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# ARTIFICIAL INTELLIGENCE AS THE COGNITIVE VALUE OF HEURISTIC MODELS

*This article is devoted to heuristic modeling of the structure of interconnections in nano-, bio- and information technologies and in cyber-physical systems, graphic images of which allow studying the fine structure of information sources of various natures. It is shown here that the information content of models of the structure of interconnections of nano-, bio-, information technologies and components of cyber-physical systems is due to the use of a fractal triangle and logic. The current work harmonizes human-computer interaction through digital complementary methods for studying the structure of information sources of various natures, as well as using the circle of natural colors by I. Goethe and a new interpretation of the Star of David. Here we show that balanced conjugate triangles in heuristic models allow inversion of transition states of information sources of different nature. Static, dynamic and statistical generalized heuristic models are based on the balance of resources and the asymmetry of feedback between the elements of a complex dynamic system. Their relationship determines the variability of cyclic processes, and the complementarity of dynamic and statistical heuristic models is associated with the dualism of nature. A systematic analysis of explicit and hidden relationships in information flows of various natures opens up qualitatively new opportunities for a cognitive dialogue with nature and an understanding of reality. The complementarity of heuristic and cognitive models in the transdisciplinary cognitive space provides innovative potential for solving urgent problems of education, science and new technologies. This is especially important for the further development of artificial intelligence and the harmonization of human-computer interaction. In particular, online forecasting of the transient functional states of information sources of various nature under unforeseen conditions simplifies the interdisciplinary exchange of ideas, methods and technologies. Since the number of honeycomb structures in nature is two to three orders of magnitude greater than that of artificial models, their connection with the harmony of colors in nature contributes to the development of emotional intelligence, creating new opportunities for solving relevant security problems.*

***Keywords:*** *information security; space-time structure; cyber-physical systems; cognitive sciences; transdisciplinarity; inversion.*

## Introduction

***Multidisciplinary development of sciences, education and technologies.*** In the 21st century, scientists and educators face the cognitive aspects of digitalization and new challenges [1]. The severity of the problems is associated with the manifestation of the human factor in science and education, as well as in the development of IT and ICT [2-4]. This work is a development of a convergent approach to heuristic digital modeling, the concept of which is given in [2]. They promote glare perception of information and discrete thinking, resulting in fragmentation of knowledge and the illusion of knowledge [5-7]. To overcome interdisciplinary barriers in science, education and technology, the harmonization of human-computer interaction is proposed. The identification of three key problems of human-computer interaction (interdisciplinary barriers, cognitive distortions, psychophysiological compatibility) made it possible to reveal the hidden relationships between them. They are caused by systemic problems that lie at the intersection of neurosciences and cognitive sciences, as well as ergonomics, modern psychology, etc. The existing standards, approaches and methods for ensuring biological, informational and functional security do not take into account the duality of perception and individuality of thinking, which are associated with the functional asymmetry of the cerebral hemispheres. They determine the individuality of cognitive activity, which is associated with an intuitive search for a spatio-temporal balance between extremes. This balance depends on the functional and mental state of a person, as well as on the aesthetic perception of the digital world.

***Computer science differentiation.*** It contributes to the increase of uncertainty in the interaction of individuals in the digital world. Neurosciences (neuroergonomics, neuropsychology, etc.) have established the dominance of cognitive styles and emotional memory when studying the interaction of individuals [8]. The works [9-11] draw attention to the fact that cognitive problems are also associated with the mentality of interacting people. Therefore, the main goal of the work is to find ways to harmonize human-computer interaction. In the digital world, cognitive aspects give rise to new difficulties, problems and contradictions, for the solution of which it is important to solve the problems of finding new ways to:

– visualization of poorly formalized information for presentation and analysis;

– revealing hidden individual cognitive distortions;

– taking into account the individuality of the style of thinking in the processing and analysis of information.

The solution of these problems requires the consideration of sensory and biosensor signals of various nature in the form of information flows [12]. The processes of organization (structure) of control in objects of animate and inanimate nature are similar [13]. This is confirmed by the analogy between the processes of pattern recognition in cognitive processes and the dynamic processes of shaping in natural systems [14, 15]. Therefore, it is possible to analyze not only the dynamic (coarse) structure of the information flow, but also the fine (information) structure.

Thus, the connection of cognitive aspects with the functional asymmetry of the cerebral hemispheres was most manifested in the dynamic similarity and statistical difference between the fractal electrophysiological signals of individuals. Hybrid (analogue-digital) processing of these signals made it possible to convert them into 3D models, the orthogonal projections of which are three 2D models. Spatio-temporal relationships of configurations of these models under the influence of stress factors indicate a change in their dynamic structure, energy balance and order [9, 11]. In this article, we use the fractal triangle and fractal logic for heuristic modeling, which made it possible to add 4 more veracity, viability , value variability and visualization to the initial set of VVV features (volume, velocity, variety) [16, 17]. And these are new opportunities for the further development of artificial intelligence (AI).

