

Man in the world of complex systems: ecology of intelligence

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Abstract

The sustainable development of modern societies from the information society to knowledge societies (UNESCO 2005) involves the creation of information and communication infrastructure that ensures the production, transfer and functioning of knowledge in accordance with the needs of society. In these conditions, the problem of development and evolution of intelligence (intellect, mind) in the new information and communication environment, the problem of ecology of intelligence, and the problem of social responsibility of developers of intelligent information systems (see: The Journal of Intelligent Information Systems) becomes urgent and acute.

Methodologically, it is possible to solve this group of problems on the basis of third order cybernetics (Lepskiy, 2018), according to which modern society can be represented as a set of complex self-developing systems. This type of systems can be represented as poly-subject (multi-subject), self-developing reflexive-active environment. If using third order cybernetics to study the problems of ecology of intelligence and giving recommendations for developers of artificial intelligence (AI) apps, it is possible to introduce the level of reflection to the study of these complex systems. It is at this level that the philosophical and methodological concepts of intelligence can be linked with the methodology of interdisciplinary research of AI and the practical level of the use of intelligent information systems.

The study provides a comparative analysis of the basic definitions of intelligence in philosophy, psychology, artificial intelligence studies. The paper discussed the question whether the Turing test can serve as a universal criterion of intelligence of all objects included in complex information technology systems. The author analyzes the levels of social responsibility of developers of complex intellectual systems used in various human activities.

Keywords: complex systems, information technologies, control, third-order cybernetics, reflection, intelligence, social responsibility

Človek v svetu kompleksnih sistemov: ekologija inteligence

Povzetek

Trajnostni razvoj sodobnih družb od informacijske družbe do družb znanja (UNESCO 2005) vključuje vzpostavitev informacijske in komunikacijske infrastrukture, ki zagotavlja proizvodnjo, prenos in delovanje znanja v skladu s potrebami družbe. V teh razmerah so problem razvoja in razvoj inteligence (intelekt, uma) v novem informacijskem in



komunikacijskem okolju, problem ekologije inteligence in problem družbene odgovornosti razvijalcev inteligentnih informacijskih sistemov (glej: The Journal of Intelligent information systems) postali nujni in akutni.

Metodološko je mogoče rešiti to skupino problemov na podlagi kibernetike tretjega reda (Lepskiy, 2018), po kateri lahko sodobno družbo predstavimo kot sklop kompleksnih samo-razvijajočih se sistemov. Takšne sisteme lahko predstavimo kot poli-subjekte (multi-subjekte), samo-razvijajoče se refleksno-aktivno okolje. Če uporabljamo kibernetiko tretjega reda za proučevanje problematike ekologije inteligence in dajemo priporočila razvijalcem aplikacij za umetno inteligenco (AI), je možno uvesti stopnjo refleksije za preučevanje teh kompleksnih sistemov. Na tej ravni lahko filozofske in metodološke koncepte inteligence povežemo z metodologijo interdisciplinarnih raziskav umetne inteligence in praktično uporabo inteligentnih informacijskih sistemov.

Študija zagotavlja primerjalno analizo osnovnih definicij inteligence v filozofiji, psihologiji, študijah umetne inteligence. V članku je obravnavano vprašanje, ali lahko Turingov test služi kot univerzalno merilo inteligence vseh objektov, vključenih v kompleksne sisteme informacijske tehnologije. Avtor analizira stopnje družbene odgovornosti razvijalcev kompleksnih intelektualnih sistemov, ki se uporabljajo v različnih človekovih dejavnostih.

Ključne besede: kompleksni sistemi, informacijske tehnologije, nadzor, kibernetika tretjega reda, refleksija, inteligenca, družbena odgovornost

1. Introduction

The environment of the daily life of people can be analyzed as a set of complex evolving human-sized systems, which include information and computer technologies. These are: "man-machine" systems, urban objects, and complex system, based on biotechnology, nanotechnology, cognitive technologies, intelligent information technologies.

