https://doi.org/10.48417/technolang.2023.04.05
Research article

Ontology of Artificial Intelligence as a Field of Engineering

Anna Kolovskaia [1] and Andrew Ilin[2] (✉)
[1]Siberian Federal University. 79 Svobodny Avenue, 660041, Krasnoyarsk, Russia
akolovskya@sfu-kras.ru
[2] Peter the Great St. Petersburg Polytechnic University, Polytechnicheskaya, 29, 195251, St. Petersburg, Russia
and-man-star@ya.ru

Abstract
A major point of interest and fascination in our contemporary world is to include artificial intelligence (AI) technologies in resource turnover based on the development of multidisciplinary (convergent) scientific areas combining engineering and cognitive sciences. Such areas as philosophy and linguistics occupy an important place as a tool for creating metatheories, as well as inclusive AI pedagogy requiring special pedagogical tools and other approaches to learning that are based on the principles of biomimetics. Convergence is necessary in terms of the interaction between technical and social systems. Computational and cognitive models of consciousness, language, intellectual and cognitive functions from the standpoint of the philosophy of science and technology are actively developing modern fields of knowledge. The effectiveness and quality of intelligent technical systems (ITS) is determined by cognitive technologies. Developments of hardware and software and applied (meta) materials lead to an increase in resilience and durability, reliability, and fault tolerance. Convergence raises the issue of the nomenclature of existing specialties and the need to introduce the qualification of an "ontology engineer" who should solve the problems of functional integrity in emerging systems engineering. In systems engineering the conceptual design for the life cycle of artificial objects is currently inspired by classical metaphysics. In real practice, when implementing the life cycle of ITS, postmodern presumptions appear giving rise to problems of irreducibility and incompleteness of languages describing various models (paradigms). This approach requires an ontology engineer as a new profession.

Keywords: Ontology of artificial intelligence; Ontology engineering; Language of science; Metaphors

Citation: Kolovskaia, A., & Ilin, A, V. (2023). Ontology of artificial intelligence as a field of Engineering. *Technology and Language, 4*(4), 46-57. https://doi.org/10.48417/technolang.2023.04.05

УДК 1: 004.8
https://doi.org/10.48417/technolang.2023.04.06
Научная статья

Онтологии искусственного интеллекта как сфера инженерной деятельности

Анна Юрьевна Коловская[1] и Андрей Дмитриевич Ильин[2] (✉)
[1]Сибирский федеральный университет, Свободный пр., 79, 660041, Красноярск, Россия
akolovskya@sfu-kras.ru
[2] Санкт-Петербургский политехнический университет Петра Великого, Политехническая, 29, 195251, Санкт-Петербург, Россия
and-man-star@ya.ru

Аннотация
Важнейшим предметом интереса и увлечения в современном мире является включение технологий искусственного интеллекта (ИИ) в естественный ресурсооборот на основе развития мультидисциплинарных (конвергентных) научных направлений, объединяющих инженерные и когнитивные науки, среди которых важное место занимают философия и лингвистика, в качестве инструмента создания метатеорий, а также инклюзивная педагогика ИИ требующая особых педагогических средств и иных подходов к обучению, построенных на принципах природоподобия. Конвергенция необходима с точки зрения взаимодействия технических и социальных систем друг с другом. Вычислительные и когнитивные модели сознания, языка, интеллектуальных и когнитивных функций с позиций философии науки и техники – активно развивающиеся современные области знания. Эффективность (качество) интеллектуальных технических систем (ИТС) определяется: когнитивными технологиями; hardware и software; применяемыми (мета)материалами; приводит к увеличению времени активного существования, надежности, отказоустойчивости. Конвергенция поднимает вопрос о номенклатуре существующих специальностей, о необходимости ввода квалификации “инженер по онтологиям”, которая должна решать проблемы эмерджентной (функциональной) целостности в системной инженерии и системотехнике. Концептуальное оформление жизненного цикла объектов искусственной природы в системной инженерии, на сегодняшний день инспирировано классической метафизикой, а в реальной практике, при реализации жизненного цикла ИТС, проявляются презумпции постмодерна, порождающие проблемы несводимости (неполноты) языков описания различных моделей (парадигм), для чего и требуется новая профессия – инженер по онтологиям.

