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Three Approaches to Artificial Intelligence †

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Abstract: The aim of this paper is the expansion of understanding what intelligence is, what is being performed in the area of AI and in which direction to move further in this area. To achieve these goals, the stratified componential model of intelligence in general and AI, in particular, is introduced and studied. Its application entails three approaches to the development of artificial intelligence.

Keywords: intelligence; actor; agent; oracle; environment; problem solver; assimilation; adaptation; accommodation

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1. Introduction

Currently there is no generally accepted definition of intelligence. Furthermore, there is no consensus on what intelligence is. Researchers have elaborated a variety of models of intelligence and constructed many measures of intelligence such as analytical intelligence and analytical IQ, creative intelligence and creative IQ, social intelligence, practical intelligence and practical IQ, and emotional intelligence and emotional IQ. In this paper, we further develop our understanding of what intelligence is, what is being pursued in the area of AI and the directions in which to develop in this area. To achieve these goals, the stratified componential model of intelligence in general and AI, in particular, is introduced and studied. The application of this model provides three approaches to the development of artificial intelligence.

2. Levels of Intelligence

It is possible to distinguish three ways of defining intelligent systems.

The first approach implies that a system is intelligent when it can solve some complex problem or carry out some complex activity in a simple environment [1]. It is called ***local intelligence***.

Examples of intelligent problems are games such as chess or GO as well as image recognition. Examples of an intelligent activity are conversation, as in the Turing test [2], or a robot that performs an intelligent task.

A system of local intelligence can be simply called a problem solver.

It is the *unit-component approach* to intelligence. One problem is a unit component of intelligence.

The second approach considers an intelligent system as a system that can well function in a definite domain, which demands solving a group of (complex) problems. It is called (***advanced***) ***cluster intelligence***.

It is the bona fide *componential approach* to intelligence.

Cluster intelligence is used in the Triarchic Theory of Intelligence developed by Robert Sternberg [3,4].

A self-organizing system that can read a textbook and answer questions displays cluster intelligence [5,6].

It is necessary to understand that cluster intelligence is not always higher than local intelligence. For instance, by contemporary measures, cluster intelligence that can solve a

group of problems by performing arithmetical operations is lower than local intelligence that can play chess on the level of a world champion.

The third approach assumes that a system is intelligent when it can efficiently function in complex conditions or successfully survive in a hostile environment. It is called *global intelligence*.

Although it is important to construct artificial systems that solve complex problems or/and display intelligent activity, the imperative goal of AI research is to create systems that can achieve global intelligence.

In each of the considered groups, we can separate different levels of intelligence. For instance, to be able to perform arithmetical operations without technical devices is also a kind of human intelligence although it is considered to be a very low intelligence by the criteria of contemporary society.

3. Intelligence in Science and Mathematics

The suggested stratification of intelligence has interesting connections to the types of scientists and mathematicians, which are presented in the following classification.

Mission-oriented types of scientists and mathematicians include:

1. World explorer;
2. Theory builder;
3. Problem solver.

The lowest level in this classification, a problem solver, corresponds to the lowest level of intelligence—local intelligence. Indeed, as we mentioned before, a system of local intelligence can simply be called a problem solver.

The middle level in this classification, a theory builder, corresponds to the middle level of intelligence—advanced cluster intelligence. Indeed, a theory, as a rule, cansolve-many problems.

The highest level in this classification, a world explorer, corresponds to the highest level of intelligence—global intelligence. Indeed, in science and mathematics, a world explorer studies nature or the ideal world of mathematical structures [7].

4. Intelligence Stratification

According to the theory of intellectual activity [8,9] and the Existential Triad of the world, intelligence is stratified into three principal forms:

- *Mental intelligence* mirrors the level of thinking;
- *Structural* (in particular, *linguistic*) *intelligence* reveals the quality of expression;
- *Action intelligence* exposes the reflected in behavior.

Note that mental intelligence can be essentially different from action intelligence. First, there are many examples of people who have very advanced intelligent thinking abilities but their behavior is far from optimal. Second, mentality with its mental intelligence is essentially different from the physical world with its action intelligence. People often create a specific world in their mentality and even their mental models of social and natural environment can poorly reflect the physical world.

It is important to understand that these forms of intelligence often interact and one system can possess two or all of the three forms of intelligence. For instance, action intelligence is often based on mental intelligence.

In addition, by its organization, intelligence can be of three pure types:

- Cognitive intelligence;
- Emotional intelligence;
- Instructional intelligence.

This classification is based on the Triune Model of the brain.

These pure types can interact and form the combined types of intelligence, for example, cognitive–emotional intelligence.