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This type of complex systems includes objects of different nature - physical, chemical, biological, technical, information and social. Complex systems can be represented as poly-subject, self-developing reflexive-active media (Lepsky, 2018, p. 14). In these systems, the subjects of knowledge and activity are organically connected with the means of activity and objects of activity. In this case, an important role is played by the value-target structures of the subjects (Lepsky, 2018, p. 13).

Information and control processes in these systems are associated with reflection and Third-order cybernetics. First-order cybernetics is typical for classical science. In classical science, the observer was thought to be outside the observed object located in the external objective world (first-order cybernetics). In second-order cybernetics, the observer is thought to be included in the surveilled system. People learn to see themselves as part of the observed world. The cybernetic style of thinking is based on the ideas of cyclicity, recursiveness, self-organization, self-awareness, as the system must reproduce itself and maintain its own existence. In accordance with the cybernetic style of thinking it is impossible to separate the result of knowledge from the cognitive abilities of a person. There is no observation independent from the observer. Cybernetic thinking is "circular" in nature, constantly returning to itself. In third-order cybernetics, the reflection of an active developing poly-subject environment plays an important role.



The processes of self-organization in complex human-sized systems are implemented through information and communication technology environment. As a result, a human-machine type of cognition is gradually formed, in which human thinking is combined with machine calculations, biological memory combined with external memory on information carriers, face-to-face communication and communication mediated by information technologies, human and machine vision. A variety of computer systems that have the functions of memory, navigation, decision-making, systematically used by man to find, process and store information for management, become part of the human cognitive system. They turn into an external component of the internal thinking of a person and participate in intellectual activity (Alekseeva, 2016, Nikitina, 2016, p. 47). In these systems, the boundaries between natural and artificial are often blurred.

An important element of such systems is the intelligence of a person with professional knowledge and designing the environment of its existence. In addition, in complex systems of this type, it is the subjects included in the system that generate information that is important for the self-organization of systems. It is important that a complex human-size system affects, first of all, the intelligence of the person included in it. Under these conditions, the question of the ecology of intelligence becomes of fundamental importance.

How do intelligent information systems affect the natural intelligence of a person? According to the well-known expert in the field of artificial intelligence, V. K. Finn (Finn, 2006, 122-123), intelligent systems perform an educational function and increase, thanks to intelligent interfaces, the average level of intelligence of the individual. Intelligent information systems, through knowledge engineering, combine personal and non-personal knowledge. Intelligent systems enhance the logical culture of the individual, enhance mental activity and support human creativity.

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Other researchers draw attention to the fact that information technologies, on the one hand, equalize the capabilities of people with different intellectual abilities, and on the other – reduce the number of reasons motivating a person to develop intelligence (Gorbacheva, 2014, 139).

The development of the digital society, in which big data, Neurotechnology and artificial intelligence, industrial Internet, wireless communication technologies, virtual and augmented reality technologies will play a significant role, raises questions about the prospects for the development of intelligence, the creation of a generalized theory of intelligence, ecology of intelligence and social responsibility of information technology developers.

2. Diversity of approaches to the definition of intelligence

2.1. Basic definitions of intelligence in psychology

The main vector of development of intelligence research in psychology was the search for a variety of manifestations of intelligence in various psychological disciplines – in general, age, engineering and differential psychology, pathopsychology and neuropsychology, psychogenetics. At the same time developing views on intelligence as a general, universal psychological ability.

It is important that in the early twentieth century, intelligence was considered in development of the level of mental development achieved by a certain age. Intelligence is manifested in the



formation of cognitive functions, in the degree of assimilation of mental skills and knowledge. The following factors were considered: the influence of the environment on the individual level of intelligence, i.e. the influence of intellectual age family, the intellectual climate in the family, profession of parents, social interactions in childhood, etc. The importance was also attached to the conditions under which the intellectual experience of the child was intensively increased and the conditions under which the accumulation and integration of intellectual experience slowed down.

In psychology there is a tradition of defining intelligence as a set of characteristics: testology intelligence – this is an indicator of the speed and success of solving test problems. In experimental psychology, intelligence is treated as a set of functional characteristics. The founder of the first French laboratory of experimental psychology A. Binet interpreted intelligence operationally: intelligence is something that can be measured by tests. In testology to date, there is an understanding of intelligence as a mental ability to act rationally in a new situation.

