Design of Structure and Realisation of Game Rules Database of Robot-Soccer Game

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Abstract. In this paper we developed system for coordinatization the robot-soccer game. This coordinatization we want to use for strategy extraction. The robot soccer is bimilar ant-like systems, which take advantage of agents' situatedness to reduce or eliminate the need for centralized control or global knowledge. This reduces the need for complexity of individuals and leads to robust, scalable systems. Such insect-inspired situated approaches have proven effective both for task performance and task allocation. The desire for general, principled techniques for situated interaction has led us to study the exploitation of abstract situatedness – situatedness in non-physical environments. The port-arbitrated behavior-based control approach provides a well-structured abstract behavior space in which agents can participate in situated interaction. We focus on the problem of role assumption, distributed task allocation in which each agent selects its own task-performing role. This paper details our discretization the robot-soccer game.

Keywords: mobile robotics, multi-robot coordination, behavior-based control, group behavior

1 Introduction

The typical example of distributed control system with embedded systems is the proposal of control system of mobile robots for the task robot-soccer game. The selection of this game for laboratory task was the motivation both for students and for the teachers as well because this was a question of proposal and realization of complicated multidisciplinary task which can be divided into a whole number of partial tasks (the evaluation of visual information and processing of image, the hardware and software implementation of distributed control system, wireless data transmission and processing of informations and the control of robots). For sophistication of the own (and opponent) game and strategy is necessary her description. With it is related design of structure of game-rules-database of robot-soccer game.

Ant-like systems take advantage of individual agents' situatedness to reduce or eliminate the need for centralized control or global knowledge. This reduces the need for complexity (of sensing, computation, and communication) of individuals and leads to robust, scalable systems. Such insect-inspired situated approaches have proven effective both for task performance see [4,12,5].

The game system is represented by up to 11 own and 11 opponent autonomous mobile robots at game site up to 200x100cm. The core of mobile robot is digital signal processor Motorola DSP56F805. PWM outputs of signal processor are connected to pair of power H-bridge circuits, which supply pair of DC drives with integrated pulse encoders. For communication with the higher level of control system is used the communication module with the control IC Nordic nRF2401. The higher level of control system is represented by personal computer. In the PC entered the signal, which represent the picture of scene with robots scanned with above the playground placed CCD camera. At the output is connected radio line which transmits commands for all own mobile robots. The software part of distributed control system is realized by decision making and executive agents. The algorithm of the agents cooperation was proposed with the control agent on higher level. The algorithms for agents realized in robots are the same. The control agent determines the required behaviour of the whole control system as the response on dynamic behaviour of robots and on the own global strategy of the task and knowledge about last situations which are saved in the database of the scene. The agent on higher level controls the other agents [11]. The separate task is the transformation which converts the digital picture into the object coordinates (robots and ball in the task of robots soccer) which are saved in the database of the scene [1]. This database is common for all agents in the control system. Each agent sees actual the whole scene and is capable to control its behaviour in a qualified way. The basic characteristic of control algorithm of subordinate agent is the independence on number of decision making agents for robots on the game site. Both agent teams (own and opponent) have common goal, to score the goal and not to have any. For successful assertion of own game strategy is very important the extraction and knowledge of opponent game strategy. From object coordinates of samples of picture scene and game-rules-database create strategy extraction algorithms the own (and opponent) game strategy database.

2 Game site

Own and opponent robots created by own movements very dynamic changed environment. This environment is scanned by CCD camera with sample frequency (in present time) up to 75 fps. Picture sample before processing is demonstrated at Fig.1.

In our approach, a game is coded as a game matrix. We can extract vector V_t in time t from game:

Fig. 1. Picture sample from CCD camera signal before processing.

