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On Mathematical Modeling in the Humanities

ABSTRACT

In this work the problems of mathematical modeling in the humanitarian area are discussed from the position of structuralism, computer science and complex systems research methods.

Keywords: complex systems; mathematical modeling; humanitarian analysis; method of analogies; structuralism; computer science

Epigrams scorn details and make a point:
They are a superb high-level documentation.
A. Perlis

Introduction

But without a parable spake he not unto them...

Mark 4:34

A parable is an edification in an example.

V. Dahl

In a number of the East cultures the parable about an elephant and blind men is known. Four blind people tried to learn what is an elephant by palpation, and then shared impressions. One told that the elephant is something like a flexible pipe, another - that it is a column, the third - that it is a rough wall, and the last - that the elephant is something like a rope with a brush on the end. There are options where there are less or more than four blind men. In some versions also similarities of an elephant's components may differ: for example, the trunk can be like a snake, but not a flexible pipe; the leg can seem not like a column, but like a tree; the side can be apprehended as a barrel or a fence; tusks - as spear, peaks or even root crops, etc.

On the author's opinion, this parable illustrates quite likely a situation with which any modeling begins. The success of modeling, perhaps idealized a little, is illustrated by the Taoist tale (retold by J.D. Salinger) about the superlative horse:

“Duke Mu of Chin said to Po Lo:

- You are now advanced in years. Is there any member of your family whom I could employ to look for horses in your stead?

Po Lo replied:

- A good horse can be picked out by its general build and appearance. But the superlative horse – one that raises no dust and leaves no tracks – is something evanescent and fleeting, elusive as thin air. The talents of my sons lie on a lower plane altogether; they can tell a good horse when they see one, but they cannot tell a superlative horse. I have a friend, however, one Chiu-fang Kao,

a hawker of fuel and vegetables, who in things appertaining to horses is nowise my inferior. Pray see him.

Duke Mu did so, and subsequently dispatched him on the quest for a steed.

Three months later, he returned with the news that he had found one.

- It is now in Shach'iu - he added.

- "What kind of a horse is it? - asked the Duke.

- Oh, it is a dun-colored mare, - was the reply.

However, someone being sent to fetch it, the animal turned out to be a coal-black stallion!

Much displeased, the Duke sent for Po Lo.

- That friend of yours, - he said, - whom I commissioned to look for a horse, has made a fine mess of it. Why, he cannot even distinguish a beast's color or sex! What on Earth, can he know about horses?

Po Lo heaved a sigh of satisfaction.

- Has he really got as far as that? - he cried - Ah, then he is worth ten thousand of me put together. There is no comparison between us. What Kao keeps in view is the spiritual mechanism. In making sure of the essential, he forgets the homely details; intent on the inward qualities, he loses sight of the external. He sees what he wants to see, and not what he does not want to see. He looks at the things he ought to look at, and neglects those that need not be looked at. So clever a judge of horses is Kao, that he has it in him to judge something better than horses.

When the horse arrived, it turned out indeed to be a superlative animal".

Natural Sciences and Humanitarian Methods

If people do not believe that mathematics is simple, it is only because they do not realize how complicated life is.

J. von Neumann

I consider a problem of introduction of informatics in "descriptive" sciences as one of the major, perhaps the most important problem of the close future.

A.A. Dorodnitsyn

After his teachers, N.N. Moiseev and Yu.N. Pavlovsky, the author considers that in humanitarian field the researcher usually faces more complex challenges, than in the field of natural sciences. Let us cite the work [Belotelov, Brodsky, Pavlovsky, 2009]: "... those systems for which there are conventional adequate mathematical models will be called *simple*. The systems for which there are no adequate mathematical models, but the experts dealing with them are able to carry out their adequate forecast, will be called *complex*. The methods which such experts use for their forecasts for complex systems will be called *humanitarian*".

From this point of view, it is possible to call complex – the problem of the superlative horse searching, and humanitarian – the methods to its decision, applied by Chiu-fang Kao.

The Essence and the Phenomenon

Man must persist in the belief that the incomprehensible is, in fact, comprehensible;
else he would cease to do research.

J.W. Goethe

The product of knowledge by optimism is a constant.

L.D. Landau

Mathematical model constructing is foremost a definition of the operator structure,
and there are no algorithms for this...

A.A. Dorodnitsyn

Let's try to comprehend what the parables tell in philosophical categories of the phenomenon and the essence. The elephants' observers will agree that the blind researchers face various manifestations of the same elephant. Whether our blind people will be able, speaking in the words of philosophical encyclopedias, to advance their knowledge from superficial, tangible level, to deeper, hidden from them (by the blindness in a smaller degree, by the ignorance - in the bigger), – to the essence of these phenomena - to what we in common speech call the elephant?