## 1. Material and methods

***Induced feedback asymmetry.*** The natural sciences have accumulated large databases (Astrophysics, Particle Physics, Physionet, Covid-19, etc.). Their rapid growth limits the processing of information in real time. At the same time, extreme conditions bring the state of self-organizing objects of various nature closer to the bifurcation point and self-organized criticality appears [18]. At the bifurcation point, the inhomogeneities of the environment and sources of information appear in different studies, which makes it possible to combine the results of several studies using statistical methods, i.e. carry out a meta-analysis. The advantage of meta-analysis (over literature reviews, etc.) is that it can detect bias. They, like hidden cognitive distortions, affect the optimality of decisions made online. A consequence of the presence of heterogeneities in information sources and information transmission media is the asymmetry of induced feedback [19]. In particular, its features are characteristic of critical phenomena (phase and structural transitions), critical technologies (smart materials) and thinking. Critical events result in induced feedback asymmetries that create new technologies or problems (see Fig. 1).

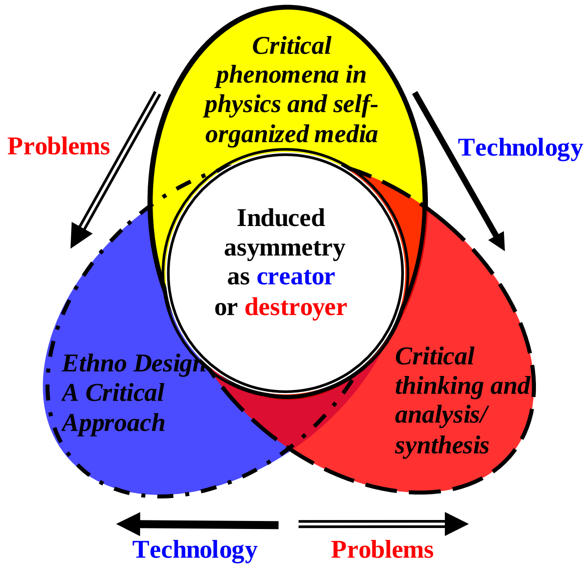


Fig. 1. Induced feedback asymmetry as creator (clockwise) and destroyer (counterclockwise) of new relationships

## 2. Problems of development of artificial intelligence

***Limitations in the development of AI.*** AI technologies help make computers smarter, not take over the world. Therefore, the limitations in the further development of AI are due to the fact that:

– training is only based on data, and any inaccuracies are reflected in the results;

– AI is focused on well-defined tasks and is vulnerable to biases and errors;

– self-learning systems are not autonomous.

Such a narrow specialization leads to legal problems of liability for unmanned vehicles (drones, etc.) and automated control systems. Therefore, AI contributes to the intuitive process in human-computer interaction when decisions are made within certain tasks. However, under unforeseen conditions, increasing complexity limits cognitive computing.

***Simplified heuristic models of NBIT and CPS.*** Research on nanostructures at the end of the 20th centu-

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ry contributed to the development of nano, bio- and information technologies [20, 21]. However, the realization of the fruitful idea of technology synergy through convergence is hindered by the manifestation of cognitive aspects in human-computer interaction. In works [2, 19, 22] it is shown that the asymmetry of feedbacks determines:

– uncertainty and causes cognitive dualism;

– uncertainty of dynamic parameters and statistical integrative indicators;

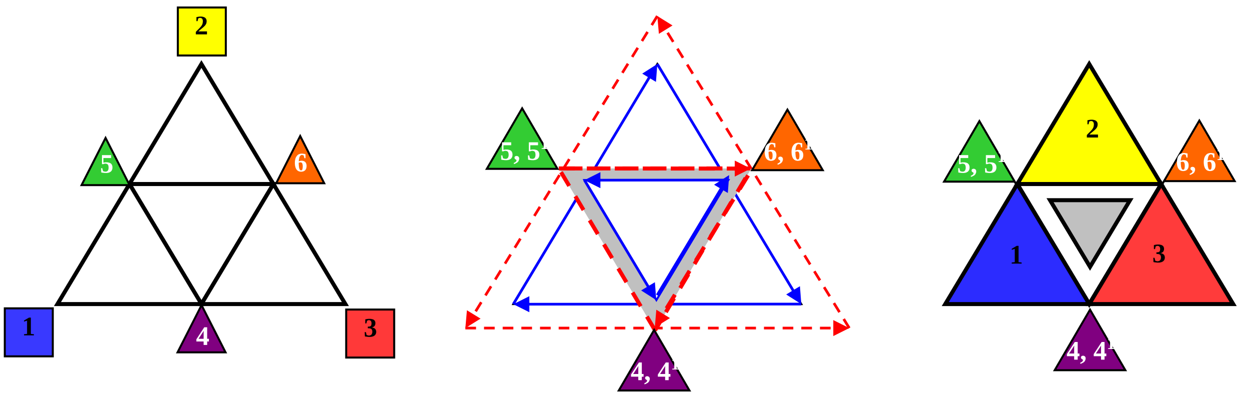
– instability of the balance of information and other resources.

Consequently, the asymmetry of links and the growth in the number of distortions of information flows of various nature limits the possibility of implementing a sustainable synergy of NBIT and reduces the security of the CPS in unpredictable conditions. Thus, space-time fluctuations (noises, jumps) limit the further development of intelligent technologies (machine learning, AI, etc.) [23].