5. Terminological Aspect of AI

It is also important to establish a consistent terminology in the area of AI. A terminology is a system of terms (names) used in a definite area, e.g., in science, art, business or industry. Importance of the usage of correct names was stressed by the famous Chinese philosopher Confucius, who wrote:

> "*If names be not correct, language is not in accordance with the truth of things. If language be not in accordance with the truth of things, affairs cannot be carried on to success. When affairs cannot be carried on to success, proprieties and music do not flourish. When proprieties and music do not flourish, punishments will not be properly awarded. When punishments are not properly awarded, the people do not know how to move hand or foot*" [10].

Observing the terminology of AI, we can see that the most popular term in contemporary theoretical and philosophical studies of AI is that of an agent. However, oftentimesthat whichis called an agent, e.g., an intelligent agent, is actually an actor. The difference between actors and agents is described by the following definitions [11].

Taking a system C that consists of interacting systems $\{R_k; k \in K\}$, which have the lower rank than C, the systems R_k are called **actors** and treated as actors.

An **agent** is an actor that (who) acts on behalf of another system performing some tasks of that system.

This shows that an agent performs the role of an actor, who (which) can also have other roles.

An **operator** also performs the role of an actor, that is, an operator is an actor that (who) transforms the environment to achieve the necessary or desired goals.

6. Features of Global Intelligence

For global action intelligence, the environment consists of living systems, communities and societies of living and artificial systems, artificial devices, and unanimated natural and artificial objects.

For global mental intelligence, the environment leads to the creation of the mentality and can include models of physical reality as well as mental systems deliberately generated by the mind. Note that it is possible to consider mental intelligence on different levels, which comprise individual mentality, group mentality, and social mentality [6,7].

For global structural intelligence, the environment consists of a variety ofknowledge and data structures such as mathematical or linguistic systems.

We see that on any level and especially on the global level, intelligence is expressed in terms of functioning, e.g., problem solving, in a particular environment. As the result, the exploration and development of intelligence in general and artificial intelligence in particular must take into account their environment und thus, must explore the context of ecology. The foundations of this approach are developed in the works of Yixin Zhong and Mark Burgin (see, for example, [12–15]). Projecting this situation on the realm of rituals, we see that by the investigating rituals, it is useful to make a distinction between a ritual, performance of a ritual, and description of a ritual.

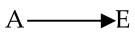
7. Forms of Global Intelligence

The functioning of a system on the level of global intelligence can have three forms:

- *Assimilation*;
- *Adaptation*;
- *Accommodation*.

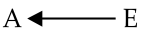
By defining these forms, we reflect the functioning of a system in some environment by the diagram, in which the arrow moves from the essence that is changing to the essence that determines changes and the size of the arrow shows the extent of changes.

Adaption of a system A to the environment means changing A to better fit the environment.



Assimilation into the environment means becoming a part of the environment.

Accommodation of the environment by a system *A* means changing the environment to better fit the system *A*.



The invention of technical devices is an example of adaptation. Many games, such as chess or GO, provide examples of accommodation.

Assimilation, adaptation and accommodation can be inner, outer and combined, that is, both inner and outer.

Inner adaptation is a changing of the inner world, e.g., values, goals, habits, attitudes, the worldview, etc., of a person to fit the environment.

Outer adaptation is a changing of the behavior, relations and if possible, an individual on the physical level to fit the environment.

Inner assimilation is making your inner world (mentality) similar to the mentality of (the members of) the social environment.

Outer assimilation is adapting behavior, relations and if possible, themselves, to the physical level similar to the members of the social environment.

Inner accommodation is changing the inner model of the environment to better fit to the environment.

Outer accommodation is changing the environment to better fit to them.

With respect to its environment, a system can be:

- Non-interfering actor;
- Experimenting actor;
- Operator.

In this context, it is possible to set apart three approaches in the creation of globally intelligent systems.

In the *non-interfering actor approach*, an intelligent system is treated as an actor that only observes and adapts to the environment but does not impact it.

In the *experimenting actor approach*, an intelligent system is treated as an actor that only observes and adapts to the environment by performing experiments.

In the *operator approach*, an intelligent system is treated as an operator inits environment.

The difference is that an actor simply functions in the environment while an operator transforms the environment to achieve the necessary or desired goals.

8. Conclusions

Different approaches to understanding intelligence in general and to building artificial intelligence in particular are explicated and analyzed with the goal of better decision making and a selection of ways to develop artificial intelligence. Now, this process is based on the invention of better tools for solving more and more complex problems. However, a real breakthrough in this area is only possible by building a general theory of intelligence.

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