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REPRESENTATION METHODS IN AI SEARCHING BY GRAPHS

Angel GARRIDO
Facultad de Ciencias, Universidad Nacional de Educación a Distancia
Paseo Senda del Rey 9. 28040, Madrid, Spain
agarrido@mat.uned.es

ABSTRACT

The historical origin of the Artificial Intelligence (A I) is usually established in the Darmouth Conference, of 1956. But we can find many more arcane origins [1]. Also, we can consider, in more recent times, very great thinkers, as Janos Neumann (then, John von Neumann, arrived in USA), Norbert Wiener, Alan Mathison Turing, or Lofti Zadehfor instance [6, 7]. Frequently A I requires Logic. But its classical version shows too many insufficiencies. So, it was necessary to introduce more sophisticated tools, as fuzzy logic, modal logic, non-monotonic logic and so on [2]. Among the things that A I needs to represent are: categories, objects, properties, relations between objects, situations, states, time, events, causes and effects, knowledge about knowledge, and so on. The problems in A I can be classified in two general types [3, 4]: search problems and representation problems. In this last "mountain", there exist different ways to reach their summit. So, we have [3]: logics, rules, frames, associative nets, scripts and so on, many times connected among them. We attempt, in this paper, a panoramic vision of the scope of application of such Representation Methods in A I. The two more disputable questions of both modern philosophy of mind and A I will be Turing Test and The Chinese Room Argument. To elucidate these very difficult questions, see both final Appendices.

Keywords: knowledge representation, heuristic, graph theory, bayesian networks, A I.

1. Representation Problems

We can use a series of resources [4] to approach the problems in A I, *Logic, Rules, Associative Nets, Frames and Scripts.*

The election between these methods must be based in the own characteristics of the problem and our expectation about the type of solution [2].

In many cases, we take at a time two o more tools, as in the case of the Frame System, with participation of Rules, and so on.

2. Rules

About the usual way of appearance of Rules [2,4], as ***RBS*** (acronym of *Rule Based Systems*), we need four elements,

- *Interface of Usuary (I. U.)* - It will be very useful for the interaction with the usuary.
- *Motor of Inference (M. I.)* - It is devoted to the control of the flow of information between the modules.
- *Base of Facts (B. F.)* - It contains the initially known facts and created during the process.
- *Base of Knowledge* (B. K.) - Which contains the Rules used for the Representation of knowledge, into a determined Domain.

There exists a two-way flow: *from the M I to I U*, and *from M I to B A*, but only one between B K and M I, not in the reverse sense, except if we accept the system capacity of learning.

3. Inference in SBR

Such *Inference* consists of establishing the certainty of some statement, from the disposable information into B A and B K.

We have of two methods, *concatenation going forward* or *concatenation going backwards*

In the first case, we depart of Rules with verified affirmations in their antecedent, advancing through the affirmations which we find in their consequents.

Whereas in the second case, we depart of Rules verified in certain consequent (all the consequent must be also verified in this sense), and we turn back to the antecedent. This convert its affirmations in new sub-objectives for the proof, searching Rules where appear in their consequent, and so on.

The Rules shows a great advantage on the Classical Logic [3]. In the Classical Logic, as you known, the Reasoning was Monotonic, with inferences without contradiction with the pre-existing, in SBR.

Nevertheless in the RBS, we may delete facts or affirmations of the Base of Facts, according the new inferences.

This makes the Reasoning Non-Monotonic, because we can modify the conclusion. Then, appear a question: which we must to make with the conclusion of the affirmation now invalided?

For this problem [2], we need to introduce the concept of *Type of Dependence of a Rule,* which can be r*eversible.* If we delete the affirmations, then we delete automatically the above inferred facts.

Or i*rreversible.* If the facts, once inferred, it is not deleted neither changed.

And in the case of some applicable rules at time, which must be executed firstly?

Such Rules constitutes, in each step, the *Conflict Set* (obviously, a dynamic set)

The subjacent decision problem is called *Resolution of Conflicts* or *Control of Reasoning*

There exist different strategies, for to elect each time a Rule into the Conflict Set, as such *Ordering of Rules, Control of Agendas, Criterion of Actuality, Criterion of Specificity.*

About the first and the second, the commentaries are un-necessaries: they consist in the disposition of the Rules in the order as must be executed.

The *Criterion of Actuality* consists in apply first the Rules in whose Antecedent there exists the more actual information. The Motor of Inference must be charged of the control of their respective moments.