***Development of heuristic modeling on a transdisciplinary basis.*** To harmonize human-computer interaction, generalized heuristic models of NBIT and CPS are proposed, based on the fractal triangle and fractal logic, as well as the natural color circle of I. Goethe. He developed the theory of color for 40 years and considered it his greatest achievement [24]. The Goethe circle of natural colors includes primary colors (blue, red and yellow) in the form of a triangle, and first-order colors in the form of an inverted triangle (violet, orange and green), and harmonization is achieved through the balance of conjugate components and the contrast of opposites. Highlighting spatio-temporal features with natural colors (red, blue, and yellow) and with auxiliary colors (green, orange, and purple) of relationships induced by visual analyzers stimulates intuition (see Fig. 2). As can be seen from the figure, a combination of harmonious colors located next to them strengthens them, and a combination of less harmonious colors leads to disharmony. In addition, generalized NBIT models visualize the uncertainties that limit the reproducibility of technologies. This simplifies the identification of the features of human-computer interaction in unpredictable conditions under the influence of stress factors of activity and the environment for transmitting information.

***Spatio-temporal features of generalized heuristic models.*** These features of heuristic models not only expand the possibilities of meta-analysis, but also allow revealing hidden relationships. Thus, a static model (a.) can be represented in various ways in the form of a fractal triangle, Sierpinski triangle, Koch-snowflake fractal, etc. [25-27]. The original dynamic model (b) displays the induced uncertainty that is created by the feedback asymmetry. The statistical model (c) takes into account the growth in the uncertainty of the power balance of conjugated subsets of microstates. Therefore, the complementarity of models (b) and (c) testifies to the cognitive value of the boundary between probable and improbable dynamic events. On the one hand, feedback asymmetry generates distortions (noise, fluctuations, jumps), and on the other hand, it increases the uncertainty of the dynamic structure of the information flow and its statistical order. Therefore, digital modeling blurs the line between truth and falsehood, which limits the possibilities for further development of artificial intelligence. It is obvious that a convergent approach on a transdisciplinary basis will allow predicting information and other security.

***Security of cyber-physical systems in unforeseen conditions.*** Based on NBIT, there was a revolution in automation and cyber control. Unique cyber-physical systems (CPS) have been created and INDUSTRY 4.0 and INDUSTRY 5.0 are being intensively developed. However, the use of CPS (airbuses, nuclear reactors, technologies, etc.) in unforeseen conditions actualized the problem of their safety [28, 29].




a) Static model – graph b) Dynamic Model c) Statistical Model

Fig. 2. Generalized heuristic models of NBIT interconnections
(in Fig.: 1 – Nanotechnologies, 2 – Biotechnologies, 3 – Information technologies,
4, 5 and 6 – induced states (connections, subsets), respectively

The manifestation of space-time relations in the dynamic structure of the information flow is associated with the extreme principle of the shortest path or least curvature proposed by Heinrich Hertz based on the ideas of Jacobi and Gauss [30]. Therefore, the safety of CPS is determined by the spatio-temporal uncertainty of signals (information flows) of various nature. In this case, the uncertainty of human electrophysiological signals as the most unreliable element of CPS is of particular importance. The increase in complexity and uncertainty is most clearly manifested in the transitional psychophysiological states of a person [9, 11]. Today it is important to realize that the cognitive aspects of digitalization are associated with emotional memory, which depends on mental health. Therefore, in unforeseen conditions, only the harmonization of human-computer interaction with the digital world will reduce the impact of cognitive aspects on the security, reliability and stability of CPS.

## 3. Metaphysical approach to the development of artificial intelligence

***Problems of functioning of CPS in unforeseen conditions***. Most of the problems are related to the limitations of the theory of artificial intelligence (machine learning, etc.) [23]. The main problem in unforeseen conditions is the individual functioning of the CPS elements, as well as the increasing complexity of their interaction. Individuality manifested itself most clearly within the framework of the metaphysical approach [31, 32]. Further development of the metaphysical approach was carried out through the geometric interpretation of information flows of various nature in the cognitive space, which made it possible to use:

– extreme principles of natural science for the analysis of information flows (signals) from different angles;

– dynamic similarity criteria for the analysis of information flows of various nature;

– principles of the general theory of relativity for the analysis of a geodesic curve from different angles of view.

The hidden complementarity of cognitive distortions was most evident in the visualization of fractal electrophysiological signals in the cognitive space. This made it possible to establish the influence of the psychophysiological state of a person on the cognitive perception of changes in the structure of information flows of various nature [9, 11, 12]. It became obvious that genetic or technological heredity is hidden in the nature of the restructuring of the space-time structure of the cyclic process [32]. It is the variability of cyclic processes that reflects the self-organization of new connections, in the individuality of the fine structure of which a heuristic algorithm for finding solutions based on natural selection is hidden.

