Innate Planning Mechanisms

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Abstract

In this paper, we will discuss whether there could be any means to bridge the gap between the Symbolic and Subsymbolic AI. One way to do this is to ask ourselves if human brain executes any planning algorithms. We see that we have taken a series of steps when we are done with planning in a situation. Taking a series of steps during planning might be a result of the execution of an innate planning algorithm. If we really are executing a planning algorithm, then we believe, its function is very general and is to set the conditions which will trigger a next step to take. A step to take might be the execution of an IF rule as an example. IF rule executions are not the only steps to take while planning, however, for simplicity, they are assumed as the only ones here. There is not any neuro-scientific evidence against the possibility that human mind incorporates an innate planning algorithm that triggers the next rule to execute (the step to take) yet. For that reason, in this paper we will investigate that possibility.

Keywords: Action sequencing, action associations, concept-action associations, emergence of association mechanisms

1 Introduction

Classical AI symbol systems are criticized basically for two points [Steels, 1996]:

1) Their problem solving functionality such as planning needs to be programmed by hand as opposed to evolving adaptive intelligent systems.
2) The symbolic descriptions of the reality need to be given to them.

As a result, there are already many studies where adaptive intelligent systems are evolved as opposed to being hand designed [Nolfi and Floreano, 2000]. There are also studies which reject the presence of any kind of representations [Brooks, 1991].

In [Steels, 1996] it is stated that most of the work assumes that there are abstraction facilities in neural networks or a new higher level dynamics that may emerge. However, none of the systems developed in this studies are yet able to achieve the high level capabilities of human beings such as planning and reasoning.

In this paper, we will consider the possibility of having an innate planning algorithm that sets the conditions which will trigger a next step to take. We will mainly consider task planning but not motion planning and navigation. In robotic literature, task planning is defined as the planning activity that calculates the order in which a robot should execute "actions" or "sub-tasks", in order to reach a specified goal. Assembly and "travelling salesman"-like jobs go into the task planning category.

The idea of having the innate algorithm is similar to the idea of having a traversal algorithm in Symbolic AI because a traversal algorithm, although is not as much general in function as the innate planning algorithm we are thinking of, shows a way to trigger the next action or step to take also.

An innate task planning algorithm might be what we need to borrow from Symbolic AI and if we do so then we can direct our studies to emerge the innate planning algorithm.

In Section 2, we will elaborate on the presence of rules in human mind with a movie planning example. Section 3 will talk about association of concepts with each other and with the rule in execution. We will explain the composition of the innate planning algorithm in this section also. Section 4 will be our conclusions.

2 Presence of Rules in Mind

The sentences we encounter either on paper, on computer screens or in spoken language are analyzed syntactically before we can actually get meanings out of them. This is managed by us using a set of grammar rules which have their mental representations [Jackendoff, 1993; Pinker, 1993].

We many times per day experience ourselves applying grammar rules while forming sentences. This becomes more obvious when we learn a new language. Although [Jackendoff, 1993] suggests a universal grammar inherited genetically in addition to other steps of learning a language, our point here is to keep attention to the fact that if we have grammar rules in our minds then we might have rules other than grammar rules represented in our minds as well.

How could it be inferred that we have other rules than grammar rules represented in our minds and what other importance does this have in addition to knowing we represent rules as well as symbols in our minds?

If we knew we did execute rules in our minds, we would be closer to inferring that we might also be capable of executing planning algorithms in our minds.

When I think about rather seeing a movie than attending a party this evening, the questions that occupy my mind are possibly the kind of movies that are on show tonight, whether there being any science fictions movies on or not, whether I have already seen them or not, whether the show times are too late or not and some more whether questions if not What, Which, Where and How questions. A "whether" follows a previous "whether". For practical purposes we will replace a "whether" with an "If" from this point on. It is true that one "if" might remind me of another "if". As an example, I might ask if there are any science fiction movies on and then this might remind me of a science fiction movie I have already seen and of its director and I might start wondering if I could find a movie for tonight which is directed by the particular director. However, regardless of one if leads me to another if or to other thoughts, it is definite that I am applying an IF rule as a part of my thinking process. These rules are represented in my brain in the form of various biological neuron patterns.