The *Criterion of Specificity* lead to execute, firstly, the more specific Rules, that is, that with more facts in its antecedent.

So, between

R_1*: if a, then b*

and

R_2*: if a and d, then c*

we must to select R_2, because it is more specific than R_1.

We also have of *Mechanisms of Control in RBS.* So, with

- *Mechanism of Refractority.*

So, we prevents to execute newly a Rule, once utilized, if do not exist more information which allow or recommend such (in general, anomalous) case

- *Rule Sets*.

It allows activate or neutralize Block´s Rules.

- *Meta-Rules.*

They are rules which treat (or reasoning) about other Rules.

Such Meta-Rules can collaborate in the Control of Reasoning, with the change or assignation of priorities to different Rules, according the evolution of the circumstances.

4. Frames

It is the more general and more integrating method, between all the Representation Procedures [2,4]. They permits introduce some different elements. For instance, by Rules, in Frame Systems. We denote such System as *FS.*

We must distinguish between *Facets,* as properties of the Field, and *Devils,* as procedures associated to the Frame System

Types of Facets

- *Defect value* - It is the value which we assign to the Field, when it is previously inexistent.

- *Multivalued* - *w*hen more than a value is admissible.

- *Restrictions* - They will be limitations on the values in the Rang of the Field.

- *Certainty* - It gives us the credibility of the values of the Field.

- *Interface Facets* - It allows the control of the interaction with the usuary.

Types of Devils

- *Devil of necessity* - To give a value, before inexistent, to the Field.

- *Devil of modification* - When it change the value of the Field.

- *Devil of deleting* - If the value of the Field is eliminated.

- *Devil of assignation* - It will be when we add the value to the Field.

- *Devil of access* - When we reclaim the value of the Field.

5. Scripts

They are structures of knowledge [2, 3, 4] which must organize the information relative to dynamical stereotyped situations, that is, ever or almost ever identical sequence of steps, or at least very similar. For instance, go to such cinema or such big store. The words and the subjacent ideas remember to movies.

The *elements of a Script* can be *scenes, roles, objects, places, names, conditions, instruments* and *results.*

Its signification is evident according their name: for instance, the Scenes must be events described sequentially, being necessary each scene for the realization of the subsequent.

With Results, we say the facts obtained, when we have finished the sequence described in the Script.

6. Searching Methods

We will distinguish between Blind Search Procedures and Heuristic Procedures.

In the first case, the oldest, it is possible to apply *Breadth Search* and *Depth Search*.

But with the trouble associated of Combinatory Explosion, which appears when the ramification index, or branching factor (the average cardinal of the successors of each node) increase without reasonable bounds. See the figures.

For this reason, it is necessary a more efficient procedure of search, by the introduction of heuristic functions, which give the estimation of the distance among the actual node and the final node. In such case, we said that will be the Heuristic Search.

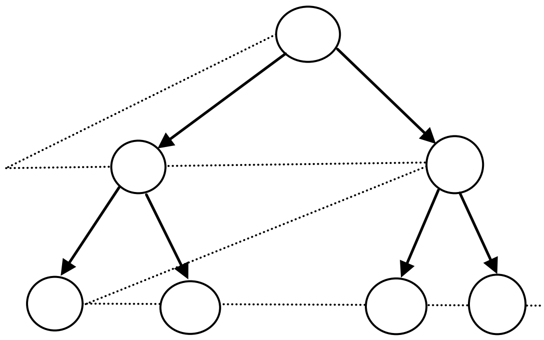

Fig. 1. Breadth first search = try the shortest path first

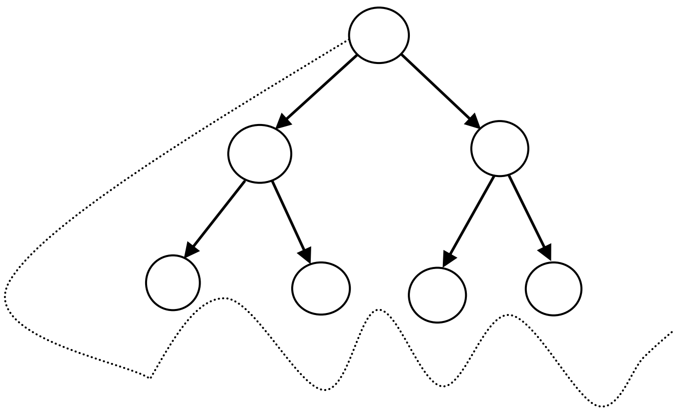

Fig. 2. Depth first search = follow a path as far as it goes, and when reach a dead end, return until the precedent node a "cul de sac" back up and try last encountered alternative.

