Extracting Indicators for Safety Level Fluctuations

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Abstract. Predicting the internally and externally initiated crisis in human societies is an unsolved problem. In this paper we describe the contribution toward the formulating the set of indicators of a society which: (i) are function of easily and regularly measured statistical parameters, (ii) are few in number, and (iii) clearly separate the states in which crisis is possible from other states.
The construction of indicator set is presented, its application to agent based model conducted and its implementation in characteristic synthetic complex systems described.

Introduction

The conventional, technical sector of our daily environment, which has been the scope of the NDT, and diagnostic and monitoring related activities, is within the programme of technical safety and security NDT techniques so interconnected with the human, social sector, that in many cases it is easier to treat them on equal footing, than to separate them.

Recent intensification of activities including public threats brings about additional need for methods and techniques based on NDT, which provide one with a definite answer as to whether in some observed region there is or there is not a public threat.

In this paper we present two techniques for assessment of possibility of a public threat. One is numerical simulation using agent based modelling, and the other is exploiting autonomous groups of mobile robots. The former approach, within virtual domain, aims in obtaining the most probable scenarios of threats, while the later provides one with a definite answer of a threat in the domain of a real world. Both approaches are characterised with a variety of related parameters. By indicators we refer to the rather small subset of these which provides one with a sufficient quantity of information.

Improved understanding of the social system dynamics makes possible more reliable predictions and modelling of their future states [1]. That contributes to forming the feedback loop in which the presently observed system state values induce processes which purposefully change the values. However, the very first step toward such a loop, the sufficient understanding of the social system, is not reached yet. There are three approaches to reaching and expressing appropriately the sufficient level of understanding of the social system dynamics, here denoted as:

- indicator-based approach,
- modelling-based approach, and
- meta-theoretical approach.

In the next section we present the meaning of indicators within the conventional NDT scheme, in the third section we concentrate on the role that agent based modelling could have, and in the fourth section we present level reached with the autonomous groups of mobile agents in relation to detection of public threats in some region. Main points are summarised in the last section.

Indicators

Parameters describing indication, conventional non-homogeneity in the NDT, or a source of a public threat in modern applications, are linked with the parameters describing environment, at least the surrounding.

The number of such parameters is generally rather high. While it is on the one hand useful to collect, record and analyse as many parameters as possible, on the other hand it is opportune to have a rather small sub-set of parameters as a representation of a local situation. That representation is useful in decision making, in determining scenario of further treating the indication, etc.

The smallest subset which reliably represents the indication we refer to as the basis. The basis and its dynamics enables decision makers, analysts, scientists and professionals to track development and evolving of different states in a region.

In the indicator-based approach the set of regularly measured characteristics - the global and social indicators [2], is used to represent a social system state. The phenomenologicaly determined system dynamics is used in predicting future system dynamics. The description is efficient if a significant part of its information content is expressed using few indicators. The recognition of important indicators and their use depend on many factors. Usually, the more detailed the description, the higher the number of the indicators required. In general, there is some redundancy and non-completeness of the indicator set, what is emphasised in the larger indicator sets. In order to overcome the problem of indicator set complexity, many small sets of indicators were formulated e.g., a set of demographic indicators, a set of economic indicators, or a set of quality of life indicators. Despite the diminishing of the system information content, the reduced sets are still large. Furthermore, the indicators are phenomenological constructs which are often vaguely related to system micro-quantities. Finally, the rules of dynamics are extracted during relatively large time intervals in order to make possible observation and confirmation of regularities. All stated suppresses the efficiency of the indicator-based approach in reliable description of rapidly developing systems, the examples of which are found in a number of systems.

As two-element basis of the socio-technical environment, recently the entropy and free energy were addressed. The researches in the related area has since recently intensified [3]. The basis of the approach is that the quantities used should: refer to the whole system, have recognised meaning, be independently measurable, and be little in number. The combination of the free energy and entropy is the indicator-like set which optimises the requirements imposed on the number of measures used and the quantity of information thereby obtained. It is the combination having meta-theoretic origin. Owing to the highly formalised relations among these functions in physical applications, they are to be easily modelled. Moreover, they have to be modelled in order to obtain clear view of their dynamics, and of the way how changes in surrounding are reflected in changes of free energy and entropy.

