Hierarchical Associative Frame with Learning and Episode memory for the intelligent Knowledge Retrieval

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Abstract: In this paper, as one of these efforts for making the intelligent data mining system we propose the Associative frame of the memory according to the following three steps. First,the structured frame for performing the main brain function should be made. In this frame, the concepts of learning memory and episode memory are considered. Second,the learning mechanism for data acquisition and storing mechanism in the memory frame are provided. The obtained data are arranged and stored in the memory following the rules of the structured memory frame. Third, it is the last step of processing the inference and knowledge retrieval function using the stored knowledge in the associative memory frame. This system is applied to the area for estimating the purchasing degree from the type of customer's tastes, the pattern of commodities and the evaluation of a company.

Keywords: Hierarchical Associative memory frame,knowledge retrieval, learning

1. Introduction

As the computer technology has made rapid strides, the amount of information is increasing very quickly. The importance of data mining technology is laid great emphasis in this environment. Many researchers have implemented Data mining system in different various ways for many years. In past days, simple searching methods could be successfully applied to the small amount data, but nowadays more intelligent efforts for finding the good information from the large amount data are needed. For making more intelligent data mining system, we should consider the structured frame similar to the function of human brain. It seems that human brain has the most efficient structure and functions for processing the large amount data in the dynamic environment.

Human brain still in the veil of secret. But many functions of it have become known and guessed by the brain studies for many years[2]. It has the characteristics of learning, knowledge retrieval, structural memory, different cortical areas, parallel distributed processing, association and etc..

In this paper, as one of these efforts for making the intelligent data mining system we propose the Associative frame of the memory according to the following three steps. First,the structured frame for performing the main brain function should be made. In this frame, the concepts of learning memory and episode memory are considered. Second,the learning mechanism for data acquisition and storing mechanism in the memory frame are provided. The obtained data are arranged and stored in the memory following the rules of the structured memory frame. Third, it is the last step of processing the inference and knowledge retrieval function using the stored knowledge in the associative memory frame.

We implemented this associative memory frame for medical diagnosis and experimented with patients' data.

2. The structured frame, memorizing and information retrieval in Human memory

'Memory' has been studied by the brain scientists for many years. According to the results of the brain research, it is known that memory consists of neural network and its parts have the different functions for data storing and processing. The memorizing process is composed of the following four steps: First, The information from the Sensory organ is propagated to the cerebrum through the neural transmitted path. Second, The cerebrum checks the transmitted information and allocates the storing location in the memory. Third,the structure of memory is made a form of network. Fourth, When the stored memories are retrieved, the special mechanism is used.

The brain scientists classify memory to four parts,namely Episode memory, Learning memory, Proceeding memory and Priming memory. Those parts take charge of the different functions and are linked very complexly.

'Episode memory' stores the events of our living. In the type of this memory, consciousness takes part in and the information about time and location is memorized. 'Learning memory' stores the logical facts and rules. It acquires the new facts using the learning mechanism. The consciousness also takes part in this memory. 'Proceeding memory'stores the flow of action.This memory is activated by the repeated exercises. It is based on the repeated exercises and its contents are stored in a form of unconsciousness. 'Priming memory' takes all kinds of information and stimulus without filtering. These data remain unconscious. When the similar stimulus is given, these data can be retrieved.

We are conscious of the two types of Episode memory and Learning memory. These memories get the various information from the surrounding environment,arrange the data and allocate them to many parts in the cortex.

3. The Design of Associative memory Frame

3.1. The structure

The first step of constructing the intelligent system is to make the well formed memory frame for managing the information. The well formed memory frame should have the structure for information acquisition, storing and retrieval. This structure of memory frame has much effect on the performance of the memory.

In this paper, we designed Associative memory frame based on the structure of Brain which was introduced in chapter 2.

As shown in Fig. 1, memory consists of Learning memory, Rule base, and Episode memory. They are related to the others according to their association. The memory is constructed by information acquisition process. The obtained data from the knowledge envi-

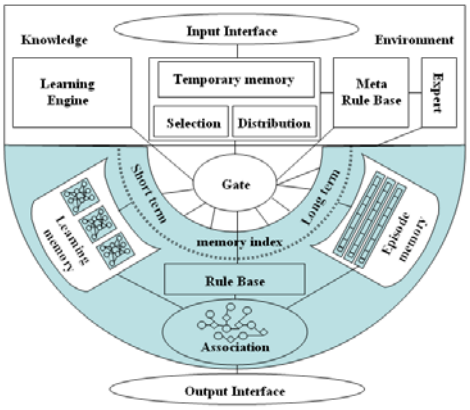

Fig. 1. Associative memory frame

ronment come into Input Interface and are temporarily stored in Temporary memory. They are selected and distributed by the basic mechanism.

