An Autonomous Decision Making Framework for a Multi-Agent System in an Ambient with Limited Communication and Unreliable Vision

M.Sc. Nelson Iván González and Ph.D. Leonardo Garrido

Tecnológico de Monterrey, Campus Monterrey, México
ni.gonzalez.phd.mty@itesm.mx, leonardo.garrido@itesm.mx

Abstract. RoboCup 2D Simulation league is an ambient with limited communication and unreliable vision where two teams of autonomous agents must play a simulated soccer game. In order to win a match the agents must cooperatively chose the individual best actions against the opponent team. In this research it is proposed an autonomous decision making framework using the current world state and the individual intentions of each agents.

1 Motivation

The soccer domain is a highly competitive domain in where one team attempts to be better than the other team, in the case of RoboCup this is translated to better control methods and AI algorithms to solve complex problems.The RoboCup 2D Simulation league focus completely on AI, team strategy and multi-agent cooperation. In this league, autonomous software players (agents) play soccer in a simulated soccer field through a network. This league aims to pure research on AI since it does not need to deal with mechanics neither electronics. RoboCup 2D Simulation league is a suitable platform to do researching in AI and multi-agent systems techniques. It offers a highly dynamic and stochastic environment as a testbed for this new techniques. Phoenix2D team (formerly Borregos2D [5]) is a group of graduate and undergraduate students in areas related to intelligent systems from Tec de Monterrey. Phoenix2D team is an effort to construct a competitive team for the RoboCup 2D Simulation league, and it is also used as a testbed for research on multi-agent systems techniques.

2 Hypothesis and Research Objectives

The main objective of the Phoenix2D team is to be a competitive team in the RoboCup 2D Simulation league. In order to achieve this objective the next problem needs to be solved:

To choose the best action to perform in an autonomous way based on a cooperative strategy within a highly dynamic and stochastic ambient with limited communication and unreliable vision.

It is stated that each agent is completely autonomous and the only communication channel is a say command with limited size and limited aural range. The research aims to solve the problem proposing the next hypothesis:

The individual action can be choose according to the agent role, meanwhile the role is given by the current tactic and strategy choose by the current world state and an intention model, such as is shown in Fig. 1.

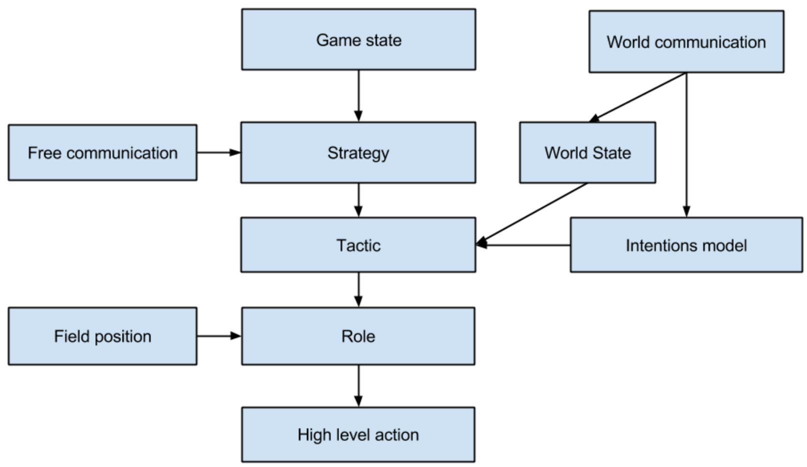

Fig. 1. Decision making architecture

Since the world model comes from a continuos set, it must be mapped to a discrete world state set. The methodology shown in Fig. 1 uses the world state as input. From the hypothesis the next specific objects are stated:

– To construct an accurate current world model using the vision sensor and the communication channel. To fully satisfy this objective an accurate self-localization and world model generation algorithm is needed
– To implement a mapping between the world model and the world state.
– To implement a communication protocol to carry reliable information about the world state and intentions.
– To implement the decision making algorithm to chose a high level action from an action set S previously defined, using the information of the world and the individual intentions, using the flow shown in Fig. 1.
– To minimize the computational resources usage of the proposed methodology.

3 Related Work

Several researches have been done in the RoboCup 2D Simulation league ambient. FC Portugal, one of the pioneers in the league, uses a generic coordination strategic layer [3] to chose the role of each agent in the system. One of its advantages is the possibility to be implemented in other multi-agent system. FC Portugal also uses set plays to coordinate attacks near the opponent goal [6]. CMUnited team, one of the first RoboCup 2D Simulation league team and winner of the RoboCup 2D 1998 and 1999, made a large research on layered learning in multi agent systems [7]. Also, Peter Stone, a member of CMUnited, has been actively publishing papers on multi agent systems since then, such as [9] where he uses reinforcement learning in the decision making task for intelligent agents. WrightEagle, the winner from RoboCup 2D 2011, uses a partially-observable Markov decision process [10], meanwhile HELIOS, winner of the RoboCup 2D 2012, uses a framework to search for the optimal action sequence in a continuos state-action space using a game tree search methodology [1].

