Integral knowledge as methodologic foundation for design of Artificial Intelligence systems

O Netrebskaya

Department 517, Moscow Aviation Institute (National Research University), 4 Volokolamskoe Highway, 125993, Moscow, Russian Federation

E-mail: netrebskayaon@mai.ru

Abstract. An all-system, interdisciplinary approach in the field of artificial intelligence research, applicable for airspace industry is proposed. It is important to determine the philosophical direction in which the cognitive functions of “machine thinking” are implemented. The cognitive activity of intelligent machines depends on what is meant by the categories “intelligence”, “consciousness” or “social consciousness of machines”. In the Russian context, the system of concepts of Russian philosophy, such as integral knowledge, is relevant as a worldview basis for the practical development of artificial intelligence systems and industrial development of anthropocentric artificial intelligence. Integral knowledge – is the leading category of Russian philosophy of the XIX century – organic synthesis of various types of knowledge. Within the framework of an interdisciplinary approach, based on system research, it is obvious that full-fledged empirical technical modeling of artificial intelligence systems is possible. Such modeling can be carried out with the imitation of “intelligence” and with the use of well-known categories: science, philosophy, etc. Scientific and methodological levels of interdisciplinary research of information interaction of robots in groups are analyzed. A scheme of systematic research of specific technical developments is proposed, which uses the features of forms of social consciousness and the integral knowledge of a person.

1. Introduction

The artificial intelligence (AI) technologies having acquired the status of strategic ones have been successfully applied in Aviation. Firstly Artificial Intelligence Systems (UASs) helps to design aircrafts diminishing the general improvement time and cost for a flying machine. Present day airplane incorporates an assortment of programmed control framework that helps the flight team in route, flight administration and expanding the dependability attributes of the plane. AI is now being utilized at air terminals and via carriers for various things, for example to enable clients to check in and find out about their flights etc. [1].

In this paper consideration of AI is primarily associated with designing Unmanned Aerial Vehicles (UAVs). UAVs are becoming very popular nowadays due to the emergence of application areas such as the Internet of Drones (IoD). They are finding wide applicability in areas ranging from package delivery systems to automated military applications [2].

Except for military purposes they are applied to support firefighting and in search and rescue operations, to monitor and assess critical infrastructure, to provide disaster relief by transporting emergency medical supplies to remote locations etc. [3].

Philosophy as a universal knowledge of existence is of particular importance in the formation of an interdisciplinary approach in the research activities. Performing a methodological function, consisting
in the fact that on the basis of philosophical principles, methods, laws, concepts, etc. the methodology of science as a whole, as well as the methodologies of particular sciences are formed, it is philosophy that is able to solve the problem of joint consideration of problems belonging to different areas of knowledge. Equally, philosophy is called upon to implement a systematic approach, which consists in the application of theory of knowledge and dialectics to the study of processes taking place in nature, society, and thinking.

On the other hand, AI is an interdisciplinary science. Its study is based on research in the field of cognitive psychology, neurophysiology, applied mathematics, computational linguistics, programming, etc. There are also quite new areas of knowledge related to AI such as ontologies, soft or fuzzy computing, machine self-learning, etc., used in autonomous robotic systems technologies. Artificial Intelligence is understood as a set of technological solutions that allows us to simulate human cognitive functions (including self-learning and search for solutions without a pre-set algorithm) and get results when performing specific tasks that are comparable, at least, with the results of human intellectual activity [4].

Therefore, it is important to determine the philosophical direction in which the cognitive functions of “machine thinking” are implemented. The cognitive activity of intelligent machines depends on what is meant by the categories “intelligence”, “consciousness” or “social consciousness of machines”. In the Russian context, the system of concepts of Russian philosophy, such as integral knowledge, is appropriate as a worldview basis for the practical development of AI systems.

The relevance of this work is determined by the need to formulate a system-wide, interdisciplinary approach to the design of human-machine systems of AI.

