NEURAL NETWORKS FOR MODELLING OF LARGE SOCIAL SYSTEMS. APPROACHES FOR MENTALITY, ANTICIPATING AND MULTIVALUEDNESS ACCOUNTING.

Alexander Makarenko

Abstract. It is consider the new global models for society of neuronet type. The hierarchical structure of society and mentality of individual are considered. The way for incorporating in model anticipatory (prognostic) ability of individual is considered. Some implementations of approach for real task and further research problems are described. Multivaluedness of models and solutions is discussed. Sensory-motor systems analogy also is discussed. New problems for theory and applications of neural networks are described.

ACM Classification Keywords: I.6.5 Model development: modelling methodology

1. Introduction

There is one principal feature of the present state of contemporary World: their evolutionary nature. That is the rate of changes that is accelerating 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. One of the main tools for the investigation of evolution is the approach from the physical theories - that is synergetic.

There also exists the great variety of the mathematical models. It is known that the above models present mostly three types of global blocks (biospherical, climate and anthropological). The block of human (anthropogenic) factors actually seems to be the less developed one. The artificial intelligence theory can give the answers on some questions, but there is the lack of practical operational models with artificial intellect.

We may say that in spite of many successes of system analysis and mathematical modelling there is the necessity to have socio-economics models. So, main basic items for the theories and models of the World exist: the society as the whole object, the evolutionary nature of the society, the mentality problems and some propositions on the laws of their behaviour. In proposed report, we briefly consider the principles of new models construction, some applications and further scientific problems. The main goal of this report is to describe the ways of mentality accounting and especially the anticipatory property accounting consequences.

2. Short Description of Models

Let us take that society consisting of N >> 1 individuals and each individual characterising by vector of state $S_i = \{s_1^i,..,s_{k_i}^i,s_{k_i+1}^i,..,s_{M_i}^i\}$, $s_l^i \in M_i^l$, $l = 1,...,M_i$ where M_i^l is a set of possible values s_i . There are many possibilities to compose the elements in blocks and levels in such models. 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 Thus the set Q = ({ s_i },{ J_{ij}^{pq} }, i,j = 1,...,N) characterises state of society. Analysis of recent models for media from sets of elements and bonds shows the resemblance of such society models to neural network models.

2.1 Possible Structures of Models

Now we follow the description of hierarchical systems similarly the one in papers by Mesarovich and Takahara. We suppose initially that there are M hierarchical levels in the socio-economical system with N_j elements on

j-th level. Each I-th element on j-th level have description by vector of parameters Q_i^j i=1,2,...,N $_j$; j=1,2,...,M. Some elements on chosen levels can be in associations, marked by set of possible indexes in associations $L_i^j \subset \{1,2,...,N_j\}$. Many elements in developed society have a vast number of interconnections on there and on upper and lower levels. We may denote connections (bonds) between i1 elements on j1 level with i2 element on j2 level by J(i1,j1;i2,j2). Remark that other fields of interest (political, social, educational and so on) have similar network representation and society, as a whole is a union of such networks.

The bonds from the connection sets may be very different on the nature. The values of bonds may represent the normalisation of economical, informational, control channels, nationality, family bonds, and participation in professional associations and so on. The general model of system as in general system theory can be introduced with the help of input X1, X2, …, XM and output Y1, Y2, …, YM spaces for every level with input variables xi ∈ Xi and output variables yk ∈ Yk.

In reality society is evolutionary system with dynamical changes on time. Further we for simplicity will consider only discrete time models with moments of time: 0, 1, 2, ..., n,… . Following evolutionary nature of systems considered it is natural to consider as input of system in moment n the values of parameters from X in n-th time moment and as output the values at next (n+1) time moment (for n=0, 1, 2, …). Remark that in developing society the content of elements set may changes. For example in economics the list of firms and corporations changes gradually by bankruptcy and by creating of coalitions. Social, political, governmental networks are often in transformations. This lead in general to changing the number of elements N $_j$ (n) and number of hierarchical levels M(n) for different moments of time. Next if we wish to take into account the past states of society explicitly we should introduce to equation (1) or (2) the values X(0), X(1), X(2), … , X((n-1)). Than the system description takes the form

$$Y(n)=f(X(0),X(1),X(2),\ldots,X((N-1)), X(n), P, E).$$

2.2 Dynamics in Model

The equation above is rather general but for further investigations and practical applications we should have more developed models. Because we should consider evolutionary problems the main difficulties consist in searching the principles for modelling dynamics.

