Journal of Siberian Federal University. Humanities & Social Sciences 4 (2014 7) 738-743
~ ~ ~

УДК 167.7

Computational Experiment: Philosophical and Methodological Foundations of the Cognition of the Complex Systems

Jury F. Abramov and Olga V. Bondarenko*
Irkutsk State University
1 Karl Marx Str., Irkutsk, 664001, Russia
Irkutsk State Agricultural Academy
Pos. Molodejniy, Irkutsk area, 664038, Russia

Received 12.01.2014, received in revised form 22.02.2014, accepted 24.03.2014

Inclusion of information technology equipment in the process of obtaining new knowledge actualizes the problem of the subject-object relationship. Computational experiment is considered as the development of mental experimentation, consequently, in the process of constructing numerical models of the complex objects the meaning of existence (semantics and pragmatics) is the human – «privileged» existent. We analyzed the philosophical and methodological bases of modeling the dynamics of complex systems. It is shown that the computational experiment becomes a kind of «bridge» between the sciences and the humanities culture in processes of the cognition of the complex systems.

Keywords: cognition, computational experiment, complex system, abstraction of potential realizability.

Introduction

Nowadays it is difficult to find a field of scientific activity, which would have developed without the use of information technology. Information technology equipment for the first time even became a tool for humans to increase productivity. Mankind thought that the dream of implementation of Leibniz's overall method with the advent of computers is rapidly approaching. Some of today's problems are close to his dream-idea: when in the event of disagreement the two philosophers no longer have to resort to the dispute, as it does not resort to the counters. Instead of dispute they would say to each other: «Let's calculate».

Variety of applications of computers is able to hit any imagination. In a world that becomes more and more «digital» and that connects to powerful communication networks, information technology, which led to the information revolution, occupies a central place. Modern Information revolution has become the most important social phenomenon, qualitatively changing all human activities, including scientific cognition.

* Corresponding author E-mail address: ov-bond@yandex.ru

Statement of the problem

It is well known that a radical change of cognition means, introduction of experimental techniques has led to the establishment of classical science. Trends in the development of the experiment and mathematisation made the transition to nonclassical and later to postnonclassical science possible. How comparable epistemological consequences of computerization and previous periods in the development of science? Are computers (essentially not so much computing as information technology) able to create «artificial intelligence» and replace what is usually meant by human creative activity? Uncover the underlying mechanisms and sources to give an accurate description of the processes of self-organization of complex objects?

Discussion

Appearance of the term «artificial intelligence» is due by historically the first scientific direction in simulation of using electronic computers creative processes: the game of chess, writing poetry and music, proofs of theorems, and others. It does not matter how creative processes occur in reality at human and the more so that science with absolute certainty knows little about this subject. Final result is important. «Artificial intelligence» is not what «artificial kidney» or «heart.» This concept is only metaphorical. Computer is always no more than a tool, even intelligence tool. In this sense, the notion of «computer science», the expression adopted in the English-speaking world, but not «artificial intelligence» is more successful and does not cause adverse emotions.

Experts emphasize that the establishment of thinking (without quotes) computers, either now or in the foreseeable future is out of the question. In computer programs the anthropomorphic metaphor is embedded and in some cases natural intelligence of professionals is a bad role, replacing one reality by another. Without «software» computer is elegant bunch of chips. In a detailed approach becomes apparent that computer «intelligence «, «creativity» has a narrow local character and is determined entirely by human activity. New in science, engineering, life – is the result of human creativity, often reinforced with a powerful means of information processing – computer technology.

Experienced practice methods for obtaining new information are not canceled with the advent of new computing, but are modernized according to modern needs and possibilities of science. Actual today math (computational) experiment serves as the development of mental experimentation with numerical models of real processes, as modern technology and methodology of theoretical studies.

Historical roots of mathematical experiment goes precisely into the period of classical science, when for the first time precise quantitative mathematics methods were applied to describe the phenomena of nature and a simple mathematical model were constructed. Modern computer experiment requires painstaking and lengthy preparation. Currently, the design of scientific research information system for many orders of magnitude the time spent on purely computational operations. In the «Human – Information Technology» system the strategic experimenter remains the subject of cognition. Wiener slogan: «The Human Use of Human Beings, Machine – Machine one's» (Wiener, 1989) will be relevant as long as the computers are not able to perceive the world as people and to set themselves the of socio-deterministic goals. Otherwise – the highest value is not a man, but a machine. What will come of this a long time ago was described in works of science fiction R. Sheckley «Watchbird», E. Elmer «Robot Nemesis», etc. It is unlikely that we will arrange it.

Inclusion of information technology equipment in the process of obtaining new knowledge actualizes the problem of the subject-object relationship. In this situation it is necessary to re-solve the classic philosophical problems, to distribute the borders in a new way: «objective – subjective», «rational – irrational». The problem of the identity of thinking and being in the history of science occurred more than once, for example, what was regarded as an objective in the physics of Aristotle proved subjective in Newtonian physics. More complicated is the situation with the cognition of complex objects characterized by nonlinear dynamics. Shifting boundaries of subject-object relations in the process of cognition of the complex systems involves the rejection of dogma existence of a unique «kingly way» in science, means a variety of approaches and possible solutions to problematic situations – the set of epistemological trajectories of the truth cognition. This is due, ultimately, by philosophy as the limiting form of our conscious choice, or as Kierkegaard said, – «indirect communication».

