Modeling Of Machine Intelligence Under Uncertainty

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Abstract: The paper proposes a method how to model of Machine Intelligence in Intelligent Systems through of computational perception of reality, situational awareness, cognition, machine learning and system of computational Systemic Deep Mind. The modules of this model, determine the states and properties of objects in the environment of unknown in advance situation, represent, store, process the objects using machine memory and display the objects, that are recognized and understood by systems and humans. The method applies the principles of the systemic and situational control, the main achievements of fuzzy logic, linguistics and cyber-physical approach to the perception, understanding and processing of languages, images, signals and other essences of reality. The technology for implementing the functionality of this method is based on the following interconnected main modules: a) Computational Perception objects of Reality, a) Situational fuzzy control of data, information, knowledge, objects and subsystems, b) Fuzzy Inference, c) Decisions making, d) Knowledge Representation, e) Knowledge Generalization, f) Knowledge Explanation, g) Reasoning, h) Systems Thinking, i) Situational Awareness, j) Cognition, k) Machine Learning, l) Computational Systemic Mind, and m) Intelligent User Interface. The use of this method in unmanned systems allows them to be self-developed and to operate without natural intelligence in various subject areas under uncertainty.

Keywords: Intelligence, modeling, machine, uncertainty.

I. INTRODUCTION

The main problem in existing modern computational Intelligent systems consists in the fact that in such systems the level of business logic of reality is modeled and predefined in advance mostly by *natural intelligence*. In case of changes, human intelligence is involved in reprogramming the model and the algorithms. This circumstance reduces the degree of machine intelligence in a system, which is aimed to function under conditions of uncertainty and in a mode of continuous real time.

In these conditions, these systems are not able to analyze previous, current and future knowledge states of objects of reality. Also, they cannot independently, systemically and computationally think, understand, to take in a timely manner smart and correct decisions in the existing situation, cognize, learn, generalize, explain and communicate at the level of a human thought and a language speech, and conceptually interact with systems and humans in real time.

Today, the systems are mainly developed using the principle of a “menu” type (Fig.1), with the preprogrammed models and algorithms. The use of neural networks leads to unpredictable results [8], which significantly limits their implementation in machine intelligence systems and require reliability in obtaining relevant conclusions in current situation.

This shortcoming of neural networks limits the ability to resolve the aforementioned problems in the modern systems of machine intelligence, as the neural network cannot control changes in the processes following changes in models, algorithms and sub-segments of these systems, in conditions of uncertainty and autonomy.

The Fig. 1 includes the following designations: 1) (HPU, LPU and NPU) are, respectively, Highly

Professional, Less Professional and Not Professional Users in Programming, 2) (OS/ DBs/ KBs) are, respectively, a group of Operation Systems (OS), Data Base Management Systems (DBs) and Knowledge Base Management Systems (KBs), 3) (APP and SYSAPP) are, respectively, Application and Systemic Systems, 4) (UI and IUA) are, respectively, User Interface in the Traditional systems and Intelligent User Interface in the Intelligent systems, and 5) (HW) are Hardware resources.

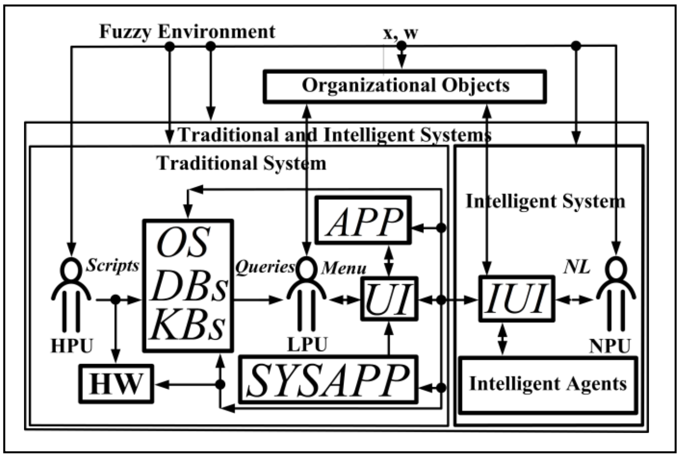

Fig. 1. Traditional and Machine Intelligence systems.

In Traditional systems the users interact with these systems via UI, based on scripts and "menu" type queries, using its professional knowledge in programming, while in the intelligent systems the users interact with all systems via IUI in Natural Language (NL) mode. In standalone mode, the intelligent systems become self-organizing, informing the user (if necessary) on the status of the functioning process by using human language thought communication, and the IUI becomes a stand-alone self-controlled module.

Thus, in the Traditional systems, any change in the business logic of the object, which occurs in a continuous real time, does not result in adequate change in models and in algorithms.

In addition to the mentioned above and considering other drawbacks, the modern systems cannot competence the human mind, transfer it to other humans, perceive the objects of the reality by way of cognition and explanation, accumulate the data, information and knowledge under the mentioned above conditions.

The solution to the mentioned above and additional problems are addressed in this paper by applying the principles of the Systems Approach [3] and Situational Control [4], the main achievements of Fuzzy Logic [1], [2], Linguistics [21] and Cyber-physical approach. The paper also suggests using our method, which applies the functionality of Perception, Situation Awareness, Cognition and Machine Learning, which are main components in the System of Computational Systemic Deep Mind (SCSDM) [5], (Fig. 2 & 3). The SCSDM is the main component in the Machine Intelligence System (MIS) and we consider its implementation as a plug-in in the Complex Adaptive Systems.

The MIS method uses its Cyber-physical system for computational perception of the language fragments, images and signals, generates and stores the computational knowledge in the form of the human language and thought, in the memory. The MIS determines the subject area and the essence of content fragments sets, generates and performs actions to obtain results.

