STUDIA UNIV. "BABEŞ-BOLYAI", INFORMATICA, Volume I, Number 1, March 1996

THE DEVELOPMENT OF THE CONCEPT SYSTEM

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Abstract. The concepts are basic bricks of the cognitive processes. The development of the concept system is a very challenging problem. Theories dealing with this problem can be used in various solutions of the human speech processing and written text understanding. In this paper three individual and one communitarian concept system development process are presented. A formal / theoretic framework will be build, by which all of the presented processes can be modeled. Finally an application example is presented.

1. Introduction

The concepts are basic bricks of the cognitive processes. They play a very important role in the understanding of the speech, the reading of the text or in generating intelligent and rational decisions ([2, 3, 4, 5]).

The development of the concept system is a very challenging problem. Theories dealing with this problem can be used in various solutions of the human speech processing and written text understanding. The development of the concept system means the process within which the individual develops its own network of concepts.

In this paper three individual and one communitarian concept system development process are presented. A formal/theoretic framework will be build, by which all of the presented processes can be modeled. Finally an application example is presented.

2. Concept System Development Processes

In this section some concept system development processes will be presented, which are based on natural processes ([6]).

We have to distinguish two types of such processes, the micro level processes, and the macro level processes. We will call micro level processes, those development processes, which are taking part separately within an individuals concept system. The macro level

Received by the editors: October 27, 1996.
1991 *Mathematics Subject Classification.* 68T30, 68T05, 92J40.
1991 *CR Categories and Descriptors.* I.2.6. [Artificial Intelligence]: Learning – concept learning.

processes are those development processes which are working in groups or communities of individuals. The macro level processes works as standardization processes, which set up common meanings of the individually developed concepts.

We will suppose that the concepts are organized in a network ([1, 4]). Each concept will be represented by its name, a set of attributes and a set of behaviors. The attributes are representing the important features of the concepts realizations. The behaviors are specific processes which can modify the attributes of the concept. Each attribute of a concept is a virtual realization of another concept. The concept network is organized along the parent - children relations, which link the concepts ([1]). A concept is the child of some other concepts, if it was developed based on those concepts, inheriting some of their attributes and behaviors. We will use in addition the notion of the pre-concept, which is a structure, which has attributes and behaviors, but not yet has a name and not is inserted as a concept in the concept network. The pre-concept can have multiple attributes, which are attributes with different names, but which are designing the same feature, or it can have behaviors, which are can act contrary in the same time.

The first micro process is describing the process, when the increasing importance of an object or of a phenomena results the creation of a new concept. The steps of this process are the following:

Step 1. *The individual observes the some features of the phenomena (ex. there are a lot of symbols, with a specific meaning, these symbol strings are transformed into machine code, etc.)*

Step 2. *The importance of the observed phenomena is increasing (the cod strings became important, there is a lot of discussion about them), and there is forming a pre-concept, which contains most of the attributes of the phenomena and the collection of main behaviors of it.*

Step 3. *The pre-concept is inserted in the concept network as a descendent of some existing concepts. First there is a searching for existing concepts, which has similar attributes and behaviors like the pre-concept. The pre-concept is inserted as the descendent of the found concepts, inheriting some new attributes and behaviors, too. The new concept gets a new name or gets the name or modified name of one of its ancestors. (It is starting to use the name of source code for the designation of the symbol strings.)*

Step 4. *Some new concepts are inserted in the concept network, which are descendants of the previously inserted concept. The new concepts are realized by the elimination of non- applicable attributes and / or behaviors.*

The second micro level process is describing the case, when a new concept is formed as the consequence of the use of a phrase (some words which are used together). The steps of this process are the following:

Step 1. *A word combination is used, which cannot be interpreted correctly with the existing meaning of the concepts belonging to these words. (ex. it is said that the pipe is burning, but we know that the pipe is not burning normally, only eventually, if it is put in the fire, but this is not the normal use of the pipe)*

Step 2. *To interpret the word combination it is searching for a linkage between the concepts. (It is found that the concept of pipe has an attribute with the name pipe- tobacco, which is a virtual realization of the concept of tobacco, which has the behavior is-burning, by which can be found the interpretation of the word combination.) The linkage can be done through a multiple linkage, too.*

