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PERSPECTIVE ON SIMULATION OF CONCEPTUAL KNOWLEDGE

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Abstract- The paper discusses a principle existence of computer models of the chess game concepts by linking them with classes of winning positions in the game tree specified by Zermelo's method. The requirements to simulation environment necessary for concepts representation and formation as well as further research issues are discussed.

Keywords- knowledge representation, learning, game tree, chess, strategy

Introduction

We intend to advance in our understanding of human knowledge and its adequate computer simulation. Usually, the concept of knowledge is approximated as solutions of problems, components of the solutions or any of their descriptions as well as any procedure or record acquired by systems in a way that improves their performance. The mechanisms responsible for knowledge processing, i.e. its formation, learning, transformations, transmission, communication, etc., are associated with the *mind, or the intellect.*

The mind is considered as one of the basic categories that different views and beliefs identify in the human nature. They distinguish between its spiritual and *material* components along with the following categories:

spiritual: the *will*, the *soul*, the *mind/intellect*

material: the *mind/intellect*, the *desires/instincts*, the *vitality/energy*, the *body.*

The most exciting categories are, of course, the will and the soul but our knowledge about them, unfortunately, is too hypothetical yet to come in to tangible models. Intuitively, some links between "the will" and *consciousness* are not excluded.

The inborn desires and instincts are considered as inherited knowledge preserving basic survival goals. The performance of instincts is interpreted as passions and emotions. Artificial Intelligence say a lot about the material mind and, actually, the computers allow to simulate many symbolic procedures that are typical for human intellect higher than about 7 years old.

However, along with progress in modeling systems, the attempts to advance in simulation of early childhood abilities face principal barriers. Some researchers explain those barriers by symbolic nature of computer simulation which makes principally impossible to adequately represent the inborn and early childhood abilities which is considered as a bottom part of the iceberg of human abilities. There is an ongoing long time discussion about the nature of human image processing and its adequate simulation between the followers of the view on universal "coverage" of the "seeing by mind" against the proponents of irreducibility of the image based depictive thinking to the prepositional one.

Another view of the mind refers to a religious or some other belief based interpretations emphasizing the importance of the spiritual mind which is performed as a tiny intuition of not ordinary intellectuals allowing them to communicate with the World Mind for learning of not directly experienced knowledge. Because the intuition is associated also with the functions of the right hemisphere of the brain, more tangible physical models of new knowledge discovery are possible. In general, while interpretations of material categories of human nature already have some adequate models, and our understanding of early childhood and spiritual intellect abilities are approaching the level of constructive hypothesis, the categories of the *will* and the *soul* stay far away from understanding.

We plan to progress in understanding of knowledge processing aspects of the mind by separately focusing on the above-mentioned inherited, learned and intuitive types of knowledge. We aim to consider a comprehensive repository of *communicable* expert knowledge for a typical representative of an important and wide class of problems for answering the following principal questions:

Whether it is possible to find an adequate computer representation for an "alive" fragment of expert knowledge associated with solving problems of a target class?

Whether it is possible to reproduce, or learn, procedurally with an acceptable computational complexity the expert knowledge associated with the problem?

Answering to the first question will either strengthen our belief in computer simulation of the mind, or illuminate the kinds of human knowledge that principally cannot be computerized.

The second question can help to turn our principal understanding of expert knowledge into constructive models of knowledge formation.

To advance in the knowledge representation and formation problems we take as a guiding line the Jean Piaget's theory on developmental psychology. Human knowledge by Piaget is comprised from *schemas of exterior actions* (like catching, sucking, etc. ones) and *cognitive structures* - compositions of interior operations (like arithmetic, logic, quantity and size understanding, etc.).

The development originates from the inborn schemas of actions enriched to about 2 years old period by acquired schemas which are continuously transiting to the up about 11 years old preparation stage of development of elements of cognitive structures completed to the 15 years old period by forming structures of abstract and symbolic thinking. Further development is going on by enrichment of the amount the structures of those kinds.

