Arian Robocup 2003 Team Description

Decisioning based on the non-deterministic areas Instead of deterministic positioning In non-stationary environments For Robot Agents

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February, 2003.

Abstract: *One of the most important parts in designing anonymous intelligent robot agents is to determine where the robot is positioned. In case the robot agent is designed to operate in non-stationary environments, the results of this section are of great importance; because the results originated from positioning are directly used in intelligent layers. Decisioning in most common methods, for intelligent robot agents are being done using exact values (resulting from positioning) where gaining exact values require heavy algorithms and high processing. In this document we have tried to point out the causes and benefits of changing this method and substituting the non-deterministic areas instead of deterministic positioning.*
Here, instead of decisioning based on the deterministic positioning of each agent, decisioning is based on the area of which the agent is positioned in the environment.
These environments getting affected by the agent's position and the environment's parameters at each moment are the basis of the team's basic movements and decisioning in the agent's intelligent structure.

Keywords: *Non-deterministic areas, Positioning, Robocup, MultiAgent Systems, Non-stationary Environments, Intelligent Robots*

1 - Introduction

The most important part in designing and assembling intelligent robot agents is to employ methods for determining robot's position in the environment.

In case that the robot is designed to operate intelligently and in non-stationary environments; the position phase will be of great importance in processing intelligent methods. Because most decisioning methods are done by depending on the robot's deterministic position at each moment and by using heuristic methods, try to determine the robot's tasks.

Whereas each robot agent should be independent from the other robots and should intelligently make decisions, all the operations of determining the position are done by the robot itself and without the help or supervision of an external conductor.

Generally in these kinds of environments (non-stationary environments), there are signs that the deterministic position of these signs in the environment, are predefined for the robot. The robot by depending on vision and seeing those signs, will determine its current position. The level of accuracy of positioning in these methods depends on the number of signs seen.

The deterministic positioning has disadvantages which will be mentioned along this document and it is tried to introduce methods in the form of non-deterministic positioning to substitute with those methods. The methods introduced besides lowering the cost of installation and optimizing time in determining the position, are also closer to the terms of object orientation and multi agent. Whereas the non-deterministic positioning method is designed with the capability of multi layering, it can be used directly n decisioning levels.

The test of this method is done on the intelligent soccer player robots, because one of the best non-stationary environments for designing intelligent robot agents is the soccer pitch. The Robocop international competitions have been an appropriate place to test our goals in this section.

Of course there are too many algorithms today for performing basic tasks and intelligent decisioning of robots soccer which are far away from artificial intelligence principals. Our team aiming to improve the existing methods and by making non-deterministic decisions in non-stationary environments has done the hereunder tasks.

The intelligent structure of each soccer player robot agent is formed of two sections of low level and high level.

The low level section is the center of examination and analysis of primary data and deduction and classification of data. Obviously doing tasks such as running, dribbling, shooting, etc is done in this section. It is necessary to point out that positioning is a part of this section.

The high level section is the center of intelligent decisioning of each robot agent. In this section by depending on the classified information in the low level; decisions will be made for the subsequent moments.

In this document we will first point out the benefits and the rate of using this method in the low level section of the soccer player robots and in the next part the efficiency rate of this method in high level decisioning will be investigated.

2 - Low Level Making

The Low Level Making of each intelligent soccer player robot agent that will be named as player for short is a place for basic examination and analysis of the input information.

Each robot has inputs like vision (often from camera), hearing (often from wireless radio communications) and sense (often from sensors). This information after the primary processing will be turned into robot's raw data (for storing in information banks). The most important input information is the vision information. The vision information is a report of the place of the seen objects with their distance and angle from the robot. In most cases by simulating the seen area, a rough picture of the whole environment will be made.

In these methods that are known as "World modeling"; the received information after detachment will go to the deterministic positioning section and each of the polar information of the seen objects will be turned to Cartesian information. Then the new information after comparison with other input information and previous information an imaginary world will be made for the robot. This modeled world which is an imaginary model from the whole environment is the principal and basis of robot's decisioning in High Level Making.

In most teams, this section's tasks are based on the results from deterministic positioning and often by depending on heavy and time consuming algorithms try to eliminate the environment's noise and simulating the polar environment to Cartesian environment.