***Transdisciplinarity of cognitive space.*** Today, the recommendations of UNESCO and the UN on the transdisciplinarity of education in the 21st century, as well as the report "ARISE-2" (Advancing Research in Science and Engineering), the main goal of which is to make "the transition from interdisciplinarity to transdisciplinarity" [33-35]. Transdisciplinarity also includes what is between disciplines and beyond, i.e. manifestation of unintended side effects. The assumption that the spatio-temporal structure of information flows contains hereditary information is confirmed by the analysis of the dynamic similarity of cyclic processes of various nature in the transdisciplinary cognitive space [22, 32, 36]. The dynamic similarity of cyclic processes in sources of information of various nature indicates its connection with the phenomenon of self-organized criticality [18] and the principle of local dynamic equilibrium. It turned out that hereditary information is hidden in the nature of the restructuring of fractal signals of self-organized complex dynamic systems (sensor responses, electrophysiological signals (ECG, EEG, etc.) [9, 11, 19]. The similarity of the dynamic structure of time series of various nature in the cognitive space indicates the existence of a hidden connection between spatial micro- and macro- inhomogeneities. Therefore, temporal fluctuations (noises, jumps, etc.) are sources of qualitatively new information about biological, physical and informational security [2, 19]. Has a holographic nature, is confirmed by the transition from two-dimensional to three-dimensional cognitive images. It can be assumed that the nature of the restructuring of the coarse and fine dynamic structure of cyclic processes in the transdisciplinary cognitive space is most important for the further development of science, education and technology [12, 22].

***Generalized heuristic models of a cyber-physical system.*** The integration of computing resources with physical processes under unforeseen conditions is limited by the increasing complexity of human-computer interaction [19]. To harmonize the interaction, generalized heuristic models of the cyber-physical system have been developed. Thus, the static CPS models (a) (Fig. 3, a) and the NBIT model (see Fig. 2, a) are the same, while the dynamic and statistical NBIT models complement each other (see Fig. 2, b and Fig. 2, c). At the same time, the allocation of space-time features with natural colors (red, blue and yellow), and auxiliary colors (green, orange and purple) induced by visual analyzers of relationships, stimulates the use of intuition. In addition, the generalized NBIT and FSC models visualize the induced uncertainties, taking into account the interrelations of which makes it possible to predict their stability. Therefore, the complementarity and similarity

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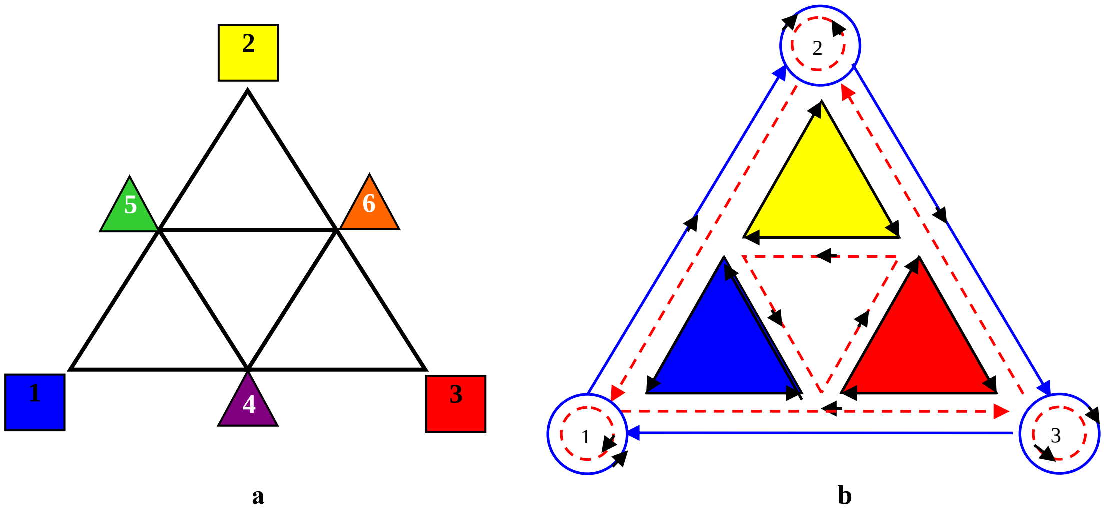


Fig. 3. Generalized Static (a) and dynamic (b) CPS models
(1 – physical layer, 2 – digital layer, 31 and 32 –communication interfaces)

of the heuristic models of NBIT and CFS has a higher cognitive value than the models of NBIT and CFS in the article [9].

Such complementarity and similarity between the heuristic models of NBIT and CPS has a cognitive value.

As can be seen from the figure, a combination of harmonious colors located next to them strengthens them, and a combination of less harmonious colors leads to disharmony. This simplifies heuristic modeling of the influence of stress factors on information sources and information transmission media.

When modeling the functioning of the CPS in unforeseen conditions, you can use: a) a static model in the form of a fractal triangle, as well as a graph, an octahedron face; b) a dynamic model that fractally displays feedback loops, the induced asymmetry of which is quite informative. Thus, the symmetry of static links and the increasing uncertainty of their dynamic links under unforeseen conditions leads to the loss of CPS stability. Therefore, the visualization of the variability of the fine structure of the signal, as well as the complementarity of the static and dynamic models, has a cognitive value.