Sight, of course, does not give us in the senses the essence of the elephant, but brings a step closer to it, allowing directly perceive one more of its manifestation, uniting those that were perceived by the blinds. Nevertheless this step is very important: it gives a belief that the attributes of the object studied that were apprehended separately, are actually related among themselves by some law that expresses the essence of this object.

May we learn this law? The famous philosophers argued about this problem, but did not come to the conventional opinion. Kant believed that we can never know the "things-in-themselves". Hegel - that nevertheless the essence is shown in the phenomena, and the phenomena express the essence. Marxist philosophers – that in the course of the scientific and practical activities we can approach to the essence "asymptotically". Positivists – that there is no essence at all, and it is necessary to be engaged in the phenomena – the only things that really exist and are available to the measurement and scientific studying. As a researcher, the author likes Goethe's statement taken as the first epigram, – without optimism it is hardly worth even to start investigations. At the same time it is worth to mark the limits of such an optimism and Landau's aphorism does it.

Constructing a model, we actually invent relations between its characteristics ourselves, to reflect the attributes relations of the phenomena studied. During the model creation, we try that

the characteristics relations of the model were as similar as possible to the observed relations among the attributes of the phenomenon studied. Even if our model is successful in practice, this fact is only a necessary condition of our comprehension of the essence of the phenomenon. We are not able to prove or check its sufficiency. It is always possible to assume that we did not face some manifestations of the essence studied in our practice yet and therefore our model does not reflect them.

The geocentric model of the Ptolemaeus planets movement can be an example. It has worked successfully for about 1500 years and could still work to calculate the planets positions in the sky, solar and lunar eclipses. Real practice for which the Ptolemaeus's model was insufficient arose more than in 200 years after the models of Kepler and Newton emergence. Why there was a change of models? First, a new knowledge – the laws of Newton and the law of masses gravitation appeared. Secondly, a new science language arised – the differential equations for the description of communications between attributes of the phenomena studied. This language remains the main for modeling up to now. As a result, there appeared an opportunity to answer to the question “How do the planets move?” in the language of the differential equations instead of the language of Euclid geometry (very unusual for modern modelers, but there vere no other mathematician language at the Ptolemaeus times). And most importantly - not only to the question "how?", but also to the question "why?" – the whole one "why?" more! Because Ptolemaeus model said nothing about “why?”.

How can we build a model so that it reflects the essence of the phenomenon as much as possible? Unfortunately, the author does not know the formal way to do this. The parable of the superlative horse also talks about this. Simple things can be learned, by taking a corresponding training course and making exercises for it, as for the comprehension of the essence – the sons of Po Lo carried out all the life near the father, but did not succeed in comprehension of the superlative horse essence.

Kant said that, perhaps, nobody is able ...

For preservation of the optimism we have the only hope that perhaps, somewhere Chiu-fang Kao still hawks his vegetables and fuel.

Concluding this section, we note that no matter what smiles caused the first acquaintance with the parable of the elephant and the blinds, in our knowledge of physical nature there is a very similar situation, although this area was successfully studied by humanity for a long. Similarly, we are blind in the forefront of the sciences and we learn about its phenomena indirectly, according to instruments and photographs in the invisible regions of the spectrum. Similarly, we have four models of fundamental interactions, that are not related to each other.

Analogies

That which is below is like that which is above
and that which is above is like that which is below to do the miracles of one only thing

Tabula Smaragdina Hermetis (Translated by Sir I. Newton)

A mathematician is one who can find analogies between theorems; a better mathematician is one who can see analogies between proofs and the best mathematician can notice analogies between theories. However, the ultimate mathematician can see analogies between analogies.

S. Banach

There is a deep and nontrivial analogy between mechanics and optics.

E. Fermi

The parable of the elephant and the blind men tells us that in order to start studying something unknown, one must liken it to something known. The very word "model" can be raised to the Latin root "modulus" – a measure, a yardstick; so to understand something unknown, we try to measure it by something known. If we face something absolutely from the depths of unknown, and no comparisons exist, - we need to wait until the development of science and practice throws the bridge from the coast of known, closer to the phenomenon considered.

The analogy (Greek αναλογία), is more likely compliance, than similarity. The similarity can also take place, but it is in the fact, that the fruitful analogy transmits (reveals and preserves) some structure of the likened, as, for example, in Bourbaki's morphisms [Bourbaki, 2004], or in functors of the theory of categories [Mac Lane, 1998]. Not so fruitful analogy can be just compliance, a sign. The questions of legitimacy and fruitfulness of this or that analogy, apparently, are not formalized. It is possible therefore, that the method of analogies dominating in medieval science, was criticized from the positions of rationalism of the Renaissance and receded eventually into the background. Nevertheless, in mathematics analogies have always been applied, and, for example, the category theory [Mac Lane, 1998] can afford quite "free" analogies, even by the medieval standards.

