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Complementarity of Heuristic and Cognitive Metamodels – Hybrid Approach

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The structural similarity of biological, organic and inorganic substances in the nanoworld, on the one hand, blurs the lines between them, and on the other, creates new opportunities for digital modeling. The fundamental characteristic of the nanoworld is its spatiotemporal structure as a set of stable connections that ensure integrity, adaptation and preservation of the basic properties of a self-organized dynamic system under internal and external influences. The goal of the work is to develop an integrative methodology for modeling 3D structures, within the framework of which to create a meta-theory of digital modeling of physical reality.Human activity in real and/or virtual space creates cognitive problems that are caused by a hybrid subject environment. However, the commonality of biological, organic and inorganic substances in the nanoworld makes their structures similar, which made it possible to develop an integrative methodology for modeling 3D structures of information sources of various natures. The methodology is based on the complementarity of paradigms and tools for digital modeling of physical reality, which are united by physical and social ontology.The harmony of perception of triads of conjugate opposites in information sources of various natures is the basis of a hybrid approach to the integrative metatheory of digital modeling of physical reality. Therefore, in extreme conditions, the connection of hybrid thinking with the holographic nature of memory, which also has a semiotic nature, is important. The prospects and innovative potential of the methodology for modeling 3D structures and the complementarity of metamodels of physical reality are discussed.

Keywords: Space-time structures, Hybrid nanoworld, metamodels, Integrative methodology, Balance of conjugate opposites, Inversion, Second-order metasciences, dynamic complexity, Static complexity.

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1. INTRODUCTION

Cognitive problems and new possibilities for modeling physical reality. Human activity in real and/or virtual space creates cognitive problems that are caused by a hybrid subject environment [1, 2]. In the hybrid nanoworld, the structural commonality of biological, organic and inorganic substances, on the one hand, blurs the boundaries between them, and on the other, creates new opportunities. A fundamental characteristic of the nanoworld is its structure as a set of stable connections that ensure the integrity and identity of objects to themselves, as well as the preservation of their basic properties during internal and external changes. Transdisciplinarity takes into account the consequences of flow, which circulates from one branch of knowledge to another, allowing unity to emerge in diversity and diversity through unity. To reveal the nature, characteristics and structure of the flow of information and search for new approaches, the need arose to combine methodological and conceptual tools within the framework of metasciences [3]. The nanometric scale of information interaction has led to the study of cognitive aspects, the study of which is important for education, science and the further development of modeling technologies [2-4]. As a consequence, the complementarity of mathematics and physics, as well as the connection with their metasciences, has opened up new possibilities for modeling physical reality. In particular, the development of nature-like technologies contributes to the creation of unique nanomaterials, automation of transport and the search for new ideas and approaches to solving many pressing security problems.

Hybrid subject environment – features of interaction. The increasing complexity of interaction has given rise to systemic contradictions, as well as many problems. They are studied by computer science, neuroscience and cognitive science [2, 5, 6]. This allowed us to establish that:

- computer models of real processes have become more complex than physical reality;
- transition states are inherent in sources of information and elements of complex dynamic systems (CDS), as well as in the psychophysiological state of a person;
- cognitive aspects of digitalization give rise to unconscious actions and errors [2, 6].

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A consequence of increasing complexity is the manifestation the human factor during active interaction with the artificial digital environment, immersing itself in which cognitive problems manifest themselves:

- duality of perception of physical reality;
- distortions of reality, generating cognitive dissonance;
- irrelevant selection of information in extreme operating conditions.

Risks associated with management automation. The inconsistency of existing standards and methods reduces the physical, biological and information security of CDS [7]. Under contingency conditions, the emergent properties (vitality, survivability, and resilience) of CDS depend on the balance of:

- system-forming and system-destroying factors;
- symmetry and asymmetry of feedback [8];
- opposites induced by influence.

Their complementarity creates a synergy of instability and uncertainty, the nonlinear relationship of which increases the risks of CDS management.

The relevant goal of the work is to develop an integrative methodology for modeling 3D structures, within the framework of which to create a meta-theory of digital modeling of physical reality.

2. HYBRID APPROACH TO SIMULATING PHYSICAL REALITY

Cognitive phenomena. In digital reality, there is a problem of determining the boundaries of human competence, which is associated with the objectivity and accuracy of cognitive judgments. Features of the perception of physical reality are most manifested in the following cognitive phenomena [2]:

- sense of knowledge – error in the accuracy of knowledge actualization;
- illusion of knowledge – exaggeration of the degree of understanding of the material;
- Dunning-Kruger effect – people with low cognitive abilities tend to overestimate self-esteem, and people with high abilities tend to underestimate it [9].

This triad reflects the general principle of determining the limits of human competence - the judgments of every person, without exception, are subject to the Dunning-Kruger effect to one degree or another in those areas where they cannot objectively assess the limits of their competence. The main methodological problem is induced cognitive distortions, which are caused by the intellectual activity of an individual in a hybrid subject environment.

