Organization and Selection Methods of Composite Behaviors for Artificial Creatures Using the Degree of Consideration-based Mechanism of Thought

Woo-Ri Ko and Jong-Hwan Kim

Abstract This paper proposes organization and selection methods of composite behaviors for artificial creatures. Using the degree of consideration-based mechanism of thought (DoC-MoT), each pre-defined atom behavior is evaluated by the fuzzy integral of the partial evaluation values of atom behaviors over the artificial creature's wills and external contexts, with respect to the fuzzy measure values representing its degrees of consideration (DoCs). Based on these evaluation values of atom behaviors, a composite behavior is organized as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' However, in the organized composite behavior, the behaviors connected by 'choice' relationship can not be generated at the same time, and therefore, only one atom or composite behavior is randomly remained in each set of atom or composite behaviors connected by 'choice' relationship. The effectiveness of the proposed scheme is demonstrated by simulations carried out with an artificial creature, "DD" in the 3D virtual environment. The results show that the diversity of the generated behaviors is increased fourfold compared to the behavior selection without the organization process of composite behaviors. Moreover, the generated composite behaviors satisfy the artificial creature's wills more and the logical connectivity of them is increased compared to the method without the process.

Key words: Composite behavior, artificial creature, behavior selection, fuzzy integral, fuzzy measure

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1 Introduction

An artificial creature needs an intelligent behavior selection method to be used as an entertainment robot or an intermediate interface for interaction with users [1]. In other words, the generated behaviors from the artificial creature should be the ones provided from the human-like mechanism of thought considering both its internal wills and external contexts. Besides, they should show various series of behaviors even in the same situation to get and hold a user's attention. For this purpose, there has been much research on the behavior selection method for artificial creatures. The architectures consisting of perception, motivation, behavior and actuator modules were proposed for behavior selection [2]-[4]. A behavior selection method for entertainment robots was proposed using intelligence operating architecture [5], [6]. However, in the previous research, there was a limit to the variety of generated behaviors, since a behavior was selected among pre-defined list of behaviors.

In this paper, organization and selection methods of composite behaviors are proposed for artificial creatures. Using the degree of consideration-based mechanism of thought (DoC-MoT), each pre-defined atom behavior is evaluated by the fuzzy integral of the partial evaluation values of atom behaviors over the artificial creature's wills and external contexts, with respect to the fuzzy measure values representing the degrees of consideration (DoCs) or preference defined by a user [7]. Based on these evaluation values of atom behaviors, a composite behavior is organized as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' However, in the organized composite behavior, the behaviors connected by 'choice' relationship can not be generated at the same time, and therefore, only one atom or composite behavior is randomly remained in each set of atom or composite behaviors connected by 'choice' relationship. The finalized composite behavior is called a definite composite behavior. To show the effectiveness of the proposed scheme, simulations are carried out with an artificial creature, "DD" in the 3D virtual environment.

This paper is organized as follows. Section II presents the degree of consideration-based mechanism of thought (DoC-MoT), which is a well-modeled mechanism of human thought. Section III proposes the organization and selection methods of composite behaviors using the DoC-MoT. Section IV presents the simulation results to demonstrate the effectiveness of the proposed scheme. The concluding remarks follow in Section V.

2 Degree of Consideration-based Mechanism of Thought (DoC-MoT)

The DoC-MoT is inspired by the basic concept of 'confabulation theory' that explains how a human brain functions [8]. The human brain is composed of approximately 100 billion neurons and the sets of adjacent neurons represent input or target symbols, such as “red,” “round,” as input symbols and “apple” as a target symbol. The link between the input and target symbols represents a knowledge about the perceived entities, e.g. the “likeliness” of an “apple” to be “red” or the “likeliness” of an “apple” to be “round.” Therefore, a link between the input and target symbols is called knowledge link and its strength describes the degree of belief about the target symbol. The cognitive information processing is accomplished by selecting a target symbol with the highest degree of belief when some input symbols are perceived.