MIS is self-developed in continuous real time, using the mentioned components, operates under uncertainty in fuzzy environment, with perception and recognition of reality objects. In addition, the method generates the best actions in a precise .

MIS should be used in systems, which consume large amount of unstructured data, information and knowledge in unknown situations. The other advantage of the method is in cases where the business logic and algorithms are constantly may change in continuous real time, providing of the functionality of the system without the need of reprogramming of the system.

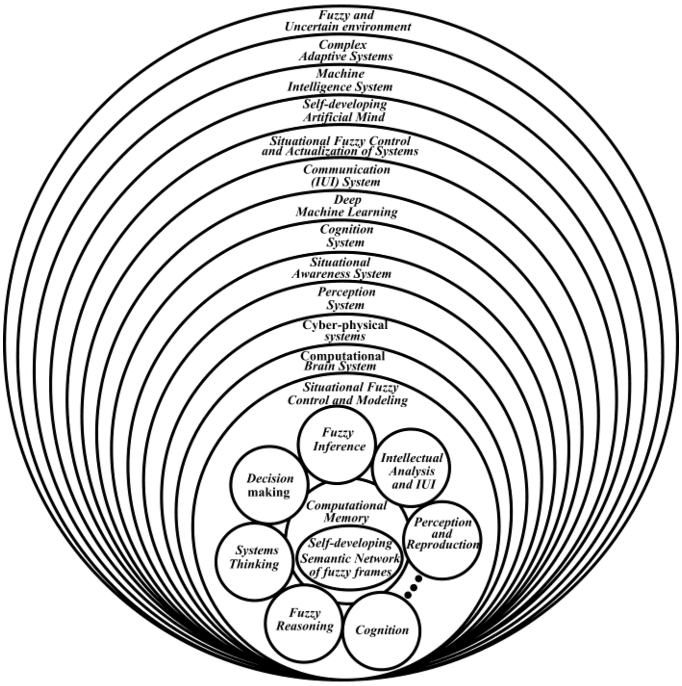

Fig. 2. Machine Intelligence System.

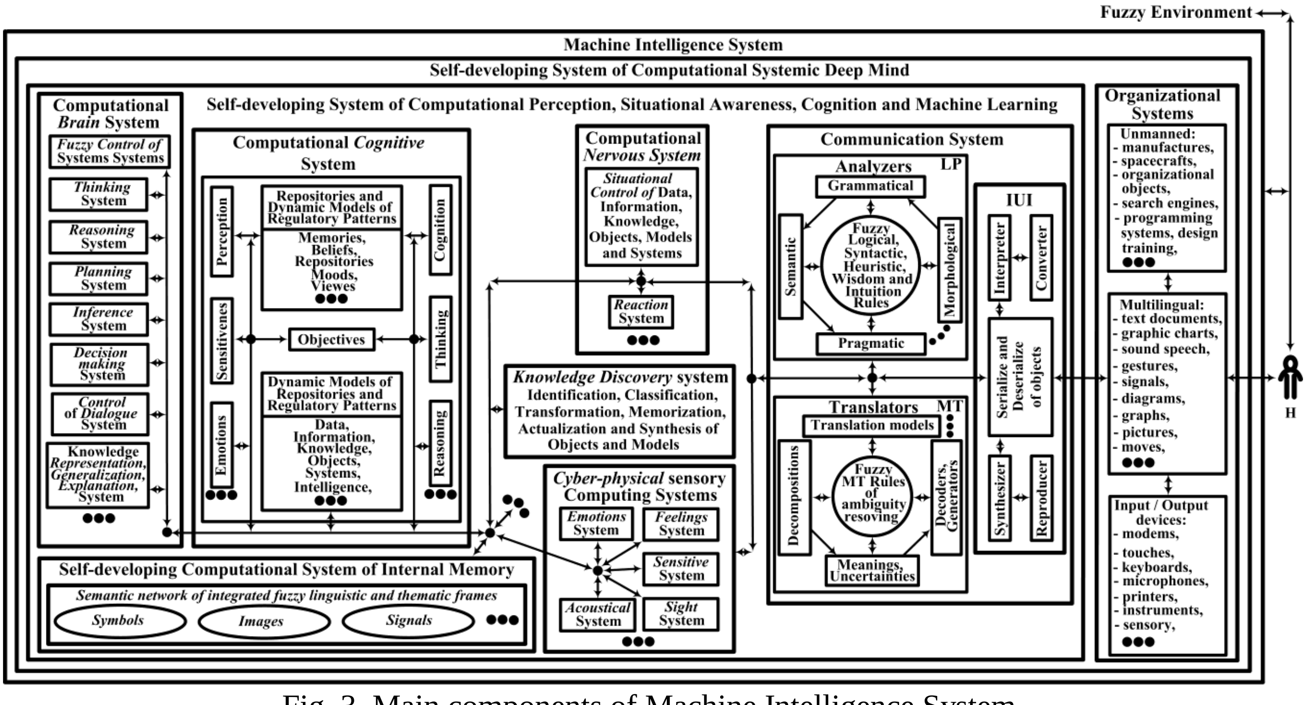

Fig. 3. Main components of Machine Intelligence System.

Sensors, IOT and other sources, which enrich data, information and knowledge should be integrated in order enable the system functionality.

