Results of the Information and Cognitive Approach in Assessing the Impact of Investments on Sustainable Agricultural Development

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Abstract: The aim of this paper is to study the impact of investments on the results of agricultural activities using the author's information and cognitive mechanism of adaptive control for open systems. We propose to achieve this goal by studying the functioning laws and developing the agro-industrial complex (AIC) as an open system (OS), which interacts with the surrounding environment, balances its effects, using the exchange of matter, energy and signals (energy pulses) with the environment. The successful functioning of the OS in typical situations and its development in unusual situations is provided by the freeze-framework of the adaptive control mechanism (ACM) of the OS. It calculates the matrix of typical knowledge (MTK) based on the system-cognitive analysis implemented by the Eidos system. In typical AIC situations, a computer can create this matrix automatically, where it has a form of a continuous generalized mathematical control model (GMCM). In unusual situations, the MTK is created with the help of a human manager. It is partially optimized or fully adapted to the new real conditions.

1 INTRODUCTION

The main focus of this research is improving the management of the agro-industrial complex (AIC). The subject of the research is the use of the latest achievements of science and information technologies (IT) to increase the payback of investments in the agro-industrial complex in its functioning and development, in a fast-changing socio-economic situation. The aim of the research is to develop mathematical models and methods for their effective implementation in the agro-industrial complex based on the integrated use of the advantages of natural and artificial intelligence (NI and AI) (This approach allows us to effectively simulate human cognitive functions (including self-learning and finding solutions without a pre-set algorithm) and quickly get the desired results comparable, at least, with the results of human intellectual activity. At the same time: a) the investments should take into account the AIC interests, as well as interests of the investors (Laptev and Lutsenko, 2002) in the agribusiness ACM it is necessary to use the next triad: KNOWLEDGE-ABILITIES-SKILLS, linking together the functioning and the development of the OS (Anokhin, 1978; Grahen, 2006; Evreinov, 1981) the MTK must use the requirements of the natural laws of dialectics and the provisions of the theory of functional systems (TFS) (Engels, 1986), , The Decree of the President of the Russian Federation, October 10, 2019 No. 490 "The development of artificial intelligence in the Russian Federation". In Russia, the question of the need for a scientific breakthrough in improving the efficiency of the ACM in the agro-industrial complex has become acute. So far, the best ACM for the OS is the control mechanism of human activity. It is a specific device that determines the order of certain activities of the human body as an OS. Namely: a) the human body focuses on getting a useful adaptive result (survival); b) its receptors work accurately, as they fix the effects from outside and from internal organs; c) rapid transmission of control signals (energy pulses or chemicals) from the receptors to the

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central nervous system (CNS), spinal cord and brain; d) formation and comparison of freeze-frame models of the current model $Y_k(x_n)$ with typical freeze-frames of the MTK $Y_m(x_n)$; e) when they coincide, the brain generates a spectrum of resonant frequencies $\omega_1, \omega_2, \ldots, \omega_q$ which, according to the law of resonance (the response of all functional elements (FE) to ω_q), triggers the mechanism of (collective) synchronous operation of these q FE in the human body, thereby ensuring its survival in the current freeze-frame $Y_k(x_n)=Y_m(x_n)$ (otherwise, it acts by intuition no matter what happens next); e) performs selective association of neurons in a neural network, which in the shortest way brings the spectrum of control signals generated by the brain to the desired q functional elements; g) ensures the friendly team work of these FE, i.e. the implementation of a specific behavior model of the human body with the proper "system effect". Only a human uses the ACM OS described above in their activities. Through a series of typical freeze-frame interactions with the external environment, he exchanges matter, energy and signals with it, and he also uses his ACM skillfully, both for an instant correct reaction in a typical situation, and for adapting his behavior to changes in the surrounding environment. This clearly shows the adequate response of the human body of a person who considers to be a creator to changes in the external environment (i.e. the world).

The need for this research is due to the urgent practical need for rapid radical improvement of the functional and the adaptive capabilities of the OS in any situation (including the agro-industrial complex), whereas the significance and the scientific novelty of the research consist in the advanced development of new theoretical provisions and working tools that really improve the management of their effective functioning and development. The solution to this problem is in the construction and use of MTK, which is a continuous generalized mathematical control model (GMCM) of the $Y(x)$ open system, in which its variable discrete coefficients of mathematical models of control $Y_m(x_n)$ (CMMC) are successfully used by the OS for its survival, moreover, with a constantly decreasing real time interval Δt_n, which was supposed to be the implementation of the latter. This study is devoted to the formulation and solution of this problem.

