

ASSOCIATION MEMORY MODEL USING THE NOTION OF "IMPORTANCE"

Weinzweig M.N.

The Institute of the Information Transmission Problems U.S.S.R.
Acad, of Science, Moscow, Aviamotornaya str., 8

The model is described in which the choice of notions out of the principal (long-termed) memory is determined by their connections with the notions of the contextual (short-termed) memory and by the importances of the notions at a certain moment. A molecular computer is suggested as a possible mechanism of the realization of such memory.

In simulating the problems of recollection and paying attention we shall consider human consciousness as an analogue of the arithmetical device of a trivial computer. Assume here that the notions which get in the field of attention, namely, the elements of the description of various pictures of the external world, the relations between these elements, general judgements about them, problems and etc. are processed by the consciousness mechanism in a way similar to that of the contents of the computer memory at the input registers of its arithmetical devices. Thus, for consciousness to operate in the necessary sequence a mechanism should exist which will supply consciousness with necessary information, that is to place into the field of attention some notions or other. This mechanism we call "the mechanism of paying attention".

Notions may enter the field of attention both from the organs of sense of a person and from his memory (the recollection process). In this case the human memory and the attention paying mechanism are arranged in such a way that they permit a person to find very rapidly a great deal of information

which is necessary at the moment. In particular, a person, as a rule, promptly recalls the situation possessing certain definite properties, finds laws which can be used in solving a given problem, recalls a way for the problem solution if the problem has been once solved. On this ground the idea is sometimes suggested that a human memory forms as certain hierarchical structure (a tree-shaped one or of some other kind) which permits a person to perform sequential checks in the branching knot and due to it excludes consideration of hopeless ways and at this expense allocs to find necessary information in a relatively rapid way. Still, the hypothesis based on the idea of the associative memory seems more probable to us.

Since the regularities obtained are described by a person, as a rule, in the form of statements it is but natural to assume that the statements are one of the main types of the memory elements.

In this case all the concepts contained in the statement can be regarded as naturally connected with this statement by means of including a record in a record and it can be suggested that the switching of attention occurs as follows. If the attention was called by a certain statement, and the latter was in some way transformed into other notions by means of the operators of the consciousness mechanisms (for example, divided into the notions of which it consists), then according to these notions (on the basis of these notions) a certain (connected with them) statement is chosen out of the memory

which contains those notions and the attention is switched over to this statement. However, there can be very many statements connected with the given notions. So the question arises as to which of them the attention should be paid to.

First of all, note that in dependence of the situation different notions (statements, in particular) are of different importance for a person; this importance can be interpreted as a prior (subjective) probability of the fact that he will manage to use this notion in solving some problems or other. The existence of the importance value of notions, as well as transformation of notions is a result of the action of the operators of the consciousness mechanisms. Here it is natural to suggest that this or that "importance" value is ascribed to each memory element and used on the stage of choosing them out of the memory into attention field. Thus, the solution of the problem as to which of the statements should be paid attention to will be determined not only by connections of the statements with the notions considered but by the importances of the statements as well.

Also note, that there exists "the attitude to the context" due to which the selection of notions the attention switches over to depends not only upon what the consciousness deals with at a present moment but also upon which has been recently spoken about.

Evidently, in general case, the very notion of "context" can be related not only to the information, emerging in the process of conversation, but to any other notion, which has been recently paid attention to. Thus, e.g., if we are asked: "Have you recently seen Pete?" - the image of Pete emerging in our consciousness proves in evitably connected with the image of the person

who is asking, as well as with the place where the question is asked and with what we have thought about before the conversation. We may know many Petes, and still, as a rule, the first Pete we think about is the one who is known not only to us but to our interlocutor as well. It is noteworthy that the process of search for the image of that very Pete operates, as a rule, out of our consciousness - no other Petes occur to us. This makes the probability of hypothesis of sorting the images of various Petes very small. We think it more plausible that out of the memory the statement is directly chosen which ascertains the very fact of Pete and the questioner being acquainted, i.e. which is connected both with the notion (image) of Pete and that of "the questioner" simultaneously. On obtaining this statement and dividing it into separate notions in our consciousness, we seem to be able to find among them the image of the very Pete which is known both to us and to our interlocutor. If there exist several Petes known both to us and our interlocutor, then we generate the image of the one who is in greater correspondence with the situation of the question; e.g. the image of the Pete whom we together with our interlocutor met at the place where the question is asked etc. So we can assume that out of the memory the statement is chosen connected with the image of Pete, and with the questioner and with the place where this question is asked. Thus, "the questioner" and "place of questioning" serve us as notions forming the context. It is noteworthy, that we can already pay no attention to these notion at the moment of questioning. At the same time it was quite recently that they have been in our consciousness and they are somewhere "at hand" now (have great importance), so that our attention can be easily paid to them. Stress that

these notions differ considerably in their functions from the statements which we recall for they are used to establish connections with these statements and to elicit them from the memory into the attention field. Therefore, it is natural to consider that such notions lie in a separate memory which we shall further call contextual memory (or just context) as apposed to the principal *memory* where the statements recalled are located.