Analogies are used in modeling to map the attributes of a phenomenon simulated into a set of model characteristics. Sometimes such a mapping is obvious – for example if we study the movement of planets – the mapping brings only measurement errors in their visible situation in the sky. But often this mapping is not so obvious, but opposite, may be challenged easily from the formal positions, however it can turn out, that simply there is still nothing best.

For example, if someone thinks that the analogy of a trunk with a curled snake or a tusk with a carrot is somewhat strained, one can recall that for almost a hundred years we have been considering the characteristics of quantum mechanical objects as Hermitian operators in a Hilbert

space. Perhaps, this is cooler than the simulation of elephant tusks with root crops. Of course, all would like simple models, however, the existing ones are working, and there are no better yet.

Nontrivial analogies from the field of natural sciences sometimes appear in models of social processes, which is due to the stock of analogical tools available to their authors who came from the mathematics and physics. For example, in work [Dimitrienko, 2011] marketing preferences of consumers are modelled by a solid body, and in work [Mikhailov, Lankin, 2010] a transfer of the power through the domineering hierarchy – by the heat conductivity equation. In our opinion, these works are witty, successful and undoubtedly such kind of works is needed, especially at the beginning, when the processes have not yet been studied by mathematical methods.

The only remark - apparently, you can not be too carried away by the successes of such works and insist that it is namely the carrot, that is the real tusk.

The choice of the analogy that maps the attributes of the object of research into the model characteristics also determines whether the model will be "atomistic" or "thermodynamic". The fact is that if the object modeled is complex sufficiently, it has too many attributes for subsequent comfortable work with them. For practice, we need the models, that we can deal with.

In order to reduce the number of simulated attributes, you can either factorize them by some equivalence relation and get a "thermodynamic" type factor-model, or split the modeling object into interacting subobjects, model them separately and then build from them a synthesis of the model-complex – that is an "atomistic" modeling.

In Yu.N. Pavlovsky's works devoted to the geometrical theory of decomposition, the justification is given to such an approach - shown that all decompositions of any mathematical objects are exhausted by two main types: P-decomposition (on subobjects), F-decomposition (factorizations) and various combinations of these two types.

Summing up what was said in the paragraph, we can conclude that to build a model, analogies are needed that map the attributes of the simulation subject to the characteristics of the model. The choice of the analogy-mapping can hardly be formalized, moreover, excluding the simplest obvious cases, the almost always the analogy chosen can be criticized from a formal standpoint. Formal principles for evaluating the proposed analogies for adequacy are also absent – at the first glance a very pretentious analogy may become the basis of the models used for a long time. In a word - the choice of the analogy - is rather an art, than a science.

Structuralism

Twas brillig, and the slithy toves
Did gyre and gimble in the wabe.

L. Carroll

Mathematics is the art of giving the same name to different things.

H. Poincare

The parables in the introduction, as well as it is necessary to parables, are deep and multidimensional. Let's pay attention to their structuralist aspect. Recall that the basis of the structural method is identification of the structure as a set of relations upon base sets, which is preserved under certain transformations of these sets [Gretsky, 1978]. Therefore, the researcher's attention is transferred from the base sets objects and their properties to the relations between these objects and system-wide properties which this relations determine.

Characteristics of the attributes of the phenomenon studied vary during the time, but something constant is in these changes - the regularity of their connection with each other, which is the subject of identification and study by mathematical modeling. An analogy specifies a certain mapping of the attributes of the modeling object into a set of characteristics of the future mathematical model.

To build a model is to define the communications among its characteristics so that they preserve the regularity of the relationships among the attributes of the modeling object. The best thing that can be done is to invent such relationships among the model characteristics that would maximally compare their changes to the changes in their prototypes - the attributes of the modeled object.

Mathematics has accumulated a stock of very different structures, by which it is possible to establish relations among the base sets. As examples it is possible to begin with geometrical kinematics of the Ptolemaeus model, then systems of the algebraic equations appeared, for example, "Masha and Petya have five apples, Petya has one more". The structure can be set by the table, for example, Mendelejev's table. Attempts to generalize and universalize various mathematical structures led to emergence of the concepts of N. Bourbaki's species of structure [Bourbaki, 2004], algebraic models, categories [Mac Lane, 1998]. It should be noted that all listed above structures are static. Perhaps this is the reason why the Bourbaki's structures were used for database design. Some authors, for example [Gretsky, 1978], even draw a conclusion on this basis, that a lack of structuralism as a method is in its static character. It is possible to give dynamism to a static structure, for example, by means of a computer program, i.e. consecutive performance of some algorithm. In Ptolemaeus's model, for example, the uniform motion in a circle of the epicycles and planets was such an algorithm.

A specific place among the mathematical structures is held by the differential equations. If such an equation contains a time derivative – it overcomes mentioned above static character at

once. Actually, therefore the differential equations from the moment of their invention became the main tool for creation of the most different mathematical models so that often the mathematical modeling is considered to be exclusively computing or supercomputing of partial differential equation systems.

