# Visual event-situational approach for information preparation of decisions and operational technological management of complex dynamic objects

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***Abstract*—Operational work with the image of an object not directly perceived is a difficult task for the operator. The mapping methods used are not relevant to the mental image; they prevent the operator from performing actions in the mind and contribute to data interpretation errors. It is supposed to change the state of affairs using the visual event-situational subject-oriented approach, which consists in computer simulation of a multi-structural, multi-layered by concreteness and clarity display. In this approach, the subject action is considered as an ordered sequence of two-step transformations by the subject of a deformable, limited amount of mixed perceptual and subject-schematic information about the situations and state of the object, in the form of a reasonable, regulatory impact on it. The result of the implementation of this approach should be a new class of artificial intelligent systems, namely cognitive hybrid intelligent systems.**

***Keywords*—visual event-situational approach, management of complex dynamic objects, cognitive hybrid intelligent systems**

## I. Introduction

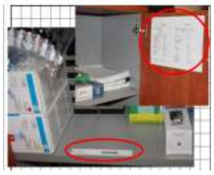
Management in a dynamic environment is associated with heterogeneity and state of distribution in the space of the problems being solved or the systems being developed. The decisions are interconnected and impose restrictions on each other, making it impossible to correct an erroneous decision in the future, since even a small initial error rapidly increases over time. The processing of heterogeneous information through the integration of expert knowledge has been investigated in the researches on hybrid intelligent systems (HIS), synthesizing a method for solving a complex problem over a heterogeneous model field.

However, traditional HIS [1], [2] do not involve the operator's right-sided, visual-imaginative reasoning, complicating the operational work with an object that is not directly perceived, forcing him to think logically instead of providing intuitive decision-making. It is proposed to overcome this drawback by obtaining new knowledge about operational-technological, human-machine management of complex, dynamic systems, developing a visual event-situational subject-oriented approach of information preparation of solutions and operational technological management of complex dynamic objects and its implementation in a new class of artificial intelligent systems, namely cognitive hybrid intelligent systems. Visualization of spatial-temporal relations of resources and actions for expressing the semantics of the state of a complex system, introduction of the psychologically justified heuristics of the functional system of subject action and dynamic operational image in the supporting solutions will return the subject of operational activities to the space of meanings, the space of things, properties and relations. It will promote the connection of the sensual and the rational, the individual and the universal; make out the ideas emerging from him; show the structure and dynamics of changes in the operational image; help to follow the movement of thought, fix it, facilitate mental activity, establishing cause-effect and functional relationships; significantly reduce the time to solve operational tasks, reduce the risk of errors; qualitatively improve the system of artificial intelligence.

## II. Visual management and control

It is believed that visual management was born in the concept of Taichi Ono [3], who is the author of lean manufacturing, the core of the Toyota system (Japan). Visual management is a clear, simple and effective way to organize work and report on it, so that everyone can see the work of everyone, and the organization becomes "transparent" [4], a process that provides the human factor with simple visual signals to immediately respond to new terms and conditions.


(a)



(b)

(c)

Figure 1. Examples of visualization: (a) problem solving board in the tradition of “gemba” at GAZPROMNEFT-SNABZHENIYe LLC; (b) visualization at the office of the Atomic Energy State Corporation Rosatom; (c) an example of the visualization of the entrance group in the workshop, signs of harmful substances and noise exposure

One of them is gemba from Japanese management practice that is the controlling “walk” of decision makers to workplaces to inspect and evaluate what is happening. Visual control is an effective and self-regulating factor in the measurement of visual signals: plans, unfinished tasks, inventory, resource consumption, and quality [5]. The objectives of visualization of control are to see problems and understand situations in the workplace and to see the decisions, clarify actions to achieve goals. The methods of visual control are key indicators, photos and markup (Fig. 1).

