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FUZZY COORDINATOR BASED INTELLIGENT AGENTS FOR TEAM COORDINATION BEHAVIOR IN CLOSE COMBAT GAMES

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ABSTRACT

Nowadays, many commercial computer games on the market have employed some AI techniques especially on the behaviors of NPCs (Non-Playable Characters). The aim is to make the NPCs game more human-like, immersive or natural. In a close combat game, creating strong AI forces require team coordination of NPCs. By employing an AI based agent (i.e. intelligent agent) for team coordination of NPCs leads to a deeper sense of immersion since NPCs are allowed to work together to produce better tactics and strategies. This technique faces many challenges since the intelligent agents are based on state transitions. The state transition leads to the decision for selecting the appropriate behavior by itself. Therefore, sometimes the selection could be failed to accomplish a team objective. This is due to weak coordination between NPCs and the intelligent agent. This paper describes the Fuzzy coordinator method to support the intelligent agent for selecting suitable behavior for each NPC. The intelligent agent who becomes the team leader will monitor and analyze health of each NPC, which one is strong and weak, which one has to back off or stays in the battle**.**

The experimental result demonstrates that by employing the above technique, NPC behavior selection lead to appropriate coordination from leader which represented by keeping the health parameter 75 % and 50 % at maximum and minimum respectively

Keywords: *NPCs (Non-Playable Characters), Intelligent Agent, Intelligent behavior, Close Combat Game, Fuzzy Coordinator*

1. INTRODUCTION

One of the challenges in close combat game technology researches is how to develop coordination techniques that enable an intelligent agent to interact coherently as a team to pursue a common goal. It is also possible for an intelligent agent to perform a set of task and also to pursue better performances than their opponent. A team strategy refers to a collection of decisions made by a team of agents while facing various situations. The intelligent agent access the routine behavior to produce some actions for team coordination. Recently, almost all the decision made by intelligent agent employs state transition methods like Finite State Machine (FSM), or Hierarchical Finite State Machine (HFSM) [1][2][3].

In intelligent agent game researches, McPartland[4] employs a Reinforcement Learning method to control agent task in first person shooter (FPS) game. H. Wang[5] also employs Reinforcement Learning method for commander NPCs decision making in Unreal Tournament Domination. Mike Preuss[6] use Self Organizing Map (SOM) method to support team composition and maneuvering. Darren[7] implements Genetic Programming method to improve communication in team based shooter games.

In this research, a fuzzy coordinator method is employed for coordinate a team of NPCs based on intelligent agent as a leader. The intelligent agent decides which suitable behavior for a team. The coordination is yield to the state transition methods that employ an intelligent agent

The intelligent agent makes a decision by selecting an optimal action from a pool of possible actions. The optimal decision here refers to the contribution of executing this action with respect to a team, rather than to a single agent.

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Without coordination, agent can unintentionally waste their efforts and squander resources or fail to accomplish objectives that require collective efforts. Among several methods of coordination, fuzzy control is adopted to coordinate the various system behaviors in response to the environment. The use of fuzzy control and behavior based architectures has been intensively researched. Dedid et al [8] use fuzzy controller to design motor speed control system. In the field of robot navigation, Wei Li [9] proposed a method for behavior fusion for robot navigation in uncertain environment using fuzzy logic. Saffiotti [10] proposed behavior coordination using fuzzy logic. Changman [11] employ a fuzzy coordinator to adjust robot manipulative motions.

Another interesting research using fuzzy coordinator is to coordinate robot manipulator as proposed by Pham, et al [12]. A closely related research to game technology is the implementation of fuzzy coordinator on robot soccer robot hockey as proposed by Vadakkepat, [13] and Hagras [14].

All the above reviewed techniques employ the fuzzy coordinator for robot agents. In this research, we proposed to employ it for NPCs, from our previous research [15]. The paper is organized as follows. A brief description about behavior coordination scheme is presented in section II. Discussions about fuzzy coordinator design in section III. The experimental results are shown in section IV and conclusion in section V.

2. A STATE TRANSITION BASED BEHAVIOR COORDINATION

In a Real Time Tactical (RTT) computer games like close combat games, the player takes control of a small unit so called a team of troops and leads them to battle.