2. Concept of integral knowledge

Integral knowledge is the leading category of Russian philosophy of the late XIX - early XX centuries - an organic synthesis of various types of knowledge, both rational and non-rational (empirical - experimental science; abstract thinking - speculative philosophy; faith-theology, etc., therefore, has not only a theoretical character, but must meet all the needs of the spirit, satisfy the highest aspirations in the will, mind and feeling). Such knowledge is the most complete and adequate reflection of reality – truth itself when the knower completely coincides with the known.

Therefore, it is important to determine the philosophical direction in which the cognitive functions of “spirit” (consciousness) is a kind of unity and in the cognitive process acts as a kind of integrity: it is impossible to completely separate any of its manifestations, for example: emotional, rational, or any other its component.

However, according to one of the most consistent adherents of the concept of integral knowledge, the Russian philosopher S N Bulgakov, this is exactly the attempt made by I Kant. In the sphere of pure reason, the cognizing subject of Kant, according to Bulgakov, appears as an exclusively “logical function” outside of relation to the integral consciousness [5].

At the same time, it is obvious that Kant himself understands the essence of man as a multi-faceted unity of various manifestations of his personality. This is reflected in the works of the great German thinker, analyzing rational, moral, value and aesthetic consciousness (“Critique of Pure Reason” (1781), “Critique of Practical Reason” (1788), and “Critique of the Power of Judgment” (1790). It should also be noted that Kant was the author of the idea of systematic scientific knowledge, as well as the founder of the concept of constitutive (defining) subjectivity. Thus, the unity of scientific knowledge according to Kant has the character of an organic integrity, acts as a kind of epistemological imperative of its concept [6]. On the other hand, Kant's theory of constitutive subjectivity allows us to speak of the subject of any type of activity, including cognitive, as a goal-setting, active person.

Regarding AI it is also necessary to take into account the most important position of modern cognitive science and philosophy - namely, that the formation of consciousness (and therefore intelligence) of an individual is possible only in the interaction with other individuals, i.e. in society, in a group of their own kind. Even the great Aristotle defined man as a “social animal”.

The idea of the social nature of man was one of the earliest and predominant in Marx’s philosophical themes. It is fully expressed in the “Theses on Feuerbach”, where Marx speaks of the essence of man as
“an ensemble of social relations”. He also asserts that consciousness is a social product and remains so as long as people exist at all [7].

The remarkable Soviet thinker M K Mamardashvili in fact repeats this idea, defining sociality as a kind of “commonality of our attitude to what we transcend our empirical being”. The philosopher recognizes that “it is necessary, according to Marx, to have first communication, that is, sociality” and that “it is really impossible to be a person outside the society” [8].

Outstanding Russian Soviet scientist and philosopher-cosmist V I Vernadsky, in his work “Scientific Thought as a Planetary Phenomenon” (1936-1938), stating the fact of the creation of the human brain in the evolutionary process, suggests that “it follows that reason is a complex social structure, erected similarly for contemporary Man, as well as for Paleolithic Man, on the same neural substrate, but in different social circumstances that formed over time (essentially over space-time)” [9].

Cosmism is a set of philosophical and religious trends that go back to the ideas of antiquity, exploring the problem of the cosmic unity of all living things, as well as mystical and intuitive knowledge of extraterrestrial spaces. The planet Earth is considered as a part of the cosmos with general, universal laws of development.

Russian cosmovism is a worldview that emerged as a branch from cosmism in the middle of the XIX century in Russia as a result of the mutual influence of natural sciences, humanitarian scientific disciplines, philosophical and religious trends, literature and art in the environment of the original culture of Russia.

Russian cosmovism, in a broad sense, is the philosophy of the late XIX - early XX centuries - the philosophy of unity, the most important category of which is integral knowledge. The founder of this philosophy is V S Solovyov, but the concept of integral knowledge was developed by his predecessors. Thus the Slavophile thinker I.V. Kireevsky, “sought spiritual and ideological integrity. This idea of wholeness was not only an ideal for him: he saw it as the basis for the construction of reason. It was in this plan that Kireevsky raised the question of the relationship between faith and reason, only their inner unity was the key to the whole and all-encompassing truth” [10].