That can be said that in a certain context of cognitive activity reveals only a part of the system («world – knowledge – human») properties, structure, functions of objects that act as fractals of our knowledge of the world, as a localization of endless whole. Our specificity as macro creatures with finite physical and intellectual abilities in the infinite world limits the scope of cognitive activity. Therefore, we always work with a specific fractal – «regional tenderloin» of our knowledge. In contrast to the knowledge, the specific feature of information is the possibility to highlight the formal syntax side in specific scientific studies and to operate with it is relatively free of semantics and pragmatics. Autonomy of formal «signal-code» form of information always presupposes an interpreter. Both in the logical-mathematical symbols, and in the process of constructing numerical models of complex objects using information technology the sense of existence (semantics and pragmatics) finally rests with the human – «privileged» existence. This is especially important if we understand «mathe» in Heidegger's sense. Essence, which according to M. Heidegger, is prior to conceptual seeing of things, that is, the cognition of things is always carried out in the light of pre-existing ideas (and, mathematics itself acts as a derivative of the so understood «mathe») (Heidegger, 1967). Projective function of cognition provides its mathe, allowing the subject of cognition to predict, assume force «to act the physical reality under «scenario» as close as possible to the theoretical description» (Prigogine, 1986).

Mathematical models, which were used to describe the objects of classical and non-classical science, were usually built on the basis of abstractions of potential infinity. Abstract potential infinity mathematically interpreted as preservation of phase volume (that means in the physical sense of system energy conservation) and corresponds to the average distribution of spatially symmetric and invariant under time structures. However, in real systems, the phase volume is reduced and leads to their quality regeneration.

Before 70-th years of the twentieth century, science mainly designed models to research the actual being of complex objects. Study of the dynamics of dissipative systems through processes of selection and combination of random events in nonrandom (localization effect) and the application of numerical modeling allowed to reveal underlying mechanisms of the sources and causes of self-organization – the effect of creating structures in the process of energy dissipation (decreasing phase volume of the system) . «In other words, the number of states in which the system may be becomes lower. This property is called dissipativity, and is analogous to the self-organization ... With

the passage of time, the phase volume tends to zero and all the trajectories of the system will be committed to attracting this finite set, called attractor» (Kurdyumov and Malinetsky, 1996). Abstract of potential feasibility corresponds to that the state of system explicitly depends on the space coordinates and on the time and results in a localized process configuration. Abstraction of potential realizability became theoretical and methodological basis of the synergetic approach to the dynamics of complex systems. This means the conceptual transformation, when the description of development (not as a result, but as the formation, i.e. therefore the process of autogenesis from chaos at micro level of macro order parameters, whereby evolutionary selection is realized) from a scientific point of view must meet four minimum requirements are «responsible» for the process of entering into a chaotic system creative phase:

- Nonlinearity, meaning in human terms disproportionate of results to efforts expended; mathematically – a violation of the principle of superposition;
- The irreversible, expressed in symmetry breaking (difference) between the past and the future;
- Instability that characterizes the capabilities of the system to change the course of evolution and do some phenomena (polyfurcations) the starting point of a new path of development;
- Disequilibrium (loss of stability), manifested increasing differences in the structure and functioning of the system under the influence of small perturbations from the environment (situation where small causes, due to the presence of feedback, there are large consequences).

In terms of the construction of numerical models of complex systems in «prior development of synergy we can distinguish two periods, two paradigms. The first period can be called the era of dissipative structures ... The next period can be described as a period of dynamic chaos ... It appears that the new paradigm will be based on a combination of dynamics and statistics. Mathematical models based on such combination, proposed by the theory of self-organized criticality, allowed a new look on the set of nonlinear processes» (Malinetsky, 2010). In fact, in the phase space of many natural and social objects characterized by a large variety of dynamical regimes, there are places called regions of «jokers». In these areas, accident or factor, which has no value in any other situation can be decisive (leading to loss of stability) and not only affect the «destiny» of the system, but also the leap to translate it to another point in the phase space (to another stable state). Rule by which this step processes is called the «joker». Clearly, this greatly increases the number of variants and the degree of uncertainty, and means that the behavior of the system with acceptable accuracy is defined by only a few variables, everything else is unimportant in this case. Regions of phase space areas where these conditions are implemented were termed riverbeds (Malinetsky and Potapov, 2000).

The method of «riverbeds and jokers», used to describe the different (micro, macro) levels of systems, which vary by large different dynamic regimes, is «based on a selection by asymptotic analysis of areas with large forecast horizon and a small number of essential variables and areas of poor predictability. For «riverbeds and jokers» different modeling algorithms are used» (Zulpukarov, 2007). And here comes the paradox: the adequacy of a qualitative and quantitative of model of the observed dynamics of a complex system depends largely on the degree of scientific intuition and «understanding» of reality.