Agent based modelling

A model complexity is reduced in comparison with the realistic systems complexity, what serves in gaining the insight into consequences of the chosen rules of dynamics of system elements, i.e. agents, like individuals or firms. Important parts of the model are the characteristics of the agents, and the global characteristics such as those describing in detail the non-equilibrium nature of some system states. Using modelling, several disadvantages of the indicator-based approach are overcome. Firstly, in the modelling one defines the micro-context, while the macro-context and systemic quantities are formed in a definite averaging procedure. Secondly, the modelling is based on the numerical simulations hence the relevant part of dynamics is obtainable in relatively short periods which computers need to process the model. Thirdly, in modelling one may modify dynamics in a number of ways for a number of similar systems. Nevertheless, the modelling-based approach has some limitations in comparison with indicator-based approaches. The models are useful if the agents are relatively simply described. The consequences of the complex agent behaviour and description of the myriad of observed system subtleties are still out of the scope of modelling. Therefore, the potential of using the modelling in predicting the future system dynamics along with some detail is still somewhat limited.

Computer modelling of a system incorporates the whole set of perspectives from micro- to macro-level. Models are of reduced complexity in comparison to the realistic systems complexity. That enables the insight into consequences of the chosen rules of dynamics of system elements, i.e. agents, like individuals or firms, sub-cultures, or other groups. The advantage of modelling is that one defines the micro-context and obtains the macro-context and systemic quantities in a definite averaging procedure. Secondly, the modelling is based on numerical simulations, hence the relevant part of dynamics is obtainable in relatively short periods which computers need to process the model. Thirdly, in modelling one may modify dynamics in a number of ways for a number of similar systems. Fourthly, in modelling one can predict different impacts of institutions, agents or other elements in the model, and rank corresponding future states in accordance with a given set of criteria. Nevertheless, the models are useful if the agents are relatively simply described, thus a lot of subtle phenomena and their global consequences are out of the model scope.

For the needs of computer simulation, culture is often operationally defined as a corpus of shared traits held in common by a social group.

In relation to computer simulations of cultural phenomena, two approaches are generally distinguished: in the first approach, one typically studies the consequences of the theoretical assumptions, hoping that he or she will be able to generalise findings to explain something about real people. This approach is characteristic of social scientists. In the second tradition, most often arising from computer science, applied mathematics, and engineering, research is predominantly guided by a desire to find better ways to solve hard mathematical problems.

Related to computer modelling in general, let us emphasise here the system dynamics modelling. In this approach a system is divided into functionally related units, having definite relations to environment. System dynamics was originally rooted in the management and engineering sciences but has gradually developed into a tool useful in the analysis of social, economic, physical, chemical, biological, and ecological systems. Initially, we exploit that approach in order to model population dynamics of cultures in contact. More precisely, we model the dynamics of population with given characteristics, that may be nation, culture, social class, ideology, etc.

Autonomous groups of mobile robots

Recent trend in the field of mobile robotics became development of autonomous groups of mobile robots. On the one hand, the enlargement of number of robots is related to management of high-risk situation, and on the other hand it contributes to development of character of the group as the distributive, mobile sensors.
The advantage of such groups is that they are considerd to be capable of replacing humans in a variety of situations, primarily in hostile environments, or environments dangeours for humans (because e.g. of a risk of explosion, presence of a chemical and other agents).

Summary and Conclusions

Modern technology offers a large number of solutions to applying NDT in traditionally non-covered areas. One direction in applying the technology is through simulations, e.g. numerical. Within that approach in a number of virtual environments, evolving in such a way that they resemble some modelled system, is classified according to a given set of criteria for probability of occurrence and degree of suitability. In another direction, in a restricted surrounding, in realistic conditions, autonomous groups of mobile robots are exploited as a set of intelligent, distributed sensor system for continuous monitoring and even some degree of modification of the observed elements.

References

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