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OPTIMIZING OF BOXING AGENT BEHAVIOR USING ELITISM BASED GENETIC ALGORITHM

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Abstrak

Pola perilaku agen tinju pada permainan tinju dipengaruhi oleh beberapa faktor antara lain teknik gerakan bertinju, jenis pukulan tinju, stamina, dan energi pukulan. Pola perilaku agen tinju secara umum menggunakan variabel random dengan distribusi *event* dari setiap *state* secara acak. Penelitian dengan menggunakan FSM (*Finite State Machine*) berbasis algoritma genetika, menghasilkan nilai *fitness* 0.96, untuk pola perilaku agen cenderung maju kearah lawan, energi pukulan cenderung sedikit, dan menggunakan jenis pukulan dengan objektivitas tinggi. Penelitian ini menggunakan fungsi elitism pada algoritma genetika untuk dapat menghasilkan nilai fitness yang stabil dan pola perilaku agen tinju yang lebih baik dibandingkan tanpa menggunakan fungsi *elitism*. Nilai *fitness* yang dihasilkan dari penelitian ini diantara 3.101748 sampai 3.14738 dan nilai *fitness* optimal diantara 2.78083 sampai 3.167174, dengan siklus algoritma genetika lebih besar sama dengan generasi ke-25. Pola perilaku agen tinju yang dihasilkan berdasarkan nilai *fitness* adalah menyerang menggunakan satu jenis pukulan *uppercut right* dan tiga pukulan jab, dengan energi pukulan diantara 48 sampai 52 dan pola permaianan cenderung maju sambil melindungi wajah (*covered*). Pola perilaku agen tinju dari nilai fitness adalah menyerang menggunakan satu jenis pukulan *uppercut right* dan tiga pukulan jab dengan energi pukulan diantara 48 sampai 52 dengan pola permaianan cenderung maju dan melindungi wajah (*covered*).

Kata kunci: Perilaku agen, Algoritma Genetika, Optimasi, Permainan Tinju, FSM.

Abstract

Boxing agent behavior patterns in the game of boxing is affected by several factors, i.e. the technique of boxing movements, type of punch, stamina, and energy of the punch. Boxing agent behavior patterns in general use variable random event where is state distribution randomly. A study using FSM (Finite State Machine) based on genetic algorithms, resulting fitness value 0.96 for boxing agent behavior patterns that tend to move towards the opponent , used energy to blow is likely small, and it uses the kind of blow that has high objectivity. This study will utilize elitism function in genetic algorithms to produce a stable fitness and better boxing agent behavior patterns than the one use genetic algorithms without elitism function. Fitness value result from this study between 3.14738 and 3.101748 and the optimal fitness value between 2.78083 to 3.167174, with a genetic algorithm cycle equal or more than the 25th. The boxing agen behavior patterns generated from fitness value is to attack using single type of blow, right uppercut punch and jab with a three-punch blow energy between 48 to 52 and patterns game that tend to move foward with covered the face.

Key words: Agent behavior, Genetic Algorithm, Optimation, Boxing game, FSM.

INTRODUCTION

A dynamic and challenging boxing agent behavior will cause a player engaged in a game. An optimum boxing agent behavior is one of the methods to create a dynamic behavior pattern by calculating several factors which influence it. For example, a boxing agent won't always choose a hook punch which require some amount of blow energy if the remaining stamina is great or it won't always use jab punch which require less energy to do the punch if the remaining stamina is low. In the boxing (game), a boxing agent behavior is a form of problem solving technique for a boxer behavior [1]. There are three main part of boxing which have to be learned by a boxer, attacking which is a basic punching technique, defense/defending and foot steps, even in every exercise, these main part of shaping a boxer behavior are kept repeated[2]

FSM is used for behavioral scheme planning [3-6]. The usage of FSM for agent behavior in general utilizes random variable, where event distribution of each state is random. Therefore it can't reach an optimum value of agent behavior. An optimum boxing agent value using fitness calculation algorithm results in an average optimum boxing agent behavior value, 0.96.[1] The value is produced by genetic algorithm cycle without elitism function.

In this research, the used genetic algorithm cycle utilizes elitism function, in order to obtain a stable fitness value and to tend fitness values are not on the minimal , so that it results in a better behavior pattern than the genetic algorithm without elitism function.

