SECTION 2. COMPUTER SCIENCE

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2.1 Connectionism: facets of noon-models of digital twins on nD switching patterns by Berezovsky

The third industrial revolution – a symbiosis of mathematics, intelligence, scientific methods, and new silicon (semiconductor) technologies *Si* (*Si* being one of the most common elements in the environment, in Fig.1) – has led to the start of the digitization process (in a broad sense) – the development and implementation of digital transmission systems at the level of primary networks, switching and control devices, enabling the transmission and distribution of information flows in digital form at the level of secondary networks, as well as the rapid development of electronic computers.

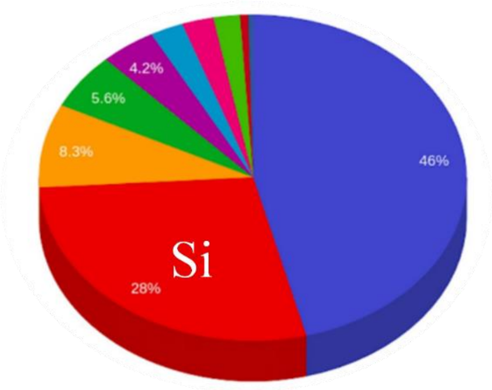

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Figure 1. Silicon *Si* is one of the most common elements of the medium.

The evolutionary development of computer technology on new silicon technologies involved: reducing dimensions, transitioning to more advanced components, increasing computational power, expanding the capacity of random-access memory and permanent storage devices, enabling widespread application in various industries, and providing computer personalization.

The late 1960s brought new transformations to computer technology: the degree of integration increased (allowing for the placement of all system components on a single board, known as the planar technology, in Fig.2; integrated circuits were developed, consisting of a chain of transistors combined on a semiconductor wafer; semiconductor and memristor memories emerged as the primary memory elements. The increase in integration level enabled faster processing, reduced power consumption, improved precision through better component alignment, and increased reliability.

A distinctive feature of silicon technology is the placement of electronic components on silicon wafers in a planar configuration, in the form of microchips, large-scale integrated circuits, and various-purpose processors in Fig.2.

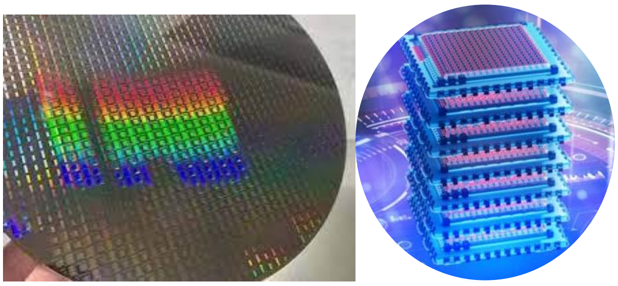

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Figure 2. Planar design of electronic components *Si* technologies.

The processes of technological design of *Si*-techniques, which occur using corresponding "planar" objects (line, plane), are interpreted as occurring in Euclidean three-dimensional space (*3D*) in Fig.3. To describe the processes that take place in space, a coordinate system is introduced, which serves as a reference system (parameterization of space).

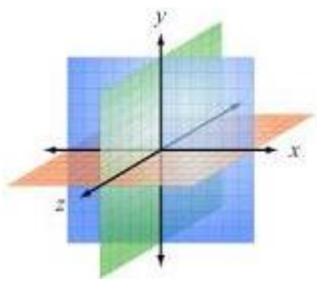

Figure 3. Euclidean three-dimensional space (3D).

This space is called three-dimensional because it has three homogeneous dimensions: length, width, and height. In other words, three-dimensional space is described by three orthogonal unit vectors. In the three-dimensional Euclidean space where the mentioned processes take place, which involves the development (design) of elements (boards) and racks, cabinets (for placement or containerization) of computer technology, a basic fixed Cartesian coordinate system *Oxyz* with zero curvature ($\kappa=0$) is introduced.

Components of computer technology, using a metaphor, are placed/containerized on boards using "planar" technology, from which blocks, modules, and boards are composed, which, in turn, are structurally combined into racks, and racks are placed in cabinets. Cabinets are located in "machine" rooms (based on "planar" technology) and are an integral part of implemented projects for modern complexes, architectures, and networks in Fig.4.

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Figure 4. Containerization of computer equipment.

Let’s note in particular that silicon digital technologies have enabled explosive growth in electronics, telecommunications, and have «opened the doors» for space expeditions, biotechnological research, and the formation of the Internet. However, a computer as a device/system has remained capable only of automatically executing a given, modifiable sequence of operations aimed at enhancing, accelerating, improving, and developing human computational capabilities. The symbiosis of mathematics, intelligence, and scientific methods gave a new breath to the pioneers of artificial intelligence in the 1950s, who set an incredibly bold but clear goal for themselves: to transition from being mere «helpers» to the category of «intellectuals». In other words, the use of computers for simulating human intelligence, which is not necessarily limited to biologically plausible methods.

Existing intelligent systems today have fairly narrow application areas. Component-based artificial intelligence is a simplified version of artificial intelligence implemented in a subject-informational form, allowing for the imitation of individual components of natural-intellectual thinking [22]. For example, programs capable of defeating humans in chess, answering questions, machine translation of text, expert systems, *Chat GPT* – those that are empirically (experimentally) determined by psychology.

The global community is rapidly approaching the creation of "general-purpose *AI*," increasing the speed of chips, enhancing the performance of computer systems while simultaneously expanding the volumes of containerization and occupied territories. However, as Robert Colwell (one of the experts at *DARPA*) noted, there was a time when the clock frequency of chips increased in 5000 in 30 years, from 1 *MHz* to 5 *GHz*, while architectural improvements during the same period led to a 50-fold increase in performance.

The solution to this issue is currently replaced by the development and production of complex multilayered structures (with more than 50 layers) and combined structures. In other words, we see that the processes of development and compacting/containerization - the "constructive packaging" of computer technology - are also based on outdated planar technology. And all of this is the result of an outdated planar paradigm that "relaxes" creators/theorists in developing new multidimensional (spatial) models of basic elements/modules for new volumetric integrated technologies that should motivate/interest/stimulate researchers/practitioners to develop parallel architectures and new three-dimensional semiconductor technologies.

Progress doesn't stand still, and the modern market demands the rapid creation of new digital products for computer technology, hybrid systems, and artificial intelligence. Today, in the overwhelming majority of cases, the human operator/solver/designer has to deal with symbolic information in intelligent systems rather than numerical information. It is worth noting that humans possess specific cognitive systems: firstly, reasoning, intelligence, or symbolic thinking, and secondly, perception and imaginal thinking. These two systems exist in humans as a «seamless whole» [23].

The imaginal system of humans is characterized by remarkable speed in processing images and the integrity of imaginal representations. The physiological ability of the human operator to perceive light electromagnetic radiation with the eye, transform and «reflect» information about this radiation in the human brain as associative images, expands the possibilities of using imaginal models and allows the designer to engage in the process of finding a solution to a real scientific problem under natural conditions.

The human operator can demonstrate understanding, apply acquired knowledge, analyze information, evaluate information, and create something new. Therefore, the problems of creating new digital products for computer technology, hybrid systems, and artificial intelligence need to be addressed using cognitive technologies – the next milestone in the development of information systems [24].

Cognitive science, in the broadest sense, is a combination of sciences related to cognition: the acquisition, storage, transformation, and utilization of knowledge. Historians identify three roots of cognitive science:

1) the development of computers and programs that simulate human problem-solving abilities (Homo);

2) the advancement of cognitive psychology, which investigates the processes involved in perception, memory, thinking, and language in Homo;

3) the development of generative grammar theory (a branch of linguistics).

Cognitive technologies are an excellent addition to the traditional ecosystem of information technology. Their functions are integrated into many programs. Cognitive information technologies are one of the most «intelligent» branches of artificial intelligence theory.

The first direction is based on the computer metaphor, which involves examining human cognition and its relationship to brain function using the analogy of a personal computer. In this metaphor, programs (software) that perform specific functions can be implemented on different «substrates» (hardware). However, the presence of a central processor with limited processing capacity imposes certain constraints on information processing.

The modular approach theorists conceive human cognition as a set of parallel functioning associative «modules» that operate independently. The output of these modules is used in central processes of knowledge coordination and decision-making. However, these processes are often too complex to study due to the multitude of factors influencing their current state.

Lastly, connectionism is based on the «brain» metaphor of cognition, where cognitive processes are viewed as parallel information processing within a network composed of simple units (neuron models) at multiple levels. The connections between these units have different weight coefficients, which can change depending on the training of the neural network to solve specific types of tasks.

One of the distinctive features of the author's modification of the model, compared to the base model, which incorporates key components such as experimental psychology of cognition, philosophy of consciousness, neuroscience, computer science and artificial intelligence, cognitive anthropology, and linguistics, is the inclusion of demiurgic components - audio and coloristic properties (Demiurge ($\check{D}$) - in Christian theology - refers to the "Creator," God as the Maker and Organizer of all that exists) in Fig.5.

By the present moment, cognitive science has developed three main theoretical approaches [25]:

1) Model-symbolic approach,

2) Modular approach, and

3) Connectionism (CO).

Connectionism is a more recent and less common direction that describes cognitive systems as networks of interconnected elements. It is based on the «brain» metaphor of cognition, where cognitive processes are seen as parallel information processing processes in a network consisting of multiple levels of simple units - neuron models, with connections between them having different weight coefficients that can change based on the learning of the neural network to solve specific types of tasks [26].

Figure 5. Cognitive Science Model with Demiurgical Components.

In computer science, specialists adhere to the view that more is better: networks with a larger number of nodes/layers allow systems to solve a variety of tasks. The central principle of cognitive science is that a complete understanding of the mind/brain cannot be achieved by studying only one level. Ultimately, a deep neural network with a single layer may be created, but in that case, it would likely require much more information and time to train such an algorithm.

The year 1980 was marked by the invention of functional magnetic resonance imaging (fMRI). MRI brain scans allowed for a preliminary analysis of the unique structure of the human skull (which we will discuss below) and the formulation of ideas for the development of neural networks. Scientists were inspired by natural neural networks in the brain. These networks were modeled based on the analogy of natural neurons. Our knowledge of the computational complexity of individual neurons has significantly expanded, and we know that biological neurons are more complex than artificial ones. But to what extent?

The research on the cognitive properties of the brain in biological organisms has provided interesting information about the level of connectivity between neurons in Fig.6. The nodes of connectivity are referred to as «cliques». The more cliques there are, the higher the dimensionality (number of coordinates). During the research, network architectures with dimensions reaching up to 11 were "discovered." Higher dimensions, by definition, imply the ability to choose a point from which a broader, global overview is revealed.

