# ANFIS Based Method to Implement Flexible Positioning of Secondary Attackers in RoboCup Simulation League

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**Abstract**: In this paper, we are proposing an approach for coordinating Flexible Positioning of Secondary Attackers (FPSA) based on ANFIS training and working. We also introduce corresponding player role and formation-adjusting strategy. The Everest team, developed taking use of this approach was 2nd Place Winner in RoboCup2002 Soccer Simulation League.
**Keywords**: ANFIS, FPSA, positioning, RoboCup.

## 1 Introduction

Positioning is a critical problem in the situation of attack. When a wing forward is dribbling toward opponent's goal, the positions of other assist-attack players are very important to decide whether this attack can score or make threat to the opponent. In this situation, we call all the without-ball-player of our side except our defender as Secondary Attackers (SAs), whose formation server as the basic rule for individual task assignment. FCPortugal proposed the concept of Situation Based Strategic Positioning[1]. This coordination mechanism enables a team of agents to move in a coordinated way in a field, based on common apriori knowledge and simple environment knowledge. TsinghuAeolus introduced the concept of Basic Formation Point to allocate a default position of without-ball-player, who has the attribute of attackness, leftness and aggressiveness[2]. In order to implement flexible attack positioning, we pay more attention to SAs and their default positioning according to the position of ball and their own role.

## 2 Related Definitions of FPSA

**Definition 1:** The Strategy of FPSA is defined by a set of scenes.

$Strategy = \{scenes_1, scenes_2, \ldots, scenes_n\}$

**Definition 2:** A scene is defined by the position of ball and the set of positions of all the SAs decided by the formation. In off-line training, we assume that all the players except defender are SAs.

$Scene_i = \{BallPosition_i, SecondaryAttackerPosition_{i,j}\}$

**Definition 3:** Secondary Attackers' Position(SAP) is a set of positions defined by the formation applied and the position of ball.

$SAP_{i,j} = \{ BallPosition_i, Formation_j\}$

SAP of an individual player is additionally defined by the role of that player.

$SAP_{i,j,k} = \{ BallPosition_i, Formation_j, Role_{j,k}\}$

**Definition 4:** A role is defined by attackness and leftness of a player under a certain formation[2].

$Role_{j,m,n} = \{Formation_j, attackness_m, leftness_n\}$

**Definition 5:** As far as the positioning action of secondary attacker, on-line situation is taken into consideration besides the above factors. And 4 types of positioning action are defined:

- **Support**: supporting the dribbler by coordinated action such as running to the best receiving-ball-point to ensure team-ball-control possibility. Such player is always the one whose basic attack point is closest to the dribbler.
- **Utilize Space**: retaining the good position that he already had. Such player is already staying at a loose area of forward field and need not to change his positioning greatly.
- **Create Space**: creating more pass route and attract the defender of opponent side. Such player is now being marked and has to break away from defender.
- **Point Attack**: staying at the basic attack position calculated by ANFIS[3].

**Table 1** shows some data of SA of our final design.

**Table 1** Common Assignment of SAs

| | |
|---|---|
| Maximum Number of SAs | 6 |
| Maximum Number of Forwarders | 5 |
| Minimum Number of Midfielder | 1 |
| Maximum Number of Midfielders | 3 |
| Minimum Number of Forwarder | 3 |
| Number of Supporter | 1 |
| Number of Space-Utilizer | 2/1 |
| Number of Space-Creator | 1/2 |
| Number of Point-Attacker | 1 |

## 3 Off-line Scenes Construction

To clearly put soccer experience into every scene of positioning, we developed a design tool called Field Editor using Delphi showing in Figure 1. In the main part of the window there is a grid that exactly represents the soccer field by scale. We predrawed the background such as center line, penalty area, goalie box and goal etc and loaded them as gray squares in the field. Then in each scene, with the help of soccer knowledge, we may design attacker position of different formation just with mouse clicking. With this visualized tool, we may easily shift from one scene to the other and navigate through all the scenes according to the index of x/y-coordinate and current formation. Finally, all the scenes are saved in the format of text and can be read easily when training ANFIS. Detailed format of an individual scene is shown as **Table 2**.