Another approach to the visual management has been adopted in information, situational and dispatch centers that are designed for deep immersion in the process, setting up constructive communications, prompt response to key events and organizing a multi-level problem solving system (Fig. 2) [6]. Morning, ten-minute “volatiles” are sufficient to obtain operational strategic information, which allows to see priorities, identify deviations, and outline actions to correct the situation. A huge amount of data, previously scattered, is collected, systematized and presented in a convenient for perception, digitized form: graphs, charts, diagrams and tables.

Two approaches to centralized visual control are known namely event and situation description of control objects in complex systems.

## III. Event and Situational Management

L. Wittgenstein held an event-based view at the level of logical, linguistic systems: “The world is a totality of facts, not objects ... Progressive, the fact is the existence of events” [9]. Hence, the control object is considered as a stream of events through the set of which things are determined. If all the events in which the object participated are recorded, then we will get its full description, not an abstract, but a concrete and comprehensive description of how the object “looks” for a particular system, what properties, at what moments it has and how it participates in the functioning of the system.

(a)

(b)

Figure 2. Examples of visual management information centers: (a) complex solution of the company POISK [7]: mnemonic scheme, plastic appliqué, LCD panels; (b) S - 2000 dispatch board, built-in video cubes of NTK Interface LLC [8]

Event management is based on the event description of complex systems, which is the process responsible for managing events during the life cycle, the main activity of operational management. Event is a change in the state, which is important for the management of objects and their relations. To be effective, operational management must know the state of the control object and its elements, as well as track any deviations from the norm. Event management is a proactive and systematic approach aimed at predicting problems, anticipating threats, minimizing surprises, making decisions on emerging issues. According to M. Lauzen, effective event management requires two-way communication, a clear formal monitoring of the environment and active, meaningful strategies [10]. According to J. and V. Coates, event management is an organized activity to identify emerging trends, troublesome or controversial issues that may affect the organization over the next few years, and to develop a wider and more positive response range of organizations in relation to the future [11]. The order of event management is following: detection, filtering, prioritization, correlation, determination of the response method.

The entity approach, entity thinking is traditional for the modern man, for whom the description of the world as a multitude of spatially localized objects-entities-resources is peculiar. Things are predetermined. The relationship of objects is described through relations. Modern methods of describing or modeling complex systems adhere to the entity ontology: at first decomposition and selection of objects, then their classification, with attributing properties to objects and establishing relations between them (“part-whole”, “gender-type”, “depends”, etc.). A.I. Uyomov [12] held an entity-based view at the level of logical, linguistic systems, who expressed own world view through the “entity-property-relation" triad, which was adapted by A.V. Kolesnikov, I.A. Kirikov and

V.F. Ponomarev [13] to the “resource-property-action" triad in relation to the operating activities of dispatchers in complex systems.

Situational approach is based on the entity thinking. In the 20s of the last century, M. Follett spoke about the “law of the situation”. She noted that “different situations require different types of knowledge” and different responses. A fully situational approach was developed in the late 60s. The entity approach to the ontology of the world was reflected in the situational approach, it was formed in the USA in the late 1960s. Representatives are F. Kast [14], H. Koontz [15], P. Lawrence, J. Lorsch [16], J. Thompson [17], etc. The term “situation management” was formed in the 60s of the last century, when Soviet scientists Yu.I. Klykov and D.A. Pospelov [18] introduced this concept. It appeared due to the development and application of logical-linguistic models to the management practice, when situations were described in the language of qualitative concepts and relations, and the means of mathematical logic were used to organize symbolic transformations from the initial situation to the target one.

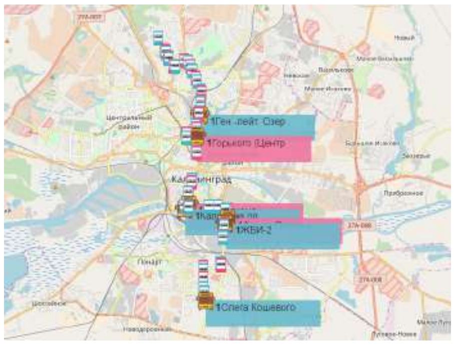
To develop a visual event-situational subject-oriented approach, it is proposed to develop the concept of relational, symbolic-logical language for describing the state and situations of the control object proposed by A.V. Kolesnikov and V.F. Ponomarev [1] on the basis of the situational approach and the entity view of A.I. Uymov [12].