GENETIC ALGORITHM USING ELITISM FUNCTION

In this method, a function is added into a genetic algorithm cycle, elitism function and reverse the selection after reproduction process [7]. The flow chart of algorithm cycle for boxing agent behavior using elitism function is as shown in Figure 1.

Elitism function, in this research, keeps the individual with high fitness in each genetic algorithm cycle. Therefore, in order to find elitism, a population length is twice as long as the previous generation. This population is a combination from an individual before and after selection, then best individuals are taken as many as the population number [7,8]. So if the number of chromosome in each population is 50, by combining the new generation and the previous generation, we have 100 chromosome of which fitness later be evaluated and found the best value.

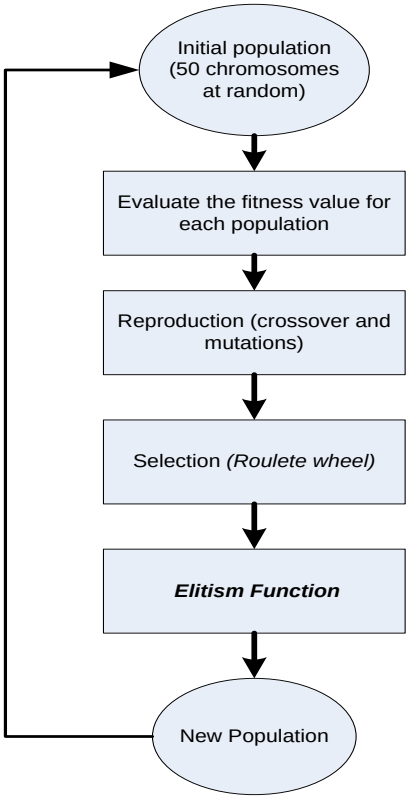

Figure 1. Genetic Algorithm Flow Using Elitism Function.

Elitism function from genetic algorithm in detail is as shown in Figure 2. By doing evaluation between the previous selection and the new selection results in an individual with good fitness survive in the next cycle of genetic algorithm.

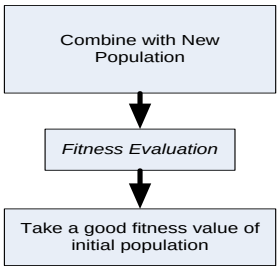

Figure 2. Elitism Function Flow.

The origin/previous population is a population before selection process and the new population is a population produced after

selection process. In this research, a good fitness value is a big number produced by calculation.

BOXING AGENT BEHAVIOR DESIGN

FSM is used to describe the boxing agent behavior in a boxing game. It has several states:

1. Stand by, boxing agent position is in the corner of boxing ring with transition: round start and round end.
2. Rotate position, boxing agent's position always follows the opponent movements so the triggering event is opponent agent movement.
3. Energy refresh, it happens when the agent energy reaches 0 (zero/empty) so it can't do any punch, and if the energy has been replenished, equals or more than 10, the agent can perform attack normally.
4. Lose happens if the stamina of boxing agent has run out or equals zero
5. Game playing scheme is a state in which a boxing agent behavior in game includes idle, move forward, move left or move right.
6. Offense/Attack scheme is a state in which boxing agent behavior includes jab, cross, left uppercut and right uppercut.
7. Defense scheme is a state in which boxing agent behavior defends it self from the opponent attack. It includes uncover no hit, cover no hit, uncover hit and cover hit.

The boxing agent behavior design using FSM is as shown in Figure 3.

Figure 4 shows the game playing, attack and defense pattern states for distribution event of FSM using genetic algorithm with elitism function.

BOXING AGENT BEHAVIOR OBJECTIVITY DESIGN

Boxing agent behavior scheme in the game is expected to perform actively in attacking and blocking while being attacked. With the mentioned agent behavior, the behavior objectivity in game with the highest result is the one which move forward and corner its opponent by using the best punch and blocking while being attacked [9].

In this research, objectivity value uses decimal number as in boxing agent behavior FSM and and combinations of punches in boxing [10,11].

The highest game scheme objectivity is in moving forward state and the lowest is in moving backward, as seen in Table 1.