**Table 2**. Format of an Individual Scene in the File of Training Data

| $Scene_i$ , $Formation_j$ | | $BallPosition_i$ | | $SAP_{i,j,1}$ | | $SAP_{i,j,2}$ | | $SAP_{i,j,3}$ | | $SAP_{i,j,4}$ | | $SAP_{i,j,5}$ | | $SAP_{i,j,6}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | $j$ | $X_B$ | $Y_B$ | $X_1$ | $Y_1$ | $X_2$ | $Y_2$ | $X_3$ | $Y_3$ | $X_4$ | $Y_4$ | $X_5$ | $Y_5$ | $X_6$ | $Y_6$ |

Here in the file of training data, positions were represented by the index of grid instead of exact coordinate of field. To reduce the amount of training data, symmetry of the field were taken into consideration and in our final design, 3 formations (moderate, aggressive and full aggressive) and 256 different scenes for each formation were deliberately designed and saved as training files.

Then by the indexing of formation, the matching scenes can be selected easily and be taken as training data sets.

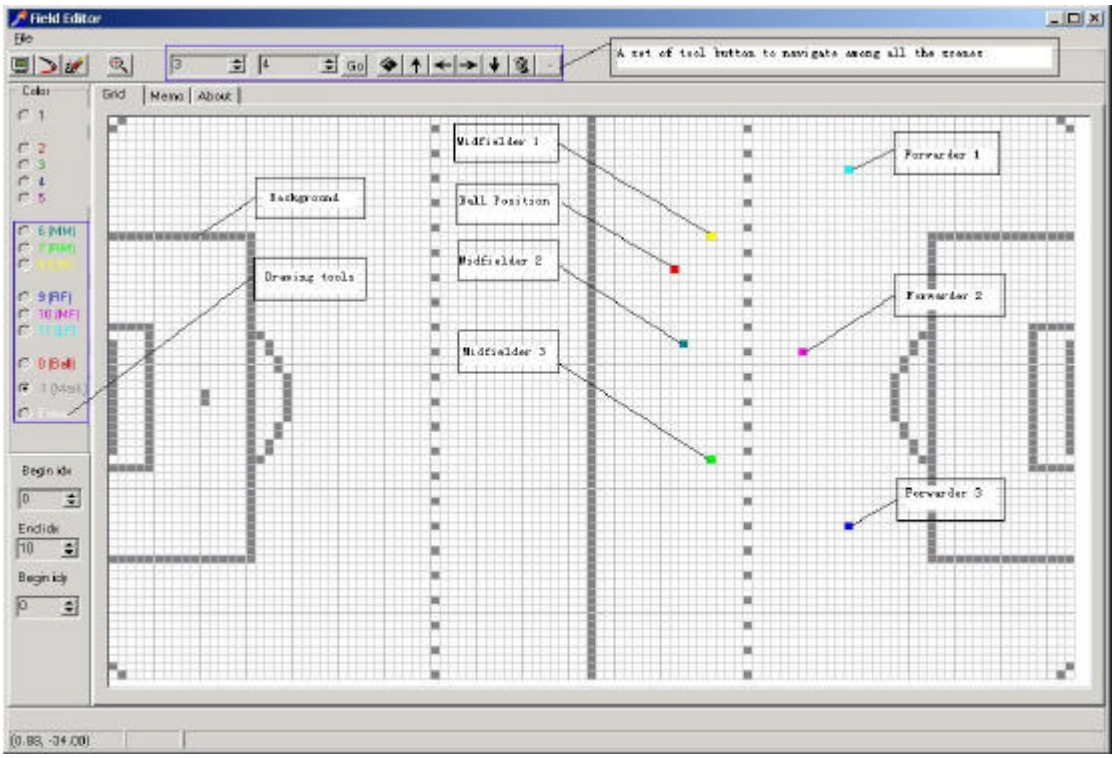


**Figure 1.** Interface of Field editor

## 4 Off-line Training based on ANFIS

Adaptive-Network-Based Fuzzy Inference System was proposed by Jang[4]. A simple ANFIS architecture is shown as figure 2. This fuzzy inference system has two inputs x and y, one output z, and the rule base contains two fuzzy if-then rules of Takagi and Sugeno's type. An ANFIS has five layers, whose definition and function are as follows.