Solovyov connected the problem of comprehending truth and meaning with integral knowledge, considering it in the context of a broader concept - integral life, that is, the result of the historical development of humanity as a living organism, consistently developing this idea in the General historical introduction to the work “Philosophical principles of integral knowledge” (1877) [11]. Thinking, according to Solovyov, can be considered in three aspects: knowledge of the actual, formal and absolute. These aspects are represented by positive science, philosophy and theology.

In Solovyo"v’s teaching, the highest task of thought is to understand everything as one whole in the Absolute, the world as an all-unity. To accomplish this task is called whole knowledge, which must see everything in one and, therefore, cannot be exclusively theoretical in nature. Although the search for truth, according to Solovyov, is a function of the mind, but without the desire to possess it, it would be absolutely impossible to search for it. Will is also inseparable from reason, since it requires a meaningful existence, while the search for reason and the desire for will are inextricably linked with a sense of the missing fullness of the unconditioned content. And finally, only in a life imbued with unconditional content and meaning our feeling can find complete satisfaction. It is obvious that the highest ideal of knowledge is the great synthesis, that is, the union of all particular knowledge in one whole knowledge. Only integral knowledge, according to Solovyov, can overcome the contradictions of purely rational knowledge associated with its abstraction.

A direct follower of Solovyov in the development of the concept of integral knowledge is S N Bulgakov. The methodological basis for the formulation of the problem of meaning for Bulgakov was the philosophy of unity and the doctrine of Sophia [12]. The doctrine of Sophia is one of the most important in the philosophy of that period. Sophia's understanding is ambiguous. According to one interpretation, Sophia is the content of all meanings. The importance of Sophiology in Bulgakov's teaching is pointed out by P Valliere [13].

As a result, Bulgakov developed a concept according to which any antinomies (contradictions) of the mind are overcome “in the highest vital unity”, in metalogical contemplation, which implies the
connection of various forms of knowledge.

Another Russian thinker P A Florensky like Solovyov, distinguished three types of knowledge: sensuous, intellectual, and mystical. But at the same time he himself was a living embodiment of the ideal of integration that Solovyov had proclaimed, so that was even called “the Russian Leonardo”. He contributed a lot to mathematics, physics, electrodynamics, folkloristics, philology, marine botany, art history and theory, earth science, philosophy, theology, and esotericism. He strove for a comprehensive worldview, uniting science, religion, and art; reason and faith. His main ideas he expressed in “The Pillar and Ground of the Truth” (1925) [15].

The theory of integral knowledge is also reflected in ontological epistemology, a teaching developed by many Russian thinkers of that time. Thus, N A Berdyaev wrote that new organic knowledge is possible only if the act of cognition is considered as an act of life, and thinking as a function of a living whole. The development of his theory of knowledge had begun with an ontologically grounded epistemology, epitomized in “The Philosophy of Freedom” (1911), where philosophical reflection is envisioned not merely as speculative and abstract, but, on the contrary, as a participation and multifaceted involvement in Being. Cognition and philosophical reflection are represented at this relatively early stage as rooted in Being itself and as inseparable from it [15].

Concept of meaning by E N Trubetskoy can also serve as an example of ontological epistemology. Developing it he proceeded from the position that “every logical thought seeks to establish itself in something unconditional and universal, which is called truth or meaning” [16]. The justification of the category of meaning leads Trubetskoy to the idea that meaning presupposes an absolute synthesis in which all representations are connected with each other before any conscious subject comprehends this connection. “To presuppose truth,” writes Trubetskoy, “is to presuppose not only an absolute, all-one, but at the same time an eternal synthesis of all possible contents of consciousness”.

3. Methodology
Active research in the field of creating systems of interacting robots has been conducted for almost a quarter of a century. Robot is defined as a machine with anthropomorphic behavior, which has the ability, using heterogeneous information sensors, to analyze the situation, predict it, make decisions, conduct certain actions to perform them, analyze the results, as well as learn and function together as part of groups when solving a common task. At the same time, a robot is a technical system that can replace a person when performing certain operations, primarily those in which a person may be injured or killed [17]. Concerning the airspace branch such robotic systems can be represented by groups of UAV or multi-satellite orbital groups (in self-organization mode) [18].