Ключевые слова: Онтология искусственного интеллекта; “Инженер по онтологиям”; Язык науки; Метафоры

Для цитирования: Kolovskaia, A., Ilin, A, V. Ontology of artificial intelligence as a field of Engineering // Technology and Language. 2023. № 4(4), 46-57. https://doi.org/10.48417/technolang.2023.04.05

INTRODUCTION

Today, when technologies are developing so rapidly, the terms and concepts related to scientific and engineering principles and specialized sectoral thesauri sometimes seem outdated and irrelevant, but just at first glance. Ontologies are suitable for representing both formal-mathematical and substantive-descriptive, i.e., semantic models.

Ontology, sometimes existing as a metaphor, remains a meaningful semantic construct for understanding what is present in the world (Kozlova, 2020). Ontological metaphors can be used to explain complex concepts and ideas. For example, an ontological metaphor is implicit in the concepts of biomimetics, and convergence, which are necessary in terms of understanding the interaction between technical and social systems that are applicable to artificial intelligence systems. The cognitive ability of subjects to explore existence in the world of discrete objects and to find relations between them is generally postulated as a prerequisite for the choice of the basic elements of ontological specifications. This is because the relatedness of objects relates to the development of connections between properties and associations of objects, thus providing the properties and classes for modeling the elements of ontologies.

THE "ONTOLOGICAL TURN" TO MULTIPLE ONTOLOGIES

The efficiency of technical systems (TS) is determined by the applied structures, connections, functional elements, materials, their functional properties and so on. This amounts to an increase of resilience and durability, reliability, and fault tolerance. The conceptualization of the life cycle in systems engineering today is inspired by classical metaphysics, and in real practice, the postmodern presumptions, conceptualized in the discourse of poststructuralism, manifest themselves in the construction of the life cycle of TS. As an illustration, it is appropriate to cite here the metaphor of "tree and rhizome" by Gilles Deleuze and Felix Guattari, which gave rise to many subsequent ideas (see the following Figure 1).

The key problems of the discussion are related to the multidimensionality and multidisciplinarity of cognitive sciences and technologies: the theoretical ontological or metaphysical basis of biomimetics due to the decomposition of complexity, affords a scientifically sound, full-scale description of the brain of a living being - its structure, functional connections and, "building blocks" of neurons, including a cybernetic model of artificial neurons (cf. Fig. 1.1. – 1.5., Kolovsky et al., 2020; Kolovsky & Morenk, 2013; Kolovskaia & Kolovsky, 2021).