Speaking about the problems of constructing mathematical models of complex systems,

attention should be paid to one important caveat associated with the use of information technology in research. When modeling the processes within the computational experiments should be considered the fact that if the trajectory of the system fills a certain region of phase space, such a trajectory on the computer cannot be predicted «pathwise». The fact is that computers have a digit capacity. All equations are translated into numbers (for example, the system of partial differential equations using sampling to a system of ordinary differential equations, and goes on the bill). But when we wrote the system of equations in conventional derivatives, we assumed that the continuous part of the coordinates: one part of the coordinates we discretize, another left continuous. The computer has no continuous coordinate – all coordinates are discrete. Therefore, at each time interval there is a finite set of points, which can get a system that is non-periodic motion, in principle, cannot be. The distribution only can be predicted, but not each path individually.

Conclusion

Therefore, in the case of nonlinear equations describing the evolutionary processes in open systems that exchange matter and energy with the «outside world», available mathematical methods and techniques are sufficient to reconstruct mainly qualitative analysis of real situations. Full approximation of knowledge about complex systems, quantitative processing them using modern information technology is practically not yet possible not only for physical reasons, but also the level of mathematical research inhibits that process. Nevertheless it is a computational experiment that allows to solve the problem of sensitivity «trajectories» of complex objects to the initial data and the diversity of their account in the phase space, the problem of redundancy mathematical models. However, the primary heuristic role is played by scientific creativity. Without the use of special techniques of approximation and reconstruction of reality, changes of the significantly important by algebraic variables (dimensions, correlation parameters, the smoothness of solutions, etc.), topological, etc. the opening the fundamental properties of complex systems would not become real. And, first of all, mathematical images of structures – attractors, «trees» of bifurcations. There would be no understanding of chaos as a fundamental property of formation processes and specific scientific logical-mathematical models to describe it. In other words, the computer experiment becomes a bridge between the sciences and the humanities culture in the processes of cognition of complex.

References

1. Viner, N. Kibernetika, ili upravlenie i svjaz' v zhivotnom i mashine.[Cybernetics: Or the Control and Communication in the Animal and the Machine] Moscow, 1989. P. 67.

2. Zul'pukarov, M.-G.M., Malineckij, G.G., Podlazov, A.V. (2007). Primenenie metoda rusel i dzhokerov dlja opisanija dinamiki sistemy Rozencvejga–Makartura. [Application of method of riverbeds and jokers to describe the dynamics of the Rosenzweig-Macarthur system] Matem. modelirovanie, 19 (6), 3.

3. Kurdjumov, S.P., Malineckij, G.G., Potapov, A.B. Nestacionarnye struktury, dinamicheskij haos, kletochnye avtomaty. Novoe v sinergetike. Zagadki mira neravnovesnyh struktur. [Nonstationary structure, dynamical chaos, cellular automata. New in synergy. World Riddles nonequilibrium structures] Moscow, 1996. P. 120-121.

4. Malineckij, G.G. Sinergetika. Korol' umer. Da zdravstvuet korol'![The King is dead. Hail to the King] (2010) Available at: http://www.synergetic.ru/science/sinergetika-korol-umer-da-zdravstvuet-korol.html (accessed 4 december 2013).

5. Malineckij, G.G., Potapov, A.B. Dzhokery, rusla, ili Poiski tret'ej paradigmy. Sinergeticheskaja paradigma. Mnogoobrazie poiskov i podhodov. [Jokers, riverbeds, or search for a third paradigm. Synergetic Paradigm. Variety of searches and approaches] Moscow, 2000. P.140-143.

6. Prigozhin, I., Stengers, I. Porjadok iz haosa: Novyj dialog cheloveka s prirodoj. [Order out of Chaos: Man's new dialogue with nature] Moscow, 1986. P. 65.

7. Heidegger, M. Sein und Zeit. Tübingen: Max Niemeyer Verlag, 1967. P. 219.

Вычислительный эксперимент: философско-методологические основания познания сложных систем

Ю.Ф. Абрамов, О.В. Бондаренко
Иркутский государственный университет
Россия, 664003, Иркутск, ул. Карла Маркса, 3
Иркутская государственная сельскохозяйственная академия
Россия, 664038, Иркутская обл.,
Иркутский р-н, пос. Молодежный

Включение информационной техники в процессы получения нового знания актуализирует проблему субъект-объектных отношений. Вычислительный эксперимент рассматривается как развитие мысленного экспериментирования, следовательно, в процессе построения численных моделей сложных объектов смысл сущего (семантика и прагматика) остается за человеком – «привилегированным» сущим. Проанализированы философско-методологические основания моделирования динамики сложных систем. Показано, что вычислительный эксперимент становится своеобразным «мостиком» между естественно-научной и гуманитарной культурой в процессах познания сложного.

Ключевые слова: познание, вычислительный эксперимент, сложные системы, абстракция потенциальной осуществимости.