is considered to be the same point, the matching between both images by using the number of feature points, and calculates the similarity of both images. To summarize the similarity calculation method can be expressed as follows.

$\{p_i\},\ i=1,2,\cdots,N$ a set of feature points in I_1 for both video I_1, I_2 which has N number of feature points, and the set of feature points in the I_2 and $\{p_j\},\ j=1,2,\cdots,N$, can be calculated by the equation (2-42).[20]

$$\begin{aligned} &\text{for } i=1,2,\cdots,N \\ &\qquad \text{if}\,(d_{\min}(I_1(p_i), I_2(p_j)), \quad \text{for } j=1,2,\cdots,N) < Threshold) \\ &\qquad\quad count = count+1 \\ &Similarity = count/N \end{aligned} \tag{2-42}$$

About the degree of similarity is large, it showed that type information between the two images are similar.

III. Types and characteristics of the corner detection algorithm

Corner information of the video signal processing and computer vision is one of important information along with the image of the contour. In particular, the image matching, and in the system of object recognition, the position of the corners, can be displayed together on the contour image. The development of existing digital computer and the processor, when the image data processing speed of the data and the operation speed is improved, it has a huge data, it is impossible to consider the subject of considering all the many data.

In addition, although the computer recognizes detects sequential object programmatically humans it is possible to simultaneously process a change of position which can detect the morphological analysis and the object, is progressed far object recognition capability. In computer vision that detects the position of an object, of a number of video data, it is possible to simplify the feature points of the object, also, to extract a key feature point, improvement and operation of the processing speed of the image data it is an important element that can be reduced the amount. Of these feature points, the feature of video data how to characteristically use a corner point contrast distribution is rapidly changing part image than wherein the contour by detecting the overall image of the outline while reducing the points, it is possible to represent characteristics of the image, and an input image to a variable that can perform object recognition more quickly and easily. Distortion of the image, but is not easy to detect corners for reasons such as fogging, the information corner in the field of image processing and recognition is an important reference point, such as the form (shape) or tracking, such as in particular the number of corners and engraved angle of shape, to provide a very important information in object recognition.

In this chapter, we describe issues that may be present with the most widely used type of conventional corner detection persons and their property.

A. Moravec corner detection algorithm

Moravec corner detection algorithm was proposed in 1997 by Hans Moravec. This algorithm was extracted into a corner at the change in the size of the contrast value in a certain window is large with respect to all directions of the pixel [20].

Figure 3.1 shows the case where it is divided into four modes by the Moravec algorithm.

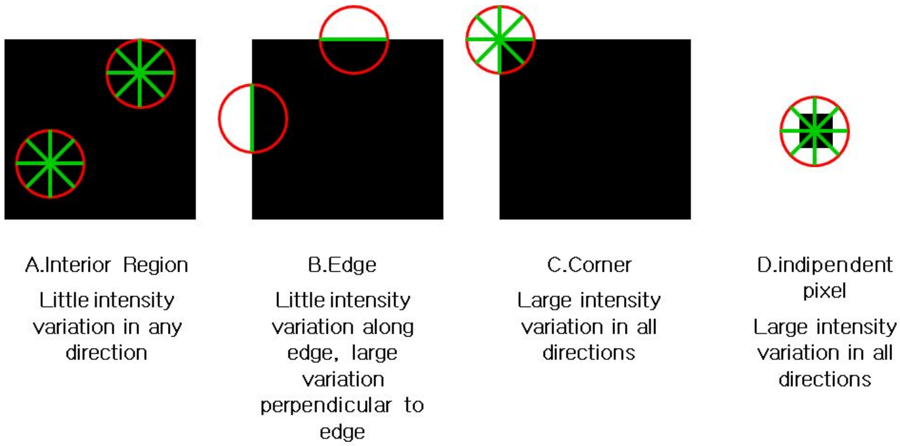


Fig. 3.1 Moravec operator by Type

In (A) in Figure 3.1, because less contrast in any direction in the window is set in the inner region, (B) have a small change in width along the contour. Figure 3.1 and (C) (D), is defined in the corner because of the difference in the change in large contrast with respect to all directions.

The window size is composed of a 3 * 3, the amount of change in contrast, shown in Figure 3.2, Equation 3-1 and Equation 3-2.

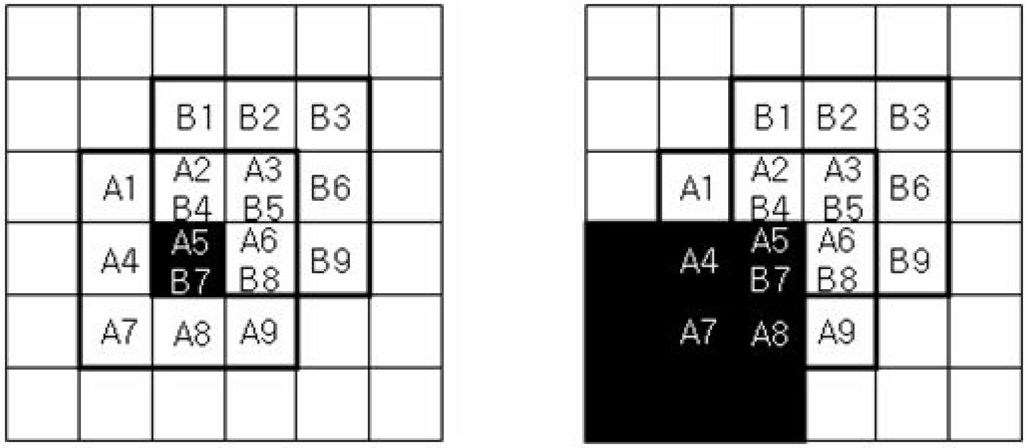


Fig. 3.2 Window masking for intensity variance value

$$Intensity = \sum_{i=1}^{9}(A_i - B_i)^2 = 2 \times 255^2 \qquad (3\text{-}1)$$

$$Intensity = \sum_{i=1}^{9}(A_i - B_i)^2 = 3 \times 255^2 \qquad (3\text{-}2)$$

Region feature of which has been defined to a corner Moravec algorithm is as follows.

1. Corner (Corner), I have a local maximum value (Local Maximum).
2. Separate the pixel values shown in (D) of Figure 3.1, has the same value as the change value of the brightness of the corners.
3. The entire input image is not a process of change value in the dark corners.

Application of Moravec algorithm is as follows.

1. Each pixel of the input image (x, y) by transitioning the constant value to calculate the change in contrast in the window.

$$Intensity(x,y) = \sum_{a,b=WindowPixel} (I(x+u+a, y+v+b) - I(x+a, y+b))^2 \quad (3\text{-}2)$$

2. Generate a corner map (Cornernesss Map)

$$C(x,y) = \min(Intensity_{u,v}(x,y)) \quad (3\text{-}3)$$

3. Set the threshold at the corner map.
4. Set in the corner to find the local maximum value.

Moravec algorithm has a problem that it is impossible to find a corner point of a feature is always the same when the rotation of the image is.

B. Harris corner detection algorithm

Harris corner detection algorithm was proposed by 1988 Harris.C and Stephens.M. [21] The operator, based on the local autocorrelation method of video signal with a combination of Moravec's corner detection and contour extraction operator (Local Auto-correlation function), analyze the spatial variations of contrast due to the movement of the window and then, it is arranged to detect the corner. How to apply the Harris corner detection operator is as follows.

1. Calculate the spatial variation of contrast.

$$
\begin{aligned}
&E(u,v)=\sum_{x,y} w(x,y)[I(x+u,y+v)-I(x,y)]^2=[u,v]M\begin{bmatrix} u \\ v \end{bmatrix} \\
&M=\sum_{x,y} w(x,y)\begin{bmatrix} I_x^2 & I_{xy} \\ I_{xy} & I_y^2 \end{bmatrix}
\end{aligned}
\tag{3-4}
$$

Here, $I(x,y)$ represents the brightness value of the image, $E(u,v)$ shows the mean of the contrast value of the image. And $w(x,y)$, is a strong Prewitt windows of vertical and horizontal components of the image.

2. If the λ_1 and λ_2 is the eigenvalues of a matrix M obtained, it determines the corner to changes in the values of the decision variables R.

$$
R=\det(M)-k(Trace(M))^2 \tag{3-5}
$$

Here, $\det(M)$ is meant the product of the eigenvalues λ_1 and λ_2, $Trace(M)$ means the total of the two eigenvalues λ_1 and λ_2. In addition, k is means constant, the variation width is of the order of [0.4~0.6].

3. By applying a threshold Obtained the decision variables R, detect a corner in the local maximum value.

The R value of the decision variable that depends on a value between the eigenvalues L and M, the image as can be seen in Figure 3.2, can be expressed by the following three areas.

(1) if the small values both the eigenvalues L and M, which is that the change in the contrast of the image is small, it means that decision variable R has a substantially constant value, which means a flat state.

(2) if any of the eigenvalues of the eigenvalues L and M is much greater than the other eigenvalues, this means that the closer the contour of the video.

(3) As shown in Figure 3.2, if very large both eigenvalues L and M, this means that the decision variable R is increased in all directions, which means that closer to the corner.

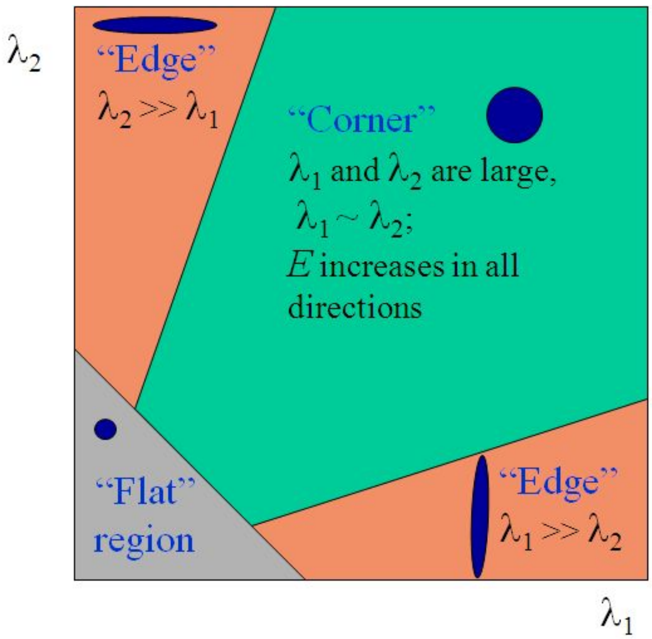


Fig. 3.3 Feature point division according to the distribution of eigenvalues

However, Harris corner detection, has the following problems.

1. Because you use the Moravec corner detection's and self-correlation function, take more computation time.

2. If there are many parts that have an isolated point, such as Salt & Pepper noise in the video, it is difficult to detect the correct corner. That is, Harris corner detection has a problem which is sensitive to noise.

3. Because we use the Prewitt window, Harris corner detection, but strong in corner detection to become a vertically and horizontally, but weak on the diagonal components as Moravec operator.

C. SUSAN corner detection algorithm

SUSAN corner detection algorithm, Smith and Brady proposed in 1997. This algorithm uses a circular mask form based on the values of adjacent pixels in the mask, to detect the corners. I determine the number of pixels having the value of the luminance value and close to the brightness of the central pixel in the mask. The basic idea of this algorithm, "size of the USAN is, a is a corner point geographically smallest pixel" is that. In other words, when you apply a circular mask in the video, it is shown in Figure 3.4. And applying the method of comparing the brightness values in the method of evaluating the corners of determining whether a pixel is USAN. Figure 3.5 is the USAN (Univalue Segment Assimilating Nucleus), the brightness value between the other pixels in the central pixel and the mask of the circular mask is a set of similar pixels.

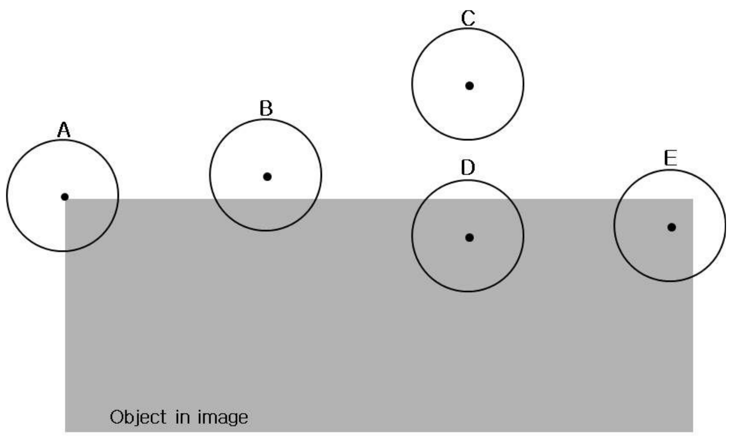


Fig. 3.4 Circular mask applied to an object in the image

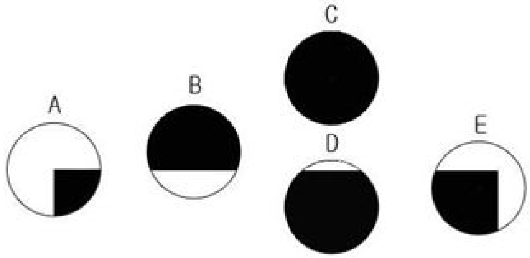


Fig. 3.5 USAN area

C and D in Figure 3.5, it means that the number of pixels, as similar to the central value in the mask are present most often, in these cases, means that in many cases the edges or corners are not present. For B, the mask is made to exist on a straight line contour, the number of surrounding pixels, such as an intermediate value for having an intermediate degree of the maximum value, it will be detected by the contour line. For A, is to have the least number of pixels is supposed to be the center value of the mask is present in the corner points of the image, in this case, is detected in the corner.

The basic equation of the corner detection using the SUSAN algorithm is as follows.

$$C(r, r_0) = \begin{Bmatrix} 1 \text{ if } |I(\bar{r}) - I(\overline{r_0})| \leq \textit{Threshold Value} \\ 0 \text{ if } |I(\bar{r}) - I(\overline{r_0})| \geq \textit{Threshold Value} \end{Bmatrix} \quad (3\text{-}5)$$

.Here, $I(\overline{r_0})$ is the contrast value of the center of the circular mask, $I(\bar{r})$ is the contrast value of the surrounding pixels. And $C(\bar{r}, \overline{r_0})$ is a determination output value.

Through these comparison process, to extract the comparison value for all pixels, that number is obtained by the following method.

$$n(\overline{r_0}) = \sum_{\overline{r}\, C(\overline{r},\overline{r_0})} C(\overline{r},\overline{r_0}) \tag{3-6}$$

In comparison with the threshold value set in advance the number of n in the formula (3-6), to distinguish whether the contour is a corner.

$$R(\overline{r_0}) = \begin{Bmatrix} g - n(\overline{r_0}) & \text{if } n(\overline{r_0}) \le g \\ 0 & otherwise \end{Bmatrix} \tag{3-7}$$

Where g is a preset threshold.

SUSAN corner detection is to use a circular mask of certain size, the case that discontinuity is frequently occur in the size and a certain threshold value and the image, the number of corner detection is frequently occur.