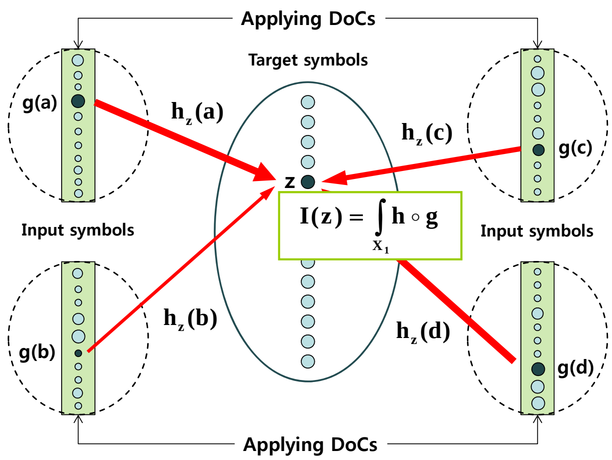


Fig. 1 Cognitive information processing in the DoC-MoT.

Fig. 1 shows the cognitive information processing in the DoC-MoT. In the DoC-MoT, the degree of belief $I(z)$ of target symbol z over the input symbols $X = \{x_1, x_2, \ldots, x_n\}$, where n is the number of input symbols, is calculated by the Choquet fuzzy integral as follows [9]:

$$I(z) = \sum_{i=1}^{n} g(A_i)\{h(x_i) - h(x_{i-1})\}, \quad (1)$$

where the input symbol set X is sorted so that $h(x_i) \geq h(x_{i+1}), i = \{1, \ldots, n-1\}$ and $h(x_0) = 0$, $g(A_i)$ is the fuzzy measure value of A_i, $A_i = \{x_i, x_{i+1} \ldots, x_n\}$ is the subset of X, and $h(x_i)$ is the partial evaluation value of the target symbol z over the ith input symbol x_i. Note that the value of $I(z)$ also represents the evaluation value of z to be a conclusion of the information-processing.

The fuzzy measure value of a subset of input symbols is calculated by the Sugeno λ-fuzzy measure as follows [10]:

$$g(A \cup B) = g(A) + g(B) + \lambda g(A)g(B), \quad (2)$$

where $g(A)$ and $g(B)$, $A, B \subset X$ represent the degrees of consideration of the subsets A and B, respectively, and $\lambda \in [-1, +\infty]$ denotes an interacting degree index. If the two subsets A and B have negative (positive) correlation, (2) becomes a plausible (belief) measure and λ is a positive (negative) value so that $g(A \cup B) < g(A) + g(B)$ $(g(A \cup B) > g(A) + g(B))$. If the two subsets are independent, (2) becomes a probability measure and the value of λ is zero so that $g(A \cup B) = g(A) + g(B)$. Another interaction degree index ξ, which is scaled to be in $[0, 1]$, is employed to efficiently calculate the fuzzy measure values.

3 Organization and Selection Methods of Composite Behaviors

In this section, organization and selection methods of composite behaviors using the DoC-MoT is described. Fig. 2 shows the overall architecture of the proposed scheme. In the internal state and context modules, the strengths of input symbols on will and context are updated, respectively. The memory module stores all the necessary memory contents including the normalized weights of input symbols and the partial evaluation values of atom behaviors over wills and contexts. In the behavior selection module, each atom behavior is evaluated by the fuzzy integral of the partial evaluation values over wills and contexts, with respect to the fuzzy measure values. Based on their evaluation values, a proper composite behavior is organized and selected as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' In the actuator module, the selected behavior is generated through actuators. In the following, the key modules for behavior selection, namely internal state, context and behavior selection modules are described.