## IV. Constructing of visual-symbolic statements about the position of resources (resource-based situation, r-situation)

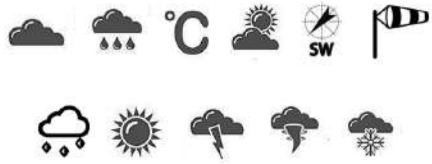
Definition 1. R-situation (resource-based situation) is a set of spatial relations on resources used in production operations at a given point in time and in the context of the spatial structure of the control object.

Position is a characteristic of the spatial relationship of one of the object’s elements to other elements within a certain area. Graphically the position is usually shown in a diagram of related elements, for example, in a street and neighborhood map. The position is interpreted as “resource-based situation” or “r-situation”. In Fig. 3(a) graphic statements about the position of resources (about the r-situations) are shown by means of the graphic interface of the online service “Bus Time” in Kaliningrad (www.bustime.ru).

Monitoring of weather conditions (weather r-situation) that are graphical statements about the weather r-situation can be performed by pictograms (Fig. 3(b)) according to data widely presented by meteosites on the Internet in two aspects: current weather conditions and forecast of weather conditions on the required number days. The symbolization and the schematization of resource-based situations as applied to sectioned power grids should visually express the correlation of variability and constancy, which requires displaying the position as a characteristic of the spatial relation of one of the resources (dynamic) to other resources (static) within some area (also static resource) at some point in time. So, we interpret three components of the p-situation: 1) a dynamic resource; 2) a group of static resources; 3) an area of establishing spatial relations “resource-resource" between the first and second resources. The dynamic resource is electricity, characterized by three main parameters: voltage (volts), amperage (amperes) and power (watts). It is the object of the operation “transmission” over a distance within the “resource-action” relation. Static resources are the power grids, their devices and installations, i.e. the means of electricity transmission that are characterized by the main parameter - transmission capacity. They are the means of transmission of electric energy over a distance within “resource-action" relation. In general case, a power transmission line should be considered as an object with parameters distributed along one spatial coordinate (along a line). One of the main indicators of power transmission is the transmission power, i.e. the amount of energy transmitted per unit of time. The transmission capacity is the highest power that, given all technical limitations, could be transmitted through the line. For example, for a 110 kV line, the capacity is 30 MW. Power grids are characterized by a number of indicators, which primarily include the magnitude of the transmitted power, nominal




(a)




(b)

Figure 3. Graphic statements: (a) about the situation (r-situation) in the online service “Bus Time” (www.bustime.ru) in Kaliningrad; (b) icons for monitoring weather conditions (left - right, top - down): cloudy, rain, temperature, partly cloudy, wind direction, wind force, freezing rain, clear, thunderstorm, tornado, snow

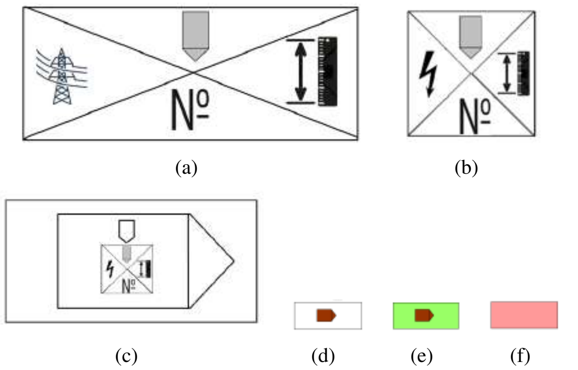



Figure 4. Graphic statements: (a) about the resource “section of the overhead power line”; (b) about the resource “electricity”; (c) about the role-based visual relation “resource-action”, where “overhead power line section” resource and “transfer electricity” action are simplified; (d) “section of the overhead power line is a mean of electricity transmission"; (e) “section of the overhead power line, as a mean of electricity transmission, is under load (powered)"; (f) “section of the overhead power line, as a mean of electricity transmission, is de-energized”