$V_t = \{t, X_1; Y_1; \alpha_1; X_2; Y_2; \alpha_2; X_3; Y_3; \alpha_3; X_{100}; Y_{100}; \alpha_{100}; X_{200}; Y_{200}; \alpha_{200}; X_{300}; Y_{300}; \alpha_{300}; X_{30}; Y_{30}; \alpha_{30}\}$

Where are:

X_i is x coordinate of own robot i
Y_i is y coordinate of own robot i
α_i is angle of orientation of own robot i

X_{i00} is x coordinate of opponent robot i
Y_{i00} is y coordinate of opponent robot i
α_{i00} is angle of orientation of opponent robot i

X_{30} is x coordinate of ball
Y_{30} is y coordinate of ball
α_{30} is angle of motion α ball

A game matrix GM we can define by following way:

$GM = (V_0^T, V_1^T, \ldots, V_{n-1}^T, V_n^T)$

The game matrix GM is very wide matrix (up to 420000 vectors - processed samples in time of game). This matrix inputs in the proper extraction of game strategy process by using the latent semantic analysis (LSA).

LSA is a statistical model of word usage that permits comparisons of the semantic similarity between pieces of textual information. Was originally designed to improve the effectiveness of information retrieval methods by performing retrieval based on the derived "semantic" content of words in a query as opposed to performing direct word matching. LSA was used for extraction semantic in many other situations see [2,3,4].

In this paper, LSA is used as a tool for strategy extraction problem. In our approach, a game is coded as a game matrix.

The results in [2,3,8,9,6] indicate that LSA can perform matching based on semantic content. The game matrix we analyze by LSA and obtain semantic information about game. This semantic information we can interpret as strategy. This strategy is use for for agent management see [10,7].

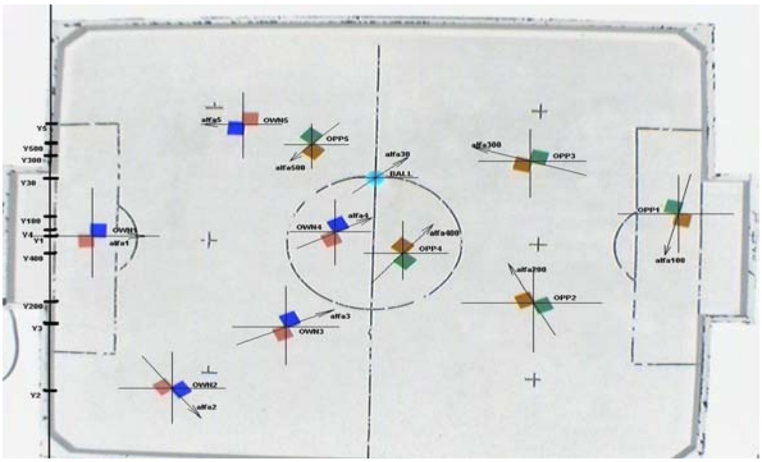

Fig. 2. Picture sample with transposed marked positions.

Extent of real position-game-matrix is wide (1024x768 pts, this is up to 787 kB). Very important is sequentially data reduction without information loss. The presented idea of game site description is similar to board game - chess. Thus be created virtual grid covered the same game site. Dimensions of grid are calculated from technical parameters of CCD camera and velocity of mobile robots. This step allows position data reduction without information loss up to 200-times (in dependence on grid dimensions). Reduction of data volume allows increase computation speed and advantageous motion description.

3 Virtual grid

The virtual grid allows reduction of data volume for game-strategy purposes and easy motion description. Description system with virtual grid works parallel

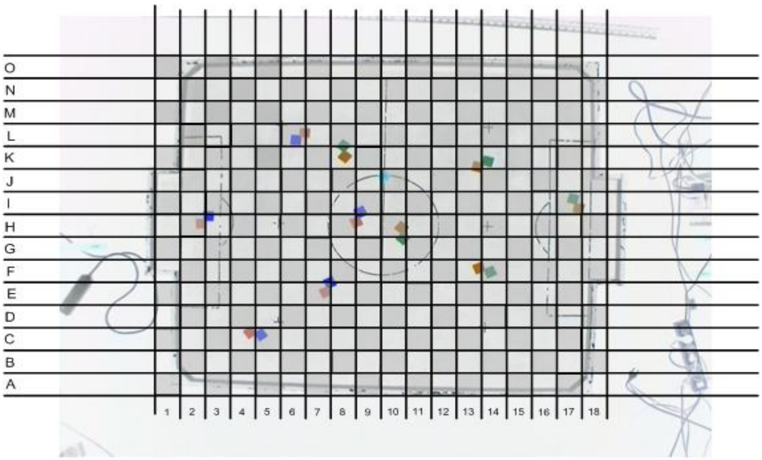

Fig. 3. Picture sample with (similar to chess) transposed grid.

