AI: "… It Sails. But Whither Do We Sail?…[1]"

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Abstract

Current content for the concept of AI is discussed. Key specific features characterizing AI as a research and development area are presented. Key differences between *intelligent data analysis* and computer *data analysis* (as a whole) are demonstrated.

Keywords

Artificial Intelligence, intelligent data analysis, research and development

1. Introduction

Three years ago, at the previous Russian national AI conference (RCAI-18), a point of view was already formulated (see [1]) reflecting the desire to clarify the mutual positioning of Artificial Intelligence (as an area of research and development) and Machine Learning (in particular, Deep Learning). Today, when Artificial Intelligence has become the object of universal attention (and, as a result, only the lazy do not speak out about "talking irons, thinking vacuum cleaners, self-guided syringes with a splitting head and a deep maneuver not only in pitch and yaw, but also in speed, ..."), it seems appropriate to clarify a number of circumstances characterizing the subject area under discussion. Following the well-known formula given in the title of this work (see, for example, [2], etc.), it is useful "while still on shore" to determine the basic concepts so that the appropriately named "boat" at least "floated".

2. To the concepts of *Strong AI* and *Artificial General Intelligence*

To the deep regret (of the authors of this work), today any unbiased observer will have to state the obvious devaluation of the meaning of the words Artificial Intelligence (AI). Formed over decades (see, for example, [3, 4, 5], etc.), the meaning and practical justification of the term AI even in a professional environment (see, for example, the work of [6], among the authors of which – including professional researchers) is becoming more and more blurred. Strong AI, weak AI, general AI, private AI, ... – then everywhere? Yes, at one time J. Searle [7] and R. Penrose [8] excited the minds of the community interested in the issues under discussion with the idea of an automatic device that surpasses a person in all areas that are traditionally characterized as intellectual activity. However, calm reflections on this topic quickly lead to the question: *And, in fact, in what exactly* (this automatic device surpasses a person)? Next – an even more understandable question: *Is it possible to see a proof of the "theorem of existence" of such a solution*? The questions are by no means idle. And when (in particular, when getting acquainted with the book already mentioned above – see [6]) – it turns out that in such a discussion there was no place for mentions of ideas, for example, J. McCarthy [9] or D. Pospelov [10], there arises a natural fear in the operational efficiency of the proposed conceptual constructions. (For example, the well-known definition of life as the mode of existence of protein bodies, proposed in 1883

[1] A.S. Pushkin. Autumn (the Excerpt). URL: https://1000petals.wordpress.com/2008/11/07/autumn-by-a-pushkin/

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by F. Engels, unfortunately, is not operational – it does not provide reliable tools for separating the living and inanimate). How, following the proposed conceptual tools – the concept of strong AI or Artificial General Intelligence (AGI) and related concepts, to evaluate applied results (for example, how, in terms of strong AI or AGI, to evaluate the expected results of the formed Russian state program for the development of AI, how, in fact, to make sure (to "measure") that it is a "strong" AI or AGI)?

Formally speaking, the concept of Strong AI since its introduction into use by J. Searle and R. Penrose to date has not received an accurate (operational – see above) definition. Indeed: even, it would seem, by that time (see the famous work [11] by J. McCarthy and P.J. Hayes, which was published in 1969) the already generally accepted pare of words Artificial Intelligence required clarification on both its first and second components. Formulating the task of design and developing ideas about intelligence, J. McCarthy and P.J. Hayes highlighted two priority areas of research – epistemology (understood as the formation of a system of knowledge necessary for solving problems using computer systems) and the development of heuristics (understood by them as "tools" for generating new knowledge – constructive means/procedures for problem solving). Over the past half century, impressive results have been achieved in both of these areas. Over the past half century, impressive results have been achieved in both of these areas. However, things are much worse in terms of a detailed comparison of the capabilities of natural (NI) and artificial intelligence (AI): the existing ideas about some of the important functions of natural intelligence (for example, about the organization of intuition, the nature of goal-setting, etc.) today, unfortunately, are still characterized by approximately the same level of "transparency" as 50 years ago. As a result, attempts to compare the capabilities of NI and AI in these positions, as before, remain practically outside[3] the scope of scientific knowledge (and certainly – applied). Due to the indicated context, reliable of understanding the additional characteristics of strong (AI), even taking into account purposefully accentuated parallels between *strong* and *general* (cf. the above quote from [11], for example, with comments on the term general AI in [6], etc.) still does not remove the need to give (or at least – to look for) an accurate operational definition of the concept of strong AI.