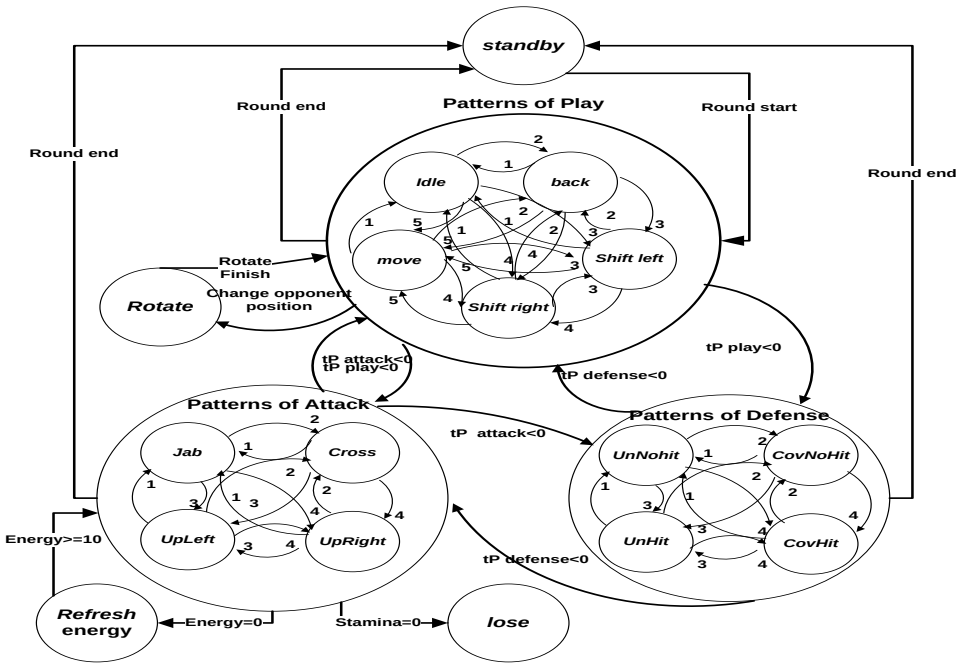

Figure 3. FSM of boxing agent behavior [1].

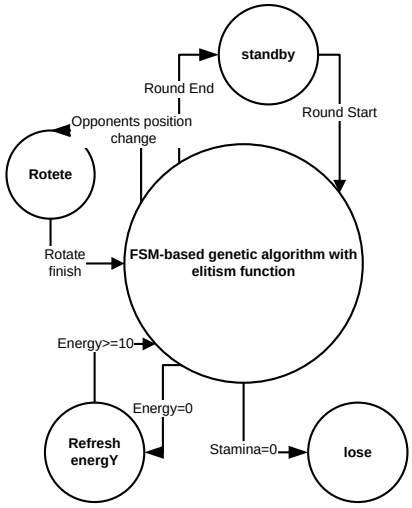

Figure 4. Genetic algorithm with elitism function in boxing agent behavior pattern FSM [1].

Table 1. Game Playing Scheme Objectivity.

Score	Gameplay scheme
1	Back
2	Idle
3	Shift left
4	Shift right
5	Move

The highest defense score is on defending agent behavior which doing covered hit and the lowest is on defending agent which in uncovered no hit state, as shown in Table 2.

Table 2. Defense Scheme Objectivity.

Score	Defense
1	Uncovered noHit
2	Covered noHit
3	Uncovered Hit
4	Covered Hit

The highest offense/attack scheme objectivity score is at agent behavior which doing punch with uppercut right and the lowest is at the agent behavior which doing jab punch, as shown in Table 3. The uppercut right punch, in this research, is given the highest objectivity score since the boxing agent is considered as a right handed and the uppercut belongs to the deadliest punch if it hit the right spot, the lower jaw.

The score of energy scheme objectivity refers to the kind of punch objectivity, in this research, 10 is for energy used for jab punch, 15 for energy used for cross, 20 for energy used for uppercut left, and 25 for energy used for uppercut right. So for an agent behavior which does a four times continuous attack/punch, the energy used ranges from 40 to 100. This is as shown in Table 4.

Table 3. Attack Scheme Objectivity.