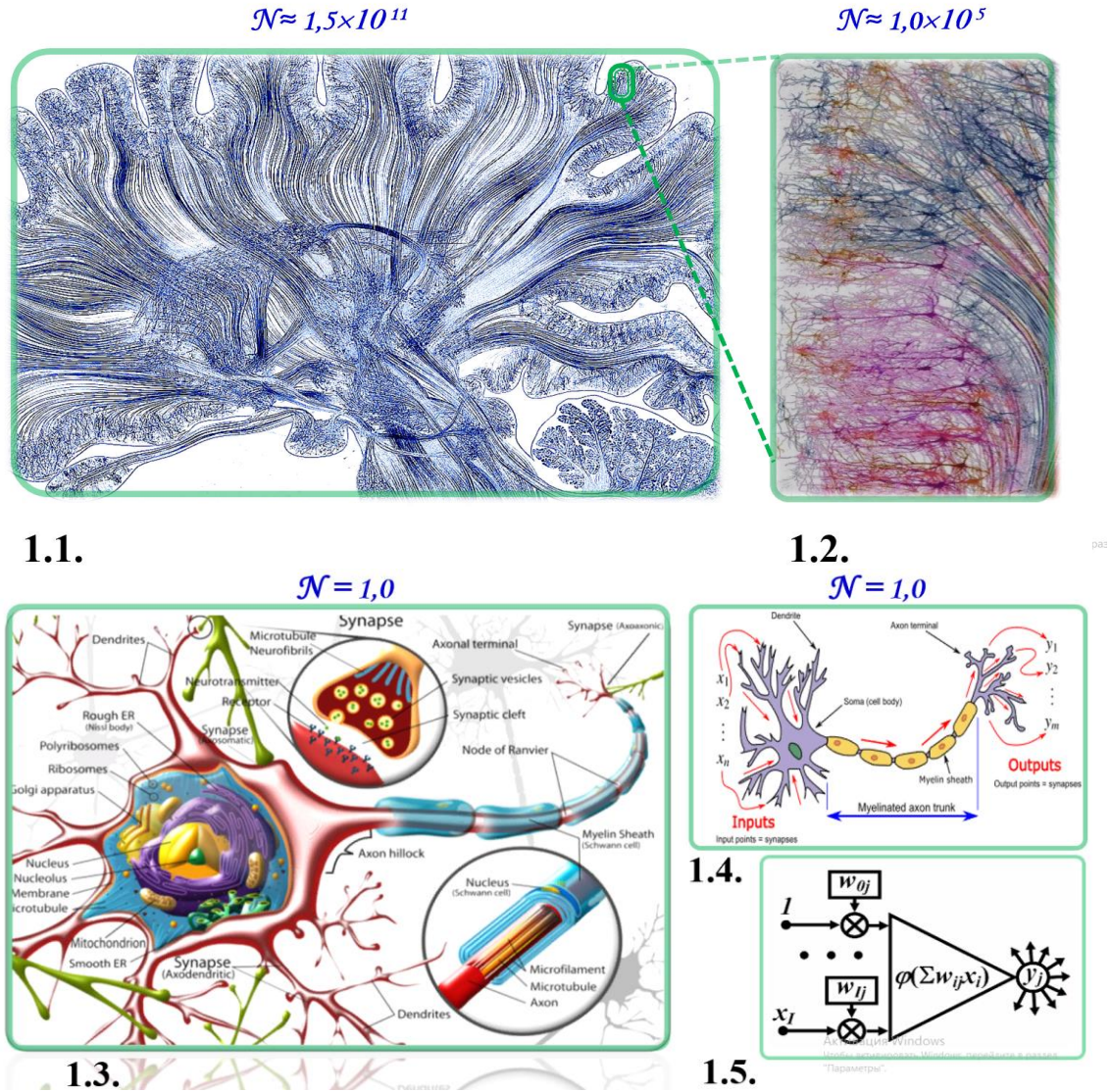

Fig. 1. Likeness to nature, convergence, analog renaissance, inclusive deep learning in cognitive science (1.1., 1.2, 1.3, 1.4.). Ontological or metaphysical basis of likeness to nature and the decomposition of complexity (1. 5.). Cybernetic model of an artificial neuron (Gorban, 1994).

To realize the upward branch of artificial intelligence (AI) development, namely the synthesis of neural network structures, it is necessary to form a fundamentally different, neuro informational paradigm, based on the presumptions of poststructuralism. The created methodology, hardware, software for cognitive technologies demonstrates countless practical results, showing a cardinal increase in the quality and efficiency of “smart things” Figures 2.1 to 2.6 provide examples illustrating and justifying re-engineering and the “analog renaissance” of monitoring, diagnostics, and soft control systems.

