O. V. Bisikalo, Cand. Sc. (Eng)

CONSTRUCTION OF PATTERNS CHAIN WITHIN THE MODEL OF ASSOCIATIVE PATTERN THINKING

The given paper considers formalization of psycholinguistic notion of associative – verbal network based on the model of human pattern thinking. Taking into account the peculiarities of the model method of route on graph determination is considered; the given method enables to reduce considerably the search space Algebraic model of recursive construction of patterns chain by criteria of minimum length and maximum force of associative connection is suggested.

Key words: *pattern thinking, associative – verbal network, search in graph recursive algorithm, algebraic model.*

Paradoxes of associative pattern thinking have long been attracting of attention of researches, but phenonomenological character of corresponding psyholinguistic processes considerably complicates their formal description. Developments carried out in the sphere of logic models of linguistic processor, actual due to rapid growth of the Internet have already reached the limit of their syntactic and semantic possibilities – in the human brain more profound understanding of naturaral linguistic constructions is achieved due to pattern per ception of the real word.

The given problem is of the great scientific importance due to the lack of the methodology of modeling of associative pattern thinking processes needed for construction of linguistic processor [1].

Analysis of the recent research and publications containing the approaches to the solution of the given problem enables the consider conceptual character of existing models of pattern thinking. Free associative experiment, probably, is the closest scientific tool, having relation to considered problem. The given method of research is connected with psycholinguistic study of human speech activity, formation of human speech ability. Definition of associative meaning of the word was introduce modern scientific paradigm by J. Deez, who became one of the most prominent researcher in the sphere psycholinguistics of the 20 th century. In J. Deez' s interpretation associative was considered the meaning most adequate to psychological structure, in other words – "potential distribution of answers (associative words) to certain word - stimulus". In the process of associative study J. Deez investigated probabilistic characteristics of the associatives connections of the word with other words on the basis of cluster analysis [2].

Long – term and large – scale experiments dealing with the study of peculiarities of text – creative potential of associative field of the word, carried by A. A. Zalevskaya and the group of 10 – researches, elaborated the approach to word meaning analysis, suggested by J. Deez. In the opinion of A. A. Zalevskaya, is still valid, and prospects of its further application and determined by the possibility of integration into far more general theory of individual knowledge and principles of its functioning [3]. The results of recent research in the given direct allow to speech about the advent of separate direction in psycholinguistics - associative linguistics (concept of Yu. G. Karaulov), represented in modern state by associative lexicography, lexicology and grammar [4]. According to this concept, language can be representative not only in the form of system of relations, not only as the set of texts, but in the form of associative – verbal networks (AVN) which correlates with speech ability of language speaker. AVN consists of hierarchically subordinated levels, which become more and more complex: word or word combination – associative field – totality of associative fields. On the basis of such approach within the limits of associative linguistics associative space of texts isomorphic to language is built [5].

Formal aspects of associative theory are partially investigated in the literature, however, basic methods of associative search are already known, for instance, when for one element of the set, the closest ones by the power of associative connection are determined in the form of Hash – Table. It is evident, that the intersection of the words – associates lists for two various elements (ABC nodes) enables to determine the closest among them common elements [6].

The problem of construction of the chain of three and more ABC nodes, which appears in linguistic processor while answering the question and in other problems of pattern thinking remain unsolved [7, 8]. Let us introduce the linguistic notion of the pattern as the set of verbal designations of single – root object – quality – method [9].

The associative network of patterns we obtain by "compression" ABC, when several related nodes are united in one, corresponding associative bands being inherited by a new node.

