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A CONCEPTUAL MODEL FOR ONTOLOGY BASED LEARNING

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Abstract: *Utilizing learning features by many fields like education, artificial intelligence, and multi-agent systems, leads to generation of various definitions for this concept. In this article, these field's significant definitions for learning will be presented, and their key concepts in each field will be described. Using the mentioned features in different learning definitions, ontology will get presented for the concept of learning. In the ontology, the main ontological concepts and their relations have been represented. Also a conceptual model for learning based on presented ontology will be proposed by means of model and modeling description. Then concepts of presented definitions are going to be shown in proposed model and after that, the model's functionality will be discuss. Twelve main characteristics have been used to describe the proposed model's functionality. Utilizing learning ontology to improve the proposed conceptual model can be used also as a guide to model learning and also can be useful in different learning models' comparison. So that the key concepts which can be used for considered learning model will be determined. Furthermore, an example based on proposed ontology and definition features is explained.*

Keywords: *Conceptual Model; Learning, Memory, Modeling, Ontology.*

I. INTRODUCTION

Complex phenomena can be always represented simple through eliminating some details. Although during this process some effective parameters in the main phenomena might be ignored, but these simplifying results in a better understanding of concepts [1]. This process has been settled for a relatively broad range of natural phenomena to social systems like neural networks, stock market, and social changes. Different reasons can be found for eliminating a phenomenon details from which, some can be noticed as, failure to identify all the parameters involved in a problem, inability to represent all parameters and unknown factors in a phenomenon [2].

As a common cognitive phenomenon among all the organisms, learning has been always considered by different fields [3]. The lack of a common expression for learning in different sciences such as psychology, behavior, cognitive science, sociology, philosophy, education, and artificial intelligence has led many definitions and different concepts of learning to be provided [4]. Therefore, there are various models of learning. Focusing on represented descriptions, different aspects and various parameters of this phenomenon be recognized and as a result, a better understanding of relations between different components can be achieved [5]. This can lead to a comprehensive concept in this regard. This concept is to be efficient in representing a suitable model and it would also reduce the errors [6].

In the following sections, at first different learning concepts will be expressed and some of definitions will get represented and after that, efficient components within them will be described. Then different modeling methods will be considered and the significance of ontology in modeling will get clarified and consequently, learning ontology will be represented and ultimately the proposed model will be presented and described according to the represented ontology. Finally, an example based on mentioned features will be described.

II. LEARNING CONCEPT

Broad use of learning in different fields led to different definitions of learning. Based on the applications and needs, each definition focuses on different concepts as learning. So representing a common concept of learning seems to be difficult. Having a conceptual model of learning can be helpful in solving relative problems of learning effectively. To

reach the concept of learning, significant definitions in different fields should be considered.

A. Learning Definitions

Definition 1 (Encyclopedia Britannica): "the alternation of an individual behavior as a result of experience" [7]. This definition indicates to development of reflexes, emergence, evolution, and knowledge acquisition is not considered.

Definition 2 (New Webster Dictionary): "learning is a knowledge or skill acquired by study in any field" [8]. In this definition learning is a process depends on environment and presumes getting the information validity by an acceptable level of belief.

Definition 3 (G. A. Kimble): "Learning is a relatively permanent change in a behavioral potentiality that occurs as a result of reinforced practice" [9]. The new characteristic in this definition is potentiality. The potentiality needs somewhere for storage, therefore memory is a necessary unit for learning.

Definition 4 (Y. Tsypkin): "Under the term learning in a system, we shall consider a process of forcing the system to have a particular response to a specific input signal (action) by repeating the input signals and then correcting the system externally" [10]. This definition given by specialist in control theory and has a conceptual relation with biological learning like reinforcement learning.

Definition 5 (M. I. Shlesinger): "Learning of image recognition is a process of changing the algorithm of image recognition in such a way as to improve, or maximize a definite reassigned criterion characterizing the quality of recognition process" [11]. In this definition learning is considered as improvement and optimizing.