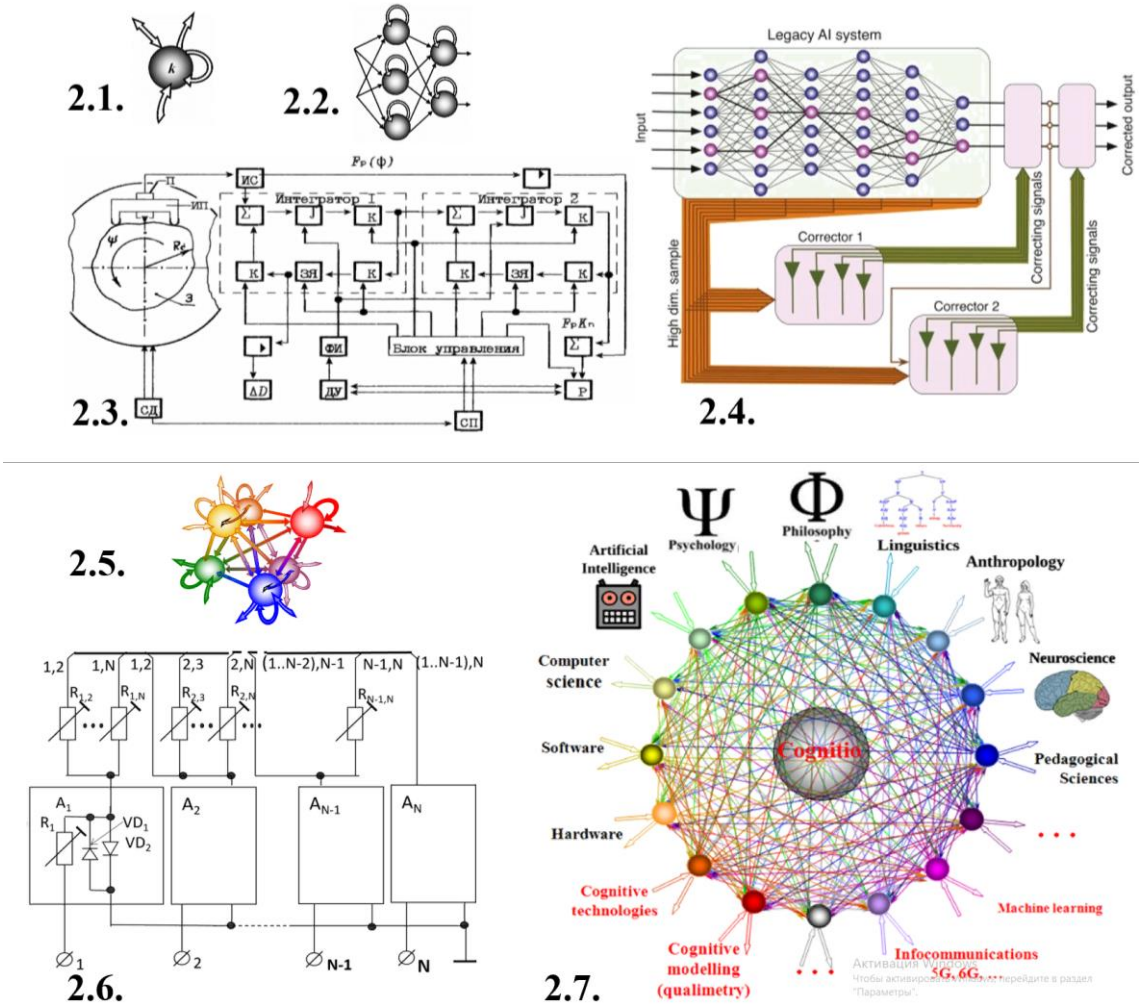

Fig. 2. Synthesis of a rhizome-like structure of an artificial neural network (ANN): 2.1., 2.2. show basic structural elements of a cognitive model (Kolovsky & Morenk,, 2013); 2.3. a functional diagram for analog intelligent measuring system (Truten & Kolovsky, 1979); 2.4. the structural version of an AI error correction technology (Gorban, 2020); 2.5. the structure of a fully connected ANN; 2.6. the structure of an analog passive high-speed neuroprocessor (Kolovsky et al., 2000, Kolovsky & Morenk, 2013); and 2.7. a fully coupled framework for cognitive science convergence (Kolovskaia, & Kolovsky, 2021).

The problems of functional error elimination and other stages of life cycles for objects of artificial nature are next in line. Unlike system analysis, rhizome analysis relies on the poststructuralist presumption "function and structure are orthogonal." Constantly confirmed by the results of engineering activity, it is focused on the functional (semantic) efficiency of the created product, and the associated palliative approach allows to shift

the exact criteria of system analysis to the background when forming structural and communicative solutions.