One more example of the important dynamic structures (in our opinion, very perspective, but still underestimated in modeling) are computer programs, to be exact, the operating systems, whose appointment - realization of the behavior, i.e. ability in an established way to respond to the standard requests of the environment.

There can be objections – the operating system is too complex (millions of operators of a source, regular "patches", etc.) to become an instrument for modeling. In fact, in [Brodsky, 2015], for a sufficiently broad class of objects with behavior, the functional analogues of operational systems realizing their behavior are constructed, on the basis of the family of species of structure in N. Bourbaki's sense and a universal computer program, providing behavior dynamics to any member of the mentioned family.

Apparently, further the role of the systems realizing behavior, – functional analogs of computer operating systems – will grow, and one of problems of informatics – studying of such systems. In World War II the warplane had no operating system, its functions were carried out by the pilot. On the modern military plane the network operating system, is important not less (and already in the next generation of planes, most likely will be more), than its base sets: engine, glider, radar, arms, means of communication.

Spinoza's Ethics and the Proofs in Humanities

There are trivial truths and there are great truths.

The opposite of a trivial truth is plainly false.

The opposite of a great truth is also true.

N. Bohr

Many wise men of different times and peoples believed that in any science there is as much truth as there is mathematics in it. Therefore, attempts to apply mathematical methods for studying humanitarian processes are known for a long time.

The "Ethics" by B. Spinoza [Spinoza, 2018] can be considered as one of such attempts. The famous philosopher tried to start from the beginning in it - to give strict "mathematical" definitions to philosophical categories - to clearly fix what will be discussed later, as it is usual in mathematics, in order to use them to prove lemmas and theorems in the spirit of Euclidean geometry and thus to receive indisputable, mathematically-proved philosophical truths.

In our opinion, the truth generator did not work. Definitions of Spinoza are not obvious, therefore can be challenged. In addition, the philosophical categories "died", fixed by rigid definitions, became empty and uninteresting, and the same can be said about many theorems built upon them, adding to this their controversy as an inheritance of controversial definitions.

Why so occurred?

The author agrees with a look at natural languages by a mathematician Vasiliy Vasilievich Nalimov (1910 - 1997), professor at Moscow State University, an employee of A.N. Kolmogorov. He writes that in the natural language the semantic field of the word is continual. Hence, the arguability of the selection of a single sense from the continual set by the definition – too many significant meanings are lost.

The question arises, why did Spinoza consciously go on reducing the semantic field of the philosophical categories? In our opinion, the coming era of rationalism in the person of Spinoza exposed a number of claims to the humanitarian discourse, demanding from it a mathematical clarity.

Let us take as an example a classical sample of a philosophical discourse – Plato's dialogue "Parmenides" [Plato, 2006]. For more than two thousand years, the set of comments on it was written, beginning by Plato's contemporaries and finishing by ours. It turns out that treatments of the dialogue by commentators considerably differ.

So, one of the most authoritative researchers, A.F. Losev, writes that one of the main ideas of the dialogue is criticism of the dualism of ideas and things. Nevertheless, many commentators (as noted by A.F. Losev too) believe that this dialogue, on the contrary, asserts such a dualism. Perhaps this contradiction can be removed by saying that "Parmenides" is one of the most significant works of not only the ancient but also the world dialectic (many commentators consider that Hegel's dialectics grew up from the Plato's "Parmenides"). Nevertheless, there is a quite common point of view that since the dialogue was directed by the Eleatic sophists – they practiced their sophistry (in the modern sense). Proved that black is white, then refuted this proof, and then its refutation, etc. Demonstrated their abilities so appreciated in that time – in the courts and assemblies, and therefore it is not necessary to treat too seriously the subject of the dialogue – it was just a session of advertising and promotion of the sophistry.

The humanitarian discourse was ambiguous even in the times of Socrates, it is the same today - it is easy enough to have opposing opinions on some complicated issue¹ and it is impossible to prove that one of them is better. Spinoza's attempt to deprive a philosophical discourse of ambiguity and uncertainty, in passing deprived it of life and depth.

¹ Modern mathematicians are well aware that there is such an issue in the systems more complex than the Arithmetic.

However, our criticism of the “Ethics” from the structuralism and modeling point of view is not at all in the fact that during the mapping of base sets some set of continual power goes to a point. - This is not forbidden under transformations if the image preserves the original structure. Such a mapping can be useful when aggregating the attributes of an object simulated, building its factor model.

Criticism is that the philosophical categories were subjected to the separate, uncoordinated among themselves mappings. Therefore, the resulting system of definitions did not reflect any structure and this was not the goal. The purpose of Spinoza's definitions was to outline the range of initial concepts from which it was supposed to deduce philosophical truths "mathematically".

Spinoza's "Ethics" is aimed at finding truth through the mathematical proofs, but the essence of mathematics is in the structures identification, and the proofs are just its technique.