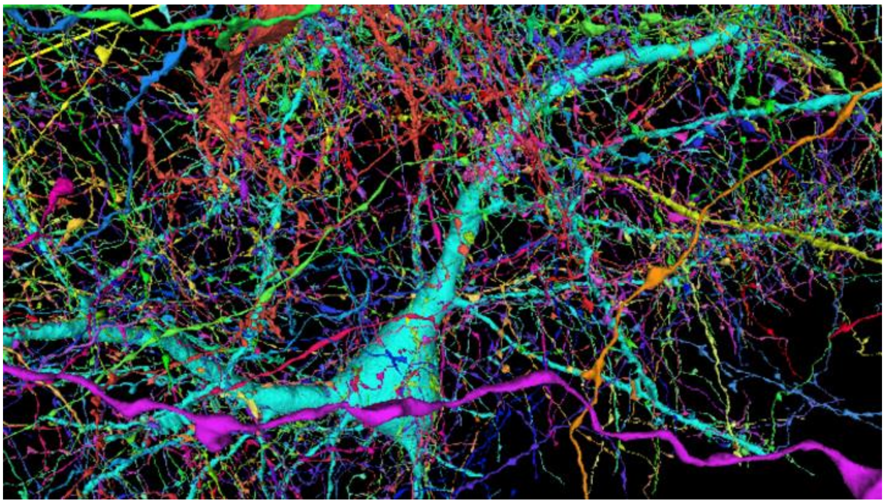

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Figure 6. Photo of MRI images of the brain

Indeed, our gelatinous brain and the solid silicon chips of computer processors seem like two completely different entities (biological neurons are 1000 times more complex than artificial ones). However, scientists have been comparing them for many years. The computational capacity of the brain is of scientific interest, and we are eager to understand why the brain employs certain computational complexities in individual neurons. Deep neural networks have successfully learned to predict the input-output function of a neuron using five to eight artificial layers. For most networks, this means that nearly a thousand artificial neurons correspond to a single biological neuron [27].

In the human brain, there are trillions of synapses forming a flexible and intricate network, which allows us to behave, feel, and think as *Homo sapiens* [28].

Traditional methods of geometry, widely used in natural sciences, are based on an approximate approximation of the structure of the investigated object with geometric shapes (lines, planes, polygons, polyhedra, spheres, etc.) and their compositions, whose metric and topological dimensions are equal. However, many natural systems are so complex and irregular that the use of familiar objects from classical geometry for their modeling seems hopeless (as mentioned above, especially in Euclidean space with a rectangular Cartesian system and curvature $k = 0$). For example, a 3D MRI image of the cerebellar cortex, where among other nerve cells, dendritic trees of Purkinje neurons extend with their branching, capable of forming up to 100,000 connections (synapses) in Fig.7.

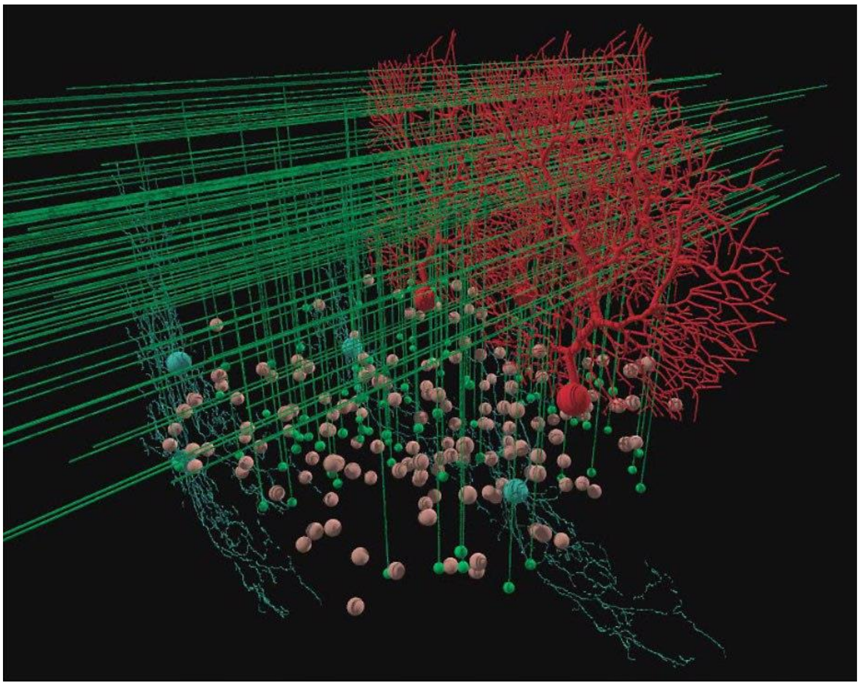

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Figure 7. MRI photograph of the cerebellar cortex in 3D

One of the nearest perspectives of cognitive science is the development of a new technology for interactive-graphic interaction between humans and their imagistic mechanisms of creative thinking, not just with computers but directly with the problem under investigation. Advances in hardware and software development enable the activation of the Brainware creation process, which comprises a set of intelligent algorithmic tools that form the factual basis of modern mathematical modeling methodology and computational experimentation with a unified information language space.

Communication, the interconnection of cognitive elements within the structure, is facilitated through communication equipment and switching structures (*SS*). However, despite the apparent inefficiency of current classical *SS* models, there has not been a shift towards more promising, efficient, and accelerated multidimensional models of switching. Why is that? This is a complex question tied to established traditions, accumulated knowledge, and a legacy of outdated paradigms.

The most significant characteristic of *SS* is the type of switching (switching) equipment. The development of new equipment utilizing new *3D* (spatial models of *SS*) is crucial for three important indicators of structure/architecture performance (the «brain» of the computer): its dimensionality (multidimensionality), reconfigurability, and the speed of transmission between its constituent components (particularly processors).

The existing models are essentially semiotic and consist of a system of logical statements in descriptive logic. However, as new knowledge is added, a problem arises in terms of understanding and effectively conveying the new knowledge to the human operator, who is an active participant in the modeling process. This is where Information-Intelligence Technology (*I2T*) comes into play. *I2T* utilizes synergistic means to interact with information objects, aiming to achieve cognitiosis, the stage of introspection in the operator's thinking. It facilitates reasoning, subject-based inference, and the formation of cognitive semantic reflections of technical entities in the operator's thinking.

I2T enables the transition from databases in a unified information space to knowledge bases in a unified information-intelligence space, with the symbiotic use of other subject-specific languages. In other words, to solve this problem, when visualizing, it is necessary to consider the psychological characteristics of perception and structuring of information by the human operator. Additionally, it is important to apply general principles for defining concepts in new knowledge [29].

Additionally, let's consider another feature of today's level of knowledge: we'll add one more dimension to the four dimensions of space and time — the fifth dimension, which pertains to light.

From the perspective of cognitive semantics, visual representation is crucial as it helps to form mental images that, in turn, facilitate understanding and reduce the cognitive complexity associated with abstract concepts in Fig.8.

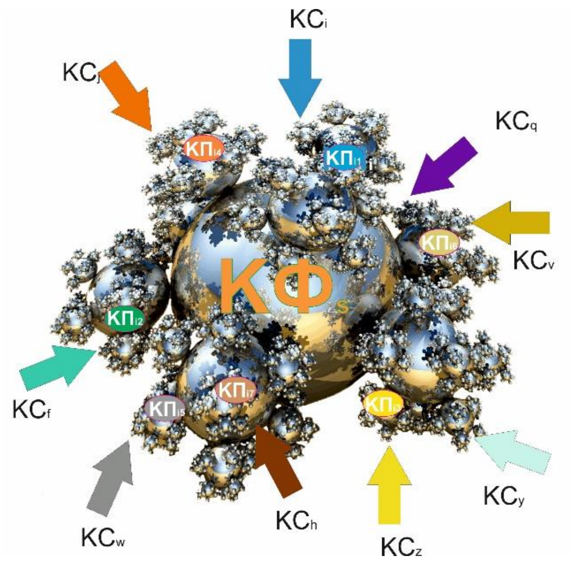


Figure 8. Connectionistic abstract image - switching structure model

The need for developers and consumers to have real-time information about the structure, composition of switching systems (*SS*), and the state of individual switching elements (*SE*) has led to the adoption of the concept of an abstract image or model, borrowed from psychology and philosophy, to represent a certain perception stereotype.

Existing models of *SE* are created during the design and production of semiconductor devices and are based on specific technological processes. They are essentially internal by-products of developing specific products and are proprietary, meaning they are closed solutions.

Platforms with open source code or, at the very least, compatible platforms are highly relevant. These platforms allow for seamless integration of open-source and commercial tools, including computer-aided design (CAD) tools. This is an evident requirement in terms of security, as it necessitates the presence of independent verification tools that check each other.

It is equally important to ensure that manufacturers of integrated equipment and their supply chains have access to the best, most competitive solutions for each specific design and verification task.

The ability of modern researchers/solvers to depart from conventional approaches in creating something new, to find new answers by combining previously unrelated concepts, through extensive and laborious analysis and contemplation, to see solutions where no one else has seen them before, i.e., to reveal hidden connections between apparent phenomena, is the magic of connotation and creativity.

Creativity is demonstrated in the ability to generate ideas, abstract constructs, and images that are simultaneously original and useful. It is worth noting that customers of design tool providers show greater activity during the specification development stage (technical and functional characteristics). This is advantageous for them because the value of transitioning to a virtual environment lies in achieving greater clarity on how hardware and software interact, which, in turn, provides greater benefits. This is why the "shift left" approach has emerged, transitioning to a concurrent, parallel, and interconnected (rather than sequential) development of hardware and software. This shift has enabled the more efficient application of verification and validation technologies.

It is essential to utilize physical developments of switching elements from various manufacturers. In cases where the physical properties of switching elements are not crucial, it is preferable to employ intellectual, i.e., creative, methods of knowledge representation to describe the functions of the model as a unified solution.

As a convenient abstract representation of the basic switching element for computer-aided design of geometric and topological structures of switching systems, it is proposed to use a real closed non-decomposable second-order geometric curve. The underlying model for this proposed abstract representation is based on a physical entity [30].