The data and information are pre-processed and transmitted to computational Brain system by the Nervous computational system. The computational Brain system detects, percepts and analyzes of the data about objects of reality, forms new information and knowledge, memorizes them in repositories. Further, this system uses the previously accumulated knowledge provided with the methods of the

Situational fuzzy control of data, information, knowledge, objects and subsystems [11], [13] for implementation of Fuzzy Inference [6], Decision Making [7], Reasoning, Systems Thinking [10],[9], Situational Awareness, Cognition, Machine Learning and Computation of Mind [25]. Based on the results obtained from the operation of these subsystems are generated of control actions, which are transmitted through the computational Nervous and Cyber-physical systems to the Computational Brain as a reverse reaction to the perception of the reality for generation of new decisions (Fig. 3). These new target solutions transform and shift the entire system of Machine Intelligence into a new state in accordance with the changed situation in the surrounding its reality. The Intelligent User Interface [26], Fig. 3. provides interaction (if necessary) of the system of Computer Intelligence with other systems and humans.

According to [12], the “Situation Awareness” refers to “the perception of the environment elements, time, space, meaning and status future prediction”.

Hence, as per [5], (Fig. 3), the problem of computational perception and comprehension of reality object meaning consists of computation of the previous, current (new) and future states of situation awareness and events associated with it. This process is applied by computational fuzzy modeling and situational fuzzy control [13] of data, information, knowledge, objects and agents, fuzzy inference [6], decision making [7], generalization knowledge [14], reasoning, thinking [9], [10], cognition and machine learning, in continuous real time and under uncertainty of the environment.

The modeling of data, information, knowledge, objects, languages, images and signals is implemented by analysis and identification of the previous, current and predicted in future states of the situations awareness with the use of models, methods and system. Such system is a component of computational systemic deep Mind system [5], (Fig. 3), which is a component of MIS.

The MIS contains computational models and subsystems (agents), which provide: a) perception of the objects of the reality objects, extraction and generalization of knowledge, cognition, deep learning, machine learning and full understanding of the languages, images, signals and their essences in the current situation, b) extraction, determination, conversion, representation and memorization of the states and of the object relationships in the memory by the language of thought, c) comparison of current and previous states of situational awareness and relationships between these states and forming of the new state, based on their effect on environment, which is vary in time, d) analysis of regularities and conditions of generation of previous and current situational understanding and predicting of their future states, e) computational actualization of these generalized states and relationships, and f) reproduction of the current situation of machine representation in the form of the human and system language of thought.

II. CONCEPTION

We consider *Understanding* as a *property* of reasonable systems, which is *measured* by *degree* of achieving level of the knowledge truth awareness of a specific. *Understanding* is computed by the fuzzy conceptualization of mental systemic computational thinking process in the current situation. This process is executed in computational memory, in real time, in fuzzy environment by way of identification, analysis, classification, memorization and updating of fuzzy conceptual situational model and state of fuzzy data, information, knowledge and objects, related to the particular subject area. It realizes the intelligence of reality objects, by the way of their cognition, representation, generalization, determining their essences, and also their synthesis, which are related to each other concepts, in the form of languages, images and signals.

The *Situation* is considered by us as a *state* of reality, which is perceived by humans and systems as computational and systemic form of interrelated linguistic, themed, psychological, visual, signal and other objects. These change continuously and are synchronized, respectively, in the computational and human memory of mental images, which are generated, respectively, by system of artificial and natural mind in real-time and space.

According to [12] *Situation Awareness* we understand previous, current and future states of elements and events, perceived in time and space by way of the comprehension of their meaning in their new state, after these elements and events have changed.

Uncertainty is understood by us as property of reality, which displays the current state of changes in data, information, knowledge, objects, models, fuzzy environment, regularities and algorithms. The properties, structure, origin, nature, constructing method and the steps sequence of these attributes are unknown in advance and required an intelligent analysis in real time by applying a computational Perception, Situation Awareness, Systems Thinking, Cognition and Machine Learning methods.

Perception is understood by us as the processing of unstructured data, information and knowledge, generated by languages, video, images, symbols and signals, which reflect in computational memory the properties of the fuzzy environment elements (objects) of. This process of generating these objects is implemented at a cyber-physical level of processing by using touch sensors, sight, smell and taste, and by systems of Systems Thinking, Situation Awareness and Machine Learning on computational level of processing. The purpose of this process is to organize the computational Cognition of the environment and gain computational management decisions, which justify the validity of the obtained knowledge of the environment.

The process of *Machine Learning* is understood by us as a systemic computational self-organized purposeful process, which computes the previous, current (new) and predictable in the future data, information, knowledge, objects, models, decisions and situations, generated through of computational Perception, Situational Awareness and Cognition in conditions of real time, in heterogeneous subject areas and in the current situations, which are unknown in advance. The prediction is implemented by way of detection and confirmation of regularity objects properties changes, and their knowledge, and as a consequence, the use in this case of computational intuition and wisdom need to be assessed.

Mind is understood by us as a property of brain activity result of an individual subject of Natural Intelligence or machine Intelligence, which perfect itself to the best of their abilities or degraded when interacting with the environment in the fight for survival and existence

The *Machine Intelligence* System (or MIS) is understood by us as a system that possesses more advanced properties than Natural Intelligence and operate *without* his help (but in cooperation with him by the goal of providing him assistance if necessary) on the basis of self *organization*, self *development*, self *improvement* and self *control*. The MIS perceives, understands of the objects of reality, is aware of the situation and generates structured and interconnected data, information and knowledge. On basis of them are computed and realized the topical, wise and evolutionary solutions, that lead this system into a state adequate to the current situation. This circumstance helps to this system to function systemically in conditions of uncertainty, in the mode of continuous real time and in various interconnected subject areas.