The complex development of cognitive technologies, with inclusive, convergent technologies among them, implies the inevitable adaptation of organizational, theoretical and practical activity, methodology and the whole arsenal of accumulated multidisciplinary tools and resources to find a complex convergent solution to engineering problems of a particular object, first of all, to reduce the level of erroneous AI solutions.

Metaphors often accompany the changing picture of the world. The metaphor of "network" (rhizome) is present in the most significant names of events, reflecting the changed picture of reality, coming from the so-called "flat ontologies", replacing the previous one which represented the world as hierarchically structured and centered, with these flat ontologies expressed by the metaphor of "tree" (system) (Kolovskaia, & Kolovsky, 2008). These linguistic manifestations are ubiquitous. In particular, they are relevant to models of consciousness, intellectual and cognitive functions. One example is the "semantic web" (SW) as a name for the direction of development of the WWW to present information in a form suitable for sophisticated machine processing (Volodin, 2023).

SW implies recording information in the form of a semantic network with the help of ontologies. An adequate request is articulated as a "frontier" engineering problem, relevant for the future development of artificial intelligence. This is the need for a new qualification – the profession of "ontology engineer" (Gorban, 2020).

"Ontologies generated by artificial intelligence working with data are refined in a dialog with the researcher [...] In software development, there may be a new line – a request for flexible ontological work and creation of micro-worlds" (Gorban, 2020). The researcher, before each attempt to modify the knowledge base, will consult the metadata stored in the ontology for consistency. If conflicts are identified, the ontology is modified.

In the dialogue between ITS and a researcher in the process of machine learning, the problem of the language of science becomes salient since it mediates between them. This means that language is always connected to a certain culture and society, and its meaning and use depend on this context (Kolovskaia, 2016). Current research shows how language affects our ability to think and understand the world around us. It should be emphasized that language does not affect the content of the scientific picture of the world (SCW), but only adapts it to the needs of a particular language community. The linguistic picture of the world (LPW) changes not under the influence of new scientific knowledge, but under the influence of changing conditions of life and new realities. It preserves and conveys a simplified view of the world, using both traditional categories of ontology and creating new ones, adequate to the nature of change.

IDEATION AND AUTOPOIESIS IN THE CONTEXT OF LINGUISTIC AND COGNITIVE ONTOLOGIES

Modern language research is increasingly moving away from the strict structuralist interpretation of language as a simple system of signs. In this new paradigm, the focus is

on the deep foundations and resources of language in the context of human spiritual energy and cognitive activity. This brings to the fore the notion of ideation as a function of consciousness responsible for the ability to create new ideas, concepts, theories and models. Ideation is associated with creative thinking and imagination, as well as with the ability to see things in a new way and find unusual solutions. Ideation and autopoiesis are key mental and linguistic factors in the context of the current consideration of linguistic and cognitive ontologies.

Back at the turn of the 18th to 19th centuries Wilhelm von Humboldt proposed and substantiated the idea of the active creative essence of language, embodying spiritual energy and cognitive human activity. He argued that language does not simply reflect cognizable reality but is a means of discovering a previously unknown reality, is a continuous creative process (Humboldt, 1985, p. 249-343; Soboleva, 2005).

Human language is the most powerful tool of thinking for categorization and classification of the world, which is possible due to its complex structure that is not only lexical, but also grammatical. The language of science, in this sense, appears as a part of the general idea of language. Within the presumptions of classical metaphysics and according to its ontology, the language of science should be characterized by precision and unambiguity of concepts (Loktionov, 2008). However, against the background of presumptions of postmodernism which constitute an alternative to classical metaphysics, actor-network theory, flat ontologies, etc. are characteristic of the post classical ontologies of the 20th century (Ivakhnenko, 2019). On the basis of the ideas of multiplicity, heterogeneity, anti-essentialism, the presumptions of astructurality, de-centeredness, randomness, removal of oppositions, problematic status of meaning, there are attendant changes in the ontology of the language of science. This is manifested similarly in the field of cognitive ontologies, including cognitive modeling in information technologies (Kolovskaia & Kolovsky, 2021).