3. AI as a *basic research* problem area

From the point of view of the authors of this work, an approach that considers AI as a scientific and practical direction (see, for example, [12]), in which the focus on solving specific applied problems in specific subject areas is linked to conducting the necessary fundamental research (*academic* and *basic* – [13, 14], etc.), seems more productive.

The fundamental scientific (both in *academic* and *basic* senses) part in AI research and development today cannot be called adequately developed. Indeed, let's compare the current situation in the field of AI with the current state of affairs in the already "established and well-formed" sciences. Let's turn to the example of physics (including its applications in engineering): there is an established system of concepts (terminology), generally recognized (and commonly used) mathematical models and methods, an "established" system of descriptions of the surrounding reality (analyzed subject areas), etc. Unfortunately, there is clearly no such state in the field of AI today.

Nevertheless, today we can point out a number of noteworthy attempts to move towards solving the problem under discussion – building AI as a field of scientific and practical research and development. Here are some examples.

Studies of the so-called human cognitome enjoy overwhelming popularity in the world today (see, for example, [15], etc.). This problem interacts organizationally with AI research along the "vector"

human brain ⇒ cognitive research ⇒ AI

Despite the attractiveness of such an approach (see, for example, [16, 17], etc.), at the moment, the question (formulated for a long time): "*Is there any confidence that we will be able to know the brain at the appropriate level of depth of understanding of problems and effects*?" – remains without an exhaustive answer. In other words: is there any confidence that studies of the structure of the human brain will make it possible to understand its functions such as the ability to reason, the ability to evaluate the results of conclusions, arrange them by significance, etc.?

[3] A rare example of an exception here, apparently, can be considered the problems of analyzing the philosophical aspects of correlating the capabilities of NI and AI.

4. A view on AI as a set of five system-forming technologies

Another fairly common approach is the idea of AI as a combination of five (system-forming) technologies: technical vision, natural language processing, speech recognition and synthesis, decision support and future (perspective) AI methods. It is this view of the "topology" of AI as an area of managerial decision-making that determines today the choice of priority areas (so-called perspective and promising products and services) for financing for the next 5-10 years. The task formulated at the same time is to present competitive (so-called "champion") solutions on the world market, naturally requires clarification: and how exactly to ensure the selection of "champion" results? At the same time, the typical answer to this question boils down to the following scheme: champion results will be based on champion technologies, those, in turn, will "grow" from the "champion" know how that will arise in start-ups! And where is the ecosystem for goal-oriented research and development, which allows you to effectively select promising and perspective groundwork for start-ups? (An example of such an infrastructure is the ecosystem of Barclays Bank and the Eagle Labs community [18], which has currently provided the UK with leadership in Europe in terms of the number and productivity of AI startups).

5. AI as a field of scientific- and practical-oriented research and development

However, the discussed problems (AI as a field of scientific and practical research and development) can be "entered" and "in another way". Based on phenomenological ideas about intelligence, it is possible to outline the range of abilities of natural (human) intelligence. This allows us to form (phenomenological) ideas about ideal (theoretical) intelligence and exact epistemology ([19], see also Annex) and further focus on studying, simulating (modeling by computer means) and strengthening (by means of AI systems) the intellectual abilities of natural intelligence.

One of the obvious advantages of this approach is the ability to separate *intellectual* and *non-intellectual* in a reasoned way in applied solutions and systems. Thus, the boundary between computer data analysis (AD) and intelligent data analysis (IDA), if we take into account the phenomenology of natural intelligence, can be built on the basis of an assessment of the ampliativity (the term of C.S. Peirce [20, 21], characterizing the generation of new knowledge from existing data and knowledge) of the results of computer data analysis.