2 RESEARCH METHODOLOGY

The term “mathematics” means "exact knowledge". Mathematical description of world events, including the AIC is based on a sophisticated game of its continuous and discrete things and can be easily displayed in mathematical models as various functions. The latter are represented as "stiff" (unchangeable) and "soft" (changeable) mathematical models. It should be noted that the absolute laws of the World are (Anokhin, 1978) , (Laptev at al., 2019), (Engels, 1986): the law of the space and time continuum of the motion of matter and the three laws of the dialectic of nature: 1) mutual penetration of opposites (or more precisely, their balanced interaction); 2) the transition of quantity into quality and back; 3) negation-negation (a new definition of the interaction of opposites), interpreted by Hegel as the laws of thought (Laptev, 2013; Engels, 1986). From the first law of dialectics the principle of sequential quantization follows or ut also may be called a freeze-frame balanced interaction of opposites (nature and human) (Takhumova, 2018).

Therefore, living creatures and artificial open systems must fit into the framework in order to obey these laws, because only in this case they will ensure their survival in real time. These laws of dialectics of nature, based on the principle of primacy of matter and secondary consciousness (reflecting the interaction of a person with the surrounding environment in our brain, in the form of freeze-frame models), only confirm the fact that matter and mind are just a convenient way found by nature, linking a sequence of "quantum" (freeze-frames) of events together.

Natural intelligence (NI) (or human intelligence) appears only when the ability to make a probabilistic choice that ensures its survival (preservation of integrity) is required for the survival of the OS. The term "system" is used when referring to something put together, but it does not always refer to the criteria by which its components have been assembled, ordered, and organized. Whereas the ultimate goal of any OS is its survival in any current freeze-frame $Y_k(x_n)$ by balancing it with the counteraction $Y_m(x_n)$, which means getting a positive final result (+FR). If this impact is typical $Y_k(x_n)=Y_m(x_n)$, then the "stiff" $Y_m(x_n)$ model starts working automatically, giving this effect needed balance. In the case of any atypical impact, the OS launches one of the "soft" models with the hope that its implementation can save it from destruction.

The TFS is based on the following postulates:

1) the result of behavior is the leading objective indicator of the FS activity;

2) self-regulation is the principle of dynamic self-organization of the FS;

3) isomorphism (uniformity of organization) of FS of different levels;

4) representation of continuous OS interaction with the World through a sequence of freeze-frames;

5) the FS hierarchy;

6) multiparametric interaction of the FS on final results;

7) sequential dynamic interaction of the FS;

8) selective maturation of the FS and its parts in the course of life of the human body.

Studying the models of a calculator and a calculating team (table 1) made it clear that an OS can only survive if the condition $Y_k(x_n)=Y_m(x_n)$ is met. At the same time, it became obvious that the distributed or concentrated model of a calculating team is the main tool that provides a breakthrough in the growth of high-speed computing. It turned out that the desired performance of "system effect" $Y_m(x_n)$ in the OS can be achieved in the same way, namely, by synchronous (parallel) operation of its executive /functional/ elements (FE) (Evreinov, 1981).

Table 1: Comparison of models of a calculator and a calculating team.

Calculator model	Calculating team model
sequential execution of operations; fixed logical structure of calculations; structural heterogeneity of elements and connections; has a performance increase limitation	parallel execution of operations; variable logical structure and structural uniformity of the elements and connections; has no performance increase limitation

In 1957, academician Kolmogorov (1957) proved the theorem which stated that the representation of continuous functions of several variables in the form of superpositions of continuous functions of one variable and addition. It postulates that any n-dimensional continuous function defined on an n-dimensional unit cube can be represented as a series of 2-dimensional discrete functions defined on the segment [0, 1].

$$Y(x_1, x_2, ..., x_N) = \sum_{n=1}^{2N+1}(g_n \sum_{m=1}^{M} h_{mn}(x_m)) = \sum_{m=1}^{M}(\sum_{n=1}^{2N+1} h_{mn}(x_n)\Delta x_n) \quad (1)$$

In his book (Grahen, 2006) it is convincingly stated that "concrete mathematics" stands for CON-tinuous and dis-CRETE mathematics, that is, as a unity of continuous and discrete mathematics. Its purpose is to teach the reader the technique of operating with discrete objects, similar to the technique for continuous objects. The authors, avoiding any generalizations, use concrete examples to teach the reader how to study discrete-continuous systems in the world around us. In 2002, Professor E.V. Lutsenko, without relying on the above scientific achievements, independently developed the system information theory (SIT). Within the framework of this theory, he developed a technology for its application, which he called automated system-cognitive analysis (ASC-analysis) and implemented it in an outstanding software package called "Eidos. With its help, any manager can recognize a typical current situation and launch an appropriate mechanism for the company's survival. MTK allows the manager to establish real connections and their strength for all of its parameters and use this knowledge to achieve the desired +FR. All the above information was described by Lutsenko (2002), where he also indicates the traditional procedures of the ASC-analysis:

- conducting cognitive-target structuring of the subject area;
- formalization of the subject area (development of classification and descriptive scales and gradations, training sample);
- implementation of synthesis and verification of statistical and system-cognitive models, description of the technology for working with the Eidos software complex, which provides the solution of the task. In our case, it is a solution to the problem of studying the impact of investment on the results of agricultural activities. The Eidos system is presented in open access mode, on Professor Lutsenko's website (http://lc.kubagro.ru/aidos/_Aidos-X.htm).

But in the Eidos system, there is no mechanism for creating a "system effect" due to the synchronous operation of the desired number of FS in the OS in one particular freeze-frame, especially in the case of situations atypical for the Eidos system. Nevertheless, in live OS their survival is ensured by creating the necessary "system effects". In other words, the human brain manages to make different FS work synchronously in a particular *freeze-frame and thus provide the necessary* "system effects". The answer turned out to be very simple – due to the natural use of the law of resonance and fractals (communication systems) in living OS, which simultaneously bring the frequency spectrum of the control signal $\omega 1, \omega 2, ..., \omega q$ to q of the executive FS, which are working synchronously. Surprisingly, the fractal called "Serpinsky's Triangle" copes with this task easily. As a reliable communication system, it is constructed by comparing the elements of the "Pascal's Triangle" using the module 2 ($a \equiv b \pmod 2$). The brain sends its

"own" control signal to all functional elements involved in the current freeze-frame, but not separately; it has the form of their spectrum. This spectrum includes specific frequencies that coincide with the proper frequencies of the desired FS, and as they are included in the collective activity, they create the desired "system effect" together, ensuring the survival of the OS. According to the law of resonance, each FS "responds" only to a frequency that coincides with its own circular frequency. Upon receiving such a signal, any FS is instantly involved in the joint collective work of the FS team, whose own frequencies are included in the spectrum of frequencies sent by the brain. Currently, there are very good software tools for processing such discrete signals. Any signal is a message that is uniquely recognized in the human body due to its decomposition into a complex Fourier series. To calculate individual eigenfrequencies of the FS, signalers use a discrete Fourier transform (DFT), which is processed on computers using the fast Fourier transform (FFT) program.

Currently, problems 1, 2, 3, 4 and 5 of this study have been successfully solved. In this regard, it should be noted that the human brain effectively uses both typical $Y_m(\Delta x_n)$ and current $Y_k(\Delta x_n)$ models in its operation. The M number fixes the total number of typical models stored in its memory; $2N$ is the total number of identical segments $\Delta x_n=n\ (x_{n+1} - x_n)/2N$ for the interval [0, 1]; K is the number of the current model $Y_k(\Delta x_n)$, where $K>>2N$. If $Y_m(\Delta x_n)=Y_k(\Delta x_n)$ matches, it means they are balanced, and the OS maintains its integrity and survives. When $Y_k(x_n)\neq Y_m(x_n)$, the OS most often dies.

The human body as an OS is a highly flexible executive mechanism. Its organs, which are FS and FE, "respond" only to the spectrum of control signals $\omega 1,\ \omega 2,...,\ \omega q,\ q$ circular frequencies of which coincide with their own circular frequencies, coming from the brain via neural networks. Only in this case, the OS creates the necessary "system effects". This point, unfortunately, has fallen out of the field of view of management specialists, whereas signalers use it very effectively. They are the ones who effectively use their Fourier series decomposition, discrete Fourier transform (DFT) and fast Fourier transform (FFT) when processing pulse signals. In this case, the FE involved in creating the desired "system effect" must be taken into account. Under these conditions, the system theory of information (STI) (*Laptev* 2013) allows (using its tool which is the "Eidos" system) to calculate the amount of information quickly (with a plus or a minus sign, or equal to zero) contained in the fact of the impact of any factor on the OS or vice versa of the OS on the external environment. Moreover, it allows us to judge which structure can go to some future state, desirable (target) or undesirable. And the amount of information reflects the impact of a specific factor on the OS or the environment, and the sign shows if it promotes or hinders the OS in certain condition. When several factors affect the OS, their effect on its state can be calculated as the sum of the effects of each of them. At the same time, it turned out that no one has yet fully used the dialectic of nature as a general theory of the functioning and development of open systems.