Paradigms of cognition of physical reality. Real environments for processing and transmitting information are nonlinear, heterogeneous and unstable, which gives rise to the divergent development of science and ICT [2]. The model of nonlinear communication by T. Newcomb, which is presented in the form of an equilateral triangle, is widely used [10]. The following paradigms are important for the development of methods of cognition:

- Triadic harmony paradigm, which allows to unify creative development through the harmonization of related triads in science, art and design. In particular, an analysis of the connection between key sciences and their metasciences (mathematics – metamathematics, physics – metaphysics, philosophy – metaphilosophy, etc.) is given in [3]. Such an analysis reduces uncertainty and most fully reflects physical reality [2, 3]. This paradigm is also the basis of the theory of solving inventive problems [11].
- Synergetic paradigm, which extends not only to the structures of the macro- and microworld, but also to the relationships that develop between matter, energy and information within the framework of self-developing open nonlinear systems [12, 13]. This is the key paradigm for modeling physical reality within the hybrid approach.
- Semiotic paradigm, which uses the complementarity of key types of signs (sign-image, sign-indicator, sign-symbol) in the main directions of semiotics (activity-theoretical and socio-psychological. Therefore, in the semiotic space, each sign act has reality [14].

The complementarity of these paradigms combines physical and social ontology, which allows us to consider a hybrid subject environment as a semiotic space. In this space, the transfer of emotional and intellectual content between objects and subjects of the digital world is realized.

Harmony in the knowledge of digital reality. The process of cognition is closely related to the perception of the harmony of the subject environment and is inevitably subject to cognitive distortions (systematic errors). Therefore, the harmony of perception of digital models is facilitated by the use of:

- natural colors (yellow, blue and red), which are the basis for obtaining all other colors, as well as associated secondary colors (orange, purple and green), which are obtained by combining two natural colors. With the help of such a palette it is possible to achieve both contrast and harmony at the same time;
- inversions, the universality of which has manifested itself in physics, biology, logic, geometry, computer science, psychology, computer and other sciences. Inversion allows you to study and understand harmony as the agreement of opposites in human activity (design, art, programming);
- the principle of detailed equilibrium reflects the equality of probabilities of direct and reverse processes (cycles) of different nature. These processes can be quantum transitions, cycles of functioning, reactions between an object and a subject.

Consequently, the complementarity of color harmony, inversion and the principle of detailed balance allows us to consider the cycle of functioning of the CDS element as a dynamic process, and the change in structural energy as the driving factor in its evolution [15]. In particular, the shape of the 3D structure of metamodels of physical reality reflects the harmony of fractal nature [16]. Therefore, the true beauty of metamodels lies in the harmony and balance of opposites, which is most manifested in the hexagonal structure of the relationships between key sciences and their metasciences [3]. Obviously, therefore, the complementarity of opposites is most manifested in those heuristic meta-models that look like the Star of David [2, 3].

Intellectual activity of the individual. In the Eastern and Western perception of fractal nature, aspiration and the need for harmony has been and is a global vital guideline in human intellectual activity (learning, design, art, programming) [16]. Therefore, harmony is achieved only when the essence most accurately and beautifully expresses its form. These are in which the intellectual activity of an individual is determined by the functional asymmetry of the cerebral hemispheres, which connects design, art and aesthetics, namely:

- the ability to find similarities between things that are different;
- searching for differences between things that are similar;
- creation of a possible "whole" from impossible "parts".

Their complementarity allows the individual to generate ideas and their interconnection to visualize them. However, the intellectual activity of an individual when implementing ideas is limited by the difficulties of choosing strategies for solving real problems in computer science and technology, which are caused by the functional asymmetry of the cerebral hemispheres. Thus, the right hemisphere is aimed at processing complex and unfamiliar information, and the left hemisphere processes information that is familiar to us in more detail and structure. Thus, functional asymmetry of the brain determines psychophysiological and mental (phylo- and ontogenetic) aspects. The brain, working as a paired organ, implements any mental function and determines the choice of learning strategy.

Generalized cognitive model of interdisciplinary connections. Psychologists, engineers, and philosophers used the principle of structural-functional analogy: the similarity of the functions of a computer and a "human cognizer." This allowed us to talk about the similarity of 3D structures that implement these functions. The information metaphor, using terms from the theory and practice of programming, is more open to interpretation than the computer metaphor. Space and time, matter and energy, information and entropy have become basic metascientific categories for scientists [17, 18, 19]. Thus, a psychologist views a person as a self-organized system that reflects the spatio-temporal and energetic characteristics of physical reality in sensations, images of perception, ideas, etc. Therefore, the generalized cognitive metamodel of the structure of interdisciplinary connections in the form of a hexagon reflects the internal unity of opposites (see fig. 1).