All these issues are located in an exploratory field, pointing to the presence of metaphors in its definition, which in turn points to the creative component in language, without always clarifying it. As noted by Michel Foucault (1994), the existence of speech in an active setting of self-organization is a creative environment where speech can be repeated, modified, revived, and related to previous utterances, etc. This is another argument for the need to consider the creative nature of language when comparing different ontological constructions (Chomsky, 2005, pp. 22-69; Lebedev, 2009).

The development of artificial intelligence and "especially the rapid improvement of neural networks raises completely new existential questions, not so long ago considered fantastic and irrelevant to science and even to reality itself" (Chernigovskaya, 2023, p. 7). Language, existence and thought are firmly connected through the aspect of human creativity. Is it possible to argue that non-human subjects of linguistic creativity are now emerging, and are there also non-human ontologies underlying the relations of these subjects with reality?

THE ONTOLOGY OF LANGUAGE AND THE METAPHOR OF INTELLIGENCE AS AN IMAGE OF THE WORLD

The dynamics of thinking about language metaphysically is determined by a wide range of research projects, the systematization and classification of which represent a significant task. Language research in different time periods has been characterized by different approaches related to the functional side of the ontological status of language.

The directions of language research, broadly speaking, can be presented as follows:

- The philosophical-methodological approach invokes the basic categories of existence, questions of objectivity, rationality and the degree of hermeneutic freedom.
- The logico-methodological and logico-pragmatic approaches emphasize the foundations of language and communication (Heidegger, 1993; Wittgenstein, 1994).
- The logico-semiotic approach studies the generation and analysis of signs (Saussure, 1977; Barthes, 2009).
- The cognitive approach is situated within the framework of evolutionary epistemology and formal logic, allowing for conceptions of artificial intelligence.
- The cultural approach investigates the movement of language in modern culture, along with a comparative analysis of national and cultural traditions (Matsumoto, 2002).
- The synergetic approach studies language in the context of its stability-instability, diversity, and other functional features (Nazaretyan, 2009).

The wide choice of approaches is determined by the scientific interest in the problems of language which open up new areas and methods of research. The main difficulty lies in keeping the topic within its own boundaries, since contextual multivalence is an obligatory attribute in the analyzed works, and cognitive dissonance is present within a single article (Chernigovskaya, 2009). The priority for our work is to reveal the significance of the ontological aspects related to the language of science and to consider the theories of its functioning as a conceptual system based on the potential of creativity. Considering the linguistic nature of culture, Tomas Kacerauskas (2006) states that “language is part of human reality, in which things are reconstructed as parts of our vital wholeness, thus becoming real” (p. 137). In science, as an element of spiritual culture, the language of science functions as a complex categorical system that forms ideas about the world. This implies the need to consider two sides: language in science and science about language.

The systematization of works clearly points to three main programmatic directions in the ontology of language. The first is the immanent-sign concept, which was developed in structuralism. Here language is considered as an ordered system of signs. The second direction is anthropological, associated with the concept of language proposed by Humboldt. Language is a metastructure that determines all socio-historical structures and has the capacity for self-development. The third program direction is the anthropocosmic concept, adopted by many Russian philosophers, namely the cosmists and religious philosophy. It implies am understanding of language not only as a part of consciousness and thinking but as the logos of the Universe as a whole (Losev, 1974; 1993). Word and name, being the result of thinking, represent a phenomenon. Losev uses the

phenomenological method to describe the word's "energeme", which has not only a physical but also a biological value (Losev, 1993, p. 662).

The correlation between the creativity of language and its cognitive resources is a subject of discussion in the context of the relationship between language and the thought process, between language and the thinking subject. There are many scholars who have devoted their works to this topic. Humboldt noted that the main influence of language on a person is due to his thinking and creative power. Aleksandr Potebnya (1989) created a special work entitled "Thought and Language" in which he presented his philosophical and linguistic concept of language which he considers as culturally and anthropologically conditioned. The classicist understood language as a force that shapes and transforms thought. Potebny's contribution to linguistics is related to his "linguistic aesthetics" (Potebny, 1989): The general understanding of the nature of the word is related to his thinking in images, metaphors, especially in the context of artistic work. However, the language of science is also increasingly becoming symbolic and metaphorical (Ankersmit, 2007). The more deeply science penetrates into nature, the higher the level of symbolism in scientific discourse. Scientific language must be able to convey knowledge about hidden levels of existence that cannot be described using the formal-conceptual language of rationalism. This requires other semantic tools such as symbols and metaphors (Ableyev, 2008).

