Image Searching Using Heuristic Method for Image Retrieval System

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***Abstract*–Heuristic method is introduced as one of solutions for efficient searching process in Content Based Image Retrieval System. This method deals with structural database which is built in indexing phase. The structure is graph-formed and also known as landscape. Each node represents an image and each edge is labeled with similarity value as nearness prediction between connected nodes. The similarity value is calculated using combination of three image features, those are color, shape, and texture. In retrieving phase, the heuristic searching moves along these nodes with Breadth-First Search mechanism under certain constraints until meeting stop criterion. Each visited node that fulfills the requirements will be retrieved as searching result. The result shows that implementation of this method might fasten retrieval process up to nine times faster with keeps on maintaining the relevancy of retrieval result.**

I. INTRODUCTION

THE current development of information media especially in Content Based Image Retrieval System challenges researchers in finding efficient retrieval methods. This is one of the ways to meet user demand for a fast and accurate search engine. For that reason, heuristic method is proposed in this research.

When an input query is given to the system, most of searching process compare the query to all database content and compute the similarity value between them. It becomes a problem for a system with large-sized database because the computation takes so much time to explore database content entirely. This basic idea encourages this research to implement heuristic method to make searching process more efficient. This method deals with structural database, which transforms database content into landscapes. Landscape is kind of directed graph, which consists of nodes and edges [5]. Each node represents an image, and between one node to others is connected with an edge whose similarity value and nearness prediction as its label [9]. The similarity value between images itself is computed using combination of color, shape, and texture feature.

When system is running, searching algorithm moves along those graph nodes with Breadth-First Search (BFS) mechanism and finding the relevant results until meeting stop criterion. The searching tries to find the most relevant query first and then continues to the lesser ones. The result of searching process is then showed as retrieval result.

This research uses images which are downloaded from http://www.fei.edu.br/~psergio/MaterialAulas/Generalist 1200.zip. These images are manually grouped into ten classes, they are car, lion, sunset, texture, bear, elephant, arrow, landscape, reptile, and aircraft.

II. HEURISTIC METHOD

Heuristic comes from Greek word, *heuriskein*, which means searching or finding. In studying searching methods, heuristic might be a function that gives an estimation value of the solution.[10].

A. The Making of Graph Structure

The graph structure is made in these following steps:

Landscape 1

1) Node Representation

Representation of a node is described in Figure 1. Each node is an image which consists of three vectors of feature extraction result. Those vectors are color vector which contains 162 elements, shape vector contains 72 elements and texture vector contains 7 elements.

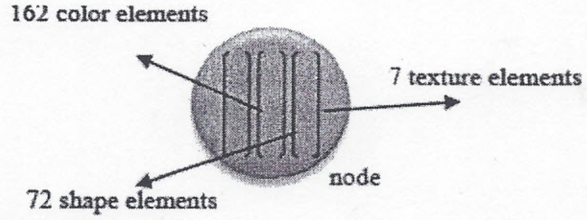

Fig. 1. Representation of a node for landscape.

2) Similarity Measurement

The similarity values between images are computed using cosine similarity formula:

$$\cos ine\ similarity = \frac{\sum_{i=1}^{t} x_i y_i}{\sqrt{\sum_{i=1}^{t} x_i^2 \cdot \sum_{i=1}^{t} y_i^2}}$$

Variable x corresponds to vector of image x and y for image y. Each feature vector between two images is computed using this formula. It obtains three results which correspond to color similarity, shape similarity, and texture similarity. Those results are then totaled. The computation is carried out between the first member of image database and all databa images. The result is 1×n matrix with variable shows the amount of image in database. Figure illustrates landscape 1.

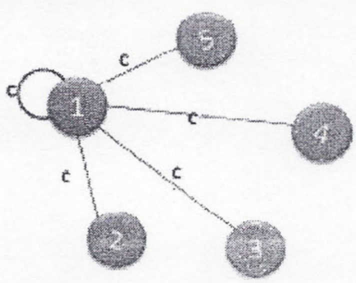

Fig. 2. Illustration of landscape 1

Landscape 2

Each node also represents an image and each edge is labeled with similarity value that is computed using automatic weight assignment using Genetic Algorithm (GA) based on previous research by Pratama [8]. The weight value obtained in GA process is always changed since initial value of the process itself is generated randomly. Although the difference is not too significant, however it affects the produced final precision value. Therefore, this similarity value is computed several times and finally the best result is chosen to be implemented in graph structure. This computation produces $n \times n$ matrix, where n shows the amount of image in database. Illustration of this landscape is showed in Figure 3.