Score	Attack
1	Jab
2	Cross
3	Uppercut Left
4	Uppercut Right

Table 4. Energy Boxing Scheme Objectivity.

Energy range Score	Defense	Punch energy
40 - 100	Jab	10
	Cross	15
	Uppercut Left	20
	Uppercut Right	25

By referring to a series of boxing moves, it is assumed that there are four consequent punch in an individual. This is as shown in Figure 5.

G	C	P1	P2	P3	P4	E

Figure 5. Boxing agent chromosome string.

G is gameplay scheme objectivity, *C* is defense scheme objectivity, *P1* to *P4* are objectivity offense scheme steps which represent punch type string, and *E* is energy objectivity.

The game scheme objectivity function is as shown in Equation (1).

$$FoG(x,y) = G(x,y) - makG \qquad (1)$$

FoG(*x*,*y*) is game scheme objective function on chromosome (*x*,*y*), *G*(*x*,*y*) is a game scheme chromosome score at (*x*,*y*) and *makG* is the highest objectivity score of boxing agent game scheme. The defense scheme objective is as shown in Equation (2).

$$FoG(x,y) = G(x,y) - makC \qquad (2)$$

FoC(*x*,*y*) is an objective function of defense state at chromosome (*x*,*y*), *C*(*x*,*y*) is chromosome's score in defense state at (*x*,*y*) and *makC* is the highest objectivity score of defense scheme. Offense/attack scheme objective function is as shown in Equation (3).

$$FoP(x,y) = \sum_{y=1}^{4} P(x,y) - \sum_{y=1}^{4} makP(x,y) \qquad (3)$$

FoP(*x*,*y*) is an offense scheme objective function at chromosome (*x*,*y*), *P*(*x*,*y*) is the score of punch type for the gen *y*=1 to *y*=4 and *maxP* is the highest objectivity score of punch type for *y*=1 to *y*=4. The boxing agent energy objective function is as shown in Equation (4).

$$FoE(x,y) = E(x,y) - makE \quad (4)$$

FoE(x,y) is energy objective function of chromosome at (*x*,*y*), *E*(*x*,*y*) is energy score at (*x*,*y*) and *makE* is the highest score of energy used by the boxing agent.

BOXING AGENT BEHAVIOR CHROMOSOME FITNESS FUNCTION

Fitness and probability function of boxing agent objective function decides the chosen individual for the next cycle of genetic algorithm process. The process of mutation is repeat of the same happens fitness value [12]. The whole fitness function in an individual F(x) is as shown in Equation (5).

$$F(x) = \frac{1}{fg(x) + fc(x) + fp(x) + (1/fe(x))} \quad (5)$$

Where the *fg*, *fc*(*x*), *fp*(*x*) and *fe*(*x*) are fitness scores for each behavioral pattern, as shown in Equation (6), Equation (7), Equation (8), and Equation (9).

$$fg(i) = FoG(i)^2 \times wi^2 \quad (6)$$

$$fc(i) = FoC(i)^2 \times wi^2 \quad (7)$$

$$fp(i) = FoP(i)^2 \times wi^2 \quad (8)$$

$$fe(i) = FoE(i)^2 \times wi^2 \quad (9)$$

wi is chromosome weight of i, in which to find the weight (*w*) is as shown in Equation (10).

$$wi = \frac{xi}{Total\ x} \quad (10)$$

Total *x* is the final sum of weighting of chromosome in each individual and *xi* is weighting at *i*. To find the *x* is as shown is Equation (11).

$$xi = a + \left| (b-a)/(2^{li} - 1) \right| * vi \quad (11)$$

li is the number of chromosome probability of *i* and *vi* is chromosome value at *i*. With *a* and *b* is any real number, in boxing agent objectivity, *a* is the minimum value of behavioral scheme objectivity and *b* is the maximum value of behavioral scheme objectivity.

RESULT AND DISCUSSION

The usage of elitism function is applied in the experiment with energy objectivity on each chromosome. The genetic algorithm in the experiment uses weighting in fitness calculation process from Equation (10), so the sum of fitness calculation for each objectivity using Equation (6), Equation (7), Equation (8), and Equation (9), with total fitness as shown in Equation (5).

The result of genetic algorithm cycle generation 1 to generation 50 by comparing the maximum and minimum fitness score is as shown in Figure 6.