Let us denote by binary code $Bi–I_i$ *i*-th element of patterns *X* set, and associative network will be presented in the form of pairs space $Assoc-Twice \subset X \times X$. Let us assume that within the model of pattern thinking algorithm *Hash-Table* $(Bi–I_i)$is constructed, which defines sorted list of patterns $List_i$, the closest to *i*-th pattern by the power of associative bond S_i. Algorithm *Find-1*$(Bi–I_1, Bi–I_2)$ – search of intermediate or insight pattern – chain between patterns $Bi–I_1$ and $Bi–I_2$ can be considered to be known as result of operation *Hash-Table*$(Bi–I_i)$ execution for each of the pair $(Bi–I_1, Bi–I_2)$ pattern two sorted by reduction S_i lists of associated patterns $List_1$ and $List_2$ are determined, then operator *Find-1*$(Bi–I_1, Bi–I_2)$ find those patterns, which are present in both lists (intersections of two sets). Fig 1 shows the image of $List_1$ and $List_2$ in the form of bubbles of associative bonds $S_{i,}$. ,common elements of two lists (patterns – insight) being marked by colour.

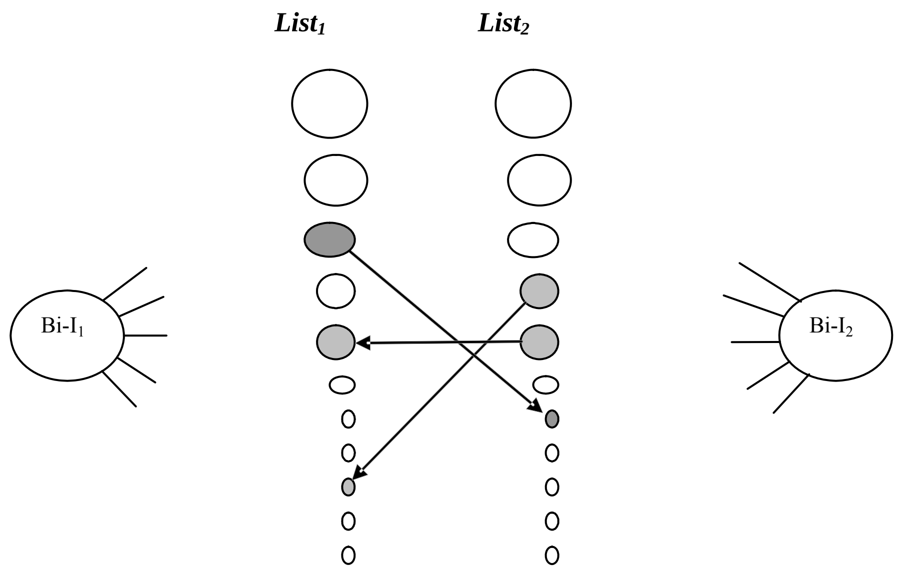

Fig. 1. Intersection of $List_1$ and $List_2$ as a result of operator *Find-1*$(Bi–I_1, Bi–I_2)$ action

In these conditions we will consider the case, when it is necessary to find *n* unknown links in the chain of parameters. The problem becomes actual when algorithm *Find-1*$(Bi–I_1, Bi–I_2)$ does not find common elements in $List_1$ and $List_2$. We will **formulate the research task** as follows: by means of already known algorithms *Hash-Table(Bi–I)*, *Find-1*$(Bi–I_1, Bi–I_2)$ find minimum by length n chain of intermediate links between initial $Bi–I_1$ and final pattern $Bi–I_2$ with maximum total weight of associative bond.

$$S = \sum_{i=1}^{n-1} S_i \ .$$

Method of solution of the problem we will illustrate by the image of the fragment of associative

Networks samples in Fig 2. The given fragment of network shows the negative result of initial action of *Find-1*$(Bi–I_1, Bi–I_2)$ operator, since parameters $Bi–I_1$ and $Bi–I_2$ cannot be united by one element. If we apply already known methods of the search of critical route in networking models, then, in general case, the solution of the problem requires direct exhaustive search by *n!* dimensionality of possible routes for *n* nodes of graph.