In conclusion, it is worth saying that even if ontology may seem irrelevant in the modern world, it remains important for constructing the image of the world. It is in fact no coincidence that back in the 70s of the last century the answer to the question, what is intelligence, came in the form of a cybernetic image or model of the world. Ontological metaphors help us construct models of the world with all its complexity, which then becomes a second, virtual reality.

IN LIEU OF A CONCLUSION

Cognitive sciences and technologies are the basis of a new scientific and technological mode, the transition to which requires conceptual and methodological analysis. The conceptualization of the life cycle in systems engineering is currently inspired by classical metaphysics which "hinders" its development (Terekhovich, 2018). Other, poststructuralist explanatory principles and presumptions are required. This, in turn, creates the problem of the effective semantic reducibility to one another of the languages of description with different ontologies - to be achieved within the cognitive modeling framework of conceptual analysis, cognitive monitoring, diagnostics, or prognostic control.

Convergence occurs in the interaction of various applied science, technical and social systems with each other. The problematic of language is extremely relevant in inclusive AI pedagogy, requiring special pedagogical methods, tools and other approaches to "learning with a teacher" (engineering ontology). The effectiveness and quality of ITS is determined by bio-inspired cognitive technologies, an increase of resilience and durability, reliability, fault tolerance; a solution to the problems of emergent (functional) integrity in systems engineering and system engineering.

Distinction is first of all a linguistic marker, which is universal in any linguistic manifestation. Through distinction (audiovisual, tactile, thermal, temporal, semantic, axiological) existence reveals itself to humans. The basic recording with the most superficial attention of the existence of some object is based on discernment, and thus on the manifestation of language. Likewise, the distinction of constructed ontologies within artificial intelligence also has a linguistic manifestation - with similarities and differences a matter of ontology.

REFERENCES

Ableyev, S. R. (2008). Filosofskiy metod i problema nauchnogo yazyka v issledovaniyakh soznaniya [Philosophical Method and the Problem of Scientific Language in the Studies of Consciousness]. *Philosophy of Science*, *4*(39), 16.

Ankersmit, F. R. (2007). *Sublime Historical Experience*. Europe.

Barthes, R. (2009). *SZ*. Academic Project.

Chernigovskaya, T. V. (2009). Human in Man: Consciousness and Neural Network. In D. I. Dubrovsky (Ed.), *The Problem of Consciousness in Philosophy and Science* pp. 335-336. Kanon+.

Chernigovskaya, T.V. (2023) Language and Consciousness in the Digital World: Human, too Human? In V. A. Lektorsky (Ed.), *Consciousness, Body, Intellect and Language in the Age of Cognitive Technologies* (pp. 7-8). PSU Publishing House.

Chomsky, N. (2005) *Cartesian linguistics. Chapter from the History of Rationalist Thought*. KomKniga.

Foucault, M. (1994). *Words and Things. Archaeology of Humanities*. A-cad.

Gorban, A. N. (1994). *Neurocomputer, or Analogue Renaissance*. PC World.

Gorban, A. N. (2020). *Frontier Engineering Problems and Tasks with Examples from the Development of "Artificial Intelligence"*. [Video]. Center for STI SPbPU. https://youtu.be/j9VVPHlyw0w

Heidegger, M. (1993). *Time and Being*. Respublika.

Humboldt, W. von (1985). *YAzyk i filosofiya kul'tury* [Language and Philosophy of Culture]. Progress.

Ivakhnenko, E. (2019). Annmarie Mol on the Way to Multiple Ontologies. *Epistemology & Philosophy of Science*, *56*(3), 219-224. https://doi.org/10.5840/eps201956360

Kacerauskas, T. (2006). Language and Culture in Phenomenological Perspective. *Voprosy filosophii*, *12*, 137-144.