Definition 6 (H. A. Simon): "Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn from the same population more efficiently and more effectively the next time" [12]. In this definition the reasons of learning is improvement of behavior. Therefore behavior generation and improvement in it considered as a fundamental characteristics of learning.

Definition 7 (M. Minsky): "learning is making useful changes in the working of our minds" [13]. The focusing of this definition instead of behavior is on knowledge acquisition. The mind considered as a metaphor.

Definition 8 (R. Michalski): "Learning is constructing or modifying representation of what is being experienced" [14]. The main focus in this definition is representation and the learning mechanisms are not considered

B. Necessary Characteristics for Learning

Each of these definitions focus on some specific aspects of learning and the other aspects will be disregarded by them. Churchland's definition could almost cover those ignored aspects, and from his point of view [15], learning should have the following characteristics [16]:

1. Process of obtaining a skill (here skill means behavior generation program).
2. Produce alternation of an individual behavior (alternation means the program could be changed).
3. Produce change in a behavioral potentiality (potentiality indicates to store the program).
4. Develop an inner program better adapt to its task (the term better indicates that goodness of performance should be measured).
5. Enable a task to be performed more efficiently (the term efficiency indicates that goodness of performance should be measured).
6. Change the quality of the output behavior (the term quality indicates that goodness of performance should be measured).
7. Make useful changes in mind (the term useful indicates that goodness of performance should be measured).
8. Construct or modify representations (the term construct indicates the ability of storing and creating a new program).
9. Be essentially an act of discovery (to create a new program).
10. Form new classes and generalized categories (generalization provides the formation of new programs).
11. Changing the algorithm (here algorithm is similar with the program).
12. Force the system to have a particular response to a specific input signal by repeating the input signals.

The definition has all the above characteristics had presented by A. M. Mystel and J. S. Albus [16]. Definition 9: "Learning is a process based on the experience of intelligent system functioning (their sensory perception, world representation, behavior generation, value judgment, communication, etc.) which provides higher efficiency which is considered to be a subset of the (externally given) assignment for the intelligent system" [16].

III. MODEL AND MODELING

Modeling is the process of generating an abstraction out of existing phenomena which had been first presented by Archimedes. This abstraction can be conceptual, graphical, and or mathematical [17 and 18]. Modeling is the dominant and inseparable part of

scientific activities and each science branch has its own specific basics for that and also follows the principles of its own field [19]. Generally a model tries to show an experimental matter, a phenomenon, or a physical process, in a logical and objective way. Despite all mentioned differences, almost all models operate as similar methods; providing a simple reflection of reality [20]. Although the explicit and right display of a phenomenon seems to be impossible but disregarding inherent error in every model, modeling is a useful process because provides the possibility of a having a simpler perception from phenomena and exchanging them. In order to have a more accurate consideration, modeling methods and also a model's characteristics should be represented. In Stachowiak's point of view [21], a model should have three features below [19]:

1. Mapping feature: A model should be based on an original.
2. Reduction feature: A model should just show selected characteristics of the relevant original.
3. Pragmatic feature: A model should be usable to reach some goals in the original place.

If a model is noticed as a projection, the two first features will be achieved together and they both refer to the two things which are to be the projection (original). In a projection represented by a model, some information would be lost through abstraction and what remains depends on the modeling ultimate goals. The third feature presents details of a model's practical use in a highly precise way.