3.1 Internal State Module

The internal state module deals with the input symbols on will and updates the strengths of them. Since the human needs are categorized into five levels, i.e. physiological, safety, love and belonging, esteem and self-actualization needs, 15 input symbols on will are defined, as shown in Table 1 [11]. The will strength at time t, $\Omega_j(t)$ of the jth will w_j, $j = 1, 2, \ldots, n$, where n is the number of wills, is updated by

$$\Omega_j(t+1) = \Omega_j(t) + \alpha_j(\overline{\Omega_j} - \Omega_j(t)) + S^T \cdot W_j(t) + \sum_i \delta_{ij}(t), \tag{3}$$

where α_j is the difference gain, $\overline{\Omega_j}$ is the steady-state value, S is the stimulus vector, W_j is the strength vector between stimulus and the jth will and $\delta_{ij}(t)$ is the amount of change of the jth will strength caused by the ith atom behavior of the previous composite behavior. If the ith atom behavior affects positively on the jth will, $\delta_{ij}(t)$

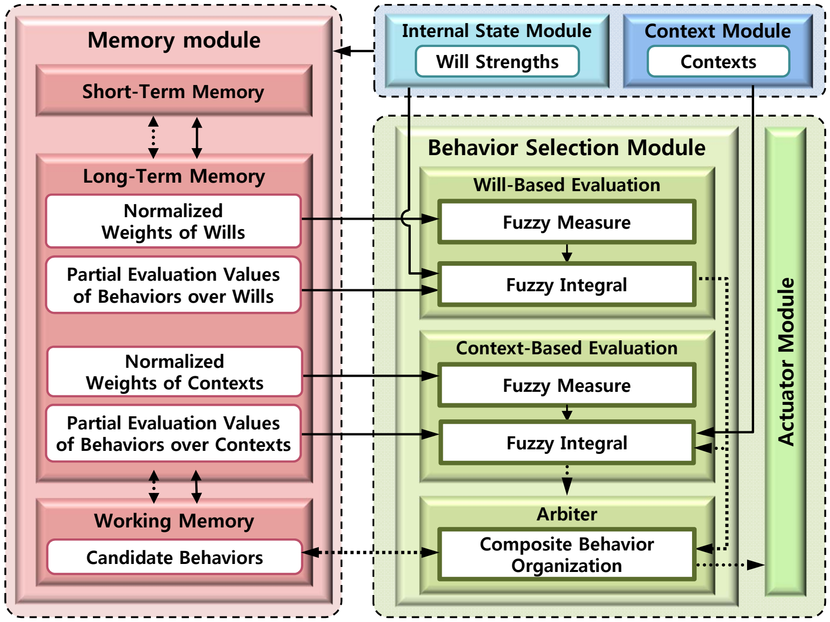


Fig. 2 Overall architecture. The solid arrows denote the movement of data related to wills and contexts, and the dotted arrows denote the behavior recommendation.

is a positive value. If the ith atom behavior affects negatively on the jth will, $\delta_{ij}(t)$ is a negative value. Note that the calculated strengths of wills are scaled to be in $[0,1]$ and they are used in the behavior selection module.

Table 1 Maslow's five human needs and input symbols on will.

Maslow's human need	Input symbol
Physiological needs	Fatigue (w_1), Hunger (w_2), Thirst (w_3), Excretion (w_4)
Safety needs	Safety (w_5), Dirt (w_6), Exercise (w_7)
Love and belonging needs	Comrade (w_8), Express (w_9), Play (w_{10})
Esteem needs	Decorate (w_{11}), Pride (w_{12}), Study (w_{13}), Wealth (w_{14})
Self-actualization needs	Self-actualization (w_{15})

3.2 Context Module

In the context module, 35 input symbols for "time", "place" and "object" are defined, as shown in Table 2. In each category, only one input symbol is perceived as context. It means that three input symbols are perceived as context at each time.

Table 2 Input symbols on context.

Classification	Input symbol
Time	Morning (c_1), Afternoon (c_2), Evening (c_3), Night (c_4)
Place	Livingroom (c_5), Bedroom (c_6), Kitchen (c_7), Restroom (c_8)
Object	Sofa (c_9), TV - Document (c_{10}), TV - Entertainment (c_{11}), Livingroom table (c_{12}), Chess table (c_{13}), Chess chair 1 (c_{14}), Chess chair 2 (c_{15}), Phone (c_{16}), Door (c_{17}), Flower (c_{18}), Bed (c_{19}), Dress (c_{20}), Seasonal clothes (c_{21}), Book (c_{22}), Diary (c_{23}), Bedroom chair (c_{24}), Radio (c_{25}), Mirror (c_{26}), Food (c_{27}), Kitchen chair 1 (c_{28}), Kitchen chair 2 (c_{29}), Water (c_{30}), Close stool (c_{31}), Basin (c_{32}), Comrade 1 (c_{33}), Comrade 2 (c_{34}), Comrade 3 (c_{35})