Most of the modern applications of mathematical methods in the humanitarian field can be called positivistic - this is mostly the compilation of time series, the calculation of correlations, the processing of experimental results by statistical methods. This state of affairs would be normal for the current state of mathematization of this area, if it did not create a skeptical attitude toward timid attempts to get to the essence of the phenomena studied – to build substantial models, for example, on the base of differential equations. From the positivist point of view, there is no essence at all, and he prefers to deal with what is.

A Mythology in the Language of Mathematical Models

Myth is a lie that becomes a truth.

J. Cocteau

How then to apply mathematical methods? In our opinion, it is necessary to act as the blinds with the elephant – to search for a mapping of a part of attributes of a modeling object to a set of characteristics of a simplified mathematical model by means of analogies so, that its structure transmits the observed relationships between the original attributes. The author does not know, how to formalize this process, it is rather an art, than a science. Nevertheless, it is possible to give examples. Thus, the evangelical parables explain a very complex and unfamiliar to their listeners object – "The Kingdom of Heaven", likening some of its properties to the most common things that each of the listeners repeatedly faces in the everyday life: "The Kingdom of Heaven is like to a grain of mustard seed...", Matthew 13:31-32. "The Kingdom of Heaven is like unto a man a householder, which went out early in the morning to hire labourers into his vineyard ...", Matthew 20:1-16. "The Kingdom of Heaven is like unto treasure hid in a field...", Matthew 13:44. "The Kingdom of Heaven is like unto a certain king, which made a marriage for his son...", Matthew

22:2-14. "The Kingdom of Heaven is like unto leaven...", Matthew 13:33, etc., just twelve parables devoted to this subject.

As a result, we receive a series of simple models, apparently, not related among themselves, where the structure of each reflects one or several aspects of the complex object studied. This approach is peculiar not only to the Christianity, but to the ancient mythological consciousness in general. Any mythology gives a set of simple and clear models of a cosmogenesis, anthropogenesis, and history in the language, available to the listener. Simplification (sometimes very considerable) in the mythology takes place, but it never "kills" the depth of the complex processes in the modeling domain.

The creation of the "mythology" of the modeling domain in the mathematics language seems to us to be a correct approach to the mathematical modeling of the humanitarian processes. It gives a chance either to keep elements of the structure of the initial complex processes as to apply to them the mathematical apparatus. As a result, a number of simple, perhaps, heterogeneous and multiscale mathematical models reflecting various aspects of the subject area should be obtained.

One of the Russian leading experts in area of mathematical modeling of the economy I.G. Pospelov considers, that in modern modeling of the economy the situation is quite similar - there is a set of multi-scale, uncoordinated models of its various manifestations. Even in the physics, the most mathematized science, we have four models of the fundamental interactions, independent from the each other.

The moment of simplification in mapping by the analogy of the attributes of the object studied into the model characteristics of the same nature, as in Spinoza's Ethics and the controversy of the analogy itself, remains. However, in each specific case, there is a hope that the part of the essence of the original object transferred to the model by the analogy and the possibility of mathematical methods applying for its study will outweigh these shortcomings.

As it was already told, the analogies applied nevertheless may be challenged. By all means there will be a "Pharisee" who will say: "Well, why suddenly the mustard seed is like the Kingdom of Heaven? These are incommensurable things! And did somebody saw how the tree grows from mustard grain?" He sees the reduction of base sets by the analogy and criticizes it for being not bijective, but the most important – the structure conserved – he does not notice or does not want to notice. A positivist will tell: "What else kingdom of heaven? - I do not know it! I know a grain of mustard seed and I know leaven, I know a treasure too, let us study them!" As a result, he will really study them (but not the Kingdom of Heaven) in all details. Nevertheless for passed 2000 years, the parables mentioned above directed many generations to substantial reflections, helping to understand important questions, so the system of models set by them was fruitful.

The controversy of the initial analogies is a common place for criticizing the simplest mathematical models in the humanitarian sphere. Formally, there is nothing to object to such a criticism. However, the author has an observation (developed as a result of many years of discussions of such models with students in the curriculum of mathematical modeling) that these models are not as simple as they seem at first glance. Their mathematical analysis and attempts of its substantial interpretation in the subject domain (usually demanding much more time and efforts, than the actually mathematical analysis) often direct to very serious generalizations which are far beyond these elementary models, to the area of structures and programs called in the next paragraph the "World of Informatics". Let us give examples.