From disadvantages of these kinds of methods we mention the hereunder points:

- One of the primary principals in modeling the intelligent agents is the similarity between the decisioning algorithms and human being. This is so while the real soccer players continue playing without knowing their distance from the center of the pitch. However, due to investigations done the soccer player while playing will

know its position in the pitch by seeing some signs from the pitch and the surrounding environment and never calculates its exact distance from a point like the center of the pitch. Briefly, no soccer player calculates its distance from the center of the pitch for decisioning during the play, but imagines itself in an area with rough distance from the center of the pitch.

- Secondly, autonomously is the basic condition for an agent, while decisioning based on deterministic positioning in some methods are in contrary with this principal because some teams for determining each robot's current deterministic position use methods such as putting a robot or a conductor to determine the position of all the robots.
- The result of the deterministic positioning method is only a Cartesian coordinate that comparing to the volume of processing and the time consumed, is of less efficiency. In the non-deterministic positioning method each player will make basic decisions, by considering an area based on its position.

These areas that also determine the range of each agent's performances at each time do not have a predefined size, but their extent is based on the position and the extent of each robot's range of performance (**Fig. 1**).

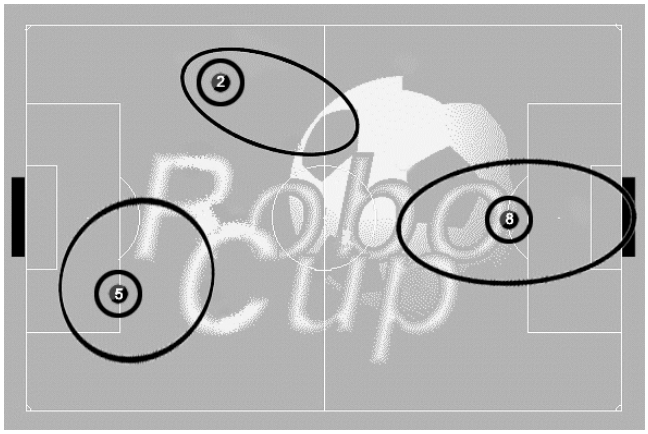

Fig 1: Performance Area

Choosing non-deterministic area instead of deterministic positioning has many advantages.

- The processing volume of positioning algorithm: In this method there is no need to increase the precision of positioning, but with an appropriate approximation we can reach suitable results. Thus there is no need for heavy processing to eliminate the environment's noise or mean calculation.
- Elimination of unexpected jumping: In the deterministic positioning methods, in some cases errors in the input information or the environment's noises or problems in the positioning algorithm will give unexpected results of the current position that by using statistical methods and information storing from previous positions tries to find the unusual points. Thus if the distance of the current position from the last position does nit match with robot's speed, the calculated position will not be verified. While in the non-deterministic positioning method the volume of the overlapped areas will determine the rate of noise that highly affects the decisioning processing speed and its correctness.
- Flexibility: The results of the deterministic positioning are no more than a coordinate, while the result of the non-deterministic positioning defines a flexible area.
- Dynamic phase of the Low Level Making: Whereas the non-deterministic positioning beside depending on the agent's position also depends on the environment, the environment's changes at each time will affect the activation area of the agent. Therefore for a player that does not have position change at a time unit; due to environment's variation we will see a change of area for that player. This change of area at each time will result dynamic decisioning in the Low Level Making. This privilege in a way reflects the player's sensations during the play. For instance if a soccer player is standing in a space which no other player is standing within radius of 10 meters will feel more free , while its surrounding being crowded will tighten its area of maneuver . The positioning parameter as a constant value will not show this changes while defining a non-deterministic area can also reflect this fact.

3 - High Level Making

The High Level in a robot agent holds the task of decisioning and behavior making.

Now a days most intelligent methods used on robot agents are done by simulating the whole environment. Although in reality, simulating the whole environment with correct information is impossible and too expensive but it is tried to have some information even incomplete but general so by these information and intelligent methods try to eliminate noises and make correct decisions.

The results of the positioning section are the most useful values in High Level Making because it is used for both simulating the environment and decisioning and behavior making. Although the positioning phase is not essentially in relation with the High Level Making but in the non-deterministic positioning method and by getting help from the areas and their special characteristic we can greatly help the development of High Level Making goals. Each of the characteristics of the non- deterministic areas can help a part of the decisioning or they can make a relation between different decisions.

In the following we will mention the privileges and specialties of positioning based on non-deterministic areas and we will also mention the type of communication and efficiency of that characteristic in the decisioning layer.