Thus, obtaining new knowledge in the process of data and knowledge "processing" by means of computer "tools" turns out to be a system-forming characteristic of AI as a field of scientific and practical research and development. The critically important components of such a "view" on the architecture of scientific research and applied developments in the field of AI thus turn out to be the representation of knowledge and the formalization of reasoning (see, for example, the ideas already mentioned above about the actual problems of AI, formulated by the "founding fathers" of this field of knowledge and technology J. McCarthy and D.A. Pospelov).

Moving "deep into" the AI concept "architecture" described in this way, we will naturally have to switch to

– methods and means of knowledge representation, studying and using the descriptive (expressive) capabilities of problem-oriented knowledge representation languages designed for computer applications (taking into account the needs of specific subject areas);

– clarification and development of ideas about reasoning implemented by computer means (allowing for the search and selection of premises relevant to the purpose of reasoning, the next step is to implement the actual "calculations", and then – an assessment of the sufficiency of grounds for accepting the results obtained).

Further, it seems appropriate to move forward to the study of the dynamics of changes in the initial analyzed data and in the structure of empirical regularities generated on their basis: to analyze the sequences of expanding databases of facts accumulating more and more empirical data on the effects and phenomena under consideration; to study the properties of open empirical theories replenished with new data, to isolate and investigate the effects of stability – "heritability" – generated empirical regularities (i.e. "heritable" empirical dependencies) when replenishing databases of facts with new information, etc.. It is on this path that opportunities appear to create workable IDA tools for working with Big Data. As an example of a critically significant methodological "challenge" that we have to face when analyzing Big Data, let's pay attention to the need to develop a non-classical theory of truth. Classical ideas about the reliability of computer data analysis systems are usually based on methods of statistical analysis of accumulated information. However, in the situation with Big Data analysis, their application may be incorrect: in the conditions of the *Open* effect that is inherent to Big Data, traditional ideas about reliability formed on representative samples of precedents may not be applicable, because in the conditions of openness of collections of analyzed data, the classical concepts of the general population and the representativeness of samples from it turn out to be irrelevant and inapplicable.

6. Conceptual map of AI as an area of *basic research*

Thus, if we look at the entire "conceptual map" of AI as an area of basic research and development from the positions just formulated, the following "picture" may be formed:

- In contrast to the already "established (well-formed)" fields of scientific knowledge and technology (see, for example, physics and its modern applications in engineering) AI has yet to form a *generally accepted* system of concepts, approaches, methods and "tools". However, on the way to this goal, it seems natural to take into account the experience of other fields of knowledge, where some kind of "test" objects and problems have been identified for a long time. For example, in biology it is the study of specific phenomena and effects on the example of a fruit fly, for physiologists it is the well-known "Pavlov's dog", etc. It is in this "set" of test objects that it is proposed in the field of AI to choose the problem of formalization of research as a "polygon" that allows us to judge the potential and possibilities of the approaches, models and methods being created.
- The most attractive area of application of AI systems (and, first of all, those generating new knowledge of IDA systems) are such subject areas (as well as classes of tasks and research problems) where knowledge is poorly formalized, but data can be structured. So, obvious examples of such areas can be the life sciences (medicine, ecology, ...) and social behavior (including sociology), as well as management. At the same time, in classical natural sciences (physics, chemistry, etc.), as well as engineering disciplines (for example, technical diagnostics, the theory of reliability of machines and mechanisms, etc.) in situations of multi-causality (where the occurrence of the analyzed phenomenon or effect is due to the causal effects of a large number of factors of "influence"), even the successful "packaging" of available information about the object of research into a system of balance relations (for example, a system of equations describing certain invariants – conservation laws, etc.) is difficult (in particular – in terms of assessing the degree of adequacy of the model of the analyzed phenomenon generated in this way) the task. And the question of the correct solvability (analytical or numerical) of the resulting system of relations may generally be beyond the limits of the possibilities actually available today. It should be noted separately that the "phenomenological" version of the description of subject areas proposed here for the application of AI methods and "tools" makes it possible to eliminate the problem of completeness of the "lists" of promising AI applications massively offered today (see, for example, [6, 22], etc.).
- The main products of AI as a field of *basic* research and development are theoretical constructions (mathematical models, methods and algorithms) that are implemented in corresponding intelligent computer systems and intelligent robots.
- Main priorities for AI research and development today are [18, 23, etc.]:
  i. development of partner human-machine AI systems (interactive mode of interaction between an expert and an intelligent computer system),
  ii. development of mathematical methods and tools of the so-called *symbolic reasoning* (which allow the integration of cognitive procedures in systems of automated formation of empirical theories designed to provide situational awareness for decision makers, as well as procedures for analysis and decision support in process-real-time management problems and tasks),
  iii. robots' intellectualization.