7. Networks, or simply Nets

Between the Nets, the more actual studies to deal with Bayesian Nets, also called Belief Networks [3]. Before than their apparition, the purpose was to obtain useful systems for the medical diagnosis, by classical statistical techniques, such as the Bayes´s Rule or Theorem.

A ***Bayesian Net*** is a pair (G, D), with G a directed, acyclic and connected graph, and D a distribution of probability (associated with the participant variables). Such distribution, D, must verify the *Property of Directional Separation*, according which the probability of a variable does not depends of their not descendant nodes.

The *Inference in BNs* consists in establish on the Net, for the known variables, their values and or the unknown variables, their respective probabilities.

The objective of a Bayesian Network, in Medicine, is to find the probability of success with we can to give determined diagnosis, known certain symptoms.

We need to work with the subsequent *Hypothesis: Exclusivity*, *Exhaustivity* and *Conditional Independence.*

According the *Hypothesis of Exclusivity*, two different diagnoses cannot be right at time.

With the *Hypothesis of Exhaustivity*, we suppose at our disposition all the possible diagnosis.

And by the *Conditional Independence*, the thing found must be mutually independents, to a certain diagnosis.

The initial problem with such hypothesis was the usual: their inadequacy to the real world. For this, we need to introduce the Bayesian Networks (BNs).

In certain cases, as in the vascular problem of the predisposition to heartbreak, from the symptoms, there exist already reasonable Systems of Prediction and Diagnosis, as the DIAVAL Net.

Let *S* and *S’* two structures of Bayesian Networks (abridged BNs) on *V*. Then, we say that *S is equivalent to S’: S X S’*, if *S can represent every probability distribution which S’ represents and vice versa.*

An *essential graph* of a structure of BN, *S*, is a Partially Directed Acyclic Graph (PDAG) such that their *skeleton is the same that of S, and the essential edges (and only these) are directed.*

Let *C* be a class of Directed Acyclic Graphs (DAGs) Markov equivalent among them. Then, their essential graph would be the smallest *graph greater than every DAG that belongs to the class.* If we denote the essential graph as *G**, this is equivalent to saying

$$G^{*} = \cup \{G: G \in C\}$$

where such graph union is reached by the union of the nodes and edges of G:

$$V(G^{*}) = \cup V(G)$$

$$E(G^{*}) = \cup E(G)$$

So, G^{*} *will be the smallest of upper bound for all graphs of the represented class.*

8. Fuzzy Modeling

Fuzzy Logic can be conceptualized as a generalization of Classical Logic, dealing mathematically with imprecise information usually employed by humans. As a Multi-Valued Logic, it extends Boolean Logic, usually employed in classical science. Fuzziness describes event ambiguity. Hence, it measures the degree to which an event occurs, not whether it occurs, whereas Randomness describes the uncertainty of event occurrence. Whether an event occurs is random; to what degree it occurs is fuzzy. A linear combination like a fuzzy model is clearly understandable. The fuzzy model proposed by Takagi, Sugeno, and Kang (TSK, by acronym) is described through fuzzy IF-THEN rules which represents local input-output relations of nonlinearity. The main feature of a TSK fuzzy model is to express the local dynamics of each fuzzy implication (rule) by a linear system model. The overall fuzzy model is achieved by fuzzy "blending" of the linear system models.

Fuzzy Modeling is many times used to transform the knowledge of an expert into a mathematical model. The emphasis is on constructing a fuzzy expert system that replaces the human expert. Because a fuzzy model represents the real system in a form that corresponds closely to the way humans perceive it. Thus, the model is easily understandable, and each parameter has a readily perceivable meaning. The model can be easily altered to incorporate new phenomena and if its behaviour is different than expected it is usually easy to find which rule should be modified, and how. Furthermore, the mathematical procedures used in fuzzy modelling have been tried and tested many times, and their techniques are relatively well documented.