Planning for tonight is mostly dependent on our beliefs (what we already know about our world although our interpretations of the world might be different from reality), desires and intentions which are internal at the time of thinking although they might be produced as a result of earlier interactions of human beings with the real world. For example having already seen a good movie of John, we can believe that John is a good director. This particular belief necessitates having representation of the real person John internally as well as having the internal representations of concepts "good" and "director". Thinking that "John is a good director" demands us to refer to the concepts of "director" and "good" explicitly as well as the real person John at the time of thinking.

If we now go back to our discussion of having If rules represented in our minds, we can say that it is the case that first we find answers to conditional parts of an "IF" expression, such that we can apply the THEN part of the expression (rule). However, it is also possible that because of lack of information, we might suspend working on the conditional part of an IF rule and jump to another if rule or another thought. The execution of the new if rule might supply us with enough information to resolve the previous if rule so we can go back to the execution of the previous one and complete it. If we continue like this, we might come up with a list of things or ideas that we would want to achieve.

In the movie example, I might finally decide to go to the party instead, if I conclude that none of the movies on the show are interesting. On the other hand, I might have decided to go to see one of the movies at 7 o'clock but after having dinner in a nearby restaurant and yet meeting with a colleague in the mathematics department to deliver him his book I borrowed a week ago before that.

As a result, human brain actually might be acting like a computer which executes the steps of an algorithm while executing IF rules.

The statement that brain acts like executing the steps of an algorithm is a metaphor to the execution of an IF rule, suspending the execution of an IF rule and jumping to another IF rule, going back to the execution of the previous IF rule and so on. Each rule in the execution sequence can be inspired by the other and hence appear and take its term in the whole thought process.

If we consider all of the rules that are invoked during planning as a part of a rule search space, then there can be an *algorithm,* which decides which rule is followed by which rule.

It does not seem to be a mistake to consider each of these rules as corresponding to a node of a search tree in symbolic AI. We can also use symbolic AI tree search strategies (i.e. depth first, breadth first) as a metaphor for the type of algorithm we mention here. The algorithm can trigger other rules for execution than the one which is now in execution. It is possible that the first rule is triggered by a problem from the environment as well as by internal beliefs, desired or intentions.

Although planning, decision making or thinking happen in the frontal lobe, they are in tight communication with other parts of the brain in terms of retrieving other rules or symbols (from memory), sending back newly inferred rules and symbols (to memory), making associations between rules and concepts, activating motor cortex and other possible handling (actions).

3 Rule and Concept Associations

In a situation of making a decision, as above, between attending a movie and a party, IF rules seem to be applied and one IF rule seems to lead to another IF rule.

Following statement can be the very basic algorithm of our minds which invokes the next rule to execute:

"Execute the next associable rule while resolving the current rule or after the execution of the current rule is finished and do concept associations meanwhile".

This algorithm resembles a one step traversal algorithm that can be applied on a search tree but it is more general and since it considers associations of the current rule to other rules and concepts, it is situated in the sense that these rules and concepts are exposed to updates from environment.

In order to achieve the statement of the algorithm, we could possibly have yet other rules which actually form the algorithm itself. We will call these rules as meta rules to separate them from other IF rules. An example "meta IF rule" could tell our mind how to execute an "IF rule" as follows:

"Execute the preconditions of an IF rule first and then execute the THEN part".

If several IF rules are invoked by real world problems at the same time for simultaneous thoughts, the meta rule can be applied to each IF rule and two or more rule executions can take place in parallel.

Given the message of executing the preconditions first, the possible associations with the current rule and the other rules and concepts will be achieved.

From dynamical systems perspective, the meta rules will correspond to the laws of change [Holland, 1998] because these rules create the dynamism to execute new rules and make associations.