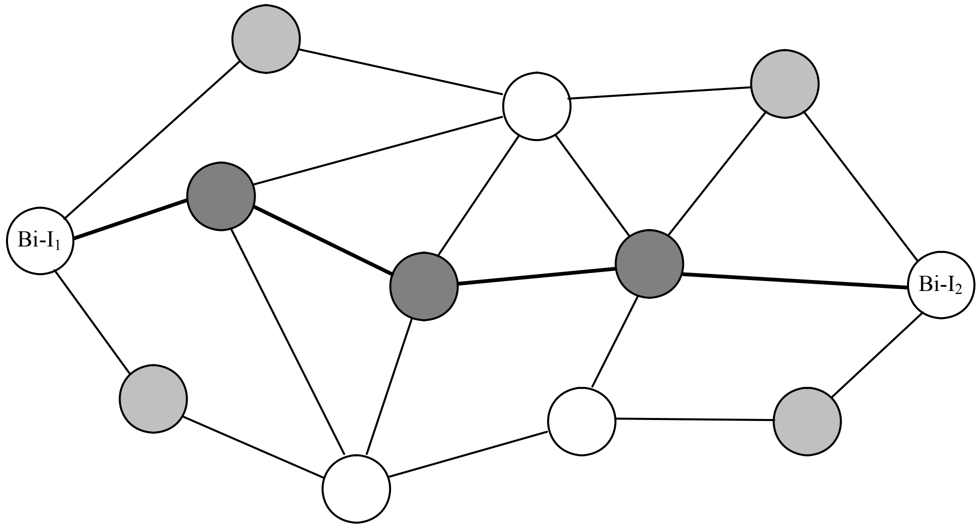

Fig. 2. Fragment of associative network patterns with the result of operator *Find-n(Bi–I₁, Bi–I₂)* action

However, we should take into consideration the following peculiarities of the graph, determibed by the model of pattern thinking [10], and, hence, digress from NP–complete problem:

1. The number of valid bonds from each node of the graph (patterns) is not greater than 7±2, , but not less than2.
2. There are no two different nodes (patterns), having identical set of contiguous (associated patterns).
3. There exists finite route between any two nodes of the graph of n dimensionality, the length of the route does not exceed $(n+1)/2$.

The following approach to the solution of the given problem is suggested:

References route is constructed on the basis of recursive sorting by the power of S_i bond, obtained at each i th step of pattern list. For the next step the best pattern from the list is taken, except those patterns, which were involved in the previous iterations. Stack $Route_i$, provides storage of route elements, introduction of new element of the rout(pattern) is accompanied by recycling test, i. e. there must not be any two identical patterns in the stack. Reference route obtained is optimized in order to reduce the number of associative elements, since laconicism of language structure (utterance) is the second efficiency function.

Algorithm of the given problem solution will be constructed by means of the following formal operations and predicates:

1. Operation *Hash-Table(Bi–*I_i determines $List_i$, sorted by the power of associative bond S_i pattern – stimulus $Bi–I_i$:

$$(Bi-I_i, S_i) \xrightarrow{Hash-Table} List_i \, . \tag{1}$$

2. Predicate *Stop*, indicating complete construction of associative route:

$$Bi-I_i = Bi-I_2 \rightarrow Stop \, . \tag{2}$$

3. Operation *Find-1(*$Bi–I_1$*,* $Bi–I_2$*)* finds intermediate elements $Bi–I_x$ (pattern insight) $Bi–I_1$ and $Bi–I_2$:

$$(Bi-I_1, Bi-I_2) \xrightarrow{Find-1} Bi-I_x \, . \tag{3}$$

4. Predicate *Insight*, indicating the search of pattern – insight as a result of operation *Find-1(*$Bi–I_1$*,* $Bi–I_2$*)*:

$$\exists \; Bi-I_x \rightarrow Insight \, . \tag{4}$$

5. Predicate *Cycle*, determining recycling in the operation of the algorithm of the pattern chain construction due to repetition of identical pattern in the stock $Route_i$:

$$Bi - I_i \in Route_j, \; j = \overline{1, i-1} \rightarrow Cycle. \tag{5}$$

For solution of the given problem, taking into account formal operations and predicates (1)÷(5) we will present two – bases algebraic system in the following form :