- The simplest demographic model of Malthus shook contemporaries. Disputes over its occasion has not settle even up to our time. A modern area of global studies and sustainable development - its heritage.
- Verhulst's model of the competition surprised scientific community of the 70th - the 80th of the 20th century with the fact that, being completely determined, in some modes leads to chaotic dynamics and crises problems.
- The simplest model of military operations of Osipov - Lanchester leads to the problems of psychological stability in the armed struggle.
- The model of armament by L.F. Richardson [Saaty, 1968] at its doubtful adequacy in a quantitative assessment of arms is capable to predict the beginning of the war. A prediction essence - in the field of structures: the trajectory comes to the knot - the structure (the status quo of the rivals) remains, it suits all of them, and the war, most likely, will not be. The trajectory runs like an exponent on the infinity, such a race cannot be sustained for a long, there will be not enough resources, the rivals begin to worry, everyone is afraid to appear in the worst stage, than before, sooner or later either nerves give up or resources come to the end, and the war begins.
- The competition model by A. Lotka – V. Volterra brings to problems of the cross-cultural interactions [Brodsky, 2014b].
- The predator-prey model by A. Lotka – V. Volterra, when adding the competition member to the law of the prey's dynamics, suggests that perhaps, the preaching of non-violence by L.N. Tolstoy² and M. Gandhi was not as detached from the life as it is usually represented. If the environment capacity in the member of the competition is made equal or less then the

² Justifying his preaching, L.N. Tolstoy back in the 19th century, 40 years ealier than A. Lotka and V. Volterra, conducted a humanitarian discourse, essentially describing the "predator-prey" system and proved the impossibility of the preys disappearance from such a system [23].

average number of preys necessary for feeding of predators, then the predators lose their place in the system, they disappear from the system without any violence to them from the preys.

What is common and educative in these examples?

Yes, all these models are very simplified, and even emasculated by the analogies used for their creation, and it is improbable to receive the adequate quantitative forecast of characteristics with their help. For this they are subjected to criticism by the positivists. Of course, temporary ranks and correlations more precisely than the elementary substantial models: experimental data indirectly consider all richness of the studied object which essence, not changed by analogies. But if the analogies were fruitful, i.e. conserved a particle of the modeled object essence in the structure of the simplified model, then the study of the model by mathematical methods and attempts to interpret the results of these studies in the subject area (which is much more complicated and, apparently, unformalizable), lead to the expansion of the model structure. The model returns us to the essence of the modelled object, which generated it. Behind separate "trunks", "legs", "tails" also the other contours of the "elephant" studied begin to appear. So, then it is possible to look for new analogies and with their help to create new more complex models, which consider relations and compliances, obtained during the research of simple models. And the "mathematical mythology", created by a set of simple models, gets a chance to come one step closer to the truth.

Complex Process "in the Three Worlds"

Wanted as better – it turned out as usual.

V. M. Chernomyrdin

Science is built of facts the way a house is built of bricks: but an accumulation of facts is no more science than a pile of bricks is a house.

H. Poincare

Vladimir Aleksandrovich Levansky (1942 – 2010), senior research scholar of the Institute of State and Law of the Russian Academy of Sciences, lawyer, poet and translator, in his work [Levansky, 1986] attempted to enter into scientific use the analysis of social institutes in three aspects. The ideas and the principles lying in foundation of some public institute. A set of laws and regulations governing its operation. Finally, its real activity, sometimes very different as from the underlain principles, either from the existing laws and regulations.

This attempt seems be very fruitful from the computer science positions, – it is important to study and model complex processes in these three aspects:

- ideas and principles;
- structures that formulate ideas and principles; programs that manage structures and form together with them operating systems that implement behavior;

- realization of behavior on base sets of characteristics, possible actions and reactions to events.

It is important because though these three aspects interpenetrate and mutually influence at each other, they are somewhat "linearly independent" – no one of them can be reduced completely to a combination of two others - they obey different laws; different influences, obstacles and dangers can prevent them to function normally. Here about these aspects – "worlds" the further speech will go.

The first ideal world may be compared with the Plato's world of ideas of [Plato, 2006]. Here is "as better" which was "wanted" in the known aphorism. The third world – is a material world of realizations in which "it turned out as usual". And why so it turned out? But because in the well-known aphorism there is a dash instead of the second world. And a purpose of the second world – is just to order the bricks from H. Poincare's aphorism about the house (i.e. to create the architectural project of it) this is a static part of structure and to develop a program of this house construction, for example, as Gant's charts – that is a dynamic part of the structure. And then still trace and correct implementation of this program when something tries to go wrong. The second world can be compared with the Aristotle's world of forms [Aristotle, 1908]. It is the world of data structures, organizing the base sets from the realizations world – and the programs processing these data. The second world – just is also the world and the field of studying and activity of the computer science. Hugo Steinhaus spoke: "Between spirit and matter mediate mathematics ", but in his time the computer science just began to arise, now the author would give this mediator place to it.

Why complex processes should be taken into account in the three worlds? Because these worlds live under different laws. In a material world the conservation laws dominate: mass, energy, momentum, angular momentum, charge, etc. The concept of property is essential to the social systems operating in this world.

In the world of projects, plans, programs these entities themselves do not obey any conservation laws, they can be copied at a price of the information carrier, however so far as these plans and programs assume their material embodiment and performance, they have to consider conservation laws (for example, limitation of the resources available).

