GLOBAL MODELS OF SOCIETY OF NEURONET TYPE WITH ANTICIPATORY PROPERTY.

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ABSTRACT: It is considered the new class of models for global socio- economical processes. The key topic in such models is the mathematical modelling of 'general culture of society'. The main tool and analogy for such property is the associative memory property in large complex systems. The proposed models allow considering the mentality properties, sociological, historical, politologicaler questions. We also consider anticipatory aspects in proposed models.

KEYWORDS: Society global models, neuronets, associative memory, anticipatory property

1. INTRODUCTION

In the contemporary World of the end of XX century the humanity collides with some serious challenges: the ecological and food consumption problems, the international security after Cold War, the accelerating in the rate of changes in the basic fields of life. Now it exists the entirely new situation. The many interconnections between states cause the emergency of new object - the whole World as unique global systems. There was a long history of development of this concept in different area: in economics - World-system (I.Vallerstein), in culturalogy - global culture (R.Robertson), in ecology see D.Maknair, L.Brown, D.Odum and Sustainable Development concept.

There is further development of the concept toward the descriptions from regions to integrity (S.Aizenstadt, D.Wilkinson, and A.Frank). This concept seems very fruitful, but the difficulties are in the absence of the qualitative and quantitative measure of basic notions. For example there aren't the measurement and strong description of civilisation in the sense of M.Veber, A. Toinby, C.Hantington and many others. But the notion of civilisation or formation, or regimes implicitly exists in all above-mentioned concepts. There are some models for the Global World (J.W.Forrester, D.L.Medous and their followers, F.Marchetty, some expertise type models) and several other more local models for some problems (L.E.Richardson, W.Weidlich, many macroeconomics models and so on). But these models also can't actually give answer on all such questions.

There is another principal feature of the present state of contemporary World: their evolutionary nature. That is the rate of changes that accelerates rapidly now and the problems of evolution of global systems became more and more complicated. So the applicability of existing theories and models of society are under question. For example, there are many economical theories based on the equilibrium or quasiequilibrium concepts (Pareto, Gail, Kanes, Samuelson, Valras, Neuman, Nash and others). These theories had many truly brilliant achievements, but now in the actual situation when too many changes have occurred they also are under question. Say, in economics there is recognised now the necessity of accounting the global and continue changes in economical structures (for example, J.Foster, Evolutionary economics, 1987, many papers in such journals as "Methoduth", " The economical journal" and so on). One of the main tools for the investigation of evolution is the approach from the physical theories - that is from synergetic and self - organisations theory (I.Prigogin, H.Haken, G.Nikolis and many others). There are many achievements of such concepts in human sciences (for example see the description of role of nonlinearly and chaotic dynamics in economics by

K.Lorentz, Sheinkman J, Mosekilde G.). But till now the principal difficulties in building the elaborating theory of such type has been enormous.

It is of common knowledge that such variety of problems cannot be resolved without the modern scientific methodology. Obvious decisions can make the opposite to desirable effects (the principle of counterintuitive solutions). So in connections with such problems we can see the re-emergence of cybernetics role as the science for control. There are many tools: system analysis, mathematical modelling, artificial intelligence and many others. Of course the methods of abstract systems theory (Metharovich, Klir C., P.Chikeland, Atkin, Falb, A.Arbib, D.von Neuman, Wiener and many others) can in principle describe and solve many such problems in future. But there are some kinds of difficulties. First of all system analysis is being developed now. Secondly the real life is so involved that it is very difficult to put forward the global abstract theories enabling to answer the practical questions.

It is especially interesting to understand the living systems as not strictly formalised systems. For examples see soft system theory by P.Checkland, living system theory by J.G.Miller in "Behavioral science" journal with 7 system levels, approach by K.Baily of social entropy theory and many particular models. There are also a lot of investigations in pure humanity sciences (philosophy, politology, sociology, demography, and psychology) without formal and yet verbal models but with very deep description of some aspects. For example see the description of elements, notions and others. Remark that such investigations developed the basis for further researching by cybernetic methods. As an examples see the works by T.Parsons, D.Iston, R.Merton, C.Mann, E.Durkhime, P.Burdie, and above mentioned papers by I.Vallerstine, A.Frank, A.Toinby, and L.White. But nevertheless the frontiers of new theories are not clear.

There also exists the great variety of the mathematical models: the global models of J.Forrester, D.Meadowes, N.Moiseev, Krapivin, Tarko, the works carried out in IIASA (Luxenburg, Austria); A. Luterbaher's model and others. It is known that the above models present mostly three types of global blocks (biosperical, climat and anthropological).