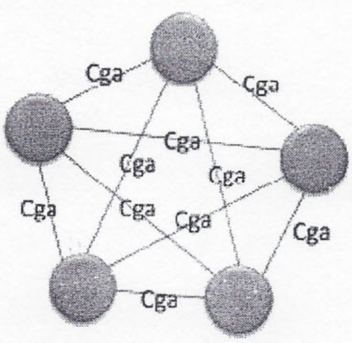

Fig. 3. Illustration of landscape 2

B. Heuristic Process and Image Retrieving

First, query image is given. This query is also processed for feature extraction and produces three vectors. Color vector consists of 162 elements, shape vector consists of 72 elements, and texture vector consists of 7 elements. The searching process always starts from database member number one. Next, it moves through two formed landscapes.

Landscape 1

Each edge has been labeled with cosine similarity value. The steps of searching process on this landscape are explained as follow:

1 Computing cosine similarity value c1 between query image and start node.
2 Finding other node(s) whose equal or close similarity value to c1, or cx≈c1.
3 If there exist more than one node whose similarity value satisfies requirement in point (2), then similarity value of those nodes will be computed towards query image. Searching process will choose a node with the highest similarity value.

The result of searching in this landscape is the index of retrieval result candidate with the highest cosine similarity value.

Landscape 2

The initial node's index on this landscape is the index of node found in searching on landscape 1. Each edge is labeled with similarity value, which is computed using automatic weight assignment with GA. Searching process moves under these following rules:

1 Searching process starts from initial node and moves according to the descending order of similarity value under BFS mechanism.
2 The similarity value between initial node and visited node is checked and its index is saved as candidate of retrieval result.
3 The searching process keeps moving until finding the node whose similarity is less than 0.5.

The process will be stopped if searching process finds node that fulfills criteria above. The indexes found in searching process which has been saved as retrieval candidates is then sorted descending. Finally the result is shown as retrieval result. Figure 4 illustrates searching process on both landscapes.

III. EXPERIMENT

By implementing this heuristic method, indexing phase takes so much time but it guarantees that retrieval method would be so much faster. Indexing process is held while constructing the system. The computation in indexing phase is invoked all

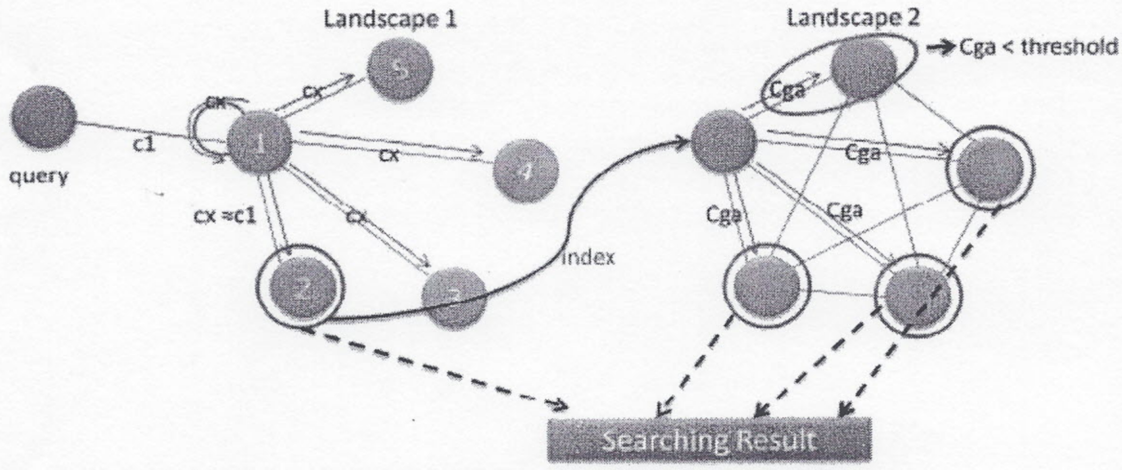

Fig. 4. Illustration of searching process on both landscapes

database content to form graph structure. Whereas in retrieving phase, thing that system do is investigating the values computed in previous phase. Therefore, minimum computation process in retrieval phase would make searching process faster.