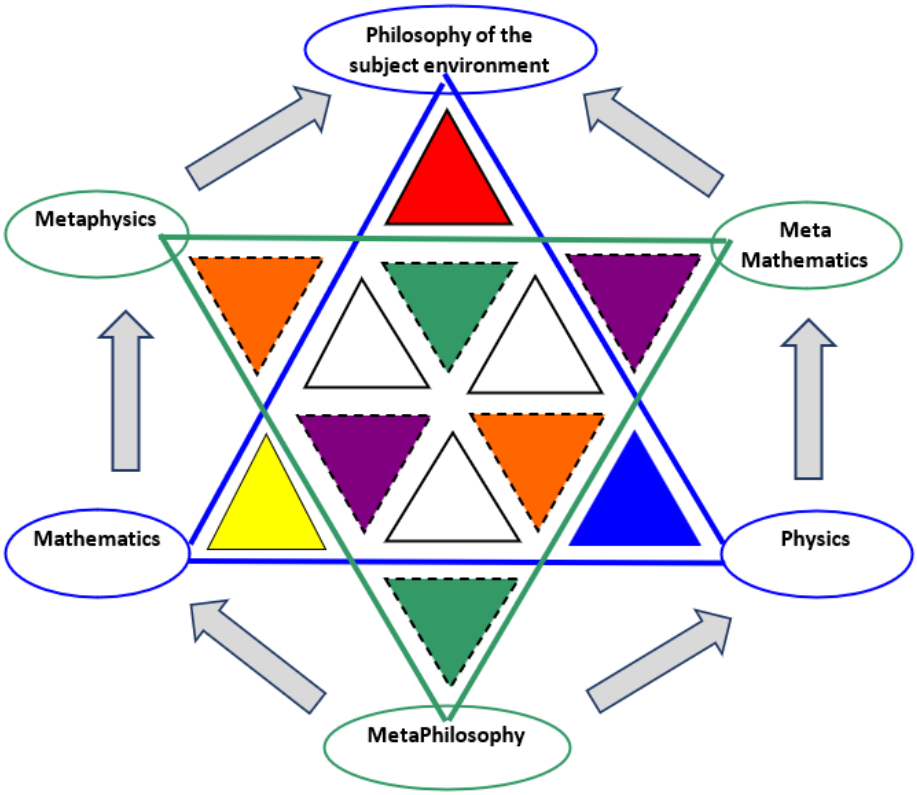

Fig. 1 – Generalized cognitive metamodel of the structure of interdisciplinary connections between key sciences and their metasciences

From the system analysis of Fig. 1, two approaches to the strategy for studying the subject environment follow, which reflect the internal unity of its opposites. Thus, the dominance of the left hemisphere of the brain determines the first strategy, which includes the triad – mathematics, natural philosophy and physics. Their obvious clockwise connection is highlighted in natural colors (yellow, red and blue). When the right hemisphere of the brain dominates, the second strategy for studying the subject environment is implemented, which includes the triad of metasciences (metamatics, metaphilosophy and metaphysics). The balance of these strategies is achieved through a cognitive metamodel, in which the vertices of the triangles (triads of sciences and their

metasciences) are directed in opposite directions. Therefore, the generalized cognitive metamodel in the form of a hexagon displays:

- internal unity and balance of opposites;
- cognitive value of the relationship between key sciences and their metasciences;
- the desire for stability, balance and harmony of conjugate triads of opposites.

Obviously, therefore, complementarity allowed the authors to overcome interdisciplinary barriers and synthesize heuristic metamodels of complex dynamic systems of various natures in the form of a hexagon. It is symbolic that this is the only possible choice of 6 natural colors in Fig. 1 [2, 3].

Features of computational neurobiology of the brain. The complementarity of the two strategies allows for the formation of balanced thinking in the process of an individual's activities. This is facilitated by the hexagonal view of heuristic metamodels of complex dynamic systems (cyberphysical, information flows of various natures) [2, 3]. This is a consequence of the fact that the structure of the subject hybrid environment takes into account the features of computational neurobiology of the brain, namely:

- decomposition of information into three types – synergetic, intuitive (individual) and redundant;
- the dynamics of calculations carried out by the brain includes the color harmony of triads of opposites;
- search for a balance between opposites – order-disorder, harmony-disharmony, truth and lies, which is carried out by the brain continuously.

On the one hand, the triad of key sciences (physics, mathematics and philosophy) forms a broad worldview based on the perception of the harmony of nature. On the other hand, the triad of neuro-cognitive sciences (neurophysics, neural networks and neurodesign) develops a person's ability to work with sources of information, the dynamic complexity of which forms metathinking [3, 20]. It is based on metacognitive knowledge, experience, goals and strategies. Thus, knowledge of one's own knowledge includes conscious reflection on cognitive actions and abilities that require self-regulatory mechanisms. Neuro-cognitive sciences and metasciences increasingly contribute creative activity because the development of metathinking in a hybrid subject environment allows you to regulate and control the learning process.

3. HYBRID SUBJECT ENVIRONMENT – DISTORTION OF INFORMATION FLOW AS A UNIVERSAL

Complexity and simplicity of metaheuristic models. On the one hand, the number of CDS elements and the number of connections between them determine the static complexity of information transmission lines. On the other hand, their dynamic complexity takes into account the cyclic processes that occur in the CDS system and with its participation [21]. The consequence of the many interacting elements of CDS is the connection between dynamic and static structure, the simplicity/complexity of which is most manifested in a hybrid self-organized dynamic system. Indeed, when processing information flows in the brain, cognitive distortions (systematic errors) arise, to identify the features of which we synthesized a heuristic meta-model of information transmission channels. It contains many microsources of information (defects, fluctuations, etc.) that affect the dynamic and static complexity of the perception of physical reality (see Fig. 2).