The ideal world of purposes, ideas, principles until they are not issued in structure of the program yet, are less of all subjects of influence of the material laws. About the ideal world the author can tell less of all - so high he usually does not fly. However, as an example, the main ideas of this pretty vast article are listed in the Conclusion – they can be considered as an ideal component of the article. The article itself can be attributed to the world of forms, the world of computer science – it constructs a number of structures to support and justify the ideas listed in the Conclusion.

Conservation Laws or Conservation of Laws?

Seldom do more than a few of nature's secrets give way at one time.

C. Shannon

... but theory itself becomes a material force when it has seized the masses.

K. Marx

The first two from these worlds it is possible to call a noosphere, after V.I. Vernadsky. What is it? V.I. Vernadsky's followers E. Le Roy and P. Teilhard de Chardin looked for its interpretation in Plotinus' Neoplatonism, i.e. eventually, again in the Plato's world of ideas. The interpretation of the noosphere is much simpler for the modern computer scientist: the world of forms, plans, programs, ways of behavior we can find in the Internet, which though is a human creature, but has indisputable objective being in relation to a certain researcher or group of researchers.

The scientists coming to humanitarian field from natural sciences usually come not empty-handed, but with the devices well proved in the natural-science area. The main component of these devices – conservation laws, especially the energy conservation law. A. Lotka promoted the Energy approach in biology, L.N. Gumilev – in ethnology.

If conservation laws determine interactions in the world of physics, then in the noosphere everything is different: if I have shared with someone an idea or information, unlike the matter, I have not lost either one or the other. Laws of a noosphere are still insufficiently studied. Next, we will talk about what "lies on the surface" and was noticed by the author.

The physical conservation laws are reflected in the legal law of property in the relations between people over material objects. In the world of forms, structures, programs, apparently, it is necessary to consider three aspects: In the world of forms, structures, programs, it seems that three aspects should be taken into account: first, these intellectual property objects themselves are copied easily and almost without costs. Secondly, if we want to embody them in the material world, we must take into account the conservation laws (that, for example, instead of creating a palace that is magnificent, but beyond our means, not create something unfinished). Thirdly, the work of those who develop the objects of intellectual property is worthy of payment, in spite of the fact that their copying is almost free. All this together produce contradictory legislation in the field of intellectual property, which, moreover, is technically easy to violate. In the world of ideas, everything is even more interestingly. Ideas often want to be shared not just for free, but even forcing them by the power. Sometimes the wars begin because of this. And almost always, from the ancient times to our days, the winner in the war imposes his own set of ideas on the defeated by the force.

In physics conservation laws are fair for the closed systems. Among the complex systems in the humanitarian sphere open, dissipative (in I. Prigozhin sense) systems prevail, which exchange streams of matter, energy and information with the world around. At these exchanges the structure of systems remains, but base sets can change. Here the analogy to solitons, not obligatory described by the equations like Korteweg – de Vries is pertinent. All of us are capable to keep the structure changing the material content, – in our body there are practically no atoms left from those 3,5 - 4 kilograms with which we once were born (but because of this nobody, even the most inveterate materialists, say that now they are not themselves). Or, for example, an old car from the Soviet period: in it there could be no original details, including the body and the engine, nevertheless both the family driving it, and the traffic police, - considered it as being the "same". It appears, even the car is not so material as it seems at the first sight, care of the owner allocates it with some wave properties. The same can be told about an enterprise: workers can be employed and leave, productions and offices may change addresses, but the enterprise remains the same, which is fixed by the concept of the "legal entity". Conservation of the structure takes place – the complex system keeps the laws of its life. Yu.N. Pavlovsky in [Belotelov, Brodsky, Pavlovsky, 2009] wrote about conservation of the structure in complex systems. So, we can state, that in the world of computer sciences instead of the physical conservation laws the conservation of laws takes place.

Unlike the conservation laws, the conservation of laws does not work "for free", it is necessary to pay for it by the work in the unit of time, at the enterprise it is necessary to pay regularly a salary to employees, to pay rent of rooms, utility fee, taxes, etc. It is necessary to pay regularly for the car maintenance, if you wish to drive it. We need to eat regularly. Costs of maintenance of the structure in unit of time were called a potential of dynamic balance of the complex system. If the complex system appears incapable to support the potential of dynamic balance, it loses structure, ceases to exist in former quality. Usually at that time other systems that are more successful get its material components (base sets) practically free.

In addition to solitons, in our opinion, another analogy from physics could be fruitful for studying social processes: solid-state structure and phase transitions. Actually, works of such plan already appear [Dimitrienko, 2011]. Just as different structures are possible on the base set of carbon atoms, giving completely different physical properties: graphite – coal – diamond. In the twentieth century, we saw on the base sets of societies with approximately the same human and technical potential, implementations of three different social structures, the Second World War between them, and then the information war, which left the simplest structure that currently, is surviving a crisis. The revolutions we experienced in the twentieth century are very similar to phase transitions because they touched all the "atoms". For example, none of the "atoms", who for

decades received their salaries for only maintaining the structure, did not go to defend it in August 1991 – nobody at all!