There is a unified mechanism of development - a *meta* procedure, that has as the outputs those schemas and structures. It is *organized* from the components responsible for *adaptation - assimilation* and *accommodation*, and *equilibration* where assimilation is responsible for the process of involvement of new problem situations and their solutions into old or modified schemas and structures , accommodation constructs new schemas and structures when the assimilative abilities were not enough for adequate representation of the realities, and equilibration is responsible for converging the process of adaptation to the final adequate solutions of the problems.

While that model covers human procedural knowledge, particularly having form of concepts, there is no room to explain:

- How we address consciously or not to memorized depictions which some patients during operations on the brain could reproduce with arbitrary details, and
- How our associations and intuition mechanisms act.

They were reasons we find useful to consider the modified Piaget's model where in addition to the above procedural forms of knowledge processing it is supposed a repository for storing depictions, precedents, objects and other not generalized, closed to the original realities their individual or detailed presentations.

The Piaget's view on the development of cognitive structures in its concepts formation projection can be identified as the *Concepts Unified Formation* problem where simulation of a unified procedure of development of concepts is required and its interpretation and correspondence to the cognitive structures of Piaget's mechanisms are desired.

As a step to approach to the CUF solution we identify the *Concepts Adequate Simulation* problem where achievement of max adequacy of concepts simulation is required. In its chess interpretation we consider the *Understanding Expert Request in chess* (UER chess) problem to concretize the research goals and examination of the results.

The UER chess problem is similar to an analog problem of understanding instructions by robots. It seems promising to link models of chess concepts in the UER chess solution with the *chunks* to answer whether models of concepts correspond to the chunks and are common for players or are individualized.

Combinatorial Game Tree Problems and Positions Winning by Zermelo

We study class of problems where the *Solutions Space* is specified by combinatorial *Game Trees* (SSGT). Many security and competition problems belong to SSGT class. Specifically, these are network Intrusion Protection Optimal Strategy Provision (IP OSP) and Management in oligopoly competitions (MOSP) problems, chess-like combinatorial problems -Chess OSP, etc.

Many other security problems such as Computer Terrorism Countermeasures, Disaster Forecast and Prevention, Information Security, and Medical Countermeasures, may also be reduced to the SSGT class.

SSGT problems are identified in a unified way by game tree constituents, which create the base for a unified methodology for their resolution. The constituents include, particularly, the list of competing parties and their goals, their actions and (contra) actions, states of trees and rules for their transformations.

For the Chess OSP problem the GT constituents are determined as the following:

- White and black players with checkmate as the goal,
- Chess piece moves as (contra) actions and
- Composition of the chess pieces on the board as specific game states transformed by actions corresponding to chess rules.

Zermelo in 1912 [17] proved the theorem that all chess positions are strongly divided into three classes: winning, losing or drawing. If the descriptions of the above classes were available with an acceptable complexity form the perfect game player would be possible. The theorem's proof technique is the base of current the most successfully used strategy search min max algorithms. Using the same technique similar statements can be proved for other SSGT problems.

Problems Requiring Adequate Models of Human Knowledge

Problems with human independent formal specifications, like problems of mathematical optimization, program synthesis, improvement, etc., may deliver knowledge on a variety of types but say little about the nature of human knowledge.

That is why further progress in human knowledge understanding we associate with studying the problems where the quality of target solutions is determined by the adequacy of models of human knowledge imbedded in those solutions and being inseparable from them. Corresponding class of problems, named Solvable by Adequate Models of Human Knowledge, includes, particularly, problems where solutions have to be learned by systematic acquisition of human knowledge in a given application area.

A pioneer research of strengthening the performance of chess programs simulating the process of chess masters decisions by systematic acquisition of human knowledge was studied in which induced two important problems:

- To form a variety of adequate models of human concepts
- To build a program able to acquire human concepts.