There are two pathes as the information acquisition methods in this system. The first path is the method of information acquisition by autonomous learning mechanism. Learning engine receives the training data of the special domain. After Learning engine selects the data ,distributes and starts the learning mechanism, it stores the learned results to their domains in memory. Learning and Storing process are accomplished by Learning mechanism and Learning memory. In the second path, Rule base is constructed by meta rules and rules obtained from the expert. This is a form of pre knowledge rather than the collected training data. This approach can be regarded as the acquisition of 'If-Then' production rule type in the perspective of symbolic AI. The second path is the acquisition of Episode memory. Episode memory stores the event oriented facts with the information of time and location. The obtained data are memorized according to the flow of events sequentially.

In this system the obtained data construct Learning memory, Rule base and Episode memory structurally and are connected to Memory Index for the efficient knowledge retrieval. memory Index is composed of Short term memory Index and Long term memory Index. The Information frequently used is connected to Short term memory index and the information not frequently used is connected to Long term memory index. Short term memory index is connected to Long term memory index. These pointers to the index is not fixed but flexible and movable according to the degree of frequency or importance.

When this system retrieves the knowledge, it searches the pointer first in Short term memory index. Learning memory, Rule base and Episode memory are connected in the memory. From this memory structure, the associative facts are retrieved. The process of the knowledge retrieval is realized by the information retrieval mechanism in the system.

4. Data acquisition and Storing in the memory

4.1. Autonomous learning mechanism

According to the study of brain, permanent memories are stored in the different cortical areas that process the different types of information. Permanent memories consist of a set of records that can be activated when their associated cues are in the environment or in the rehearsal systems[1].

This concept is adopted for deciding the structural frame of the system. As shown in Fig. 2, Knowledge Learning Frame has the Hierarchical structure and also has KLN(Knowledge Learning Net) module which consists of modular Neural networks representing the domain knowledge for the autonomous learning process. These domains are connected to the corresponding areas in the other layers vertically and related with the associative relation in the association module.

The overview of the processing mechanism in Knowledge Learning Frame is as follows. The obtained data from the knowledge environment belong to the different classes and are mixed. They are selected and distributed to the corresponding NN(Neural Network) in the Selection/Distribution module.

Selection module performs the filtering mechanism by filtering the data from the Input Interface. In the filtering mechanism, it calculates the filtering factor, F_i, which is the criteria for determining the state of firing.

$$F_i = P(C_i|e_1, e_2, \ldots, e_n) = \prod_{k=1}^{n} (C_i|e_k) \quad (1)$$

where C_i denotes a hypothesis for disease class and $e_k = e_1, \ldots, e_n$ denotes a sequence of observed data. F_i can be obtained by calculating the belief in C_i.

If filtering factor F_i is over the threshold, q_i, ($F_i \geq q_i$) , the corresponding class is fired. The corresponding KLN of the fired class starts the learning or perception mechanism and produces the output. The values of the cells that don't belong to the activated class, are filtered and cleared.

The activated KLN starts the learning mechanism with the selected training data. KLN module contains multi Neural Network(NN) modules which perform the learning mechanism of the corresponding classes. The structure of NN is three layered neural network trained by BP learning algorithm[3].

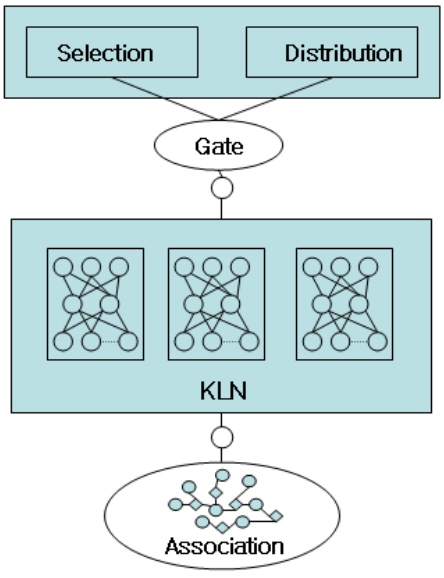

Fig. 2. Knowledge Learning Frame

4.2. Learning mechanism for Rule Base by the expert

The second method for obtaining the information is the way which takes the rules from the expert. the obtained rules make the forms of 'If...Then' type production Rules. This Rule Base is used for the simple symbolic reasoning in the high level.

4.3. Episode memory

Episode memory stores the events or the situation which was experienced. This memory system also provides the information about time and location sequentially.

We designed Episode memory as DataBase that is composed of six attributes,namely, actor, action, object, reason, location and time. This system analyzes the events and stores the facts according to the six attributes. Such a distribution can be very important factors for the information retrieval.