A. Feature Extraction

The feature extraction is applied in three image's visual properties, those are color, shape and texture as the result of previous research by Pebuardi [7]. It produces three vectors consist of 162 elements of color vector, 72 elements of shape vector, and 7 elements of texture vector.

B. Graph Structure

Landscape 1

This landscape has nodes that represent database images and edges that represent the sum of three values of similarity features. The higher similarity value means the more similar those images are. The computation time of similarity value between images spend about 90 seconds.

Landscape 2

Each node in this landscape is also represents an image. Each edge is labeled with similarity value with GA automatic weight assignment which has better performance based on previous research. This computation invoked entire database images and obtains 1100×1100 sized-matrix.

Research result of Pratama (2009) shows that the process of automatic weight assignment using GA is computed as input query is given. As the effect, retrieval process become longer, that is about 5.96 seconds due to the influence of iteration while GA is running. Beside, the resulted weight value is always changed because initial value for the weight is generated randomly.

This research uses GA automatic weight assignment in indexing phase. The changed weight values are tried to be determined by doing ten times trial iteration of generating weight values using GA. Next, the chosen weight values are the iteration that produces highest average precision value. Those weight values would become constant values between images in database. The computation in this step takes about 1618 seconds.

C. Searching Process

Searching process moves along these nodes under BFS mechanism. This system will retrieves relevant images whose similarity exceeds the threshold 0.5 due to assumption that similar images would have high similarity value.

The first searching works on landscape 1 to find the most similar image towards query. The index of found node/image is saved and the searching is then continued to landscape 2. The purpose of this second searching is to find other relevant image(s) that has not been found in previous searching. The searching starts from initial node whose index is defined in searching result on landscape 1. Next, the searching process is continued to its neighborhood and visiting each node based on descending order of similarity value between them. The searching is stopped when it visits the node whose similarity value less than 0.5.

IV. RETRIEVAL RESULT

The result is defined from searching process on both landscapes. It uses entire database content as input query. Average time obtained in this retrieval process is about 0.66 second. The example of main interface is shown in Figure 5, and then an example of retrieval result is shown in Figure 6. The figure shows that retrieval result is succeed with retrieving top 37 similar images and all of them are relevant towards the query.

Evaluation of Retrieval Result

The evaluation is applied using recall and precision value. The computation uses entire database content as input query. Recall values are defined at 0, 0.1, 0.2, 0.3, …, 1. Then the precision values at these defined recall values are computed using maximum interpolation with the rule shown below:

$$P(rj) = \max(rj \leq r \leq rj + 1)\, P(r)$$

where

rj {0.0, 0.1, …, 1.0},

r0 = 0.0, r1 = 0.1, …, r10=1.0

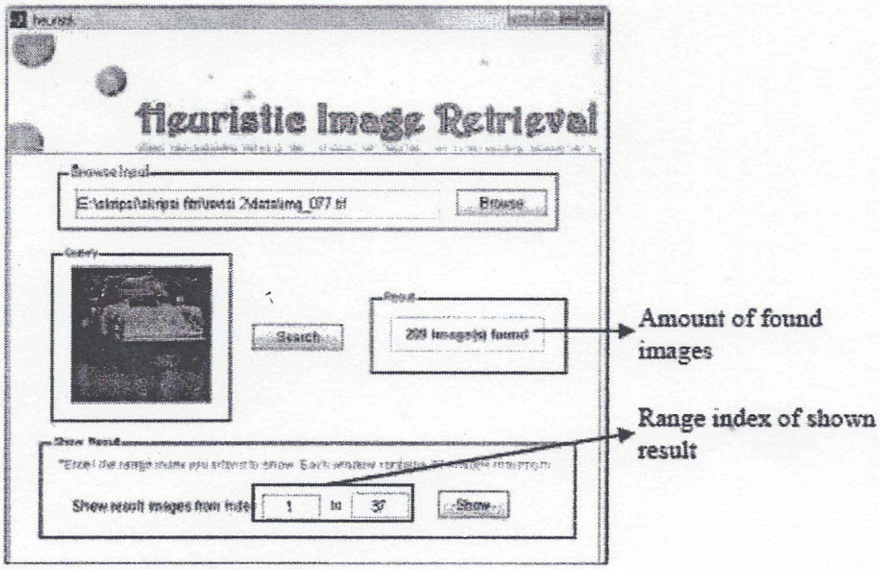

Fig. 5. Example of the main interface

Fig. 6. Example of retrieval result

If not all relevant images could be retrieved, then precision value at related recall value will drops to zero [1].

The precision values shown in Table 1 are the average precision value from entire queries. Figure 7 shows comparison chart of recall and precision value. Precision value at level recall between 0 and 0.1 are more than 0.5 although it decreases significantly. It means that in average, more than half part of a number of top retrieval results is relevant. For next recall values, precision obtained is less than 0.5 with non-significant decrease between levels.

Retrieval process with heuristic method runs faster as shown in Figure 8. This retrieval time computation uses all database content as input query to two systems with and without heuristic method. The average retrieval time between two systems without and with heuristic method decreases from about 5.97 seconds to about 0.66 second, or become 9 times faster.

TABLE I
AVERAGE PRECISION VALUE OF RETRIEVAL RESULT

Recall	*Precision*
0	1.0000
0.1	0.5746
0.2	0.4779
0.3	0.3957
0.4	0.3385
0.5	0.2929
0.6	0.2511
0.7	0.2116
0.8	0.1697
0.9	0.1159
1	0.0231
Average	**0.3501**

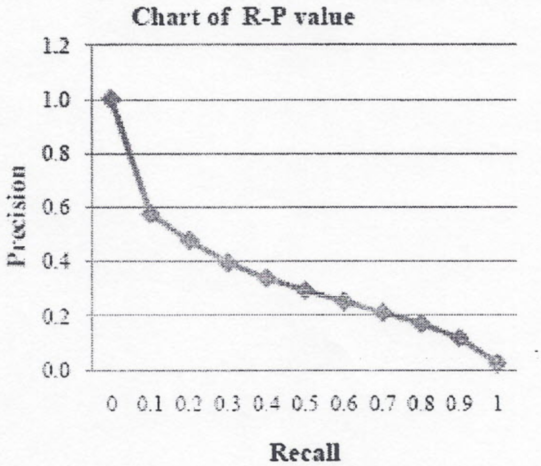

Fig. 7. Comparison charts of recall and precision value

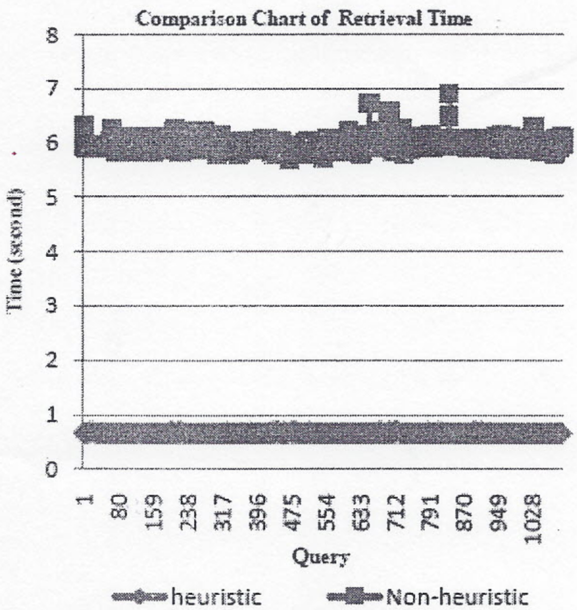

Fig. 8. Comparison chart of retrieval time

V. CONCLUSION

Heuristic method is implemented successfully and makes average retrieval time become up to nine times faster compared with the non-heuristic one. The performance of this method would be better if it is supported with good similarity values between images. Hence, this method is promising to be used in image retrieval system because it makes searching process faster.

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