D. Corner detection using line intersection

In the proposed algorithm, we use the corner geometry information i.e., corner and intersecting line angles, for image retrieval. For the purpose of our algorithm and as a methodology for obtaining corner points in an image we define the corner as an intersection of two or more straight lines. So in order to find corners first we need to find straight lines in an image. Hough transform has been used to search the straight lines in the images [52] using the parameterized line equation (1).

$$\rho = x\cos\theta + y\sin\theta \tag{3-8}$$

Each line in the image can be associated with a couple (ρ, θ) which is unique if $\theta \in [0, \pi]$ and $\rho \in R$, or if $\theta \in [0, 2\pi]$ and $\rho \geq 0$. The (ρ, θ) plane is sometimes referred to as Hough space. From the Hough space the lines can be found using the inverse Hough transform [53]. As corner represent certain local graphic features at abstract level, corners can intuitively be described by some semantic patterns.

A corner can be characterized as one of the following four types:

- Type A: A perfect corner as modeled in [54], i.e., a sharp turn of curve with smooth parts on both sides.
- Type B: The first of two connected corners similar to the END or STAIR models in [54], i.e., a mark of change from a smooth part to a curved part.
- Type C: The second of two connected corners, i.e., a mark of change from a curved part to a smooth part.
- Type D: A deformed model of type A, such as a round corner or a corner with arms neither long nor smooth. The final interpretation of the point may depend on the high level global interpretation of the shape.

Figure 3.6 shows some examples of the four types of the corner. It is obvious from the figure, that the corner points at very small level are the intersection points of the two or more straight lines.

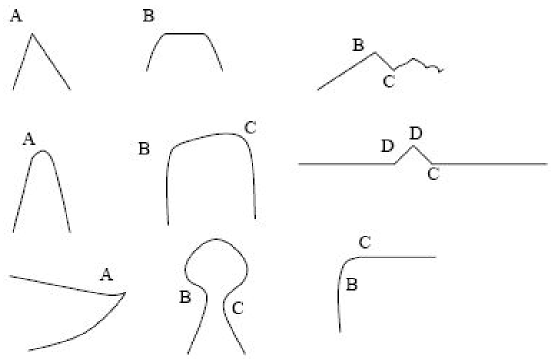


Fig. 3.6 Four types of corners

Figure 3.7 shows two intersecting line segments with given end point coordinates.

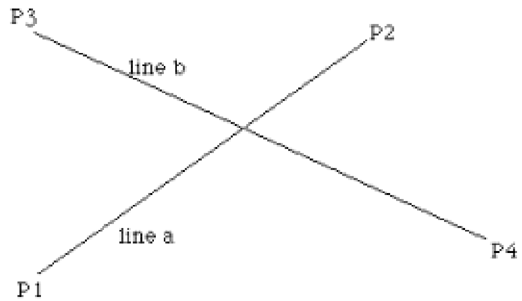


Fig. 3.7 Two intersecting line segments

The intersection point of the line segments can be computed as follows:
The equations of the lines are:

$$P_a = P1 + u_a(P2 - P1)$$
$$P_b = P3 + u_b(P4 - P3) \tag{3-9}$$

Solving for the point where Pa=Pb gives the following two equations in two unknowns (ua and ub).

$$\begin{aligned} x1 + ua(x2 - x1) &= x3 + ub(x4 - x3) \\ y1 + ua(y2 - y1) &= y3 + ub(y4 - y3) \end{aligned} \tag{3-10}$$

Solving gives the following expressions for ua and ub.

$$\begin{aligned} u_a &= \frac{(x4 - x3)(y1 - y3) - (y4 - y3)(x1 - x3)}{(y4 - y3)(x2 - x1) - (x4 - x3)(y2 - y1)} \\ u_b &= \frac{(x2 - x1)(y1 - y3) - (y2 - y1)(x1 - x3)}{(y4 - y3)(x2 - x1) - (x4 - x3)(y2 - y1)} \end{aligned} \tag{3-11}$$

Substituting either of these into the corresponding equation for the line gives the intersection point. If the denominator for the equations for ua and ub is 0 then the two lines are parallel. If the denominator and numerator for the equations for ua and ub are 0 then the two lines are coincident.

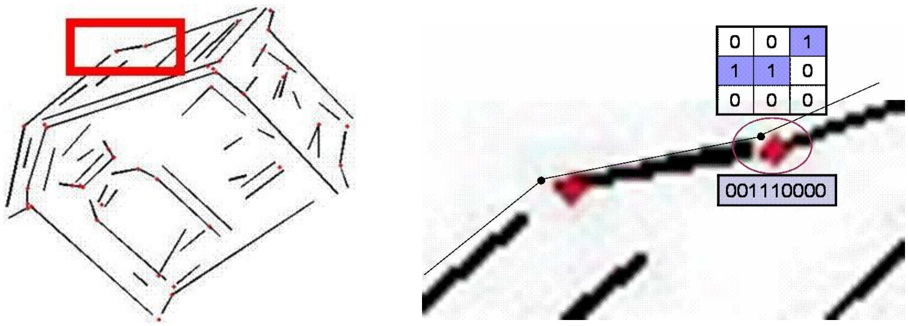
There are other cases also, such as if point of intersection lies on the projected lines. Because of many intersections of lines, false corners are also detected. To avoid false candidates, the detected corners whose vicinity does not contain any edge point are discarded.

Once the lines and corner information is obtained, lines intersection angle and the angles which the intersecting lines make with the x-axis are found.

A 3x3 matrix has been used to represent the angles. The centre cell of the matrix being the corner and origin, each cell can represent intersecting lines within a range of 45 degrees. A ‘1’ in the cell represents a line and ‘0’ for the absence of a line. This information can be written using ‘9’ binary digits (bits) corresponding to the 3x3 matrix.

Figure 3.8 (a) below shows the detected lines in an image. The red rectangle shows the selected corners shown in the enlarged view in (b).

The geometry of the circled corner has been represented in the 3x3 matrix to show the angles of intersecting lines.



(a) (b)

Fig. 3.8 Corner Geometry

The information can be written in binary form as ‘001110000’. Similarly corner geometry of each detected corner in an image can be represented using 9 binary digits. Figure 3.9 shows few corner patterns and their binary representations.

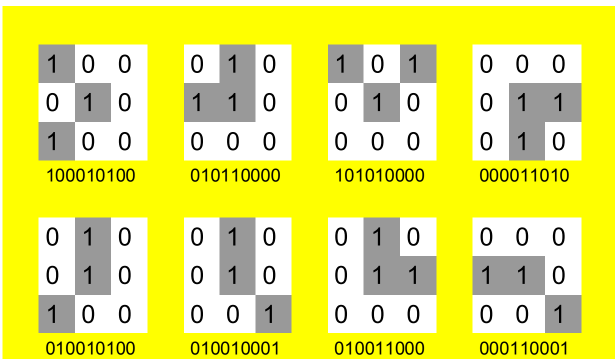


Fig. 3.9 Corner geometry representation

IV. Design of the proposed algorithm

Proposed in this paper, variance rearrangement algorithm of the corner regions, algorithm using the double rearrangement of the corner regions and the corner patches based DCT rearrangement algorithm construct a feature vector using corner point algorithm of shape feature analysis algorithm of the image in various ways.

First, variance rearrangement algorithm of the corner regions, after extracting a corner point in the image, extracts a difference value of neighboring 8 pixels in the corner point and is a method for relocating a variance value. Secondly, the algorithm using the double rearrangement of the corner regions, after extracting a corner point in the video, calculate the luminance amount of gray levels using the Representative value and is a technique of applying correlogram between the total amount of the average level value and the gray-level intensity in the corner regions. Thirdly corner patches based DCT rearrangement algorithm, after extracting a corner point in the image, calculates the DCT coefficients of the corner patch and is a method which construct the rearrangement histogram of the corner patch-DCT coefficients to feature vector.

A. Existing algorithms

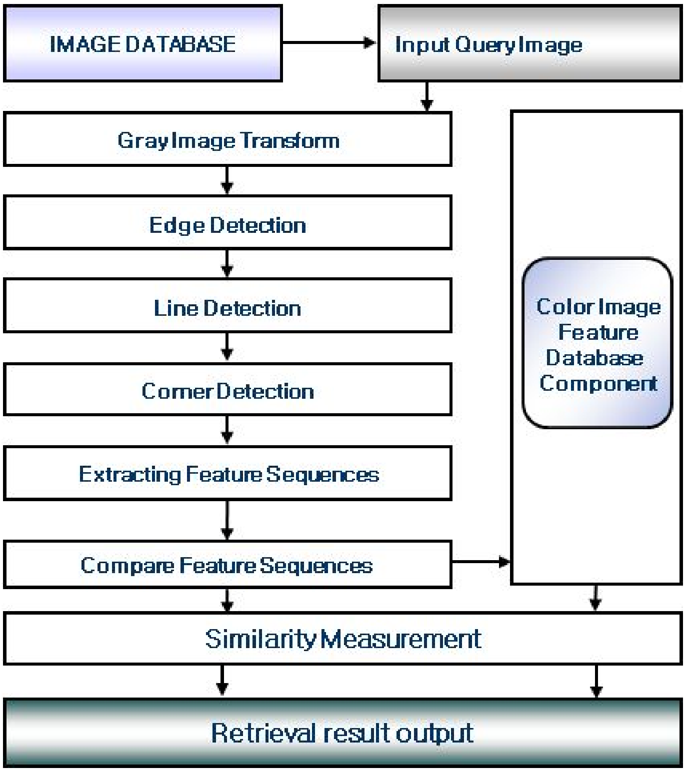


Fig. 4.1 Flowchart of the existing algorithms

As shown in Figure 4.1, the existing algorithm first converts the query image to the edge image. Extracting lines from the converted edge image, to acquire the information of the corner point in the extracted line. By using the table of the patch that is configured around the information of the next is obtained by converting a color image corner points are used as feature information. The characteristic information is compared with the target image in the image DB is made to be output similar images.

1. Algorithm using the sum of the corner points

After extracting a corner point of the existing algorithms, mainly the information of corner points configure the neighboring pixels in the corner patch table and the algorithm using the characteristics of the sum of the pixel values compared with proposed algorithm. Algorithm using the sum of the corner point is to extract the corner points in the image as shown in Fig4.2, because it is used as a feature by adding the value of a pixel, if the corner point number of images and the number of the database are different, the larger the error range there is a drawback.

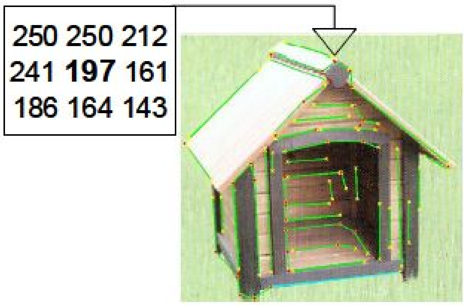


Fig. 4.2 Pixel values of the corner points

Table 4.1 Some data of the corner points

Corner #	Pixel value of corner patch									Sum
1	250	241	186	250	197	164	212	161	143	
2	73	34	48	99	36	37	101	57	28	513
3	179	178	194	177	166	151	177	176	139	1537
4	19	48	184	15	6	208	11	72	226	844
:	:									:

2. Corner patch histogram algorithm

Secondly, existing algorithms used for comparison with the proposed algorithm is an algorithm that uses a histogram of the corner patches. Obtains a histogram of the corner patch configured around a corner point information, and an algorithm for comparing the images of the video and the quality of the database. In order to use the histogram and the number of corner points and are not affected, according to the data interval histogram, the different characteristics of the information of the corner point, if the size of the corner patch is small, the object Corner is disadvantageous in that the characteristics of point information becomes insensitive.

Fig. 4.3 Corner detection in image patch histogram

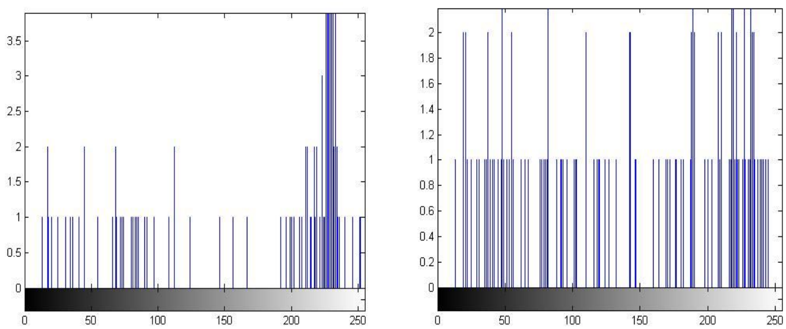


Fig. 4.4 Histogram of corner points

B. Design of the algorithm using neighboring pixel difference value of corner points

In this section, after extracting the corner points of the image in the video search algorithm using corner points as the interest point having a position and shape information of a specific object in the image, the difference values of close neighbors pixels to the corner points 8 is extracted, and would like to propose a method for rearranging the variance. Figure 4.5 shows the flowchart of the proposed algorithm.

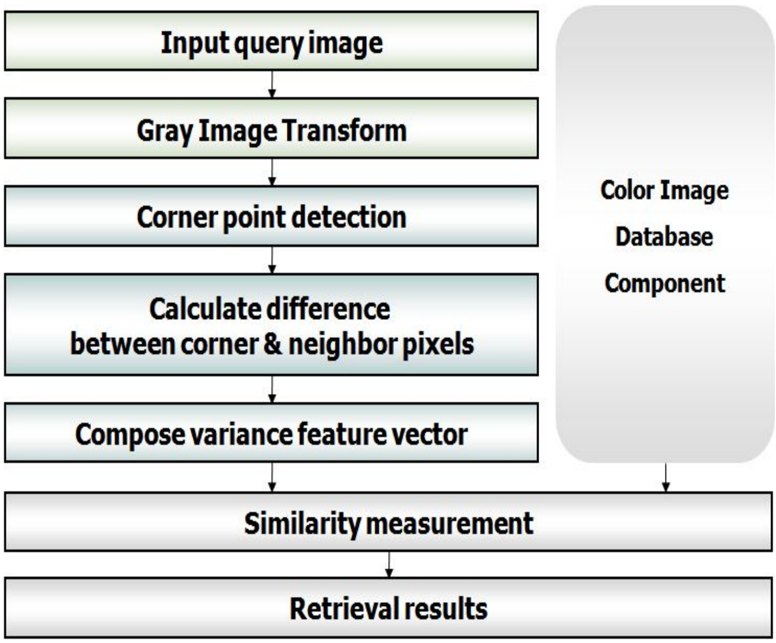


Fig. 4.5 Corner area variance values rearrangement algorithm flowchart

Order of the operations of the proposed algorithm is as follows.

Step1. Converts the video quality gray scale.

Step2. After converting to the edge image using the edge detection Canny, to detect line images using the Hough transform.

Step3. Using the image that is complemented by the Hough transform to extract the corner points of the edge and the edge intersect.

Step4. Make up a 3 * 3 corner patch table with all of the corner points in the query image.

Step5. Calculate the difference between the pixels adjacent to the corner points and the corner, and calculates the variance value, constitutes a feature vector.

1. Convert to gray scale image

In this algorithm, I was using the edge information. Method of extracting edges, can be divided into a method in which binding is extracted from the large and extraction method after converting an image into a gray image, each channel of the color image. Edge extraction of a color image, must be recombined by extracting edges from each channel. In an attempt to alleviate these effort, in this algorithm, to convert the image quality of the gray scale image in the first step. Figure 4.7 is a diagram obtained by converting the query image to a grayscale image.