voltage, functional value and transmission distance, the configuration (topology) of the network. The area of spatial relations “resource-resource" is a region, i.e. a part of the space occupied by the resource in its natural environment. This could be the physical place shown in connection with the natural characteristics of the place itself and its immediate surroundings. This could be the formalized place, showing the structural nature of a place in terms of its essential characteristics with the replacement of natural properties by a simplified form, which does not reproduce the exact image of the resource, but gives its generalization. This is the case when technical clarity is more important than visually perceived reality. Fig. 4 depicts a graphic statement about the resource “overhead power line section”.

The construction of complex graphic statements “overhead power line section as a mean of power transmission that contactly connects transformer and recloser is powered” and “two-sections branch of the overhead power line is powered” is shown in Fig. 5.

The complex graphic statement about the p-situation “normal power transmission mode, the emergency transfer switch resource is off" is shown in Fig. 6(a). Fig. 6(b) shows the role visual relation “resource-resource”. The role on the left is occupied by the complex graphic statement about the resource “emergency power transmission mode, the emergency transfer switch resource is on”.

Fig. 7 depicts graphic statement about r-situation “normal power transmission mode” and its position.

## V. Constructing visual-symbolic statements about actions that are simultaneously performed (operation-based situation, o-situation)

Definition 2. O-situation (operation-based situation) is “simultaneously” relation over the set of operations with

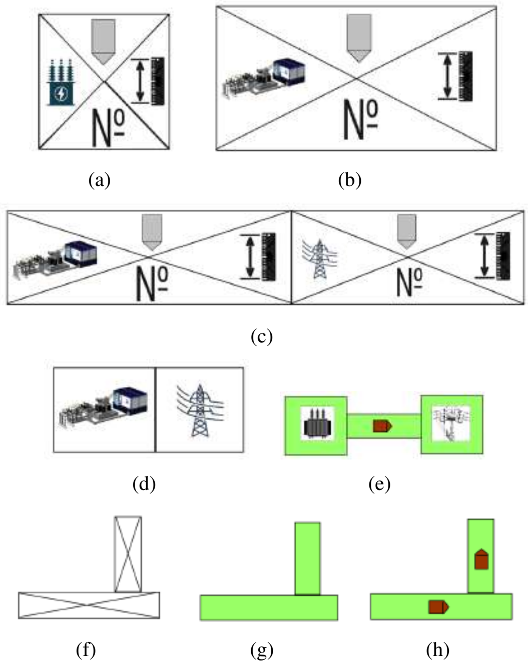



Figure 5. Graphic statements: (a) about the resource “transformer”; (b) about the resource “substation”; (c) about the role visual relation “resource – resource” (“contact connection”); (d) “contact connection” is simplified; (e) two role visual relations “resource – resource” form the composite graphic statement “overhead power line section that contactly connects transformer and recloser is powered”; (f) about role visual relation “resource-resource" (“branch", “tap off"); (g) “two-sections branch of the overhead power line is powered”; (h) “two-sections branch of the overhead power line, intended for electricity transmission, is powered”

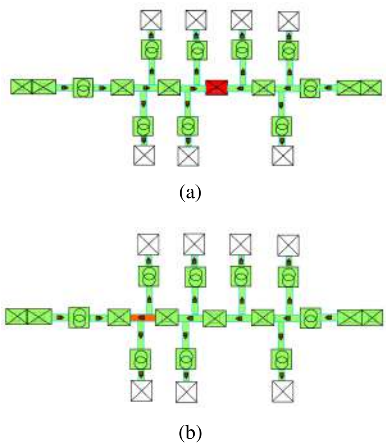



Figure 6. Graphic statements about r-situation: (a) “normal power transmission mode, the emergency transfer switch resource is off"; (b) “emergency power transmission mode, the emergency transfer switch resource is on”