3.3 Behavior Selection Module

In the behavior selection module, a proper determinate composite behavior considering both internal wills and external contexts is selected by the following procedure. First of all, each atom behavior in Table 3 is evaluated by the fuzzy integral of the partial evaluation values over wills and contexts, with respect to the fuzzy measure values. Then, based on their evaluation values, a composite behavior is organized as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' Finally, a determinate composite behavior is selected by randomly remaining a behavior in each set of behaviors connected by 'choice' relationships.

3.3.1 Evaluation of Atom Behaviors

The evaluation value $E(b_i^a)$ of the ith atom behavior $b_i^a, i = 1, 2, \ldots, l$ over wills and contexts, where l is the number of atom behaviors, is calculated as follows:

$$E(b_i^a) = E_w(b_i^a) \cdot E_c(b_i^a), i = 1, 2, \ldots, l, \tag{4}$$

where $E_w(b_i^a)$ is the evaluation value of b_i^a over wills and $E_c(b_i^a)$ is the evaluation value of b_i^a over contexts. The evaluation values $E_w(b_i^a)$ and $E_c(b_i^a)$ are calculated by the following Choquet fuzzy integrals:

Table 3 A list of atom behaviors.

Classification	Body part	Atom behavior
Facial movement	Face (head)	Watch TV (b_1^f), Listen radio (b_2^f), Talk (b_3^f), Shout (b_4^f), Sing loudly (b_5^f), Sing softly (b_6^f), Look at (b_7^f), Observe (b_8^f), Mumble (b_9^f), Sermon loudly (b_{10}^f), Sermon softly (b_{11}^f), Look around (b_{12}^f)
Gesture	Upper body	Eat cheerfully (b_1^g), Eat slowly (b_2^g), Drink (b_3^g), Sleep (b_4^g), Nap (b_5^g), Scratch fast (b_6^g), Scratch slowly (b_7^g), Wash quickly (b_8^g), Wash slowly (b_9^g), Close door (b_{10}^g), Put on (b_{11}^g), Chess hard (b_{12}^g), Chess roughly (b_{13}^g), Call (b_{14}^g), Exercise cheerfully (b_{15}^g), Exercise normal (b_{16}^g), Exercise slowly (b_{17}^g), Read hard (b_{18}^g), Read roughly (b_{19}^g), Write hard (b_{20}^g), Write roughly (b_{21}^g), Work hard (b_{22}^g), Work roughly (b_{23}^g), Raise flowers (b_{24}^g), Clean hard (b_{25}^g), Clean normal (b_{26}^g), Clean roughly (b_{27}^g), Make up (b_{28}^g), Wave hand strongly (b_{29}^g), Wave hand softly (b_{30}^g), Shake hand strongly (b_{31}^g), Shake hand softly (b_{32}^g), Hit strongly (b_{33}^g), Hit softly (b_{34}^g), Meditate (b_{35}^g), Pray cheerfully (b_{36}^g), Pray normal (b_{37}^g)
Movement	Lower body	Sit (b_1^m), Walk (b_2^m), Stand (b_3^m), Lie (b_4^m), Kneel (b_5^m), Bow (b_6^m), Follow closely (b_7^m), Follow slowly (b_8^m), Wander cheerfully (b_9^m), Wander normal (b_{10}^m), Wander slowly (b_{11}^m), Kick strongly (b_{12}^m), Kick softly (b_{13}^m) Excrete (b_{14}^m), Urine (b_{15}^m)

$$E_w(b_i^a) = \int_{X_w} h_w \circ g_w = \sum_{j=1}^{n} \{h_{ij}^w \cdot \Omega_j(t) - h_{i(j-1)}^w \cdot \Omega_{j-1}(t)\} g(A_w), \tag{5}$$

