Analysis of CGF’s Behavioral Simulation Based on Motives

Chuanhua Wen, Guoning Zhang, Chengsen Bai, Jiang Zhu and Shoulin Shen*

Army Command College Battle Lab, Nanjing, Jiangsu, 210045, China

*Corresponding author’s e-mail: 2488205931@qq.com

Abstract. In this paper, we analysed the Agent’s behavioral simulation based on motives. In Army Combat Complex System, the motives of agent can affect the behaviours of CGF (Computer Generated Forces) obviously. In this paper, we did the experiment that how the different motives effect on the CGF. The conclusion is that different motives settings will get different effect. In conditions of some urgency task, such as in offensive warfare, we may choose the Motives Setting1. The Motives setting2 may be used in the other conditions, such as in defensive warfare.

1. Introduction
Computer Generated Forces (CGF) is an important part of the military simulation experiment. The computer-generated entities provide a dynamic and realistic environment for interaction of human participants. These CGF entities are comprised of two specific objects: equipment model and behavioral model. Behaviour is the range of actions and mannerisms made by individuals, organisms, systems, or artificial entities in conjunction with themselves or their environment, which includes the other systems or organisms around as well as the physical environment.

2. Motive and CGF

2.1. Motive-driven behaviors of Agents
Motive is a theoretical construct used to explain behaviour. It gives the causes for CGF’s actions, desires, and needs. Motive can also be defined as one's direction to behavior or what causes an agent to want to repeat a behavior and vice versa. The process of behavior includes need, motive, behavior and effect, as shown in the Figure1, this framework is the theoretical pillar of behavioral science.

![Figure 1. Framework of behaviors based on Motives.](image-url)
A motive is what prompts the agent to act in a certain way. Motive is the cause of action to achieve a certain target. The target of an agent may be determined by the agent itself or may be assigned by the superior. The behavior results from all the actions that the agent performs in the battlefield. These actions are selected by the agent from the abilities in order to accomplish the target. Motive triggers action, and the ability determines the action effect.

Motive is an individual’s internal process, and behavior is the manifestation of this internal process. The internal condition of motive is need, and the external condition of motivation is inducement. The external factors that drive the agent to produce certain behaviors are called incentives. The agent can do the perception, judgment, understanding, prediction and decision etc., with using the cognitive ability. When an individual agent tends to induce and thus be satisfied, this inducement is called a positive inducement; when an individual is satisfied with the inducement of escape or avoidance, this inducement is called negative inducement. The research focuses the motive on the observable behavior and theories founded on experimental evidence. Motive is an important part in study on the behaviors. Motive comes from two sources: the need of oneself and the cognition of the environment. Incentive theory in psychology treats motive and behavior of the individual as they are influenced by beliefs, such as engaging in activities that are expected to be profitable.

2.2. CGF based on MAS (Multi-Agent System)

Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent to solve. The MAS tends to be used in engineering and technology. Multi-agent system combines elements of game theory, complex systems, emergence, computational sociology, agent-based model, and evolutionary programming. Multi-agent systems research may deliver an appropriate approach in the military battle and modelling social structures. A multi-agent system is a method of simulation by using multi-agents based on agent model. The MAS theory is serving as a formal specification to guide the development of a multi-agent simulation platform. An agent-based model is one of a class of computational models for simulating the actions and interactions of autonomous agents with a view to assessing their effects on the system as a whole.

There are many CGFs in the battlefield environment; and every CGF can include many Units, and every Unit has many agents as shown in Figure2. CGF models are a kind of micro-scale model that simulate the simultaneous operations and interactions of multiple agents in an attempt to re-create and predict the appearance of complex phenomena. CGF based on agent may experience "learning", adaptation, and reproduction.

![Figure 2. CGF based on MAS.](image)

![Figure 3. Effect of Motives on CGF’s behaviors.](image)

2.3. Effect of Motive on CGF’s behaviors

The CGF based on MAS can have intelligent behaviors. Tactical psychology is a part of military psychology. It is a sharp focus on what soldiers do once they are in contact with the enemy and on what a front-line soldier can do to win a battle. It combines psychology and historical analysis to find out how tactics make the enemy freeze, flee or fuss, instead of fight. Tactical psychology examines how techniques like suppressive fire, combined arms or flanking reduce the enemy’s will to fight.

