Rabin-Karp Elaboration in Comparing Pattern Based on Hash Data

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Abstract

The Rabin-Karp algorithm is known as the algorithm used to analyze a document based on a hash value. This algorithm is not for testing the image pattern. However, hash value can be occupied to compare the images patterns. K-Gram is a hash value-forming component. It determines the relationship between adjacent pixels in each image. Adjustment of base and modulo values affects the image similarity level. The samples used are flower images consisting of train and test data. Each sample will be analyzed by this method and compared with the test image. The image tested is the grayscale image. This analysis uses $gram = 2$. The lower the value used, the higher the accuracy is generated. Modulo adjustment also affects the hash value. The combination of the three values is the important factor in image testing. The creation of a feature value against the resulting hash values aims to compare the proximity between two images. The feature extraction function will calculate the distance between the two hashes using Euclidean. The comparison applies to two similar-sized images. The smaller the feature value, the more similar the two images are. This approach produces similar levels according to the processed parameters.

Keywords: Image Recognition, Similarity, Rabin-Karp, Pattern

1. Introduction

A picture has a thousand meanings. Images are often performed to describe an event or activity in the digital world [10][11]. Using images, this can replace a thousand words. Searching for data by an image is a difficult thing to do because the image has a considerable amount of pixel data. It is different when searching for a string. The string only has a few characters long [1][2][3].

There are many algorithms for image matching [9]. In general, in digital image processing, image matching is done with the help of artificial neural networks. The image will be divided into two types, training and testing. Rabin-Karp is a string matching method that utilizes the word pieces in each string [7][8]. This algorithm has hash value to determine the feature value of each piece of the word [4][5][12]. This algorithm can be developed or tested using an image as a test medium. In the present study, it will be attempted to test Rabin-Karp's method of image pattern. The results of the calculation are expected to determine how similar the image test with the image in the training data.

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2. Related Work

Ashish Prosad Gope and Rabbi Narayan Behera had research in 2014. Their research examined the relationship of the Rabin-Karp method with Deoxyribose Nucleic Acid (DNA). DNA has its own rules and sequences in the order. This arrangement is to determine the nucleotides present in DNA. Each sequence has a specific pattern for determining human genes. Their research is a field of bioinformatics research. This study combines computer science with biology. The purpose of this study was to find suitable algorithms to determine patterns that exist in DNA. This research tested several matching algorithms. The results of the evaluation will produce a new method based on Rabin-Karp method. This algorithm looks for sequence patterns in DNA [6].

A.Improved Rabin-Karp Implementation

The following table is an example of the development of the Rabin-Karp algorithm for DNA.

Table 1. Rabin-Karp DNA Test

A	B	B	C	A	B	C	A
hash (ABB) = 0							
q_t0 = 328965							
A	B	B	C	A	B	C	A
hash (BBC) = 1							
q_t1 = 334026							
A	B	B	C	A	B	C	A
hash (BCA) = 0							
q_t2 = 334045							
A	B	B	C	A	B	C	A
hash (CAB) = 7							
q_t3 = 339047							
A	B	B	C	A	B	C	A
hash (ABC) =							
11							
q_t1 = 328984							
A	B	B	C	A	B	C	A
hash (BCA) = 0							
q_t2 = 334045							

Table 1 describes the hash = 0 and quotient = 334045, both matched. BCA pattern is suitable. ABB = 0 and quotient = 328965, which has not matched, ABB is not compared.

In certain cases, the development of this algorithm does not have some striking advantages with the Rabin-Karp algorithm. The complexity of this algorithm can be increased significantly [5]. Time complexity is $O((n-m+1)m)$ to $O(nm+1)$. It depends on the prime number being the modulo. Choosing the right prime numbers will improve good optimization [6].

3. Methodology

Some steps need to be taken to determine the resemblance of an image. These processes are Image Retrieval, Grayscale, Feature Extraction, K-Gram and Hash value.

A. Image Retrieval

Sampling is done to determine the object of research. The sample can be an image of a certain size. The following image is an RGB image taken from the internet that has a 300 x 300 resolution. The image must be divided into three layers, Red, Green, Blue and converted into Grayscale.

Figure 1. RGB Image

B. Grayscale

Previously specified images must be converted to grayscale mode. The method used is Luminosity. The algorithm is by multiplying each value of Red, Green, and Blue with certain constants that have been assigned value, then the result of multiplication of all values added together. The mathematical formula is:

$$GS = (0.21 * R) + (0.72 * G) + (0.07 * B)$$

The grayscale technique with luminosity has better brightness than the average technique. The resulting color is brighter so that pixel block determination will be better when matching the test image to the sample.

The following figure is the result of the grayscale process on the previous flower image.

Figure 2. Grayscale Image

C. Feature Extraction

The coordinates used in image objects are two dimensions. This field has two coordinates (M, N). The picture below is an explanation of the image expansion in the coordinate plane.

Figure 3. Coordinate Plane

This section uses a snippet of two images (Image 1 and Image 2). The image has a size of 5 x 5 pixels. The feature extraction on each image takes the grayscale color intensity value with the gray degree from 0 to 255. The color intensity chunks have identical similarities. By using 25 pixels, five of them have different intensities between the two images.