2.1 State Transition

Recently, many AI based agent or intelligent agent employs state transition method for autonomous movement of NPCs [1]. In our previous research [3], we develop NPC behavior using Hierarchical Finite State Machine (HFSM) and fuzzy logic (Figure 1). The transition of intelligent agent based NPCs are not human-like behavior since there is no coordination between NPCs. Therefore in this research, we propose to put fuzzy coordinator for behavior selection.

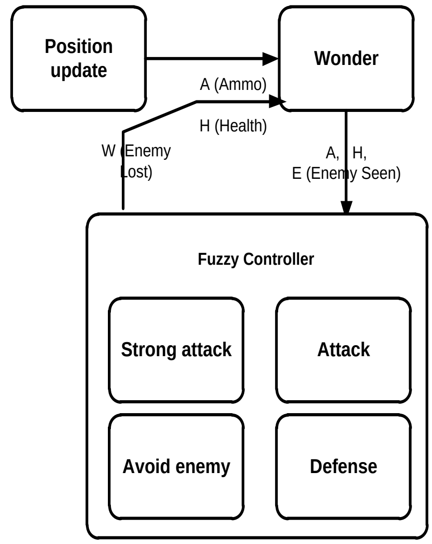

Figure 1. NPC State Transition

2.2 Team behavior Coordination

A behavior is a reaction of stimulus from other entity or environment. Behavior is a way of acting [13].

This research describes the behavior of each NPC as the composition of fuzzy coordinator decision and fuzzy controller of NPC decision (Figure 2).

We design three types of behaviors which components are some fuzzy option of a team objective control parameter.Those behaviors are **Offense**, **Defense**, and **Runaway** decomposed into actions as follows:

- **Offense** behavior consists of:
  - **punch**: weak attack, medium attack, strong attack,
  - **kick:** medium attack and strong attack.
- **Defense** behavior consists of:
  - **block** defense
  - **avoid** defense.
- **Runaway** behavior consists of only one action i.e. runaway.

3. FUZZY COORDINATOR BASED BEHAVIOR COORDINATION

This research describes the coordination of each NPC behavior for close combat games. A fuzzy coordinator method is employed due to more realistic behavior of NPCs. For simplicity and literacy to the game technology itself, we adopt the term Terrorist (T) as the opponent of our NPCs which are the Counter Terrorist (CT).

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Figure 2 illustrates a behavior coordination of CT NPC Team. The coordination is based on average health of CT and T teams combined with fuzzy coordinator. This combination provides team objective parameter to select suitable routine for CT action.

3.1 NPC fuzzy controller

Regarding for suitable selection of NPC action, each of CT NPC employs a fuzzy logic to generate its action parameter itself.

CT fuzzy controller use two input functions: CT health (CTH) and T health (TH). Given CTH (also TH) valued in range 0 to 100.

Since we employ five healthiness category therefore fuzzy membership for Very Weak(VW) function is

$$\mu_{CTH,VW} = -\frac{1}{20}h + 20, \quad 0 \le h \le 20, \qquad (1)$$

for Weak(W) function is

$$\mu_{CTH,W} = \begin{cases} \frac{1}{20}h + 10, & 10 \le h \le 30 \\ -\frac{1}{20}h + 30, & 30 \le h \le 50, \end{cases} \qquad (2)$$

for mEdium(E) function is

$$\mu_{ACTH,E} = \begin{cases} \frac{1}{20}h + 30, & 30 \le h \le 50 \\ -\frac{1}{20}h + 50, & 50 \le h \le 70, \end{cases} \qquad (3)$$

for Strong(S) function is

$$\mu_{CTH,S} = \begin{cases} \frac{1}{20}h + 50, & 50 \le h \le 70 \\ -\frac{1}{20}h + 70, & 70 \le h \le 90, \end{cases} \qquad (4)$$

and for Very Strong(VS) function is

$$\mu_{CTH,VS} = \frac{1}{20}h + 80, \quad 80 \le h \le 100. \qquad (5)$$

Figure 3 illustrate membership function VW, W,E,S, and VS of NPC fuzzy controller.

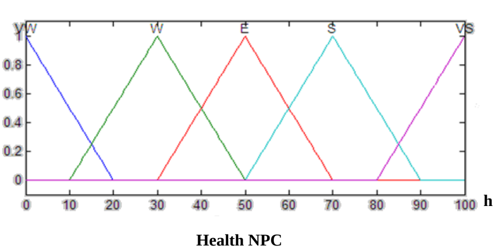

Figure 3. Input Membership Function For NPC Fuzzy Controller, Both From CTH And TH

CT fuzzy controller generate one of eight possible action parameter, which are: **RunaWay(*RW*)**, **Block Defense(*BD*)**, **Avoid Defense (*AD*)**, **Punch Weak Attack (*PW*)**, **Punch Medium Attack(*PE*)**, **Punch Strong Attack(*PS*)**, **Kick Medium Attack (*KE*)**, and **Kick Strong Attack(KS)**.