The author's models consider the Society as large complex object constructed from many elements with interconnections. The considerations of Society properties allow picking out some interesting properties and then to propose the models, which can imitate society behaviour. Surprisingly the models are familiar with models of brain activity - the neuronets [1]. Such models are under investigation by author since 1992 and yet had some interesting applications. In the processes of model consideration author continuously tried to take into account recent state of above mentioned sciences.

Now let us briefly describe the models. The first step of model building consists in the choice of model element and their description. Because it is need to take into account mentality of peoples in simplest models as the elements was took the individual with their description by series of mental and other (economical, demographic, and other parameters). These parameters may be evaluated in some scales psychology, sociology and other humanity sciences.

Next there are a lot of interconnections between elements in society - informational, business, relationship, and infrastructure. The elements are connected by bounds. The bounds correspond to influence by individual, the money flows and others. Such connections are created historically. The set of element states and bounds give the description of society in some period of time. Remark that such description is familiar with verbal description in humanity sciences. For example the pictures in L.White's works remember the pictures for global socio-economical models. But if we wish to describe the dynamics of society and to evaluate the influence of control, we must to know dynamical laws or tendency in dynamics. The proposed models have such dynamical principles

that they can imitate the behaviour of global culture in time. This is because the models have the property of associative memory. That is it can learns from historical processes the bounds and tends to very stable constructions- to so called attractor in pattern recognition in informatics and neuroscience. It is important that many social sub-processes in society also have the properties above allow considering the separate sub-models.

In earlier papers author introduced new class of society models as modification of neuronet models such as Hopfield, Potts, Izing. It is well known that Hopfield model is derived from the functional called 'energy'. In case of hierarchical systems and symmetrical bonds between different elements and different levels there also exist functional – counterpart of 'energy'. Remark that there also may be formulated generalisation of Hebbian learning rules.

3. Mentality Accounting

The mentality accounting requires considerations internal structures and incorporating them in global hierarchical models. There are many approaches for mentality accounting (see review of some aspects in [2, 3]). The most natural way for implementing this task is to consider as model for internal structure also neuronet models. Remember that originally neuronet models were introduced in the investigation of brain. Firstly we can change the basic laws. On phenomenological level it may be implemented by introducing subdivision of elements parameters on external and internal variables and establishing separate laws for two blocks of parameters. But one of the most prospective ways for mentality account lies in searching equation also in neuronet class. Here proposed to introduce the intrinsic mental models of World in elements, which represent the individuals or decision-making organisations with human participation. The simplest way consists in representing image of World in the individual's brain or in model as collection of elements and bonds between elements. In such World pattern there exist place for representing individual himself with personal beliefs, skills, knowledge, preferences. The mental structures on other individuals are also represented. Then the laws for element evolution should depend on such representation.

4. Anticipatory Property

The next step of developing models consists in accounting anticipatory aspects of individuals. It is evident that individuals in decision-making processes have prognoses on future. In such case the states of elements in model should depend on the images of the future described in internal representation. As in usual reflexive system there may exist some stages of iteration in anticipating future. We call such case as hyperincursion.

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 was the system in section above 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 above. Second part of dynamic is connected with internal dynamics of individual. Remark that such dynamic partially accounts 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 above 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. $Q^{(1)}{}_{wish}(t)=(\{s_l{}^{wish}(t)\},J_{ij}{}^{wish}(t)\})$. Then we assume that the change of first individual state depend on difference between real and desirable image of the world. The resulting system takes the form:

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

where R is the set of remaining parameters. It is very prospect that the structure of system above coincides with anticipatory systems with incursion [4]. This follows possible similarity in properties.

5. Multivaluedness in Neural Networks

So far the neuronet approach had followed after the original problem formalisation. But with spreading neural network methodology some new mathematical problems had aroused which may have long- term influence on the development of neurocomputing and not only it. Such problems follow from models above. First topic concerned the neuronet models with hierarchical structure. The second and very interesting connected with possible multivaluedness in neuronet.