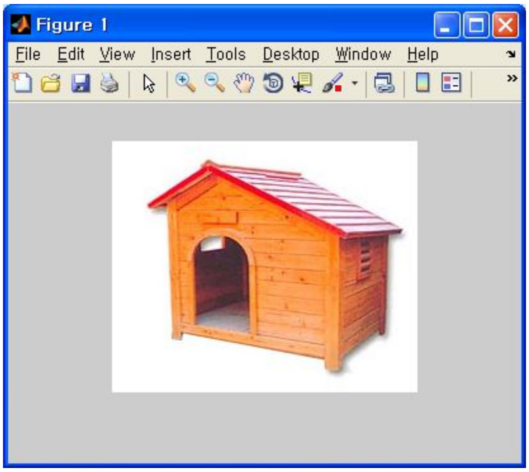


Fig. 4.6 RGB image

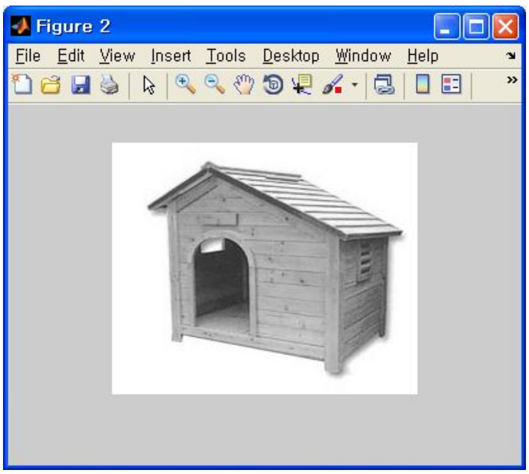


Fig. 4.7 Gray scale image

2. Convert to edge image that you use the Canny edge detection

After converting the image quality of the gray-scale image, using a second edge detection calculation Canny. Canny edge detection operation, to perform noise removal processing to remove unwanted noise prior to the contour extraction. When implementing a noise reduction operation, by its effect, the change in the value of the pixel is slowed. That is, if a sudden change in pixel value is such to change in a gradual change, step edge line edge loops vary ramp edge, changes in the edge easily feel that the difference in brightness variation it becomes possible. Canny edge by pre-removal contour such as very small noise, can grasp the large contour of the object of interest.

Figure 4.8 is a diagram showing only the edge components through a gray scale image Canny edge detection.

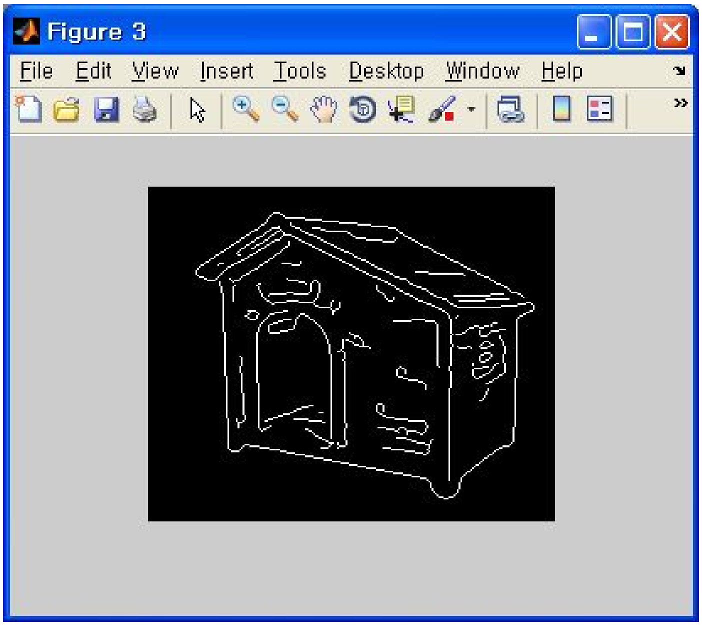


Fig. 4.8 Canny edge image

3. Detection of the line image through the Hough transform

The edge detection method, there are a number of ways. Edge detection is, but needs to detect only the pixels that are located in the edge, these methods can not be substantially completely represent the characteristics of the edges.

This noise, damage to the edge due to non-uniform illumination, because of other effects that cause discontinuities in brightness. Therefore, after applying an edge detection algorithm, usually through the connection process to collect pixels, it will be followed later work of creating the edge meaningful. One approach to connect by searching towards the line in the image is a Hough transform. After edge detection, via a Hough transform an image showing only the edge component, and converts the line edge is more meaningful.

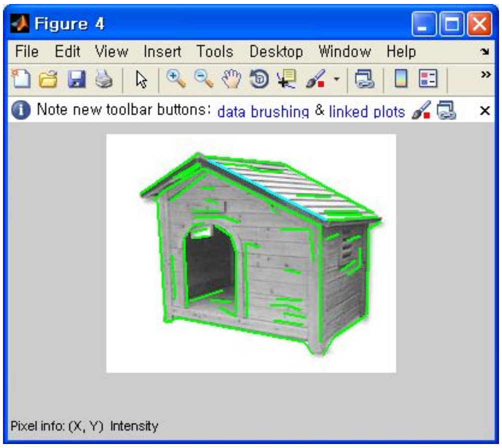


Fig. 4.9 Image after Hough transform

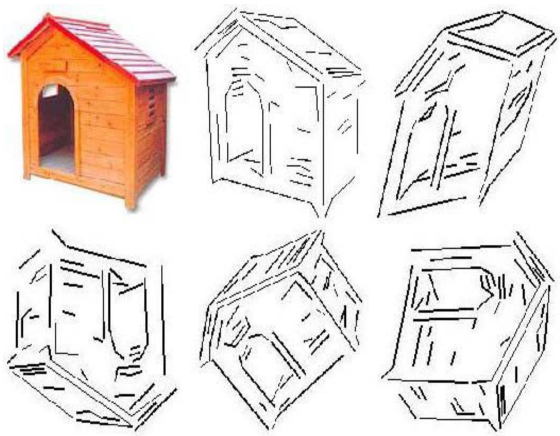


Fig. 4.10 Extracted line image

And the angle and length of the line changes in the line of the Hough transform obtained video obtained line and the circle through the Hough transformation of the original image as shown in Figure 4.10 of the video that Affin transformations, and connecting points common straight line and the intersection of the line that was to be understood that it is maintained. By utilizing these features, rotation, it is possible to obtain a tough corner characteristics resizing.

4. Corner point extraction in the image

That edge and the edge in the edge image, which is supplemented by the Hough transform intersect, that is, to extract the corner points. A corner point and values of the neighboring pixels of original image and horizontal deformed image is same as shown in Figure 4.11. Once all the corner points are located in the image as shown in Figure 4.12 is extracted, while moving from the upper left of the image on the right, is determined arbitrarily ordering from the first corner point is detected until the end of the corner points.

Fig 4.11 Pixel values of the corner patch

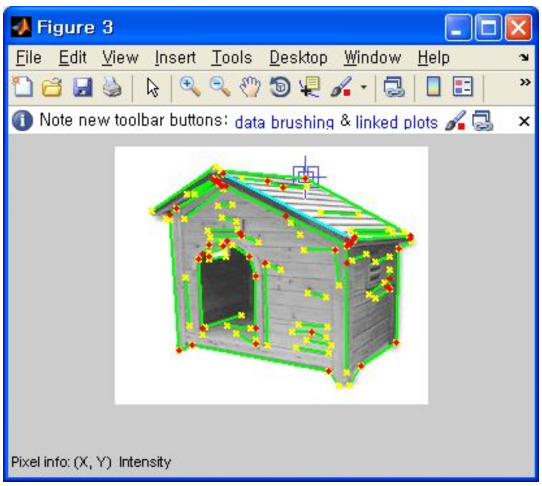


Fig 4.12 corner points Image

5. Calculation of Difference variance between the corner and the neighborhood pixel

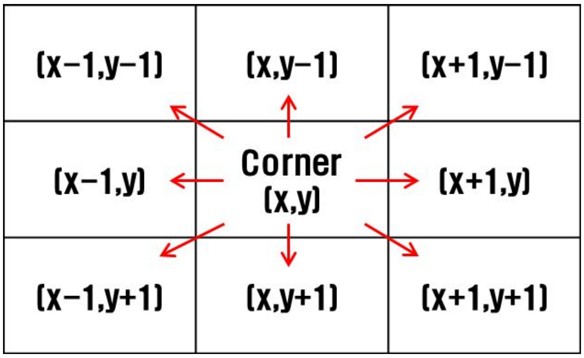


Fig. 4.13 3*3 corner patch

Shown from the extracted corner points as shown in Figure 4.9, including the next pixel. By using the equation (4-1), to determine the difference between the corner point and neighboring pixels to determine the variance value. Here, $f(x_i, y_j)$ is the pixel value of the corner patch, $variance$ indicates a variance value.

$$variance = \frac{1}{n}\sum_{i,j=-1}^{1} f(x,y) - f(x_i, y_j)^2 \qquad (4\text{-}1)$$

By sorting the variance values obtained in this way in descending order, is used as a feature vector of the algorithm proposed in this section.

C. Design of the algorithm using the corner double rearrangement

In this section, after extracting a corner point of the image, it is desired to propose a method for applying correlogram between the gray levels the total luminance value of the average value and the corner regions of the corner regions. Figure 4.14 shows a flowchart of the proposed algorithm.

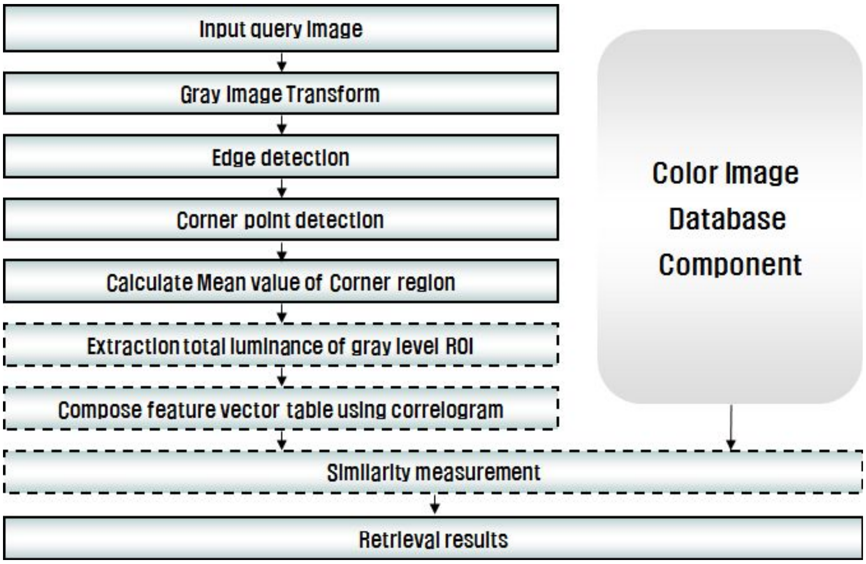


Fig 4.14 Flowchart of the algorithm using correlogram to corner point

Order of the operations of the proposed algorithm is as follows.

Step1. Converts the video quality gray scale.

Step2. After converting to the edge image using the edge detection Canny, to detect line images using the Hough transform.

Step3. Using the image that is complemented by the Hough transform to extract the corner points of the edge and the edge intersect.

Step4. Make up a 3 * 3 corner patch table with all of the corner points in the query image.

Step5. To obtain the representative value area from the extracted corner regions, to determine the total amount of gray level intensity of a region with a value at or above the threshold by the representative value threshold.

Step6. Constitute a feature vector by applying the average level value and Step5. Correlogram gray level intensity of the total amount of the corner regions.

The order of operations as described above, first, converts the circular video as shown in Figure 4.2 in gray scale, as shown in Figure 4.4, is converted to the edge image using the Canny edge detection. After edge detection, and the land converted into lines constituting the edges of meaningful using the Hough transform, as shown in Figure 4.5, the edge and the edges intersect with the complementary edge image as shown in Figure 4.8, extract the corner points.

By using the equation (4-2), to obtain the representative value corner regions. Here $f(x_i, y_j)$ are the pixel values of the corner patches. By using the equation (4-3), after acquiring the representative value corner regions, to obtain the total brightness of the gray level of the corner areas in the threshold representative value as shown in Figure 4.15.

$$mean = \frac{1}{n} \sum_{i,j=-1}^{1} f(x_i, y_j) \qquad (4\text{-}2)$$

$$threshold = \sum corner(x,y)/9 \qquad (4\text{-}3)$$

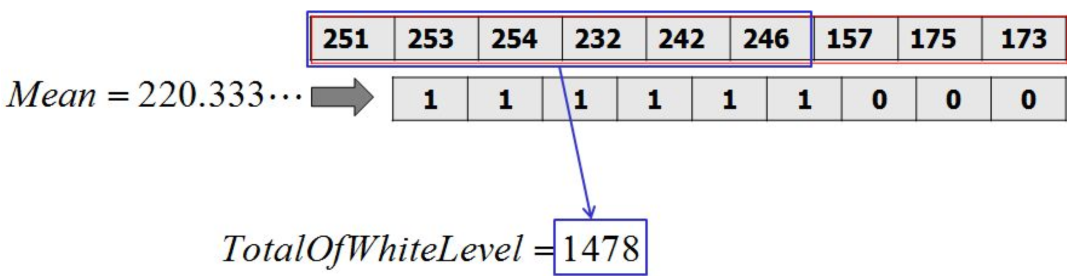


Fig 4.15 Total luminance of gray level

Apply a Correlogram between the total amount of the average level value and the gray level brightness of the corner area as Step6.

Here, I refers to representing a certain color distance is displayed in the distant pixels in the color of all pixels in grams and Corel image on a two-dimensional probability. The distance between pixel from the quantized image I with the m color is k, the Correlogram $r^{k}_{C_i, C_j}(I)$ for color C_i & C_j is the same as equation (4-2).

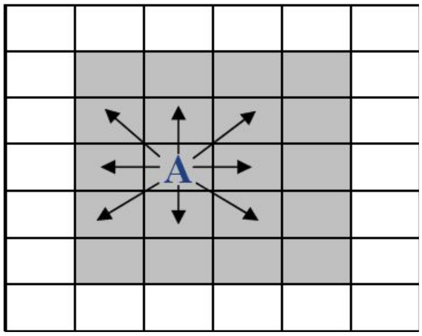
Here Pr[·] is the probability of $i, j = 0, 1, \cdots, m-1$, which fills the interior of the condition, m is the number of colors that have been quantized. I_{C_i} and I_{C_j}, the image shows all of the pixels that have the i and j-th color. The distance between pixels p_a and p_b are as defined in the formula (4-4).

$$|p_a - p_b| = \max(|x_a - x_b|, |y_a - y_b|) \tag{4-4}$$

Here, the coordinates of each pixel is $p_a = (x_a, y_a) \in I$, $p_b = (x_b, y_b) \in I$. In this case, that grams area of $C_i = C_j$ to auto-correlogram. Here, although having information on whether a pixel having the same color as the color image pixels have is distributed how around it, and includes size information of the area with a single color. In addition, most of the energy of correlogram is displayed in this area

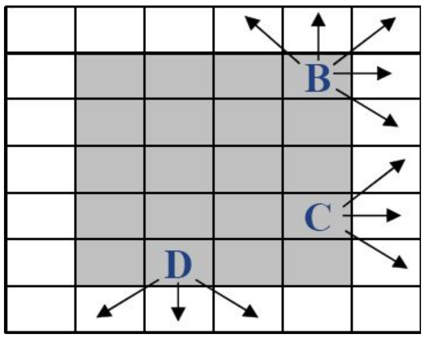
$$r^{(k)}_{C_i, C_j} = \Pr_{p_1 \in I,\, p_2 \in I}\left[p_2 \in I_{C_i \neq C_j} \middle| |p_1 - p_2| = k\right] \tag{4-5}$$

Equation (4-5) is, except for the probability distribution with the same color as the grams of the cross correlogram. That is a color except as around the pixel, I show the probability of part that other color comes out.



color	0	1	2	3
0	◎			
1		◎		
2			◎	
3				◎

Fig. 4.16 How to get the auto-correlogram



color	0	1	2	3
0		◎	◎	◎
1	◎		◎	◎
2	◎	◎		◎
3	◎	◎	◎	

Fig. 4.17 How to get the cross correlogram

The following Figure 4.16, is a way to get correlogram, correlogram is an algorithm that has been calculated according to the distance and angle. By a distance with respect to the pixels A to 1, as shown in Figure 4.16, is intended to show the probability of finding a color of a pixel, such as around the reference pixel. Pixel B in Figure 4.17, C, D is a part of grams Kurogukoreru. B, C, and set to 1 the distance with respect to the pixel D, and is intended to show the probability of finding the reference pixel and the other color pixels around.