4 - Multi Layers of Areas

Two layers are used for each player's situation for positioning using this method (**Fig.2**).

The First Layer: It is a circular area with constant radius which its radius is proportional to the player's vision error and the environment's noise. This layer determines where the player is situated in the pitch.

The Second Layer: It is an ellipse that defines the player's relative performance area based on some defined parameters. This layer's parameters originate from team and individual strategies.

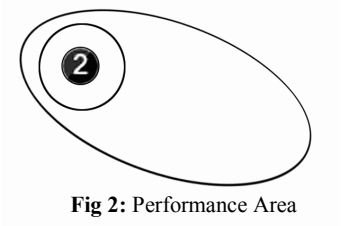

Fig 2: Performance Area

One of the advantages of Multi Layering in area determination is the increase of layers based on decisioning layer's needs. (e.g. having layers for defining the movement area or opponent marking area). Multi Layering and allocating each layer to a particular task can inform the agent of previous decisions so that the extent of each area is showing our thinking manner of that decision in previous moments. Doing the Multi Layering for non-deterministic areas is very easy and do not require much memory for storing its information.

5 - The Areas Over Lapping and Tasks Permeation

One of the big problems in Multi Agent Systems is the synchronized decisioning and making a common decision for a task at a time for two or more agents placed in the same area. This problem exists in not only the robot agents but in all agent systems and even in human beings. There are many solutions used in intelligent decisioning methods for eliminating this problem which surely bring limitations, but making non-deterministic layers besides preventing the limitations, will decrease the probability of this permeation occurrence. Thus without needing Agent Conference, it will prevent synchronized performances.

Whereas the layers have the ability to over lap, there are no limitations in choosing layers in aspects of direction and rate of extent.

From another view, the possibility of two players from one team at the same time being in the same area is very low or almost zero in this method, because the performance area of each player depends on different parameters like:

- Position in pitch
- Magnitude of power in making basic movements
- The extent of authority based on the predefined line ups
- Individual and team goals.

All these parameters being equal at the same time for two or more players from the same team is very rare. Therefore the probability of making similar decisions is very low.

6 - The Environment's Division

In many decisioning methods one of the simplest and most efficient ways, is the environment's division to stable and predefined areas, like the soccer environment. In these methods of decisioning, a set of authorities or a table of decisions will be allocated to each area based on experience or results drawn from learning. The robot will use the predefined decisions after determining its position by referring to the table of the environments division.

As it is obvious any effort for dividing the environment to predefined areas is in opposition with some of the agents simulating principals and even the agent's intelligence. In this section we substitute the deterministic and accurate positioning with the environment's division as a set of non-deterministic areas. This method is fairly simple to execute which is explained hereunder.

We first determine the area of each robot to be positioned in the environment and then cover the whole environment by extending the areas to empty districts.

After a few reforms that are done according to the environment's characteristics the whole environment will be divided as an irregular network (**Fig.3**).

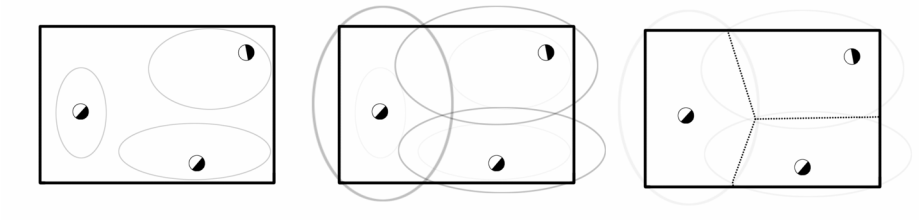

Fig 3: Environment's division based on areas extension

One of the advantages of changing the method of environment division from stable areas (with predefined specialties are learned) to non-deterministic areas for decisioning in non-stationary environments for simulating the robot agents is that the non-deterministic areas at each moment (during the play) can be made based on player's viewable area and based on remembering the pitch's model from previous moments and other factors.

Although environment division for decisioning, is not a reliable method and is seen as a semi intelligent method but this division (based on areas) has given it a dynamic state.

7 - Opponent Modeling

One of the most important effective layers of decisioning in environments with opponents is the Opponent Modeling.

In environments which our agents should compete with other intelligent agents, a layer in decisioning is set to estimate the opponent agents' performances. In this section we can use the non-deterministic areas as well.