with real coordinate system for exact sensing of subject position. Data volume of description with primary and secondary virtual grid is dependent on frequency of samples of used CCD camera (25-75 fps) and velocity of movement of mobile robot (robot-soccer player) at game site (up to 2,5m/s). In constituent discrete frame samples is possible study of movements of own (and opponent) robots. Distance between two points, which drive the robot at two in sequence frames, determine dimensions of primary virtual grid. To calculate with velocity of movements of robot, was primary virtual grid divided to more $(2, 4, 8, \ldots)$ parts. So was created secondary virtual grid (in next SVG).

Note: Primary virtual grid has, with maximal robot velocity 2,5m/s and frame samples frequency of CCD camera 25Hz, a dimension 10 x 10cm. By other velocity of robot and other frame samples frequency will be dimensions of primary virtual grid others.

Description of robot position and game movements If is for description of movements and velocity of robot in one frame sample used the secondary virtual grid, is afterwards possible alphanumeric description of robot and his direction and velocity of movement. Description is illustrated at Fig.4.

Note: Alphanumeric description of position of robot in given picture sample, his velocity of movement and direction of movement considering to previous picture sample by calculation or for prediction for next progression of game situation is possible describe by symbol (alphabetic) of player e.g. attacker (A), goalkeeper (G) and defender (D), by symbol (numeric) sequence of player function in team $(1, 2, \ldots)$, by symbol (alphanumeric) his current position in secondary virtual grid e.g. (HA24) and by symbol (alphanumeric) in case of strategic planning of his next direction and velocity of movement (HC24). Situation illustrates Fig.5. Robot goalkeeper No. 1 state at position CHA24 in secondary virtual

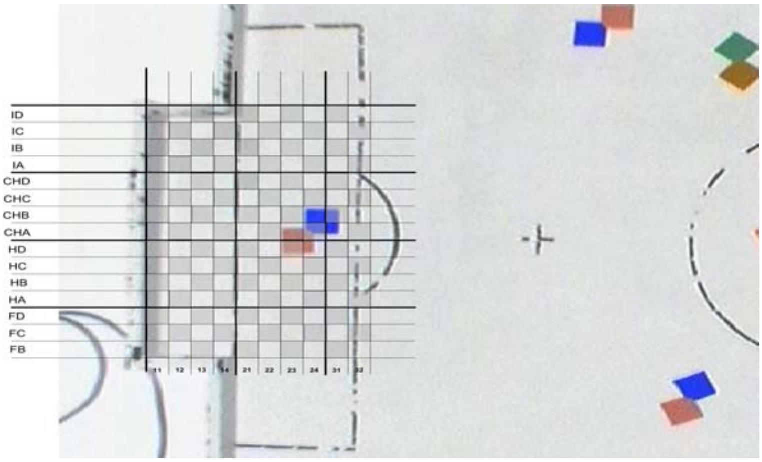

Fig. 4. Illustration of robot position description in SVG $\frac{1}{4}$ (Goalkeeper at position [CHA,24]).

grid (with division 4SVG=1PVG). Is planned strategic expedient movement (at HC24) with direction y-axis with velocity vT (vT = 3/4 . vmax). Alphanumeric description of such movement is [G1HA24HC24].