The main source of multivaluedness lies in neural elements with internal structure with anticipatory property when the dynamical behaviour of element depends from desired pattern of future [3]. Some preliminary results were received with R.Pushin on modelling unique multivalued neuron. Also the principles for dynamics were considered.

In parallel (and forwards) some possible range of applications may be proposed. Some such issues are brain processes and conscious, quantum mechanical analogies, many worlds concept in physics, logic and philosophy, complexity, multivalued solutions of differential equations.

6. Some Relations to Sensor-Motor Robotics

The models described in previous sections already were applied to some practical problems. Further development will follow by exploiting concepts from another research fields. Surprisingly such enrichment leads to considering some fundamental problems of cybernetics. The main tool is inter- disciplinarily methodology.

One of the sources of new ideas is the psychological investigation of visual perception. Remember that the perception process not only include the reception of signal by visual sensor system but also include internal comparison with patterns. Such patterns are internal constructs of visual perception system [5, 6]. Further development of proposed models will lead to complication of internal models and to modelling of process of norms learning. It is directly connected the investigations on norms ruled behaviour. Society norms, morals, religion and so on determine the rules. Remark that till now there was a little investigation on such topics mostly of model character [7].

From another side further development of proposed models needs further re- considering of basic principles of artificial intelligence in application to such problems. From such point of view especially interesting are investigations in formally different research field in automation and control – that is from behaviour theory of mobile robot. The short list of investigations (see [8, 9]) includes analysis of sensor- motor robotics; comparison of formal language's and behavioural approaches; internal representation of external environment; role of sensor information channels. Some of such concepts may be transfer to the neural type models of large socio-economical systems. One of the basic concepts in the mobile robot theory is physical landscape. In social systems case the evolution takes place in many- dimensional space constructed from physical and mental space. The points in this space are representation of system space in different time moment. Remark that the description of environment as network from [10] may be useful building internal description of world.

Conversely, the author's model may be interesting for considering mobile robot problems. The neuronet description of external environment is first example for such application. But more prospects may be the investigation on anticipatory agents. As already had formulated above, anticipating property account leads to multivaluedness of behaviour scenarios in systems with self- reference. Concerning mobile robot it may lead to more intelligent behaviour (in definition of intelligence from [11]).

The next perspective approach follows from the considering neuronal models with many agents. As background for modelling large systems it allows to solve the optimal control and game- theoretical problems. The robot soccer may be one of such issues. The second is the control problem for many vehicles with internal structure in 2D and 3D space cases.

7. Applications and Discussion

Now we should discuss some issues connected to above problems. It should be stressed some relations to another topics in artificial intellects. One of such item is so called artificial agent's theory. Now there are many investigations on artificial agents. In this approach some non-classical logic are accepted. Moreover our neuronet type models follows to consideration of some non-classical logic. Another interesting aspect is the structure of neuronet models itself. Our investigations lead to the necessity of considering set valued neural networks.

The possible applications of models with mentality account to election processes, negotiations, public relations, education are discussed. Also pure mathematical problems on multi-valued maps and on conflictly-controlled systems are posed. As application it were considered the modelling future geopolitical relations and collective security system structure in World after the destruction of the USSR, sustainable development, epidemiology, conflict theory, stock market and others [12, 13]. It was created as mathematical model as computer program implementation. Remark that recently we had received interesting result on models with internal structure application to the stock market process. This is the example of mental agent application. Recently new possible fields of applications are outlined. Moreover the connected to multi–agent modelling, cellular automata, decision-making in social systems became visible. Also new analogies of quantum mechanics and social system behaviour are found. Besides, the theory of distributed reflexive systems can receive the strict models for consideration. Ontology of knowledge and systems description may easy take into account mentality aspects. All this follows to new problems in neural network design and in neural network theory, which the author supposes, discuss in the report. One of the main conclusions is that the new proposed fields of neural network applications can lead to reconsidering some backgrounds of the network considerations.