The result of applying the correlogram, such as described above is as Figure 4.14.

Table 4.2 The result of applying the correlogram

								1531 ~ 1785
	4							1276 ~ 1530
	2	4						1021 ~ 1275
1		3	10	5				766 ~ 1020
	1	3	5	4				511 ~ 765
			1	5				0~510
224~ 255	192~ 223	160~ 191	128~ 159	95~ 127	64~ 95	32~ 63	0~ 31	Total of WL / Mean level of corner region

D. Design of the corner patch DCT rearrangement algorithm

In this section, after extracting a corner point of the image, and rearranging the histogram of the DCT coefficients by calculating the DCT coefficients of the corner patch, it is desired to propose a method for configuring the feature vectors. Figure 4.18 shows a flowchart of the proposed algorithm.

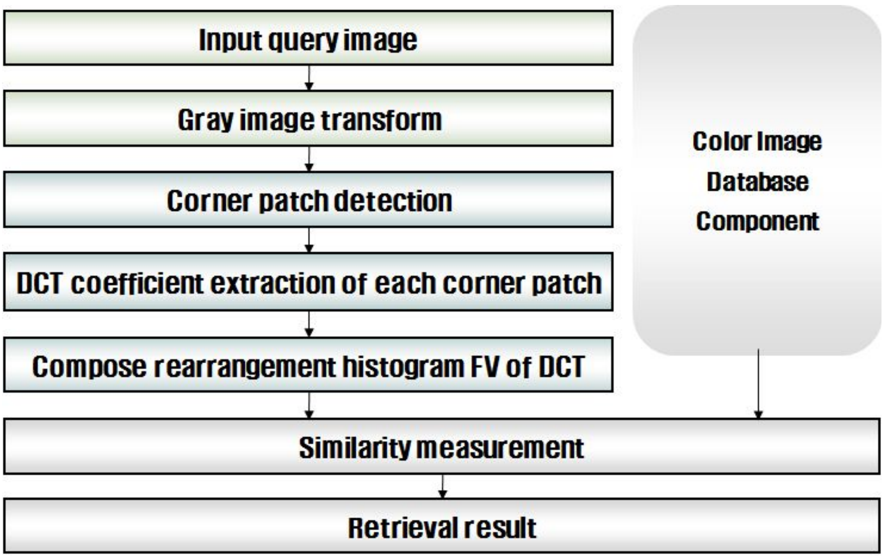


Fig. 4.18 Design of the corner patch DCT rearrangement algorithm

Order of the operations of the proposed algorithm is as follows.

Step1. Converts the video quality gray scale.

Step2. After converting to the edge image using the edge detection Canny, to detect line images using the Hough transform.

Step3. Using the image that is complemented by the Hough transform to extract the corner points of the edge and the edge intersect.

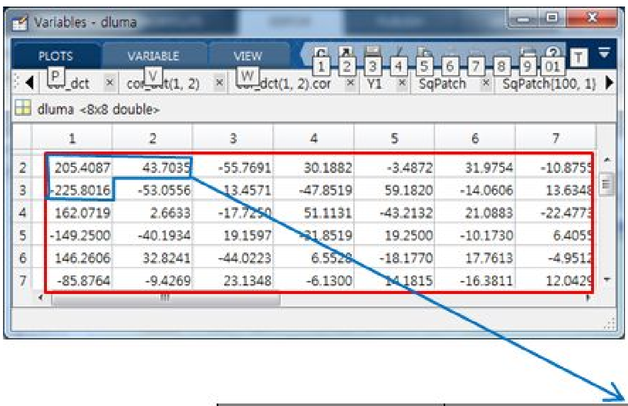
Step4. Make up a 3 * 3 corner patch table with all of the corner points in the Q & video.

Step5. By calculating the DCT from the corner patch to extract DCT coefficients.

Step6. To obtain a histogram by selecting a portion of the extracted DCT coefficient sequence, construct a feature vector by rearrangement.

The order of operations as described above, first, converts the circular video as shown in Figure 4.2 in gray scale, as shown in Figure 4.4, is converted to the edge image using the Canny edge detection. After edge detection, and the land converted into lines constituting the edges of meaningful using the Hough transform, as shown in Figure 4.5, the edge and the edges intersect with the complementary edge image as shown in Figure 4.8, extract the corner points.

Then, after extracting a part of the corner patch DCT coefficients as shown in Figure 4.19, and calculate histogram.



205.4087	-225.8016	43.7036

Fig. 4.19 DCT coefficients extraction of the corner patch

Finally, by rearranging the histogram as shown in Figure 4.20, constitute a feature vector.

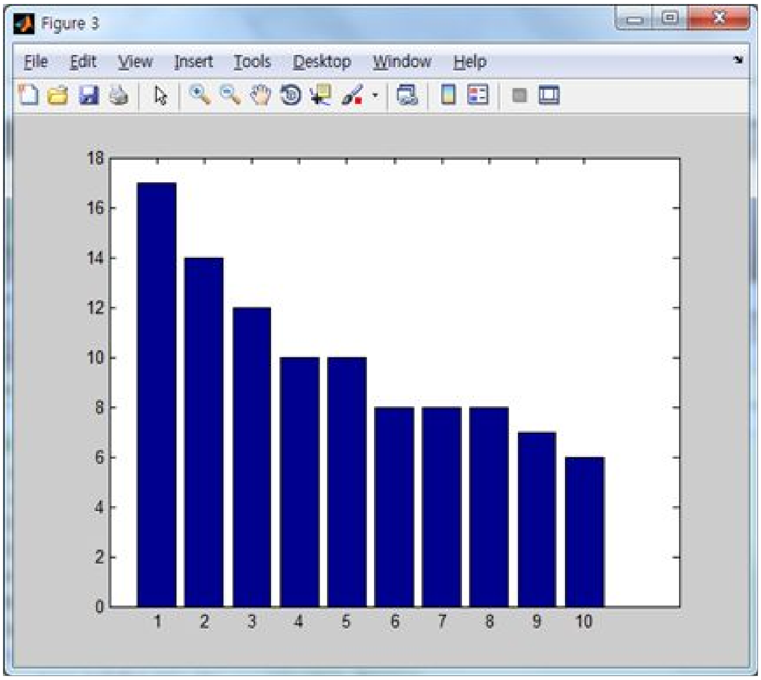


Fig. 4.20 The Rearrangement histogram of corner patch DCT coefficients

V. Experiments and analysis

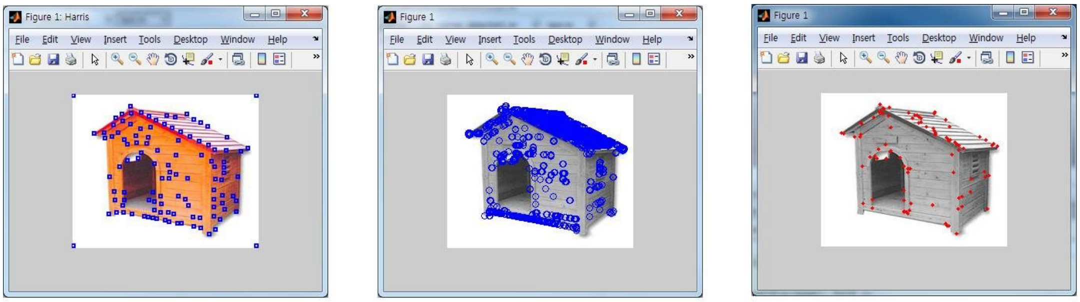
A. Experiments

Algorithm proposed in this paper were performed by using the MATLAB 7.8 software with various video images. First, to analyze the corner detector's performance used in this study, I compared the corner detection performance according to the rotation, scale change of the image by using the SUSAN, HOUSE, BOXES, COIN image which is often cited in the papers on the corner detection in general. Also, in the case of the algorithm using the corner patch DCT rearrangement, it is derived the value of the optimization by comparative analysis of retrieval performance in accordance with the corner patch size and search performance according to the number of the DCT coefficients of the corner patches.

Simulation of this algorithm, to subject the various video, was the feature value of common corner point method and proposed algorithm of the advance of data storage. The stored data is calculated only the quality of the video without the computation separately when it was subsequently enter another question video, derives the resultant image by comparing the measure of similarity by using the feature value of the data.

1. Comparison of the Corner Detectors

To compare the Harris corner detection and SUSAN corner detection and corner detection using line intersection used in the proposed paper were experimented with the house image.



(a) Harris corner (b) SUSAN corner (c) Corner using line intersection

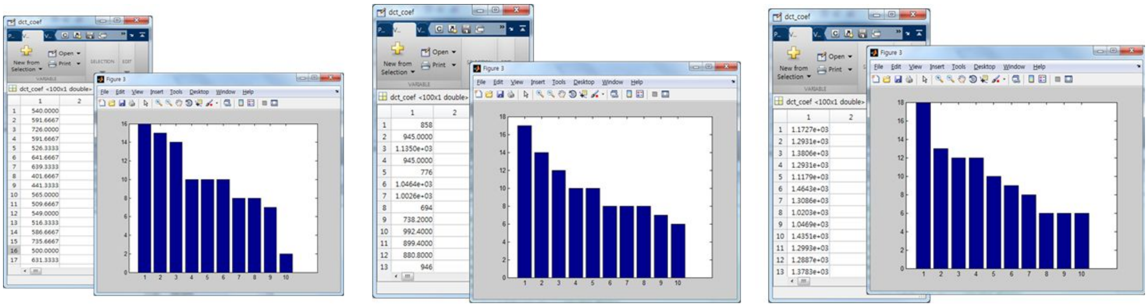
Fig. 5.1 Comparison of the corner detectors

As can be seen in figure 5.1, The Harris corner detection can be differentiated depending on changes in the respective predetermined threshold value, it extract a corner feature points in the case of the isolated points form. In the case of the isolated corner, that its intensity variation is large, is sometimes recognized as a corner because its calculation result of the curvature value is substantially similar to the curvature value of the corner point. Method using the SUSAN algorithm extracts a corner feature points by using intensity distribution in the circular mask. Since using the change value in the mask, it generates a number of errors than the actual corner.

If the corner does not contain the edge points around the detected corner, the corner detector using a line intersection removes the corner to recognize the dummy candidate, so as well as to find the optimal corner, the detection rate is faster than the Harris corner detection and SUSAN detector.

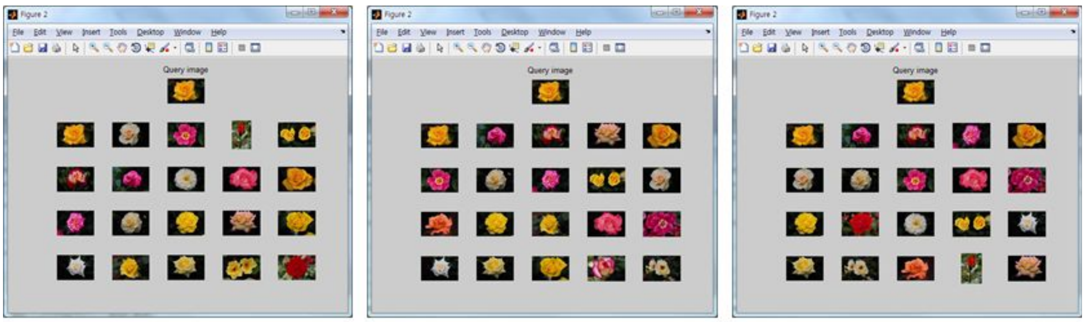
2. Optimization of the Corner Patch DCT

The following Figure 5.2 compares the search performance depending on the number of the DCT coefficients of the selected corner patch and according to each corner patch size in the corner of the corner patch algorithm using DCT.



3*3 corner patch DCT 5*5 corner patch DCT 7*7 corner patch DCT

Fig. 5.2 Comparison according to the corner patch size



3 DCT coefficient 5 DCT coefficient 7 DCT coefficient

Fig. 5.3 Comparison according to the # of DCT coefficient

Change in the features in accordance with the corner patch size as shown in Figure 5.2 is insignificant. Given the retrieval speed, performance of when I search for size of the 5 * 5 corner patch is best. Figure 5.3 is a search result based on the number of corner patches DCT. When selecting the three DCT coefficients can be confirmed that the search performance is best.

3. Retrieval result Comparison of the proposed algorithms

Experimental image in Figure 5.1 were used in the experiment picture for implementing this simulation. First, in order to aid the understanding of the present algorithm, after defining the experimental images as shown in Figure 5.1 the database to select the video quality at the 25 images. Images of the selected quality, by using this algorithm, it is compared to a database image, shows the search results.

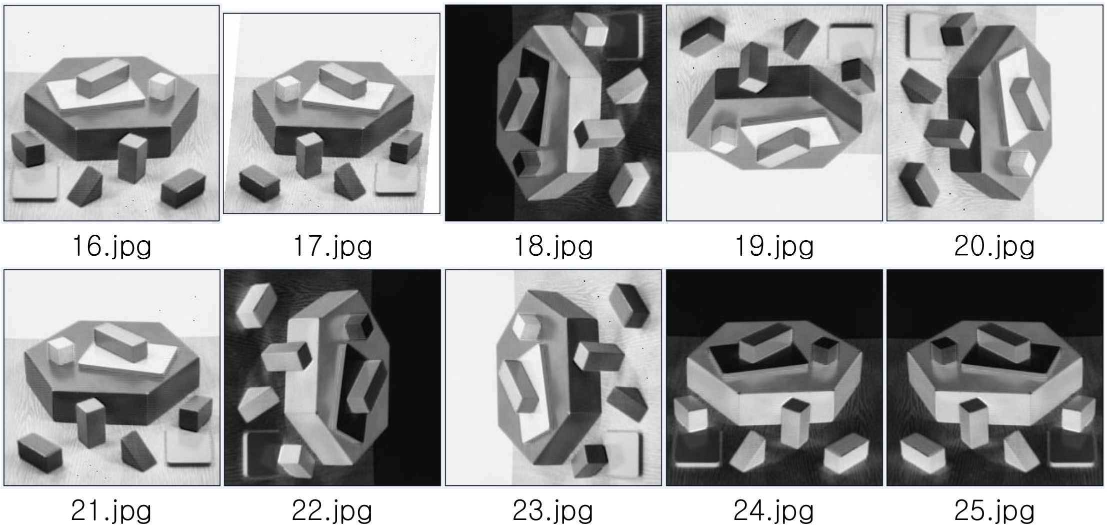


Fig. 5.4 Experimental images

First, leaving Figure 5.1 in the experimental images, after defining the 2.jpg in Figure 5.1 the question video, and experiments were conducted. Figure 5.2 is a query image.