Psychometric and experimental psychological studies of intelligence were accompanied by the development of conceptual approaches to the study of intelligence and its development. Thus, R. Sternberg identified the following forms of intellectual behavior: 1) verbal intelligence (vocabulary, erudition, the ability to understand what one read); 2) intelligence as the ability to solve problems; 3) practical intelligence, manifested in the ability to achieve goals, etc. (Sternberg, Conway, Kerton, Bernstein, 1981).

Structural-genetic approach to the study of intelligence and its development is based on the ideas of J. Piaget, who considered intelligence as the highest universal way of balancing the subject with the environment. Piaget distinguished four types of forms of interaction "subject-environment": 1) forms of the lower type, formed by instinct and directly arising from the anatomical and physiological structure of the body; 2) holistic forms, formed by skill and perception; 3) holistic irreversible forms of operation, formed by imaginative (intuitive) preoperative thinking; 4) mobile, reversible forms that can be grouped into various complex complexes formed by "operational" intelligence.

In psychology, there are two basic paradigms that use different methods to study intelligence, and offer different definitions of intelligence: "1. Histologically paradigm (intelligence is what is measured by intelligence tests; the last time this definition is clarified by introducing the concept of "psychometric intelligence"). 2. Experimental-psychological paradigm (intelligence is a characteristic of intellectual activity due to the action of certain factors)" (Kholodnaya, M. A. 2006, p. 150).

Experimental psychological studies of intelligence have developed several approaches: phenomenological, which treats the intellect as a special form of organization of consciousness, the genetic approach, in which intelligence is understood as a form of adaptation to natural and artificial environment, as well as sociocultural, in which intelligence is understood as the result of socialization, and a number of other approaches (Kholodnaya, M. A. 2006, p. 150).

One of the most famous definitions of intelligence in modern Russian psychology is the following: "intelligence (eng. intelligence; from lat. intellectus — understanding, cognition) — 1) general ability to cognize and solve problems, determining the success of any activity and underlying other ability; 2) the system of all cognitive (cognitive) abilities of the individual:



sensation, perception, memory, representation, thinking, imagination; 3) the ability to solve problems without trial and error "in mind". The concept of Intelligence as a General mental ability is used as a generalization of behavioral characteristics associated with successful adaptation to new life challenges" (Meshcheryakov, Zinchenko, 2006, p. 672).

2.2 Intelligence in cognitive research and philosophy

The cognitive approach is based on the understanding of intelligence as a cognitive structure, the specificity of which is determined by the individual's experience. In accordance with the factor-analytical approach developed by Charles Spearman, intelligence is "mental energy", the level of which determines the success of any tests. Ch. Spearman identified the so called general factor of intelligence that has the greatest impact on the search for abstract relationships in the performance of tests, and the least impact - when performing sensory tests; "group" factors of intelligence - mechanical, linguistic, mathematical, as well as "special" factors that determine the success of individual tests.

R. Cattell's concept of "fluid" intelligence and "crystallized" intelligence is widely spread. This concept takes an intermediate position between the views of intelligence as a single General ability and ideas about it as a set of mental abilities. According to Cattell, "fluid" intelligence is used in the tasks, the solution of which requires adaptation to new situations; it depends on the hereditary factor; the "crystallized" intelligence acts at the decision of the tasks demanding the reference to the past experience (knowledge, abilities, skills), in a large degree borrowed from the cultural environment.

John Gilford identified three dimensions of intelligence: mental operations; features of the material used in the tests; the resulting intellectual product. The "cube" of Gilford, i.e. the combination of these elements, gives 120-150 intellectual "factors", many of which were identified in experimental studies. Gilford identified social intelligence as a set of intellectual abilities that determine the success of interpersonal assessment, forecasting and understanding of human behavior. Gilford highlighted the creative ability to divergent thinking, ie. the ability to generate original non-standard solutions and the ability to convergent thinking, which is revealed in problems that require a unique solution, which is found with the help of learned algorithms.