Using zero-order Sugeno Method, the output of CT fuzzy controller (CTZ) is defined by:

If (*CTH* is *CTX*) AND (*TH* is *CTY*) THEN *CTZ* = *A* (6)

Where

CTX,CTY∈ (VW,W,E,S,VS)

A ∈ (*RW, BD AD, PW, PE, PS KE, KS*)

And the possible output of CTZ displayed in table 1.

Table 1. NPC Action Based Fuzzy Rule

Input	Teroris Health (TH)					
Counter Terroris Health (CTH)	Level	**VW**	**W**	**E**	**S**	**VS**
	VW	*RW*	*RW*	*RW*	*RW*	*RW*
	W	*AD*	*BD*	*RW*	*RW*	*RW*
	E	*PW*	*PE*	*PS*	*BD*	*AD*
	S	*PW*	*PE*	*PS*	*KE*	*BD*
	VS	*PW*	*PE*	*PS*	*KE*	*KS*

3.2 Fuzzy Coordinator for NPC Leader

Addressing above behaviors and actions, a fuzzy coordinator is employed to assist the intelligent agent (i.e the CT leader) for coordinating its team.

Two input parameter is used by fuzzy coordinator: average CT team health (ACT) and average T team health (AT). Since we employ three healthiness therefore fuzzy membership for Weak(W) function is:

$$\mu_{ACTH,Weak} = \begin{cases} \frac{1}{20}h, & 0 \le h \le 20 \\ -\frac{1}{20}h + 20, & 20 \le x \le 40, \end{cases} \qquad (7)$$

For Medium(M) function is

$$\mu_{ACTH,Medium} = \begin{cases} \frac{1}{20}h + 30, & 30 \le h \le 50 \\ -\frac{1}{20}h + 50, & 50 \le h \le 70, \end{cases} \qquad (8)$$

And for Strong(S) function is

$$\mu_{ACTH,Strong} = \begin{cases} \frac{1}{20}h + 60, & 60 \le h \le 80 \\ -\frac{1}{20}h + 80, & 50 \le h \le 100. \end{cases} \qquad (9)$$

Figure 4 illustrate membership function Weak(W), Medium(M), an Strong(S) of fuzzy coordinator.

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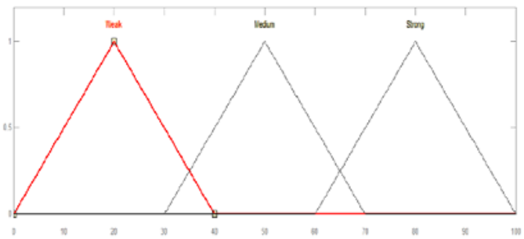

Figure 4. Input Membership Function For Fuzzy Coordinator, Both From ACT And AT Function

Using fuzzy rule as displayed in table 2 and using zero-order Sugeno Method, the output of fuzzy coordinator (*CTC*) is defined by:

If ($ACTH$ is AHX) AND (ATH is AHY) THEN $CTC = K$ (10)

Where

AHX,AHY ∈ (W,M,S)

$K \in (RA, DF, OF)$

Fuzzy coordinator generates three type team objective control parameter: **RunAway(*RA*)**, **Defense(*DF*)** and **Offense(*OF*)**.

Table 2. Coordination of behavior based on fuzzy rule

Input	Average Terroris (T) Team Health			
Average Counter Terroris (CT) Team Health	Level	W	M	S
	W	*RA*	*RA*	*RA*
	M	*OF*	*DF*	*DF*
	S	*OF*	*OF*	*OF*

3.3 NPC Team Objective

For the NPC team objective, we employ heuristic rule based (11),(12),(13) to adjust the NPC action as displayed in table 3.