The use of methods for solving the 3rd, 4th and 5th problems in the study has convincingly confirmed the need for their advanced solution. We have obtained practical confirmation of the correctness of a clear goal for a reasonable investment in the agro-industrial complex and their competent use. Together with the latest scientific and practical achievements in the field of natural and artificial intelligence, concrete mathematics, technologies of system-cognitive and spectral analysis, this approach has fully justified itself. At the same time, it was confirmed that it is necessary to include software tools in the Eidos system that ensure the creation of proper "system effects" from a well-organized collective work of the FS of the OS in a particular situation. The method of solving the 5th problem justifiably includes solving a number of tasks to study the impact of investment on the results of agricultural activities, including cases of typical and atypical situations that require a person to display extraordinary intellectual and inventive abilities. It involves describing the technology of the author's information and cognitive ACM in the OS, taking into account the complex use of the technology of system-cognitive analysis, the theory of Fourier series, discrete and integral Fourier transform and the law of resonance. The acquired experience allows us to reasonably assume the successful solution of the remaining tasks.

3 MAIN RESULTS

The expected result of our research will also consist in finding a new way to resolve cognitive dissonance – psychological discomfort of the manager caused in his mind by the clash of conflicting ideas about ways to solve the problem of effective functioning and development of the agro-industrial complex in the new external investment environment. With its help, multiparametric, dynamic, non-linear OS, such as AIC with complex structures, can successfully function and develop in typical and atypical freeze-

frame interactions with a changing environment. To solve these problems, in the future we a going to develop the principles of automatic operation of all private mathematical models of agribusiness management, optimization of some of them, and, finally, a complete recalculation of the MTK ACM of the OS, ensuring its effective functioning and development in the new conditions. The scientific significance of the expected results in the fact that for the first time the improvement of the mechanism of adaptive management of the agro-industrial complex will be implemented on the basis of adaptive interaction of generalized and partial mathematical models of its management (in full accordance with the laws of modern Economics). The adaptive model of the agro-industrial complex will be implemented by the ACM of the OS as an application to the Eidos-ASA computer system.

Step-by-step solutions to each of the tasks have already contributed to the results of the study, its scientific novelty and practical significance, while providing certain advantages over traditional approaches.

The principles of this section reflect their combined complex impact on the construction of more accurate standard mathematical models for complex, multiparametric and dynamic solar power plants for the AIC, including incomplete and noisy heterogeneous empirical data in them. The main idea of the proposed improvement of the mathematical method is to study the impact of investment on the results of agribusiness activities, using the freeze-frame system information theory (SIT) for any current situation, based on empirical data reflecting the interaction of the operating system with the changing environment of E (i.e. $OS_m \leftrightarrow E_k$), the integral value of the amount of information is calculated, that is, the qualitative characteristic of Y_m (Δx_n), due to the influence of various external and internal factors on it in the current *k*-th freeze-frame of interaction (during Δt_k). This allows the OS to divide $Y_m(\Delta x_n)$ clearly into non-overlapping classes. The integral characteristic of the current model $Y_k(\Delta x_n)$, is also calculated, and then, with an acceptable error in practice

$$\left|Y_k(\Delta x_n) - Y_m(\Delta x_n)\right| \le \varepsilon \quad npu \ \Delta x_n \le \delta \qquad (2)$$

We determine whether the $Y_k(\Delta x_n)$ model is typical or atypical for the current interaction freeze-frame with the Δt_k time interval. If yes, i.e. $Y_k(\Delta x_n) \approx Y_m(\Delta x_n)$, then the $Y_k(\Delta x_n)$ model is typical for the OS. According to this m typical model, a fast Fourier transform (FFT) program is launched, as it provides calculation of natural frequencies ωq for q FE, whose synchronous (parallel) operation will ensure the proper "system effect" that balances the external influence. If not, then in the case of $Y_k(\Delta x_n) \neq Y_m(\Delta x_n)$ the human brain will have to optimize one of the typical $Y_m(\Delta x_n)$ models by a creative process, and on its base it will start synchronous (parallel) operation of the required number of executive FE, with the hope that they have built a new typical $Y^{opt}{}_m(\Delta x_n)$ model. If this hope is not justified, it has to re-calculate all the standard models, taking into account new information about their generic parameters. If these actions fail, the OS dies immediately or gradually.