Apparently, not all the notions in contextual memory are equal in rights. There are more important notions and less important ones. E.g., "the person questioning" is usually a more important notion, than "the place of questioning" (the former is easier to pay attention to), though generally speaking it may be just the other way around. This importance seems to tell upon the "weight" of the connections of these notions with the statements from the principal memory (the greater the importance of the notion, the greater the "weight" of its connection). Thus, we may consider that the probability of selecting a statement out of the principal memory is determined by the importance of this statement and by the total weight of its connections with the notions from contextual memory.

Seemingly the content of the term "connection" should be widened to some extent assuming that it is not only statements and the notions they use that can be connected, but also any other pairs of notions such that the record of one contains with itself the record of the other (words and their parts; pictures and their elements etc.). Then our finite concept of the memory arrangement can be summed up as follows.

1. There exist two types of memory: the principal and the contextual one. It is only from the contextual memory that the notions enter the principal

(long-termed) memory. The contextual (short-termed) memory gains the whole information from the organs of sense, and also all the results of the operation of the consciousness mechanism (in particular, the statements as to in which way and in which order the notions attention has been paid to were processed in a corresponding situation). In the attention field (the input register of the consciousness mechanism) the notions may enter both from the contextual memory and from the principal one.

2. All the notions in the principal and contextual memories are always ascribed with certain importance value (that is probabilities of paying attention to these notions, their connection with the context not being taken into consideration). To information from the organs of sense the importance is ascribed by means of specific (input) operators. To the other notions of the contextual memory the importances are ascribed by means of the consciousness mechanisms operators. The *notions* entering the contextual memory immediately enter the principal memory as well, but with a very small importance. In the course of time the importances of the notions in the contextual memory decrease; and with this their importances in the principal memory grow and finally achieve the values proportional (with a coefficient smaller than 1) to the initial importances in the contextual memory.

3. The probability of paying attention to the notions from the contextual memory is determined only by the importance of this notion in this memory. The probability of paying attention to the notions from the principal memory are determined by 1) the importance of this notion in this memory which defines the probability of choice without taking

into consideration their connections with the context; and 2) general importance of the notions of the contextual memory connected with it which enlarges the probability of choice.

Therefore, the probability of selecting notions out of the principal memory, connected with the notions of the contextual memory proves, as a rule, considerably larger than that of selecting any principal memory notion which has no such connections. Consequently, it is to the "necessary" notion that our attention switches over with large probability. In the frames of such a model we can also interpret many cases of the "frustration" of attention when the latter is paid to the notion which is not connected (or, weakly connected) with the notions of the context.

A Possible Mechanism of Memory Realization

Programmers might be dissatisfied by our hypothesis as to the arrangement of human memory. Indeed while realizing this arrangement at an ordinary computer the selection of the necessary memory element will demand scanning of the whole memory; that means that the search according to the hierarchical structure could be substantially more effective. Still, it nowise follows that the arrangement of human memory is realized in the same way as at an ordinary computer. In particular, from our point of view a molecular computer /1, 2/ could be the most accommodated for realization of this arrangement. The memory elements of such a computer are words-molecules, e.g. of DNA, RNA or proteins. In our case these molecules can serve as records of notions, in particular, of statements. The search for the memory elements is being done at the expense of the thermal movement of molecules, and the selection of a "necessary" element occurs at the expense of complementarity of some

regions of molecular surfaces to the surfaces of other molecules. As a result, the molecules corresponding to the attention field or to the notions from the contextual memory are stucked to by those molecules corresponding to the notions of the principal memory, the regions of the surfaces of which (e.g., some notions entering the statement) are complementary to the surfaces of the molecules constituting the attention field or the context. Therefore, the connection between the notions is established by means of complementary properties of the surfaces of the molecules corresponding to these notions.

Note, that in frames of such model the importance of the notions is naturally set in the form of the concentration of the molecules corresponding to this notions. The greater concentration of the molecules of the given type, the more probability of colliding with a molecule of this type. This is equally true of the molecules of both the principal memory and the contextual one; the only difference being the fact that the contextual memory molecules should be considered "cited up" to a certain place wherefrom they can easily transmit the "captured" molecules from the principal memory into attention field. Thereof the notions enter the consciousness mechanism which most probably is realized at the neuron level but not at the molecular level.

References

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