The block of human (anthropogenic) factors actually seems to be the less developed one. There are the models for little groups in sociology and psychology or the global models with lack of details or the so-called models with microdynamics (Weidlich and Haag, K.Troitz and others). But as described in [Troitch, 1996] the influence of the existing models on the humanity sciences is rather for many reasons. For example one of the main difficulties in microdinamics approach lies in necessity to have the transition probability. The common difficulties in above models are also the almost full lack of mentality representation in them. This is in contradiction with grate role of the mentality in recent local and global processes, especially in transition problems. The artificial intellect theory can give the answers on some questions, but there is the lack of practical operational models with artificial intellect.

So as the resume of introduction we may say that in spite of many successes of system analysis and mathematical modelling there is the necessity to have socio- economics. So, as resume it exists main basic items for the theories and models of the World: the society as the whole object, the evolutionary nature of the society, the mentality problems and some propositions on the laws of their behaviour. New principles and models allow for solving the real problems of the World community. In proposed report we briefly consider the principles of new models construction, some applications and further scientific problems. Some details of approach are in author's publications.

2. The principles of new models construction.

First of all we must select the elements of model and laws of evolution for state of elements in model having in mind simultaneously the necessity to take into consideration mentality, natural, ecological, and some exogenous factors.

2.1 Levels of description.

If we wish to take into account the human factor it is natural to consider an individual as the basic element. Thus basic "elements" of society is individuals and society is considered to be the set of individuals. Let us take that society consisting of N >> 1 individuals and each individual characterising by vector of state $S_i = \{s_1^i, .., s_{k_i}^i, s_{k_i+1}^i, .., s_{M_i}^i\}$, $s_l^i \in M_i^l$, $l = 1, \dots, M_i$ where M_i^l is a set of possible values s_i . In the simplest case we assume that first k_i components of state vector characterise material state of individual (accumulation, value of production and so on). Another $M_i - (k_i + 1)$ components characterise inner (mental) properties of individual such as motivation, satisfaction and so on. Remark that we can take the usual package of parameters from economics and humanity sciences as material and mental parameters. One package of parameters is displayed in [Baily, 1993]. Note that in more elaborated models we can consider as elements not only individuals but also factories, organisations, branches of

industry, elements of nature and so on. Of course, the aggregation procedure may be applied for some objects of 'elementary' level receiving the highest levels. For example the factories, the branches of industry, the separate countries as elements are results of aggregation. A.Petrov and A.Shananins considered some aggregation procedures in economics. The blocks may be the result of aggregation and the objects of higher level. There are many possibilities to compose the elements in blocks and levels in such models. Automatically or 'at hand' classification procedure can be applied to creating the levels of description. We can also consider the hierarchy of levels and the basic element as complex object. See for example the models of individual with internal brain structure and activity. In such case the specific models for dynamics of mental parameters - say neuronets, or fuzzy cognitive maps or expert systems may be applied.

2.2 Connections between elements and dynamical laws.

In sufficiently developed society individuals have many complex connections. Let us formalise this. We assume that there are connections between i and j individuals. Let J_{ij}^{pq} is the connection between p components of element i and q component of element j . Then we call all set of connections between N individuals as bond matrix. For example, the bond between components of material state may be the flux of goods in some production chain. Bonds between inner components of subject for example can describe the influence of one individual on another and so on. Remark that in some cases the connections reminds the productive chains in Leontieff's economical models. Also the bounds on different levels may have the different types.

Thus the set Q = ({ s_i },{ J_{ij}^{pq} } , i,j = 1,...,N) characterises actual state of society as a whole construction including both elements and bonds between them. T.Parsons, L.White, C.Mann and others should remark. Note that society description with the help of set Q reminds in some sense the description used in relational models or in semantic nets, but the exist some difficulties with their applications connected with the selection of parameters intrinsic to considering the socio- economical systems and suitable to proposed models. The choice of parameter for real problems needs the deep understanding of the subject.

But more difficult problem is to construct the principles for model construction. The models must correctly imitate dynamical processes in society. Strictly speaking, many dynamical principles may exist for fixed set Q. Dynamical models may be continuous or discrete in time. (In such case the state of elements and connections are considered in discrete moments of time t= 0,1,2,3, with dimensionless unit time step). For example in discrete time the models must take the forms

$$s_i(t+1) = j_i(\{s_i(t)\}.\{s_i(t-1)\},...,\{J_{ij}(t)\},\{J_{ij}(t-1)\},...,b)$$

$$J_{ij}(t+1) = y_{ij}(\{s_i(t)\},\{s_i(t-1)\},...,\{J_{ij}(t)\},\{J_{ij}(t-1)\},...,c\}$$

The key step then consists in concretisation formulas above. Thorough examination of real society properties allows us to pick out one class of models Following considerations are the leading ones. First of all, there exist some global structures in society dynamic (formations or civilisations in alternative approaches [Toinby, 1991, Vallerstine, 1983, Makarenko, 1994]). The society develops in the frame of such structures. Secondly, alternation in individual state follows under the influence of some society environment. This can be described by some mean field approach. Such field influences the subject state. Third, it is possible to see global structure in society from the structure in some smaller object (for example in subregion). This property in some sense is analogous to holography.