Tests by G. Eysenck represent a quantitative estimate of intellectual abilities. Verbal, digital, graphic material is used for the overall assessment of human intelligence, when the person follows the instructions. Eysenck also developed tests to evaluate verbal, mathematical and visual spatial abilities. G. Eysenck argued that the basis of intelligence lies in the genetically determined characteristics of the nervous system that determines the speed and accuracy of information processing (Eysenck, 2003, p. 192).

Currently we observe integrative processes in philosophical, psychological, cognitive studies of intelligence and thinking. In the New Philosophical Encyclopedia, intellect (lat. intellectus – mind, reason, reason) is defined as follows: "...in the General sense, the ability to think; in epistemology – the ability to mediate, abstract knowledge, which includes functions such as comparison, abstraction, the formation of concepts, judgment, reasoning; opposes direct types of knowledge – sensual and intuitive; in psychology – rational, subordinate to the laws of logic



thinking; opposes irrational areas of the psyche – emotions, imagination, will, etc." (Suvorov, 2000, p. 127).

Due to the success in the development of Cybernetics, systems theory, information theory, artificial intelligence, there is a tendency to interpret intelligence as the cognitive activity of any complex systems capable of learning, purposeful processing of information and self-regulation. Research in the field of artificial intelligence (AI) made it possible to clarify "the phenomenon of natural intelligence (NI), because AI (as a field of research) is engaged in the approximation of NI, more precisely, the set of abilities that form its real phenomenon. These are:

- (1) the ability to isolate and organize essential data and knowledge (it is a necessary aspect of intuition);
- (2) the ability for goal setting and planning behaviour – a product of the sequence »goal – plan – action«;
- (3) ability to select knowledge (assumptions of conclusions relevant to the purpose of reasoning);
- (4) the ability to derive consequences from available facts and knowledge, i.e. the ability to reason, which may contain both plausible conclusions used for hypotheses and reliable conclusions (hence, reasoning is understood as a sequence of plausible and reliable conclusions);
- (5) ability to make reasoned decisions using ordered knowledge (knowledge representation) and reasoning results corresponding to the goal;
- (6) ability to reflect – evaluate knowledge and actions;
- 7) cognitive curiosity: the cognizing subject should be able to ask the question "what is it?" and look for the answer;
- (8) ability and need to find an explanation (not necessarily deductive!), as the answer to the question »why?«;
- (9) the ability to synthesize cognitive procedures that form heuristics of the problem solving and problem consideration, for example, such heuristics is the interaction of induction, analogy and abduction (taking into account the falsification of hypotheses by searching for counterexamples), followed by the use of deduction;
- (10) ability to learn and use memory;
- (11) the ability to rationalize ideas: the desire and ability to clarify them as concepts;
- (12) the ability to create a complete picture of the subject of thinking, combining knowledge relevant to the goal (ie, the formation of an approximate "theory" of the subject area);
- (13) the ability to adapt to changing situations and knowledge, which means the correction of "theory" and behavior.

It should be noted that the characterization of "practical intelligence" in cognitive psychology contains three abilities – goal-setting, adaptation and evaluation (the ability to be critical of one's thoughts and actions)" (Finn, 2009, p. 89).

3. Conclusions

In modern epistemology, there is a need to develop the theory of intelligence as a carrier of the whole variety of the revealed manifestations and properties. The peculiarity of the modern stage of philosophical understanding of intelligence is determined by the following factors: 1) numerous experimental data on various types and manifestations of intellectual activity accumulated in psychology, psychophysiology, cognitive science, neuroscience, artificial intelligence and other disciplines; 2) the need for systematization, generalization and inclusion



of these data in the corpus of modern epistemological knowledge; 3) the lack of a General theory of intelligence in psychology and the need for ontology of intelligence, as intelligence is considered in psychology mainly as a process; 4) the development of cognitive science and cognitive disciplines that implement a computational approach to intelligence; 5) the diversification of modern epistemology, which creates prerequisites for the systematization and integration of experimental data on intelligence in epistemology (Nikitina, 2014, Nikitina, 2017).

Generalized ideas about intelligence will be the basis of a comprehensive Turing test. This will form the direction of "intellectual assessment of technology" in the framework of social responsibility of developers of intelligent systems and technologies used in complex human-size systems.

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