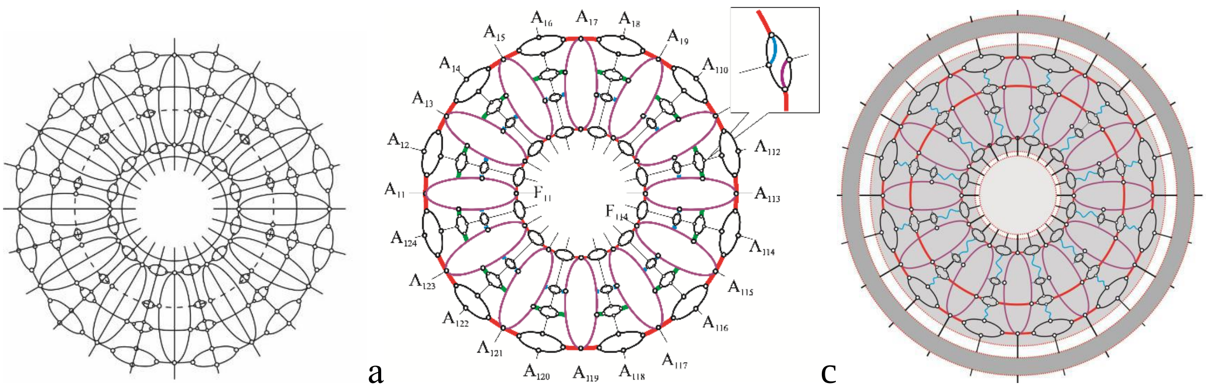
The management of the process of creating sign models is a symbiosis between designers and the technological process, visualizing/optimize/managing the creation/development and control of configurable switching structures.

However, today, each component of cognitive science utilizes its own terminology and research tools, and there is a lack of effective switching between specialists. As a result, despite the high competence in the individual components, knowledge synthesis does not occur.

The adoption of virtual prototypes expands the possibilities of design. Following the progressively developing notion of the abstract object (inheritance hierarchy) of switching elements (*SE*), and based on the synthesis of a new physical entity of switching elements in the form of *SEB*, the declared abstraction will be redefined into a noon-model *SEB* [31].

Noon-models of discoses of the *SS* on *SEB-1* with a metric of *p=1* (taking into account the requirements of UGO GOST) in Fig.9a and *SEB-2* with a metric of *p=1*, considering the demiurgic component (coloristic reflection of SEB properties) in Fig.9b,c, are information object-subject noon-models of the considered material environment (switching structure/network) and activities within this environment, in a form adequate to the emergence and functioning of information exchange processes in human (operator) thinking perceiving (applying) these models.

The noon-model of the CE in the form of a real closed non-decomposable geometric line of the second order is an idiom - a pattern of the lowest level of abstraction with a metric of p=1This applies to both design and implementation.



a c

b

Figure 9. Noon-models of switching elements SEB-1 and SEB-2.

It should be emphasized that an important initial stage when working with noon-models of *SE* is the adequate modeling of the considered information situation and the information position of the design object in that situation. This is a necessary condition for problem formulation and the selection/development of suitable noon-models for design, taking into account the new paradigm of *SS* development.

Noon-models of knowledge representation of *SE* are one of the most important research directions in the field of computer science and artificial intelligence.

Noon-models serve as situational information for control, analysis, operation, and synthesis procedures of *SS*, and they are used for information visualization as elements of cognitive graphics: depicting the composition (used switching elements (*SE*), topology), the choice of dimensionality of the employed structure (*2D*, *3D*, *nD*), and coordinate spaces of representation.

The concept of forming *SS* architecture is closely related to the fundamental ideas of *SDN* (Software-defined Networking), where the control plane is separated from the data forwarding devices and implemented in software. This approach enables reducing the variety of equipment types, applying unified standards and technologies, and centrally managing the switching environment.

Special attention is devoted to the task of ensuring intelligence, access invariance, and service complexity in a unified transport environment of multiservice SS implemented based on *3D* technologies.

3D technologies offer a multitude of possibilities for constructing various topologies of SS – a universal transport environment, which ensures the flexibility of the environment and accelerated data transmission through the least congested routes.

The *2D* noon-model of the above-mentioned pattern on *SEB* helps to "bridge" the next level of modeling – the modular in *3D* space in Fig.10.

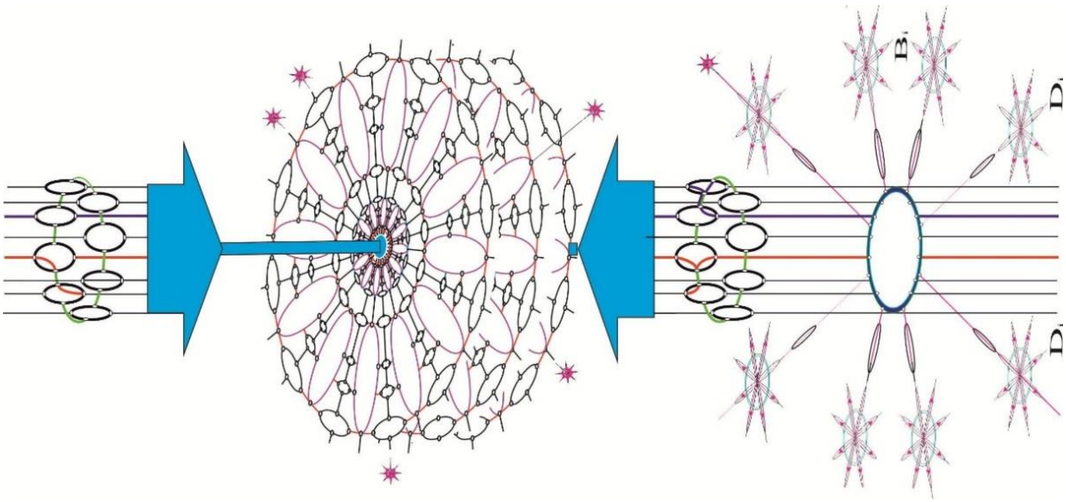


Figure 10. *3D* noon model of the *SS* module on 2D patterns on *SEB*.

During the development of *SS*, designers/solvers may require a set of switching patterns that differ in their application domain, scale, content, and description style. Depending on the application domain, patterns such as design patterns, testing patterns, analysis patterns, and others can be identified.

Formalizing the semantics of the subject domain in the form of an ontology (specification) serves not only the purpose of compact and consistent description but also establishes a conceptual basis for noon-models to represent the entire body of knowledge about it [32].

The application of noon-model patterns on *SEB* as design patterns allows solving tasks related to creating new entities or groups of similar entities. They eliminate code duplication and make the process of object creation shorter and more straightforward.

There can be a classification based on the level of abstraction of the considered systems and the degree of their detailing. Let's consider noon-model patterns on *SEB* for *SS* design in the following two categories:

- *3D* noon-model patterns on *SEB* with a metric of $p \geq 2$,
- *3D* noon-model patterns on *SEB* types: factory, abstract factory.

3D noon-model patterns on *SEB* with a metric of $p=2$ are low-level patterns that implement tasks considering the specific characteristics of the space or coordinate system in Fig.11. To use them, it is sufficient to know the characteristic equations governing the operation of the base switching element.

It can be stated that *3D* noon-model patterns on *SEB* used in the design of information systems represent a formalized description of a previously solved design problem. They possess reliability assessment and operational experience. They provide recommendations for applying the design solution in various information situations.

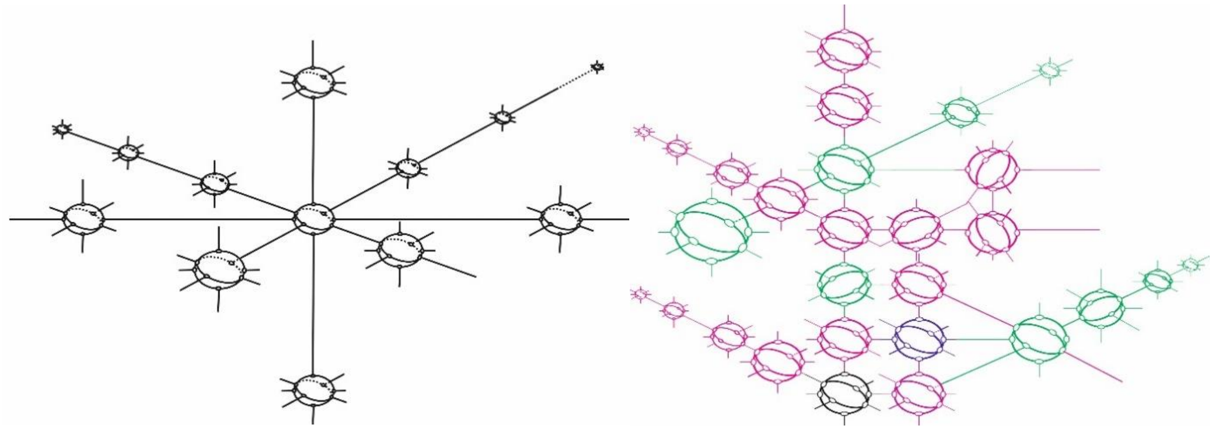


Figure 11. Noon-models of neural and abstract factories on *3D* noon models of patterns on *SEB* with metric $p = 2$/

Indeed, there can exist well-thought-out and elegant solutions created by experts that are accessible to other designers (characteristic of open systems). Studying and systematizing such information allows considering individual solutions as templates or examples for optimal problem-solving within similar classes.

Noon-model patterns on *SEB* in design enable the application of successful solutions to similar information situations. They serve as a noon-model for the module of the *SS* "crystal" factory on *3D* noon-model patterns on *SEB* with a metric of $p=2$. By utilizing these patterns, designers can leverage the benefits of previously developed solutions and adapt them to comparable scenarios in Fig.12.

3D noon-models of switching factories on *3D* noon-model patterns on *SEB* with a metric of $p \geq n$ represent the description of the interaction between objects and classes adapted to solve the general problem of designing *SS* in a specific context. Connectionist works will address increasingly higher levels of cognitive processes, driven by the efficiency of network representation and the transition from semantic relationships to various forms of quantitative expression of connections.