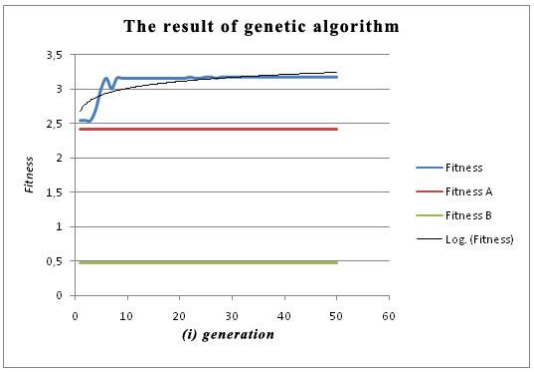

Figure 6. Graphics of Fitness from 50 Cycles of Genetic Algorithm. Fitness A is The Fitness Score with Chromosome String of 1,1,1,1,1,1,100. Fitness B is The Fitness Score with Chromosome String of 5,4,4,4,4,4,40.

By doing ten experiments, it results in in average fitness score as shown in Table 5. Ten experiments in Table 5 result in the highest average fitness is 3.14738 which produced from experiment #9. The highest fitness score is 3.167174, gained from experiment 2, 3, 5 and 7, while the lowest fitness is at 2.78083 gained from Experiment 9.

The maximum fitness from 10 experiments is gained from above generation 25 in Experiment #1. So if it is drawn a line, the optimum score will be gained from after generation 25.

By referring to the highest/lowest fitness rate and average highest/lowest fitness, also generation when it reaches the highest fitness

score, so the result of genetic algorithm based on experiment outcome is as shown in Figure 7.

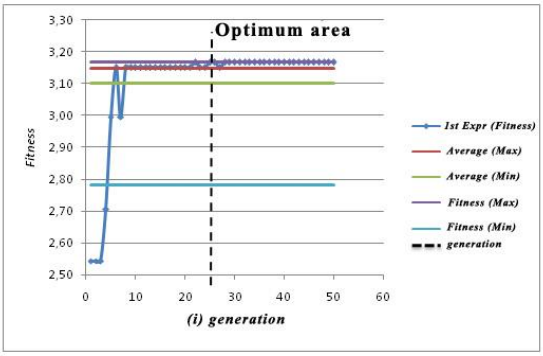

Figure 7. Optimum Area Graphics of Fitness Resulted from 10 Experiments with Genetic Algorithm by using Elitism Function.

As seen on Figure 7, the 25th generation to 50th generation reach the optimum score. So if the generation is higher than 25 or if it reaches fitness maximum/minimum range, it is concluded that the genetic algorithm has reached the optimum value. The optimum score which acquired from the experiment is at the average maximum/minimum fitness.

Being compared to the genetic algorithm without elitism, it is obvious that by using elitism function results in a stable fitness score, so there's no fitness reduction as shown in Figure 8, which of genetic algorithm comparison with and without elitism function.

In order to find boxing agent behavior by resulted fitness score, the score is converted to chromosome form as shown in Table 6 with 10 experiments of boxing agent by eliminating data duplication.

From the Table 6 data, agent behaviors are:

1. The game play scheme is move forward which means pushing the opponent.
2. The defense scheme is covered which always keep the lower part of the head by performing block covering the lower part of the face while delivering punch.
3. Offense/attack scheme using combination of jab, jab, jab, uppercut right punch continuosuly.
4. The used energy is 49, which means lower that the maximum energy value 100.

Table 5. Fitness Value from 10 Experiments.

Experiment	50 times genetic algorithms every test cycle		Average	Generation
	Fitness (Min)	Fitness (Max)		
1	2.542908	3.166853	3.107155	25
2	2.692236	3.167174	3.103207	26
3	2.45041	3.167174	3.126864	26
4	2.61865	3.166853	3.138911	47
5	2.553585	3.167174	3.142086	43
6	2.65805	3.163826	3.101748	28
7	2.66373	3.167174	3.120921	42
8	2.549667	3.166853	3.106375	47
9	2.78083	3.166853	3.14738	30
10	2.643181	3.166853	3.117541	30