The paper had been partially supported by Ukrainian Grants 0205U000622, 0105U000490

References

1. Makarenko A. About the models of Global Socio- Economic process. Proceed. of Ukrainian Acad. of Sci. (1994). N.12.p.85-87. (in Russian).
2. Makarenko A. New Neuronet Models of Global Socio- Economical Processes. In "Gaming /Simulation for Policy Development and Organisational Change" (J. Geurts, C. Joldersma, E. Roelofs eds.), Tilburg Univ. Press, (1998). pp.133-138.
3. Makarenko A. Models with anticipatory property for large socio-economical systems. Proc. 16 th World Congress of IMACS, Lausanne, 21-25 August, (2000). Switzerland, Paper n. 422-1
4. Dubois D. Introduction to Computing Anticipatory Systems. Chaos Newsletter (Liege), January, (1998). n. 2. pp.5-6.
5. Zinchenko T. Perception and coding. Leningrad, Leningrad. Univ. Publisher, (1981). 183 p. (in Russian).
6. Perception. Mechanisms and Models. W.H. Freeman and Company, San Francisco, (1972).
7. Epstein J.M. Learning to be thoughtless: social norms and individuals computation. Santa Fe Institute, CA, USA, Working Paper n.6. January, (2000). 31 pp.
8. Tani Jun Model- based learning for mobile robot navigation from the dynamical system perspective. IEEE Trans. Syst . Man. Cyb., Part. B. (1996). V.26, n. 3. Pp.421-436.
9. Lect. Notes. in Artificial Intelligence, Springer - Verlag, (1998). N.1515. 260 pp.
10. Makarenko A. Complexity of individual object without including probability concept. Fourth Int. Conf. on Computing Anticipatory Syst., Abstract Book. Liege, Belgium, August, (2000). 3pp.
11. Albus J.S. Outline for a theory of intelligence. IEEE Trans. On Syst. Man. Cyb. , (1991), v.21. n.3. pp. 473-504.
12. Levkov S., Makarenko A. Geopolitical relations in post USSR Europe as a subject of mathematical modelling and control. Proceed. 7 IFAC/IFORS/IMACS Symposium: Large scale Systems. L.UK: Vol.2. (1998). p.983-987.
13. Levkov S., Makarenko A., Zelinsky V. Neuronet type models for stock market trading patterns. Proc. 5th Ukrainian Conf. AUTOMATICA'98. Kiev, May, 1998. Pp.162-166.

Author's Information

Alexander Makarenko – National Technical University of Ukraine "KPI", Institute for Applied System Analysis
Department of Mathematical Methods of System Analysis
37, Pobedy Avenue, 03056, Kiev-56, Ukraine, makalex@i.com.ua, makalex@mmsa.ntu-kpi.kiev.ua

TOWARDS THE PROBLEMS OF AN EVALUATION OF DATA UNCERTAINTY IN DECISION SUPPORT SYSTEMS

Victor Krissilov, Daria Shabadash

Abstract: The question of forming aim-oriented description of an object domain of decision support process is outlined. Two main problems of an estimation and evaluation of data and knowledge uncertainty in decision support systems – straight and reverse, are formulated. Three conditions being the formalized criteria of aim-oriented constructing of input, internal and output spaces of some decision support system are proposed. Definitions of appeared and hidden data uncertainties on some measuring scale are given.

Keywords: decision support systems, straight and reverse problems of data uncertainty, three conditions of aim-oriented object domain constructing, appeared and hidden uncertainties.

ACM Classification Keywords: H.4.2 Information Systems Applications: Decision support Systems

Introduction

One of the most actual questions of decision making theory – is the question of forming aim-oriented description of an object domain, namely, description of input, internal and output spaces of decision support systems (DSS). Practically, any input data has uncertainty, sources of which can be: inaccuracy of measuring and inaccuracy of rounding-up, scale restrictions, impossibility of measuring or definition of values with needed precision, hidden semantic uncertainty of qualitative data, etc [1, 2]. In addition, uncertainty in DSS may be caused by methods, used for obtaining, storage and processing of knowledge. A great deal of uncertainty to the decision making process brings the subjective factor that appears when the person making a decision (PMD) formulates the set of alternatives decisions and the set of descriptive criteria for them.

Main known approaches to the evaluation of uncertainty in DSS are methods of the probability theory [3, 4] and methods of fuzzy logic [2, 5]. The first are used in that case, when the extensive statistical information about the decision making process is accessible. The second are applied for description of system behavior, when it is too expensive or practically impossible to construct precise mathematical models. However, frequently in real DSS there is a necessity of the composite approach for estimation and aim-oriented handling of input and output space uncertainty.

The given paper is devoted to the problems of an estimation and evaluation of data and knowledge uncertainty in DSS.