***The relationship between order and disorder.*** Relations of the same type are different in mathematics, physics and biology (chemistry). In mathematics, order is a certain system of relations, and its absence is disorder. In physics, order is the correlation (system of relationships) between a group of observed events. The biological and chemical order can be defined as the dual order of structures and processes. Therefore, in the study of the macro- and microworld, we are looking for order, using a conservative scientific method. However, in the process of digitalization of science and education, the logical basis for the search for order is increasingly moving away from reality. Researchers see other events that do not fit into the measurable or modelable. Therefore, such events are expressed by signs, the ratios of which form something immeasurable and unimaginable. Whereas the process of thinking is a process of pattern recognition [14, 15]. However, the digitalization of science, increasing the complexity of the tasks being solved, creates uncertainties that have begun to limit the unique possibilities of digital modeling. With the development of various sciences, the idea of the relationship between order and disorder is gaining more and more depth. Understanding means organizing images (impressions) in such a way that general ideas can be extracted from them.

## 4. Problems of digital modeling of nature

***Problems of human-computer interaction and development of AI.*** Archaeologists, anthropologists and environmentalists who study nature are experiencing problems with the lack of information for digital modeling. While architects, materials scientists, designers and engineers, borrowing ideas from nature (biomimicry), create smart materials, develop ethnic design, etc. Further development of digital modeling is limited to metamathematics, which is based on the incompleteness theorems of K. Gödel [37]. In any complete system of axioms, there will always be statements that are inconsistent and loop the computer. As a result, in the theory of artificial intelligence, the problem of stopping the computer arises. Since the loss of information in the process of digital modeling cannot be compensated by the redundancy of information flows of various nature [2, 22]. We see a way out of the impasse in the hybrid processing of analog and digital signals, the difference between which is the source of new information about heredity.

***Individual features of logic and intuition.*** "Logical thinking is only a tool of proof, but not an invention, and therefore does not create anything new" (A. Poincaré) [38]. In our opinion, heuristic activity includes both logic and intuition, which is based on individual successful experience and biomimicry [39]. Logic and intuition are the two components of heuristic activity, which is aimed at discovery, invention and know-how. Therefore, digital modeling is based on modern metaphysics [40, 41], and a triad of complementary principles is important in heuristic modeling [22].

***The connection of order with the perception of harmony.*** The formation of a "bridge" between the macroscopic and microscopic approaches is facilitated by the commonality of physical and mathematical antonyms (order-disorder, simplicity-complexity, structure-function, etc.), the intersection of which is the source of new information [2, 19, 22]. When moving from models to real systems, the distortion of the structure of information flows causes hidden cognitive distortions (individual systematic deviations) [11, 22]. Taking into account the duality of perception of nature, individuality of thinking and functional asymmetry of the cerebral hemispheres underlie complementary heuristic models, which are shown in Fig. 2 and fig. 3. In these models there are three keys of the human mind: number, shape (letter) and color, with the help of which they open the harmony of the real world. The complementarity of these keys allows you to know, think and visualize dreams. Obviously, the connection between knowledge, thought and the dream of creativity is inspiring. A quote from the work of A. Einstein: "The significant problems that we face cannot be solved at the same level of thinking at which we created them" [42].

***Management of CDS in unforeseen conditions.*** This requires complementary ideas of modern metaphysics. The relevance of the study of the evolution of the real world is supported by the integration of various methodologies, methods and technologies, which are based on universal principles and many fruitful ideas. Natural relationships between structure and functionality, microstructure and macrostructure, dynamics and statics follow from the principles of modern metaphysics and other metasciences. Based on their complementarity, a universal cognitive model has been created, in which three key principles have been identified: the relationship of binary and trinity, fractality (self-similarity), spatio-temporal order. On the one hand, their complementarity is manifested in natural fractals and multifractals that exhibit statistical self-similarity, i.e. self-affinity. On the other hand, the orderliness of the spatio-temporal structure is characteristic of natural phenomena, the three-dimensional modeling of which gives rise to dynamic fractals and multifractals [2, 22]. In the transdisciplinary cognitive space of dynamic events, local distortions of phase boundaries (contours, configurations) reflect changes in the spatio-temporal structure of information flows of various nature. This allows you to observe and compare what is really comparable [2, 22]. Therefore, the visualization of the spatio-temporal balance of information and energy resources in heuristic models of the relationships between NBIT, CPS and CDS allows optimizing their management in unforeseen conditions.

## 5. Cognitive models of nature cognition.

***Local changes in structure and balance.*** Self-organized criticality and the principle of dynamic equilibrium give rise to an accompanying cyclical process in which the generalized principle of Le Chatelier-Brown [43] is manifested. On fig. 4, a shows a 3D model of new phase nucleation, which illustrates self-organized criticality. On fig. 4, (b, c, d) show cognitive 2D models of the three main phases of such related cyclical processes. Yes, fig. 4, b and fig. 4, d. The 2D models represent the unstable phases, while the 2D model c. displays the stable phase (survival).

As can be seen from fig. 4, when exposed, the cyclic process proceeds clockwise, and when counteracted, it proceeds in the opposite direction (d). Cognitive models (b) and (d) reflect the dynamics of cyclic processes tending to a stable phase – a two-dimensional model of the cycle (c).