4 Self-localization

One of the critical tasks of any agent in the RoboCup2D Simulation League is to localize itself inside the soccer field. From the self-localization all of the object's positions can be computed, in specific, the dynamic objects such as players and the ball. The self-localization task can be accomplished using the landmarks with fixed positions along the soccer field lines and the actions performed by the agent during the simulation. Currently, Phoenix2D uses a geometric approach to self-locate using the landmarks on the soccer field. Each landmark pair (l_i, l_j) is used to compute an approximated agent position through a triangulation method, then all of the computed positions are averaged using a weighted average (see Equation 1) with the errors of each computed landmark pair. The error for each landmark pair is the sum of the absolute errors in the distance measures of each landmark. The results using this method are shown in Table 1

$$\frac{\displaystyle\sum_{i=0,j=i+1}^{i=n-1,j=n} pair\_triangulation(l_i, l_j) * \frac{1}{pair\_error}}{\displaystyle\sum_{i=0}^{n-1} \frac{1}{pair\_error}} \tag{1}$$

A Markov localization with a Kalman filter [2, 8] is currently being implemented in Phoenix2D self-localization in order to diminish the error produced in this task.

Table 1. Geometric approach for the self-localization task

Self-localization	Error mean	Error standard deviation
Self-localization in x	1.4978 m	1.1343 m
Self-localization in y	1.7894 m	1.1230 m
Self-localization position	2.5428 m	1.2360 m
Self-localization body direction	2.0543°	2.2283°

5 Conclusions and Current Results

The current implementation of Phoenix2D is capable of playing complete games and ready to run complete customized experiments. With this implementation a master thesis was developed [4], the main topic was to select an action to be performed using a graph constructed from the current world state and bayesian networks. A fuzzy algorithm to accomplish the navigation task in a dynamic environment was implemented in Phoenix2D with good results on stamina management and time consumption. The research "Design and Implementation of a Fuzzy-Based Gain Scheduling Obstacle Avoidance Algorithm" will be published in MICAI 2013.

References

1. Akiyama, H., Shimora, H., , Nakashima, T., Narimoto, Y., Yamashita, K.: Team helios 2012. In: RoboCup 2012: Robot Soccer World Cup XVI (2002)
2. de Boer, R., Kok, J.: The Incremental Development of a Synthetic Multi-Agent System: The UvA Trilearn 2001 Robotic Soccer Simulation Team. Master's thesis, University of Amsterdam (2002)
3. Certo, J.a., Lau, N., Reis, L.P.: A generic multi-robot coordination strategic layer. In: Proceedings of the 1st international conference on Robot communication and coordination. pp. 11:1–11:7. RoboComm '07, IEEE Press, Piscataway, NJ, USA (2007)
4. Garza, A.: Use of Graphs with Bayesian Networks and Q-Learning for Pass-into-space decision making in RoboCup Soccer Simulation 2D. Master's thesis, Tecnológico de Monterrey (November 2012)
5. González, I., Marquez, D., Garza, A., González, L., Garrido, L.: Team borregos2d 2012. In: RoboCup 2012: Robot Soccer World Cup XVI (2012)
6. Mota, L., Reis, L.P., Lau, N.: Multi-robot coordination using setplays in the middle-size and simulation leagues. Mechatronics 21(2), 434–444 (2011)
7. Stone, P.: Layered Learning in Multiagent Systems: A Winning Approach to Robotic Soccer. The MIT Press (2000)
8. Thrun, S., Burgard, W., Fox, D.: Probabilistic Robotics. The MIT Press, Cambrigde, Massachusetts (2005)
9. Whiteson, S., Taylor, M.E., Stone, P.: Empirical studies in action selection with reinforcement learning. Adaptive Behavior - Animals, Animats, Software Agents, Robots, Adaptive Systems 15(1), 33–50 (Mar 2007), http://dx.doi.org/10.1177/1059712306076253
10. Wu, F., Zilberstein, S., Chen, X.: Multi-agent online planning with communication. In: Proceedings of the International Conference on Automated Planning and Scheduling. pp. 321–329. Thessaloniki, Greece (2009), http://rbr.cs.umass.edu/shlomo/papers/WZCicaps09.html