Table 1. DataBase of Episode memory: event

Title	actor	action	object	reason	location	time
shopping	Kim	bought	apples	party	E-mart	2003-12-01
:	:	:	:	:	:	:

We designed a Relational graph for Episode memory which represents not only simple relations but also script of event as shown in Figure 3.

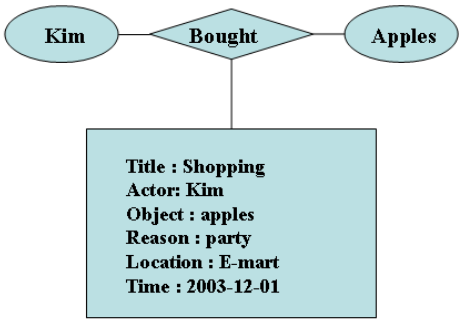

Fig. 3. Relational graph and script for Episode memory

These data are interpreted to the easier comprehensible form:

Kim bought apples for party in E-mart on 2003-12-01.

For removing the complexity of transferring to the natural language form, we fixed the Tense to Past.

4.4. Association

Association level consists of nodes and their relations. These nodes are connected to their neighbors according to their associative relations horizontally and connected to NN of the previous layer vertically. Their relations are represented by the relational graph as shown in Fig. 4.

The relation between the two nodes is represented by both linguistic term and its associative strength.

TRANSFORM-TO : transform in time

AFFECT : partial transform

IS-A : generalization

MADE-OF :component

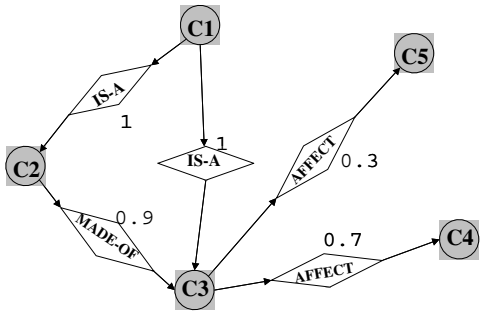

Fig. 4. Relational graph in Association level

The linguistic terms are represented as TRANSFER-TO, AFFECT, IS-A, MADE-OF, NOT and SELF. Linguistic term denotes the degree of representing the associative relation. It can be transformed to the associative strength that has a real value of [-1,1]. The positive value denotes the excitatory strength and the negative value represents the inhibitory relation between the nodes. It is used for extracting the related facts. The minus sign of the minus value means the opposite directional relation as -TRANSFORM-TO.

The relational graph is transformed to the forms of AM(Associative Matrix) in order to process the knowledge retrieval mechanism. AM has the values of associative strengths in the matrix form.

For example, the relational graph in Fig.3. can be transferred to the associative matrix A.

The associative matrix,A, is :

$$A = \begin{bmatrix} 1.0 & 1.0 & 1.0 & 0.0 & 0.0 \\ -1.0 & 1.0 & 0.9 & 0.0 & 0.0 \\ -1.0 & -0.9 & 1.0 & 0.7 & 0.3 \\ 0.0 & 0.0 & -0.7 & 1.0 & 0.0 \\ 0.0 & 0.0 & -0.3 & 0.0 & 1.0 \end{bmatrix}$$

The matrix, A, has the form of $A = [R_{ij}]$. The associative strength,R_{ij}, between C_i and C_j is calculated by equation (2).

$$R_{ij} = P(a_i|a_j)D \tag{2}$$

where D is the direction arrow, $D = 1 or -1$, $i = 1, \ldots, n$, $j = 1, \ldots, n$.

Using this Associative Matrix A, this system can extract the related facts by following knowledge retrieval algorithm.

5. Knowledge Retrieval

5.1. Knowledge Retrieval from Learning memory

After the memory construction is completed by learning mechanism, Knowledge retrieval is available. The passed input data from the Input interface,Selection and Distribution module are sent to the activated KNN in the Learning memory. KNN produces its inferential results through the output nodes which are connected to Association level and Episode Memory. Knowledge Retrieval mechanism extracts the related data connected to Association level and Episode memory by making the inferential output nodes a starting point. The following algorithm represents the knowledge retrieval process.

Algorithm 1 : knowledge retrieval algorithm

Step 1: Input the data to Input Interface.

Step 2: Calculate the reaction value by filtering function

Step 3: Select the activated class.

Step 4: Propagate the filtered data to KNN of the activated class

Step 5: Calculate the inferential value of the output node by BP algorithm in KNN

Step 6: Data Extraction in Association level:

Search the associated nodes connected to the inferential output node of KNN in the row of the activated node in AM.

Step 7: IF((not found) AND (found the initial activated node))

Goto Step 8.

ELSE

Output the found fact.

Add the found fact to the list of inference path.