III. ANALYSIS

There are many ideas, methods and algorithms to resolve the situational awareness understanding problem in a computational system of full understandable Mind. For example:

- [15] offers the approach to the assessment of decision support process situation, based on the Context-aware Decision Support system, presented by the: a) model of the situation and process of modeling of understanding of the situation and c) entity agents group, each is supported by individual user to provide a focused and customized process of decision support. The implementation and performance of the proposed system are demonstrated through a case study, which demonstrated the application control using the user commands. Consequently, the model of the situation is set in advance and is supported by the natural intelligence of the user. This fact makes it impossible to form a computational model of the situation in the continuous real-time and space, because the taken decisions will not match to the real model of situation, which varies in time. We solve the problem by enabling a computational situational systemic perception, thinking, cognition and generalization of knowledge and machine learning.

- [16] proposes a new system architecture, which: a) emphasizes the role of formal logic in system of automated of theorems proofs, and b) has a controlled natural language for the operator input / output, and provides three logical languages for adequately modeling of domain of various aspects, which allows to build the situation awareness system more declaratively, than the use of the current approaches. This approach includes "automated reasoning techniques, from low-level data fusion of time-stamped data to semantic analysis and alert generation, which is based on the linear temporal logic". The process of modeling understanding of the situation is mainly implemented using the natural intelligence.
- [17] offers the Computational theory of perception, which complements the standard methods of not fuzzy perception and in which: a) the perception is assumed to be f – granular , b) the reasoning or perception expressed as a generalized restriction of the form X is r R restriction, or a combination of such restrictions, c) the reasoning or computation by perception includes the goal, directed on propagation of generalized constraints from premises to conclusions, and d) the principal rule governs generalized constraint language and acts as a generalized extension principle. Enabling of this principle reduces, in general, to the solution of a variation problem with constraints, results in sought information. This theory complements the standard methods of perception of natural language sentences. Along with the computational theory of perception [17], which uses only the natural language as the basis of the perception, there is also a modern cyber-physical (sensory) approach to the problem of perception, which involves the perception of visual, auditory, signal and other forms of object perception of reality, presented by data, information, knowledge, objects and other. This approach to perception of reality is a basis of implementing of the generalizations, additions, extensions and clarifications of perception theory [17]. Given the following, we offer a solution to the problem of the full understanding of objects of reality in autonomous computational thinking systems, and also Computational understanding of the interrelationships of the objects in the reality by Modeling of Computational Systemic Deep Mind under uncertainty [5].
- [18] observes that "understanding of the situation has been recognized as one of the important, but unresolved, issues in many different areas, including manned and monitored mobile networks in social networks, physical and cyber security systems, monitoring of natural disasters and recovery, epidemic monitoring and control, intelligent transportation systems, financial and investment services, as well as tactical and operational command and control". In this case, "a common feature of all these systems allows them to react to dynamic environment, which changes its state, either by human or by computer".
- [12] presents a "*theoretical* model of *situation awareness* based on its role in dynamic *human* decision making in a variety of domains". As object of study are considered military pilot or tactical commander, the driver of the vehicle, the operator of the production system and the other, which are the bearers of the natural intelligence and

which are perfect in their activities. The theory does not consider the computational situation awareness under uncertainty.

In this paper we propose a *computational systemic*, *linguistic* and *cyber-physical* approach of solving the problem of situation awareness, using the principles of Systemic Approach [3], Situational Control [4], [7], [11], [13] and achievements of Fuzzy Logic [1], [2], [17], Linguistics [21], Psychology, Computational Mind and Cognitive Science, and also using of our computational models and subsystems (agents), for realizing the main functionality of MIS: a) Perception of Reality, b) Situation Awareness, c) Cognition of Uncertainty, d) Machine Learning, and e) Systemic Computational Mind.

Machine Learning comprises the following computational models and subsystems: a) Situational Fuzzy Control of data, information, knowledge, objects, models and processes [11], [13], b) Intelligent User Interface [19], c) Modeling, Representation, Generalization and Explanation of Knowledge [20], [9], [14], [21], d) Fuzzy Inference [6], e) Making Decisions and their Planning [7], f) Control of Dialogue [22], g) Reasoning and System Thinking [10], and Fuzzy Control [13], which operate systemically, and which are integrated as a plug-in into Complex Adaptive Systems, such as robots and unmanned productions.

The novelty of this paper proposed by us, consists of a *systemic*, *linguistic* and *cyber-physical* approach to the problems of modeling of computational Perception, Situation Awareness, Cognition of Reality and Machine Learning Under Uncertainty, where we use:

- Computational fuzzy modeling and fuzzy control of data, information and knowledge for implementing an automatic knowledge representation and systemic thinking by extracting the knowledge from texts (speech), images and signals, creation their patterns, finding of relations with other knowledge, applying it in the knowledge repositories on language of thought, by taking into account conditions of current situation and impacts of the fuzzy environment on them of.
- Using of automatic Fuzzy Inference for finding relevant, accurate, timely and adequate solution under uncertainty and in fuzzy environment.
- Converting and deriving images, concepts, meanings from natural languages in various subject areas and serializing them into the bases of data, information and knowledge on language of thought.
- Obtaining conclusion for control actions planning on the controlled object and realizing the fuzzy control of the organizational object in fuzzy environment.
- Processing, creating and synthesis of concepts and essences from texts in the various natural languages, graphic images and signals, related to the heterogeneous subject areas, and their existence in the repositories of data, information and knowledge.

The approach of *systemic, linguistic and cyber-physical* proposed by us applies [6], [7], [11], [19], [13], [10], [5] to modeling of Computational Perception of reality, Situational Awareness, Cognition and Machine Learning under uncertainty, has in comparison with other approaches, has the following distinctive features:

- We generalize notion of *linguistic variable* of Fuzzy Logic [11], by which we evaluate and take into account not only the morphological, syntactic and semantic, but also, behavioral, psychological and other aspects of the atomic units (stems, roots, suffixes, endings and other fragments of words) of Natural Language (NL), elements of data of images and signals.
- Situational Fuzzy Control [11], [13] in the Fuzzy environment, controls not only data and information, but also knowledge, decisions and processes (agents).

