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AGI as a means of getting "truly" new knowledge using existing experience

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Abstract

The evolution and civilization development lead us to the progress next important step - the creation of AGI. More "intelligent" tasks are successfully solved by machine learning methods using neural network algorithms. Not only the solved problems quantitative increase in the number and accuracy are important, but also a qualitative transition to the tasks of obtaining "truly" new knowledge and building "truly" new goals on their basis. This transition can serve as a criterion for determining AGI. The paper shows necessity of using existing knowledge to advance into the field of more and more diverse "truly" new knowledge. Also, the paper shows usefulness of implementing proposed ideas on a scalable hierarchical structure which has two main modes of operation: "intuition" and "thinking", and structure of vector control of these and other operation modes, similar to animal hormonal control.

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Keywords: knowledge; hierarchical structure; AGI

1. Introduction – input data, knowledge and output data

Before discussing the new knowledge acquisition, it is necessary to define how knowledge differs from data. We do not claim to have universal definitions suitable for all data processing cases, but very simply describe how data and knowledge will differ in this article.

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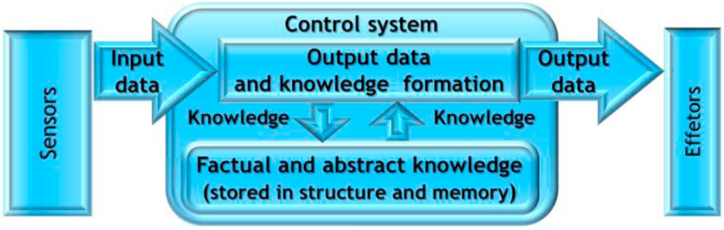

Fig. 1. Data and knowledge in the control system diagram.

At the input (through sensors), the control system receives ***input data*** and forms ***output data*** that define the output organs (effectors) states changing. ***Knowledge*** is used when converting input data into output data (fig. 1). At the same time, knowledge extracted from the input data is entered into memory: actual (contained in the data), new (the result of data processing and existing knowledge) and "truly" new (because of identifying new data properties and existing knowledge) that can be used in further data processing

Some knowledge can be hardwired into the control system in its structure and conversion factors form. and have no changes in the functioning process. There also can be control systems with a variable structure when different data are used in diver's states. The control system can be adaptive and, depending on the incoming data, change the values of the converting coefficients, i.e., in our definitions - knowledge. In the 50s of the last centuries, it seemed that this was enough to create AI. Although Ashby [1] back in those years proved a theorem on a system necessary complexity to perform difficult tasks, many tried (and continue) to search heuristically for simple universal algorithms that allow solving complex problems by adjusting a small number of parameters.

The neural network algorithms that appeared around the same years tuned much more parameters, and from the point of view of the Ashby theorem, were better suited for solving converting input data into output data complex problems. But only after about 2010 neural network algorithms have begun to outperform confidently heuristic algorithms in solving practical problems. However, the new knowledge more rapid acquisition problems, preferably using existing ones, and the knowledge representation hierarchical structure formation remain acute.

Scheme on fig. 1. does not aim to improve the existing classical models for explaining complex behavior, for example, the functional system of P.K. Anokhin (see, for example, [2]) and several other, well-known. Only some self-organization details, based on knowledge are considered.

The knowledge creation issues, its hierarchical organization and using knowledge ways to form control and its goals are important for the AGI creation, since simply intelligent systems can manage with the knowledge and goals that a person sets for them. AGI agents will be different in that they will be able to extract knowledge and form their own goals. The knowledge accumulation is not aimed at optimizing some predetermined function, but, as in the life evolution case, at increasing the possibilities and methods arsenal for implementing rational behavior that increase the survival likelihood and kinds of reproduction. If the factual knowledge obtained from the data is intuitive, then for new knowledge it is necessary to separate types of the work with knowledge: the transformation of known and the acquisition of "truly" new, previously unknown knowledge. As an example, the difference is as follows:

1.1. Existing knowledge derivation consequences.

We can (in principle) calculate the product of any multi-digit numbers with the use of multiplication table. But the result obtained will not give new knowledge, since we have transformed the existing data using known rules.

1.2. "Truly" new knowledge.

If we didn't know the multiplication table, or at least the multiplication rules "in a column", then creating a table and / or rules would give us new knowledge. Applying them later would make it much easier to do the multiplication (instead of multiple additions...).