Goto Step 6

Step8: STOP

When the class,C_i, in the relational graph is assumed to be activated, from the node, C_i, the inferential paths can be extracted using the knowledge retrieval algorithm. The inferential path, I_i has the following form.

$$I_i = \left[\begin{array}{ccc} C_i & (R_{ij}) & C_j \end{array} \right]$$

where C_i is i-th class node,R_{ij} is the associative strength between C_i and C_j.

The following example is the result from the matrix A using the knowledge retrieval mechanism.

I_1 = [C_1 IS-A(1.0) C_2 TRANSFER-TO(0.9) C_3 MADE-OF(0.7) C_4]

I_2 = [C_1 IS-A (1.0) C_2 TRANSFER-TO(0.9)]

I_3 =[C_3 MADE-OF(0.7) C_5]

I_4 =[C_1 IS-A(1.0) C_3 MADE-OF(0.7) C_4]

I_5 = [C_1 IS-A(1.0) C_3MADE-OF(0.7)C_5]

From the obtained inferential paths, this system can extract the related facts as much as user wants by masking with the threshold, θ. In this step, the connected facts that has the value of the associative strength over the threshold are extracted. In the case of I_1,when the threshold is 0.7, the extracted path is [C_1 IS-A(1.0) C_2 TRANSFER-TO(0.9) C_3].

The another function of the knowledge retrieval mechanism is to infer the new relations.

From the following extracted inferential path,

$$C_i(R_{ij})C_j(R_{jk})C_k,$$

we can elicit the new inferred path between C_i and C_k. The new associative strength,R_{ik}, is calculated by equation (3).

$$C_i(R_{ik})C_k$$

$$R_{ik} = R_{ij} * R_{jk} \tag{3}$$

The inferential path, I_1 : C_1 IS-A(1.0) C_2 TRANSFER-TO (0.9) C_3 MADE-OF(0.7) C_4, can produce the new relations, C_1(0.9) C_3, C_1 (0.63) C_4 by its mechanism[4].

5.2. Knowledge Retrieval from Episode memory

Episode memory is logically represented by Script and physically r composed of relational Data Base which has 7 attributes. Knowledge retrieval step is processed by the following form of query.

SELECT * from *table* where *table.id = value*

For example,the query of example in the previous section has the following expression. We can select the necessary attributes by adjusting this query form.

SELECT Title,actor,action,object,reason,location,time from EVENT where EVENT.object = apple

From this query this system produce the output.

Title : shopping
actor: Kim
object: apple
reason: party
location: E-mart
time: 2003-12-01

As we described in the previous section, these output data are interpreted to the easier comprehensible form.

6. Experiments

This system is applied to the area for estimating the purchasing degree from the type of customer's tastes, the pattern of commodities and the evaluation of a company. We tested with three classes. First class consists of ten customer's input term - four types of customer's tastes, second class consists of five input factors - three patterns of commodities and third class consists of eight evaluating terms - three evaluation degrees of company in the diagnostic area. Figure 5 represents the extracted data from Learning memory and Figure 6 shows the retrieved script from DB in Episode memory.

```
--------------------------------------------------
Knowledge Retrieval system from Associative Frame
--------------------------------------------------
Enter the input file name? input.dat
Enter the reaction degree? 0.6

*Input and Reaction stage
The selected group by Selection and Didtribution module
... The group G1:The pattern of commodities was selected.
... KNN1 is fired.

*KLN stage
The inferential result of KNN1 :

 Type 1   Type 2   Type 3   Type 4
0.998711 0.345600 0.245001 0.690825

Ouput value : Type1 0.998711

*Knowledge Retrieval stage from the association level
Retrieved Inferential path:
          C1: The type of Customer's tastes
          C2: The pattern of commodities
          C3: The evaluation of a Company
C2 Affected-by(0.700000) C1 Produced-by(0.300000) C3
C2 Closely-related(0.110000) C3
```

Fig. 5. Knowledge Retrieval from Association level

```
*Knowledge Retrieval stage from Episode memory
... Starting keyword :Type1
... Retrieved script from DB

Title: production
actor: ABC Co.
action: produced
object: Type1
reason: advanced function
location: ABC fac.
time: 2003-01-12

... Interpretation
ABC Co. produced Type1 for advanced function in ABC fac. on 2003-01-12.
```

Fig. 6. Knowledge Retrieval from Episode memory

7. Conclusion

We designed Associated Frame with learning and Episode memory for the intelligent knowledge retrieval. This system has a hierarchical structure which is divided by division of the memory. The memory process is divided into an acquisition stage, a retention stage and a retrieval stage. In a retrieval stage, the related data are extracted from Learning memory and Episode memory. This system is applied to the area for estimating the purchasing degree from the type of customer's tastes, the pattern of commodities and the evaluation of a company.

As a result of testing, we could find that it can extract the related data easily. This system is expected to be applicable to many areas as data mining, pattern recognition and circumspect decision making problem considering associative concepts and prior knowledge .

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