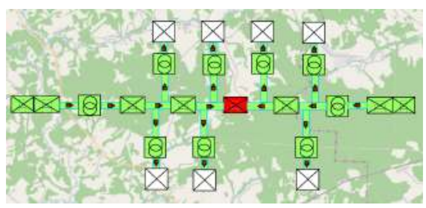
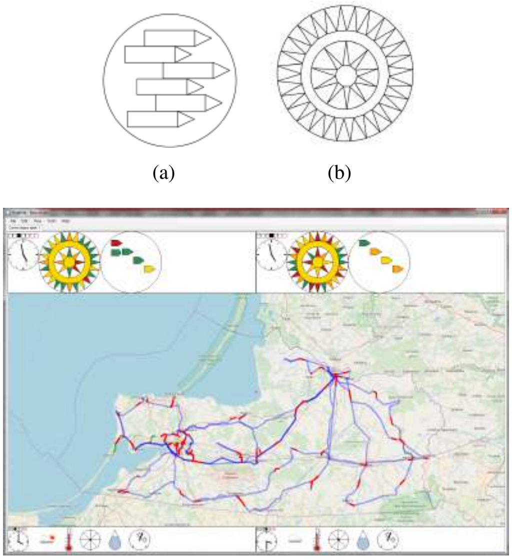


Figure 7. Graphic statement about r-situation “normal power transmission mode” and its position (shown schematically)



(a) (b)

(c)

Figure 8. Complex graphic statements: (a) about the role visual relation “action - action” (“simultaneously”), the symbols of actions are not detailed; (b) about the parameters, essential for the problem solved at the moment t, and the qualitative fuzzy characteristics of the resources (role visual “property - resource” relations); (c) about the state of the visual control object at time

the resources of the control object at a given time in the context of its production structure (process). Since the operation scenario is a plan that forms the current r-situation, the o-situation also determines the r-situation. The graphic statement about the role visual relation “action-action” (“simultaneously”) is shown in Fig. 8(a). Since this is the relation of the objects of the experts’ inner world, it is depicted in a circle. Understanding the symbol “o-situation” implies imaginative representation of the timeline and the vertical line-mark on this timeline, symbolizing the current time and crossing all actions performed in the control object simultaneously. At the same time, the left side of the action-rectangle symbolizes the actual start time of the action, and the right vertex of the action-triangle symbolizes the planned (estimated) end time of the action.

The entry (assignment) of an action to a graphic statement about an o-situation is calculated as follows. The action symbol is placed in the graphic statement if the actual start time of the action is less or equal to the current time and the estimated end time is greater than or equal to the current time. The arrangement of the symbols in the graphic expression is ordered relative to the timeline. It’s possible to move along the circle, from left to right a small round spot, symbolizing the time flow.

## VI. Designing visual-symbolic statements about the state of the visual control object

Definition 3. The state of the control object $S(t)$ at the time moment $t$ is a set of parameters, essential for the problem being solved at the moment $t$, qualitative fuzzy characteristics of resources and operations, o-situations and r-situations, at that the first is considered in the context of the production structure, and the second is considered in the context of the spatial structure of the control object.

If in the case of r-situation the accents are made on the mapping of the role spatial relations “resource – resource”, then in the graphical statement in Fig. 8(b) the accents are shifted to the role relations “property – resource”. Since this view relates to the expert’s inner world, the circles are used to symbolize. There are four of them. Between the central and the next external in relation to it circles there are graphical statements about the properties of static resources available in the graphic statement about the current r-situation. When solving problems in the control phase, i.e. when standards for the properties’ values are given, going beyond the limits of standards can be symbolized by a change in the color of triangles. In this case, the color of the central circle can symbolize integrated either the norm in properties, or the degree of deviation of the properties of static resources from standard values.

Between the outer and following to the center circles there are graphical statements about the properties of dynamic resources available in a graphic statement about the current r-situation (there are usually more dynamic resources). When solving problems in the control phase, i.e. when standards for the properties’ values are given, going beyond the limits of standards can be symbolized by a change in the color of triangles. In this case, the color of the ring between the second and third circles from the center can symbolize integrated either the norm in properties, or the degree of deviation of the properties of dynamic resources from standard values. To give imaginative character it is possible to specify a rotation for an outer star-shaped figure (or move a small circular spot around the outer circle), which will symbolize its relation to the properties of dynamic elements and the time flow.