Another kind of modeling called Cognitive Modeling is used for understanding cognitive concepts like the concept of learning. This can be percept that Cognitive modeling is somehow behavior modeling which inherent and acquired knowledge and also the action plans are getting modeled through that. Given the descriptive nature of many of the concepts in the areas of cognitive, a conceptual model expressing main features and their relationships can be useful [22]. According to Mylopoulo's idea, "Conceptual model gives an explicit description of some physical and social aspects of our world and is used for understanding and communicating" [23]. Looking from this angel, conceptual model can be considered as a process whereby people discuss, reason, and communicate about an especial field to achieve a common perception. Enormous techniques have been represented for modeling which shows the importance of conceptual modeling. Yet having such number of techniques causes another challenge, which is the method of evaluating their efficiency. A conceptual modeling language is made up of a set of structures which have been often displayed by a graphic symbol or includes the rules used for representation. This set of structures and grammar rules form a conceptual modeling. Selecting structures and rules in different modeling techniques are a reflection of the work scope nature which is to be represented [24].

Conceptual modeling techniques mostly focus on modeling the real world. From this point of view, this kind of modeling is relevant with the ontology. According to conceptual modeling, ontology is a set of concepts and their relationship about problems which are already existed or have happened in a determined field. In the next session, ontology and its importance in modeling will be considered.

IV. THE IMPORTANCE OF ONTOLOGY IN MODELING

Ontology is "the science of what is, of the kinds and structures of objects, properties, events, process, and relations in every area of reality" [25]. Totally, ontology is the study "of what might exist". Therefore, its definition includes the domain analysis, recognizing main ontological components (objects, qualities, features, relations, and processes), and operations which acts on the ontological components [26]. In [25], ontology has been proposed as a suitable context for comparison among basic agent modeling. Considering ontology's presented definition, figure 1 displays the relation between ontology, modeling, and simulation. Each model is based on an ontology however not expressed explicit and clearly. Also every simulation is to be done according to a model. So this can be said that ontology is formed based on theories, concepts, and relations between concepts and on the other hand, is the fundamental base of modeling and simulating.

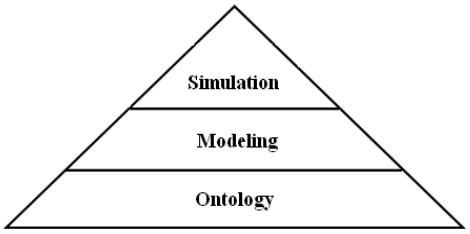

Figure 1: Ontology as Fundamental Base of Modeling and Simulation.

There is a subtle difference between modeling and cognitive theory. In general, a cognitive theory is to consider about which concepts are in relation with each other (what), while model examines the way of communication between components (how) [22]. Moreover, model is typically more formal and presents precise and considerable relations and predictions. While in the field of humanities, a theory may be derived from several different models and be correct for a theoretical sample [19]. So this can be mentioned that although theory implies an ontology but it is stronger, more specific, more general, and more abstract than model. For instance, physical laws could

have implications on ontological relations between entities but these laws describe relations in more detail while ontology just talks about which ontological kind of components are needed. In fact, different theories can have a same ontology [27].

Furthermore, ontologies can be used to represent different domains; there is a high need for efficient ontology matching techniques that can allow information to be easily shared between different heterogeneous systems [28].

V. ONTOLOGY OF LEARNING

Considering learning definitions, concepts and various components are effective on learning formation. These concepts can be used to represent learning ontology. Learning ontology deals about the learning concept; which main concepts and components have formed learning; what kind of relations do they have; and what operations act on the main ontological components.

Considering different learning descriptions, the main concepts below have been determined to form learning: communication with the environment (perception), experiment, repetition, changes and reformations according to improvement, optimization (minimizing the error), adaptation, memory, knowledge representation, evaluation and judgment, reward and punishment (excitation and inhibition), discovery and feedback. Using these main components and their relations, ontology has been presented for learning concept in figure 2.

Bold lines (without dashes) are to emphasize on main component in learning. Some concepts are describable using other concepts. For example, a feedback concept in learning can be defined by the combination of two concepts of repetition and evaluation. The important point in presented ontology is that this ontology is a primary ontology of learning. Therefore, learning concept can be expanded with further focus on it.