The most developed self-organization process, expressed in the life evolution on Earth, essentially boils down to the accumulation of new knowledge that makes it possible to carry out more and more complex and effective processes of self-organization. At the beginning, there was an improvement in the knowledge recorded in DNA, then, based on the nervous system (NS), it became possible to consider the actual properties of the real world. Of course, to use the information contained in DNA or NS, you need a "body" - a carrier that allows you to read this information to form rational behavior. Human civilization, with its oral and then written speech, made it possible the science development and the information systems creation. It is the next step in complicating and accelerating the self-organization process.

2. About AGI definitions

A significant difficulty in creating AGI is the single definition lack, so it is advisable to offer your own version.

But first let's consider the naivest definition (#1): "AGI is the ability of a system to solve any problem in complex environments with limited resources." The naivety of this definition is that the real technical device possibilities will be limited, and there will always be unsolved problems.

The second most naive is the definition (#2) that "AGI is capable of solving intellectual problems at the human level or higher." This is a little better, since most people have an idea of the limited person abilities. And if this level can be surpassed by 10 or 1000 times, then the abilities will not become limitless. But the definition leaves open the question of what it means to "solve intellectual problems at the human level" and, in general, how to measure the intelligence level. There are not only IQ tests here, but also critical assessments that the proposed tests, at least, do not sufficiently determine the intelligence level for a wide tasks range.

Oddly enough, the most constructive definition (#3) seems to many that "AGI should be able to solve all intellectual problems solved by a person." There is a significant difference of (#2): and (#3): it is not the intelligence level that should be determined, but the list of tasks. But there is no complete list, and as soon as a certain tasks begin to be successfully solved by machines, they are excluded from the list of intellectual tasks.

The most important tasks class for the civilization development is setting goals and obtaining "truly" new knowledge, that is, not obtaining actual knowledge and not using known methods to analyze existing knowledge but identifying new dependencies and forming new ways of performing actions. For example, you can update factual knowledge using an IT map and gain knowledge about a route but generating new ways to build routes and identifying new dependencies in the form of their transit duration estimates is "truly" new knowledge.

2.1. AGI definition

It is the formation of at least subjectively "truly" new goals and the acquisition of "truly" new knowledge - these are the main tasks, the ability to solve which, on our opinion, can serve as characteristics that distinguish AGI agents from AI agents. This constitutes our proposed definition (#4).

The difference definition (#4) from (#3) is that it is enough to have the ability to form "truly" new goals and obtain "truly" new knowledge and, like a person, interact with civilization. Intelligent agents that do not satisfy definition (#4) can be of great practical use, but, in our opinion, definitions (#1), (#2) and (#3) without completing the list to "truly" new goals and knowledge do not reflect main AGI properties.

2.2. Man as a civilization development product.

Articulate speech has opened opportunities for mankind to exchange the knowledge received by different communities and individuals and use them in their rational behavior formation. This radically accelerated the obtaining new knowledge process. In civilization knowledge is transmitted between living individuals. An increase in the people number leads to an increase in the frequency of discovering new knowledge. Information technologies (starting with articulate speech) are aimed at accelerating the knowledge exchange. Since the obtaining "truly" new knowledge and goals task is complex, the use of someone else's experience makes it possible to obtain subjectively "truly" new knowledge and goals in a much more simpler way.

2.3. Reflexes, consciousness, thinking, mind, and intellect

The nervous system (NS) emergence in the evolution significantly accelerated the knowledge accumulation speed, since instead of a random search, it made it possible to purposefully identify knowledge related to the surrounding world. M. Tegmark [3] considers animals with a nervous system as the second evolution stage, Life 2.0. And expects that the third evolution stage, Life 3.0 will begin with the AGI creation. Is not difficult to see that the knowledge accumulation in animals in the wild and in people in civilization proceeds differently.

2.4. Animals' behavior formation.

The animal's actions rationality (and man as a living being) is determined not only by the genetic code, but also by the state of the complex world. If innate behavior is associated with the DNA code (or AI construct) - these are unconditioned reflexes and other actions that do not require learning, then conditioned reflex behavior is based on statistically identified correlations between events and stimuli of unconditioned reflexes.

More complex NS make it possible to form complex world objects and phenomena models and, based on modeling the development of events, to carry out proactive behavior. Understanding arises - the ability to form and adjust real objects and phenomena models to their current state.

The presence of model's hierarchical system makes it possible to convert input data into output data in two modes (systems 1 and 2 according to Kahneman [4]): intuition and thinking, respectively, which will be discussed in Section 9. There may be other regimes, and they all need to be controlled, which is what the function of consciousness does. In animals, mode control is more associated with hormonal NS activity regulation, while in AI it can be implemented algorithmically.