Analysis of recent models for media from sets of elements and bonds shows the resemblance of such society models to neural network models. Remark that neural networks are widely investigated in cybernetic, biophysics images processing, physics and so on. Such objects have important associative memory property - [Hopfield, 1982, Makarenko, 1994]. Let us remind concisely the property of systems with associative memory in the theory of image recognition. Such systems include many elements and recognise small number of images by evolution of element states to the remembered patterns. These patterns are attractors of system. Images remembering are ensured by bond modification in learning processes. May be most simply and usable is the Hopfield model. In Hopfield model the element take only two values +1 or -1 and dynamics is described by formulas

$$v_i(t) = \sum_j c_{ij} s_j(t)$$

$$s_i(t+1) = sign(v_i(t) - q) \qquad (1)$$

Remark that recently much more complicated models of associative memory have been put forward. For example the more elaborated model which take into account many historical layers has the formulation (see for example [Gyonne et al., 1987]

$$v_i(t) = \sum_j \sum_l c_{ij}^{(l)} s_j(t-1) +$$
$$+ \sum_{ll'} \sum_{jj'} c_{i,jj'}^{(l,l')} s_j(t-l) s_{j'}(t-l') +$$
$$+ \sum_{j_o \dots j_g} c_{i,j_o}^{(o,\dots,g)}{}_{j_g} s_{j_o}(t) s_{jl}(t-l) \dots s_{j_g}(t-g)$$

Coming back to the socio-economical models we may assume that patterns in associative memory models correspond to the global structure (formation, civilisation). Connections between elements (individuals) alter in the historical process. If the time of alternation of these bonds is much longer then the time of alternation in element state, than it is possible to explore the models with quasiconstant bounds for the prognostic purposes. As the first step in model selection it is possible to use the Hopfield model analogous. Then we may take as mean influence field the quantity $E = \sum_{ij} \sum_{pq} J_{ij}^{pq} s_p^i s_q^j$ The dynamics of model is defined by proper rules on the basis of E. If we don't consider the mental parameters at all and take $M_1 \equiv 1$ and value state {+1, -1}, than we can interpret the pattern in such model as the distribution of consumer and producer in dependence of historically created bonds J_{ij}^{pq}. In this example $s^i = +1$ may be interpreted as production of material welfare and $s^j = -1$ as consumption. There are many subprocesses in such system - political, social, cultural and so on. In the following section inventory description on some possible applications of proposed principles and models is presented.

3. Towards the formalisation of internal structure account.

The verbal description of internal structure was described in previous section. Now we give the possible structure of models and some corollary. First we describe the model structure with one element with internal structure. If there were no internal structure it were the system in section 2 for dynamical law. Let the individual with internal structure has the index i=1. Their dynamic is determined by two components. First component determines by external mean field as in the section 2. Second part of dynamic is connected with internal dynamics of first individual. Remark that this dynamic partially account the willing of individual. There exist many models for such part of dynamics but it is useful to put the neuronet models for our purposes.

Let us named the pattern of society $Q^{(1)}(t)$ in section 2 as 'image of real world ' in discrete moment of time t. We also introduce the $Q_{wish}(t)$ - ' desirable image of world in moment t by first individual' as the set of element states and bonds wishes by first individual in moment t.

$$Q^{(1)}{}_{wish}(t) = (\{s_I{}^{wish}(t)\}, J_{ij}{}^{wish}(t)\}). \quad (2)$$

Then we assume that the change of first individual state depend on difference between real and desirable image of the world:

$$D^{(1)}(t) = [[\, Q^{(1)}{}_{wish}(t) - Q^{(1)}(t) \,]], \quad (3)$$

where [[*]] - some norm. Then we can assume the dynamical law for first element as

$$s_1(t+1) = F_1(h_1(t), D^{(1)}(t)) \quad (4)$$

In simplest variant we can assume the simplest law for F_1 as

$$s_1(t+1) = \mathrm{sign}\,(h_1 - q_1 - p_1) \quad (5)$$

$$h1 = J_{ij}\,(s^{wish}{}_j - s_j) \quad (6)$$

The next step consist in comparison wishing images of world with the real images of world in moments

$$t, (t+1), (t+2), \ldots, (t+g(i)) \quad (7)$$

that is anticipating in such moments. Remark that in simplest case here g(i) = g(1). The parameters {g(i)} define the horizons of anticipation. Than the dynamical law for first individual becomes

$$s_1(t+1) = F_1(h_1(t), D^{(1)}(t), D^{(1)}(t+1), \ldots, D^{(1)}(t+g(1))) \quad (8)$$

where

$$D^{(1)}(t+k) = [[Q_{wish}^{(1)}(t+k) - Q^{(1)}(t+k)]] \quad (9)$$

$$Q^{(1)}(t+k) = (\{s_l(t+k)\}, \{J_{ij}(t+k)\}) \quad (10)$$

The generalisation to the case with internal structures on all elements has the form

$$S_i(t+1) = F_i(h_i(t), D^{(1)}(t), D^{(1)}(t+1), \ldots, D^{(1)}(t+g(i))); \qquad i= 1,2, \ldots, \quad (11)$$

System (11) and their modifications may constitute the frame for investigation many problems with internal and external images of the world.