Concepts that are associated with IF rules refer to the mental states as described in [Dorffner, 1992] in our work. Concepts have non-linguistic representations and they are shaped by context and experiences of an agent who is forming those concepts. We extend this description of concepts to IF rules and assume them to be mental states also.

In Figure 1, an example for concept-concept associations is given. In the figure, "Movie" is a concept which has features such as "Name", "Date", "Time", "Seen before", "Type" and "Director". These features are also concepts. Each feature (concept) can have possible different values. For example date can be "Thursday" or "Tuesday". In fact, we see each feature value as a concept also.

The links between feature concepts to value concepts are absent or present depending on what value another feature has. For example, if "Name" feature has the value of "ET", "Date" feature will have a value of "Tuesday". However, if it is "XY", "Date" feature will have a value of "Thursday".

In this example, features, values and the "Movie" concept are part of a Movie context. However, "Date" and "Time" features can be part of another context such as delivering a book to the mathematics department on Thursday and before 4 pm. I might switch to the context of delivering a book while I am thinking about the date of a movie because "Date" feature is also part of the book context (Figure 2).

I can switch back to the Movie context when I decide that I should deliver the book today because it is Thursday. One of the movies, as an example, XY will supply all my conditions of seeing a movie tonight because it will activate the feature concepts of "Science fiction", "Thursday", "No", "John" and "7 pm". All these features can be connected by a node which represents an "And" concept and can lead to another concept which is "See the Movie". That is, we actually are executing and if rule which is:

IF (Type = "Science fiction" and Date = "Thursday" and Seen before = "No" and Director = "John" and Time = "7 pm") THEN See the Movie.

In the figures, arrows do not represent the spread of activations. They only represent which concept is related to which concept. Feature values given in the figure are the possible values only for the Movie context.

On the other hand, while building symbolic planning systems, researchers have encountered many problems such as frame problem, temporal projection problem etc. We ignore those problems and how their solutions could be within our work because we are not aiming at building a planning system that can plan as well as or better than the existing symbolic planners but we are questioning whether there can be any innate planning algorithms or not and if so what their role could be in human mind.

Finally, we will suggest that the innate planning algorithm is nothing but the application of the Hebb's rule [Hebb, 1949]. That is, some of the concepts in our minds are activated because of either external events or internal beliefs, desired and intentions. On the other hand, that activated concept or concepts activate another one depending on how strong or weak a link (synapse) between the current concept and the next concept is. Concepts can be part of rules and thus activation of another concept might mean activation of another rule.

4 Conclusions

We believe that existing research in artificial neural networks [Kohonen, 1984; Kosko, 1988], evolutionary computation [Nolfi and Floreano, 2000] and others [Prescott *et al.*, 2002] can be scaled up to form a computational model of human mind where the components of the model are rule representations, concept representations, concept-concept associations, rule-rule associations and belief, desire and intention representations. There are already studies in this direction [Cangelosi, 2004].

We also aimed at pointing to a similarity in terms of task planning between Symbolic AI task planning systems and a neural network task planning system which can be like the one presented in this paper. We believe that this similarity which points to a navigation in a rule search space while planning a task could be one of the means of bridging the gap between Symbolic and Subsymbolic AI.

The next step for us will be the implement the system described in this paper.

