Behavior Model of Virtual Soldier Based on Hierarchy Structure

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Abstract — In the Military Operations on Urbanized Terrain(MOUT) Simulation，It is a challenging task how to build Behavior Modeling of Virtual Soldier for apperceiving information form virtual city and accomplish independent behaviors. The thesis presents a object-oriented behavior model of virtual soldier, Which uses comprehensive and simple structure. The model is composed of basic response hierarchy, object-oriented behavior hierarchy and control hierarchy. The article introduces detailedly internal state model behavior, hierarchy structure and behavior choice mechanism of the behavior model. Finally, the model is accomplished based on the program method of combination pattern and simulates realistically soldier behavior.

Keywords-Virtual soldier, behavior model, object-oriented

I. INTRODUCTION

Virtual soldier is an important part of the virtual battle environment. It can greatly reduce real combatants and the cost of simulation training by utilizing virtual soldiers instead of simulation training opponents

In this paper, it mainly discussed how to establish the real soldier operational behavior model. Consequently, they did not need interact with people and apperceived information in the virtual operational environment, combined with their own mission goals and current internal states. Then virtual soldiers selected appropriate tactical behaviors and called the corresponding behavior procedure for performing appropriate tactical actions to complete the current mission goal.

II. BEHAVIOR MODEL FRAMEWORK

The virtual soldier behavior is that they responded to their internal properties and external battle environmental information. According to Zoology and artificial life theory, behavior has different levels and is composed of basic behaviors [1]. A variety of behaviors can implement serial or parallel execution. Hierarchy Structure has prominent advantages in dealing with conflict and information share between behaviors [2].

(1) Hierarchy structure had a high intuitionism.

(2) High level behaviors can accommodate and obtain automatically access to low level ones.

(3) Each behavior in the hierarchy structure focused on their goals which were determined by arbitration mechanism.

(4)Hierarchy structure contributed to problem decomposition.

Based on above analysis, the virtual soldier behavior model adopted hierarchy goal-oriented model. Shown in Figure 1, it can be divided into three layers: basic reaction behavior layer, goal-oriented behavior layer and control layer. Basic reaction behavior layer responded with changes in the environment which belonged to stimulus - response rules. Goal-oriented behavior layer was goal oriented complex behavior according to environmental stimulus, internal state and current target. Goal-oriented behavior layer and basic behavior layer were linked with container structure. That can achieve parallel execution between basic behaviors and goal-oriented behaviors. Control layer was the top level of behavior model, responsible for the behavior choice and termination. This model ensured the virtual soldiers response to real-time emergency, also exerted the behavior planning capacity to complete complex tasks.

III. BEHAVIOR MODEL CONSTRUCT

Hierarchical goal-oriented behavior model contained three important components: internal state model, behavior level structure and behavior selection mechanism. The virtual soldiers' behavior level structure was conducive to construct the whole behavior system. Behavior selection mechanism was to resolve how to choose the most appropriate behavior from competitive behaviors. Internal State Model

in the virtual soldier internal state model, an internal variable was designed: tiredness. Tiredness increasing can produce a rest behavior motivation. The size of tiredness affected velocity of virtual soldiers. Different values of fatigue can provide diverse maximum speed.

Virtual soldiers' tiredness model was defined as follows:

$$Tired_t = \begin{cases} Max\{Tired_{t-\Delta t} + k(V_t - V_{Normal}) \times \Delta t \ , \quad Tired_{Max}\} & (V_t \leq V_{Normal}) \\ Min\{Tired_{t-\Delta t} + k(V_t - V_{Normal}) \times \Delta t \ , \quad Tired_{Min}\} & (V_{Normal} \leq V_t \leq V_{HStrenth}) \\ Min\{Tired_{t-\Delta t} + k(V_t - V_{HStrenth})^2 \times \Delta t \ , \quad Tired_{Min}\} & (V_{HStrenth} \leq V_t) \end{cases}$$

$$Tiredness_{Min} \leq Tiredness_t \leq Tiredness_{Max}$$

V_t represented the moment speed of the virtual soldier, the constant value $V_{Normorl}$ was speed upper limit in the rest state and $V_{HStrenth}$ lower limit .K represented change rate. When the virtual solider Speed was less than the constant value the tiredness decreased over time. While the speed was greater than the constant value the tiredness increased. a state change event was produced in the case that internal Property values exceeded the designed threshold . It implemented behavior trigger.