$$Algebra = \langle B; \Omega \rangle, \tag{6}$$

where

$$B = \{Bi - I, S\} \tag{7}$$

bases, and

$$\Omega = \{OP, IF\} \tag{8}$$

– signature of the system, consisting of operations *OP* and predicates *IF*. As a bases *Image* – the set of verbal designations of pattern and *Bi–I* – binary codes of *Image* set elements are used. Operations and predicates contain previously considered

$$OP = \{Hash - Table, Find - 1\}, \tag{9}$$

$$IF = \{Stop, Insight, Cycle\}. \tag{10}$$

We will show, that the problem of pattern chain construction within the frame of algebraic system *Algebra* is reduced to recursive algorithm based on *OP* and *IF* predicates. In graph – diagrams of algebraic constructs, considered further, such designations for operators of structural programming are used [11]:

Do – cycle by parameter or condition;
If (+ -) – alternative;
* – composition.

Serial construction of the following operations from the signature (8) is sufficient for the solution of the given problem, taking into account previously introduced designations.

1. Operator R_1, increasing by 1 variable i – th number of current element of patterns chain and putting into i–th cell of the stack $Route_i$ the value of final pattern of $Bi\text{-}I_2$ route:

$$R_1 ::= \; i + 1 \rightarrow i \;\; * \;\; Bi - I_2 \rightarrow Route_i. \tag{11}$$

Graph – diagram of R_1 operator is shown in Fig. 3.

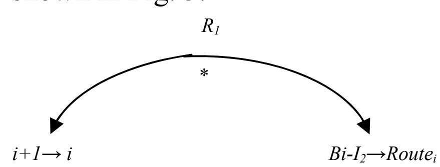

Fig. 3. Graph – diagram of R1 operator

2. Operator R_2, increasing by 1 variable i and putting the value of pattern – insight $Bi\text{-}I_x$ code into i–th cell of the stock $Route_i$:

$$R_2 ::= \; i + 1 \rightarrow i \;\; * \;\; Bi - I_x \rightarrow Route_i. \tag{12}$$

Graph – diagram of R_2 operator is shown in Fig. 4.

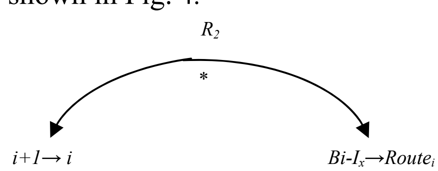

Fig. 4. Graph – diagram of R_2 operator

3. Final operator R_A, withdrawing the obtained route or recycling case in the form of filled cells of the stock $Route_i$ from1-st to the i–th by means of *Output()*procedure:

$$R_A ::= \{[j = \overline{1,i}] \;\; Output(Route_j)\}\,. \tag{13}$$

Graph – diagram of R_A operator is shown in Fig. 5.

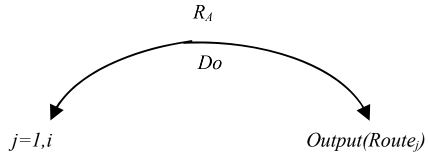

Fig. 5. Graph – diagram of R_A operator

4. operator *Begin*, starting the algorithm of route construction by reducing to zero variable I_1 further puts down the value of initial pattern code of *Bi*- route into the variable of current pattern $Bi\text{-}I_i$ and passes the control to the operation *Next*:

$$Begin ::= \;\; 0 \to i \;\; * \;\; Bi - I_1 \to Bi - I_i \;\; * \;\; Next\,. \tag{14}$$

Graph – diagram *Begin* operator is shown in Fig. 6

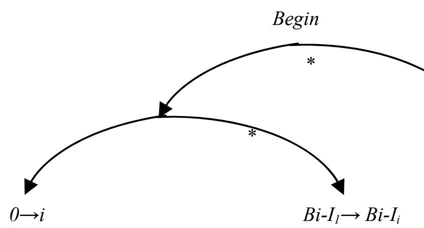

Рис. 6. Graph – diagram of *Begin* operator

5. Operator *Next*, increasing by 1 the variable *i*, further puts down the value of current pattern $Bi\text{-}I_i$ code into i–th cell of $Route_i$ stack and passes the control to operator *One*:

$$Next ::= \;\; i + 1 \to i \;\; * \;\; Bi - I_i \to Route_i \;\; * \;\; One\,. \tag{15}$$

Graph – diagram *Next* operator is shown in Fig. 7.