2.5. People behavior formation.

Man has a mind which, when brought up in a civilized environment, enables him to develop intellect. These names can be defined differently, but to describe the AGI connection with the knowledge acquisition, we use the following definitions: mind - the ability to perceive and use (part of) the knowledge accumulated by a civilization; intellect - the ability to use thinking for the developing tasks of civilization - a community with an ever-deepening labor division and competition, which allows its members to develop intellect.

The labor division deepening is associated with the new knowledge creation and accumulation and at the same time makes it possible to distribute the civilization knowledge over many carriers, which makes it possible to sum up their capacity. The appearance of drawings and writing, and then the data storage technical means outside the person's NS, made it possible to store more knowledge and, as will be shown below, to acquire new knowledge at an increasing speed.

3. Knowledge approach to self-organization

If we understand that self-organization has developed in the process of evolution due to the accumulation of knowledge that ensures the reproduction of self-organizing systems, then the **knowledge** approach should be aimed at studying possible ways of obtaining and accumulating knowledge.

3.1. Random search and accumulation of knowledge.

In the early stages of evolution, the accumulation of knowledge proceeded randomly, with small changes in DNA and testing the usefulness of various changes in the life experience of generations of the simplest organisms.

Since not only adaptation to environmental conditions was required, but also victory in competition with other organisms, those species that could adapt to changing conditions faster than others won the reproduction race, while providing the best balance of variability and retention of useful knowledge.

Not only knowledge about the processes of self-organization was accumulated, but also ways to accelerate evolution, as part of the process of self-organization. Already at this stage of evolution, knowledge was accumulated that ensured not only the reproduction of the species, but also relatively quick adaptation to changing conditions.

3.2. Directed search.

Although the improvement of sensors, data processing methods and types of effectors continued with the use of random search, methods of directed use of sensors, effectors and data processing methods for targeted knowledge search began to develop. Improvements in methods of directed search for knowledge gradually led to the emergence of understanding, intuition, thinking and consciousness, but the goals of obtaining knowledge remained the result of a random search by fixing successful mutations in DNA. Genetically based goals may change during the life of an organism, but in most animals, sensory data serve only to purposefully optimize ways to achieve these goals.

It seems that another important property that allowed a person to stand out from the animal world is the ability to form goals that are different from those genetically incorporated using both personal experience and, subsequently, civilizational knowledge.

4. Complexity of the world

If the world weren't complex, then transforming the input would be no problem: it would simply be necessary to make a table of what output should correspond to the different inputs. And the main manifestation of the complexity of the world is the impossibility of creating such a universal table.

Even a person is not able to master all the subtleties of the processes taking place in a complex world, even if they unite in civilized communities, develop sciences, and create information and computing systems. And it should be borne in mind that an absolute understanding, and even more accurate forecasting of all the processes taking place in the world, will never be achieved, and this is since the complexity of a person and AGI agents, even united in communities and using technical means, will always be less than the complexity of the rest of the world

4.1. Five Degrees of Complexity in Building Intelligent Behavior.

The progress of self-organization consists in the complication of living systems and now - intelligent agents, this allows you to show rational and reasonable behavior in an increasing part of the world.

To build rational, and at higher levels of self-organization - reasonable behavior, there are several difficulties.

1. The complexity of the description. The possibility of constructing statistically reliable descriptions of objects and phenomena is determined by the amount of data and computing resources. With an increase in the number of variables characterizing the states of objects and phenomena, the complexity of the description increases exponentially and begins to exceed the available possibilities.

2. Complexity of decomposition. Volumes and resources can be neither limitless nor exponentially scalable. It is necessary to decompose the complex world, which is possible, but requires the accumulation of various knowledge (statistically reliable descriptions) to isolate (relatively) simple components from complex signals and build their statistically reliable descriptions.

3. Combinatorial complexity of choice is the complexity of choosing a sequence of actions to achieve the goals.

4. The complexity of building goals – the complexity of choosing local and global goals. The global goals of animals are considered genetically determined, and in humans, as a rule, they are formed in interaction with civilization, which gives rise to intelligent behavior.

5. The complexity of setting needs – to select global goals, they must be compared, and the comparison criterion is the ability to meet different needs while achieving the goals being assessed. This is not only the satisfaction of hunger and the preservation of homeostasis, and even not only the desire for beauty and harmony, but entire systems of needs that people and animals have genetically, and the designers of AGI agents will have to be developed for their compatibility with civilization. And this is one of the main reasons why, to save civilization, AGI agents must be created to work together with people whose need system has been tested by evolutionary selection.