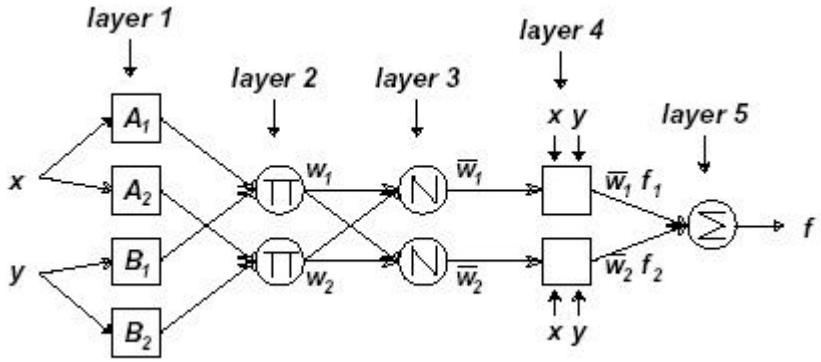


**Figure 2** An ANFIS Architecture with 4 Inputs, 1 Output, and 16 If-Then Rules of Sugeno Types

**Layer 1** Every node *i* in this layer is a square node with a node function

$$O_i^1 = m_{A_i}(x),$$

Where $x$ is the input to node $i$, $A_i$ is the linguistic label associated with this node function. That is to say, $O_i$ is the membership function of $A_i$ and it specifies the degree to which the given $x$ satisfies the quantifier $A_i$. Superscript 1 of $O_i$ indicates this is the output of first layer.

**Layer 2** Every node in this layer is circle node labeled II, which multiplies the incoming signals

and sends the product out. Each node output represents the firing strength (or weight) of a rule.

**Layer 3** Every node in this layer is a circle node labeled N. The *i*-th node calculates the ratio of the *i*-th rule's firing strength to the sum of all rules' firing strengths.

**Layer 4** Every node *i* in this layer is a square node with a node function,

$$O_i^4 = \overline{w_i}(p_i x + q_i y + r_i),$$

where $w_i$ is the output of layer 3, and $\{p_i, q_i, r_i\}$ is the parameter set. Parameters in this layer are referred to as consequent parameters.

**Layer 5** It is a circle node that sums all incoming signals.

The final ANFIS architecture being used in FPSA is shown as Table 2.

**Table 2** ANFIS Information of Aggressive Formation

| | |
|---|---|
| 4 inputs | Ball Position x, y, attackness, leftness of attacker |
| 1 output | x / y – coordinate |
| 4 member functions each input node | Sugeno types |
| Number of nodes | 193 |
| Number of linear parameters | 405 |
| Number of nonlinear parameters | 36 |
| Total number of parameters | 441 |
| Number of training data pairs | 918 |
| Number of fuzzy rules | 81 |

Because ANFIS has only one output and a player's positioning is defined by x and y coordinate together, in our implementation two ANFIS is used for every formation. Training data and ANFIS output are shown as Figure 3 and 4. In these 2 figures, the x-coordinate indicates the index of all the samples in training set, and the y-coordinate shows the desired output and actual output of ANFIS. As is shown, this two outputs is so close that we can depend ANFIS output on approaching any other input working data set.