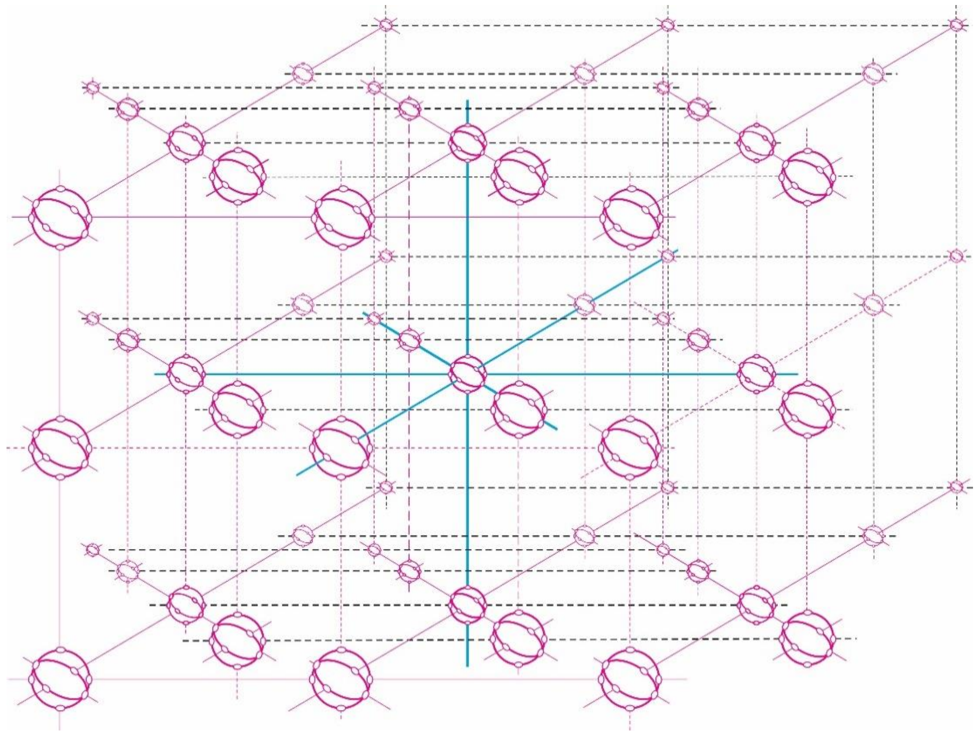


Figure 12. Noon-model "crystal" of the factory on 3D noon-models of patterns on SEB with metric p=2.

However, it should be noted that despite certain successes in the currently applied methodologies for designing *SS* in Euclidean space with zero curvature $\kappa=0$, the problem of creating highly efficient design methodologies for *3D SS* with $\kappa \neq 0$ values is far from being resolved.

3D noon-model patterns on *SEB* with a metric of $p > 2$ (considering the requirements of UGO GOST) and *SEB-2* with a metric of $p > 2$, taking into account the demiurgic component (coloristic reflection of *SEB* properties), are high-level patterns that implement tasks considering the specific characteristics of the given space or coordinate system in Fig.13.

The adequate use of noon-models of *SEB* patterns in the design of information systems provides several advantages:

1) a model of an information system built on the basis of noon-models of *SEB* patterns is a structured description of elements and relationships that are significant for solving the given task;

2) a model of an information system built using noon-models of *SEB* patterns in the design is more visually understandable than a new and unfamiliar model;

3) a model of an information system built using noon-models of *SEB* patterns in the design allows for in-depth and comprehensive development of the architecture of the developed cognitive infrastructure using new tools.

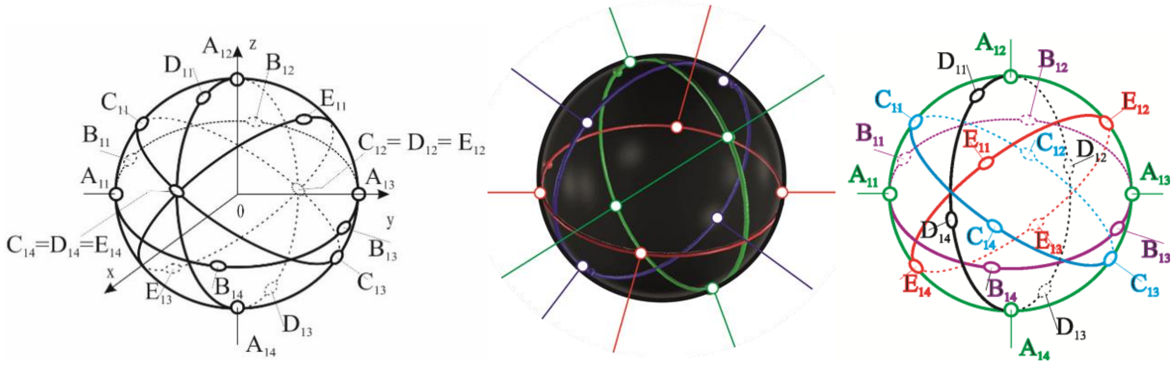


Figure 13. *3D* noon-models of patterns on *SEB* with *p>2* metric.

Properly selected design patterns make a software system more flexible, easier to maintain and modify, and the code of such a system is more aligned with the concept of reusability. If the system's documentation indicates which patterns are used in it, it allows the designer/researcher to understand the system faster.

With greater computational power, even more monumental achievements can become possible. This potential has motivated significant efforts in developing powerful and efficient computational methods.

By integrating various mathematical and computer models into a unified system, a new entity called a digital twin can be created. A digital twin provides a comprehensive description of a product and enables a systematic approach to its development, production, and operation. The application of digital twins in the industry represents an advancement in the paradigm of computer modeling and digital engineering of products [33].

Contemporary theorists of digital twins provide a rather convoluted definition for this concept. However, simplifying it, a digital twin can be understood as a virtual replica or copy of a real-world physical object or asset in the form of a multi-domain simulation. Ultimately, this simulation enables obtaining data about the state of the actual object that may be impractical or impossible to verify under real-world conditions [34].

Digital twins created in the process of designing and manufacturing semiconductor devices still remain within the scope of intra-company consumption. Firstly, they are formed based on a specific technological process, and secondly, they essentially represent a byproduct of developing a specific product. In this regard, there is still room for improvement for developers.

The concept of digital twins is gaining increasing development in the semiconductor industry, both in terms of the technological process of *IC* design and development, as well as in terms of production and operation. As the awareness of the value of this approach grows, more time, effort, and resources will be devoted to creating corresponding models and synchronizing them. Ultimately, the value of any digital twin will be determined by how much it helps improve the achieved results in terms of reducing design or production cycles, cost reduction, and risk mitigation.

In the semiconductor industry, there has long been a desire to obtain an executable specification that can be used to create specific implementations, which can then be used to generate digital twins for a given task. In this case, modifying the digital twin would begin with modifying the specifications. However, unfortunately, such ideas have not yet been realized in practice.

The application of digital twins (*DT*) to switching structures (*SS*) represents an advancement in the paradigms of computer modeling, connectionism, and digital product engineering.

By creating digital replicas of *SS*, digital twins provide a powerful tool for understanding and analyzing their behavior, performance, and characteristics in a virtual environment. They enable designers and engineers to simulate and explore different scenarios, optimize designs, and predict the behavior of the physical *SS*.

It is worth noting that the modern semiconductor industry is evolving towards increasingly configurable systems. The ability to configure, test, analyze, adjust, reconfigure, test again, and so on, provides a powerful feedback mechanism that enables the optimization of system specifications. It allows for refinement and the creation of more advanced configurations and derivative variants of basic products in shorter timeframes and with lower costs.

Furthermore, digital twins enable the testing of various scenarios for the application of cognitive infrastructure (*CI*), including "pathological cases," without the inevitable limitations associated with accessing physical-level systems.

Models and the sequence of design stages are changing. Many stages that were previously carried out sequentially can now be performed in parallel. For example, hardware development traditionally took place before the creation of software, and software development began only after the hardware was fully prepared for installation. To ensure that the parallel execution of these (and other) operations yields effective results, appropriate digital models are necessary.

Additionally, when the physical-level systems do not yet exist and the developer is at the early stages of project implementation, digital twins are the best way to accelerate and streamline the processes of design, testing, and production.

Digital twins allow engineers to model and assess the product's features based on the established requirements. With the help of a digital twin, any components of the solution can be pre-tested and optimized, whether they are electronic elements, software, or system performance.

Once again, it is important to note that a digital twin encompasses a variety of data that determines its effectiveness. It is based on a vast amount of accumulated data obtained from measuring various parameters of the object in the real world. Analyzing the accumulated data enables precise information about the system's state and performance, as well as conclusions about the need and direction of changes to cope with real operational data and possible partial or complete system configurations. This ability to configure, test, analyze, adjust, reconfigure, test again, and so on provides a powerful feedback mechanism that allows for optimizing system specifications and refining the designed structures.

From this perspective, digital twins should enable the modeling not only of hardware and software but also of the environments that exert diverse influences on this equipment and software (e.g., various operating conditions, external factors, etc.).

Ultimately, optimizing a production line for a specific product requires a three-fold digital twin: one for product development, one for equipment maintenance based on current condition, and one for operational and production aspects. The notion that the usefulness of digital twin models ends after product development and release is no longer true.

Unfortunately, some necessary models remain difficult to implement. This is attributed to the prevailing design paradigm in Euclidean space with a rectangular Cartesian coordinate system and zero curvature. Achieving full efficiency and overcoming these limitations may require the development of new modeling approaches that account for more complex parameters and real-world conditions in Fig.14.

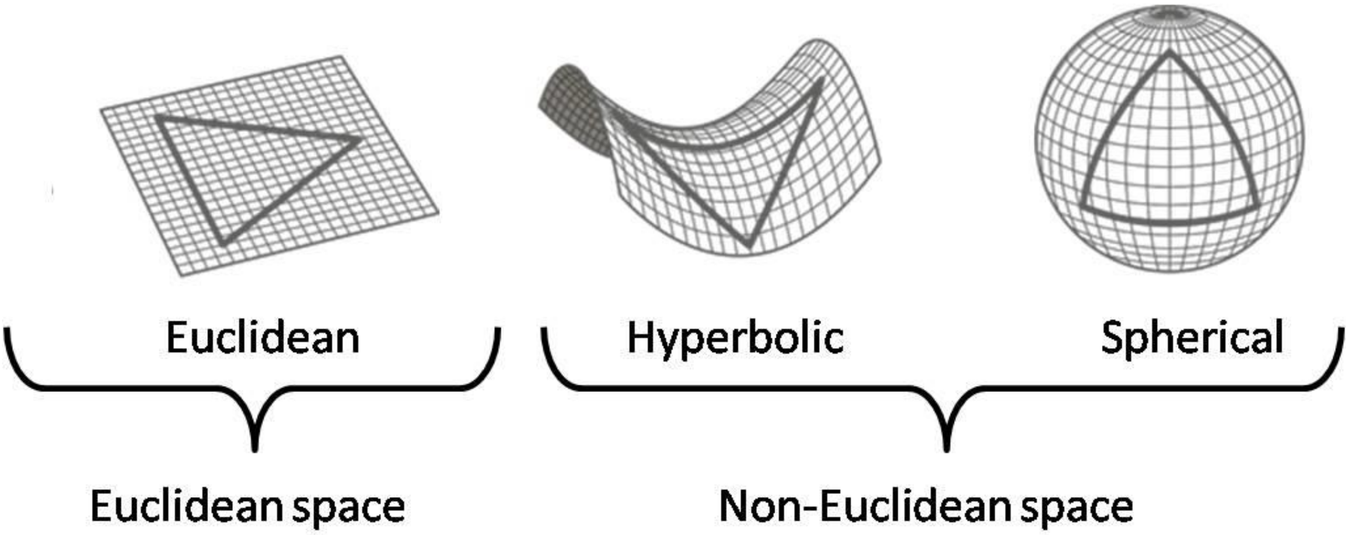


Figure 14. There are three variants of spatial geometry: zero curvature ($k=0$), negative curvature ($k<0$), and positive curvature ($k>0$).

