Towards Cellular Automata Football Models with Mentality Accounting

Alexander Makarenko[1], Dmitry Krushinski[2], Anton Musienko[1], and Boris Goldengorin[2]

[1] Institute for Applied System Analysis at NTUU (KPI), 37 Pobedy Avenue, Kiev, 03056, Ukraine
makalex@i.com.ua
[2] University of Groningen, Faculty of Economics, P.O. Box 800 9700AV, Groningen, The Netherland
b.goldengorin@rug.nl

Abstract. In this paper we deal with mathematical modeling of team sport games based on cellular automata (CA). We describe some developments of CA models of football. Presumable learning and optimization problems in team modeling based on CA are discussed. Some general problems are discussed which are related to the accounting of mentality of game participants.

Keywords: football, cellular automata, models, anticipation, mentality.

I Introduction

Recently the simulation of sport games (especially football) serves as a source for developing new approaches in understanding and modelling of games. Some aspects of collective sport games had been considered earlier: sport statistics; reinforcement learning; hardware implementations of players through robot teams and Championships on robot football (RoboCup) [1]; design of moving robots for competitions and many others. But all authors had stressed the great complexity and multi-aspect nature of the existing problems. Analysis of the demands on real world applications of CA follows to the new field of cellular automata using – namely modelling the evolution of collaborative teams of agents. As the main example of such system we consider the football. We propose some description of rules for modelling, development of models for evolution investigations, some examples of modelling and some ways for approach development.

2 Simple Football Model Based on Cellular Automata

Here we pose (only for outline of ideas) a very schematic description of CA model of football. The full description will be described in forthcoming publications.

First important assumption is that the game space is represented as the collection of cells just as in the cellular automata models for pedestrian movements. We consider

S. Bandini et al. (Eds.): ACRI 2010, LNCS 6350, pp. 149 – 152, 2010.

two teams of players. At each step we define all single available player movements within some fixed neighbourhood. In case of the Neumann's neighbourhood we compute the probabilities of player's movement into one of four neighbouring cells. Remark that we may accept extended neighbourhood for each of the players if we should take into account the different presumable velocities of players.

Each player is represented by occupied cell. The rules for player concerned the movement of player, operations with a ball and interactions between players. Only one player may be at any cell. The player also can move at the lattice step by step in vertical and horizontal directions. The rules for player's behavior in fact formalize the rules for decision of player in dependence on the situation at the field of game and in dependence of current score of the game. Also we set the probability to move for player to be zero if a neighbouring cell is occupied by a boundary, and assign non-zero probabilities to cells of all other directions. By increasing the probability in a chosen direction we model an intention of each player and the team to move simultaneously.

Proposed models had been realized as the special computer program for the modeling of game. For illustration we pose one of a computation examples.

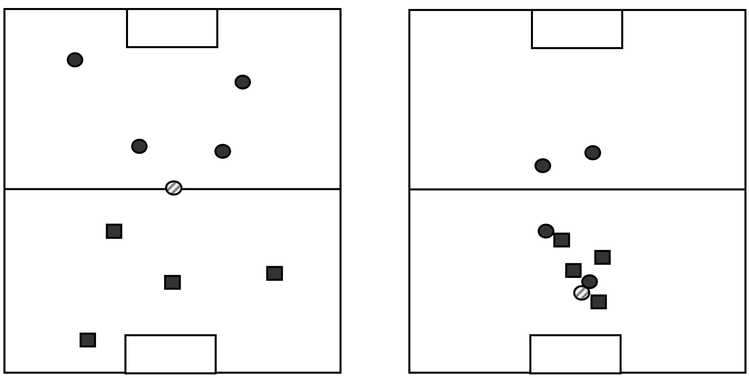

Fig. 1. At the left side of picture the example of beginning of the game situation is presented. The right side illustrates the approach of the player with the ball to the gate of opposite team after some time steps at game. (Each team has four players (black squares and black circles); the grey circle corresponds to the ball).

3 The Problems of Mentality Accounting in Game Simulation

In Sections 2 we have presented the classical approach of CA without taking into account the mentality properties for player movements. The accounting of mentality of the participants of social processes (including sport games) is one of the main tendencies in developing of more adequate models. There are many presumable ways of implementing such accounting – from the attempts to model the human consciousness and decision – making in artificial intelligence to the simplest statistical rules.

Of course many aspects related to the mentality accounting should be represented in the complicated models of the game: monitoring and recognition of game situation; decision – making process on movement direction, velocity and goals; possibilities of movement implementation etc. [1]. Because of simple spatial structure CA models allow to implement a lot of properties of a team players in rather simple way.

Here we discuss the way for accounting one of the very important properties in space game namely anticipation in game. The anticipation property is that the individual makes a decision accounting the future states of the system [2].