Whereas the soccer player agents are in a way active in a competing environment; the methods mentioned are executable for simulating the opponent players. So we can consider different areas such as performance area for opponent players as well. By considering performance area for each opponent agent we can simulate the opponent agents in three general levels.

- **Anticipating the opponent behavior:** By defining the above areas for each opponent player we can anticipate their future movements. By using this method the rate of an opponent player's effect on the agent's or the ball's movement paths on the subsequent times can be calculated. In most intelligent methods the intelligency rate of the opponent players is supposed to be less or equal to the intelligency rate of our players and the opponent players can not be modeled as more intelligent; but in this method, this impossibility has become possible. For modeling a more intelligent opponent we can consider the opponent players areas more carefully and decrease their areas extension. Using this method we can consider the opponent's rate of intelligency being floated.
- **Technique determination:** Whereas in this method a similar area to our agents' areas is considered for opponent agents, the similarity of characteristics of each assumed areas for each opponent player can show the post of that agent in opponent team's general system. We can take advantage of this method to find an own agent similar to opponent agent.
- **Team strategy (Tactic) determination:** By determining their characteristics and how much the areas of opponent players are close, we can determine the opponent's play system during the match. We can use this method to choose a suitable system for our players by the online coach.

8 - Team Cooperation

The series of methods which help and coordinate between our agents are called team cooperation. Substituting the non-deterministic areas instead of stable areas or Cartesian points simplifies the team cooperation.

The advantages of using this method for soccer player robot agents are mentioned hereunder.

- Finding the pitch's empty areas (for counter attack) from the layers of opponent players areas of position
- Leading the play to open and suitable spaces
- Finding the weak points of defending for both our agents and opponent agents
- Designing the compression model of our players or opponent players from layer of players areas of position
- Finding optimized paths in non-stationary areas
- Finding a suitable playing system for each moment

By considering these areas and intelligent methods for simulating it, we can make team cooperation at any other environment.

9 - Parameter Acceptance and Learning

Another advantage of non-deterministic areas is the parameter acceptance of these areas.

Each of these areas according to the type pf creation are stored as a set of parameters that by changing these parameters we can control the position, size and even extent of each area. However, defining each area's parameters is done by intelligent systems.

One of the most important advantages of the presented systems for intelligent agents is their ability of learning. Whereas the full control of areas is based on some parameters, we can use that in different methods of learning. Some learning methods are explained and the usefulness of areas in those is mentioned hereunder.

- **Supervise Learning:** One of the best advantages of this method is in determining the rate of environment's noise. Whereas the method of defining areas essentially has errors; by using heavy statistical methods as a supervisor we can give the rate of input and environmental errors to the teaching agent. This method is usually used in non-linear teachings. Parameter acceptance of these areas has simplified the teaching advantages.
- **Unsupervised Learning:** We can also use unsupervised algorithms for learning using existing parameters for defining the areas.
- **Enforced Learning:** Also, in this kind of learning, because of the parameter acceptance of areas and because these parameters have phase ability, we can use the enforced learning.

10 - Conclusion and Future Steps

Many of the methods in designing intelligent robot agents to work in non-stationary environments are based on deterministic decisioning methods. However the non-deterministic decisioning methods are a lot more efficient. We have briefly explained the advantages of decisioning based on non-deterministic areas instead of decisioning based on deterministic positioning in non-stationary environments and their methods were investigated.

This theory was presented two years ago aiming to decrease the volume of process in positioning algorithms in intelligent soccer player agents programs and with some changes that were done during this period for raising its efficiency it turned to an efficient method .

Nowadays there are some methods for raising this method's efficiency in Multi Agent Systems which are briefly mentioned hereunder.

- The effect of condensation in each surface so that each area besides including extent, size and etc includes condensation as well. One of the advantages of this factor in areas is that it can isolate between areas which are similar in shape and position but are different in condensation.
- Most intelligent agent systems are active in three dimensional environments. Therefore changing the type of areas from superficial to voluminous is one of the future tasks.
- One of the important points in this method is the phase state of the areas. But the next step in this method is to bring in the phase logic in parameters and other characteristics of areas.

All this method with no single change can be used for intelligent soccer player agents and it can also be used for any other intelligent agents.

In the end we would like to thank Dr. Rahnamoon and Azad University of Tehran Central Branch Robocup team for all their helps and cooperation.

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