Step 3. *The word combination gains importance, and it is used frequently. As a result is formed a new concept as a descendent of the active concept, which has a new behavior. The new concept has the same name as his ancestor, and the new behavior is realized as the direct interpretation of the behavior designated by the word combination. (The new concept will have the name pipe, and it will have the new behavior of is-burning, which represents the process when the tobacco in the pipe is burning.)*

The third micro process is more simple, and it represents the process of the conciouss learning. Its steps are:

Step 1. *A new concept is presented to the individual, indicating its attributes, behaviors and links within the concept system.*

Step 2. *The new concept is inserted in the concept network at the indicated position.*

Finally it is described a single macro level process, the standardization of the concepts, by which the concepts of the individuals are transformed in a way which results increasing similarity between the individual concepts. The common interpretations are organized in an abstract concept network, which is used with normative force. Based on

this abstract network is realized the conscious learning of the concepts. The steps of the macro process are:

Step 1. *A new concept is developed individually by some individuals who are communicating frequently among them. (Some programmers are developing the concept of functional-programming.)*

Step 2. *Within the community, the members are agreeing about the common sense of the concept, and they start to use it with its common meaning. (The programmers are agreeing about the common meaning of the concept of functional-programming.)*

Step 3. *Other individuals, who didnt knew the concept are learning it with its common meaning. (The students are learning the concept of functional-programming with its common meaning.)*

3. A formal model

In this section we will use the notion of the object for the realization of a concept. Let us consider some preliminary notations:

let $\mathbf{C}$ be the set of concepts,

let $C \in \mathbf{C}$ be a concept,

let note with $r(C)$ the set of objects (realizations) of the concept C,

if R is an object of concept C, then we have $R \in r(C)$,

let us note by $C_1 > C_2$ the descendency relation of C_2 with C_1,

let $C = (N, A, a, B, b)$ be a concept, where

N is the name of the concept (a string of symbols),

$A = (A_1, A_2, ..., A_n)$ is the set of attributes,

$a = (a_1, a_2, ..., a_n)$ is the set of the importances of the attributes,

$B = (B_1, B_2, ..., B_m)$ is the set of behaviors,

$b = (b_1, b_2, ..., b_m)$ is the set of the importances of the behaviors.

The importance of an attribute or of a behavior shows, how prototypic is that attribute or behavior, in other words, how important, or how frequent is the presence of that feature in the objects of the concept. The importances can be interpreted as exact numbers between 0 and 1, or as fuzzy numbers between 0 and 1.

For each A_i we have $A_i \in r(C_i)$, where $C_i \in \mathbf{C}$. The behaviors B_j are conceived in the form

$$B_j = process(A_{i_1}, A_{i_2}, ..., A_{i_{k_j}}),$$

denoting by this a process, within takes part the mentioned attributes, which realizes some behaviors of them.

Let us note by $\mathbf{L} = (S_1, S_2, ..., S_w, ...)$ the world of events which are realized for an individual, the events will be called scenes.

Let $S_t = (O, o, P, p)$ be a scene, where

$O = (O_1, O_2, ..., O_u)$ is the set of objects which take part in the scene,

$o = (o_1, o_2, ..., o_u)$ is the set of subjective importances of the objects,

$P = (P_1, P_2, ..., P_v)$ is the set of actions (processes) which take part in the scene,

$p = (p_1, p_2, ..., p_v)$ is the set of the importances of the processes,

$O_i \in r(C_i)$ and

$P_j = process(O_{i_1}, O_{i_2}, ..., O_{i_{k_j}})$.

Let us note $S_{t_1} \subseteq S_{t_2}$ if $O_{t_1} \subseteq O_{t_2}$ and $P_{t_1} \subseteq P_{t_2}$.

Let $I(S)$ be the importance of scene S, which determines the importances o_i and p_j , too.

After these introductory notes let us turn to the formal interpretation of processes of the dynamics of the concept system. The micro level rules can be formulated in the following way.

Let $S_{i_j} (S_{i_j} \in \mathbf{L})$ be scenes for which exists $S \subseteq S_{i_j} \forall i_j (j = 1, ..., n)$, and let $S = (O, o, P, p)$. In plus let $I(S_{i_j})$ be increasing (or increasing in trend), as j increases, so if we note by imp_j the importance for j, then we have $imp_j > imp_{j_0}$ if $j > j_0$. Then it is creating a pre- concept C (notation create_p(C)), so that $C = (A, a, B, b)$, where

$A = (A_1, ..., A_n)$, and $A_i, O_i \in r(C_i)$,

$B = (B_1, ..., B_m)$, and $B_j = P_j$,

a and b are determined based on the importances o and p.