A. Behavior Hierarchy

Behavior level structure of virtual soldiers conducted an inclusive bottom-up style structure. Behavior was divided into two layers: the bottom was basic behavior aggregate and the high level was goal-oriented behavior aggregate.

(1) Basic behavior layer

Basic behavior layer was consist of virtual soldiers' fundamental tactics behaviors supporting goal-oriented behaviors. It is the combat unit capability in the virtual battlefield environment [3]. Virtual soldiers can carry out multiple tactical activities which constituted the complete sequence of a target behavior. The basic behavior of the various tactics described public property and constituted the basic model of tactical actions to improve work efficiency.

Basic behavior layer not only determined the capacity of virtual soldiers' basic behavior but also affected the further expansion of combat simulation system. The appropriate basic behavior set choice should consider behavior properties and task demand. Mataric proposed a behavior selection standard: "We believe that, for each problem, there is a set of basic actions, the rest of the behavior can be derived from this collection. "[4] those chosen behaviors were necessary and met the corresponding task demand.

(2) Goal-oriented behavior layer

Behavior science research indicated that human always decided something according to current environmental conditions and their own needs, the thing that would be done was called a goal [5]. If this goal can be done one step, it was defined as an atomic target. Or it was defined as an abstract goal which was a combination of atomic targets. Human chose high abstract goals and then recursively decomposed into implemental action plans. [6] In this article, aims were tasks that the virtual soldier needed to complete. Based on Goal-oriented behavior control mechanism, virtual soldiers had a series of high level goals, which may be abstract or atomic goals. Virtual soldiers used arbitration module to select the most appropriate target to execute. At this level, the handling of virtual soldiers was consistent.

B. Behavior Selection Mechanism

(1) Target arbitration

Virtual Soldiers in a complex and dynamic urban combat simulation environment tried to meet many combat goals. But they had limited resources. Consequently, it was necessary to require some kind of arbitration mechanism to arbitrate high level goals. Moreover, once virtual soldiers focused on achieving a goal. They should be absorbed in this goal continuously unless there was much more important goal implemented. Target arbitration was the core of the behavior model. It can arbitrate the current high level goals and choose the most suitable high level goal.

The expected goal value was calculated by the relevant internal and external factors. To avoid small changes of the perception variables leading to the current behavior oscillating between two acts, this paper presented a goal arbitration model based on inertia coefficient weight.

Each simulation cycle selected the target as following steps:

step 1: update the expected parameters of strategic goal value according to the input sensor;

step 2: Calculate each strategy goal value $Expectation_{G_i}$;

step 3: Calculate the activation value of the goal $Activation_{G_i}$;

step 4: Compare activation values of all the strategic goals;

step 5: treat the goal with the maximum activation value as the current goal.

Calculate the expected value of goal by using formula 1

$$Expectation_{G_i}^t = k \times comb(\sum_j r_{ij}^t, \sum_j e_{ij}^t) \tag{1}$$

Calculate the activation value of goal by using formula 2.

$$Activation_{G_i}^t = \beta_i^t \times Expectation_{G_i}^{t-1} + Expectation_{G_i}^t \tag{2}$$

Inertia coefficient β_i^t affected the goal durative. If it was lower the effect changing oscillations between two behaviors would not be obvious, or the behavior continuity would be enhanced. That made the low level behavior performs difficultly. To solve this problem, Ludtow proposed a tiredness coefficient associated with each behavior. [8] The tiredness coefficient value varied between 0 and 1. The value of the tiredness coefficient and behavior multiplied during the model calculations. When the behavior is activated the tiredness coefficient decreased. When the behavior is not active, its inhibition coefficient increased. This made the lower activation behavior have an opportunity to perform like time-sharing system.

(2) Behavior planning based on goal-oriented

The goal that arbitration outputted showed the current behavior goal of virtual soldiers. In the simulation, if the current target was a complex task, the virtual soldier would first plan to determine a series of sub-goals for transferring basic behaviors to achieve sub-goals. Behavior planning processes were established as follows:

planning goal. Through internal demand and external

stimulation, the arbitration module generated current target goals;

Planning premise. Virtual battlefield environment information and its own internal properties;

planning body. Virtual soldiers coordinated their behavior and identified the best course under certain constraints;

Planning result: the completion of the current target was successful or failed.