This is all the work of an outdated planar paradigm that "relaxes" thinkers/theorists involved in developing new multidimensional (spatial) models of basic elements for new volumetric integration technologies, which should encourage/interest/stimulate researchers/practitioners in developing new volumetric semiconductor technologies.

Digital twins have been recognized as a great idea but have not yet gained widespread adoption. They have not been developed to such an extent that they can easily encompass all the abstract layers of complex systems. However, in the future, developers/solvers will increasingly approach this issue comprehensively. Standardization will support the process of implementing digital twin technology [36].

Once again, it should be emphasized that the modern semiconductor industry is moving towards increasingly configurable systems. In this context, digital twins are the best way to accelerate and reduce the costs of design, testing, and production processes. At this stage, special attention should be given to the application of hybrid human-machine intelligence in order to leverage developed creative algorithms and methods for designing configurable cognitive architectures that operate autonomously without human intervention in decision-making processes.

The set of abstractions proposed above, which includes noon-models of switching elements, patterns, modules, and factories of switching structures, provides an accurate representation of the interactions within the considered system. It allows for the consideration or exclusion of details that are not necessary for the specific digital twin research. By combining (*2D, 3D,…nD*) noon-models of switching patterns based on *SEB-1*, *SEB-2*, noon-models of modules based on *SEB-1*, *SEB-2*, as well as noon-models of factories into a unified system, a new entity is obtained - the digital twin (*DT*). This digital twin comprehensively describes the product and provides a systematic approach to the development of new intelligent-heuristic switching structures for cognitive infrastructures in Fig.15.

Noon-models of patterns on *SEB-1*, *SEB-2* are computer models that describe the behavior of products of switching structures with a high degree of adequacy at various stages of the product life cycle. Digital twins are noon-models of potentially possible situations of physical entities, implemented using specialized *IT* infrastructure software. They involve a large volume of available data, and therefore convenient methods of working with them are required.

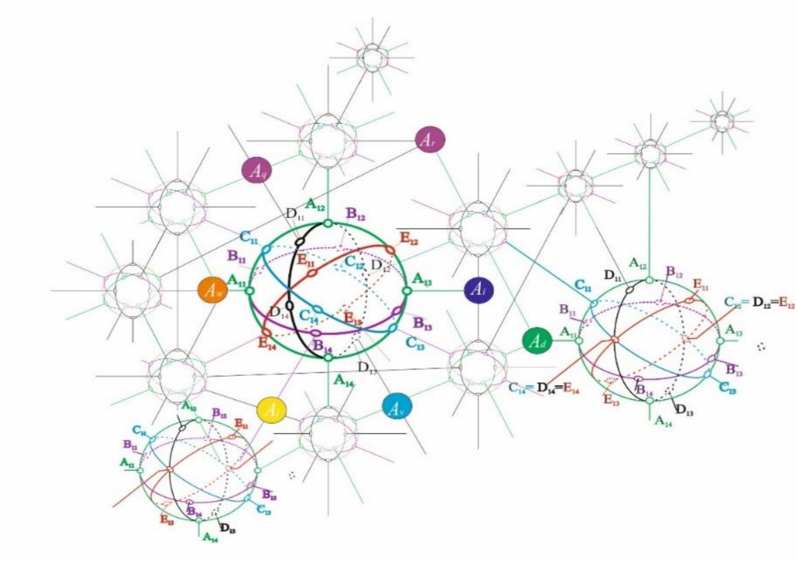


Figure 15. The Noon-model of an intelligent-heuristic *SS* based on *SEB* patterns.

One of such directions can be considered as connectionism, whose main ideas are related to modeling cognitive structures. Information is represented in noon-models of patterns on *SEB*, which interact with each other, combined in *nD* cognitive structures within the chosen coordinate system or space in Fig.16.

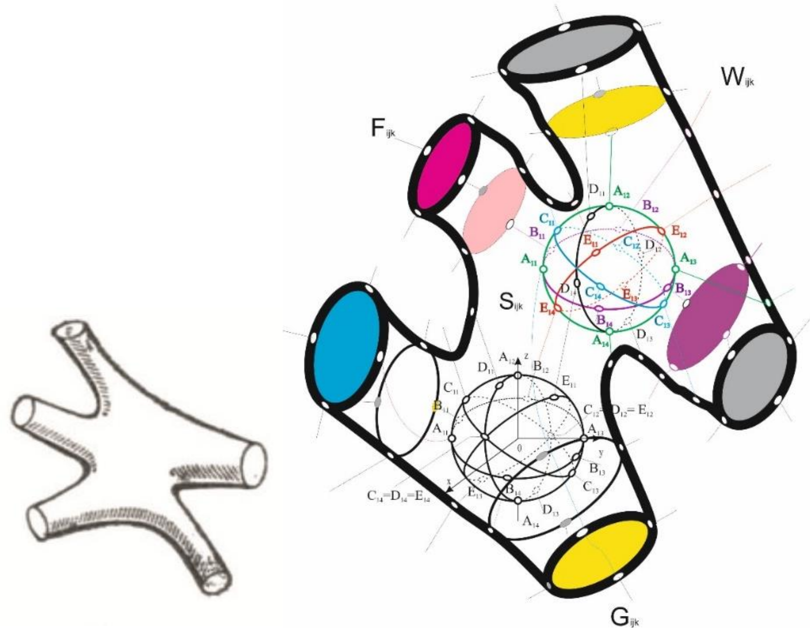


Figure 16. The intelligent-heuristic noon-model of the imagery module in a *SS* is based on *3D* noon-models of patterns on SEB with a metric $p \geq 1$, implemented for a specific task, taking into account the characteristics of the given space or coordinate system.

Noon-models of patterns on *SEB* are required for ontology reengineering (transformation) and alignment (mapping) purposes. The first group of noon-models of patterns on *SEB* is applied when constructing a new ontology (where the initial model may not necessarily be ontological). The second group is used to establish correspondences between concepts and individuals in two ontology's, ensuring interoperability without modifying existing models. Creativity is a critically important variable in the process of creating implementations of *nD* switching structures (*SS)* based on knowledge. From the perspective of cognitive semantics, visual representation is essential as it forms mental images that, in turn, contribute to understanding and reduce cognitive complexity when working with abstract concepts.

About the big data problem. Over the past three decades, there has been an unprecedented expansion of research in the field of computer modeling of discrete geometric-topological structures. Computers and cognitive structures of the new era differ from existing ones in several key aspects. In current computers, the focus is on processes and processors, while in the new ones, it is on data in Fig.17. The new architectures process symbolic and graphical data, analyze them, adapt to them, and propose data-driven solutions. They do not replace humans but rather enhance their capabilities by taking over the routine task of data processing, allowing humans to draw conclusions and make decisions.

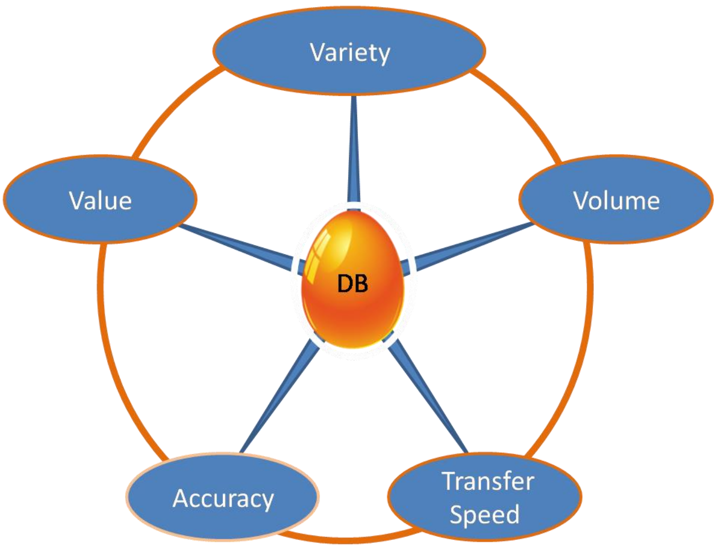


Figure 17. Main Features of Big Data (DB).

The use of *SEB* pattern noon-models allows us to transform data about switching structures into information. Big data enables us to manage a powerful flow of information about infrastructure and interpret it for the development of cognitive science, which is particularly relevant for the development of intelligent strategies or making important decisions. The quality and accessibility of scientific network content have become as important as direct interaction between designers/solvers. The substantive content and accessibility of electronic information resources and knowledge presented in national network infrastructures (in the native language) have become a key factor in the scientific, educational, industrial, and other capabilities of countries.

Today's computer system architectures, such as *A3* (supercomputer) with a *GPU*-to-*GPU* data transfer interface implemented at an industrial level for the first time and a total cloud cluster performance of up to 26 exaflops, far surpass the record of the fastest supercomputer, Frontier. The *GPU*-to-*GPU* interface, also known as an infrastructure processing unit (*IPU*), allows for data exchange between graphics processors at a speed of 200 *Gbps*.) [36].

As mentioned above, an ontology can serve as the framework for a knowledge base, providing a basis for describing the fundamental concepts of a specific domain and serving as a foundation for integrating databases that contain factual knowledge necessary for the full functioning of a cognitive system. Furthermore, ontologies can describe expert rules, enhancing their level of description and "understandability" for users [32].

Biologically inspired modeling sometimes adopts a more decentralized bottom-up approach. Bioinspired methods often involve determining a set of simple, common rules or a set of simple nodes whose interactions give rise to emergent behavior.

Let's consider the pyramid (*SOMKW*) in our perception in Fig.18: **S**tructured data - **O**ntologies - **M**odules/Factories (digital twins) - **K**nowledge – **W**isdom:

1. Structured data: data that has been processed in a way that it is now relevant to a specific purpose or context and, therefore, is considered meaningful, valuable, useful, and up-to-date.

2. Ontologies of *SEB-1* and *SEB-2* switching pattern noon-models, where r≠0.

3. Modules, factories (digital twins) of switching structures and their noon models.

4. Knowledge: a combination of formed experience, values, contextual information, expert judgments, and reasoned intuition that provides an environment (a variety of infrastructures) and a basis for evaluation, incorporation of new experiences and information (emerges and applies in knowledgeable minds). Development of new varieties of facets and digital twins.

5. Wisdom: the possession and use of broad practical knowledge and understanding of what needs to be done (designing cognitive = intelligent-heuristic - "living" infrastructures).