Kolovskaia, A. Y. (2016). Cultural-Contextual Concept of the Language of Science in the Perspective of Analytical Philosophy. *Tomsk State University Journal of Philosophy, Sociology and Political Science*, *2*(34), 76-85. https://doi.org/10.17223/1998863X/34/9

Kolovskaia, L. V. & Kolovsky, Y. V. (2008). Creative Potential of Self-Configuration of Educational Environment in the Philosophy of Postmodern. In *Proceedings of the Intern. Confer. on Problems of Education* (pp. 83-87*)*. Publishing house of SPbGETU "LETI".

Kolovskaia, A. Y. & Kolovsky, Y. V. (2021). Artificial intelligence and the language of science in the complexity paradigm. In *Proceedings: First National Congress on Cognitive Research, Artificial Intelligence and Neuroinformatics. Ninth International Conference on Cognitive Science* (pp. 565-567). National Research Nuclear University "MEPhI".

Kolovsky, Y. V., Bartsev, S. I., Okhonin, V. A., & Khlebopros, R.G. (2000). Possibilities of Physical Realization of the Fast Neural Network Microprocessors. In *System Problems of Quality, Mathematical Modeling and Information Technologies* (Part 3, pp. 39-43). Research Institute "Auto-electronics".

Kolovsky, Y. V., & Morenk, P. A. (2013). Field Neuroprocessor. In *Modern problems of radio electronics: Collection of scientific articles* (pp. 415-420). IPK SibFU.

Kozlova, L. A. (2020). Conceptual metaphor and means of its representation. *Cognitive Studies of Language*, *3*(42), 371-375.

Lebedev, M. V. (2009). The Problem of Linguistic Creativity *Philosophical Sciences*, *8*, 79-96.

Loktionov, E. V. (2008). To the Problem of the Epistemological Status of the Language of Science in the Postpositivist Period of Analytical Philosophy of the Twentieth Century. *Vestnik OGU, 7*(89), 38-43.

Losev, A. F. (1993). *Bytiye – Imya – Kosmos* [Genesis – Name – Cosmos]. Mysl.

Losev, A. F. (1974). *Istoriya antichnoy estetiki. Vysokaya klassika*. [The History of Antique Aesthetics. High Classics]. Iskusstvo.

Matsumoto, D. (2002). *Culture and Language*. Prime – Euroznak.

Nazaretyan, A. P. (2009). Meaning-making as a Global Problem of Modernity: a Synergetic View. *Voprosy philosophii*, 5, 4-19.

Potebnya, A. A. (1989). *Word and Myth*. Pravda.

Soboleva, M. E. (2005). *Filosofiya kak "kritika yazyka" v Germanii* [Philosophy as a "Critique of Language" in Germany]. St.-Petersburg State University.

Saussure, F. (1977). *Works on linguistics*. Progress.

Terekhovich, V. E. (2018). The Metaphysical Postulates of Modern Physics, Which Should be Abandoned. *Metaphysics*, *1*(27), 78-87.

Truten, V.A., & Kolovsky, Yu. V. (1978). Device for Measuring the Out-of-roundness of Large-sized Cylindrical Parts [Copyright certificate SU 697805 A1].

Volodin, A. Y. (2023). *Digital Humanities Research*. Siberian Federal University.

Wittgenstein, L. (1994). Spatial and Temporal Phenomenon of Language. In *Philosophical works* (Part. 1, pp. 126-131). Gnosis.

СВЕДЕНИЯ ОБ АВТОРАХ / THE AUTHORS

Анна Юрьевна Коловская,
akolovskya@sfu-kras.ru,
ORCID 0009-0006-6905-4244

Андрей Дмитриевич Ильин
and-man-star@ya.ru

Anna Kolovskaia
akolovskya@sfu-kras.ru,
ORCID 0009-0006-6905-4244

Andrew Ilin
and-man-star@ya.ru

Статья поступила 1 декабря 2023
одобрена после рецензирования 16 декабря 2023
принята к публикации 23 декабря 2023

Received: 1 December 2023
Revised: 16 December 2023
Accepted: 23 December 2023