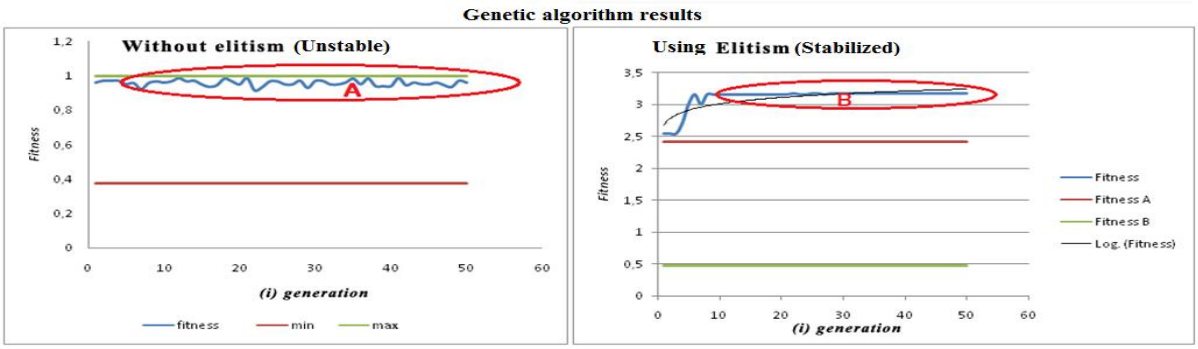

Figure 8. Genetic Algorithm Results. Left:without Elitism (Unstable); Right: using Elitism (Stabilized).

Table 6. The Chosen Individual from Boxing Agent Behavior.

Fitness	Cjosen individuals	Agent behavior
3.167	5,4,1,1,1,4,49	Move foward, Covered and perform, jab, jab, jab, Uppercut Right, Energy 49
3.165	5,4,1,1,4,1,51	Move foward, Covered and perform, Jab, Jab, Uppercut Right, Jab, Energy 51
3.167	5,4,1,1,4,1,50	Move foward, Covered and perform, Jab, Uppercut Right, Uppercut Right, Jab, Energy 50
3.164	5,4,1,4,1,1,48	Move foward, Covered and perform, Jab,Uppercut Right, Jab,Uppercut Right,Energy 48
3.164	5,1,1,4,1,4,51	Move foward, UnCovered and perform, Jab,Uppercut Right, Jab,Uppercut Right,Energy 51
3.165	5,1,1,4,1,4,49	Move foward, UnCovered and perform Jab,Uppercut Right, Jab,Uppercut Right,Energy 49
3.167	5,4,4,1,1,1,52	Move foward, Covered and perform, Uppercut Right, Jab,Jab,Jab,Energy 52
3.160	5,4,4,1,1,1,48	Move foward, Covered and perform, Uppercut Right, Jab,Jab,Jab,Energy 48
3.164	5,4,1,1,4,1,48	Move foward, Covered and perform, Jab, Jab,Uppercut Right, Jab,Energy 48
3.164	5,1,4,1,4,1,50	Move foward, UnCovered and perform, Uppercut Left, Jab,Uppercut Right, Jab,Energy 50

CONCLUSION

From the experiment of genetic algorithm and elitism function on boxing agent behavior, we conclude that:

1. Using elitism function results in stable fitness value in certain generation in the genetic algorithm cycle. In this research, generation greater than 25.
2. The stable fitness score is the optimum value of boxing agent, the average optimum fitness range from 3.101748 to 3.14738 and the optimum fitness range from 2.78083 to 3.167174 with a condition that the genetic algorithm cycle is greater than or equal generation 25.
3. The optimum boxing agent behavior is shown from the chromosome string of genetic algorithm with the highest optimum fitness score of 3.167, for the offense scheme behavior using one of Uppercut Right and three jabs, with punch energy from 48 to 52, game play scheme tends to move forward while covering the face.

This boxing agent is one of the game agents available in boxing game system, of course this is not a ready to use product yet. Therefore, there are lots of developments can be done before being sold to the market. The researcher suggests some system developments, particularly agent behavior development:

1. Reproduce agent behavior schemes.
2. Performing the further experiments with multiobjective function.
3. Inserting outer agent parameter to determine the optimum value of agent behavior, so it can adapt to opponent agent and game environment.

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