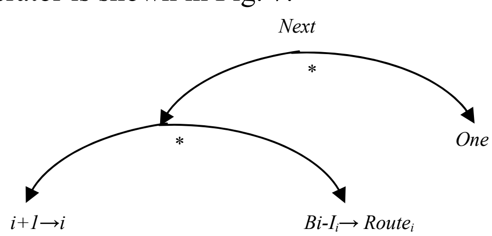

Fig. 7. Graph – diagram of *Next* operator

6. Operator *One*, which finds the list of patterns – associators to pattern $Bi\text{-}I_i$ by means of $Hash\text{-}Table(Bi\text{-}I_i)$ and checks predicate *Stop.* If final pattern of the route is determined, operators R_i and R_A, are performed otherwise control is passed to operator *Step*:

$$One ::= Hash - Table(Bi - I_i) * ([Stop] \;\; (R_1 * R_A), \;\; Step)\,. \tag{16}$$

Graph – diagram *One* operator is shown in Fig. 8.

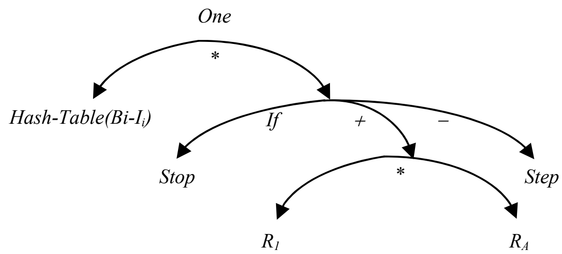

Fig. 8. Graph – diagram of *One* operator

7. Operator *Step*, which assigns the greatest value from the list for *i*–th pattern on the place of *i+1*–th section of the route $Bi\text{-}I_{i+1}$ and checks predicate *Cycle*. If recycling of the route is determined, operator R_A, is performed, otherwise the control is transferred to operator *Two*:

$$Step ::= Max(List_i) \rightarrow Bi - I_{i+1} * ([Cycle] \quad R_A, Two)\,. \tag{17}$$

Graph – diagram *Step* operator is shown in Fig. 9.

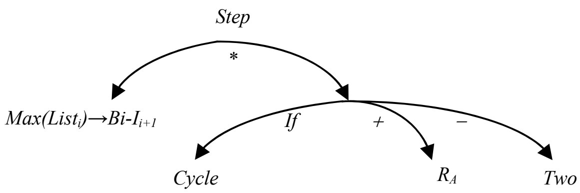

Fig. 9. Graph – diagram of operator *Step*

8. Operator *Two*, which finds pattern – insight between current pattern $Bi\text{-}I_i$ and final pattern of the route $Bi\text{-}I_2$, and then checks predicate *Insight.* Insight while determining pattern $Bi\text{-}I_x$ operators R_2, R_1 and R_A, are executed otherwise control is recursively locked – in the operator *Next* :

$$Two ::= Find - 1(Bi - I_i, Bi - I_2) * ([Insight] \quad (R_2 * R_1 * R_A), \quad Next)\,. \tag{18}$$

Graph – diagram *Two* operator is shown in Fig. 10.