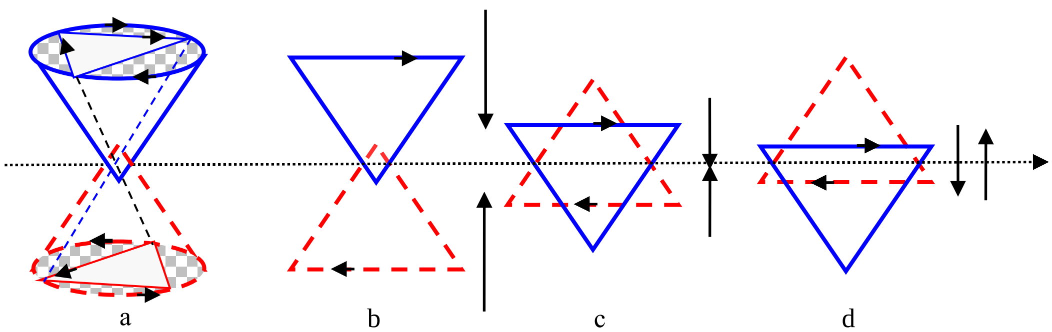


Fig. 4. Cognitive models of coupled cyclic processes

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Stability is based on the balance of opposites, which is due to the transition of trinity into duality. Obviously, therefore, 2D cognitive models and heuristic models of NBIT (see Fig. 2) and CPS (see Fig. 3) are characterized by dynamic similarity. Consequently, the structure of model (c) in the form of a Star of David reflects the thermodynamic principle of local dynamic equilibrium. This principle is inherent in all natural phenomena and follows from bionics. When moving from a 3D model (a) to 2D models (b, c, d), resources (substance, energy and information) are saved.

***Spatial-temporal structure of conjugated cyclic processes.*** It is important to note that the model of local dynamic equilibrium (в.) can be synthesized by different methods. In particular, through the superposition of two Sierpinski fractals, the Koch Snowflake fractal and the antifractal, as well as conjugated fractal triangles [25-27]. It is important that it has the appearance of the Star of David, various interpretations, both traditional and those proposed at the end of the 20th – beginning of the 21st century. These are: a) fully connected graph, b) Goethe color circle, c) magic numbers, d) mathematical theorem, e) magic knots, f) da Vinci code, etc. Therefore, every nation, studying and surviving in an environment with certain energy and information resources, interprets the Star of David in its own way. In our opinion, the Star of David is a unique genetic algorithm for studying the processes of origin (self-organization) of a new phase (structure), its survival (stability) and development (adaptation) in natural or certain information resources.

Harmonization with the help of the Star of David and Goethe's color circle makes heuristic models and their mutual transformations in the transdisciplinary cognitive space complementary. Therefore, it can be assumed that the evolution of self-organizing processes and CDS is based on a fractal cyclic process – STABILITY THROUGH THE DUALISM OF KNOWLEDGE OF NATURE AND ADAPTATION THROUGH THE DUALISM OF THINKING AND MENTALITY.

***Latent cognitive distortions.*** Works [2, 19, 22] show that local distortions in the structure of information flows of various nature in information sources and information transmission lines are associated with the perception of dynamic and statistical complexity in real time. There are interrelations between the features of dynamic and statistical complexity, which, under extreme conditions, distort the structure of information in processing, representation, and analysis systems. This gives rise to hidden cognitive distortions (systematic errors) (see Figure 5).

At the same time, visualization of changes in the structure of dynamic features with primary colors (blue, yellow and red), and statistical features with auxiliary colors (green, orange, purple) allows you to analyze changes in the symmetry / asymmetry of the structure, as well as the balance of their conjugate components. This includes intuition for uncovering hidden relationships.

As can be seen from Figure 5, a combination of harmonious colors located side by side enhances perception, and a combination of less harmonious colors leads to disharmony. The ability to use thermodynamic principles and criteria creates new opportunities for the development of intuition, which is associated with successful experience in solving real problems.