- In part (i) – see above – special attention is drawn to models and means of forming *open* (reconfigurable with the getting of new data) empirical theories[4], as well as means to formalize effective heuristics. As a consequence, the classical problems of knowledge representation and formalization of reasoning in computer systems are relevant again. (And the ability of an AI computer system to generate new knowledge is ampliativity according to Ch.S. Peirce [20, 21, etc.] – has become a characteristic that makes it possible to clarify the grounds for the separation of IDA in the framework of computer data analysis as a whole).
- To check the ampliativity, the possibility of control (of assessing the sufficiency of grounds for accepting the results) is critically important. At the same time, the need to evaluate the results of IDA in empirical theories highlights the special role of a priori knowledge "embedded" in a computer AI system in the formation of its "cognitive tools". (As an example, we can give a range of possible ideas about causality implemented in the corresponding instrumental systems of computer AD: from procedural means of supporting work with balance models – see above – before, including, the formalization of causality as a binary or ternary relation). Here, in fact, the corresponding mathematical language and the "tools" of cognition described (expressed) by its means are first formed; then the analysis of the studied phenomena of the surrounding world by such "tools" of automated cognition is carried out; and then the acceptability of the results obtained is evaluated (i.e., the correlation of the knowledge obtained by *a priori* means with the analyzed surrounding reality).

What follows from all that has just been formulated above (i.e., how to make sure that – see above – the "boat" at least "floated")? Confining ourselves only to the conclusions of the highest level, it seems that it will be difficult to challenge and to reject the following two groups of considerations:

– perspective and promising "products" of AI as area of (*basic*!) research and development are (see, for example, [19], etc.) – theory (mathematical models, methods and algorithms), intelligent systems and intelligent robots. In such "products" theory and problem-oriented variants of specific applications are integrated. An example of such integration can be, in particular, diagnostic type tasks (see [24], etc.), where a general (unified) class of mathematical models, methods and algorithms can be applied in the fields of medical or technical diagnostics, combating fraud in banking and finance, identification and organization of countering computer attacks, etc. In the designated (*basic*-relying) context, inspecting the approach often proposed today to discuss the prospects of AI (see, for example, [22], etc.), where only the already named five technologies are the subject of attention (see earlier) we can conclude: unfortunately, the announced strategy do not provide indisputable arguments in favor of the success of our country's promotion to the position of world leaders in the field of industrial use of AI systems and solutions;

– fundamental research plays a special (and sometimes critically important) role in the success of the application of AI solutions and systems (both in *academic* and *basic* "nominations"). The recommendations of the experts here (see, in particular, the Report [23] of the Commission of AI Experts to the US Congress) are unambiguous: the lack of modern models and methods in the field of AI, together with organizational and managerial errors in addressing financial support (including – insufficient funding of basic research, leading to the transition of capable and high-experienced researchers from the academic sphere to business and industry, which de facto leads to an even greater narrowing of the field of future generation new fundamental developments) generate critically significant risks for national security even of such industrialized countries as the United States.

7. Conclusion

So, let's decide: "whither do we sail?" (to *master budgets* or to ensure the *global competitiveness* of domestic AI approaches, methods, technologies and products). This will help us to responsibly "name" the "boat" (see [25, 26]) under discussion and move in a direction that can really lead us to success.