$$E_c(b_i^a) = \int_{X_c} h_c \circ g_c = \sum_{j=1}^{m} \{h_{ij}^c - h_{i(j-1)}^c\} g(A_c), \tag{6}$$

where $A_w \subset X_w$ and $A_c \subset X_c$ are the subset of will and context symbols, respectively, h_{ij}^w and h_{ij}^c are the partial evaluation values of b_i^a over the jth will and the perceived context, respectively, and $g(A_w)$ and $g(A_c)$ are the fuzzy measure values of A_w and A_c, respectively.

To measure the fuzzy measure value $g(A)$, ϕ_s transformation method is employed [7], [12]. In this method, the fuzzy measure values are calculated using a hierarchy diagram of criteria, i.e. wills and contexts, which represents hierarchical interaction relations among criteria. A fuzzy measure $g(A)$ is identified as follows:

$$g(A) = \phi_s(\xi_R, \sum_{P \subset R} u_P^R), \tag{7}$$

where R is the root level in the hierarchy diagram, ξ_R is the interaction degree between the criteria sets in the R, ϕ_s is a scaling function [13], and u_Q^P is defined as follows:

$$\phi_s(\xi,u)=\begin{cases}1, & \text{if } \xi=1 \text{ and } u>0\\ 0, & \text{if } \xi=1 \text{ and } u=0\\ 1, & \text{if } \xi=0 \text{ and } u=1\\ 0, & \text{if } \xi=0 \text{ and } u<1\\ \frac{s^u-1}{s-1}, & \text{other cases}\end{cases} \tag{8}$$

$$u_Q^P=\begin{cases}d_i, \text{where } i\in Q & \text{if } |Q|=1 \text{ and } i\in A\\ 0 & \text{if } |Q|=1 \text{ and } i\notin A\\ \phi_s^{-1}(\xi_P,\phi_s(\xi_Q,\sum_{V\subset Q}u_V^Q)\times T_Q^P) & \text{other cases}\end{cases} \tag{9}$$

where $s=(1-\xi)^2/\xi^2$, d_i is the normalized weight (DoC) of the ith criterion, and the value of $\phi_s^{-1}(\xi,r)$ is u, which satisfies $\phi_s(\xi,u)=r$. The conversion ratio T_Q^P from Q to P, is computed as

$$T_Q^P=\frac{\phi_s(\xi_P,\sum_{i\in Q}d_i)}{\phi_s(\xi_Q,\sum_{i\in Q}d_i)}, \tag{10}$$

where P is the upper level set and Q is the lower level set in the hierarchy diagram.

3.3.2 Organization of a Composite Behavior

A composite behavior is organized as a set of atom and composite behaviors which are connected by the relationships of 'parallel (||),' 'choice (+)' and 'sequence (;).' For example, a composite behavior b^c, "washing slowly after normally exercising while watching TV or cheerfully exercising while listening radio," is described as

$$b^c=\{(b_1^f||b_{16}^g)+(b_2^f||b_{15}^g)\};b_9^g. \tag{11}$$

The conditions to connect two atom or composite behaviors are described in the following.

i) Parallel

Since the two atom behaviors connected by 'parallel' relationship are generated at the same time, the body parts for generating the two behaviors should not conflict with each other. For this purpose, the three best atom behaviors with the highest evaluation values over wills on contexts, b_{best}^f, b_{best}^g and b_{best}^m, are selected in each category. Then, a parallel behavior b^p is organized by connecting every atom behaviors of $B^p\subset B=\{b_{\text{best}}^f,b_{\text{best}}^g,b_{\text{best}}^m\}$. Therefore, the number of possible parallel behaviors is 7 $(=2^3-1)$. The evaluation value $E(b_i^p)$ of the ith parallel behavior b^p over wills and contexts, is calculated as follows:

$$E(b_i^p)=\frac{\sum_{j\in B^p}E(b_j^a)}{|B^p|}, \tag{12}$$

where b_j^a is the jth atom behavior of b^p and $|B^p|$ is the number of atom behaviors of B^p. After that, a parallel behavior with the highest evaluation value is selected as the best parallel behavior b_{best}^p.