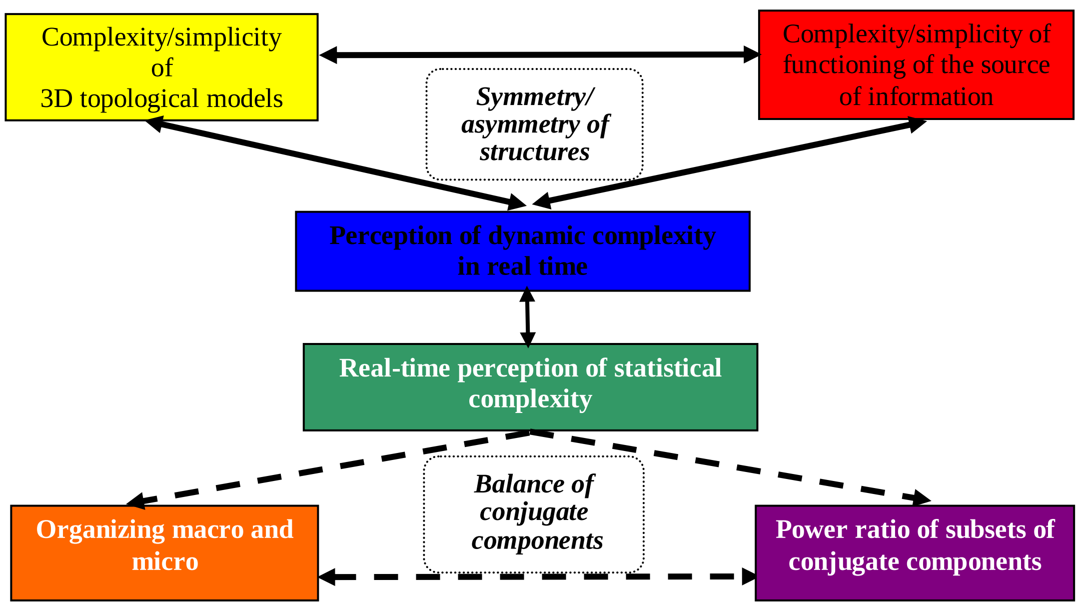


Fig. 5. Relationships between dynamic and statistical complexity

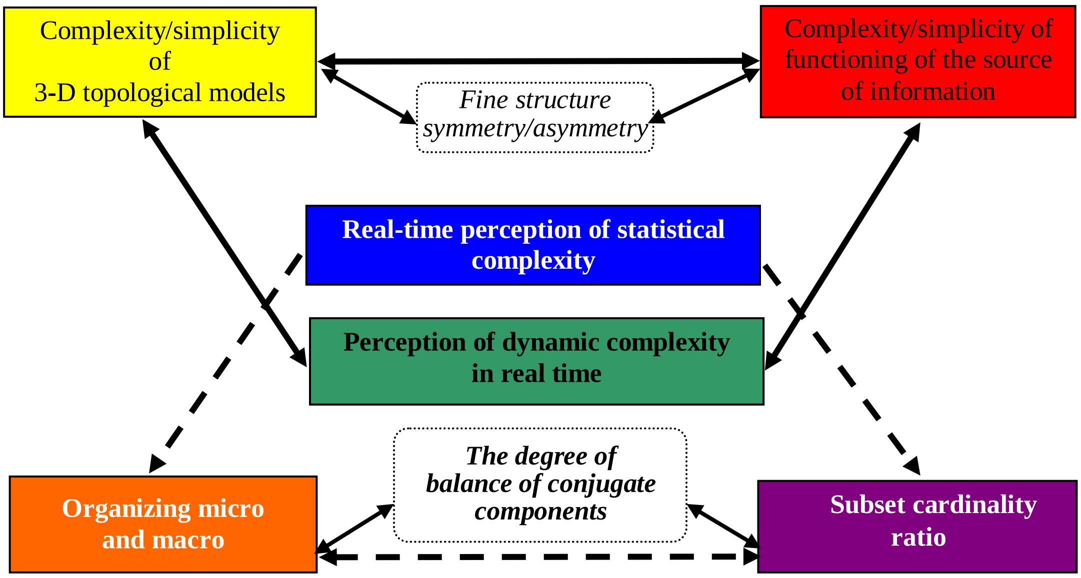


Fig. 6. Harmonizing complexity relationships through inversion

Through the inversion and use of the circle of natural colors by I. Goethe, in the analysis of electrophysiological signals in the cognitive space, hidden cognitive distortions (know-how) can be revealed. Consequently, the harmonization of human-computer interaction can be carried out by means of inversion and use of the circle of natural colors by I. Goethe (see Fig. 6.).

***Innovative potential of models.*** The innovative potential of the development of digital research methods is based on a convergent approach, the transdisciplinary basis of which allows the development of new tools for the development of artificial intelligence. The innovative potential of the development of digital research methods is based on a convergent approach and tools on a transdisciplinary basis. In particular, the amount of honeycomb structure in nature is two to three orders of magnitude greater than in artificial models. Their connection with the natural harmony of colors in nature “turns on” emotional intelligence, creating new opportunities for solving relevant problems in education and science, which are created by their digitalization. Therefore, the use of the fractal triangle and fractal logic has a high cognitive value, since it takes into account the peculiarities of the logic and intuition of the individual. Accounting for these features makes it possible to overcome those problems in the development of AI and biodesign, which are generated by cognitive distortions.

## Conclusions

In the 21st century, scientists, educators and engineers are faced with the cognitive aspects of digitalization and qualitatively new problems - increasing uncertainty, ambiguity and non-linearity in unforeseen conditions. Difficulties in solving these problems are associated with the dual nature of thinking and mental health [2, 22]. At the same time, the individuality of cognitive activity and the psyche is associated with the peculiarities of the perception of digital reality. In particular, the identification of hidden cognitive distortions (know-how) makes it possible to identify operators, designers, etc., whose successful experience contributed to the development of convergent thinking. After all, this thinking is based on the holographic structure of emotional memory, which forms intellectual intuition [2, 22]. Note that the holographic structure of emotional memory is formed in the process of solving real problems.

In the cognitive space of dynamic events, the complementarity of the three key principles of metaphysics, the duality of metamathematics and the trinity of modern metaphilosophy were manifested. Features of direct and feedback links in each metascience and between them determine new information challenges that are induced by digitalization.

Eristic modeling is facilitated by hybrid processing of analog and digital information, as well as displaying information flows of various nature in the form of topological 3D models. Structural and functional analysis of orthogonal projections of these models made it possible to establish:

– cognitive significance of information flow microstructure transformation into macrostructure by means of inversion;

– heuristic value of the circle of natural colors by I. Goethe for the further development of artificial intelligence tools;

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– qualitatively new opportunities for cognitive dialogue with nature and comprehension of reality.

Their complementarity creates a new basis for the development of more efficient IT and ICT, as well as for the interdisciplinary exchange of ideas, methods and technologies.

