ISSN 1512-1232

FINITE STATE AUTOMATON MODELING

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Key words: finite automata, random environment, collective behavior, asymptotic optimality, theory of Games.

Problems related with collective behavior of automata constitute an interesting and perspective direction in the theory of complex systems. These systems consists of large number of compound parts - subsystems possessing a comparatively high degree of autonomy. A convenient way to describe simple forms of such an interaction is the language of the Game Theory. Although the use of this language reduces the class of behavior forms under study, it leads to the construction of a series of meaningful models that allow to get vivid and well interpreted characteristics of the system, which turned our to be very useful in the design the control of the system.

The theory of collective behavior of automata, as an independent scientific trend, takes its origin in the basic works by M.Tsetlin and his collaborators. The theory assumes that the complex forms of behavior can be realized by a collection of finite automata appropriately behaving in random environment. As an elementary behavior problem, the problem on the behavior of automaton in a stationary random environment has been chosen. This is a problem of choosing one or several actions under a random reward. A well-known construction of automata suggested by M. Tsetlin possesses the property of asymptotic optimality: by choosing sufficiently many states (or the capacity of memory) per action, one can guarantee a limiting value of the average gain which is close, as much as desired, to the maximum value of the gain. A detailed account of results in this direction is given in monographs [1,2].

On the next stage of investigation there were considered games and models of collective behavior of such automata. One of the features of the models under consideration is the absence of an a priori information. Each automaton while choosing an action on a current step possesses only the information on its own gains and losses, having no information neither on gains of other automata, nor on the number of playing automata, and in general on the very game it plays. Therefore, the interaction in the game is generated only by the reaction of the environment on the joint behavior of automata. In the models of such types, of considerable interest are ways of organization of controlling actions maximizing the expectation of the gain. A controlling action can be realized on the one hand by sending control signals to automata, and on the other hand by inserting an additional structure to the collective of automata [3].

However, speaking of an effective solution to the problem of improvement of behavior characteristics, the most important is the estimation of the rate of convergence of collective of automata to the stationary distribution. The point is that under a large capacity of memory of playing automata, due to the negligibly small probabilities of changes of action, the average time an automaton stays even in the most unfavorable state, becomes very large. Moreover, the asymptotic optimality of be ha vi or of automata does not guarantee a sufficiently good behavior on a comparatively small time interval.

The first example where an additional structure has been introduced into the collective automata, is Tsetlin's procedure of "joint cashbox" which turns any homogeneous automata game into the so called the Gur Game, where the probability of reward for all automata are equal and depend only on distribution of automata in actions. This simplest model of collective behavior - the Gur Game has been studied repeatedly. Its analytical solution in different modification entails great mathematical difficulties caused by the fact that the number of states of the corresponding

ISSN 1512-1232

Markov chain grows rapidly as the capacity of memory increases. To avoid these difficulties several attempts were made to get an approximate but simpler description of the game ; however, the suggested approaches did not have a rigorous grounds. For the first time a rigorous method had been suggested or investigation of asymptotic behavior of automata in games, when $n \to \infty$. The basic theory had been developed which became a main part of the robust method for the distributed coordination based on the Gur Game and also was given a general method for the analysis of these systems which were studied only in a restricted number of cases [4].

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Article received: 2012-12-08