[4] Compare, for example, with the mathematical technique [19 et al.] of knowledge representation in the form of *Quasi-Axiomatic Theories*, where the original version of IDA is implemented (implementing a synthesis of cognitive procedures of empirical induction, reasoning by analogy and generation of abductive explanations of the results obtained).

7.1. Annex. Short glossary to explain the proposed "name" of the "boat"

7.1.1. The exact epistemology

The ideological basis of the JSM Method of Research Assistance and Support (JSM-RAS method) is the creation of a system of concepts of exact epistemology (EE) and corresponding heuristics for solving research problems and practical tasks of AI.

The central idea of EE is the definition of *theoretical (ideal) intelligence* (TI) and the corresponding main product of AI – *an intelligent system*.

So, exact epistemology (EE) is a discipline in which the interactions of the *cognizing subject* and the corresponding *object* are investigated by means of *heuristics* and *logic of reasoning* that generate *new knowledge* and its *acceptance*.

The content of the concept of EE and its means are:

An example of numbered list is as following.

1.1. research methodology,

1.2. logic of reasoning and ampliative conclusions (plausible conclusions by which knowledge is generated that is not directly contained in the premises),

1.3. verification and falsification of research results,

1.4. means ("instruments", procedural "tools") of hypotheses generation,

1.5. means of detecting empirical regularities (patterns, heritable empirical dependencies),

1.6. non-singular means of accepting research results – two scales of quality assessment, both reasoning and hypotheses,

1.7. heuristics of obtaining new knowledge from source knowledge and data,

1.8. study and generalization of the experience of experimental application of heuristics.

7.1.2. Theoretical Intelligence

The idea of an "intellectual process" is clarified by postulating a list of abilities that characterize natural intelligence (NI) such that it is understood as *theoretical (ideal) intelligence*.

The intellectual process is characterized by the following set of intellectual abilities (2.1) – (2.13):

(2.1) detection of the essential in the data,

(2.2) generation of the "*goal* $\Rightarrow$ *plan* $\Rightarrow$ *action*" sequence,

(2.3) selection of premises relevant to the goal (purpose) of reasoning,

(2.4) reasoning ability: deducing consequences from premises,

(2.5) synthesis and interaction of cognitive procedures (for example: induction, analogy, abduction with subsequent application of deduction),

(2.6) reflection – assessment of knowledge and actions,

(2.7) the ability to explain – to generate the answer to the question "why?",

(2.8) argumentation in decision-making,

(2.9) cognitive curiosity and the ability to recognize,

(2.10) the ability to learn and use memory,

(2.11) the ability to integrate knowledge to form concepts and theories,

(2.12) the ability to clarify unclear ideas - converting them into concepts,

(2.13) the ability to change the knowledge system when obtaining new knowledge and changes in cognitive situations.

Intelligent abilities (2.1) – (2.13) characterize the intellectual process formed by the interaction of the thought process (these are abilities (2.1), (2.3), (2.4), (2.5), (2.7) – (2.10)) and the cognitive process (these are abilities (2.2), (2.6), (2.11), (2.12), (2.13)).

Characterization of the intellectual process makes it possible to define the *theoretical (ideal) intelligence* (TI).

Definition 1. TI is a system of knowledge, the set of intelligent abilities (2.1) – (2.13), forming the intellectual process and higher mental functions (HMF), where HMF are intention, intuition, initiative, imagination and reflection (HMF enter the subjective world of the individual (SWI)).

7.1.3. Intelligent systems

The definition of the concept of "intelligence" necessarily leads to the definition of computer systems that are *intelligent systems*, which means the end of the irresponsible use of the term "intelligent". The constructiveness of the cognizing subject means the possibility of partial algorithmization of the intellectual process and its automated support for obtaining new knowledge (knowledge discovery) regarding the object of cognition. For this purpose, the definition of an *intelligent system* (IS) is introduced.