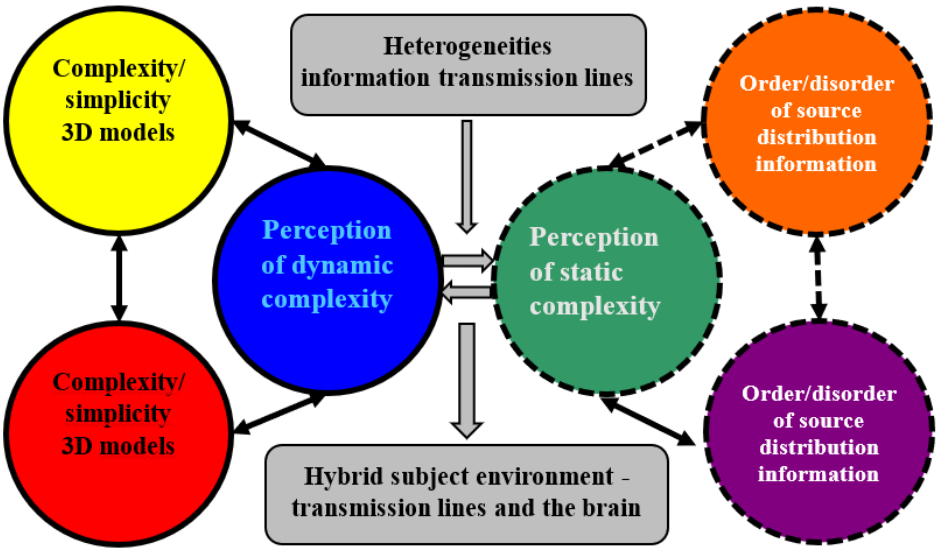

Fig. 2 – Heuristic metamodel of cyclic connections between the dynamic classification of the topological 3D model and the static classification of information sources in real time

On the one hand, the dynamic complexity of a topological 3D model is combined with its spatial simplicity, and on the other hand, the static structure of information sources is not combined with the spatial orderliness of their distribution. Within the framework of this metamodel, independent cyclic processes that occur clockwise and are structure-forming, as well as counterclockwise processes that are structure-destructive, are studied. As can be seen, there are hidden spatiotemporal relationships between the spatial structure of the topological model and the disorder of microsources of information; whose individuality is most

manifested at the nanoscale in the hybrid space of dynamic events in real time [4]. Moreover, the nature of the disordered distribution of these sources does not affect the holistic perception in real time. Thus, cognitive changes have appeared in the human brain, the presence of which indicates its hybridity. In general, the heuristic metamodel makes it possible to study the complementarity of dynamic and static descriptions of the distribution of elements of the CDS, the nature of the interaction of which is most effectively manifested in the perception of complexity [3].

Space-time distortions as universals. In various physical analogies (electromechanical, hydrodynamic, optical-mechanical, etc.), the connection between statics and dynamics, as well as the complementarity of symmetry and conservation laws (the theorem of E. Noether) is manifested. On the one hand, dynamic similarity reflects spatial order (symmetry, cycle, shape and sign), and on the other hand, it determines the cause-and-effect relationship of dynamic events in time. Displaying the harmony of space-time communication means such a relationship between elements (signs) when they repeat and balance each other. In this case, the following is fulfilled: a) the physical principle of detailed equilibrium – mutual compensation of any two oppositely directed processes; b) the law of structural harmony of systems, which indicates new possibilities for studying self-organized phenomena of Nature [14]. Therefore, space-belt distortions and fluctuations of a hybrid medium are universals.

Complementarity of dynamic and static complexity as a universal. General concepts (universals) of information flows of various natures are structure, inversion and harmony. Their interrelation and complementarity determines the functionality of the information source. Therefore, cognitive distortions create difficulties, problems and contradictions that are associated with an increase in induced dynamic and static complexity. This creates difficulties in selecting relevant sources of information in a nonlinear hybrid environment, the presence of switchable potential and dissipative forces in which leads to self-organization in nonequilibrium systems [15]. Dissipative structures tend to order through fluctuations, which is accompanied by an increase in their complexity and uncertainty. It can be assumed that the connection between dynamic and static complexity at the nanoscale leads to hidden cognitive biases.

Inversion of space-time relations in real time as a new universal. Stereochemical effects, the principle of symmetry and asymmetry, and others are directly related to the study of space-time relationships. In real time, there are hidden connections between dynamic and static models, which in extreme conditions creates new systemic problems (forecasting, knowledge extraction, etc.). To solve such problems, the idea of inversion is suitable, which is widely used in physics, biology, computer science, psychology and other sciences, as well as the color harmony of conjugated triads. Note that the degree of information distortion under external and internal influences depends on the psychophysiological state of a person. It follows from this those universal tools (inversion, harmonization of perception, etc.) are promising for solving problems of safety, reliability and stability.

Impact-induced complementarity. In the cognitive metamodel of cognition of spatio-temporal relations based on real-time inversion, induced complementarity is manifested in the dominance of intellectual intuition, which is based on the holographic nature of memory. Therefore, this meta-model takes into account the individuality of the holistic perception of the topology of physical reality, the 3D structure of which consists of many triangular elements. As we see, external and internal stress factors induce complementarity in the perception of complexity/simplicity, as well as order/disorder, which allows us to identify new patterns through the complementarity of harmonization and inversion (see Fig. 3).