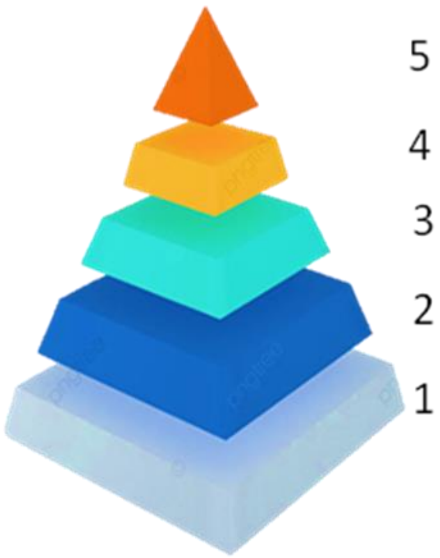


Figure 18. SOMKW pyramid

New knowledge will contribute to further refinement of the comprehensive theory of cognition, and the developed noon-models pattern, modules, and digital twins can coexist with traditional ones, complementing them and serving as a valuable component of artificial intelligence implementation programs.

Hybrid models, which combine the strengths of traditional cognitive-oriented and connectionist models, are gaining increasing popularity. They offer undeniable advantages in studying signal or pattern recognition processes.

From a connectionist perspective, the use of noon-models of *nD SEB*-based switching structures— switching patterns by Berezovsky—can fundamentally change the situation with the challenges of *3D* modeling of new intelligent and heuristic infrastructures [31].

Connectionist intelligent-heuristic noon models bring us closer to the theory of "living" systems by allowing us to predict their behavior and explore the possibilities of control and reconfiguration. They provide insights into the dynamics of complex systems and enable us to study their adaptive capabilities and emergent properties. These models capture the interconnectedness and interdependence of components within a system, leading to a deeper understanding of its functioning and the potential for effective management and reconfiguration in Fig.19.

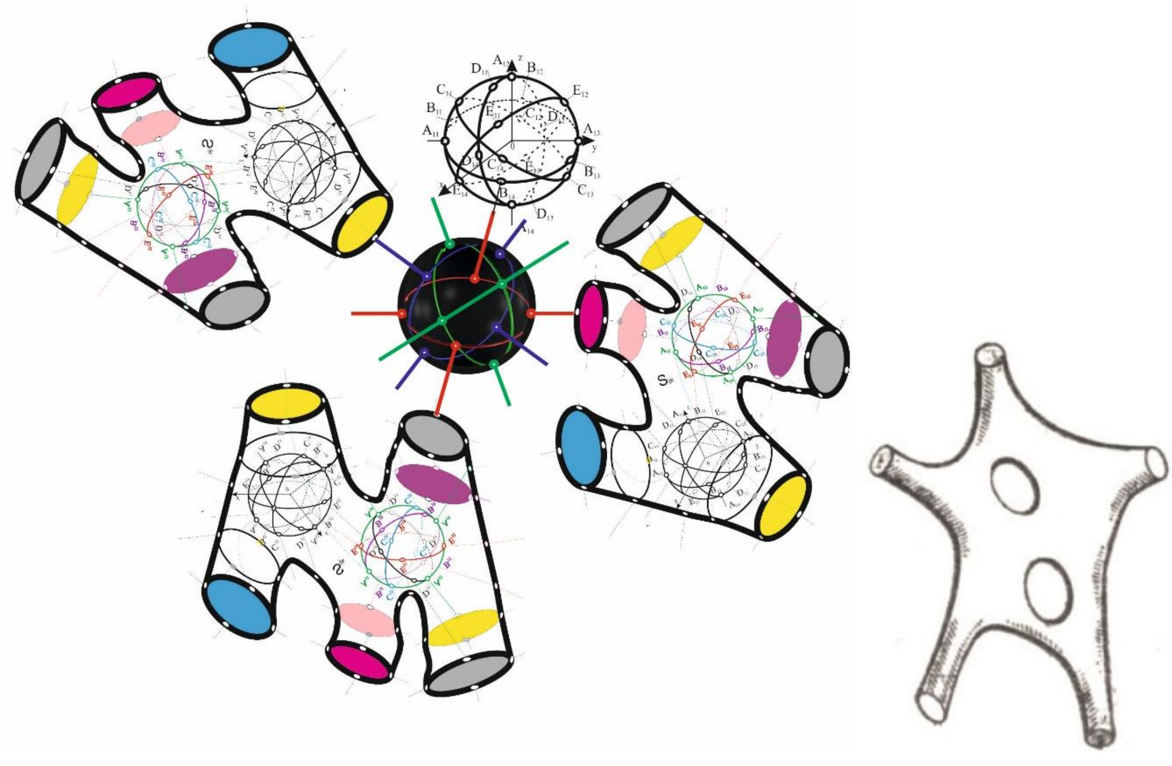


Figure 19. Intellectual-heuristic noon-model of "living" figurative SS module on *3D* noon-models of patterns on *SEB* with metric $p \geq 1$ united in *SS* in the chosen coordinate system *nD*.

The connectionist noon-model of a switching structure (*SS*) using patterns on *SEB* is a creative solution that combines the sub symbolic and symbolic levels. In turn, subsystems can consist of lower-level structural units. By combining disparate concepts, new ways of implementing *nD SS* can emerge within a chosen coordinate system or space.

The connectionist approach using *SS* noon-models with patterns on *SEB* involves describing mental phenomena through interconnected networks (*SS*) of simple and often homogeneous units. The form of connections and nodes can vary from model to model. This allows for the creation of realistic images, shapes, and architectures capable of immersing you directly into the captivating world of intelligent-heuristic exploration.

Architectures encompass proposals for organizing the ontology as a whole, including structures such as taxonomy and modular containerization forms. Cognitive architecture serves as the foundation for intelligent agents. It offers artificial computational processes that act as specific cognitive systems, akin to human cognition, or act rationally according to some definition. Cognitive architectures form a subset of general agent architectures. The term "architecture" implies an approach that seeks to model not only the behavior but also the structural properties of the modeled system. Such an approach allows the researcher/developer to be directly involved in the process of developing/modeling new intelligent-heuristic cognitive architectures.

About the problem of containerization.

The paradigm shift necessitates a new era of addressing the issues of packaging/compactization of developed *AI*, *SS*, and *IA* structures, but now in a *3D* space with curvature ($k \neq 0$). Modern cutting-edge semiconductor products can only exist due to significant advancements in packaging/containerization. At the recent *SEMI-2022* (*ISS*) symposium on industry strategy, the importance of more sophisticated constructions in the coming decades was a relevant topic.

Thus, the direction of solving the problem is defined: chiplets, which are microchips, forming a larger and more complex microchip (e.g., a central or graphics processor), should have a standardized interconnect structure to work collaboratively with similar components [37]. The new universal standard for designing and implementing chiplet interconnects, known as Universal Chiplet Interconnect Express (*UCIe*), represents a significant step forward for heterogeneous integration and the creation of a new market for semiconductor microchips. Heterogeneously integrated components rely on a structure called an interposer to provide electrical connections between the chips and components within the package. These structures are similar to printed circuit boards in the sense that they provide a foundation for connecting multiple components within a single package. From a design perspective, the interposer offers much more freedom compared to a printed circuit board. While interposers offer designers some flexibility in how they arrange and connect *2.5D* and *3D* integrated components, there are limitations to what can be done with an interposer. Design tools for microchips and printed circuit boards cannot fully automate the important tasks of interposer design, partly because this field continues to see ongoing innovations, and interposer structures are not fully standardized [38]. Other solutions to the containerization problem include *3-DMS* (*3D* Multilayer System) technologies, which encompass high-density hybrid integrated circuits (*3D-HIC*), three-dimensional circuits on molded interconnect devices (*3D-MID*), high-density printed circuit boards with embedded flexible-rigid components, and various other technologies [39].

The proposed/developed concepts will form the basis of next-generation electronics manufacturing technologies that are fundamentally different in their design and characteristics. This will allow for the utilization of three-dimensional space, simplification of product design (form), and reduction in size and weight, enabling highly flexible design capabilities. Additionally, developers of associative agents/components for cognitive systems require a conceptual framework to ensure interaction.

Modern architectures of cognitive systems allow combining immense computational power with innovative data processing methods resembling cognitive processes in the brains of biological entities. Bio-inspired modeling, derived from biologically inspired computations, is a research direction that we consider as a component of connectionism, aimed at addressing informatics problems using biological models.

It is easy to point out shortcomings, but where can one find or who will propose/offer a new paradigm for the further development of artificial intelligence-based intelligent systems in Fig. 20.

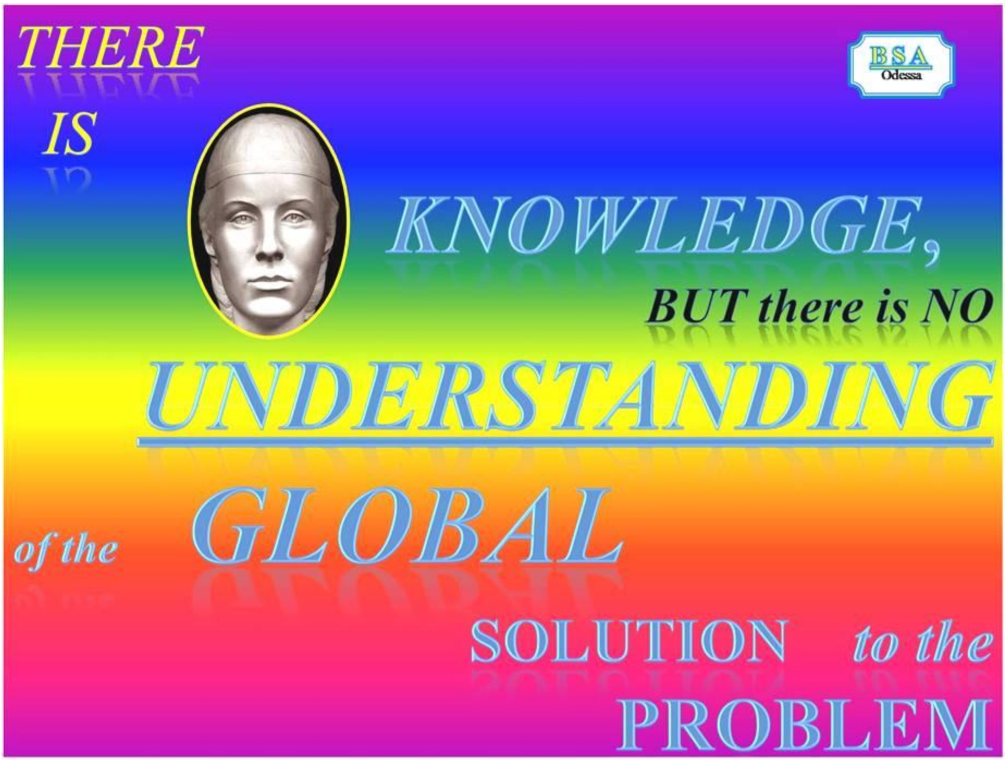


Figure 20. There is knowledge, but there is no understanding of the global solution to the problem.