Definition 2. An *intelligent system* (IS) is a computer system such that it has an architecture defined below and implements in automatic and interactive modes an *intellectual process* (IP) represented by intelligent abilities (2.1) – (2.13): *IS* = (*BF*, *KB*) + a *Problem Solver* + *Comfortable Interface*, where *BF* is a database of facts, *KB* is a knowledge base, and the *Problem Solver* has three modules – a *Reasoner*, a *Calculator* and a *Synthesizer*.

Thus, IS is a *human-machine partner system* representing an automated *cognizing subject* of precise epistemology (PE). Since the "brain" of the IS is the Problem Solver, and most importantly its "hemisphere" is the *Reasoner*, the applicability of the Problem Solver is determined by its correspondence to the subject area – the object of cognition.

7.1.4. Artificial Intelligence

Definition 3. Artificial intelligence should be understood as computer implementations of means of exact epistemology, which are means of knowledge representation and logic of reasoning.

Therefore, *AI* is a *scientific and practical discipline* of automated support of the *intellectual process* characterized by *Df*.1. The main product of AI are *intelligent systems* (IS) corresponding to *Df*.1 of the Theoretical Intelligence. There are also two other AI products – *AI systems* and *AI robots*. AI systems are any computer systems such that they use known AI procedures to solve specific tasks, for example, neural networks (they implement only two intelligent abilities (2.9) and (2.10) – recognition and learning, respectively), decision trees, reasoning based on precedents, etc.). Due to the above, AI systems are limited in supporting and replacing the intellectual process formed by abilities (2.1) – (2.13), and therefore they are not intelligent systems corresponding to the definitions of *Df*.1 (for TI) and *Df*.2 (for IS).

AI robots are a synthesis of three subsystems – Intelligent Systems, a subsystem of sensorics that provides communication with the outside world, dynamically expanding the database of facts, and mechatronics that implements action after a decision is made by a Problem Solver reacting to information from the outside world. Thus, the general scheme is as follows: *AI-robot* = *IS* + *sensor unit* + *mechatronics*, where *IS* + *sensor* unit is the *cognitive* subsystem of the AI robot.

In IS, the *phenomenology of intelligence*, characterized by the abilities (2.1) – (2.13), is imitated and enhanced. In IS, imitation and reinforcement of only *rational behavior* is permissible.

Definition 4. *AI* is a scientific and practical field of imitation and enhancement of the *intellectual process* (according to *Df*.1) and *rational human behavior* through (by means of) AI systems, intelligent systems (IS) and AI robots; these imitations and amplifications of the intellectual process implement the postulates of EE (see 1.1 – 1.7 earlier), on the basis of which *intelligent data analysis* is carried out: domain modeling, detection of empirical regularities (patterns) and reasonable decision making using heuristics for obtaining new knowledge.

7.1.5. JSM Method of Research Assistance and Support (JSM-RAS Method)

The current version of the JSM Method (JSM-RAS Method) is a formalized heuristic for supporting research using intelligent analysis of open sets of empirical data. The original version of the JSM Method of automatic hypothesis generation has undergone significant changes. The procedures of JSM Method – inductive rules of inference generating hypotheses about causes, and rules of inference by analogy generating hypotheses about predictions – were ordered. These rules form distributive lattices that characterize possible reasoning strategies. These strategies are adequate to the original fact bases of computer systems if the knowledge representation is informative about the subject area used and the corresponding tasks (see [19]).

The important section of [19] – "On the heuristics of JSM-research", which formulates the principles and procedures for detecting empirical patterns in sequences of expanding databases of facts of intelligent systems. JSM-reasoning, which implements the interaction of induction, analogy and abduction (acceptance of hypotheses by explaining the bases of facts), is applied to sequences of extensible bases of facts; the result of these applications may be the discovery of the preservation (stability) of hypotheses about the causes of the studied effects and their predictions through these causes. The discovery of this stable hypotheses means the generation of knowledge about empirical regularities (patterns), which qualifies as knowledge discovery – the goal of knowledge discovery. This process forms the JSM-study – the second stage of the application of the JSM Method of automatic hypothesis generation, which caused a change in its name, because the JSM Method is now naturally called the "JSM Method of automated research assistance and support" (JSM-RAS Method).