The nature has successfully tested the mechanism of adaptive OS management on a person. It is a very original device that determines the order of a specific type of human activity: a) obtaining a useful adaptive result of its behavior; b) the work of receptors, c) transmitting signals from receptors (in the form of energy impulses or chemicals) to the central nervous system (CNS), spinal cord and brain (where the matrix of information or typical knowledge of a particular person is stored, ensuring its successful survival in typical situations); d) selective association of neurons in a neural network that conveys control signals generated by brain to the desired functional elements (FE) of the body; e) effective collaboration of these FE that ensure the implementation of a specific typical or atypical OS behavior model, with the proper "system effect" which generally means human survival. In a changing world, people have learned to periodically refine their knowledge in a creative way and improve the mechanism for their effective application. This happens when constructing generalized and partial mathematical models of the ACM in the AIC). In their interaction, the places and roles of each subsystem of the executive mechanism are clearly defined, and a hierarchical control system is designated, which ensures the creation of various spectra of control signals and their corresponding "system effects". When creating a generalized mathematical model of the OS ACM and its propriate software, all these principles are used in a comprehensive manner (Polozhentseva, 2018).

All of the above confirms the successful solution of the remaining 6th, 7th, 8th and 9th problems. These tasks are listed below, along with how to solve each of them.

Task 6: formulation of requirements for the method of step-by-step research of the impact of investments on the results of agricultural activities in accordance with the goal; structuring and formalization of the subject area and development of classification and descriptive scales and gradations for data used in the MTK.

The solution to this problem is supposed to be implemented by a reasonable correction of the mathematical and software part of the "Eidos-ASA"system.

Task 7: synthesis implementation and verification of models of the impact of investments on AIC activities, identifying the limitations of AIC ACM and prospects of its development.

It is supposed to be solved by developing visual schemes and models of synthesis, verification of system-cognitive models of the impact of investments on the activities of the agro-industrial complex with the mandatory identification of real limitations inherent in the ACM activities of the agro-industrial complex and its development prospects.

Task 8: numerical solution of the problems of studying the impact of investment on the results of agricultural activities using the information and cognitive mechanism of adaptive OS management.

It is proposed to solve this problem by actively attracting future users to use the Eidos-ASA software tools. This allows them to develop the necessary skills independently in the presence of the developer to evaluate the impact of investments on improving the activities of their agro-industrial complex, as well as to create the desired "system effects" for them.

Task 9: development of a custom algorithm for self-study of the impact of investment on the results of agricultural activities based on the use of "Eidos-ASA" software tools.

It is supposed to be solved by the user's independent development of all the software tools of "Eidos-ASA".

4 DISCUSSIONS

The scientific novelty of this fundamental research is that it clearly indicates the way of continuous improvement of the agro-industrial complex as an operating system. It also confirms the usefulness of this study, which contributes to a fundamental improvement in the management of the functioning and development of the agro-industrial complex.

The results obtained confirm the scientific and applied significance of the work. In our case, it is necessary to apply the methodology for using typical $Y_m(x_n)$, optimal $Y^{opt}{}_m(x_n)$, or new $Y^{new}{}_m(x_n)$ interaction models for OS↔E with real-time Δt_n, required to implement the m-th "system effect". In the human body, the desired "system effect" is created by generating a spectrum of resonant frequencies $\omega_1, \omega_2, ..., \omega_q$ for q specific executive FEq, which automatically respond to their ω_q. A creative person, as a rule, manages to create refined $Y^{opt}{}_m(x_n)$ and new $Y^{new}{}_m(x_n)$ models for non-typical situations, and after that, by using their practical debugging, we may set the corresponding frequency spectra and $\omega^{opt}{}_1, \omega^{opt}{}_2, ..., \omega^{opt}{}_q$, и $\omega^{new}{}_1, \omega^{new}{}_2, ..., \omega^{new}{}_q$, which will ensure the collective operation of the desired FEq in automatic mode. This part of their work has to be checked practically by partial or complete change of MTK (Laptev, 2019).

5 CONCLUSIONS

Overall, the relevance of this research is due to a significant improvement in the functional and adaptive capabilities of the agro-industrial complex in typical and atypical situations, when we (in a complex way) use real laws of nature, resonance, dialectical and formal logic, fractals, spectral and the ASC-analysis, and improvement of the Eidos-ASA software (Lutsenko and Laptev 2008).

The proposed step-by-step automation of ACM in agribusiness allows us to identify new sources of investment quickly and accurately; also, it helps to use them to first optimize, and then dramatically improve the activities of the agribusiness. This is facilitated by the fast Fourier transform (FFT) which allows the Eidos-ASA system to calculate the spectra of the specified resonant frequencies $\omega_1, \omega_2, ..., \omega_q$ for q executive FEs in real time. The latter provides simultaneous "activation" of q executive FEs that ensure the creation of the "system effect" required for the OS survival.

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