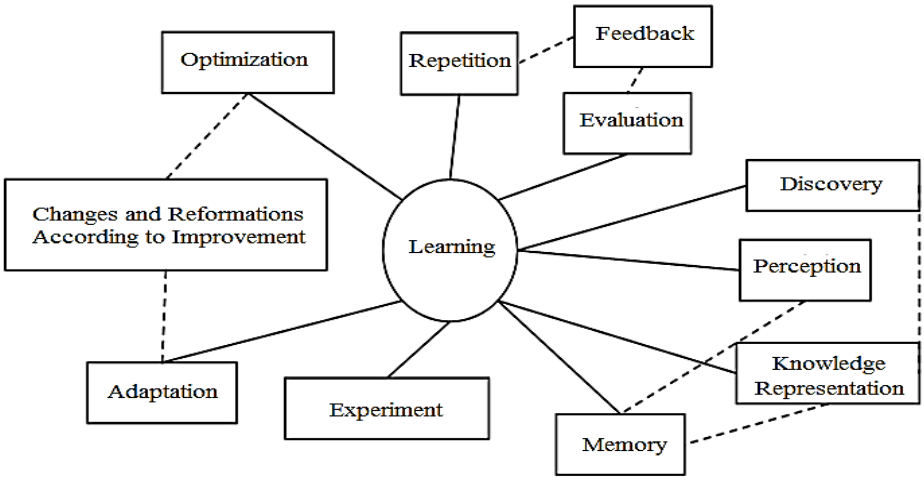

Figure 2: Proposed Ontology for Learning According to the Main Components of Different Definitions.

VI. CONCEPTUAL MODEL OF LEARNING BASED ON PROPOSED ONTOLOGY

A part of ontology is an operation which is defined on ontological components. In this paper, operations acting on learning ontological components have been represented in the form of a conceptual model. In another word, the proposed model represents learning process according to the learning ontological components. A cycle has been intended for learning in this proposed model. This cycle refers to the concept of repetition in learning ontology. It begins with perception, which means sense of environment and the world around. After that, sensed data will have an initial process in order to form the information. So in this stage, the sensed data is converted from perception to information. At the stage of representation, information will be represented in the form of knowledge. Here, perception of the environment or perception in general, is to be represented in a more abstract way. These three steps are relevant with the concept of memory (storage) which means that sensed data, generated information, and represented knowledge will be stored even temporarily. New concepts can be derived from the represented knowledge. These new concepts are to cause some former data to get confirmed or get more confirmed and some other to lose a part of their validity or become totally invalid. In another word, the concept of change and reformation has been mentioned in this part of conceptual model. Changes and their consequences will be evaluated and represented in the form of interpretation and the result of this interpretation is considered as a new perception. This new interpretation is to be effective on the way of environmental sense, because somehow it directs the level of consideration about environmental data more. The proposed model is presented in figure 3.

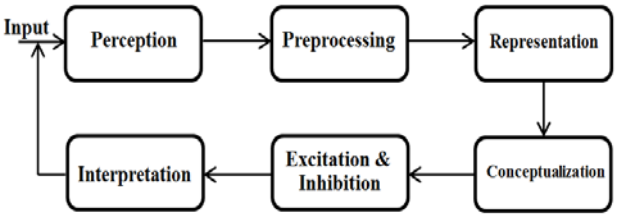

Figure 3: Conceptual Model of Learning Based on Proposed Ontology.