Let us define the similarity measure between two concepts or pre-concepts as

$$sim(C_1, C_2) = \sum_{i=1}^{n} \frac{(a_{1i}+a_{2i})}{2} \cdot d_i + \sum_{j=1}^{m} \frac{(b_{1j}+b_{2j})}{2} \cdot e_j,$$

where a_i and b_j are the importances of the attributes and behaviors, d_i and e_j are equal to 1 if the feature is identical in the two concepts, and 0 otherwise.

The similarity it is calculated for each permutation of the numbers (1, 2, ..., n) and is taken as the similarity measure, the maximum.

Let us consider that it was created the pre-concept C. There is a searching for the concepts $C_1, C_2, ..., C_m$ for which we have that

$$sim(C, C_k) > s_0.$$

Let C_0 be the concept for which $sim(C, C_k)$ is maximal. We can define different criterias by which we can select the concepts C_k, which will be the ascendants of the new concept. After the selection is created the new concept $C = (N, A, a, B, b)$, as a descendent of the selected concepts, and we will have

$N = N_0$ or it is created a new name for the new concept,

$A = combination(A, A_1, ..., A_{k_1})$,

$B = combination(B, B_1, ..., B_{k_1})$,

$a = combination(a, a_1, ..., a_{k_1})$,

$b = combination(b, b_1, ..., b_{k_1})$,

where combination means a certain combining rule, which generates non-contradictory results. So, we have that $C \in \mathbf{C}$ and $C_k > C$. After this there are created the concepts $C^i, C > C^i$, where the concepts C^i are creates by the elimination of some features, based on the importance of these.

Using this model can be modeled all of the three micro level processes.

To model the described macro process, we have to consider firstly a number of concept networks, $C_1, C_2, ..., C_q$, which contains the concept C with similar, but a little bit different interpretations. The macro process can be modeled by the calculation of some weighted mean of the concepts from the different concept networks, taking in account the importance or the influencing power of each individual, which holds the concept systems.

4. An example

In this section an application of the previously introduced formal framework is presented, for the case of the formation of the concepts of the small positive integer numbers.

Let us consider the scenes $S_k = (O_k, o_k, P, p)$, with

$O_k = (O_{1k}, ..., O_{nk})$, and $O_{ik} \in r(C_k), P = (P_1), P_1$ meaning the simultaneous existence of O_{ik}, for $i = 1, ..., n$. Let us suppose that the scenes S_k happens frequently and $I(S_k)$ is sufficiently high frequently.

Then we have $C_k \subseteq C_0$ and $r(C_k) \subseteq r(C_0)$, so $O_{ik} \in r(C_0)$, where C_0 is the root concept of the concept system.

Because $I(S_k)$ is frequently high, the pre-concept C is formed with the components

$A = (A_1, ..., A_n), A_i \in r(C_0)$,

$B = (B_1)$,

B_1 representing the process of the simultaneous existence of A_i (a and b are defined with the maximal elements).

As a result the concept $CM, C_0 > CM$, is created with the components $A = A$ and $B = B$ ($a = a$ and $b = b$), and with the name $N = many$. Similarly the concept $CU, C_0 > CU$, is created with the name one, and with the components

$A = (A_1), A_1 \in r(C_0), B = (B_1)$,

B_1 representing the process of unique existence of A_1 (a and b are defined with the maximal elements).

After this there are created the concepts C_2, C_3, with the names two, three, as the scenes with two, three, etc. elements became important for that individual. The names of the classes can be individually specific at the start, but later they are modified conform to the macro level processes.

5. Conclusions

The presented model of the concept system development gave a formal framework within which it is possible the natural - like modeling of these processes.

This model can be used as a part of intelligent agent programs or adaptive user interfaces in order to generate the knowledge background for case specific actions and mutual understanding and collaboration.

By further refinement and development of the presented model it is would be possible to create a general scope framework for knowledge base building for expert systems, intelligent agents and adaptive user interfaces.

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