We consider the problem of Understanding Expert Requests in chess (UER chess) where masters would like to get positions from a chess repository making requests in the language of chess masters.

Chess Concepts are Personalized and Quasi Specify Zermelo's Classes

Let us link concepts with classes winning by Zermelo because for defeat and draw ones similar links can be induced by analogy.

Winningness of positions, in general, is determined by winning strategies those positions are able to induce. The only exclusion is "Mat" positions where winningness is determined by a few attributes calculated either statically or by one-two plies. The attributes are the following:

K(ing) is under check, K can't escape, K haven't defenses.

Being constituents of corresponding "Mat" concept those attributes acquire their own values of winningness induced by maximum value in chess - winning positions. It is evident, that winningness utility in positions provides not only two extreme "yes" or "not" values of those attributes but also values intermediate between those poles.

Analogically, similar generalization is natural to spread to other than King pieces as well as to squares where pieces may be located. Expanding the ranges of values and definitions of the attributes in a natural way [Table-1] we get the scales where not only their max and min values but intermediate ones, too, become meaningful respectively to utilities they are associated with.

For the King	For a piece X	For a square S
K is under check (threats, capture)	T(x): set of pieces threatening to capture X	Ts(x): set of pieces threatening to S
	A(x): set of pieces attacking X	As (x): set of pieces attacking S
	Cby(x): set of pieces threaten to capture by X	
K haven't defenses (defenseless)	D(x): set of pieces defending X	Ds(x): set of pieces defending S
	Dby(x): set of elements defended by X	
K can't escape (suppression)	M(x): set of moves available to X	

Table 1- Attributes providing utilities to elements of positions

In view of our analysis of the Repository the chess concepts identify elements or configurations of elements of positions *having tangible winning utility.* Hence, chess concepts become elements of specifications of winning by Zermelo positions what argues for possible their simulation.

The concepts can only indicate some possible utilities for further deeper analysis and estimate. An uncertainty is a priory in their nature caused partly by limitations of chess players' static or quasi dynamic analysis of the winningness of positions and partly as a consequence of an individualized way in formation of concepts.

It is worth to accept that using the same names for the concepts players along with concepts having common strong meaning have, in general, not equal interpretations for many other ones and their individual representations coincide only in some "skeleton" parts. That doesn't create big casualties due of an intermediate preliminary usage of those concepts in analysis of positions.

As a consequence of that generic uncertainty in representation of concepts it is worth to formulate the UER chess problem in a way allowing both forming concepts with strong common meaning and ones that exist in the forms individualized to the particular players. Correspondingly, adequacy of the models of concepts have to be examined taking into account those individualized representations of concepts.

Conclusion

It was argued that concepts of the Repository specify in an individualized and quasi way the classes of winning by Zermelo positions which provides additional reasons to possibility of their computer simulation. The rest of the Repository - plans, ideas, attributes, etc. by our preliminary analysis specify another tangible constructions of the game tree - the winning strategies, what can be simulated. Current experiments aimed to prove those assertions.

If experiments are successful the following corollaries can become true.

1. Essential part of chess Repository - concepts and specifications of winning strategies, in principle, can be simulated by computers. Further enrichment of the Repository by new simulated units will either add new evidence in power of computers or face to principal difficulties in simulating some types of expert knowledge. The psychological and intuitive chess knowledge can be one of main types of knowledge to illuminate the edge of computer simulation.
2. It can be expected that concept and strategy knowledge of the SSGT problems can be simulated because simulation of chess knowledge was induced by their reduction to constructions of the game tree and the game trees are the base for other SSGT problems.

Chess conceptual and strategy knowledge simulation add arguments to favor of simulation of learnable knowledge not only for the SSGT problems but for wider class of them because, usually, the problems can be represented in form of games as well as to the power of prepositional form of simulation.

Conflicts of Interest: None Declared.

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