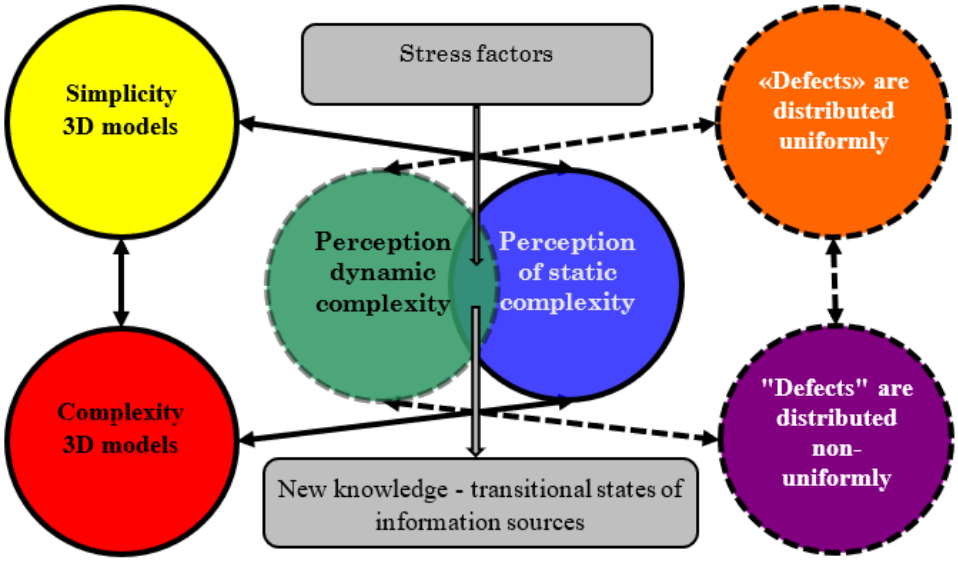

Fig. 3 – Cognitive metamodel of cognition of spatio-temporal relations based on real-time inversion

At the same time, changes induced by external and internal influences determine hidden transitional psychophysiological states of a person. Within the framework of the cognitive metamodel, structure-forming cyclic processes (clockwise) destroy structure-destructive processes (counterclockwise). By balancing the perceptions of static and dynamic complexity, it is possible to obtain new knowledge about the transition states of information sources of various natures.

Complementarity of metamodels. The complementarity of the metamodels shown in Fig. 2 and Fig. 3 is due to the fact that, on the one hand, the perception of the dynamic complexity of the heuristic metamodel is combined with its static (spatial) simplicity, and on the other hand, the perception of the static complexity of the cognitive metamodel (multiple sources of information) is combined with its dynamic simplicity (balance of complexity-simplicity and order-disorder). Moreover, the nature of the disordered distribution of these sources, which are induced by the influence of stress factors, does not affect the holistic perception in real time. As we see, in a hybrid subject environment, the perception of harmony and inversion allows us to study the complementarity of the dynamic and statistical description of the functioning of the elements of the CDS [3]. In general, there are induced spatiotemporal relationships between the spatial orderliness of the 3D structure of a topological model and the disorderliness of multiple information sources. Therefore, the individuality of the functioning of self-organized systems of various natures is most manifested in the hybrid space of dynamic events in real time [4].

4. INTEGRATIVE 3D MODELING METHODOLOGY

Integration of sciences on a transdisciplinary basis. The foundations of the integrative methodology for modeling in a hybrid environment are semiotics [14], structural ontology [16] and second-order metascience [22]. Their complementarity became possible thanks to universal principles, paradigms and new universals. So, in the knowledge of physical reality the key are:

- principles of interrelation and balance of opposites and synergetics [19];
- paradigms – triadic, synergetic and semiotic;
- universals – spatio-temporal relationships online.

Their complementarity made it possible to systematically analyze information flows of a fractal nature in the cognitive space of dynamic events [4].

This integration of semiotics, structural ontology and metasciences contributes to the search for a spatiotemporal balance of opposites in physical reality, which is achieved through the connection of signs in the form of a triangle (triharmonic), pentagon (pentagram) and hexagon (hexagram). It is the connection of these signs in physics, chemistry and biology that most fully reflects the diversity and beauty of nature. In particular, the integration of hexagrams and pentagrams are not only present in the very core of our DNA, but also in other biological, chemical and physical structures.

Neurophysiological and neurocognitive substantiation of second-order cybernetics. Neurophysiological and neurocognitive studies of the brain are reviewed in [5, 6], in which the basic ideas of second-order cybernetics are developed in [22]. The development of metathinking as thinking about one's own thinking for fruitful intellectual and creative activity is addressed in the works [6, 20]. They show that:

- knowledge is a biological phenomenon;
- each individual constructs his own "reality";
- knowledge is "coordinated" with the world of sensory experience, but not "identical" to it.

Therefore, the relevance of second-order cybernetics emerged in the study of social and biological systems, both autonomous and closed. The study of the cycles of functioning of the CDS, consisting of interacting elements, is based on the structure of a graph in the form of a pentagon. This approach makes it possible to simulate the dynamics and analyze the viability of the elements of the CDS, including the psychofunctional state of a person, which characterizes a set of signatures of electrophysiological signals [7].

The relationship between worldview, metathinking and semiotics. Worldview as a system of principles, values and ideals has a complex structure that includes a contradictory unity:

- knowledge and values;
- intellectual and emotional;
- beliefs and doubts.

However, in the process of digitalization of science and education, the logical basis of knowledge production has moved away from reality and emotionally researchers see many events that are not measured. Therefore, such events are expressed by signs, the relationships of which form something immeasurable, unimaginable and unconscious. The pragmatic understanding of information, communication and language is associated with second-order cybernetics, the essence of which is that information is the difference that creates difference [22]. It should be noted that the foundations of semiotic theory were developed by the philosopher, logician, surveyor and mathematician Charles Pierce [14].

Generalized cognitive metamodel of the structure of conjugate triads. Spatiotemporal fluctuations give rise to natural structural and functional "defects" (analogues of crystal defects), the nature of the distribution of which is a new source of information. A generalized cognitive metamodel that connects an individual's thinking with the features of the transition from dualism to triadity is shown in Fig. 4.