So far, the most relevant topic for solution is 2) The complexity of decomposition, the implementation of which will solve most of the problems existing in ML. At present, decomposition is easily carried out by humans, and the transfer of the solution of this problem to AI agents is the primary goal of the development of ML. But, choosing ways, one should have in mind other degrees of complexity. AI, which itself can receive “really” new knowledge and form “really” new goals, first, it must be able to decompose complex objects and phenomena.

5. Using knowledge to gain new

There is no way to describe complex scenes, systems, and phenomena with statistical methods. And to accumulate statistics about simple objects, you first need to select them from complex scenes, that is, to decompose them. But for the decomposition to be successful, it is necessary to have an idea about the components of the scene (Fig. 2), that is, their description obtained based on statistics. Which is impossible to obtain without decomposition... The situation looks hopeless.

There are two ways to get out of this impasse. The first is the statistical accumulation of knowledge about simple objects, circumstances, and phenomena in laboratory conditions, in which the complexity of scenes is simplified to the limit. As the only one, most likely, it is unattainable. The second, more realistic one, is that if, when decomposing a scene, all but a few components are known to us, then it is possible to pay attention to the unknown and collect statistics about its observed properties, creating or improving its description. Combining these paths will increase the probability of description of a new object or phenomenon, to be improved by statistical methods.

More than 3-5 simple objects can already constitute a complex system, the accumulation of knowledge about which by statistical methods is not available.

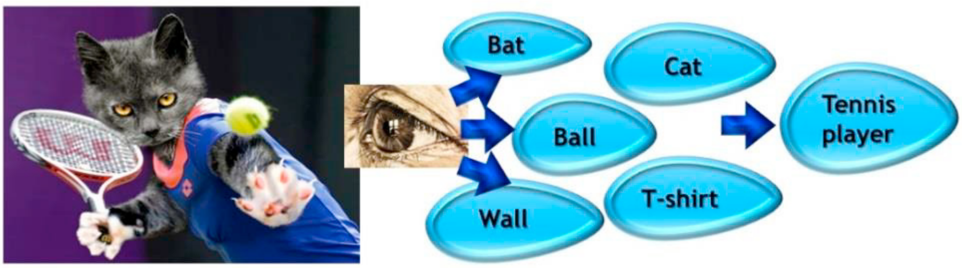

Fig. 2. Decomposition of a complex scene into simple components.

More than 3-5 simple objects can already constitute a complex system, the accumulation of knowledge about which by statistical methods is not available.

5.1. Decomposition and localization.

To describe a complex scene (Fig. 2), it is necessary to use knowledge about the components contained in it. Knowledge about dogs, giraffes, airplanes, stars, and more should be involved in the process of getting the best match between the observed scene and the known components. If we improve some simple component of the observed scene description then all other knowledge about other components should not change. Even those that are on the observed scene, do not require improvement. And even more so those that are not used in the description of the observed scene. This property of improving knowledge is possible only if the different components descriptions are localized in memory or knowledge representation mechanisms are used that are equivalent to their localization.

5.2. The need for knowledge to understand complex phenomena.

As mentioned in paragraph 3, **understanding** is the ability to form and adjust models of real objects and phenomena to the current state. To understand complex phenomena knowledge about the simple components is necessary. Knowledge about simple components can already be obtained by statistical methods if decomposition mechanisms are used. The presence of knowledge is also necessary to improve knowledge about the individual components of complex scenes and phenomena. To accumulate knowledge about the next, not previously described (or not accurately enough), it is necessary either to accumulate knowledge about all the other components of a complex scene, or to create special laboratory conditions in which all other components are known.

6. Levels of knowledge – degrees of abstraction

Statistically reliable properties can be distinguished, also between the suits of complex scenes, it is possible to identify simple interaction laws. But for this, one must first have objects models that make up complex systems or scenes. Simple properties of complex phenomena. Not necessarily in the models of simple objects, all their internal properties should be reflected. As a rule, models of external manifestations of simple objects are sufficient. Between such manifestations in parts of the system, it is possible to identify interrelations by statistical methods.