The motives settings of agent can affect the outside behaviors. In Figure3, Red CGF and Blue CGF both take action according to the battlefield environment. Based the same battlefield environment, we designed the experiment that the red CGF with the different motives.
3. Motives Model
When the agent has different motives, there will be different behaviors, and the agent’s behavior is closely related to the motives. Individual behavior in specific situations is directly determined by one or more motives settings. Agent affects its behavior choice in specific situation by adjusting various internal motives, and has an effect of behavior.

The given characterization formula of the information by getting CGF is

$$E = \begin{bmatrix} E_{11} & \cdots & E_{1b} \\ \vdots & \ddots & \vdots \\ E_{ab} & \cdots & E_{ab} \end{bmatrix};$$

The attention filter matrix of the getting information of CGF is

$$AF = \begin{bmatrix} a_{f11} & \cdots & a_{f1n} \\ \vdots & \ddots & \vdots \\ a_{fm1} & \cdots & a_{fmm} \end{bmatrix}. $$

This information is the combat environment information which can be further processed by the combat entity, and can be considered as the external incentive of the action motives of the combat agent. The Personality model of the Combat Agent is $$P_{CA} = [P_1, P_2, P_3, \ldots]$$, the personality can be considered as the internal inducement of the combat agent. Then we can construct the behavior motive model of the combat agent as follows: $$M = P^* (E^* AF),$$ where P, E and AF are all needed to be normalized.

$$M = \begin{bmatrix} M_{11} & \cdots & M_{1r} \\ \vdots & \ddots & \vdots \\ M_{sr} & \cdots & M_{sr} \end{bmatrix}.$$

The motives matrix can be marked as

$$P_{CA} = [P_1, P_2, P_3, \ldots], \quad P_1, P_2, P_3 \text{ and etc.}, \text{ may represent Bravery, Honesty, Group Spirit and other characters. For example } P_1 \in [-1, 1], \text{ a positive value represents courage, and a negative value represents cowardice. The value is greater; the individual agent’s performance in this aspect is stronger. In the current state, according to the action motive and combat rules of the combat agent, the specific actions are selected, with the change of the environment and the real state; the actions will be constantly changed, forming the action sequence from the final shape or the behavior model of the combat agent.}$$

4. Experiment
We use the Army Combat Complex System designed by ourselves. This software can be used to test how the motives changed in individual behaviors will affect the system's emerging overall behaviors. And the behaviors are changed by the different motives in the condition of two different settings. Only the personalities of the red firing units were changed in the experiments.

4.1. Original settings
The CGF units are showed in Figure4, 4(a) is red CGF and 4(b) is blue CGF. The numbers of agents are listed in the following.

We set $[i, j, k, l, m, n, p, q] = [60, 80, 60, 540, 1000, 1000, 500, 1000]$, then we get the total number of the agents of Red CGFs is 4240. We set $[x, y] = [1900, 1580]$, then we get the total number of the agents of Blue CGFs is 3480.
4.2. Motives Settings

We just changed the red firing units’ (including Artillery Company, 3 Tank Troops and Armored Company) motives settings. The settings of other parameters including blue CGF and the other red CGF are default.

\[
\text{Motives} = \begin{bmatrix}
\text{Motive to near the enemy} \\
\text{Motive to near the wounded enemy} \\
\text{Motive to keep the distance between the adjacent units} \\
\text{Motive to fire the target} \\
\text{Motive to the distance of choosing for attacking} \\
\text{Motive to the change of the scope of the aiming} \\
\vdots
\end{bmatrix}
\]

\[
\text{Motives} = \begin{bmatrix}
M_1 \\
M_2 \\
M_3 \\
\vdots
\end{bmatrix}
\]

That is \( \text{Motives} = [M_1, M_2, M_3, \ldots] \).