3.1 Some considerations**.**

We pose here some remarks. Substitution in the system (11) expression (9), (10) follows to equivalent to (11) system:

$$S_l(t+1) = G_l(\{s_l(t)\}, \{s_l(t+1)\}, \ldots, \{s_l(t+g(I))\}, R) \quad (12)$$

where R the set of remaining parameters. It is very prospect that the structure of system (12) coincide with anticipatory systems with incursion described in (Dubois 1998a, 1998d). This follows possible similarity in properties. Here we pose some considerations.

First of all we should mentioned multivaluedness of solution. Nonlinear system (12) allows multivalued solution. Then we can tell about hiperincursion in terminology by Dubois. Next if we have the set of desirable images of society than we automatically receive multyvalued operators (as in differential games). So the problems of multivalued mapping attractors arise in the spirit of theory developed by V.Melnik. Intellectual agent's application is prospective for our models. In any case the models above constitute the basis for implementations many concepts from sociology ('habitués", social space by P.Bourdier, reflexive agents by E.Hiddens, self- referencing systems by N.Luhman).

4. Applications and further results.

The whole model may be very complex and expensive because it must consider a lot of processes in detail. But even global principles shed some light on dynamic of transition processes and thus can help in development. For example, the society can go from one global structure to another by two ways: evolutionary or by revolution. Revolution makes fast rupture of bonds and destroys the attractor. Evolutionary way is long transition from one attractor to another (for example from socialism to capitalism). Yet on such global level there are phenomena of life- cycle type. The change of social formation may be considered as the change of "patterns" in proposed models. Remarks that the nonsimmetric bonds cause the chaotic oscillations occurrence that overlap the cyclic processes.

It is clear that the blocks may be fragmented and subdivided on the subblocks for different subprocesses. So the full model must contain a lot of sub-blocks. Remark that modern pure ecological or economical models include hundreds of equations of different type. The structure of proposed models allows to considering the separate subblocks independently and then combining the subblocks into more and more elaborated model. It is important that for such large and complex system as society much subprocess and subsystems are large complex objects and may be described by models with associative memory property. Such models then can be joined up. Roughly speaking such subprocess work as the connected systems in living organism or as different neurone networks in the brain. So probably the models in [Cohen and Grossberg, 1983] with few kinds of neurones will be useful. Among such networks in society one of the most important is the informational and communicational network. Some aspects of information processing were described in literature (C.Marchetty, J.Gains, Kristincen and many others). Proposed models can give new understanding of such processes.

Proposed concept and principle on model construction allow us to receive some practical applications of models. In [Makarenko and Levkov, 1995; Dobronogov et al., 1996; Makarenko, 1997] it were considered the modelling future geopolitical relations and collective security system structure in Europe after the destruction of the USSR. It was created as mathematical model as computer program implementation. Yet simplest models give very reliable results. The models displayed the neutral recent state of Ukraine, attracting Belorussia to Russia, consolidations or division of NATO and some others aspects [Makarenko, 1997]. Also proposed principle was applied to sustainable development problems in global ecology [Makarenko, 1997, Makarenko and Klestova, 1997], to infection spreading in epidemiology [Makarenko and Klestova, 1997], to some problems in intelligence manufacturing and life- cycles [Makarenko, 1997]. Now under consideration are some problems (for example attitude formation, election problems, conflictology, large business and finance problems and others). It should be noted that the proposed models are well adjusted to new informational database - Geographical Informational Systems (GIS). Proposed models also posed some interesting problems in cybernetics and mathematics - on the structure of neuronets and their axiomatisation, on control and dynamical behaviour [Makarenko, 1996].

Resume.

Thus there are proposed some consideration of recent state of social problem system analysis and new principle for constructing new type of models. The key topic for models is the associative memory property in large socio - economical systems. The construction of full really applicable models is expensive so it seems to be a good problem for future. But yet received results with simplest models are interesting for supporting decision-makers, sociocybernetical investigations and real process control.

Thus the models allow considering the anticipatory aspect by considering the hierarchical models of neuronet type. It should be noted that the proposed models are well adjusted to new informational database - Geographical Informational Systems (GIS). New control problems may be solved on the base of such models. The example is conflictly control problems in real society.

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