Automatic Adaptation Method in Intelligent Image Retrieval System

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Abstract
Information overload in modern electronic life is an inevitable problem. It is more difficult for users to find information than ever before. For resolving this problem, in this paper, we present framework design and implementation issues of image retrieval system called IIRS with the capability of user adaptation. Even though many researches have been performed on the development of efficient image retrieval engines, most of them have focused on performance of the system, but not on friendly and efficient user interface. The satisfaction of users is at least as important as the functionality and performance in image retrieval systems. Intelligent user interface with the adaptation method enables the IIRS to make more intelligent, natural, and efficient. We address the adaptation method that consists of decision tree and backpropagation neural network. They have been employed for long-term and short-term adaptations, respectively. Experimental results show automatic adaptation method can improve the performance of the IIRS.

I. INTRODUCTION
As the internet and technology of computing have been rapidly increased, the flooding of multimedia information have been a burden on user. Therefore, it is necessary to appear multimedia retrieval system and important to find out an intended information among users of these days since too much network accessible information resources in the form of various media increases rapidly everyday. This paper presents the IIRS(Intelligent Image Retrieval System) for natural scene image repository with the capability of adaptation. Computer users have been usually assumed to be familiar with applications. Not much effort has been spent for efficiency of user interface. The assumption of expertized or well-trained users is no more valid these days since today's users of computer systems are explored to ordinary people. The primary goal of adaptation method of the IIRS is to assist users in accessing images efficiently. Primary users of the image retrieval system are assumed to be novice users even though the system can be used for users at different levels of expertise. Users are not well-trained people in using computer systems. Thus, the semantic gap between users and the system must be mainly reduced from the system site. The technology of intelligent user interface is necessary to minimize the semantic gap [1, 2, 5]. For the intelligent user interface of the IIRS, we are based on a layered model for human and system interaction called HCOS (Human Computer Symmetry) model. The HCI(Human Computer Interaction) for the IIRS has been analyzed, and the IIRS has been designed and developed.

Adaptation method has been employed to make the system intelligence. The system has both features of long term and short term user adaptations. Decision tree and backpropagation neural network have been employed for long term and short term adaptation, respectively.

II. THE DESIGN OF THE IIRS
The technology of intelligent user interface is necessary to minimize the semantic gap between the user and the system. Note that the user would not feel much difference even though the accuracy of retrieval decreases or increases 1%. But, poor user interface can give a negative effect to the user directly.

For the design of the IIRS, the communication or interaction model between the user and the image retrieval system are based on a layered model called HCOS (Human Computer Symmetry). Fig. 1 is shown the diagram of this model. In this model, a human (user) is also modeled as information processing system in engineering terms in a similar way as a computer is modeled.

Fig. 1. The HCOS model
In HCOS model, the user and the IIRS have three layers, respectively (shown in Fig. 1). HCOS model has three layers of interactions between human and computer: the concept layer, the translation layer, and the media layer. In the concept layer, the user initiates a query task, requests a task to be processed by the IIRS, and the IIRS responds to the request by generating a response to the query. The user decides whether the retrieved document is satisfied or not. If it is satisfied, the task is over. If it is not satisfactory, reinforces the IIRS to find another response which is more relevant to the query. The translation layer of the user and the IIRS consists of the interpretation processing and the presentation processing. The presentation processing of the user and the IIRS translates the conceptual representation into the display representation, respectively. Conceptual representation is an internal representation used in the concept layer. The interpretation processing translates the display representation into the conceptual representation, respectively. In the media layer, physical interactions occur between the user and the IIRS.

![Diagram](image)

Fig. 2. The conceptual view of the IIRS.

Fig. 2 shows the conceptual view of the IIRS. The IM (Interpretation Module) corresponding to the interpretation processing in HCOS model translates user query into an internal query vector. The PM(Presentation Module) corresponding to the presentation processing in HCOS model translates the result of queries into the display format. The UIM(User Interface Management) performs the function of managing intelligent user interface. The UM(User Model) stores the behavioral knowledge of the user. The UM stores the history of query and response interactions to absorb errors due to semantic gaps between the user and the IIRS. The TPM(Task Processing Module) performs query processing and adaptation related task which includes to interface with the IIRS. The intelligent user interface of the IIRS is achieved by adding the UM(User Model), and the UIM(User Interface Management).

III. THE IMPLEMENTATION OF THE IIRS

The IIRS adopts a human interface model based on machine learning to adapt user's query behavior. Most ideal user model for query must match all possible queries to corresponding to images, but it is impossible due to the following reasons:

- There is no complete knowledge representation in both queries and image data.
- Image data set itself varies dynamically.
- Since the set of possible queries and the set of image data is infinite in general, there is no complete mapping relation between them.