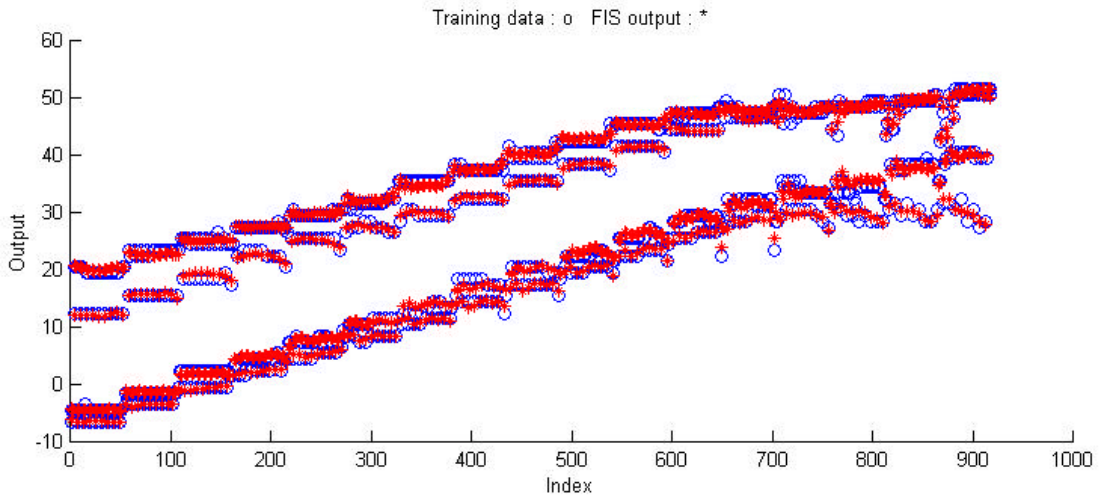


**Figure 3.** Training Data and ANFIS Output of X-Coordinate of FPSA

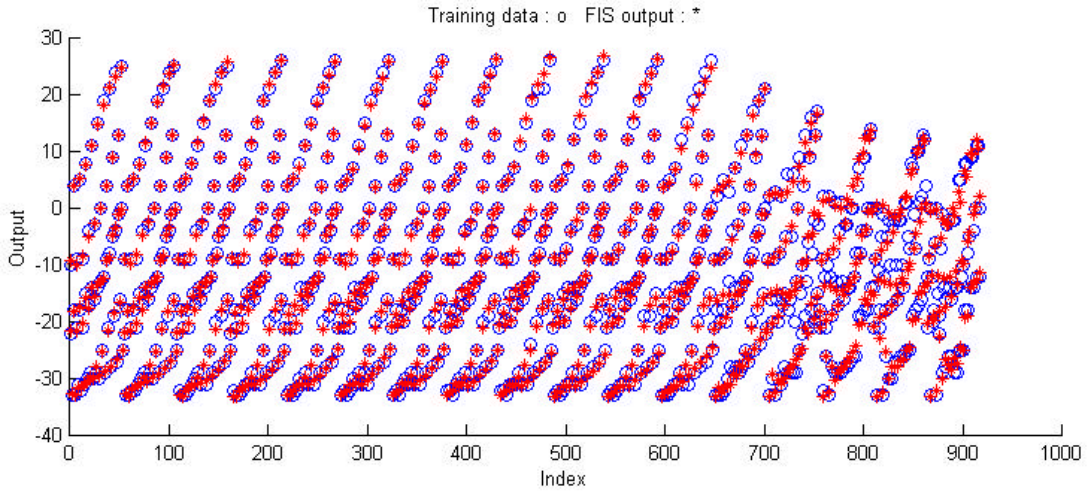


**Figure 4.** Training Data and ANFIS Output of Y-Coordinate of FPSA

## 5 On-line Working and Parameters-Adjusting

After ANFIS training was completed, emphasis of FPSA was transferred from relatively fixed positioning to flexible collaboration among Secondary Attackers. As is mentioned above, one of the 4 types of positioning action will be chosen based on an evaluation function, which is predefined by Fuzzy Inference System. Four factors were considered in the evaluation function, the degree of space congestion, the distance to the dribbler of our side, the distance to the player's basic attack point and the number and quality of receive-ball-route the player owned. Final weight and parameters of FIS were attained and adjusted by some typical scenes.

## 6 Collaboration and Formation-Adjusting Strategy

In order to achieve collaboration among SAs, reliable communication is required to make a common desire. However, there is only a single, limited-bandwidth and unreliable communication channel for all the agents in RoboCup simulation games. Especially in server version 8+, the individual message length has been drastically reduced to only 10 bytes. Under such circumstances, collaboration can depend not on communication but on observation and inferrment of each agents himself[5]. In the decision process of positioning, each agent takes the following steps.

- Maintains the model of teammate.
- Takes into account every other SA that has high confidence of position.
- Calculate all possible combination of positioning by evaluation function with the rule of assuring as least one Supporter.
- Confirm the one that has maximum sum interest to be the optimal assignment.

With the help of on-line coach, flexible formation-adjusting strategy can be implemented easily. For predefined formation is tightly related to the basic attack point of agents, formation is changed only if the on-line coach thinks it necessary. In the development of our on-line coach, task was simplified to two aspects. One is a pattern recognition problem and what is important is to recognize the opponent formation as soon as possible. The other is to identify whether attack or defense is the emphasis of opponent. Then the coach will announce the corresponding formation to ensure best counterwork.

## 7 Experimental Results

As is shown in Table 3, our team scored 91 goals and lost 13 ones in the 14 games, and finally won 2nd place of RoboCup2002 Soccer Simulation League. FPSA plays great role in most of our goals.

**Table 3** Score of Everest in RoboCup 2002 (Fukuoka)

| RoboCup2002-Fukuoka | | Score | RoboCup2002-Fukuoka | | Score |
|---|---|---|---|---|---|
| Chagamma | (Japan) | 28-0* | Baltic Luebeck | (Germany) | 11-0** |
| Cyberoos | (Australia) | 3-2* | PolyteCS | (Iran) | 15-0** |
| UTUTD | (Iran) | 2-0* | UvA Trilearn | (Netherlands) | 3-2*** |
| Virtual Werder | (Germany) | 10-0* | BrainStormers | (Germany) | 2-1*** |
| United2002 | (U.S.A) | 9-0** | TsinghuAeolus | (China) | 0-1*** |
| Helli-Respina | (Iran) | 3-0** | BrainStormers | (Germany) | 4-0*** |
| WrightEagle | (China) | 1-0** | TsinghuAeolus | (China) | 0-7*** |
| Total Score | | | | | 91-13 |

* Round Robin 1. ** Round Robin 2. *** Double Elimination

## References


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