9. Fuzzy Optimization

The Mamdani method is the most used in applications, due to its simple structure of “min-max” operations. It proceeds in four steps, evaluate the antecedent of each Rule; obtain each Rule´s conclusion, aggregate conclusions, and defuzzification. If we only take into account the factors that really matter in the problem, it is enough to write a set of rules that model the problem. Another advantage of using the fuzzy approach [2] is that, should we want to add more variables to the problem, all we would have to do is write new rules or edit the existing ones. This means a lesser amount of effort than rewriting an algorithm. So, Fuzzy Logic is adaptable, simple and easily applied. Mamdani´s method is useful when there are a very small number of variables. Otherwise, we will find certain difficulties, as may be: the number of rules increases exponentially with the number of variables in the antecedent; the more Rules we construct, the harder is to know if they are suitable for our problem; and if is too large the number of variables in the antecedent, it results difficult to understand the causal relationship between them (the antecedent and the consequents); hence, constructing new Rules may be harder. The second Fuzzy Inference method was introduced by Takagi, Sugeno, and Kang (TSK method, by acronym) in 1985. It is very similar to Mamdani´s method in many respects. The first two steps are the same. The essential difference between them is that in Sugeno method the output membership functions are either constant or linear. Also we can consider the Tsukamoto Fuzzy Model, where the consequent of each fuzzy IF-THEN rule is represented by a fuzzy set with a monotonical membership function.

10. Final appendices

And to conclude, we give the analysis of both announced questions, *Turing Test* and *Chinese Room Argument.*

APPENDIX I

The Turing Test (TT)

An interrogator is connected to one person and one machine, via a terminal, and therefore cannot see their counterparts. Its task is to find out which of the two candidates will be the machine, and which will be the human, only by asking them questions. If the interrogator cannot make a decision within a reasonable time, then the machine is considered to be intelligent.

The most important argument against the TT is that indeed only provides a test for human intelligence.

APPENDIX II.

The Chinese Room Argument

John Searle´s argument [5] is intended to show that *implementing a computational algorithm that is formally isomorphic to human thought processes cannot be sufficient to reproduce thought.*

Something more is required. So, it will be considered a refutation of both, Turing Test and Functionalism.

It begins with this hypothetical premise:

Suppose that A I research has succeeded in constructing a computer that behaves as if it understand Chinese. It takes Chinese characters as *inputs*, and produces other different characters, which it presents as *output*, by following the instructions of a computer program.

It attempts to refute a certain conception of the role of computation in human cognition.

To understand this argument, it will be necessary to distinguish among *Strong A I*, and *Weak (or Cautious) A I*

According the first of them, any system that implements the right computer program with the right inputs and outputs thereby has cognition in the same sense those human beings.

According the second of them, the computer is nothing more than a useful tool in studying human cognition, as in studying many other scientific domains.

The contrast is that according the Strong version, *the correct simulation is really **a mind***

Whereas according to the weak version, *the correct simulation is <u>only</u> **a model of the mind***

Its proof contains three premises and one conjecture:

AXIOM 1

Implemented programs are syntactical processes.

I.e. computer programs are formal (syntactic).

AXIOM 2

Minds have semantic contents.

I.e. human minds have mental contents (semantics).

AXIOM 3

Syntax by itself is neither constitutive of nor sufficient for semantics.

CONCLUSION

The implemented programs are neither constitutive of nor sufficient for minds.

Therefore, according to Searle [5],

Strong A I is false.

But the Chinese Room Argument may be expressed by two basic principles, each of which would be stated in four words,

1st.) Syntax is not Semantics.

Because syntax by itself, is not constitutive of semantics, nor by itself sufficient to guarantee the presence of semantics.

2nd.) Simulation is not duplication.

The *Chinese Room Argument* comprises a thought experiment, and associated arguments by John Searle [5].

It attempts to show that any symbol-processing machine (in particular, any computer) can never be properly described as having a “mind”, or “understanding”, regardless of how intelligently it may behave. Suppose which both, we and a computer, are in two closed, different rooms, having a book (a dictionary can be) with an computer program, with sufficient number of pencils, erasers, papers, and so on. But both without any knowledge on Chinese.

We receive from the exterior a paper each time, with Chinese characters, processes them according to the program´s instructions, and produce an answer in Chinese characters as output.

Each is simply following a program, step-by-step, which simulates intelligent behaviour.

We cannot describe what the machine is doing as “thinking”. And neither the human operator understand a word of Chinese. Therefore, we must infer that computer does not understand Chinese either.

Thus, Searle concludes,

Strong (but not Weak) AI is a mistake.

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