As we see, the generalized metamodel of the structure of conjugate triads displays explicit (social) and implicit (cognitive) connections, reflecting second-order cybernetics. From the systemic analysis of conjugate triads, it is clear that the triad of causal-dual relationships (social networks – action, subject environment – development strategy, art - emotional experience) is associated with a triad of key intellects (spiritual, social and emotional).

Interconnections as new universals. The interconnection and complementarity of principles, relationships and structure is a universal that allows for balanced self-renewal in different types of creative activity. The complementarity of these principles is

manifested in natural dynamic fractals and multifractals [16], as well as in structural functionalism (experimental psychology). Therefore, it is necessary to expand the researcher's worldview based on the relationships of modern metaphysics with metaphilosophy and metamathematics [3, 19, 20]. For modern metaphysics, the connection of cognitive aspects with different types of complexity, which is discussed in [2, 7, 8], is important. They show that cognitive distortions are a consequence of individual perception and representation of complexity, instability and nonlinearity. Therefore, structure-forming principles are relevant for heuristic metamodeling, namely:

- principles of duality and trinity, the hierarchy of which turns metaphysics into a unified system of paradigms;
- the principle of fractality (self-similarity), reflecting the unity of the whole and the particular;

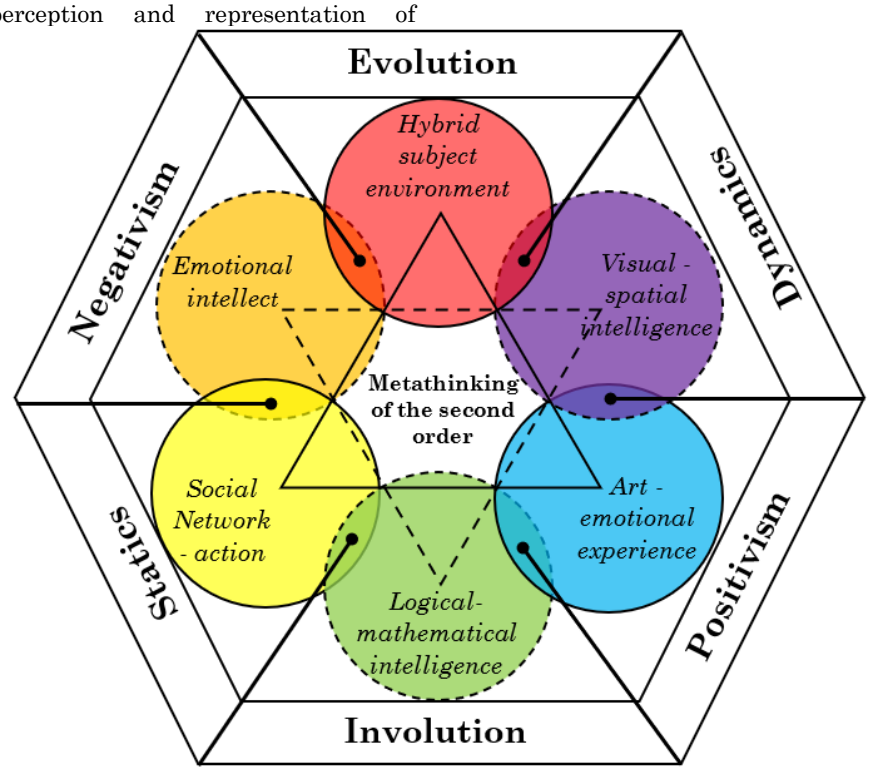

Fig. 4 – Generalized cognitive metamodel of the structure of conjugate triads, including the "contrast" of opposites

- the principle of double cyclicity, manifested in the orderliness of the spatio-temporal structure of information flows of various natures.

Triadic metastructure as a universal. The differentiation of sciences has led to the emergence of specific languages, as a result of which scientists of different specialties, speaking about the same essence, do not understand each other. Philosophers, scientists and designers are aware of the emergence of interdisciplinary barriers, resulting in second-order sciences and neurocognitive sciences (psychology, machine learning, artificial intelligence and robotics, neuroscience, anthropology, linguistics, design and philosophy). They widely use triadic metastructures (fractal triangle, pentagon, hexagon and other triune systems). The development of metathinking allowed the authors of the article to overcome interdisciplinary barriers and create an integrative metatheory of digital modeling of a hybrid subject environment. It turned out that triadic structures make it possible to model objects that have a different ontology and a different nature of development. Therefore, studying a hybrid subject environment contributes to the development of metathinking and the establishment of metacognitive distortions, which expands the worldview.

Emergence as a universal. Changing the metastructure of information sources under extreme conditions gives rise to synergism, holism, a superadditive effect, and also leads to genetically inherited cognitive and metacognitive distortions. Works [7, 8] show that local distortions in the structure of flows of various natures in information sources and information transmission lines are associated with:

- dynamic and static complexity in real time;
- unstable transition state of the information source;
- the nature of the distribution of information sources of various natures.

In extreme conditions, the individual functioning of information sources of different nature does not allow predictive analytics to be carried out. On the one hand, the heuristic model of a cyber-physical system showed the importance of the triad of NOT (nonlinearity, uncertainty and instability) [7]. On the other hand, the safe functioning of cyber-sociotechnical systems requires special integration with human and social factors. Technical progress requires the expansion of human capabilities (functional, physical and cognitive), and heuristic metamodeling of the evolution of the structure of relationships allows one to find possible scenarios for solving new problems [2].