Often, living systems – swarms of bees, anthills, etc - are considered as a model and basis. So in the family of ants the training of beginner specimens by more experienced ones during their interaction takes place. At the heart of ants’ ability to learn is a good memory. In the process of learning, imitation reactions are of great importance. The acquisition of necessary skills by insects occurs in society by the method of self-learning and self-development.

The international scientific community recognizes the possibility of forming a “society” of autonomous robots, in particular, jointly functioning in the “flock” or “swarm” mode of large groups of unmanned aerial vehicles. However, until now, the overwhelming number of studies in this area remains at the theoretical, model level. There is a lack of basic research.

One of the main features of group interaction of Autonomous Robotic Systems of the new generation is the need for rapid exchange of data, information, and knowledge between them in a group. In this context, these concepts are defined as follows:

- **Data** – is various signals and messages stored on a physical medium.
- **Information** – is data included in the communication process in a specific context, with a given goal setting.
- **Knowledge** – is data in memory formed on the basis of information.
- **Intelligence** – is support for real cognitive functions not only with learning, but also with the formation of new rules and concepts of self-learning and development [17].
These terms are defined by applying an approach based on the description of their functions and characteristics in the structures that are part of metapograms. The assumptions made in this case [17] allow us to take advantage of the absence of the need to accurately recreate the processes of knowledge formation in the human brain.

One of the goals of computer science is the formalization of methods by which both simple and complex tasks can be automated by machine. Currently, AI is modeled by a computer program. Conceptualization of the thinking model is carried out in the form of logic. To a certain extent, logic philosophers have been laying the foundations of AI since antiquity, but only with the advent of electronics did it become possible to apply their work in machines [19].

At the same time, complex systems of any kind – social, economic, biological, psychological, technical, etc. – cannot be adequately described within the framework of one traditional scientific discipline. The task of designing a complex technical system “man-machine” requires solving a large complex of technical, as well as economic, engineering, psychological, and social problems. To successfully solve this problem, it is not enough to simply combine the efforts of engineers, economists, psychologists, sociologists, etc. The process of creating a complex technical system cannot be divided into many disjoint technical, psychological, economic and other problems; all of them are interconnected in a single system. Only an interdisciplinary approach to them, focused from the very beginning on the systemic coherence of the problems to be solved, can lead to success.

Modern technological developments of Autonomous Robotic Complexes include such methods as machine self-learning, cognitive methods and systematic study of the machine society. At the same time, self-learning and self-development of complex systems is very expensive in terms of labor costs for programming and algorithm development. The problem can be solved on the basis of a systematic study of robotic projects with imitation of human cognitive functions in the paradigm of philosophical forms of consciousness of the human community and forms of “collective consciousness” of machine society interacting with partial human participation or even without it.

The relevance of solving this problem lies in the practical difficulty of manual programming of complex intellectual societies of robots by human programmers. Their automatic intellectual self-programming and self-development on the principles of imitation of the self-development of the human society are necessary.

It would be more economical to replace the programming of individual robots by autonomous self-development of the society of machines with the imitation and self-development of forms of collective or social consciousness.

The paradigm of system research (figure 1) with integral knowledge involves combining the scientific and technical approach and all other forms of social consciousness and forms the theoretical basis for self-developing cognitive and, consequently, intellectual robotic complexes.

One of the main features of group interaction of UAV (autonomous intelligent robotic systems) of the new generation is the technical requirement to ensure rapid exchange between robots in the group not only by data, but also by knowledge.

When observing the information exchange of people with knowledge in their daily lives, it is possible to deduce its main features. These features are the basis for a holistic paradigm of information interaction of people in human society, based on the use of data and knowledge. Projecting these features on information interaction in a robotic complex without human participation, we will not be able to directly use the knowledge accumulated in the minds of people and transmitted to many generations in human society in the form of holistic knowledge. Instead of data and knowledge in the machine itself, we can only use data and pre-formed special metapograms.

A metaprogram is a program that outputs another program as a result of its work. It is important that any metaprogram defines not one specific program, but a whole class abstracted from specific implementations of the model domain [20].
In this case, a *metaprogram* is a computer program built in the form of a multidimensional structure containing data, data content structures, descriptions of algorithms, specifications of methods and rules for solving problems within a certain goal setting, as well as other programs.