With respect to the new content of the JSM Method as a research support method, we will clarify the terms "*method*" and "*research*" used.

By *method* we mean a set of principles and procedures such that their application forms *research*, the result of which is the acquisition of new knowledge used in the formulation of theories (including open ones)[5].

By *research* we will understand the solution of problems by means of a *method* expressed in a language with *descriptive* and *argumentative* functions [28], such that its application generates *empirical regularities* (patterns), and its results allow falsification.

It is obvious that research is a pattern of *rational behavior*, and therefore the ability of a computer system to conduct and support research means its *intelligence*, realized through imitation of abilities (2.1) – (2.13), and, consequently, the possibility of using IS (according to *Df.*2).

The new version of the JSM Method – the "JSM Method of automated research assistance and support" – is primarily a *method* in the sense defined above, since it uses formalized languages in which there are expressive descriptive means for determining the similarity of facts and argumentative means for formalizing the rules of plausible inference (inductive inference, inference by analogy and abductive inference of the second type [27]). The rules of plausible inference of JSM reasoning have built-in falsifiers to refute candidates for hypotheses. In addition, the new version of the JSM-RAS Method has the means of detecting empirical regularities (patterns) – their extraction from sequences of expandable databases of facts generates *new knowledge* that forms the knowledge bases applying intelligent systems such as JSM – IS-JSM). Consequently, the JSM-RAS Method implements *research* in the sense defined above, and therefore simulates and supports rational behavior in two modes - automatic and interactive. This means that IS-JSM are partner human-machine systems, and their obvious scope is the sciences of life and social behavior due to the peculiarities of the structure of their knowledge, which requires the application of heuristics to open and extensible data.

It follows from the above that the JSM Method is not only a collection of data analysis procedures similar to machine learning tools, it is a means of *automated cognition* in the information society.

Automated simulation and reinforcement of research in JSM-RAS method is implemented by:

1. sequences of expandable arrays of facts (databases of facts) to which reasoning is applied,
2. discovery of empirical regularities,
3. replenishment of open theories (quasi-axiomatic theories [27]) by means of empirical nomological statements representing empirical regularities [27].

Special heuristic of the formation of open theories, representable in the knowledge bases of IS-JSM, is used in JSM-RAS Method. This heuristic operates under the conditions of its applicability, which are

– the formalizability of the similarity relationship of facts,
– the presence of positive and negative facts of the studied effects in the databases of facts,
– as well as facts with an estimate of "uncertain", proposed for prediction,
– the existence of causal relationships in the databases of facts for positive and negative facts, respectively; the existence of empirical regularities (heritable empirical dependencies) in the sequences of expandable databases of facts for cases of fruitful (bringing results) JSM-research.

[5] In the JSM-RAS Method, the idea of an open theory is refined through the concept of a quasi-axiomatic theory [27].

Thus, if there are conditions for the applicability of the JSM-RAS Method, then in the case of its fruitful (bringing results) implementation, JSM studies satisfy the postulates 1.1 – 1.7 (see earlier), which are the basis of the heuristics of the JSM Method, the result of which is the formation and support of quasi-axiomatic theories represented in the databases of the IS-JSM facts, and the IS-JSM themselves implement *intelligent data analysis* (as a result generating a new knowledge). Its result is the modeling of the subject area, represented in sequences of extensible databases of facts, and the discovery of empirical regularities (patterns, heritable empirical dependencies). The presence of empirical regularities discovered by means of IS-JSM together with the conditions of falsification of candidates for hypotheses built into predicates (used both in the rules of inductive inference and in the rules of inference by analogy) form an enhanced criterion for the demarcation of sound knowledge other than unscientific (unsubstantiated) knowledge [28].

The JSM-RAS Method has not only a theoretical justification due to its compliance with the postulates of EE (see 1.1 – 1.7 earlier), but it is also justified practically due to the experience of using intelligent systems (IS-JSM) with Problem Solvers implementing JSM-reasoning and JSM-research in various subject areas of life sciences and social behavior.

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