Table 2. Feature Extraction Image 1

12	222	113	154	235
248	252	227	108	169
55	133	132	238	109
127	156	50	193	227
42	53	45	211	231

Table 3. Feature Extraction Image 2

12	222	113	154	235
248	250	227	108	169
55	133	111	238	109
127	156	50	123	227
67	53	49	211	231

Tables 2 and 3 show the results of pixel taking on grayscale images of two images. In these pictures, there are five different pixels. The percentage of pixel resemblance is $\frac{5}{25}$. This pattern has not been able to determine the level of similarity between the two images. Further calculations should be made to analyze the hash value of the image.

D. K-Gram

The value of K-Gram can be adjusted to the needs. This study uses the value of K-Gram = 5 to determine the value of Hash in the next stage. The following table is an arrangement of K-Gram for 25 pixels.

Table 4. K-Gram

12	222	113	154	235
222	113	154	235	248
113	154	235	248	252
154	235	248	252	227
235	248	252	227	108
248	252	227	108	169
252	227	108	169	55
227	108	169	55	133
108	169	55	133	132
169	55	133	132	238
55	133	132	238	109
133	132	238	109	127
132	238	109	127	156
238	109	127	156	50
109	127	156	50	193
127	156	50	193	227
156	50	193	227	42
50	193	227	42	53
193	227	42	53	45
227	42	53	45	211
42	53	45	211	231

E. Hash Data

Hash data is a collection of unique numbers to identify the image pattern similarity of several rows of pixels. This data aims to determine the number of pixels that are similar between the two images. The value obtained is the value to be compared between the sample image and the test image. The degree of similarity depends on the same number of hash values in both images. The following tables are the example of a hash list of two images.

Table 5. Hash Value of Image 1

19875	16830	23124	17433	20546
21489	26753	13498	23846	16528
21848	28447	29994	10301	13009
18832	27217	23157	25854	22492
14952	14337	29348	19978	28809
13485	14188	13131	21215	12053
25669	13809	26508	19455	25356
29964	17723	26633	17445	11803
19477	27142	24814	15155	26266
28432	19007	21896	16625	20681

Table 6. Hash Value of Image 2

19875	26406	28424	13930	20546
18049	10867	18516	26753	19975
10152	13053	24120	21896	18351
12605	25101	21215	20750	15513
22949	26006	25045	25932	10695
13254	21504	20286	22492	10615
25565	29941	17403	23018	22666
19744	19769	19877	29535	13139
25669	16830	14297	20916	24640
16960	20681	13131	13009	18947

From the tables above, there are 12 same values. The next process is to calculate the percentage of similarity of the two lists. The following formula is to calculate the similarity.

$$S = \frac{2 * SH}{TH1 + TH2} * 100\%$$

Where:

- S = Similarity Rate
- SH = Identical Hash
- TH1 = Total Hash Image 1
- TH2 = Total Hash Image 2

The similarity rate is shown below.

$$\begin{aligned}
 S &= \frac{2*12}{50+50} * 100\% \\
 &= \frac{24}{100} * 100\% \\
 &= 0.24 * 100\% \\
 &= 24\%
 \end{aligned}$$

The percentage of similarity is 20%.

4. Experimental Result

The test results show some significant differences. The use of different K-Gram values will trigger a change in the results of similarity levels of the image as well. The following

table is the result of four experiments with different parameters. Three parameters are occupied in this method as the input, K-Gram, Base, and Modulo.

	Test 1	Test 2	Test 3	Test 4
N-Gram	5	3	6	2
Base	10	7	10	9
Modulo	∞	10007	3737	2323
Image 1	9212	9214	9211	9215
Image 2	9212	9214	9211	9215
Identic	4528	6554	7922	8576
Similarity	49,156%	71,131%	86,006%	93,066%

The following two images show a significant but different picture. Both images are 100 x 100 pixel. The first image is similar to the second image, but one of the images is flip horizontally. The calculation of the Rabin-Karp method will show how closely the similarities between the two images are.

Figure 3. (a) Normal (b) Flipped

The first test is done with several input parameters, K-Gram = 5, Base = 10 and Modulo = ∞ . The test results show the similarity level of 49,1553% with the same hash number is 4528. This hash value obtained from the total hash is 18424. Each image has a hash of 9212. The second test is done with several input parameters, K-Gram = 3, Base = 7 and Modulo = 10007. The test results show the similarity level of 71,1309% with the same hash number is 6554. This hash value obtained from the total hash is 18428. Each image has a hash of 9214.

The third test is performed with several input parameters, K-Gram = 6, Base = 10 and Modulo = 3737. The test results show the similarity rate of 86,0059% with the same hash number is 7922. This hash value obtained from the total hash is 18422. Each image has a hash of 9211.

The last test is done with several input parameters, K-Gram = 2, Base = 9 and Modulo = 2323. The test results show 93,0657% similarity level with the same hash number is 8576. This hash value obtained from the total hash is 18430. Every image has a hash of 9215.

5. Conclusion

Rabin-Karp algorithm can be used to check image similarity based on hash value calculation. The way the calculation works is the same as that done to string matching. The fundamental difference is the feature extraction of color images. The larger the

image, the longer the calculation process. Extraction can accelerate this process in certain parts. The grayscale process is one of the processes to speed up the image matching process. The downside of this method is a very slow process for calculating hash values in large images.

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