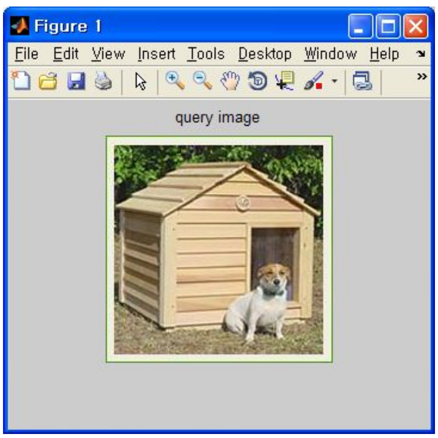


Fig. 5.5 Query image 2.jpg

Figure 5.6 shows the similarity values of the characteristic value using the corner points Doubler arranged in a graph-based algorithm. Ranking in Figure 5.7, the ranking of similarity was determined according to the number of database images.

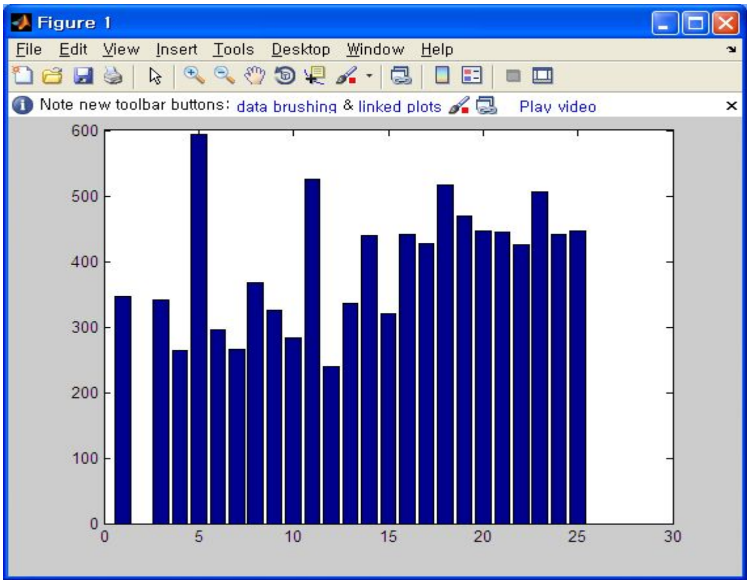


Fig. 5.6 Similarity measurements by image number using the feature value

Similarly, in Figure 5.7, there is shown in such a way that in Figure 5.6, 25 sheets of the image search is a search for images that have been rearranged in order of similarity measurements were made.

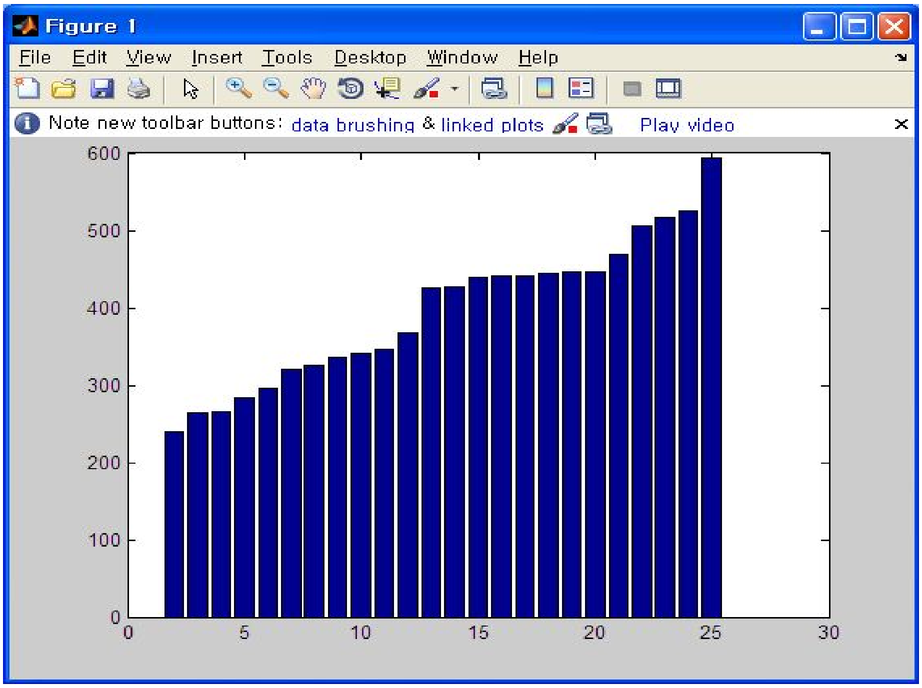


Fig. 5.7 Ranking similarity measurements using the feature value

Seen from Figure 5.7, it can be sure to find the image quality initially. The next video I was searched in the order of the same image and quality of the video. Of the 25 pieces of the database image, I can six similar image To verify that you are searching for in order of similarity. Error rate of Table 5.1 using the organic Lee Dion error distance, illustrates the error of the feature values between the images is similar to the picture quality. Since it is displayed in a similar order, the order of the error rate comes out the same as the order of the similarity. Since different threshold values of the image error rate, similar to the image, it must be given a weight based on the information of each image.

Table 5.1 Error rate of the image

Image Number	2	12	6	10	7
Relative error	0.000	0.131	0.193	0.419	0.697
Image Number	4	13	3	15	9
Relative error	0.821	0.975	0.985	1.016	1.062
Image Number	14	1	8	24	22
Relative error	1.175	2.096	2.108	2.400	2.544
Image Number	16	17	21	20	19
Relative error	2.563	2.665	3.560	3.732	4.007

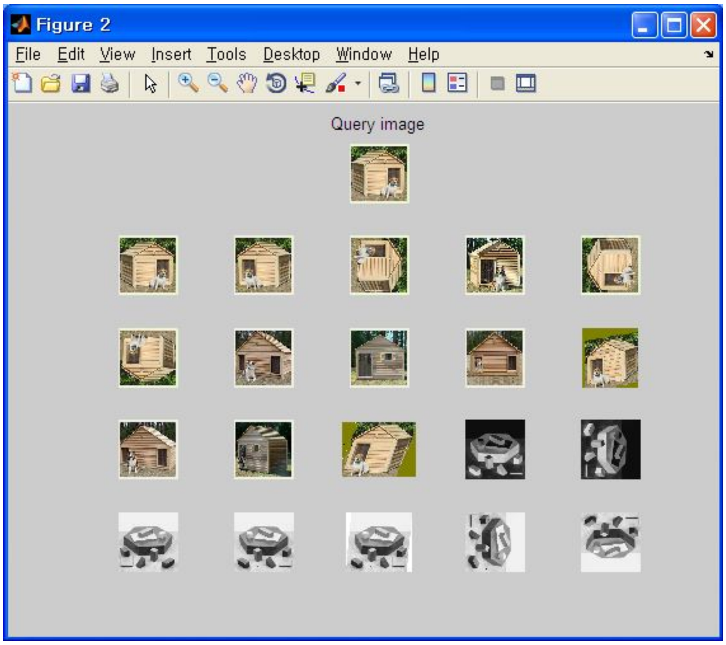
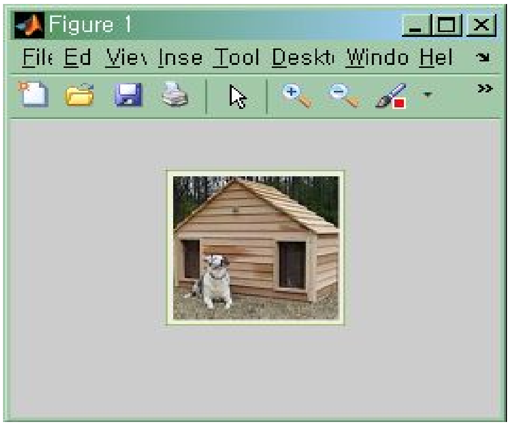


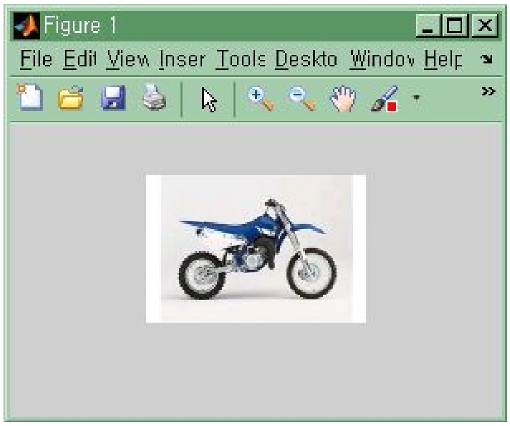
Fig. 5.8 The image search results by the similarity values

Experiments in the following figure, after changing the database for performance comparison of existing algorithms and the proposed algorithm, the proposed algorithm has conducted experiments to show better performance than the existing algorithm.

For quality images, such as in Figure 5.6, the respective databases are placed the pieces 50 to 200, a similar image of the image quality of each is shown in Figure 5.7. Shows the performance of any number of similar image in question and images of the algorithm proposed and existing algorithms are found.



Q1



Q2

Fig. 5.9 Query image Q1, Q2

Q1-1 Q1-2 Q1-3 Q1-4 Q1-5

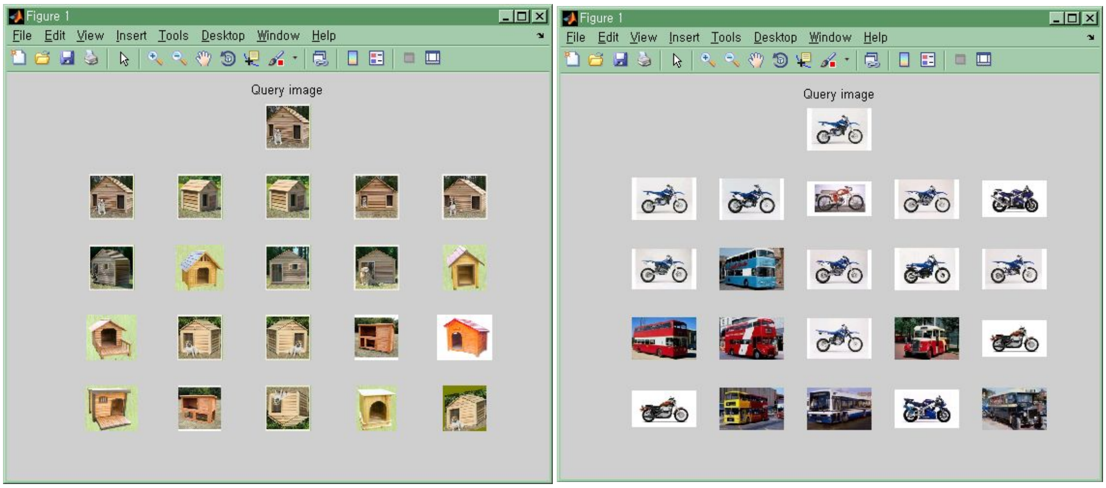
Q1-6 Q1-7 Q1-8 Q1-9 Q1-10

(a) Similar image of Q1 within the database 50

(b) Similar image of Q2 within the database 200

Fig. 5.10 Similar image of query image within the database

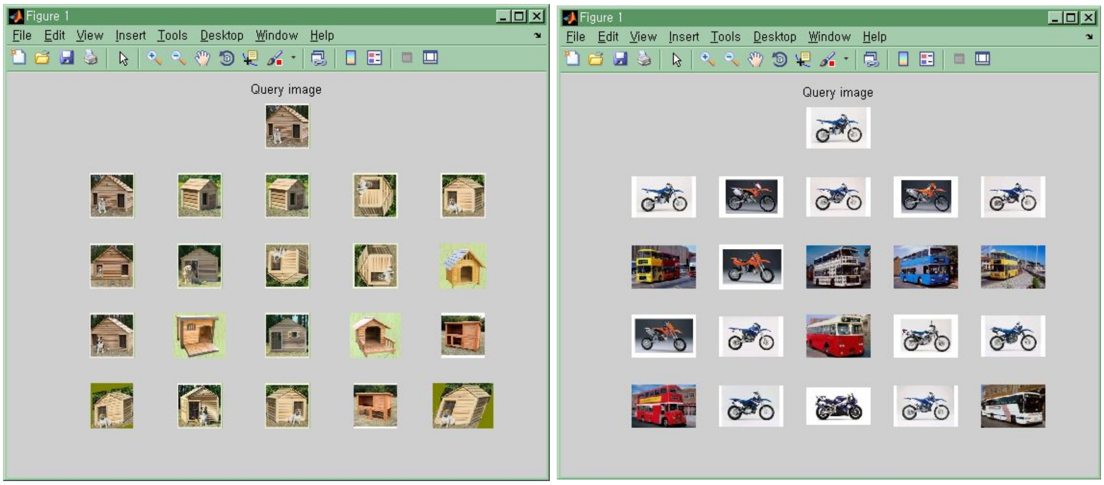
To videos of each of the quality, I was described in the following figure the search results and algorithm performance of an existing algorithm with the proposed algorithm on each of the similar image. Figure 5.9, there is a conventional corner points, it shows the search results in the algorithm, Fig. 5.10, use it shows the search results of the algorithm based on the corner close to the pixel difference values, Figure 5.11 is the correlogram the corner point and shows the results of the stomach algorithm, Figure 5.12 showed the corner patches DCT based algorithm. The proposed algorithm, and rotation there is an existing corner point algorithm can ensure that the superior expansion and reduced also retrieval performance in video.