*Goal setting* in the metaprogram is determined by the target function, since, in accordance with the set limitations of the task, there is no possibility of direct access to the memory and knowledge of a person in the machine.

An *objective function* is a function whose extreme value is searched for on a valid set in mathematical programming problems.
Launching a metaprogram in a machine starts computing processes, as a result of which other programs are obtained at the output of the computing device, which, in turn, taking into account a certain target function, can also be run in the computing device of the same or another machine in order to solve a given set of tasks.

System process research should not be confused with system analysis, since research, in contrast to analysis, allows for a consistent, iterative synthesis of whole knowledge in the process of machine self-learning with the obligatory interaction of self-learning robots. Thus, each robot is trained not so much by a person (creator or teacher) as by similar robot in society, as it happens in the children’s society of people.

There may be different methods of verification of truth in such approach. As an example of a verifying method the Bayesian method may be used.

The proposed approach based on a system study was previously partially published [21,22], but this paper for the first time (as far as the author knows) suggests the use of integral knowledge in robotic complexes, presented in the form of data structures in the space of parameters that simulate indicators and signs of interaction between people and machines in the forms of public consciousness of people and “consciousness of machines”, for example, in a legal form, comparing a set of rules for permissible behavior in permitted areas of movement and interaction of people or robotic complexes.

In contrast to engineering, a systematic approach will require the imitation of all forms, including art and religion, partly to the detriment of rationality, but only under this condition the self-development of society can occur and, consequently, the cognitive intellectual function becomes possible.

The main forms of theoretical awareness of system research methods in the framework of modern science (figure 1) are: the system approach, general systems theory, various specialized system theories – biological, psychological, linguistic, technical, etc. General systems theory sets itself the task of generalizing the description of systems of different classes and types and developing specific methods for their analysis. The system approach is one of the modern general scientific directions of research; it is focused on the identification of special methodological principles of theoretical reproduction in the knowledge of ideas about integral, systemic objects. Specialized systems theories develop the principles of system research with respect to certain classes of objects.

The problem of partial replacement of human consciousness by computer programs in autonomous robots capable of acting in groups seems appropriate to investigate and solve at three scientific and methodological levels, which include:

1) interdisciplinary systematic study of consciousness and the integral knowledge of a person with a certain worldview in the ontological model of the real world;
2) fundamental scientific research of human functions for the formation of scenarios for replacing human consciousness with its virtual counterpart;
3) applied development of autonomous robots.

4. Conclusion

Within the framework of an interdisciplinary approach, based on a system study, the possibility of if not theoretical design of AI systems, then their full-fledged empirical technical modeling, carried out in a similar way to modeling the intellectual interaction of a person with other people, is obvious. Such modeling can be carried out by imitation of intelligence, using well-known categories: information, knowledge, science, philosophy, etc.

The Philosophical category of integral knowledge contributes to the methodology of AI as it can be efficiently used as methodological foundation for design of groups of UAVs or multi-satellite orbital groups as well as any other intellectual robotic complexes.

The paradigm of system research with integral knowledge involves the integration of scientific and technical approach and all other forms of social consciousness and forms the theoretical basis of self-developing cognitive and, consequently, intellectual robotic systems.

The practical problem of ensuring information interaction of autonomous robots can be solved only if, along with fundamental scientific research, an interdisciplinary system study is carried out (figure 1),
using systems of concepts of various forms of public consciousness (in general, from Science, Philosophy and Ethics to Economics, Law and Religion). At the same time, cognitive intelligence can appear only in the conditions of self-development in the society.

Thus, cognitive intelligence can appear only in the conditions of self-development in the “society” of robotic systems.