The world of ideas is the most difficult to speak about, however we will try to tell several words about how the idea can become a material force. In the author's opinion, if there are some specific forms of biological or social energy, then it is to be a kind of the same physical energy, measured by the work in a unit of time. As the beginning of the sentence whose end is taken as the second epigraph of the section says: "Material force can only be overthrown by material force". Nevertheless, such phenomena as a passionarity (in L. Gumilev's sense) or its absence are observed and play a noticeable role in social processes.

What is a passionarity?

In our opinion, the idea can be issued in a structure (for example, a party, a sect or even a national movement) which can attract a great number of supporters capable of coordinated actions under its banner. This is an anti-entropic process, where the idea plays the role of the "Maxwell's demon." As a result, the idea, which seized masses, is capable to release a noticeable part of the internal energy even from not too energetically rich ensemble. It will be the most usual, true physical energy capable to perform a work. The result, as the XX century history shows, can be tremendous. In any case, the famous article of our Constitution about inadmissibility of any state ideology reminds to the author the widespread practice (ported on the beaten in information war) to force the war losers commit themselves not to have and not to produce certain types of especially effective weapons.

At the end of the section, it should be said that the structure analysis alone does not solve all the problems in the world. This method is so promoted here only because it often happens to be unfairly forgotten. The analysis is to be kept harmoniously in all the "three worlds". If to force only one - the distortion and vulgarization will turn out. There are enough examples, one of them – Islamic radicalism: it is only necessary to force everyone live according to the Sharia – there will immediately come a paradise on the Earth. As if in the history no one had ever lived according to the Sharia, or now someone is forbidden to live by it We see that this idea seized considerable masses (the promise of quickly achievable result often is accepted with enthusiasm, unlike the traditional ways offering constant efforts during all the life without any guarantees). And a lot of energy was already released. We already went through this matter at the beginning of the 20th century as the Bolshevism, and in 19th something similar was promised by Krylov's "the prankish Monkey, the Donkey, the Goat and the clumsy Bear".

Apparently, not on any base set it is possible to realize any structure: it is possible to construct a hut of adobe, but for the palace, the bricks are necessary to be burned. First, you need

to learn music, and then create orchestras. If violently drive everyone into the commune Vera Pavlovna dreamed of, it turns out in the reality a collective farm (if not a prison) with aluminum spoons. In social processes, it is important to consider the human potential existing.

Conclusion

Who owns the information, he owns the world.

W. Churchill

Let us list the main ideas of the work.

The hypothesis underlying the modeling asserts that the attributes of the phenomena under study are united by a certain constant law (on the time of interest), that constitutes the essence of the object under study and allows to combine the various observed phenomena into a single object of modeling.

We map a set of attributes of the modeling object into the set of the model characteristics using analogies. Such a mapping is informal, subjective and easily challenged from the formal positions, except the simplest cases where the characteristics are obvious and allow direct measurement.

On the set of characteristics of the model, as on the base set, we construct the model as a mathematical structure. The constructed structure-model reflects and represents for us the essence of the object of modeling. We cannot guarantee that the model correctly reflects the essence of the modeling object, even if it gives the correct prediction in millions of experiments over thousands of years of operation – the coincidence of the forecast with the experiment is only a necessary condition for the model's adequacy. Sufficient conditions we do not know.

The model is based on the available stock of mathematical structures (the "modeler" is in captivity of the existing mathematics, according to A.A. Dorodnicyn).

Objects of the humanitarian sphere are usually more difficult to study than the natural scientific ones. Therefore, it is a wrong way to try to turn a humanitarian field into mathematics, for example, by giving strict definitions to the attributes of humanitarian objects and building deductive systems on their basis.

It is more fruitful to begin with analogies to the simplest mathematical designs, receiving series of simple mathematical models – a kind of "mathematical mythology" of the subject domain. Then the model can complicate and pass to multi-scale modeling.

Analogies are always disputable. Apparently, the criterion of the success of even a very crude model is its ability to bring the researcher to the structure that inspired this model and to induce further development of the model.

In the study of physical closed systems, the conservation laws play an outstanding role. In the humanitarian field, an important role is played by open dissipative systems that preserve their

structures by maintaining their potentials of dynamic equilibrium at the proper level. There is a conservation of laws of the system life.

Complex humanitarian processes should be considered simultaneously in three aspects - the "three worlds": the physical, information and the world of ideas and principles. Ideas embodied in the structures may prove to be an important ordering factor, the "Maxwell's demon" for complex humanitarian processes, which allows using part of the internal energy of the system.

It can be expected that the more complex is the system modeled, the more complex is the structure providing its behavior, and the more important for its understanding is the analysis of the noosphere or the "world of computer science".

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