ii) Choice

Behaviors which have a similar evaluation value with the best parallel behavior are connected by 'choice' relationship. The similarity $\text{Sim}(b^p, b_{\text{best}}^p)$ between b^p and b_{best}^p is calculated as

$$\text{Sim}(b^p, b_{\text{best}}^p) = 1 - \frac{E(b_{\text{best}}^p) - E(b^p)}{E(b_{\text{best}}^p)}. \tag{13}$$

Note that, if the similarity value of them is bigger than 0.95, the two atom behaviors are connected by 'choice' relationship, described in Section IV. If the limit of the similarity value is set to be too low, the selected behavior may have no correlation with the artificial creature's wills. If it is set to be too high, the diversity of generated behaviors may be low.

iii) Sequence

An artificial creature usually selects a behavior which is highly related to the strong wills. However, the strengths of other wills may be increased unintendedly. Therefore, a parallel behavior, which can compensate the side effect of the previous one, is connected to the previous one by a relationship of 'sequence.' The effectiveness $\text{Eff}(b_i^p, b_j^p)$ between the ith parallel behavior b_i^p and the jth parallel behavior b_j^p is calculated as follows:

$$\text{Eff}(b_i^p, b_j^p) = \sum_{k,l} \text{Eff}(b_{ik}^a, b_{jl}^a), \tag{14}$$

where $\text{Eff}(b_{ik}^a, b_{jl}^a)$ is the effectiveness between the kth atom behavior b_{ik}^a of b_i^p and the lth atom behavior b_{jl}^a of b_j^p. The effectiveness $\text{Eff}(b_k^a, b_l^a)$ between the kth atom behavior b_k^a and the lth atom behavior b_l^a is calculated as follows:

$$\text{Eff}(b_k^a, b_l^a) = -(\Delta_k^a \cdot \Delta_l^a), \tag{15}$$

where $\Delta_k^a = \{\delta_{k0}^a, \delta_{k1}^a, \ldots, \delta_{kn}^a\}$ and $\Delta_l^a = \{\delta_{l0}^a, \delta_{l1}^a, \ldots, \delta_{ln}^a\}$ are the feedback vectors of b_k^a and b_l^a, respectively, n is the number of wills and δ_{ki}^a is the amount of change of the ith will strength caused by b_k^a. Note that if the effectiveness of two parallel behaviors has a positive/negative value, they have a positive/negative effect.

3.3.3 Selection of a Determinate Composite Behavior

In the organized composite behavior, the behaviors connected by 'choice' relationship can not be generated at the same time. Therefore, only one atom or composite behavior is randomly remained in each set of atom or composite behaviors connected by 'choice' relationship. The finalized composite behavior is called a determinate composite behavior.

4 Simulations

4.1 Simulation setting

To show the effectiveness of the proposed organization and selection methods of composite behaviors, simulations were carried out with an artificial creature, "DD," in the 3D virtual world, as shown in Fig. 3. For a DD, the numbers of wills, contexts and atom behaviors were 15, 35 and 64, respectively, as defined in Tables 1, 2 and 3. Note that the partial evaluation values of behaviors over each will and context, the strength vector between stimulus and wills, the amounts of will strength change by the previous behavior and the interaction degrees among criteria, were initialized by an expert. The generation frequencies of atom and composite behaviors were calculated from the experiment results gathered for one day in the virtual world. A composite behavior was selected in every one minute, and therefore, the total number of generated behaviors was 1,440. To show the performance of the proposed scheme, the generation frequencies of parallel behaviors were calculated and the numbers of different generated behaviors and the generation frequencies of sequence behaviors were compared between the two behavior selection methods each with and without the organization process of composite behaviors [4].

Fig. 3 Screenshot of DD in the 3D virtual world.