- Decision-making process is based not only on the use of the given in advance ranks for estimation of the alternatives, but also by way of automatic Fuzzy Logic Inference [6], Planning, Control of alternatives, situations and other objects [7].

Multi-lingual interaction, generalization, explanation, serialization, storage, actualization and playback (synthesis) of knowledge is implemented in fuzzy conditions, heterogeneous subject areas, where the situations are unknown in advance, fuzzy structured and not regulated in advance.

IV. Methods, Models, Modules and Processes

This section provides a brief description, designed by us, of a dynamically changing memory structure, models, methods, modules and processes that determine a holistic new model, a new method, a new functionality and a new MIS, that comprises of Perception of reality, full Situation awareness, Cognition of uncertainty, Machine Learning and Systemic Computational Mind.

A. Memory organization

The model (3), [9] displays graphically dynamically changing structure of data, information and knowledge in form of graphic hypothetical convex polyhedron (Fig. 4), which display a growing network of interrelated computational semantic frames, each is an integrated set of semantic codes and each identifies a group of atomic objects (up to the level of the elementary symbol).

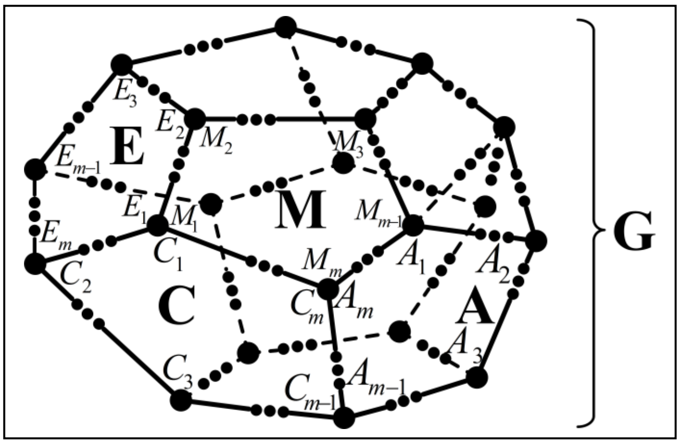

Fig. 4. Model of computational semantic network of fuzzy frames.

Each phase of the polyhedron and secant plane are described by the generalized linguistic variable containing a group of interconnected fuzzy variables, containing properties and values of membership functions of fuzzy logic, related to a specific category of language and of the subject area. Each edge defines the relationship between the fuzzy variables in related generalized linguistic variables, and values of these variables determine compatibility of the related language and subject area. Each vertex outlines the concept, which is defined by a plurality of interrelated fuzzy variables, the values of which is to establish the same meaning of the term in related languages, subject areas, mentality and other. Each object is represented on one internal machine language of thought (mentality) and its external representation is reproduced in particular language of thought (mentality) by procedures of their processing. The content of memory model is actualized, memorized and played back continuously in real time on internal and external levels of processing their data, information, knowledge and objects using the model of system of Situational Fuzzy Control System (1), [11], [13], (Fig. 3). The structure of the *Computational Semantic Frame* is represented in [9], [23] as: *Computational Semantic Frame*: (NL words (Factor, Situation: (Name of frame: Group of universal semantic codes))); *Universal Semantic Code*: (generalized linguistic variables); *Generalized linguistic variable*: (generic name of the linguistic variable: string); *String*: (fuzzy variable: object); *Object*: (attribute: data element).

For example, the Generalized Semantic Fuzzy Frame "G" (Fig. 4) consists from of dissimilar integrated linguistic, subject area, mental and other categories of objects, organized in semantic network of fuzzy frames, where the *M, E, C, A* are, respectively, designations of the Manager's, Expert's, Consultant's, Analyst's *segments* of data, information and knowledge. The $M_m, E_m, C_m, A_m,...,$ (m=1, n), are, respectively, *nodes* of units of data, information and knowledge of these and of other specialists in the subject areas of their activities.

B. Computational Model of Computational Systemic Situational Fuzzy Control module of data, information, knowledge, objects and processes

The model of this Module is presented in [5] by (1) as

$$M =< A_n^G, K_n^G, F, (S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I) > \quad (1),$$

where:

$$A_n^G (G_n^D, G_n^Z, G_n^Y) \quad (2).$$

The (2) is a computational model of a mental *Concept* (of generalized linguistic variable), which defines dictionary entries of linguistic and thematic objects in generalized thesauri, where: G_n^D, G_n^Z, G_n^Y, respectively, are determined as segments of accumulation of linguistic and thematic, data, information, knowledge and objects in the system of Computational Deep Mind [5] at whole,

$$K_n^G (R_n^D, R_n^Z, R_n^Y, A_n^N) \quad (3).$$

The (3) is a computational Model [5] of Systemic *Knowledge Module* of *fuzzy modeling* of *knowledge* and *situational fuzzy control* by the *Concepts* A_n^N (modulated indicators, generalized linguistic variables and generalized situations), using of inhomogeneous *linguistic* and *thematic* data, information, knowledge, objects, models and processes, which are organized and processed on *declarative*, *procedural* and *transformative* levels of *fuzzy modeling* of knowledge, where: R_n^D, R_n^Z, R_n^Y, respectively, define in [5] the mental compositional mapping rules of modeling of *linguistic*, *thematic* and *mental* data, information, knowledge and objects,

$$F = u(x, w) \quad (4).$$

The (4) is an *objective* function, which defines in (1) the *objectives* of modeling and situational fuzzy control linguistic, thematic and mental data, information, knowledge, objects, models and processes,

$$(S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I) \quad (5).$$

The (5) a Computational Sub model of Module of Situational Control [5].