Considering that by beginning learning, learning process will be go on until the end of system or agent's lifetime, the cycle is to be repeated and the result of this repetition is the knowledge which will be stored as experiments in system's knowledge memory. Regarding concepts in mentioned descriptions in session II (A), in the first and ninth definitions this is the environmental perception aspect which is equal to perception in the proposed model. The concept of memory has been pointed in the third and ninth definitions so that everything from perception stage to representation in sensed data storage, generated information, and represented knowledge have been represented in the proposed model according to these definitions. Knowledge representation is a concept which has been emphasized in the eighth and ninth definitions which is noticed to be equal to representation in the proposed model. Acquiring knowledge is considered as the concept of earning new knowledge from the environment around in the first, second and seventh definitions which has been mentioned in three stages of perception, pre-processing, and representing the proposed model. The fourth, fifth and sixth definitions focus on behavior improvement and the fourth one also talks about the feedback, which is to improve future behavior in biological systems through time. Considering the interpretation (evaluation and arbitration results) and its impact as the new input (feedback) on the proposed model, the concept of behavior improvement and feedback has been used.

Furthermore, the proposed model covers most of mentioned features in session II (B). Full implementation of the cycle of model results to achieving a new skill. So the first characteristic will be fulfilled. During a cycle, appropriate behavior is getting formed and consequently the second characteristic will be also provided. The result of generated behavior will be applied to the system through input. Therefore the twelfth characteristic (feedback) will be met. Having memory and feedback, the input repetition can cause improvement in system behavior so that the fourth, fifth, sixth, tenth, and eleventh characteristics will get fulfilled. The eighth and ninth characteristics are also the result of a generation and can be expressed according to concept generating, excitation and inhibition.

Due to learning functionality in different areas, effective concepts in learning can be recognized by means of ontology. This measure leads to recognition of ignored aspects and as a result system's current efficiency can be increased by applying necessary changes. On the other hand, given the need to structures with learning ability like intelligent agents, using presented ontology and model can lead to modeling and producing agents with learning ability in different areas and also this can result in generating structures with the abilities of self-management, self-maintenance, self-organized, higher and optimum robustness comparing to the current systems.

As example of ontology based learning and proposed model, a sweeper robot could be considered. For designing and implementing of the control unit in a sweeper robot, usually a supervised Artificial Neural Network (ANN) is used. The used ANN in robot control unit recognizes the environment and objects. By considering Learning Concept (section II, part B) it could be found that a sweeper robot by using an ANN try to obtain better skill in objects recognizing. This behavior through the time changes the robot's behavior, that possible by changing weights of ANN. Therefore, the inner program of robot adapts itself. In this process characteristics number 1, 3 and 4 is used. Furthermore, by changing the weight of ANN, the robot performs a task more efficiently and also, forces to have a particular response to a specific input signal. On the other hand, the quality of the output behavior changes and the characteristics number 5, 6 and 12 are used in the robot.

In another viewpoint, the robot tries to percept the environment and by new perception it adapts its behavior based on the feedback of environment's action and reaction. This process cause changing in robot behavior and it earns more experiments about the objects and environment. Furthermore, for decision making the robot needs the evaluation about objects and environment. It could memorize new experiments by changing weights of ANN. The memorizing, changing and evaluation through the time causes optimization in behavior of the robot. Therefore, the perception, adaptation, memory, experiment, feedback, change, evaluation and optimization concepts (section V) are used for the robot decision making and behavior generation.

VII. CONCLUSION AND FUTURE WORKS

Presenting different definitions of learning, used concepts in each of them was described. Considering in these definitions, this can be seen that concepts like communication with the environment (perception), experiment, repetition, changes and reformations in order to improvement, optimization (minimizing the error reduction), adaptation, memory, knowledge

representation, evaluation and judgment, reward and punishment (excitation and inhibition), and feedback are effective on learning formation. Based on the presented ontology, conceptual model for learning was proposed and the status of the concepts in various definitions such as perception, development, memory, improved behavior, knowledge acquisition, processing and feedback in the proposed model was expressed. Moreover, the twelve characteristics of learning were mentioned and the way of their implementation in the model was described. Continuing this study, by recognizing different aspects of learning and providing a more complete ontology, a more efficient model of learning can be offered. Representing more efficient learning model can lead to design and implementation of structures with higher learning capabilities and also using such systems can result in producing systems with higher robustness and efficiency.

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