(a) Search results of Q1 (b) Search results of Q2

Fig. 5.11 The image Q1, Q2 search results of corner point sum algorithm

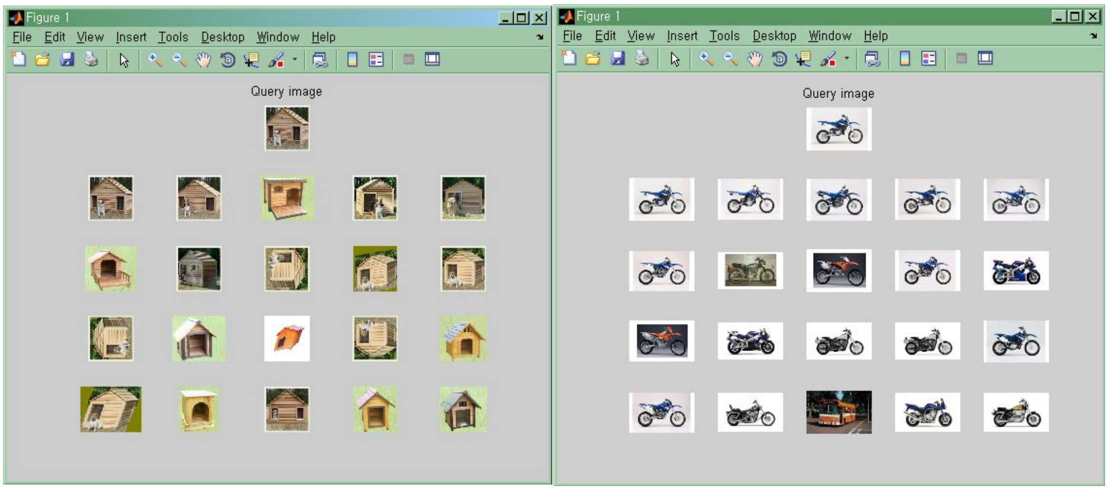
In a common corner point sum algorithm, the Recall, that is each performance measurements value were measured in (a-0.64), (b-0.66)



(a) Search results of Q1 (b) Search results of Q2

Fig 5.12 The image Q1, Q2 search results of the corner neighbor pixel difference value based on the algorithm

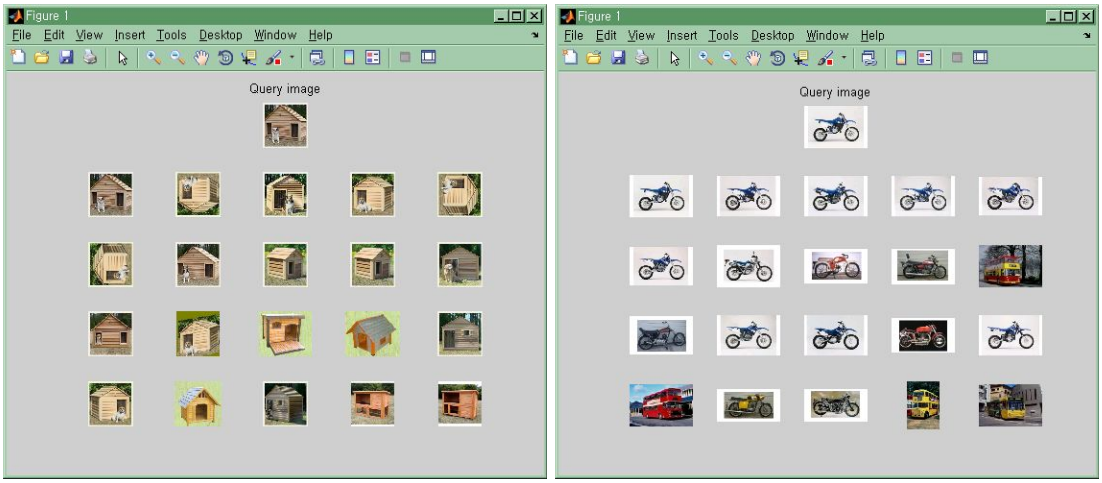
Compared to the above common corner points sum algorithm, in the corner neighbor pixel difference value based on the algorithm, the Recall, that is each performance measurements value is improved by (a-0.92), the same results (b-0.66)



(a) Search results of Q1 (b) Search results of Q2

Fig. 5.13 The image Q1, Q2 search results of the algorithm using correlogram to corner point

Compared to the above common corner points sum algorithm, in the algorithm using correlogram to corner point, the Recall, that is each performance measurements value is improved by (a-0.85, b-0.75)



(a) Search results of Q1 (b) Search results of Q2

Fig. 5.14 The image Q1, Q2 search results of the corner patch DCT based algorithm

Compared to the above common corner points sum algorithm, in the corner patch DCT based algorithm, the Recall, that is each performance measurements value is improved by (a-0.92, b-0.83)

In this paper, not only there is a common corner point algorithm, after extracting a feature vector by applying the histogram in the corner patch algorithm for corner points that have been proposed existing of, the method used for the image search [42] try to transition comparison.

In order to measure the performance of the proposed algorithm, by using the Q1 in question video in Figure 5.12, were measured results of the performance of the algorithm proposed corner patches histogram algorithms existing for the. It has a similar image to match the query image to the above as well as 50 to 200 pieces in the database. Is compared with the quality of the images in the experiment, it had been defined to find twenty images similar to the degree of similarity in descending order.

B. Analysis

1. Similarity calculation

Similarity measure (Distance measure) is must be defined in order of the image data retrieval. In this paper, in order to measure the similarity of the features of the form between the query image and database images, using a simple distance measure functions as follows.

$$D(Q, I) = \sum_{i=1}^{k} \left| F_i - F_i^{'} \right| \qquad (5\text{-}1)$$

Formula Q, the quality of the image, I is the image in the database, F_i and $F_i^{'}$ is the feature vector of each second image. Similarity between images, by calculating the absolute distance between the two feature values, can easily be obtained, the calculated similarity of content-based image retrieval system based on the quality of the image images are retrieved from the image database, such as.

2. Performance Evaluation

To analyze the content-based image retrieval efficiency, generally use two performance measure of Recall and Precision. [43] Recall is the proportion of the image detected in the image to be relevant to the query from the video database, Precision indicates the percentage of questions related images from the detected image. In other words, it is a set of images that are associated with the A image database, B is, let the set of detected images. Thus, Recall and Precision can be defined as the conditional probability, such as the following equation.

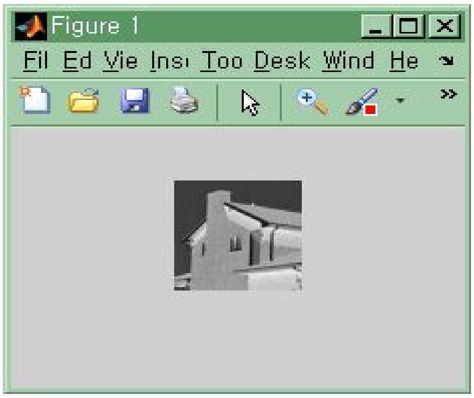
$$Recall = P\left(\frac{B}{A}\right), \qquad Precision = P\left(\frac{A}{B}\right) \qquad (5\text{-}2)$$

In the actual experiment, use the following calculation formula.

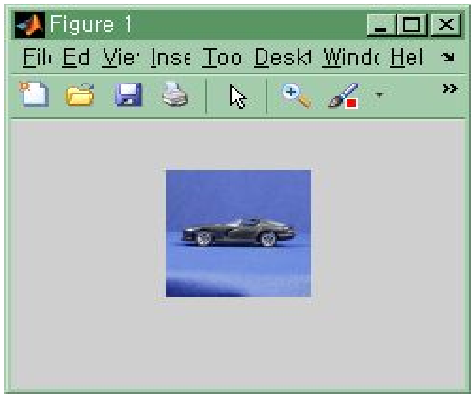
$$R_e = \frac{R_r}{T}, \quad P_r = \frac{R_r}{T_r} \tag{5-3}$$

Here, T represents the total number of items related to the query in the database being searched, R_r is the number of content items of the query from among the detected item, T_r represents the total number of the detected item.

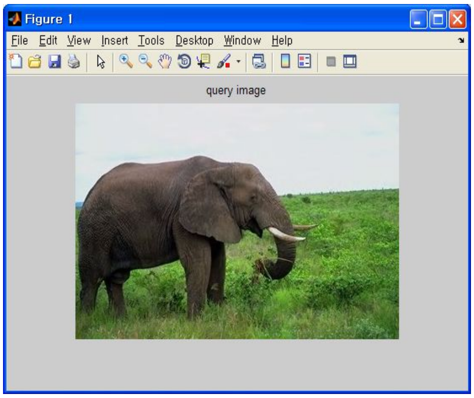
3. Comparison of the proposed algorithm with the existing algorithm



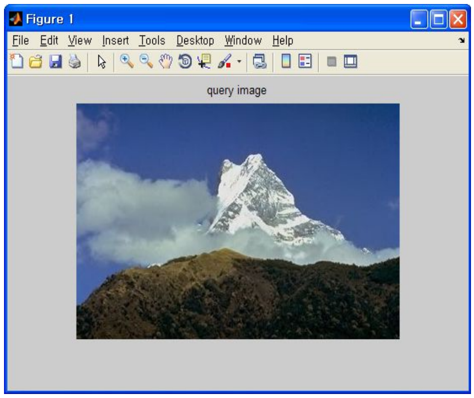
Q1



Q2



Q3

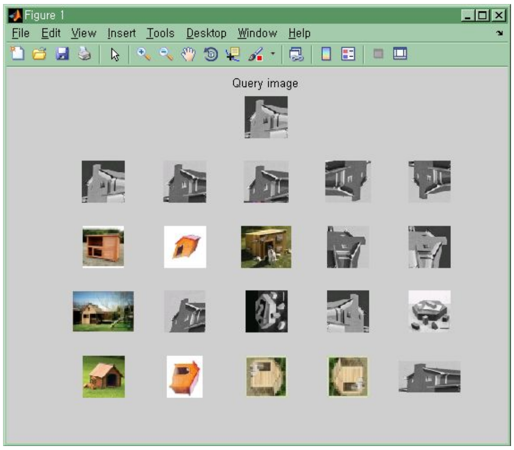


Q4

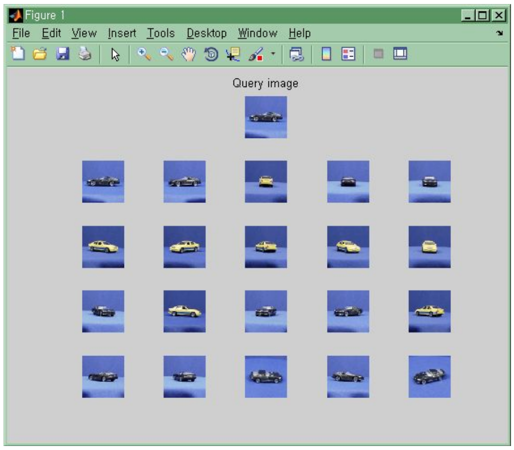
Fig. 5.15 Query image Q1 ~ Q4

To measure the performance of the algorithm proposed in this paper, and used in experiments to compare the results performance measurements of the algorithms proposed and existing algorithm with the question video Q1 ~ Q4 in Figure 5.14. The picture quality is used 10, the video Q1 ~ Q4 of the respective quality have similar images to match the query image in the database 3000. Is compared with the quality of the images in the experiment, it had been defined to find twenty images similar to the degree of similarity in descending order. Since the number of similar image quality of the video had been defined in all 20 or less, it was defined to find 20.

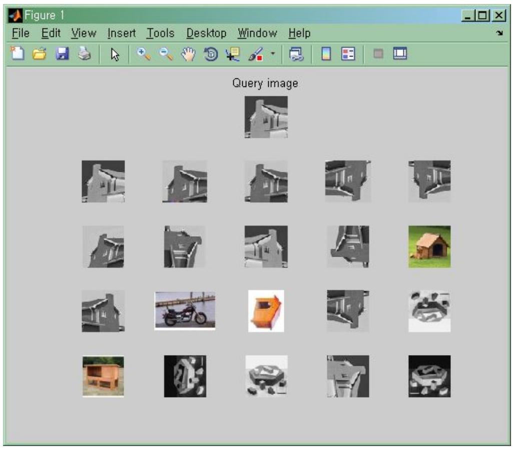
First, by using the query image Q1~Q4, when we compare the retrieval performance of existing algorithms and corner neighboring pixel difference value algorithm, Figure 5.15, is shown in Figure 5.16.



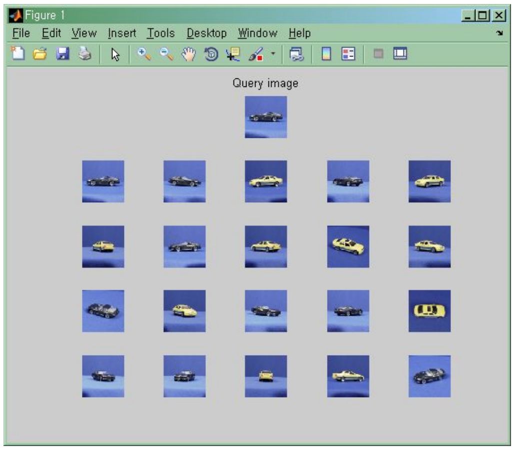
The corner point sum algorithm of Q1



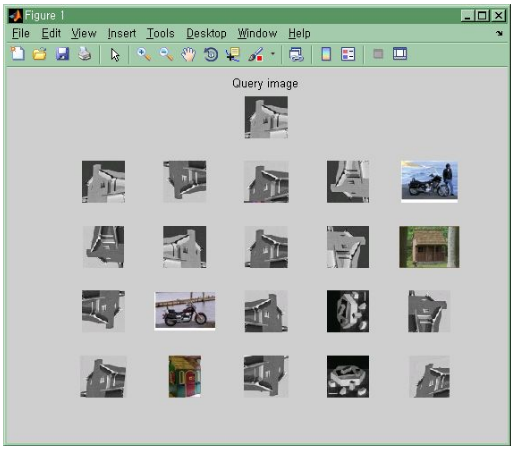
The corner point sum algorithm of Q2



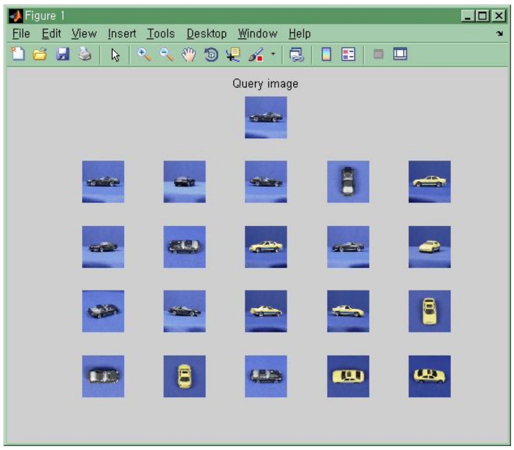
The corner patch histogram algorithm of Q1



The corner patch histogram algorithm of Q2

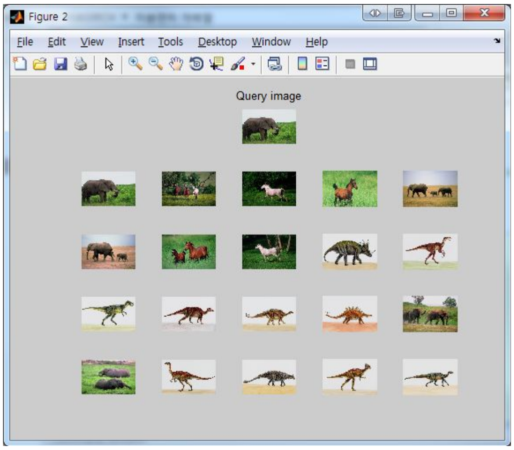


The corner neighbor pixel differential values algorithm of Q1

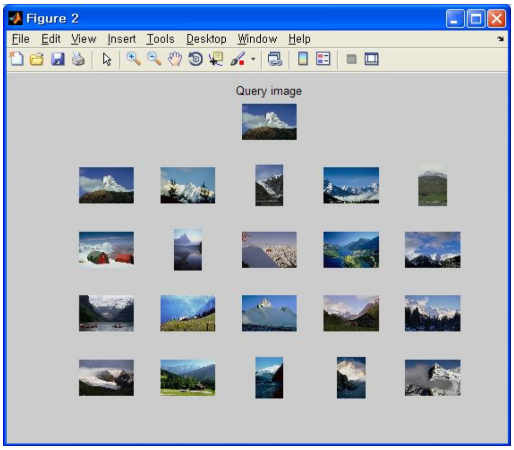


The corner neighbor pixel differential values algorithm of Q2

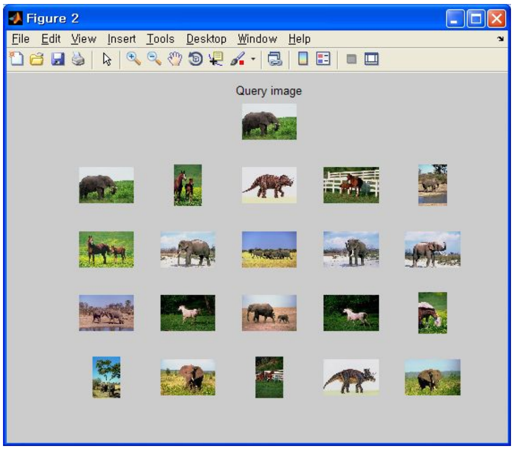
Fig. 5.16 Results of the existing algorithms and corner neighbor pixel differential values algorithm of Q1 and Q2