References

[1] Kashyap R 2019 Artificial Intelligence Systems in Aviation Cases on Modern Computer Systems in Aviation (Ukraine: IGI Global) chapter 1 pp 1-26
[2] Alladi T, Naren, Bansal G, Chamola V and Guizani M 2020 SecAuthUAV: A Novel Authentication Scheme for UAV-Ground Station and UAV-UAV Communication. Transactions on Vehicular Technology 69(12) 15068 doi: 10.1109/TVT.2020.3033060
[3] Wang S, Han Y, Chen J, Zhang Z, Wang G and Du N 2018 A Deep-Learning-Based Sea Search and Rescue Algorithm by UAV Remote Sensing. Proc.Conf. of Navigation and Control (Xiamen, China) pp 1-5
[4] Decree of the President of the Russian Federation No. 490 of 10.10.2019 On the Development of Artificial Intelligence in the Russian Federation
[5] Bulgakov S N 1993 Tragedy of philosophy. Philosophy and Dogmat. Essays in two volumes (Moscow: Nauka) Vol 1 p146
[6] Kant I 1994 Critique of Pure Reason (Moscow: Mysl) p 486
[7] Marx K and Engels F 1969 Engels Selected Works Vol 1 (Moscow: Progress Publishers) p 14
[8] Mamardashvili M K 1996 Introduction to philosophy. The need for yourself (Moscow: Labyrinth) p 136
[9] Vernadsky V I 2012 The Transition from the Biosphere to the Noösphere. Excerpt from Scientific Thought As a Planetary Phenomenon. 21st Century Science & Technology 25 (1-2) 103
[10] Zhenkovsky V V 1999 History of Russian philosophy in 2 Volumes (Rostov-on-Don: Phoenix) Vol 1 p 250
[11] Solovyov V S 1992 Philosophical Principles of Integral Knowledge. Collected Works and Letters in 15 Volumes (Moscow: Logos) Vol 1 p 290
[12] Bulgakov S N 1993 Sophia, the Wisdom of God: an Outline of Sophiology (New York: Lindisfarne Press) p 14
[13] Valliere P 2000 Modern Russian Theology: Bukharev, Soloviev, Bulgakov: Orthodox Theology in a New Key (Michigan: Eerdmans: Grand Rapids) p 264
[14] Giragosian J G 2014 Wisdom as Sophia: an analysis of the Sophiologies of the 19th-20th century Russian Philosopher -Theologians – V Solovyov, P Florensky, and S Bulgakov - implications for adult learning, PhD thesis, Virginia Polytechnic Institute and State University
[15] Linde F 2010 The Spirit of Revolt Nikolai Berdiaev’s Existential Gnosticism (Stockholm : Acta Universitatis Stockholmiensis) p 195 Trubetskoy E N 2003 The Meaning of life (Moscow: AST) pp 5-30
[16] Trubetskyo E N 2003 The Meaning of life (Moscow: AST) pp 5-30
[17] Mikheev V A and Ushakov V N 2017 Knowledge representation in metaprograms of robotic complexes. Information technologies and Systems. Proc. Int. Conf. 6th on Informational Technologies and Systems (Chelyabinsk: Chelyabinsk State University) pp 182-187
[18] Balukhto A N and Romanov A A 2019 Artificial intelligence in space technology: the state, prospects of development. Rocket and Space Device Engineering and Information Systems 1(6) 65 DOI 10.30894/issn2409-0239.2019.6.1.65.75
[19] Colburn T R 1999 Philosophy and Computer Science (New York: M. E. Sharpe, Inc.) chapter 7 p 87
[20] Ushakov V N 2007 Multiparadigm Modeling by the SODAR-2 Language. Automatic Documentation and Mathematical Linguistics 41(5) 195 https://doi.org/10.3103/S0005105507050003
[21] Ushakov V N, Vorontsov L V, Mikheev V A, Netrebskaya O N and Buleyko A B 2018 Requirements for Standardization of Control Systems for Groups of Robots Based on the
Results of a System Study. *Proceedings of the FSUE Scientific and Production Center of Automation and Instrument Making named after Academician N A Pilyugin. Control Systems and Devices* 2 pp 66-77

[22] Ushakov V N and Netrebskaya O N 2018 System-Wide Approach to Interdisciplinary Research of Information Interaction in Robotic Complexes. *Pros. Russian Conf. on New information technologies in communication and control systems* (Kaluga: Noosphera) pp 56-59