In Fig. 8(c) a complex graphical statement on the state of the control object at the time $t$ is shown, implemented using the tool “Graphite" for synthesis of functional hybrid intelligent systems (FHIS). This statement composed of the graphic statement about the set of parameters essential for the problem solved at time $t$, qualitative fuzzy characteristics of resources and operations, as well as graphic statements about the o-situation and the r-situation.

As shown in [19] operator focuses on the upper left quadrant of the working window, so it is recommended to place the schematized image of the current o-situation in the upper left part of the working field and the schematized image of the predicted o-situation in the upper right part. The left and right lower parts of the working field are for schematized images of the current and forecast weather conditions, respectively. In the center there is the graphic statement about the r-situation. When displaying the r-situation on a small scale, visual primitives depicting power lines "merge" into solid blue (gray in grayscale) lines, the power flow along which is shown by moving red (dark gray in grayscale) segments.

Laboratory studies of the developed tool prototype for FHIS with heterogeneous visual field synthesis showed that specialists who know the subject area of power grid management well, but do not have programming skills, thanks to the presence of visual designers, successfully construct models of the control object, as well as schematized images of its states and situations. The experience of developing FHIS makes it possible to speak of a significant reduction in the time taken to create them using the "Graphite" tool.

FHIS developed using the "Graphite" tool will allow to take into account the dynamic nature of complex problems and to synthesize an integrated method, which is relevant at the time of problem solving over heterogeneous visual field. Such FHIS can manage the imitation process, activating the mechanisms of visual-spatial, figurative thinking, when there is a significant uncertainty. These mechanisms allow the user to "see" an approximate solution of the complex problem or its subtasks, which can later be substantiated and refined by logical and mathematical reasoning methods.

## VII. Conclusion

The symbolization and schematization of situational relations and the state of the control object recreate operationally deformed problem situations, they're qualitatively better perceived by man, and form reference circuits for analyzing and constructing the new, complex. Drawing, and then understanding and rational awareness of the problem with the methods for activating the right-hemisphere thinking mode, harmonizing of the formless, seeing the vague context of the problem situation are the conditions for sudden, relevant decisions and actions of visual management.

Functional hybrid intelligent systems, the architectures and mechanisms of which implement the grammar of the visual metalanguage, will significantly reduce the workload of the operational and technological personnel, because visual-spatial thinking reflects the world in the fullness of a person's mind, when one sight is enough to understand the conditions of a problem situation in the control object and to assess the degree of risk of continuing of abnormal behavior.

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## ВИЗУАЛЬНЫЙ СОБЫТИЙНО-СИТУАЦИОННЫЙ ПОДХОД ИНФОРМАЦИОННОЙ ПОДГОТОВКИ РЕШЕНИЙ И ОПЕРАТИВНО-ТЕХНОЛОГИЧЕСКОГО УПРАВЛЕНИЯ СЛОЖНЫМИ ДИНАМИЧЕСКИМИ ОБЪЕКТАМИ

Колесников А.В.

Оперативная работа с образом непосредственно не воспринимаемого объекта – трудная задача оператора. Применяемые способы отображения не релевантны ментальному образу, мешают оператору выполнять действия в уме, способствуют ошибкам интерпретации данных. Изменить положение дел предполагается в рамках визуального событийно-ситуационного субъектно-ориентированного подхода, заключающегося в компьютерной имитации полиструктурного, многослойного по конкретности и наглядности отображения. В таком подходе предметное действие рассматривается как упорядоченная последовательность двухзвенных преобразований субъектом деформируемого, ограниченного объема смешанной перцептивной и предметно-схемной информации о ситуациях и состоянии объекта, в форму целесообразного, регулятивного воздействия на него. Результатом реализации данного подхода должен стать новый класс систем искусственного интеллекта – когнитивные гибридные интеллектуальные системы.

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