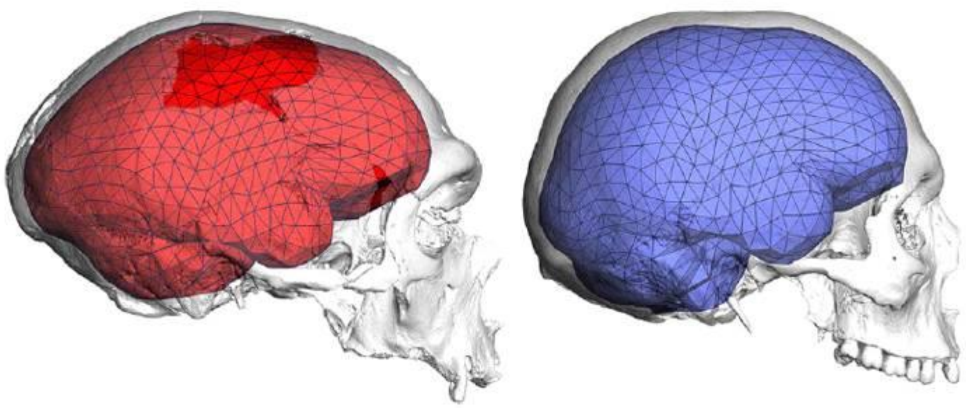
Computer science and cognitive anthropology are still weakly connected, but with the emergence of new connectionist models, we can expect similar models of culturally specific cognitive features. Only the Demiurge ($\check{D}$) is capable of seeing things as they are, from a fully objective point of view, free from time and space.

The Creator endowed intelligence not only to rational humans but also to other human species that coexisted with our ancestors in the past. Science is aware of several types of "other humans," but the most interesting and well-studied branch is Neanderthals (Homo neanderthalensis), who lived in Europe and partially in Western Asia from 28000 to 130000 years ago [40].

Neanderthals did not fundamentally lag behind Homo sapiens in any aspect, and the brain size of both species was around 1.5 kilograms. The brain size exceeded this parameter in "other humans," but like in other species, it was "housed" or containerized within the cranial cavity [41].

Based on the information that "humans are far from alone in lacking an ancestor," let us speculate: The Demiurge (***Ď***) created a "container/storage" for the cognitive environment of Homo in the form of a cranial cavity, "in his own image and likeness," and introduced divergence in the size and shape of cranial cavities among other closely related species (the problem of volumetric brain containerization). This allowed evolution to solve the problem of selection. In adult individuals of Homo neanderthalensis and Homo sapiens–two species of humans – the shape of the brain significantly differs. In an article by French and German anthropologists published in the journal Current Biology, it is noted that in terms of volume, the brains of the two human species were practically the same, but their shapes noticeably differed: the sapiens had a more rounded brain, while the Neanderthals had an elongated one. The features of the container/storage - the human skull - have long attracted the attention of researchers. Its structure and shape are truly unique.

The brain itself is rarely preserved in a fossilized state, but information about its size, shape, and partially its structure (relative development of different regions) can be inferred from the endocranial cast - a mold of the inner surface of the cranial cavity in Fig. 21.



Photos from open sources

Figure 21. The brain of a modern human (left) and a Neanderthal from La Chapelle-aux-Seine.

The endocast (from "endo" meaning "inside" and the Ancient Greek "kranion" meaning "skull") is the relief or imprint on the inner surface of the cranial cavity, which reflects the pattern of major grooves and convolutions of the brain and, in some cases, large blood vessels. The term is also used to refer to the cast or mold of the inner surface of the cranial cavity. Endocasts serve as the only source for estimating the volume and structure of the brain. They allow for the reconstruction of the surface relief of the brain and the pattern of the largest blood vessels [42].

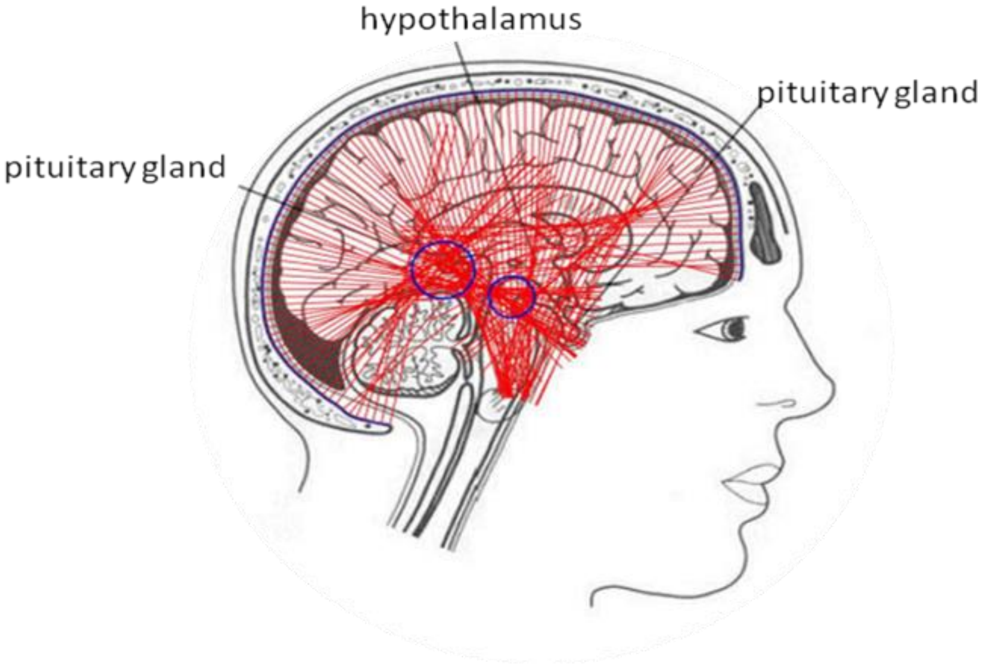
The methodology of mathematically describing the shape of the brain is based on the analysis of the mutual arrangement of *N* "reference points" that can be found on the endocasts of hominins. This methodology allows for comparing the shape of endocasts across different species, abstracting from the absolute brain size. The result of the research led to the conclusion that the key difference in brain shape is determined by the "globularization" (rounding) in modern humans, achieved through the accelerated growth of the parietal and temporal regions, as well as the cerebellum. As a result, the human skull takes on a characteristic convex, dome-like shape. During the process of "globularization," a promising dome-shaped model of the skull (containerization) formed, which is associated with significant functional changes in the brain, such as the complexity of sensory integration mechanisms and the formation of imaginary models of the surrounding world. As it is known, Neanderthals were at a disadvantage in direct competition with Homo sapiens in Europe, and it is possible to hypothesize that the world models created by the sapiens' brain were more practical.

Furthermore, "attention should be paid to the structure (shape) of the human skull from the inside and the adjacent tissues. The frontal, parietal, and occipital bones deserve special attention due to their unique relief. They represent a biological prototype of concave mirrors capable of focusing, absorbing, and reflecting waves of different frequencies. This structure serves as a good resonator (from the Latin word 'resono' - 'to resound', 'to respond'), meaning it can accumulate and focus the energy of oscillations and amplify it [43]. In physic, it is known that concave mirrors can focus various types of radiation (energy), including those emitted by biological objects. The complex interaction between a human and a concave mirror, often referred to as "Kozyrev mirrors," can have interesting effects [44].

Mirrors have directional patterns and are used in radio technology as receiving and transmitting antennas. Another characteristic of the human brain is that it continues to emit measurable electrical wave signals for 37 hours after death. In fact, it functions as a radio transmitter [45]. It is evident that the skull serves not only protective functions (including containment) for the brain but also participates in other processes of information exchange in Fig.22 [46].

Figure 22. The human brain is susceptible to electromagnetic signals

The year 1980 marked the invention of functional magnetic resonance imaging (fMRI). The fMRI images of the brain allowed for the initial analysis of the unique structure of the human skull and the formation of ideas for the development of neural networks.It should be noted that these research results were obtained through the same planar analysis mentioned earlier—two-dimensional "slices" of the skull (question: how to perform the analysis of *3D* skull models?). The researchers constructed normals to the inner surface of the skull (represented by the blue line in the figure) in Fig.23. The intersection of these normals formed certain intersecting regions, coinciding with the location of the pineal gland (epiphysis). This fact provides a basis for further in-depth study of this phenomenon, considering the peculiarities of the pineal gland and its significance.

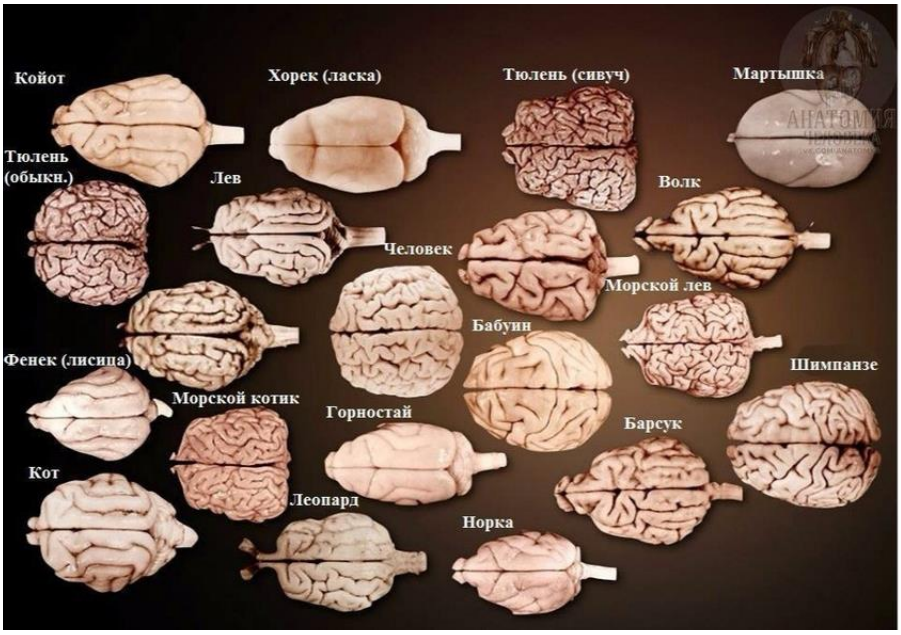


Photos from open sources

Figure 23. Intersections of the normal's of the inner surface of the skull.