Take virtual soldiers' aggressive behavior for example, the paper explored the behavior planning algorithm.

Firstly, the algorithm was definited as follows:

n represented the enemy number virtual Soldiers perceived, d was the distance between the virtual soldier and the enemy.

Planning goal: attack;

Planning premise: the virtual soldier was energetic and weapons were enough;

Planning body:

step1: Search the enemy.

step2: The detection of virtual soldiers perception model output, if n=0, turned to step1; If n=1, turned to step 3, else turned to step 8.

step3: Estimate whether there was a bunker within the perceived scope.

step4: Enter the bunker;

step5: Lie down;

step6: Shoot;

step7: Judge the living condition of the enemy, if it was dead, turn to step 9, else turn to step 1;

step8: Avoid;

step9: End.

Planning result: when the enemy was killed it was successful, else failed.

IV. IMPLEMENTATION OF BEHAVIOR MODEL

The combination model of object-oriented program provided a method to solute the goal class of goal-oriented behavior model. The combination model defined an abstract component class, which was not only an atomic component also a combination component.   The abstract class defined a common interface. The user utilized the interface interact with different component objects. Shown in the Figure 2, the atomic goals were achieved by class Goal and combined goals were implemented by class Goal_Composite. The difference between them was that class Goal acted both as abstract component class and as atomic component class. Class Goal_Composite acted as combination components which derived from class Goal and were converged by a number of Goals.

V. CONCLUSION

Based on behavior hierarchy theory and goal-oriented characteristics, a goal-oriented behavior model was built. The model can use the current task of virtual soldiers, the internal state and virtual battlefield information to plan behavior.

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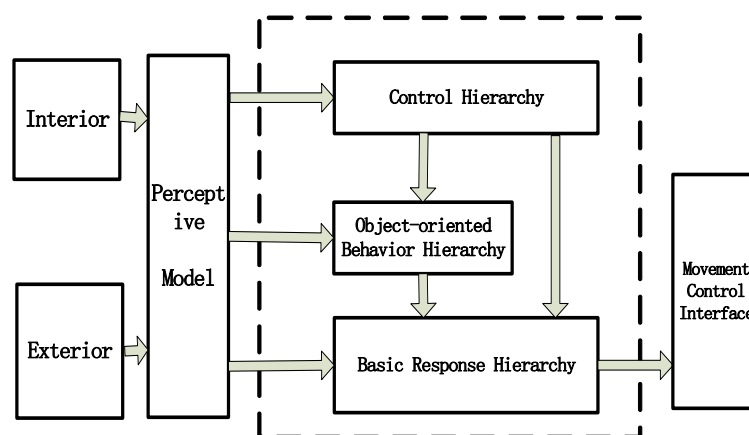[8] S.Mavor.,R.W.P.a.A.Representation Human Behavior in Military Simulations[C].Iterim Report,1997
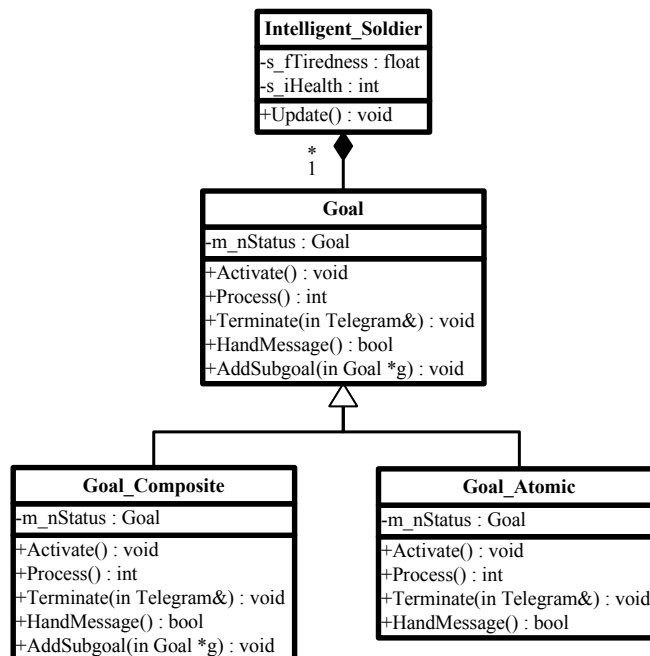
Figure1. Behavior model framework of virtual solider

Figure 2. Combination model of goal class