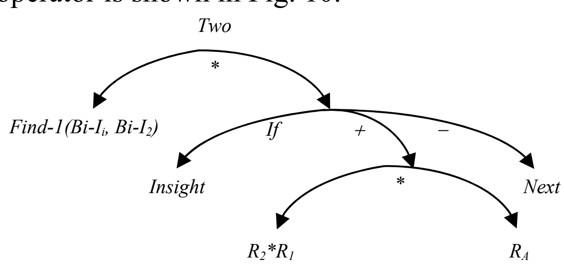

Fig. 10. Graph – diagram of operator *Two*

Hence, the suggested recursive algorithm as reference point has any operator R_A for demonstration both of found route and recycling situation. For delineation of these two different cases the algorithm can be complicated by the procedure of recycling overcoming by means of assignment of the next link after problem - containing *i*–th pattern by the next by weight pattern in the list $List_i$. Due to peculiarities of the graph, provided by the model of pattern thinking, new final route also exists.

References route. Obtained with the help of algorithm (11)÷(18) is constructed by criterion of maximum force of associative bond between its patterns - links. However, we cannot assert, that this pattern chain is the shortest one of all possible, since at each step of the algorithm, the existence of insight link only between current pattern and final one was checked. Hence, reverse application of operation *Find*- and predicate *Insight* to the pairs of patterns of the chain with numbers (*i-1,1*), (*i-1,2*), …, (*i-1,i-4*), (*i-2,1*), (*i-2,2*), …, (*i-2,i-5*), …, (*4,1*) potentially can reduce the route. In Fig 11 the series of analysis of such pairs is shown by numerated arcs for the chain, comprising 7 patterns

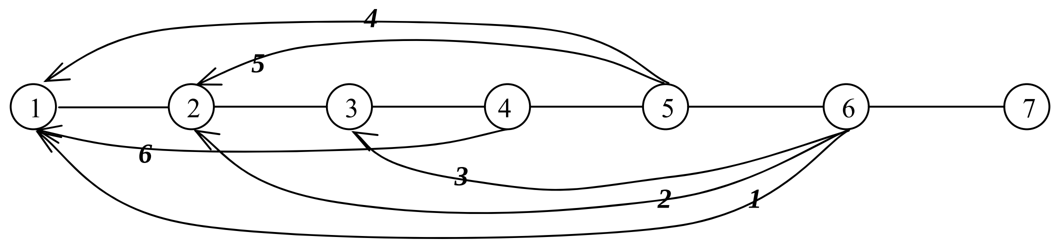

Fig. 11. Series of optimization variants by the criterion of chain length minimum

Characteristic feature of the suggested approach is considerable reduction of search space in the graph, since, applying the method of mathematical induction it is easy to prove, that the largest amount of variants V of route reduction of n links is not greater than arithmetic series

$$V = 1 + 2 + ... + n - 5 + n - 4 = \sum_{i=1}^{n-4} i \,. \qquad (19)$$

Conclusions. The given research shows that psycholinguistic notion of associative – verbal network within the frame of pattern thinking model is formalizesd in the form of graph with characteristic features of construction. Tacking into account these features the method of determination in the graph the chain of associatively interconnected patterns is considered, applying the criteria of route minimum length and maximum power of associative bond between patterns. Unlike the known methods of solution of similar problems of shortest routes search in graphs, the suggested algorithm simulates processes of pattern thinking of the man and reduces the search space from geometric series to arithmetic series. Formalization of the algorithm in the form of two – base algebraic system enables to construct recursively links of patterns chain and define main problem of the search – recycling if the route in the graph. Further problems to be solved by the given approach are algebraic formalization of:

- System reaction to recycling cases;
- Recurrent application of Find-operation in order to minimize the length of reference route.

Implementation and approbation of considered models was realized in education process at the Department of economic cybernetics and informatics of Vinnytsia National Technical University for preparation of electronic manuals for professional subjects. Existing photo type of the system was elaborated on the basic of Python-SQLite [8], which combines paradigms of object – oriented and functional programming with possibilities of enquiry SQL to relational data base.

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Bisikalo Oleg Volodymyrovych **–** Candidate of Science (Eng)., Department of Economic Cybernetics, Assistant Profssor.e-mail:. obisikalo@gmail.com, тел.: (0432)-439370.

Vinnytsia Stat Agrarian University.