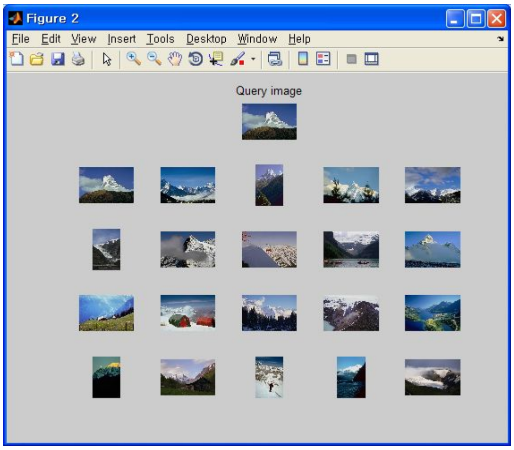
The corner point sum algorithm of Q3



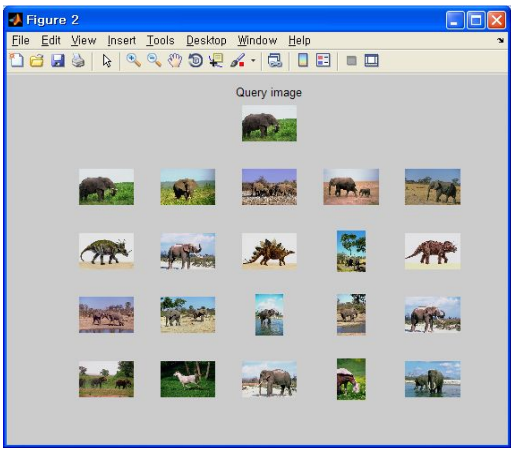
The corner point sum algorithm of Q4



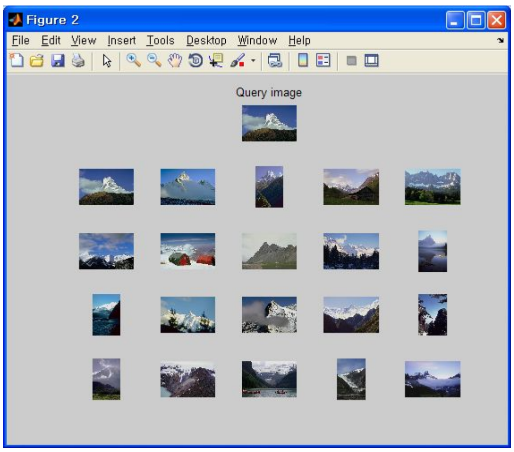
The corner patch histogram algorithm of Q3



The corner patch histogram algorithm of Q4



The corner neighbor pixel differential values algorithm of Q3



The corner neighbor pixel differential values algorithm of Q4

Fig. 5.17 Results of the existing algorithms and corner neighbor pixel differential values algorithm of Q3 and Q4

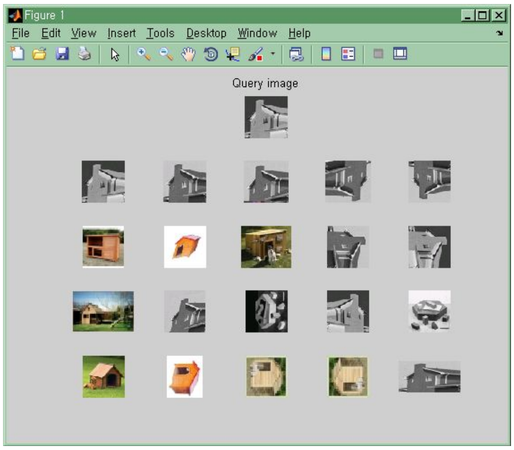
As shown in Figure 6.15 and Figure 6.16, better image algorithm is rotation and zoom in and out on the visual corner neighboring pixel difference value than the corner points to the algorithm and corner patches histogram algorithm is an existing corner point algorithm it was confirmed to find. However, quality images, such as video Q4 compared to the edges reliable images as video Q1 quality, the existing corner patches histogram algorithm while continuously four search out images similar to proposed corner algorithm neighboring pixel difference value, the fourth, first find the other video, it was confirmed that it is checked by searching the image that is rotated in the fifth. However, as shown in Table 5.2, comparing the search performance by using the Recall and Precision, both algorithms Recall is 0.70, Precision is 0.35, confirming that shows the results the same retrieval performance I was able.

Table 5.2 Performance analysis of existing algorithms and corner neighbor pixel value difference algorithm

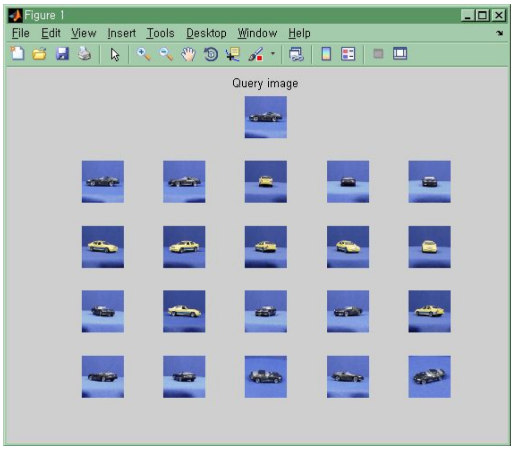
Simulation \ Method		The corner point sum algorithm	The corner patch histogram algorithm	The corner neighbor pixel differential values algorithm
Image Q1	Recall	0.66	0.80	0.93
	Precision	0.50	0.60	0.70
Image Q2	Recall	0.60	0.60	0.90
	Precision	0.30	0.30	0.45
Image Q3	Recall	0.50	0.83	1.00
	Precision	0.15	0.25	0.30
Image Q4	Recall	0.80	0.70	0.70
	Precision	0.40	0.35	0.35

By using the question video Q1~Q4, comparing the search performance of the algorithm using the correlogram to existing algorithms and corner points, Figure

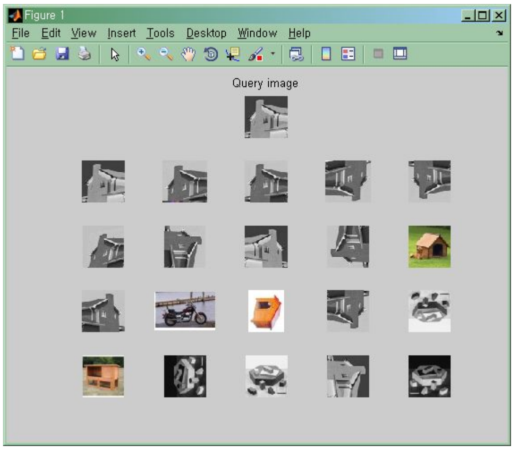
5.18, is shown in Figure 5.19.



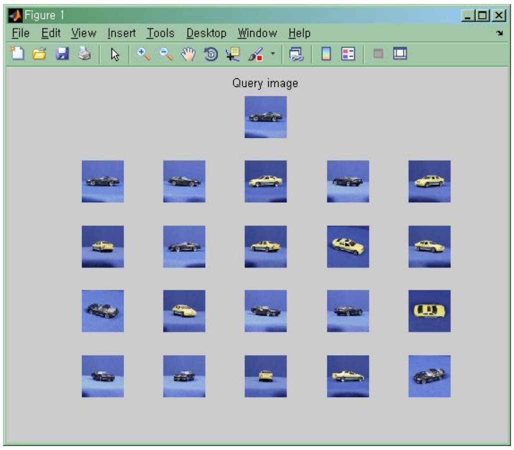
The corner point sum algorithm of Q1



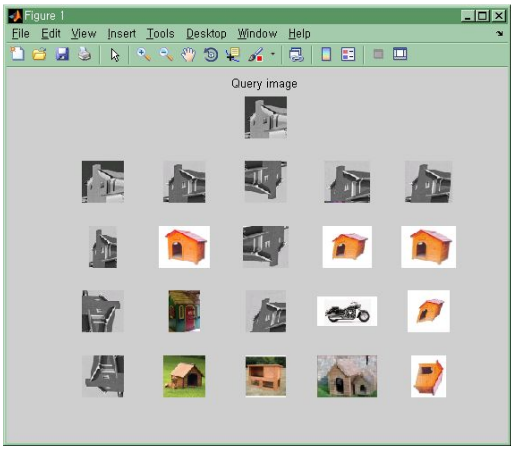
The corner point sum algorithm of Q2



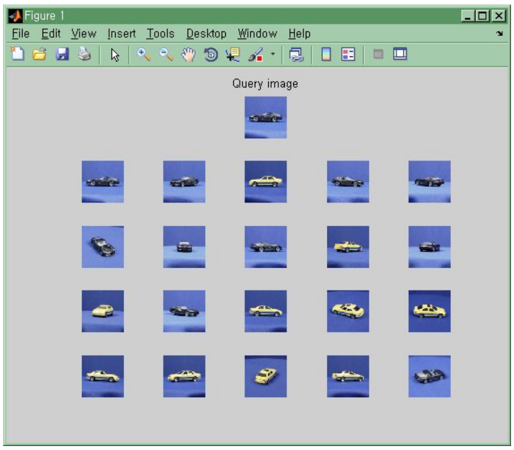
The corner patch histogram algorithm of Q1



The corner patch histogram algorithm of Q2

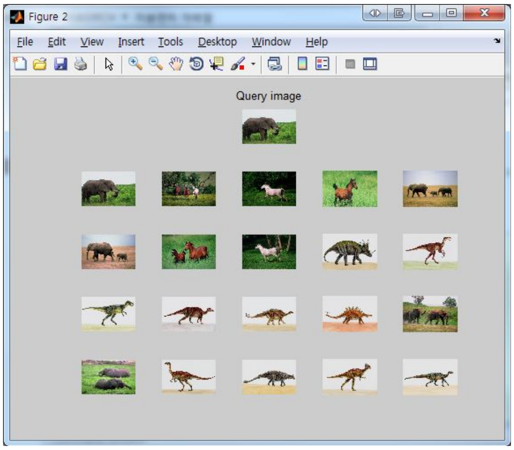


The algorithm using correlogram of corner points of Q1

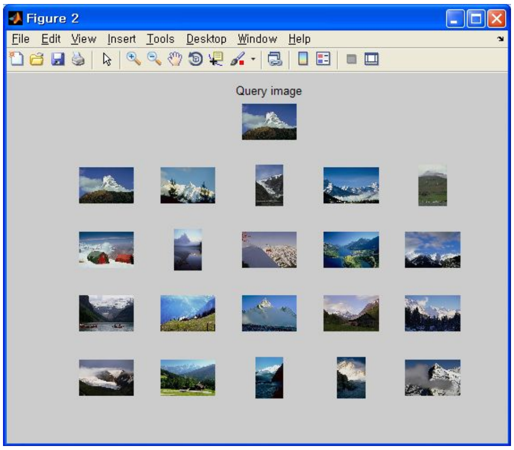


The algorithm using correlogram of corner points of Q2

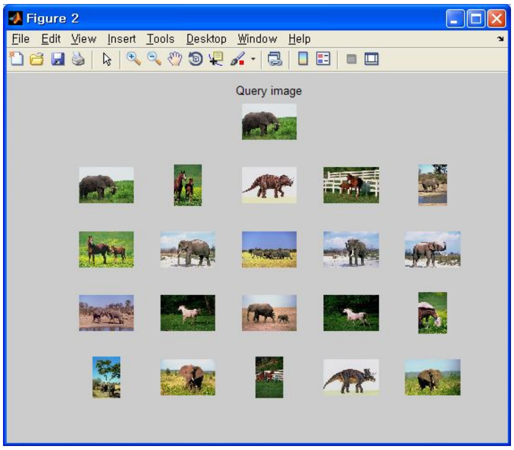
Fig. 5.18 Results of the algorithm using the existing algorithms and correlogram of corner points of Q1 & Q2



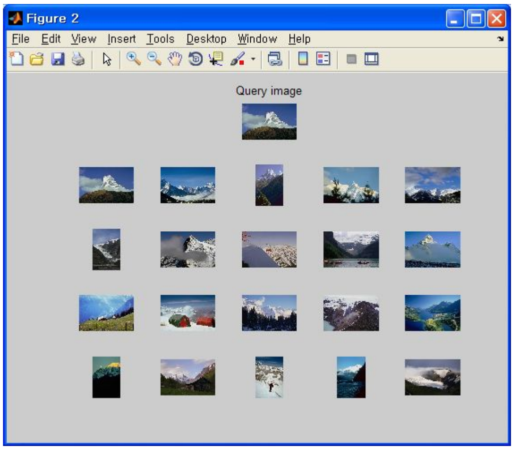
The corner point sum algorithm of Q3



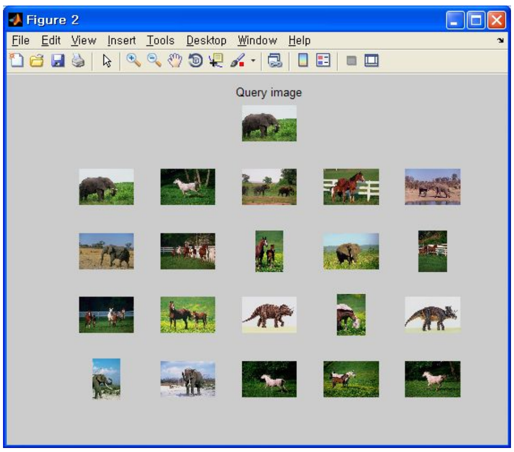
The corner point sum algorithm of Q4



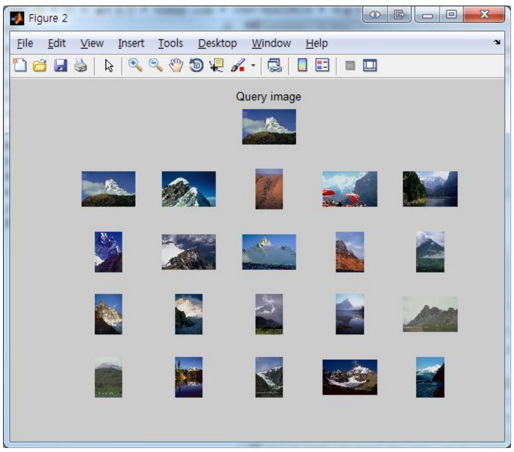
The corner patch histogram algorithm of Q3



The corner patch histogram algorithm of Q4



The algorithm using correlogram of corner points of Q3



The algorithm using correlogram of corner points of Q4

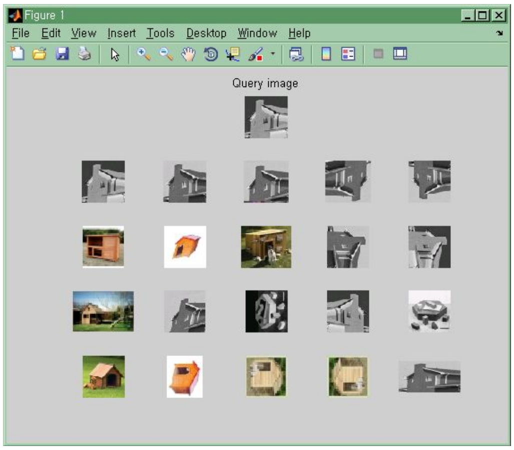
Fig. 5.19 Results of the algorithm using the existing algorithms and correlogram of corner points of Q3 & Q4

Algorithm using correlogram to the corner points as the search results for question image Q1 in Figure 5.18 in the case of the rotated image, there is a common corner point is the existing algorithms algorithms and corner patches histogram algorithm it was confirmed that it is not put out by searching than. However, the Q1 of Figure 5.18, the case of Q4 enlarged and reduced images can be confirmed from the results in Figure 5.19, was confirmed to be examined may be searched to compared to the existing algorithms. Table by using the Recall and Precision as 5.3, the results of comparing the search performance, except for the image Q1 quality, the algorithm using correlogram proposed corner point than all existing algorithms I was able to confirm that it shows a higher retrieval performance.