If (CTC) is RA then TA = RW (11)

$$\text{If (CTC) is DF then TA} = \begin{cases} CTZ, & \text{CTZ} \neq \text{KE, KS} \\ PS, & \text{CTZ} = \text{KE, KS} \end{cases} \quad (12)$$

$$\text{If (CTC) is OF then TA} = \begin{cases} CTZ, & \text{CTZ} \neq \text{BD} \\ PW, & \text{CTZ} = \text{BD} \end{cases} \quad (13)$$

Where

CTC ∈ (*RA,DF,OF*)

CTZ ∈ (*RW, BD AD, PW, PE, PS KE, KS*)

If selected team objective is **RunAway(RA)**, then all NPC action is **RunAway(RW)** too.

If selected team objective is **Defense(DF)**, then the NPC action is same as action parameter, except if action parameter is **Kick Medium Attack(KE)** or **Kick Strong Attack(KS)**, then the NPC action is **Punch Strong Attack(PS)**.

If selected team objective is **Offense(OF)**, then the NPC action is same as action parameter, except if action parameter is **Block Defense(BD)**, then the NPC action is **Punch Weak Attack(PW)**.

Table 3. Action Of Behavior For NPC Based On Team Objective

Input	Action Parameter from CT fuzzy controller								
Team Objective	Level	RW	AD	BD	PW	PE	PS	KE	KS
	RA	*RW*	*RW*	*RW*	*RW*	*RW*	*RW*	*RW*	*RW*
	DF	*RW*	*AD*	*BD*	*PW*	*PE*	*PS*	***PS***	***PS***
	OF	*RW*	*AD*	***PW***	*PW*	*PE*	*PS*	*KE*	*KS*

4. EXPERIMENTS AND RESULTS

4.1 Behavior coordinator analysis

To analyse the influence of behavior coordination to variation of team action, we create 243 health of NPC team dataset, from 3 type condition: low health (between 0-30% of health), medium health (between 31-70% of health), and high health (between 71-100% of health).

The health dataset are employed to fuzzy coordinator to see frequency of team objective parameter selected, illustrated in figure 5.

Then the health dataset are employed to CT NPC with fuzzy coordinator and compared if employed to NPC without fuzzy coordinator. Frequency of selected CT NPC actions with fuzzy coordinator compared with frequency of selected CT NPC actions without fuzzy coordinator, illustrated in figure 6.

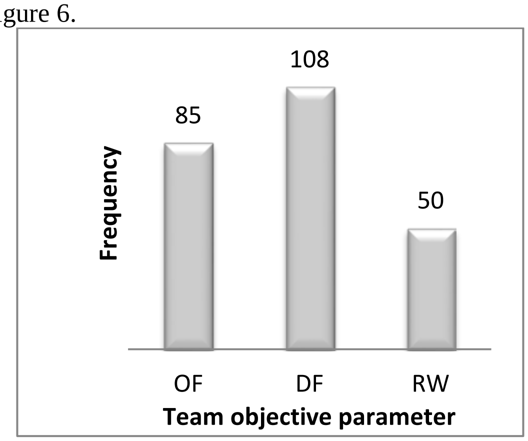

Figure 5. Frequency Of Team Objective Parameter

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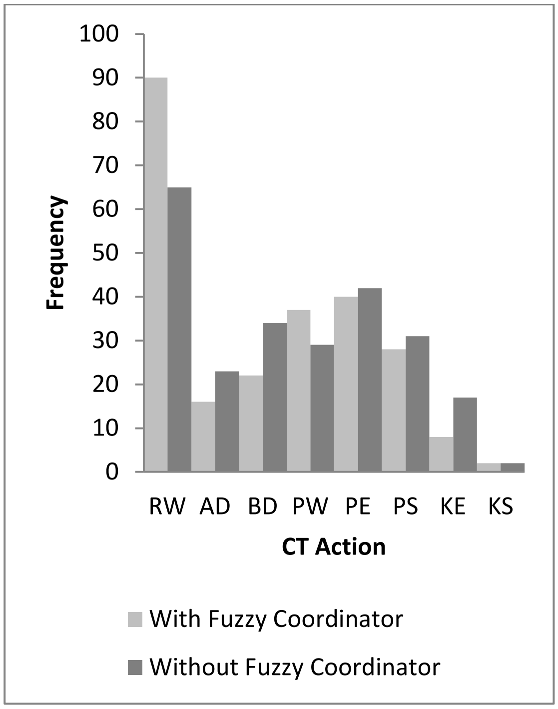

Figure 6. Frequency Of CT NPC Actions With And Without Fuzzy Coordinator.