All co-authors are equal in status.

**Contributions of authors:** conceptualization – **V. Mygal, G. Mygal, S. Mygal**; methodology – **V. Mygal, G. Mygal**; development of models – **V. Mygal, G. Mygal**; analysis of results and generalizations – **V. Mygal, G. Mygal, S. Mygal**; the connection of order with the perception of harmony – **S. Mygal.** All authors have read and agreed to the published version of the manuscript.

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## ШТУЧНИЙ ІНТЕЛЕКТ – КОГНІТИВНА ЦІННІСТЬ ЕВРИСТИЧНИХ МОДЕЛЕЙ

***В. П. Мигаль, Г. В. Мигаль, С. П. Мигаль***

Стаття присвячена евристичному моделюванню структури взаємозв'язків у нано-, біо- та інформаційних технологіях та у кіберфізичних системах, графічні образи яких дозволяють вивчати тонку структуру джерел інформації різної природи. Тут показано, що інформативність моделей структури взаємозв'язків нано-, біо-, інформаційних технологій та компонентів кіберфізичних систем обумовлена використанням фрактального трикутника та фрактальної логіки. Мета роботи – гармонізація людино-комп'ютерної взаємодії через цифрові взаємодоповнюючі методи дослідження структури джерел інформації різної природи, а також використання кола природних кольорів І.Гете та нової інтерпретації Зірки Давида. Тут ми показуємо, що збалансовані трикутники в евристичних моделях дозволяють здійснити інверсію перехідних станів джерел інформації різної природи. В основі статичних, динамічних та статистичних узагальнених евристичних моделей баланс ресурсів та асиметрія зворотних зв'язків між елементами складної динамічної системи покладено. Їхній взаємозв'язок визначає варіативність циклічних процесів, а взаємодоповнюваність динамічних і статистичних евристичних моделей пов'язана з дуалізмом природи. Системний аналіз явних та прихованих взаємозв'язків в інформаційних потоках різної природи відкриває якісно нові можливості для пізнавального діалогу з природою та осмислення дійсності. Компліментарність евристичних та когнітивних моделей у трансдисциплінарному когнітивному просторі визначає інноваційний потенціал для вирішення актуальних проблем освіти, науки та нових технологій. Це особливо важливо для подальшого розвитку штучного інтелекту та гармонізації людино-комп'ютерної взаємодії. Зокрема он-лайн прогнозування перехідних функціональних станів джерел інформації різної природи в непередбачених умовах спрощує міждисциплінарний обмін ідеями, методами і технологіями. Оскільки кількість стільникової структури в природі на два-три порядки більше ніж штучних моделей, то їх зв'язок із гармонією кольорів у природі сприяє розвитку емоційного інтелекту, створюючи нові можливості для вирішення релевантних проблем безпеки.

**Ключові слова:** інформаційна безпека; просторово-часова структура; кіберфізичні системи; когнітивні науки; трансдисциплінарність; інверсія.

## ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ – КОГНИТИВНАЯ ЦЕННОСТЬ ЭВРИСТИЧЕСКИХ МОДЕЛЕЙ

***В. П. Мигаль, Г. В. Мигаль, С. П. Мигаль***

Статья посвящена эвристическому моделированию структуры взаимосвязей в нано-, био- и информационных технологиях и в киберфизических системах, графические образы которых позволяют изучать тонкую структуру источников информации различной природы. Здесь показано, что информативность моделей структуры взаимосвязей нано-, био-, информационных технологий и компонентов киберфизических систем обусловлена использованием фрактального треугольника и фрактальной логики. Цель работы – гармонизация человеко-компьютерного взаимодействия посредством цифровых взаимодополняющих методов исследования структуры источников информации различной природы, а также использования круга естественных цветов И.Гете и новой интерпретации Звезды Давида. Здесь мы показываем, что сбалансированные сопряженные треугольники в эвристических моделях позволяют осуществить инверсию переходных состояний

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источников информации различной природы. В основе статических, динамических и статистических обобщенных эвристических моделей баланс ресурсов и асимметрия обратных связей между элементами сложной динамической системы положен. Их взаимосвязь определяет вариативность циклических процессов, а взаимодополняемость динамических и статистических эвристических моделей связана с дуализмом природы. Системный анализ явных и скрытых взаимосвязей в информационных потоках различной природы открывает качественно новые возможности для познавательного диалога с природой и осмысления действительности. Комплементарность эвристических и когнитивных моделей в трансдисциплинарном когнитивном пространстве определяет инновационный потенциал для решения актуальных проблем образования, науки и новых технологий. Это особенно важно для дальнейшего развития искусственного интеллекта и гармонизации человеко-компьютерного взаимодействия. В частности, онлайн прогнозирование переходных функциональных состояний источников информации различной природы в непредвиденных условиях упрощает междисциплинарный обмен идеями, методами и технологиями. Поскольку количество сотовой структуры в природе на два-три порядка больше чем искусственных моделей, то их связь с гармонией цветов в природе способствует развитию эмоционального интеллект, создавая новые возможности для решения релевантных проблем безопасности.

**Ключевые слова:** информационная безопасность; пространственно-временная структура; киберфизические системы; когнитивные науки; трансдисциплинарность; инверсия.

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