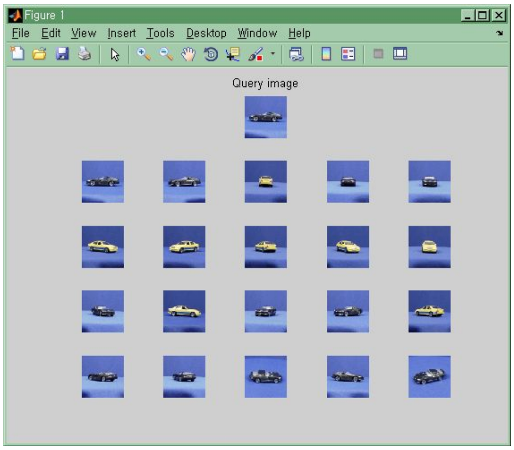
Table 5.3 Performance analysis of existing algorithms and the algorithm using correlogram corner point

Simulation \ Method		The corner point sum algorithm	The corner patch histogram algorithm	The algorithm using correlogram of corner points
Image Q1	Recall	0.66	0.80	0.66
	Precision	0.50	0.60	0.50
Image Q2	Recall	0.60	0.60	0.90
	Precision	0.30	0.30	0.45
Image Q3	Recall	0.50	0.83	1.00
	Precision	0.15	0.25	0.30
Image Q4	Recall	0.80	0.70	0.90
	Precision	0.40	0.35	0.45

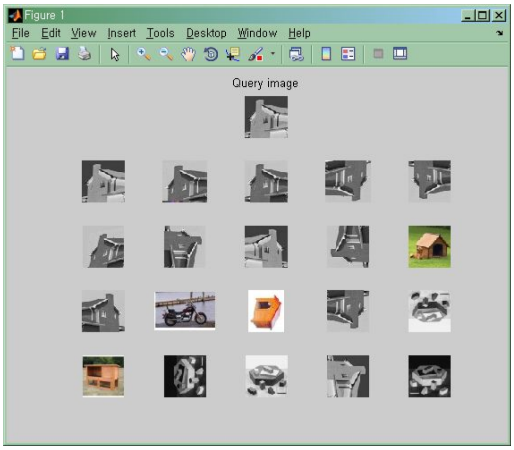
By utilizing the image quality Q1~Q4 Third, comparing the search performance of existing algorithms and corner patches DCT based algorithm algorithm, Figure 5.20, is shown in Figure 5.21.



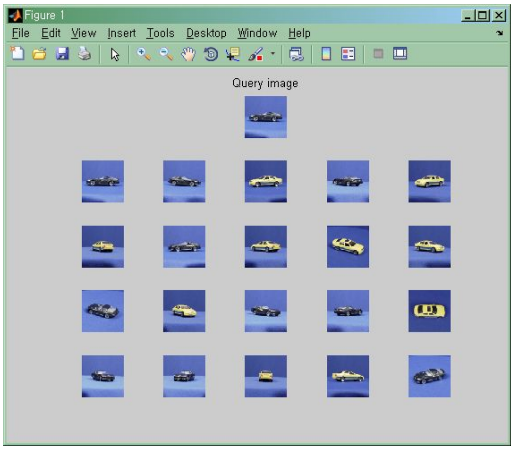
The corner point sum algorithm of Q1



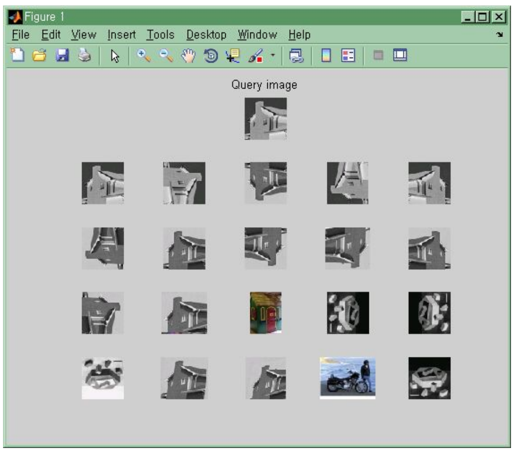
The corner point sum algorithm of Q2



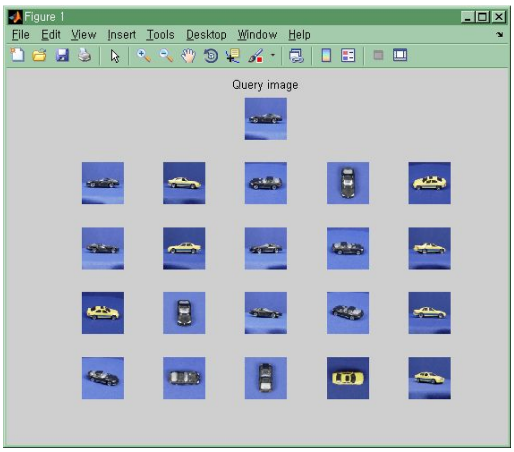
The corner patch histogram algorithm of Q1



The corner patch histogram algorithm of Q2

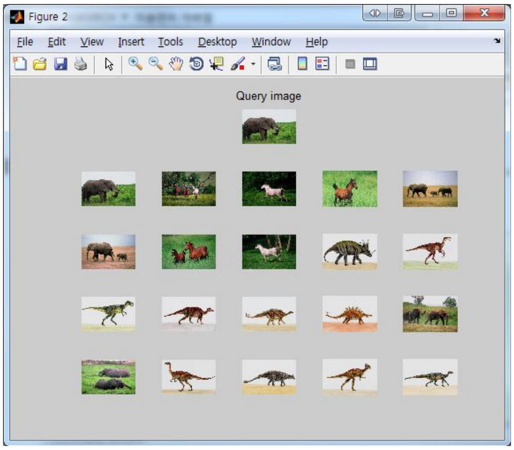


The corner patch DCT based algorithm of Q1

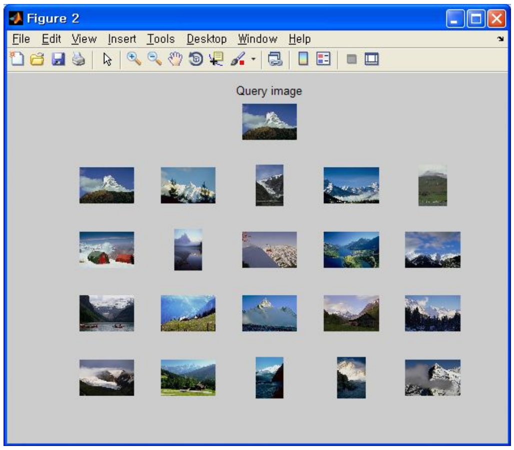


The corner patch DCT based algorithm of Q2

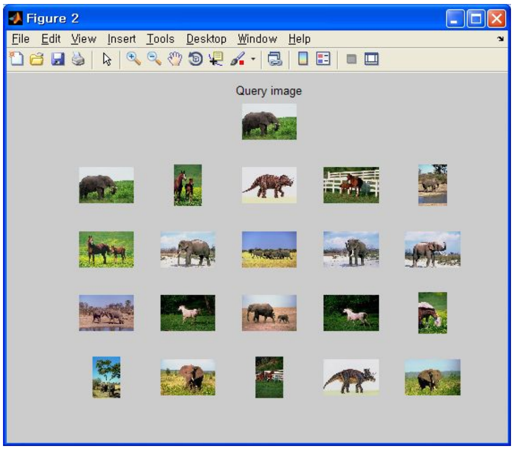
Fig. 5.20 Results of the algorithm using the existing algorithms and corner patch DCT based algorithm of Q1 & Q2



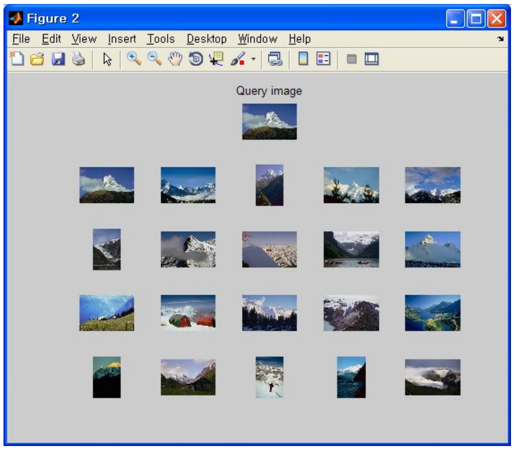
The corner point sum algorithm of Q3



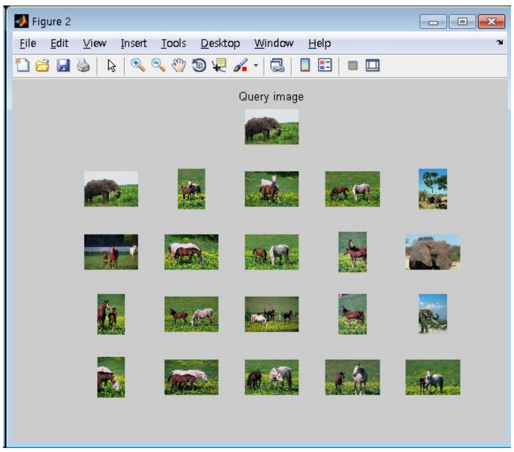
The corner point sum algorithm of Q4



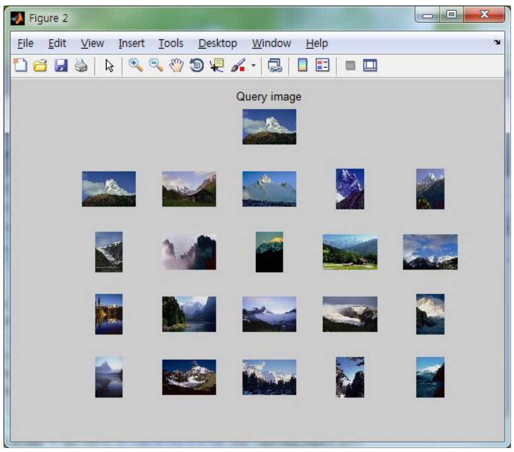
The corner patch histogram algorithm of Q3



The corner patch histogram algorithm of Q4



The corner patch DCT based algorithm of Q3



The corner patch DCT based algorithm of Q4

Fig. 5.21 Results of the algorithm using the existing algorithms and corner patch DCT based algorithm of Q3 & Q4

Corner patches DCT-based algorithm, as shown in Figure 5.20 and Figure 5.21, the image that has been rotated and the enlargement and reduction of image than typical has corner point algorithms and corner patches histogram algorithm is an existing corner point algorithm it was confirmed that to find better. Corner patch DCT-based algorithm, finds the existing well algorithm, an image similar than before the proposed corner neighboring pixels algorithm based on the difference value and the algorithm using c the corner point to a faster search order it was possible to confirm that. Not only, by using the Recall and Precision, as shown in Table 5.4, and even try to compare the search performance, not only Recall and Precision both existing algorithms, higher than before the proposed two algorithms it was confirmed.

Table 5.4 Performance analysis of the corner patch DCT based algorithm and existing algorithms

Simulation \ Method		The corner point sum algorithm	The corner patch histogram algorithm	The corner patch DCT based algorithm
Image Q1	Recall	0.66	0.80	0.93
	Precision	0.50	0.60	0.70
Image Q2	Recall	0.60	0.60	1.00
	Precision	0.30	0.30	0.50
Image Q3	Recall	0.50	0.83	1.00
	Precision	0.15	0.25	0.30
Image Q4	Recall	0.80	0.70	0.90
	Precision	0.40	0.35	0.45

Table 5.5, tried to compare the average value of the ARR of the algorithm proposed ARR average value of existing algorithms. As a result, if the proposed algorithm is Recall, from a minimum up to 0.29 0.20 in the case of Precision, since the maximum from the minimum high 0.15 0.09, it was confirmed that showed the better performance.

Table 5.5 Performance analysis results of the algorithms proposed and existing algorithms

Measure \ Method		The corner point sum algorithm	The corner patch histogram algorithm	The corner neighbor pixel differential values algorithm	The algorithm using correlogram of corner points	The corner patch DCT based algorithm
ARR	Recall	0.64	0.77	0.85	0.84	0.93
	Precision	0.36	0.43	0.47	0.45	0.51

VI. Conclusions

In this paper, we propose that the three corner points based search algorithm of rearrangement for the information search of new forms to enhance the noise invariance in conventional corner points are utilized in recognition of form, its performance I was confirmed.

Configuration of the algorithm, first, after extracting a corner point in the image, extracts the difference values between neighboring pixels of the corner points, methods to sort the corner point, a second, after extracting a corner point in the image , methods of applying the Corel program after cultivation eleven using a Depyotogapu, third, after extracting a corner point in the image, we have proposed a method for configuring a feature vector by applying the DCT.

To verify the proposed algorithm is composed of a variety of images other sizes, through simulation using the 3,000 database, it was confirmed the following facts.

- Algorithm using correlogram the corner point, the video that is reduced and expansion than the algorithm of the existing corner points, while out well Locate and rotated images, but had to from well search in the case of Recall and Precision Recall the common corner point algorithms from 0.20 to 0.07 higher than the corner patch histogram algorithms, Precision is typical 0.09 than the corner points of the algorithm, since it is 0.02 higher than the corner patch histogram algorithms, search performance, better it was confirmed.

- Corner patch DCT-based algorithm, the image is rotated than the algorithm of the existing corner points, while issuing common to find and enlarged and reduced images, it was confirmed that it is not put out by well search. However, the algorithm as well as algorithm using correlogram to the corner points, in the case of Recall and Precision, general Recall than the corner points of the algorithm 0.22, Precision 0.11 higher, than the corner patch histogram algorithm Recall is 0.09, Precision since high 0.04, it was confirmed that the retrieval performance better.

- The algorithm based on the corner neighboring pixel difference values, unlike the two algorithms described above, found good image rotation was scaled drawbacks existing corner point algorithm has. Not only common corner point of Recall 0.21 than algorithm, Precision 0.11 high, corner patch histogram algorithm Recall 0.08 than, Precision since 0.04 high, the highest search performance in the proposed algorithm I was able to confirm that it shows.

The proposed system in this way, by extracting the information of the various forms of data of the multimedia, to configure the optimum database, will be able to utilize a system that can be searched. In the future, the development of optimized algorithms expressed characteristics information of the video, optimized search engine should research on the construction of continuous video database is continued.

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