The IIRS must include the representation and acquisition of user model and adaptation mechanism to understand user's query patterns efficiently. In this paper, the UIM is implemented by backpropagation neural network for short adaptation and decision tree for long term adaptation.

A decision tree consists of nodes and edges. Each internal node is labeled by an attribute vector element. Each node is labeled by an attribute value that an attribute vector element can take. The construction of a decision tree for image case library is based on the ID3 learning algorithm. The ID3 learning algorithm constructs the smallest decision tree from a set of sample data. In this paper, each sample datum is a query represented by an attribute vector assigned by a class standing for a case. A decision tree is constructed starting from the root. The root is labeled by an attribute vector element Q[i], where i is decided based on the entropy. A child node is constructed for each attribute value of Q[i] at the root. Each child node is labeled by an attribute vector element Q[j], where j ≠ i, 1 ≤ j ≤ tmax. tmax denotes the total number of cases in the image case library. A grand child node for the child node is constructed in a similar way, and so on. Supposed that a set S of sample queries. The entropy $H(S)$ of the set S is

$$H(S) = - \sum_{k=1}^{|S|} \left( \frac{C_k}{|S|} \right) \log \left( \frac{C_k}{|S|} \right)$$

where $|S|$ is the size of S, $C_i$ denotes a set whose members are in class $k_i$, $|C_i|$ is the size of $C_i$. In general, members of a set of sample queries are in more than one case class, and there is no information to separate the set into subsets whose members are in one case. So entropy is very high. But if members of the set are in one case, the entropy is 0. The ID3 learning algorithm performs a process that minimizes the entropy of a set. Let T be a set of input sample queries and each query be represented as an attribute vector, Q. If set T is partitioned into subsets $T_1$, ..., $T_n$ according to the attribute values of an attribute vector element Q[i], after partitioned, the entropy $H_{opt}(T)$ is defined as
reduce the error.
Step 3: Repeat steps 1 and 2 until the overall error becomes below a predefined tolerance (0.1).

Algorithm (Neural Network Navigation)
Input: Ambiguous elements of attribute vectors from user's query
Output: Corresponding multimedia case class

Step 1: The back propagation neural network is presented new input vectors.
Step 2: The network produces an output value based on the experience gained from the learning process.
Step 3: The output values are sorted as descending-order. (These values are used to find out a kind of multimedia case.)

IV. EXPERIMENTAL RESULTS

To evaluate the performance of information retrieval systems is to examine the operation and the efficiency of them. The relevance, the term that is defined the relationship between user's query and image data, is important, and is required for evaluating the performance of information retrieval systems. Because the concept of relevance is different from the individual users, the retrieved results about the same query can be different. So, we listed the queries for each user that are used as questions on IIRS, and the image data relevant to these queries.

In this paper, We used the natural scene image for the experiment with IIRS. Because the module of long term adaptation found out correctly only one answer about the query given by the user, We did not consider its evaluation.

For evaluating efficiency of intelligent user interface, We used to two standard methods for evaluating the effectiveness of information retrieval system: precision and recall. They have the value of following equations.

\[
\text{recall} = \frac{\text{the number of retrieved images that are relevant to query}}{\text{the number of whole images that are relevant to query}}
\]

\[
\text{precision} = \frac{\text{the number of retrieved images that are relevant to query}}{\text{the number of retrieved images}}
\]

For the test data, high percentage of precision means less work for the user in evaluating the retrieved images. The recall number tells you for what percentage of test queries the relevant images were retrieved.

We discuss experiments on queries with the IIRS without user adaptation (i.e. without the IUI module activated) and with the IIRS with user adaptation, (i.e. with the IUI module activated), separately. The experimental results we present for precision and recall in this paper are averages. A precision score of 65.31 should be interpreted as "on
average 65.31% of the list of retrieved cases was relevant to queries, and a recall score of 73.68 should be read as "on average 73.68% of the test queries retrieved relevant cases.”

Comparison of the basic retrieval mechanism of the IIRS without user adaptation method to the retrieval with user adaptation method are given as the average results in terms of precision and recall in Fig. 3.

The experimental results show that dramatic improvements in recall and precision were achieved. If users present the unsatisfaction feedback against the retrieved image of the IIRS. The IIRS will not retrieve out this image on the next same query. Therefore, the recall and precision of the IIRS with user feedback are improved.

V. CONCLUDIN REMARKS

This paper addresses an intelligent user interface with user adaptation method in the IIRS. The analysis of human-computer interaction for intelligent user interface, the design, and the implementation issues of the IIRS are given. Techniques of adaptation and learning are employed to provide the system intelligence. Decision tree and backpropagation neural network are used for long term and short term adaptations, respectively.

REFERENCES