Integral metatheory of a hybrid subject environment. Structural ontology has wide application in various fields of science, including philosophy, biology, physics, sociology and others. The metatheory is based on the integration of semiotics, structural ontology and metasciences, the interconnection of which allows:

- study a complex system and take into account the variety of relationships between its elements and theirs;
- analyze the structure of objects and their properties;
- explain complex processes and reconcile them with your sensory experience.

Therefore, with the help of conjugate fractal triangles, universal tools have been created, based on semiotic signs – a pentagon (pentagram) and a hexagon (hexagram). These signs reflect the natural harmony of nature, which is based on the Golden Ratio. Therefore, the relationship between hexagrams and pentagrams helps to understand and explain the functioning of CDS in extreme conditions, as well as to develop more effective models and theories. From the perception of the harmony of nature it follows that thinking about one's thinking (metathinking) opens up new opportunities for optimizing an individual's activity in difficult conditions.

Foundations of metatheory. Within the framework of the integral methodology, a time series of any nature V(t) is transformed into a triad of cognitive graphic images, the configurations of which in the space of dynamic events are signatures of the 1st and 2nd orders [4]. In this case, in the evolution of the 1st order signature configuration, the Boltzmann entropy $H(t)$ is displayed, which characterizes the orderliness of the information source. The change in entropy $H(t)$, as well as the rate of entropy production dH/dt, can be represented in the form of H-signatures ($H(t) – dH/dt$) [4]. In this case, the evolution of the configuration of H-signatures can be represented in the form of a package of H-signatures ($H(t) – dH/dt$), the analysis of which is very informative [4].

Configurations of 2nd order signatures reflect the second order entropy $F(t)$, and changes in their area reflect the rate of entropy production dF/dt. They can be represented in the space of dynamic events in the form of F-signatures. In this case, in the evolution of the 2nd order signature configuration, the second order entropy $F(t)$ is displayed, which characterizes the topological ordering of the information source. Packet representation of H-signatures and F-signatures, which, in essence, are structural and functional characteristics of the evolution of the state of the information source, namely:

- $H(t)$ and dH/dt in the form of H-signatures ($H(t) – dH/dt$);
- $F(t)$ and dF/dt in the form of F-signatures ($F(t) – dF/dt$);
- the relationship of these signatures can be analyzed from complementary angles.

Therefore, the complementarity of pentagrams and hexagrams in topological 3D models and their interrelation allows us to study the structure and organization of elements of CDS of various natures - from molecular structures to the movement of the planets of our Solar System.

Synthesis of topological models in a hybrid subject environment. The transformation of hidden relationships into conjugate triads in the form of hexagrams and pentagrams is the basis of the synthesis of topological 3D models of CDS, and their visualization simplifies the system analysis of their structure through:

- balance of conjugate triads, coloring of which with natural colors harmonizes cognitive perception;
- inversion of conjugate triads, the effectiveness of which has been demonstrated in physics, mathematics, software algorithms, etc.;
- harmony of perception of structure and balance of opposites in complementary dynamic, static and statistical metamodels [2, 8].

Systematic analysis of spatio-temporal configurations showed that the perception of harmony of relationships depends on psychophysiological factors (fatigue, stress, etc.). The important role of external and internal factors is due to the manifestation of Le Chatelier's principle [23].

Thus, the trigram, pentagram and hexagram help us to uncover and deeply explore hidden patterns ranging from molecular structures to the movement of the planets of our Solar system. The interrelation of metamodels in the form of a pentagram and hexagram makes it possible to study the structure and organization of elements of CDS of various natures, which is of cognitive value for the technosphere and CDS [24, 25].

5. INNOVATION POTENTIAL OF METHODOLOGY AND METATEORY

Development of metacognitive modeling. When creating automated systems that, as control systems, reflect at a logical level the complexity of systems in the external physical world and are complemented by the complexity of supporting electronic systems, new problems arise. At the same time, many electronic elements, due to miniaturization and high frequencies, already operate within the framework of quantum physics, which is described by fuzzy probabilistic logic. As a result, external and internal stress factors distort information flows of various natures and cognitive distortions arise, which are caused by emergent complexity.

Study of emergent structures. In many natural phenomena, from physical to biological, in which order emerges from chaos, emergent complexity is characterized by disruptive or disruptive changes.

It is therefore important to distinguish between three forms of emergent structures:

- first-order emergent structure that results from interactions between shapes (e.g., hydrogen bonds in water molecules result in surface tension);
- emergent structure of the second order, which includes the interaction of forms, sequentially reproduced over time (for example, a change in the shape of a snowflake);
- third-order emergent structure is a consequence of form, time and heredity (for example, the genetic code of an organism influences the shape of the body's systems in space and time.)

In physics, emergence is used to describe a property, law, or phenomenon that occurs on a macroscopic scale (in space or time) but not on a microscopic scale.

Interdisciplinary tools for synthesis and analysis. To make decisions in real time, the development of cognitive modeling based on unified tools for processing, visualization and analysis of information flows of various natures. Therefore, the complementary tools of cognitive and heuristic metamodeling of information sources of various natures have great innovative potential. Transformation of a fractal signal into a topological 3D model of functioning and its spatio-temporal signatures allows one to assess complexity by the degree of ordering, and the degree of energy balance using probabilistic and deterministic research methods, which are based on visualization of their spatio-temporal structure, as well as interdisciplinary synthesis tools and analysis.