Thus, using of the considered above computational models of Memory organization, (1), (2) and computational models of *Fuzzy* Inference [6], Decision *making* [7], *Representation* [9], *Generalization* [14] and *Explanation* [19] of Knowledge, *Control of Dialogue* [22], Communication with users and systems on basis of *Intelligent User Interface* [19], Perception objects of reality and Cognition, *leads* to a model (6) in [5].

C. The model of Module of Perception of Reality Under Uncertainty

The model of this Module is presented in [5] by (1) as

$$\mu^P =< A_n^G, K_n^G, F, (S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I), (\mu_R^P(\mu_R^C(\mu_R^H(\mu_R^T(\mu_R^M(\mu_R^D(\mu_R^Z(\mu_R^L(\mu_R^F(\mu_R^Y(,...,)))))))))) > \quad (6),$$

where:

- It is included (1), which is a Computational Model of Module of Computational Systemic Situational Fuzzy Control data, information, knowledge, objects and agents.
- μ_R^Y is a *Cyber-physical module of perception* of reality.

- μ_R^F is a module of *generation of rules* and *Situational Fuzzy Control* actions by the *actualization, coordination* and *communication* processes.
- μ_R^L is a module of *computational Systemic Fuzzy Logic Inference*.
- μ_R^Z is a module of *computational Systemic Representation, Generalization* and *Explanation of Knowledge*.
- μ_R^D is a module of *computational Fuzzy Control* of *Dialogue* and *Communication* with users and systems.
- μ_R^M is a module of *computational Systemic Decision making* and their *Planning*.
- μ_R^T is a module of *computational mental Systemic Reasoning*.
- μ_R^H is a module of *computational mental Systemic Thinking*.
- μ_R^C is a module of *computational mental Systemic Cognition*.
- μ_R^P is a module of *computational Systemic Perception*.
- ... is a designation of the *additional Modules,* which expand the *functionality* of the *system of computational Systemic Deep Mind*.

D. The model of Module of Situational Awareness in Reality Under Uncertainty

The model of this Module is presented in [5] by (6) as

$$\mu^A =< A_n^G, K_n^G, F, (S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I), (\mu_R^A(\mu_R^C(\mu_R^P(\mu_R^H(\mu_R^T(\mu_R^M(\mu_R^D(\mu_R^Z(\mu_R^L(\mu_R^F(\mu_R^Y(,...,)))))))))))) > \qquad (7),$$

where the difference from model (6) in [5] is the following presented model μ^A (7) of Module μ_R^A of *Situation Awareness*.

E. The model of Module of Cognition in Reality Under Uncertainty

The model of this Module is presented in [5] by (6) as

$$\mu^C =< A_n^G, K_n^G, F, (S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I), (\mu_R^A(\mu_R^C(\mu_R^P(\mu_R^H(\mu_R^T(\mu_R^M(\mu_R^D(\mu_R^Z(\mu_R^L(\mu_R^F(\mu_R^Y(,...,)))))))))))) > \qquad (8),$$

where the difference from model (6) in [5] is the following presented model μ^C (8) of Module μ_R^C of *Cognition*.

F. The model of Module of Machine Learning in Reality Under Uncertainty

The model of this Module is presented in [5] by (6) as

$$\mu^R =< A_n^G, K_n^G, F, (S_i : Q_j \overset{x,u,w}{\Rightarrow} Q_l : I), (\mu_R^R(\mu_R^A(\mu_R^C(\mu_R^P(\mu_R^H(\mu_R^T(\mu_R^M(\mu_R^D(\mu_R^Z(\mu_R^L(\mu_R^F(\mu_R^Y(,...,))))))))))))) > \qquad (9),$$

where the difference from model (6) in [5] is the following presented model μ^R (9) of Module μ_R^R of *Machine Learning*, which is defined as per [24] in [5] as

$$\mu_R^R =< P_{\max}^R(E_{\max}^T(T_n^S(\mu^R))) > \qquad (10),$$

where:

- $P_{\max}^R$ is the value of property of *Productivity* of all subsystems (agents) of the system of Computational Mind [5].
- $E_{\max}^T$ is the value of property of *Experience* of all subsystems (agents) of system of Computational Mind [5] at whole.
- T_n^S are *Tasks*, solved by the subsystems (agents) of the system of Computational Mind [5].

- μ^R is a model of the Module of *Machine Learning*.
- *R* is a function of computing of *Productivity* of all subsystems (agents) of *Learning* system and System of *Computational Systemic Deep Mind* [5], with the value, which seeks to *min*.
- *T* are a variety of *Tasks*, which are involved in processes of all subsystems (agents), with value of their *Experience* of work, which seeks to *max*.
- *S* are a variety of *Subject Areas* (domains), in which the all systems (agents) are operating jointly the system of Computational Systemic Mind [5] at whole.

G. Modeling of Computational Reception of reality, Situational Awareness, Cognition and Machine Learning

According to [5] the process of Modeling of Computational Systemic mind consists of embedded computational processes of modeling of knowledge, fuzzy logic inference, decision making, planning of decisions, fuzzy control, dialog control, reasoning, systems thinking and other. These processes are implementing the modeling of Computational Perception of reality, Situational Awareness, Cognition and Machine Learning in the system of Computational Systemic Mind by using of compositional mapping rules (11) and diagram of a fuzzy matching in a fuzzy modeling of relationships in SCSDM (Fig. 5).

$$\mu^q_{B_{L_{ijk}}}(X) = \mu^q_{A_{L_{ijk}}}(X) \circ \Phi^q_{L_{ijk}} \qquad (11),$$

where:

$\mu^q_{B_{L_{ijk}}}(X)$, $\mu^q_{A_{L_{ijk}}}(X)$ are respectively, the resultant and initial membership functions in the considered generalized fuzzy relation $R^{X_{ijk}}_{ijk}$, $X = \{x_{ijk}\}$ is a *vector* of the discrete domain of definition of resultant and initial membership functions, $\circ$ - is a *sign* of the computational mapping, $\Phi^q_{L_{ijk}}$ - is a *fuzzy matching* in the procedure of *Computational Systemic Deep Mind*, $A_{L_{ijk}}$, $B_{L_{ijk}}$ - are the inhomogeneous multi-dimensional fuzzy sets, L_{ijk} - are the inhomogeneous distributive *lattices* of measurement *intervals* of the domains of definition of considered membership functions, *q* - determine the *levels* of representation of the data, information and knowledge in memory, respectively, on levels of RX-codes, USK - Universal Semantic Code and SF -Semantic Frames, *i, k, m = (1, n)*.

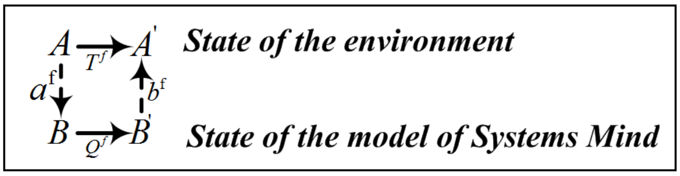

Fig. 5. Diagram of a fuzzy matching in a fuzzy modeling of relationships.

The *degree* of *conformity* of the numerical, verbal, mental and other estimates of concepts *x* from *X* are determinate by fuzzy *sets* $A^\alpha = \{x, \mu^A(x) \geq \alpha^A\}$ and by relations $R^\alpha = \{x, \mu^R(x) \geq \alpha^R\}$ on all of the levels of *modeling* of *Computational Systemic Deep Mind* and establishing the values of α - levels for A^α and R^α (in the certain and various distributive lattices L, "nearest" to the top of the curves μ^A and μ^R at each of considered levels of modeling of *Systemic Deep Mind*), which *leads* (using μ^O_R in (6-10)) to *unit* all of "tops" α - slices and to the formation of the resulting fuzzy set of unique (generalized) and relevant data, information, knowledge and objects, characterizing the reached level of *Systemic Deep Mind*.

Then,

$$\mu^{q}_{B_{L_{ijk}}}(X) = \underset{p\in P}{\vee}(\underset{k\in K}{\wedge}\mu^{q}_{A_{L_{ijk}}}(X)\underset{j\in I}{\wedge}\overset{q}{Poss}(a_{ijm}/a^{'}_{m}) \quad (12)$$

in process of creation of properties of main components of C*omputational Systemic Deep Mind* , implemented with using *measures of opportunities* $\overset{q}{Poss}(a_{ijm}/a^{'}_{m})$ on q levels of modeling data, information and knowledge.

Thus, the result of modeling of *Computational Systemic Deep Mind* is a multidimensional generalized *rule - relationship* of (a generalized computational *frame*) R^{Φ}_{ijk} with a domain of values $\mu^{\Phi}_{R_{ijk}} : \{x_{ijk}\} \rightarrow L^{\{x_{ijk}\}}_{ijk}$.This rule is the *relation*, that determines a distributed *chain* of *parcels* $\mu^{\Phi}_{R_{ijk}}$ at levels of *internal* and *external* representation, modeling and processing knowledge and each of these *parcels* is forming a group of (computing) *values*. The technology of modeling of *Computational Systemic Deep Mind* is implemented by way of using the developed by us methods of application of *situational control*, *systems approach* and *procedures* (constructions) of fuzzy logic inference, decision making, Systems Thinking and Cognition, which are realized by Module of Knowledge (3). The computer representation of one of computational *rules* (12) of resolving *lexical ambiguity* in the process of modeling *Systemic Deep Mind* is given in [5] by (13), Fig. 6, Fig. 7).

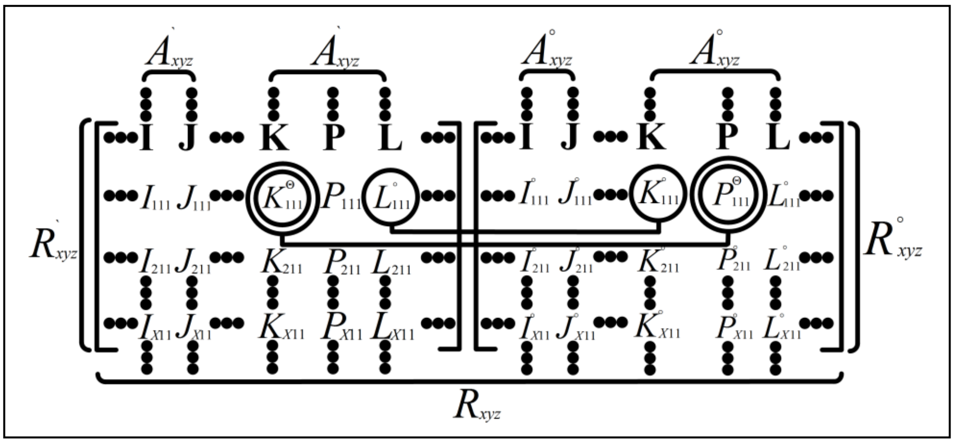

Fig. 6. Fragment of semantic domain of fuzzy sets.