4.2.1. Motives Setting 1

After the original condition is given, the red firing units’ (including Artillery Company, 3 Tank Troops and Armored Company) motives setting is as \( \text{Motives}_1 = [-0.4, 0.8, 0.8, 0.7, 0.4, 0.6] \). Let the Combat Complex system run autonomously. Then we can get: The number of Red unit’s agent’s number is \([i, j, k, l, m, n, p, q] = [40, 60, 40, 400, 900, 700, 490, 980]\). The number of Blue unit’s agent’s number is \([x, y] = [230, 1360]\). Statistics of number of agents after the 160\(^{th}\) bout in the motives setting 1 is in the Table 1. And the column diagram of Agents are shown in Figure 5 (a).

| CGF  | Total Agents | Survival Agents | Loss Agents |
|------|--------------|-----------------|-------------|
|      | Motives 1 | Motives 2 | Motives 1 | Motives 2 |
| Red  | 4240       | 3610           | 3730        | 630        | 510    |
| Blue | 3480       | 1590           | 1400        | 1890       | 2080   |
4.2.2. Motives Setting2
In this condition, the red firing units’ (including Artillery Company, 3 Tank Troops and Armoured Company) motives setting is as \( \text{Motives}_2 = [0.6, 0.8, 0.2, 0.7, 0.8, 0.1] \). Let the Combat Complex system run autonomously. Then we can get: The number of Red unit’s agent’s number is \( [i, j, k, l, m, n, p, q] = [40, 60, 40, 400, 1000, 700, 490, 1000] \). The number of Blue unit’s agent’s number is \( [x, y] = [220, 1280] \).

Statistics of number of agents after the 160\(^{th}\) bout in the motives setting1 is in the Table1 too. And the column diagram of Red and Blue Agents are shown in Figure5(b). In the condition of \( \text{Motives}_1 \), the loss of the red agents is about 630 agents and the loss of the blue agents is about 1890 agents at about 160\(^{th}\) bout. On the other hand, in the condition of \( \text{Motives}_2 \), the loss of the red agents is about 510 agents and the loss of the blue agents is about 2080 agents at the same bout.

4.3. Data Analysis
In condition of \( \text{Motives}_1 \) and \( \text{Motives}_2 \), we can get the percent of survival and loss agents of CGF after the 160\(^{th}\) bout, as shown in Table2. And the pie chart of Red and Blue Agents are shown in Figure6 and Figure7.

| CGF Rate | Survival Agents | Loss Agents |
|----------|-----------------|-------------|
|          | Motives1 | Motives2 | Motives1 | Motives2 |
| Red      | 85.14%   | 87.97%   | 14.86%   | 12.03%   |
| Blue     | 45.69%   | 40.23%   | 54.31%   | 59.77%   |

5. CONCLUSION
From the data analysis, the conclusion is that different motives settings will get different combat effect. In conditions of some urgency task, such as in offensive warfare, we may choose the Motives Setting1. The Motives setting2 may be used in the other conditions, such as in defensive warfare.
Figure 6. The pie chart of Agents after the 160\textsuperscript{th} bout in Motive\textsuperscript{1}.

Figure 7. The pie chart of Red and Blue Agents after the 160\textsuperscript{th} bout in Motives\textsuperscript{2}.

Acknowledgments

Authors thank to acknowledge assistance or encouragement from all those who helped us during the writing of this paper. This work was supported in part by the class General Financial Grant from the China Postdoctoral Science Foundation (Grant No: 2016M603049).

References

[1] Amos Azaria, Ya’akov Gal, Sarit Kraus, etc., 2016, Strategic advice provision in repeated human-agent interactions, Auton Agent Multi-Agent Syst, pp.30:4–29.

[2] Sara Karimi, Mohammad Reza Kangavari, 2011, 4th International Conference of Cognitive Science (ICCS), Procedia- Social and Behavioral Sciences, 32, pp.184-196.

[3] Oscar J. Romero, Christian Lebiere, 2015, Cognitive Modelling of Behavioral Experiments in Network Science Using ACT-R Architecture, Springer International Publishing Switzerland, pp.239–251.

[4] Pan JL, Li Y, Guo DL, etc., 2013, Morale Behavioral Operations for the Recruits from Agent-based Modeling, pp.518-523.

[5] Tan X, Lai SM, Wang W, etc., 2012, Framework of Wargame CGF System based on Multi-Agent, IEEE International Conference on Systems, Man, and Cybernetics, COEX, Seoul, pp.3141-3146.

[6] Wen CH, Ren ZB, Bai CS, etc., 2018, Analysis of the Effect of Agent’s Perception in the Combat Operation Experiments. IHMSC, Hangzhou, (Volume II) pp.347-351.

[7] E Kugu, J Li, FD Mckenzie, OK Sahingozi, 2014, Fuzzy logic approach and sensitivity analysis for agent-based crowd injury modelling, Simulation Transactions of the Society for Modeling & Simulation International, 1 (1), pp.1-18.