One of the consequences is that the accounting for an anticipatory property leads to advanced mathematical models. Since 1992 starting from cellular automata the incursive relation had been introduced by D. Dubois for the case when ‘the values of state X(t+1) at time t+1 depends on values X(t-i) at time t-i, i=1,2,…, the value X(t) at time t and the value X(t+j) at time t+j, j=1,2,… as the function of command vector p’ [2]. In the simplest cases of discrete systems this leads to the formal dynamic equations (for the case of discrete time t=0, 1, ..., n, ... and finite number of elements M):

$$s_i\,(t+1) = G_i(\{s_i(t)\},...,\{s_i(t+g(i))\},R), \tag{1}$$

where R is the set of external parameters (environment, control), $\{s_i(t)\}$ the state of the system at a moment of time t (i=1, 2, …, M), g(i) horizon of forecasting, {G} set of nonlinear functions for evolution of the elements states. “In the same way, the hyperincursion is an extension of recursion in which several different solutions can be generated at each time step” [2, p.98].

According [2] the anticipation may be of ‘weak’ type (with predictive model for future states of system, the case which had been considered by R. Rosen) and of ‘strong’ type when the system cannot make predictions.

Concerning the specific case of the game problems it had been recognised earlier that some kinds of anticipatory property is intrinsic for game. But in fact considered before in sport games anticipatory properties was of ‘weak’ type (with predictive models). The experience of investigations of models with anticipation – in game “Life” with anticipation [3] and especially in crowd movements [4] allows proposing some ways for further accounting of anticipation in team investigations.

At the local level each participant of the game process tries to anticipate the future state of game in local neighbourhood when he makes the decision on movement. Also the macro neighbourhood of game participants might be accounted for the common coach information. The adequate accounting of anticipatory property in the CA methodologies is a difficult problem because it requires also complication of CA models by introducing the internal states of CA cells and special internal dynamical laws for mental parameters. But just now we are able to propose some presumable consequences for game considerations. According [3, 4] the first step in anticipation accounting consist in the modification of CA rules by introducing formally the values in cells at next moment of time into the formal rules.

Of course the full implementation of such models is the task for further investigations but the extension of the results described in the present paper to new game models would open new possibilities for exploring behaviour of game participants. At first it may be considered the problem of accounting the different player’s visions of the field of game by different neighbourhoods for each player.

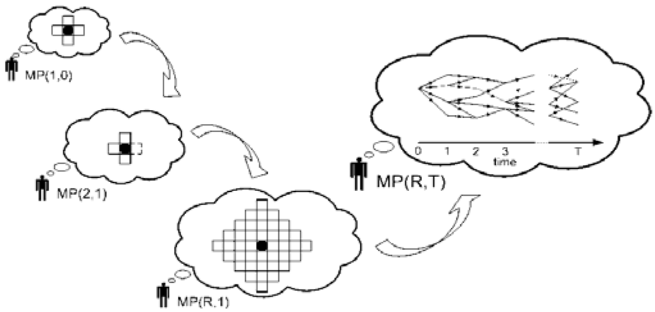

Fig. 2. Expanding neighbourhood of player (R corresponds to the size of the neighbourhood of player's vision in learning processes and T corresponds to the number of time steps accounting in the CA rules; T=1 corresponds to the absent of anticipation)

The case of MP(R, T) in upper right angle of picture illustrates important possibilities in CA models with anticipation. The graph illustrates the origin of multivaluedness of the presumable states in the models. It corresponds to the case when each player anticipates existing of many presumable states of elements of the system. Such uncertainty generating by mentality accounting of players is the example of manifestation of 'strong' anticipation. It follows from our investigations that anticipation and multivaluedness also may serve as the source of uncertainty in the systems.

4 Conclusions

In proposed paper we have presented some ways and tools for an improvement the CA based models and their software. The presented results are interesting for practical applications. Described models may be used as the polygon for testing new approaches and ideas in the field of cellular automata investigations. Also some new possibilities are proposed which are connected with the mentality of players.

References

1. `http://www.robocup.org`
2. Dubois, D.: Generation of fractals from incursive automata, digital diffusion and wave equation systems. BioSystems 43, 97–114 (1997)
3. Makarenko, A., Goldengorin, B., Krushinski, D.: Game 'Life' with Anticipation Property. In: Umeo, H., Morishita, S., Nishinari, K., Komatsuzaki, T., Bandini, S. (eds.) ACRI 2008. LNCS, vol. 5191, pp. 77–82. Springer, Heidelberg (2008)
4. Goldengorin, S.B., Krushinski, D., Makarenko, A.: Synchronization of Movement for Large – Scale Crowd. In: Kyamakya, K., Halang, W.A., Unger, H., Chedjou, J.C., Rulkov, N.F., Li, Z. (eds.) Recent Advances in Nonlinear Dynamics and Synchronization: Theory and applications, pp. 277–303. Springer, Heidelberg (2009)