In ancient India (around two thousand years BC), there was a flourishing of teachings about the pineal gland. Even back then, it was known that this gland is not only associated with clairvoyance and the memory of past incarnations but also serves as the primary chakra for the concentration of higher energies [47].

The modern structure of the Homo skull, characterized by its domed shape (due to "globularization"), makes it a unique biological construction that contains and protects the brain, enabling the successful life strategy of Homo. Furthermore, it serves as the infrastructure for cognitive agents that perform the functions of the Homo mind, while also facilitating the interaction with waves of different frequencies in the surrounding environment (i.e., a "globularized" structure with non-zero curvature).In nature, thanks to the Demiurge, there are over two million species of biological entities with a diversity of brain types that have successful life strategies, all adaptively containerized in Fig.24 [48].



Photos from open sources

Figure 24. Brain of various animals and human for comparison.

The Demiurge ($\check{D}$) guides researchers to explore the creative possibilities of utilizing the existing diversity of brain containerization forms in the biological world to overcome the limitations of the outdated flat paradigm (with zero curvature) of containerizing technical constructions and products in the fields of computer and electronic engineering. This exploration aims to create new intellectually heuristic cognitive structures.

The capabilities of the human brain (brain functions) include processing sensory information from the sense organs, planning, decision-making, coordination, motor control, emotions, attention, and memory. The human brain performs higher mental functions, including thinking [49].

However, the human brain is incapable of true intellectual multitasking. Most people believe they can perform two or more tasks simultaneously, but it turns out that multitasking is actually impossible for the human mind. What we do is called context switching - rapidly switching between different actions, rather than performing them simultaneously (nerve impulses travel at a speed of 270 km/h). By the way, human memory is reconstructive [50].

The development of *SS* is an integral part of the overall process of scientific advancement and is closely interconnected with almost all processes occurring in science, technology, industry, and other areas of human activity. The study, design, and control of the diverse range of *SS* implementation solutions require interdisciplinary efforts that bring together computer science, robotics, engineering on one hand, and behaviorism, cognitivism, neurobiology, and computational technologies on the other. None of these disciplines alone possesses the theoretical and practical framework sufficient for a comprehensive understanding and resolution of the cognitive capabilities of SS.

At the same time, specific questions and topics are primarily associated with one of these disciplines, which describes distributed parallel data processing, continuous configuration of *SS* during perception and learning, testing, etc. However, these *SS* are also n-dimensional, and their potential "states" represent collective patterns of interconnectivity that they can self-organize [51].

Improving the connectionist capabilities of *SS* contributes to accelerating the processes of search, "mutations," and selection of new solutions, inventions, and innovative ideas, which, in turn, become the foundation for "revolutions" and the modernization of cognitive architectures and their forms of packaging/containerization as a whole.

Long before the industrial era, knowledge and cognitive abilities were embedded by masters into their creations in the form of their shape (cynically - packaging/containerization). For example, the astonishing beauty of ancient sculptures or their functionality as tools (such as violins) served as vessels for knowledge and cognitive expression, even in the realm of labor.

During the course of evolutionary development, the volumes of transmitted information, types of representation, methods of transmission and storage, the number of sources and consumers, and requirements for speed, reliability, and quality change. The era of silicon technologies, which was formed during the period of the 3rd industrial revolution, and its specific feature of "flat" models in Euclidean space with zero curvature, have resulted in a certain stagnation among developers/mathematicians in terms of developing/modeling new 3D/spatial models (containerization forms) of semiconductor electronic products. These products are interconnected through a spatial switching environment/architecture (high-speed network, switch, etc.). It should be emphasized once again that all achievements have been predominantly realized through the application of electronic components based on silicon materials. Over time, the specifics of silicon technologies have presented their own surprises, particularly related to planar technologies.

From the perspective of connectionism, mathematicians/solvers are encouraged to explore the understanding of three-dimensional manifold forms by combining geometry and topology. In mathematics, manifolds often arise not as explicit objects in space but indirectly: as solution spaces under certain conditions or as parameter spaces for a system of mathematical objects. And where possible, our spatial imagination helps to comprehend the abstract description of three-dimensional manifolds.

The manifolds surrounding us are diverse. As inhabitants of a three-dimensional world, we are most familiar with two-dimensional manifolds: the surface of a sphere, a bagel; the wall of a house, the surface of a tree, or a volleyball net... At first glance, three-dimensional manifolds may seem more challenging to perceive. However, since we, as Homo, are three-dimensional beings, our spatial imagination aids in understanding the abstract description of three-dimensional manifolds, allowing us to perceive them as alternative worlds.

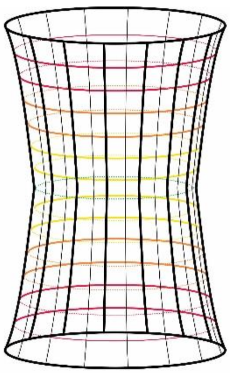
Ď has "hinted" to researchers the possibilities of search/development, as well as the utilization of alternative solutions based on new physical foundations.

The presented diversity in the biological world of forms/species, in the context of brain containerization, prompts a revolutionary solution: the introduction of a new definition - "fasce" - to represent the manifold of containerization forms for new creative scientific, technical solutions, and the synthesis of connectionist *nD* models of cognitive supersystems/architectures/infrastructures in an a priori space with a chosen coordinate system.

This solution provides researchers with possibilities for exploration, development, and utilization of alternative approaches and new physical foundations. It encourages the exploration of diverse forms and shapes in the biological realm, which serve as containers for the brain. The introduction of the concept of "fasce" enables the representation of the manifold of containerization forms for innovative scientific and technical solutions, as well as the synthesis of connectionist *nD* models of cognitive supersystems/architectures/infrastructures within a predefined space with a selected coordinate system.

The forms of fasciae in connectionist models of switching structures will evolve in parallel with the functional capabilities of the structures themselves during their evolution. Specifically, the process will involve the search and development of alternative solutions based on new physical foundations, the enhancement of configurability, *nD* capabilities, and more. Subsequently, the focus will shift to those fasciae that are analogous to higher cognitive functions associated with adaptability, such as self-diagnosis, reconfiguration, and consideration of the specific characteristics of the a priori space or coordinate system.

Fasciae provide developers with a new field of creativity, offering a variety of graphical *nD* manifold models of intellectually heuristic cognitive architectures, taking into account the peculiarities of the a priori space or coordinate system. They also offer new images/models for technologists to transform creative solutions into reality in Fig.25.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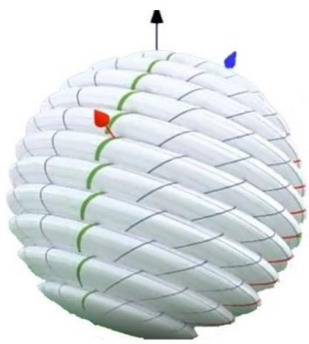
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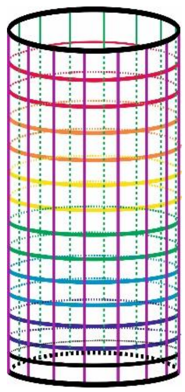
$k=0$

Figure 25. Fascia of connectionist noon models of *SS* with a priori curvature: negative curvature ($k<0$), positive curvature ($k>0$), and zero curvature ($k=0$).

Today, there is a high demand for solvers/developers with a broad scientific background, capable of integrating knowledge from related disciplines, creating conceptual systems, and skillfully interpreting, structuring, and analyzing data.

In particular, the design and engineering of cognitive structures' commutative devices involve implementing the results of circuit design into specific geometric forms and spatial arrangements. It should be noted that mathematics is much more fragmented than physics; mathematicians specializing in one area typically work independently from mathematicians specializing in another.

The recent achievements of Fields Medal laureates in the field of representing three-dimensional manifolds through the fusion of geometry and topology open up significant possibilities for applying manifolds in the development of connectionist *nD* noon-models of cognitive infocommunication systems of various types of operation: analog, digital, and combined (analog-digital), as well as in computing devices implemented on other principles (mechanical, biological, optical, and other methods).

The human mind forever retains the ability to invent logically consistent structures that cannot be expressed through a physical principle.

The great digitization of civilization has led us away from the main direction of development - analog technologies, and the question of paradigm shift and the return of civilization to the main branch of progressive development - analog, becomes relevant. Conducting research on the application of new technologies in *Li* (light) - the second basic range of wavelengths "gifted" by the Demiurge, as well as changing the basic numeral system of computer technology, are emerging topics of interest.

In conclusion of the presented material of the article, it can be noted.

Currently, there are parallel processes taking place worldwide, involving the activation of research in the fields of artificial intelligence theory, cognitive industrial networks, intelligent industrial automation, and the formation of the fourth industrial revolution. One particular feature of this revolution is the transfer of cognitive functions, previously exclusive to Homo sapiens, to industrial infrastructure and industrial products.

The discussed questions of forming connectionist noon-mon models of patterns on *SEB* to represent modules, factories, digital twins of switching structures on *SEB*, connectionist intelligent-heuristic infrastructures based on the manifold of hyper-space with non-zero curvature values (k≠0), and the manifold of "living" models of biological ecosystems provide the opportunity for an intellectualized (clarative-creative) interaction between human decision-makers and information. This interaction is facilitated through the utilization of machine-activated (computer-activated) cognitive processes.

The introduction of a new definition - "fascia" - will assist designers in reaching the next level of development and analysis, enabling them to improve their designs. The entire ecosystem of semiconductor devices will benefit from the data, aiding in solving design, performance, and miniaturization challenges.

Furthermore, the presented information is of interest to developers/mathematicians in terms of developing/creating manifold volumetric/spatial architectures and object-oriented modeling. It can be utilized for conceptual development to obtain essential knowledge related to the technical activities of switching structures. It can also be used for creating information and software design tools for cognitive structures of switching structures, including achieving necessary anthropotechnical characteristics.

The information presented above represents new knowledge for specialists/designers of new topologies of switching structures, *CAD* systems based on the *SDN* paradigm for *DIA* (Data, Information, and Analytics), *AI* systems, modern heterogeneous telecommunication switching structures. It provides situational information on synthesis, control, analysis, and operation procedures of switching structures and is used for information visualization as an element of cognitive graphics. It encompasses the composition, topology, choice of dimensional representation spaces (*2D, 3D, ...nD*).

Connectionist intelligent-heuristic noon-models promise a completely new apparatus for cognition. Such "living-type" system models serve as the basis for building future universal connectionist noon-models (based on a common metadesign language) intended to replace traditional book models in modern science.