Increasing the degree of abstraction. The parameters obtained based on the statistical analysis of the parameters of the underlying models have a greater degree of abstraction. Between the parameters of the next level of models, you can also identify the relationship and get even more abstract models. In animals, the degree of "abstractness" of models is determined by the structure of their NS. A person does not have an obvious limitation, since in the process of the development of civilization, many ways have been developed to work with data not received directly from the external environment but created because of the processing of such data by other people or information systems.

7. Intuition and thinking

7.1. Intuition is a quick response to a difficult situation.

As described, for example, in [5], neural network models of the input signals state spaces (obtained by mapping methods) can be used to reproduce (by approximation) temporally unfolded output signals corresponding to a rational response knowledge to sensory data and set goal. At the lower levels, the output data obtained by approximation is used directly to control the effectors. At higher levels, the output data sets local targets for generating the output signals of the lower levels, considering sensory data.

When the situation changes, many levels of the system are involved in the formation of goals, the actions chosen as a result can consider rather complex circumstances, which, in our opinion, corresponds to the manifestation of intuition. Which differs from reflexes in that it connects to simple and complex stimuli. It is customary to consider intuition as a separate system for choosing goals, often involving the ideas of the soul, the universal mind and God.

You can assume that an athlete "from God" has almost a "straight line", which allows him to beat his opponents. We believe that he simply more successfully implements skills acquired in training, which are more effective than others. If this is not so, why do athletes “from God” have a narrow specialization?! Is gods have narrow profiles?

7.2. Thinking is a comparative modeling of options for action.

But if in sports, as a rule, a quick reaction is required, then there are a few activities where it is not necessary to rely only on intuition. And it is better to think first, and only then start acting. As a rule, this is especially useful when performing complex, non-repetitive tasks. Why?! Is the soul losing touch with the universal mind?

In our opinion, the problem is that in complex problems (with a high dimension of the parameter vectors) a good approximation is impossible. For the same reason that it is impossible to build statistically reliable descriptions for them - the states do not repeat and the data vectors in a multidimensional space that describe the observed states are too far from the incoming vector.

But if we consider the simple components of complex scenes, then the picture is the opposite. Having descriptions of all components, it is possible to predict how the state of each will change when performing arbitrary actions of an intelligent agent during interactions between components and with the environment. It is the process of modeling, which allows us to significantly improve the choice of actions when solving complex problems, that we tend to correlate with the thinking in humans.

8. Emotions as a means of operations modes controlling

The choice between a quick intuitive and a slow, thought-based response requires switching operation modes in a hierarchical component information processing system. There is a choice between the direct action's implementation aimed at achieving the goal and behavior for obtaining additional knowledge before starting direct actions, between attacking and defensive actions and several other options. This requires vector control, and it is generally accepted that in higher animals it is regulated by consciousness using the hormonal system. But not everyone is aware that emotions are not just a smile or a grin on a muzzle or face, but a mimic reflection of various modes of NS operation.

8.1. Emotions control for civilized behavior.

Although it is generally accepted that emotions in animals are innate, even in them they can be changed as a training result. Human emotions also have a genetic, evolutionary origin, but to a greater extent than in animals, they depend on upbringing and civilizational norms. The modes themselves remain an innate property of animals and humans NS, and only the frequency and reasons for the certain emotion's manifestation of, which, in our opinion, are used to control the modes of operation of the NS, depend on education.

AGI agents will also need to use different operation modes of their information system, and this will require a vector control system for switching them. Which will not imitate various emotions on the faces of AI agents (as it is done now), but actually switch them into various (emotional) modes.

9. Conclusion

The knowledge accumulation is only one of the sides of the evolution process and development of civilization on Earth. Usually, they talk more about the living forms evolution and the material culture of different eras. But, just as information cannot exist without a carrier, so living organisms and civilization artifacts cannot be created without the knowledge accumulated in DNA and other data carriers.

The knowledge side of evolution also has two main aspects. In addition to the quantitative knowledge accumulation, algorithms for obtaining new knowledge were improved. The speed of obtaining new knowledge increased, the knowledge correspondence to the real state of the world around improved. The evolution acceleration began in the era of unicellular organisms, and only the emergency of a long series of successful methods allowed the multicellular organisms formation, animals, and humans. But, before the man advent, the main progress was achieved by accelerating the recording of new knowledge in DNA.

With the civilization construction beginning, knowledge began to accumulate in other forms (oral, written, databases, etc.). In the coming years, AGI agents will be created by design methods, they will have "truly" new capabilities. But, as before, the acquisition of new knowledge will be based on the use of existing ones. In what form it can be implemented is described in this article and in [5].

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