According to figure 6, actions selected by CT NPC with using fuzzy coordinator tend to select **RunAway (RW)** and **Punch Weak Attack (PW)** compared to actions selected by CT NPC without fuzzy coordinator.

4.2 Experiment and Analysis

The experiment simulates close combat game scenarios between CT NPC team versus T NPC team. The rules of the game are:

1. A NPC team consist of one team leader and four team members.
2. Each team member combat each enemy member.
3. Every round of the game each team member give an action against to the enemy team member and decrease the health of enemy team member. Consecutively team member also receives the action of the enemy team member, which result decreased of team member health.
4. A NPC team is lost if the average health of team members reach 30 point.

First scenario : CT NPC team versus T NPC team. Each team only employ random action.

Second scenario : CT NPC team employ fuzzy coordinator versus T NPC team employ fuzzy controller only.

Third scenario : CT NPC team versus T NPC team. Each team employ fuzzy coordinator.

For each game scenario, we run 50 simulations and we have the results displayed in table 4. The winning team is the team which reaches the higher health parameter for each simulation.

Tabel 4 Result Of Game Scenario Experiment

CT team	*Draw*	*Lost*	*Win*
1st Scenario	*8*	*20*	*22*
2nd Scenario	*0*	*12*	*38*
3rd Scenario	*1*	*24*	*25*

Table 4 display the result of each game scenario experiment.

First scenario: demonstrates both CT and T teams keep the health parameter from 40% to 44%. This due to both teams employ random coordination instead of fuzzy controller for behavior selection. Therefore the possibility of draw is 8 out of 50 (16%) and the possibility loose or win is almost the same.

Second scenario: demonstrates the CT team keep the health parameter to 76%. This due to CT team employ fuzzy coordinator instead of T team employ fuzzy controller for behavior selection.

Third scenario: demonstrates both CT and T teams keep the health parameter to 50%. This due to both teams employ fuzzy coordinator for behavior selection. Therefore the possibility loose or win is almost the same.

5. CONCLUSION

This research demonstrate fuzzy coordinator based intelligent agent for NPC team coordination in Close Combat Game. In simulation of close combat game, NPC team with fuzzy coordinator has health advantage over other NPC team without fuzzy coordinator. NPC team with fuzzy coordinator can keep health parameter 76 % and 50% at maximum and minimum respectively.

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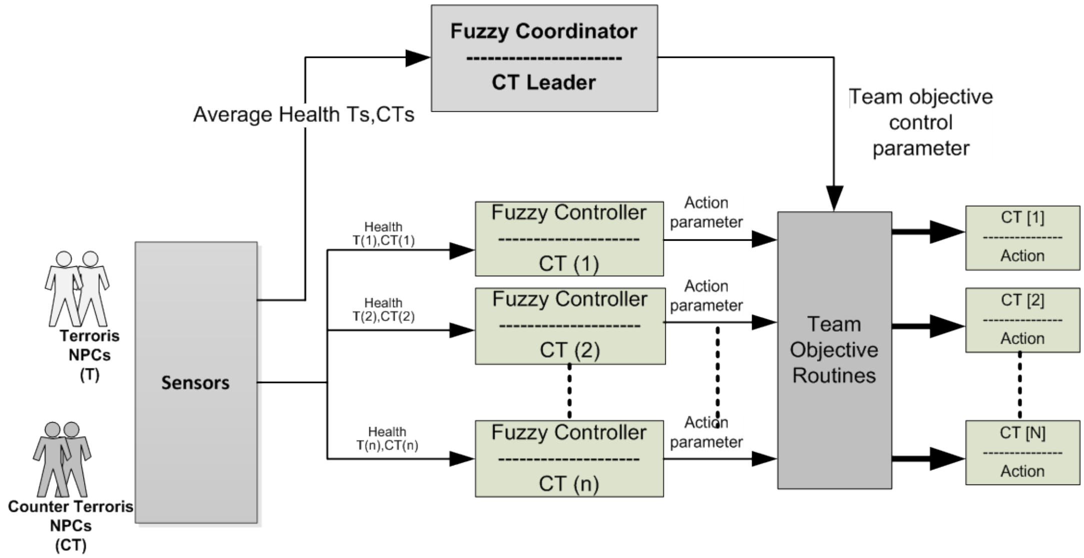

Figure 2. Illustration Of Fuzzy Coordinator For Behavior Coordination Of CT NPC