Revealing hidden spatiotemporal relationships. The application of a convergent approach and means for its implementation to sources of information of different nature (EMR sensors, radiation and acoustic radiation), as well as to human electrophysiological signals (EEG, EOG, rheogram, etc.) demonstrate the advantages and new opportunities for identifying hidden spatially – temporary relationships. They determine the safety of CDS operation in extreme conditions. An atlas of such signatures of human electrophysiological signals of models will simplify the intelligent selection of effective solutions using AI. The innovative potential of the approach, tools and atlas is enormous. Cognitive visualization and modeling will simplify human-computer interaction in training, designing and testing new dynamic systems. This will increase the safety of the functioning of complex dynamic systems, including predicting the psychophysiological state of a person.

Innovative potential of the concept of mutual complementarity. The increase in chaos in the information world is accompanied by an increase in cognitive dissonance in the cognitive process [2,3]. This can only be overcome by returning to the origins of world harmony through the geometrization of thinking with its visual representation of the 3D structure of the space of our existence. An example of such a structure is social communication networks. The generalized concept of complementarity, which was proposed by Niels Bohr, covers not only physics, but also biology, psychology, cultural studies, and humanities [25]. In particular, the developed generalized principle of spatiotemporal complementarity, the universality of which allows us to set tasks on:

- intellectualization of the technical environment (unification of modeling, automation of transport CDS);
- creation of nature-like hybrid algorithms;
- development of new green technologies, etc.

On the one hand, their solution contributes to the development of research in the field of unique nanomaterials, transport automation and the search for new approaches to solving many pressing problems. On the other hand, extreme influences on sources of information of various natures induce harmonious structures in the form of a hexagram and pentagram, the use of which makes second-order cybernetics relevant for predicting the functioning of sources of information of various natures. New universals are proposed (spatio-temporal connections, dynamic symmetry and spatial ordering), the use of which in the integrative metatheory of digital modeling of a hybrid subject environment has high innovative potential for the development of new areas of AI.

6. CONCLUSIONS

The secure operation of cyber-sociotechnical systems requires special integration with human and social factors. Therefore, technological progress requires the expansion of human capabilities (functional, physical and cognitive), and heuristic metamodeling of the evolution of the structure of relationships allows us to find possible scenarios for solving new problems.

Based on the complementarity of metadata, metasciences and metamodels, a structural-integrative methodology of scientific research has been developed, within the framework of which an integrative metatheory for modeling the structure of a hybrid subject environment is being developed. The metatheory is based on the spatiotemporal integration of semiotics, structural ontology and second-order metasciences, the interconnection of which allows:

- study a complex system and take into account the diversity of its elements and their relationships;
- analyze the structure of objects and their properties;
- explain complex phenomena and processes.

It is shown that the basis of the hybrid approach to the integrative metatheory of digital modeling of reality is a triad of conjugate opposites, which include paradigms, harmonization tools and new universals. For digital modeling of self-organized reality, the connection between hybrid thinking and the holographic and semiotic nature of memory is important. Therefore, their complementarity and interconnection makes it possible to optimize the intellectual activity of an individual.

Harmonious structures in the form of a hexagram and pentagram induce extreme effects on sources of information of various natures, the use of which makes second-order cybernetics relevant for predicting the functioning of sources of information of various natures. New hybrid universals are proposed (spatio-temporal connections, inversion and reduction, dynamic symmetry and spatial ordering), the use of which in the integrative metatheory of digital modeling of a hybrid subject environment has high innovative potential.

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Взаємодоповнюваність евристичних та когнітивних метамоделей – гібридний підхід

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Структурна подібність біологічних, органічних та неорганічних речовин у наносвіті, з одного боку, створює межу між ними, а з іншого, створює нові можливості для цифрового моделювання. Фундаментальною характеристикою наносвіту є його просторово-часова структура як сукупність стійких зв'язків, які забезпечують цілісність, адаптацію та збереження основних властивостей самоорганізованої динамічної системи при внутрішніх та зовнішніх впливах. Мета роботи – розвинути інтегративну методологію моделювання 3Д-структур, в рамках якої створити метатеорію цифрового моделювання фізичної реальності. Діяльність людини в реальному та/або віртуальному просторі створює когнітивні проблеми, які обумовлені гібридним предметним середовищем. Однак спільність біологічних, органічних та неорганічних речовин у наносвіті робить їх структури подібними, що дозволило розвинути інтегративну методологію моделювання 3Д-структур джерел інформації різної природи. В основі методології взаємодоповнюваність парадигм та інструментарію цифрового моделювання фізичної реальності, що поєднує фізичну та соціальну онтологію. Гармонія сприйняття тріад сполучених протилежностей у джерелах інформації різної природи в основі гібридного підходу до інтегративної метатеорії цифрового моделювання фізичної реальності. Тому в екстремальних умовах важливий зв'язок гібридного мислення з голографічною природою пам'яті, яка також має семіотичну природу. Перспективи та інноваційний потенціал методології моделювання 3Д-структур та взаємодоповнюваності метамоделей фізичної реальності обговорюється.

Ключові слова: Просторово-часові структури, Гібридний наносвіт, Метамоделі, Інтегративна методологія, Баланс сполучених протилежностей, Інверсія, Метанауки другого порядку, Динамічна складність, Статична складність.