4.2 Simulation 1: Diversity of Generated Behaviors

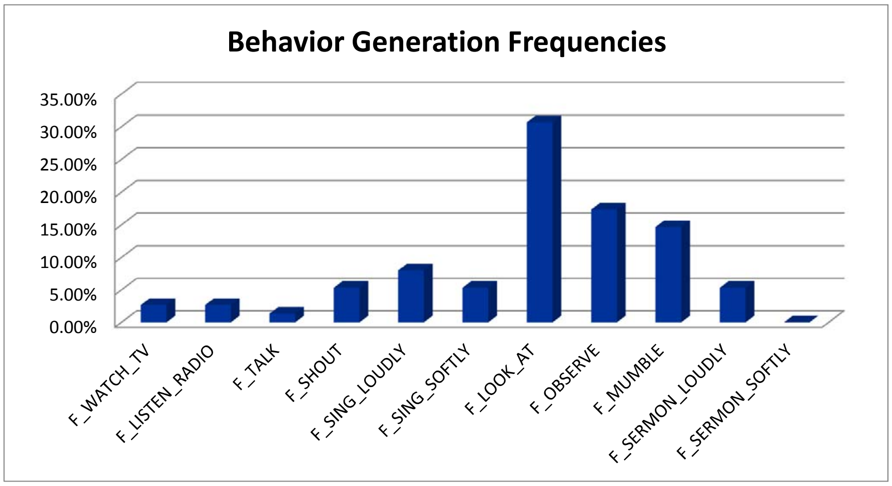
In this simulation, the numbers of generated behaviors were compared between the two behavior selection methods each with and without the organization process of composite behaviors, as shown in Table 4. In the method with the process, the numbers of different generated behaviors composed of one, two and three parallel atom behaviors, were 57, 123 and 88, respectively, and the total number of different composite behavior was 268. However, in the method without the process, the maximum number of different generated behaviors is the same as the number of atom behaviors, which is 64. In summary, the diversity of the generated behaviors was increased fourfold compared to the method without the process in which an atom behavior is selected for generation.

Table 4 The number of different generated behaviors.

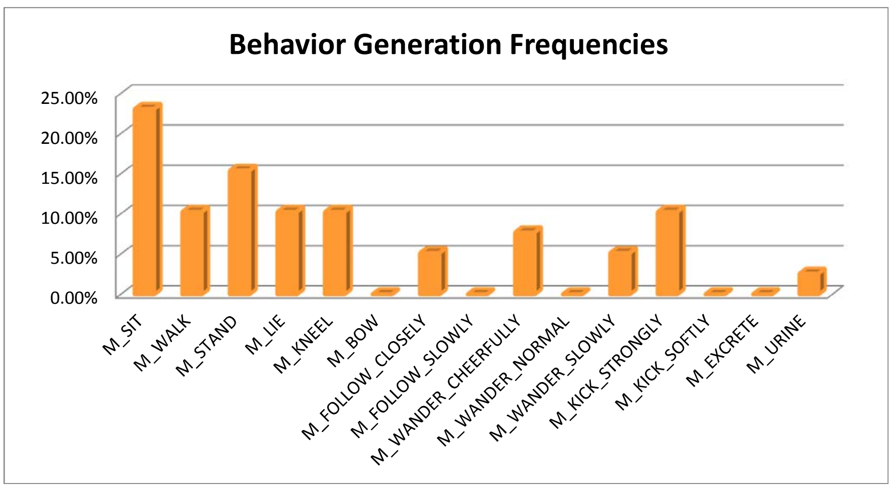
Composed of	In the method without the organization process	In the method with the organization process
One atom behavior	<64	57
Two parallel atom behaviors	0	123
Three parallel atom behaviors	0	88
Total	<64	268

4.3 Simulation 2: Generation Frequencies of Parallel Behaviors

In this simulation, the generation frequencies of co-occuring atom behaviors with “working hard” or “working roughly” behaviors were computed, as shown in Fig. 4. The atom behaviors related to gesture were not generated with “working” behaviors, since the two atom behaviors in the same category can not be connected by a relationship of ‘parallel,’ as described in Section III. The generation frequencies of “looking-at,” “observing” and ”mumbling” behaviors were approximately 31%, 17% and 15%, respectively, which are much higher than those of other atom behaviors related to facial movement. The generation frequencies of “sitting” and “standing” behaviors were approximately 23% and 15%, respectively. Since the two atom behaviors with higher evaluation values over wills and contexts are connected by a relationship of ‘parallel,’ the un-recommended behaviors, such as “watching TV,” “talking” and “following,” are rarely generated with “working” behaviors. In summary, the generated parallel behaviors satisfied the artificial creature’s wills more.