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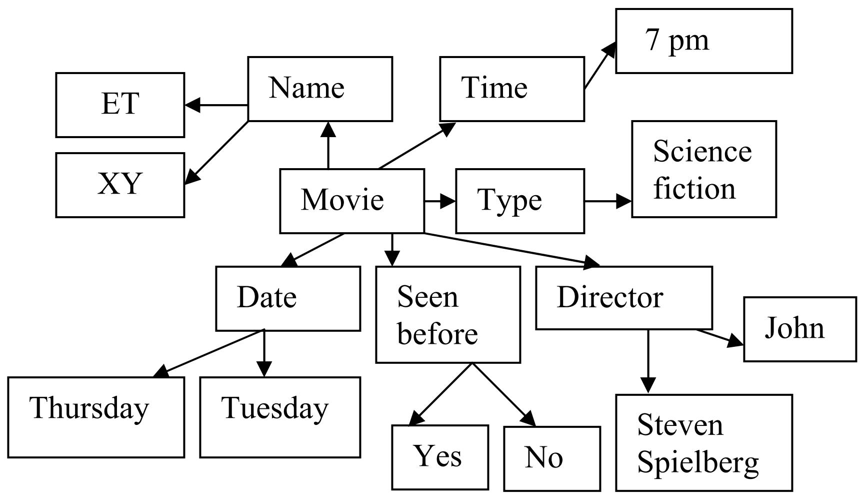

Figure 1. Concept to concepts associations

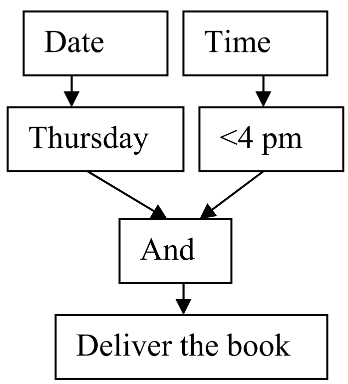

Figure 2. Concepts "Date" and "Time" remind of delivering the book.

References

[Brooks, 1991]Rodney A. Brooks. Intelligence Without Representation. *Artificial Intelligence Journal* (47), pages 139–159, 1991.

[Cangelosi, 2004] Angelo Cangelosi. The sensorimotor bases of linguistic structure: Experiments with grounded adaptive agents. In S. Schaal et al. (eds.), *Proceedings of the Eighth International Conference on the Simulation of Adaptive Behaviour: From Animals to Animats 8*, Cambridge MA, MIT Press, pages 487-496, 2004.

[Dorffner, 1992] Georg Dorffner. A Step Toward Sub-Symbolic Language Models without Linguistic Representations. In Reilly R. and Sharkey N. (eds.), *Connectionist Approaches to Natural Language Processing*, Vol. 1, Lawrence Erlbaum, New Haven/Hillsdale/Hove, 1992.

[Hebb, 1949]. Donald O. Hebb. *The Organization of Behavior: A Neuropsychological Theory.* New York: Wiley, 1949.

[Holland, 1998] John H. Holland. *Emergence From Chaos To Order*. Helix Books, 1998.

[Jackendoff, 1993] Ray Jackendoff. *Patterns in the Mind: Language and Human Nature.* Harvester Wheatsheaf, 1993.

[Holland, 1998] John H. Holland. *Emergence From Chaos To Order*. Helix Books, 1998.

[Kohonen, 1984] Teuvo Kohonen. *Self Organization and Associative Memory.* Springer Verlag, Berlin, 1984.

[Kosko, 1988] Bart Kosko. Bidirectional Associative Memories. *IEEE Transactions on Systems, Man, Cybernetics SMC-L8*, pages 49-60, 1988.

[Levine, 1998] Daniel S. Levine. *Explorations in Common Sense and Common Nonsense*. On-line book. 1998.

[Nolfi and Floreano, 2000] Stefano Nolfi and Dario Floreano. *Evolutionary Robotics*. MIT Press, 2000.

[Pinker, 1993] Steven Pinker. *How the Mind Works*. W. W. Norton & Company, Inc., 1993.

[Prescott *et al*., 2002] Tony J. Prescott, Kevin Gurney, Fernando Montes-Gonzales, Mark Humphries, and Peter Redgrave. The Robot Basal Ganglia: Action Selection by an embedded model of the basal ganglia. *Basal Ganglia* 7, Plenum Press, 2002.

[Steels, 1996] Luc Steels. The origins of intelligence. In *Proceedings of the Carlo Erba Foundation Conference on Artificial Life*, Milano, Fondazione Carlo Erba., 1996.