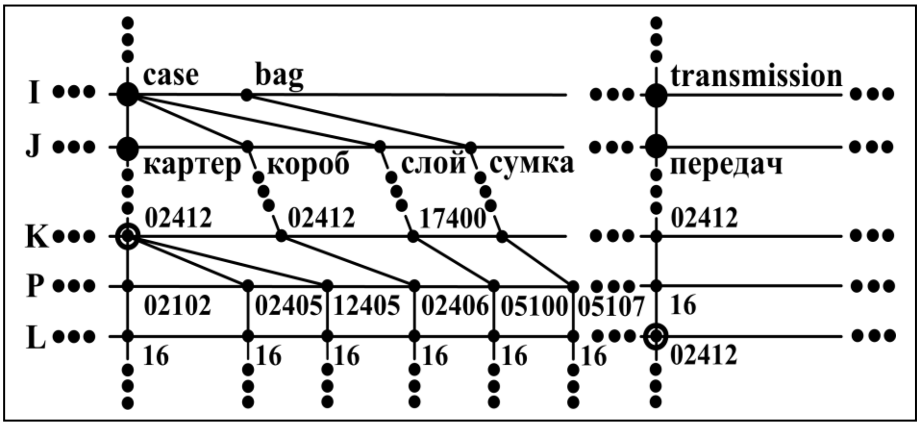

Fig. 7. Fragment of generalized linguistic variables in semantic network of frames.

This process is functioning on the *external* and *internal* levels of representation and modeling of *Deep Mind*, using multivariate generalized *matrices*, obtained from model of semantic network of computational *frames*, organized in memory of the system of *Systemic Deep Mind*.

$$IF\ ((K^{\Theta}_{xyz} = P^{\Theta}_{xyz})\ AND\ (L^{\circ}_{xyz} = K^{\circ}_{xyz}))\ THEN\ ((I_{xyz} = I^{\circ}_{xyz})\ AND\ ((J_{xyz} = J^{\circ}_{xyz}) \qquad (13).$$

This rule (13) is interpreted by the computational model of the Module (3) for example, as follows: ***if*** two words are included in sentence in both languages and the code of *right compatibility* of word, located to the *left* of a group of two words in *another* language ***is equal*** to *conceptual* code of the word, located to the *right* of a group of two words in the *output* language and the code of *left compatibility* of word, located to the *right* of a group of two words in the *output* language ***is equal*** to *conceptual code* of word, located to the *left* of a group of two words in *input* language, ***then*** these *pairs* of words of *input* and *output* languages *correspond* and are *identical* each to other at the level conceptual *disambiguation* in machine translation process.

Through of using in a *similar* way of compositional *rules* of *grammar*, *morphology*, *syntax*, *logical*, *psychological* and other compositional rules and analyzing of *languages*, *images* and *signals* of reality we are implementing *modeling* of *Computational Systemic Deep Mind*, represented on *internal* and *external* levels of perception and cognition of objects of environment under uncertainty.

The level of development of the *MIS* is mainly determined by the level of development of *its* intelligent *property* - Systemic Computational Mind.

Thus, the fuzzy control of the system of Computational Mind is performed by launch of the functional modules, which use algorithms of Modeling of Computational Perception of reality, Situation Awareness, Cognition and Machine Learning under uncertainty. This process is iteratively performed continuously in real time by the successive call of following main group of nested, integrated, computational, interconnected and cooperated with each other of functional modules (agents):

- *Perception* of objects of the reality, implemented sensory and computational software tools of cyber-physical detection of properties representations, reactions and actions, synthesized by system of Computational Systemic Mind [5], (Fig. 3) during processing of texts, gestures, sounds, graphics, images, colors and other.
- *Data Mining*, which is implemented by means of computational preliminary treatment of objects, linguistic analysis of texts, visual analysis of graphical objects, sound and other, by way of selecting, identification, classification, linking, memorization and reproduction of objects in understandable form for interpretation by the humans and systems.
- *Fuzzy Inference* [6] which is implemented by means of fuzzy situational control and fuzzy modeling of extracted data, information, knowledge, objects, and creation on their basis the models for obtaining from them a minimum set of relevant representations about their properties, compositional processing rules, necessary reactions and actions, used for their future processing.
- *Decision making* [7], which is implemented by selection of one alternative of state of representations of data, information, knowledge, objects, their models, reactions and actions on the events, used for their further processing.
- *Establishing, sorting*, *converting* and *actualization* of states of one alternative of state of representations of data, information, knowledge, objects, their models, reactions and actions on the events, used for their further processing.
- *Reasoning* [9], which represent the process of improving the representations of properties of objects, reactions and actions, which should be performed above these objects to bring the algorithms, models and systems of their processing into the actual (new) current state.
- *Systems Thinking* [10], which is implemented by means of processes of reasoning, which create representations about properties of objects and generate reactions and actions for

conversion of these objects, and their models.

- *Cognition*, which is implemented by means of intelligent analysis and comparison of previous and current actualized states of representations of data, information, knowledge, objects, algorithms, models, modules and subsystems, and establishing and memorization of their new states in their repositories for their further processing.
- Machine Learning [5], which is implemented as a systemic and self-organized process, under the influence of previous, new and predictable (by means of computational intuition and wisdom) data, information and knowledge, by way of its perception, identification their properties, regularities, rules, meanings and actions, obtained on the basis of its perceptions, its comparison with previous states, activation of processes of reasoning and systems thinking, cognition, its memorization, its improvements, using the results of this intelligent analysis for situational control of this process, generation of algorithms, changing and storing of models, detection of images of the environmental reality and subsequent its use in process of continuous computational self-learning.

V. Conclusion

This article describes a new systemic, integrated, linguistic and cyber physical (sensory) approach to modeling the Machine Intelligence under uncertainty, using subsystems of Computational Brain and Systemic Computational deep Mind [5].

A computational model, a method, a technology and a system for modeling Machine Intelligence are proposed, which can be built-in as a systemic plug-in to robots, unmanned spacecraft and unmanned production.

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