4 Strategic game movements

Strategic game movements each of robotic players can be dynamic changed and unreeled from their function during game progress and their momentary position at game site, position of opponents and ball. Game progress can be divided to three ground playing classes (in next GPC) and two ground playing situations (in next GPS):

- GPC of game opening (GPCO)
- GPC of movements in game site (GPCS)
- GPC of game end (GPCE)
- GPS attack (GPSA)
- GPS defence (GPSD)

Offensive: Interaction of simple behaviors causes the robots to fall into a V-formation when the ball is in motion roughly towards the opponent's goal. Perceptual properties limit the formation to three robots.

Defensive: When the ball is not moving roughly towards the opponent's goal, the robots cluster around it to form an effective barrier and be in good

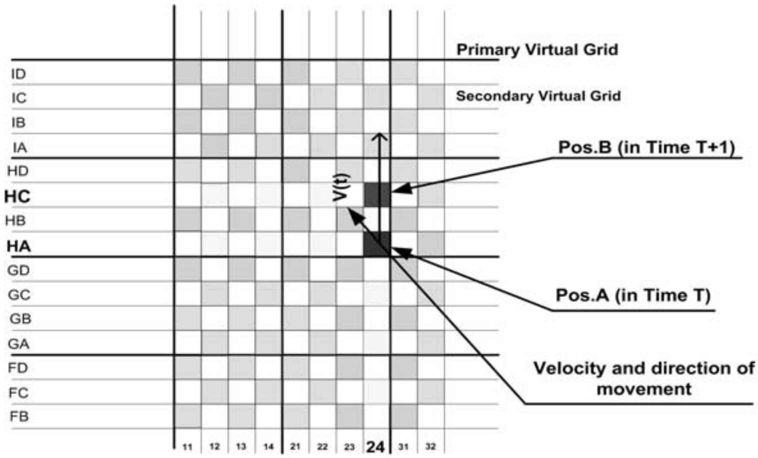

Fig. 5. Illustration of robot game movements with description [G1HA24HC24].

positions for recovery. to use similar means of assuming effcient roles. Here we discuss a system we have implemented for robotic soccer - which is also able to use local interactions to determine globally efficient roles.

Each GPC have own different movement rules. Classes GPCO and GPCE consists of finite number of movement variants. These come out from defined positions of players and ball at game site and defined direction of ball movement. Class GPCS have infinite number of movement variants, limited in current game situation (GPS) by ground game rules and game situation supported by own global game strategy (in next GGS).

Example of limitation of robot movements under the influence of his function during the game process. Example is presented via robotic player in goalkeeper function. Charge of goalkeeper is preventing the opponent to score a goal. His movements are, with only for minor exceptions, limited at own goalmouth near of goal line. Preferred movements are in goal line direction. Preference of these movements comes from idea of GGS, when goalkeeper prevent to score of goal so, that build own new position (near goal line) at line between the central goal point and ball (their point - centre of gravity and/or ball last movement vector).

Preference of other movement directions be created with GPSA, when movements of goalkeeper must secured kick away the ball from own defence zone. Situation illustrates Fig.5.

5 Conclusion

The algorithm of the control system should be proposed in a such way so that it would ensure the requirements for immediate response of control, so that the system with robots would be controlled in real-time. That is why, it is very important so that the algorithm for critical speed would be optimized. The system response should be shorter than time between two frames from camera. In the event that this limit is exceeded, the frame is cut out and the control quality is decreased. The main possibilities of the algorithm adjustment are as follows:

– Dynamic control in control and decision module of control agent.
– The control and decision modules and communication protocol of the decision agents.
– Strategy of planning in control model of the action agent.
– Extraction of opponent game strategy and using of extraction results for decision rules generation as a part of rules decision database of decision agent

It is necessary to know, that the system response should take a shorter time than the time between the frames from the PAL movie camera, e.g. 20 ms. If this limit is exceeded, the frame is dropped and a control quality decreases. Parallel proceed extraction algorithms of own (and opponent) game strategy collaborated with game-rules-database allows add and refine informations of own (and opponent) game strategy. This way is expand the rule database of decision agent for decision making within the bounds of own game strategy given by control agent.

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