(a) Atom behaviors related to facial movement



(b) Atom behaviors related to movement

Fig. 4 The generation frequencies of co-occuring atom behaviors with “working” behaviors.

4.4 Simulation 3: Generation Frequencies of Sequence Behaviors

In this simulation, the generation frequencies of the next atom behaviors to “exercising cheerfully,” “exercising normal” or “exercising slowly” behavior were compared between the two behavior selection methods each with and without the organization process of composite behaviors, as shown in Fig. 5. The generation frequencies of “eatting,” “drinking,” “sleeping” and “washing” behaviors were approximately 6%, 24%, 12% and 59% in the method with the process and 2%, 4%, 2% and 4% in the method without the process, respectively. Since the above-mentioned behaviors compensate the side effect of "exercising" behaviors, such as hunger, thirst, fatigue and dirt, they were connected by "sequence" relationship. In summary, the logical connectivity of a series of generated behaviors is increased compared to the method without the organization process of composite behaviors.

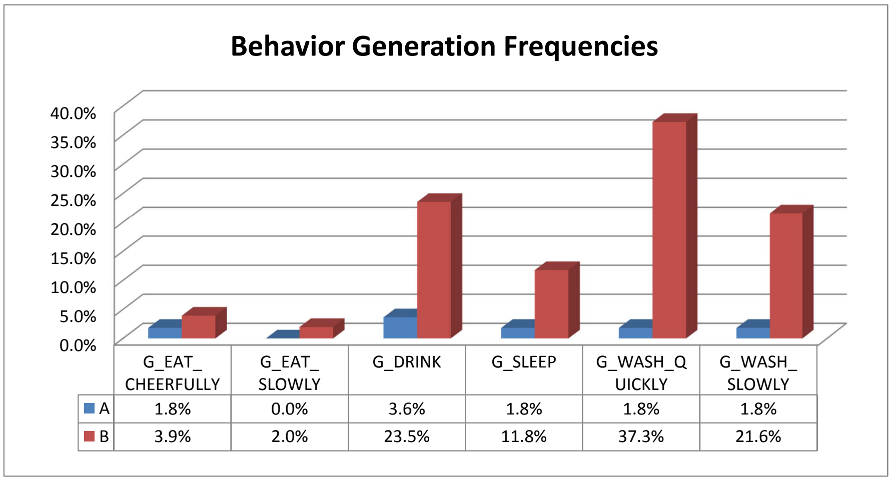


Fig. 5 The generation frequencies of the next atom behaviors to "exercising" behaviors for the two behavior selection methods: A is the behavior selection method without the organization process of composite behaviors and B is the one with the process.

5 Conclusion

This paper proposed the organization and selection methods of composite behaviors for artificial creatures. Using the degree of consideration-based mechanism of thought (DoC-MoT), each pre-defined atom behavior was evaluated by the fuzzy integral of the partial evaluation values of behaviors over the artificial creature's wills and external contexts, with respect to the fuzzy measure values representing its degrees of consideration (DoCs). Based on their evaluation values, a proper composite behavior was organized and selected at each time, as a set of atom and composite behaviors which are connected by the relationships of 'parallel,' 'choice' and 'sequence.' The effectiveness of the proposed scheme was demonstrated through the simulations with an artificial creature, "DD," in the 3D virtual environment. The results showed that the artificial creature could generate various behaviors through the proposed behavior selection scheme. Moreover, the generated composite behaviors satisfy the artificial creature's wills more and the logical connectivity of them is increased compared to the atom behavior selection method.

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