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Artigo publicado e apresentado na Spring Simulation Multi-Conference 2015 (SPRINGSIM)



Defining Behavior Of Computational Agents Based On Military Doctrine

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ABSTRACT

Since the beginning of nineteenth century combat simulations are used in military training. It's necessary to involve lots of military to these trainings occur reliably. In the late 1940s the idea of computational agents was developed in artificial intelligence and showed as an excellent tool to reduce the amount of personnel involved in combat simulations. Agents perceive the environment where they are inserted and take actions upon it following a set of rules. That reminds the behaviour of a soldier. A soldier, or a group of them, perceive the battlefield and take a series of actions based on military doctrine. Therefore, the scope of this work is to present a viable way to define the behaviour of computational agents based on military doctrine, so that they can replace some of the personnel involved in a combat simulation without affecting the reliability of the training in course. In addition making more efficient simulation systems, reducing the amount of required military for its proper implementation, can also help to check the logical consistency of the actions planned in the doctrinal manuals. In this paper you will find a introduction about military training followed by the conceptual description of computational agents and how it was modelled, passing by the basis of military doctrine and its modelling, passing by a case study until reach our conclusions.

Author Keywords

Military Modelling and Simulation; Agent-based Combat Modelling; Artificial Intelligence

ACM Classification Keywords

I.2.11 Distributed Artificial Intelligence: Intelligent agents

INTRODUCTION

Military operations usually involve many resources, large trainings and well-designed plans. A careful planning of an operation is the fundamental step in the pursuit of success in its implementation. The cost to test the implementation

of planning reaches huge values involving several logistical, personnel, materials, supplies, etc.

Combat simulations have an important role in the modern military training to minimize costs. A simulation can avoid the displacement of large amount of land, air and naval resources. Similarly, avoid the movements of large effective, cost of fuel, ammunition, maintenance, etc.

A military training can carried out in various hierarchical levels, since small fractions at a tactical level, as even at strategic levels.

In some simulations, so they can be employed in trainings of higher levels, it is necessary the presence of military personnel also in the lower levels. As an example, a simulation at a battalion-level would require the military to their companies, to their Platoons and more players to its squad. Soon, in addition to the costs involved becoming dressage in higher hierarchical levels feasible, a large number of military personnel would need. Thus, the use of computational agents can reduce the need for military in these simulations by facilitating the use of this tool in higher levels.

For that a simulation can represent reliable form of an operation, is essential and mandatory mapping the behavior of computational agents based on a pre-established military doctrine. The autonomous agents, although they are an alternative to the construction of models in this simulation type, must perfectly modeled, with its behavior fully provided in a doctrine, in order to make the simulation a support tool in the evaluation of decisions taken in the various plans, reflecting expected behaviors as set out doctrinally.

The objective of this work is to present a mapping of the behavior of computational agents based on military doctrine. To delimit the scope of the work of the Brazilian Marine Corps, will addressed in the platoon level offensive actions.

MODELLING AGENTS

Computational agents are used in the area of Artificial Intelligence. According to Russell and Norving (2004), "an agent is an entity that can perceive their environment through sensors and acting upon that environment through effectors". A similar definition about the concept of agents, presented by Maes (1995), says that "agents are computational systems inserted in complex environments and/or dynamic, that have the ability to perceive and act in such a way as to achieve goals or perform tasks for which they have been modeled".

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Given these definitions, the modeling of the behavior of the agents, should provide the necessary autonomy to understand the environment and other aspects mentioned in military doctrine that encourages the adoption of the procedures described in the Brazilian Marine Corps manuals.

The autonomy is feasible from the fact that the agent can act without external intervention. In other words, how he should act, its decisions will be due this notice of the environment in which inserted.

An example of this used in this work, is a possible contact between a fraction of troop friend and an enemy. According to doctrine, more precisely as described in the Manual of Platoon of Marines [12], to perceive the presence of the enemy, the soon the troop must evaluate the distances involved, the posture of the enemy, the terrain, the possibility of being seen and adopt a particular posture in order to surprise the enemy according to the figure and table below.

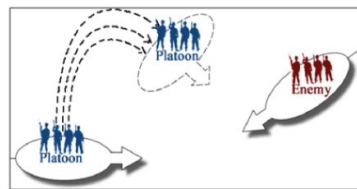


Figure 1. Possible contact with the enemy.

Table 1. Example of sensors and effectors.

States	Sensors	Effectors
Platoon Moving	Platoon detected the enemy?	Go to xy position.
	Platoon Effective is bigger?	Assumes line form.
	Enemy didn't detect Platoon?	Engage Enemy in x.y.position.

We will also map other behaviours so that the Platoon can decide what kind of formation is necessary before situations that he can encounter, as well as ways of patrolling and engagement. All these provided for in a military doctrine.

MILITARY DOCTRINAL BASIS

When starting the study on computational agent's behaviour definition, we take the infantry Platoon level and its squads as a basis for the proposed modelling.

In accordance with the provisions of the military doctrine, as a reference to this work to the Marine Corps from Brazil, when a particular platoon receives an order to move from one point to another on the ground, some factors influence the decision about which formation to use:

- The mission;
- The situation of the enemy (possibility of contact);
- The terrain;
- Weather conditions and visibility (ease of control);
- The time available for the fulfilment of the mission;
- The desired speed for the offset; and
- The desired degree of flexibility during the movement.

Thus, the platoon must understand these factors in the environment in which it is inserted, to take the most appropriate decision on each situation.

It is important to highlight some basic definitions of military structure will be discussed here, where an Infantry Battalion is composed of Companies, these by Platoons and these by squads in accordance with the Manual of Infantry Battalion of Marines [13].

An important fact to note is that when the platoon moves within their Company, the Commander (Cmte), defines its formation according to the situation and the terrain. In the case of squads, the platoon commander will always define your formation, maintaining eye contact with your squad commander.

Thus, the platoon commander has the autonomy to decide what kind of formation to adopt, even having received a specific order of his superior. This proves that self-government our agent should possess to examine the factors that lead to a decision and choose for the procedures set out in the reference manual.

BASICS MODELED

Although the Platoon is able to carry out various military actions, this work deals with a couple of offensive character in addition to the basic movement and type of formation, namely:

- Movement
- Type of formation
- Patrols
- Engagement

Movement

When receiving an order to move from one point to another on the ground, the Platoon must first meet and perform the movement. In the most basic form of behavior mapping, we can define their sensors and effectors in accordance with table 2.

Table 2. Movement Order

States	Sensors	Effectors
Platoon Stopped	1. Movement terminated, canceled or interrupted? 2. Is there an Order of Movement?	Stop Move subordinate elements.
Platoon Moving		

Soon, the agent will move as received order or remains stationary while its movement stopped for any reason. These are the simplest States in a platoon: Stopped or moving.

Type of Formation

Although, in many military forces there are several types of formations, the following features have mapped during the work, implemented and verified it is functioning. Among several existing ones, the following taken into consideration for this job:

- Formation in Column
- Formation in Line
- Formation in Triangle
- Formation in "V"

The main difference between these types of formation is not only to the position to be taken over by fractions (effectors), but also as to what should be perceived by the staff member to take such formation (sensors).

In addition, we can make a move on the ground changing formation as he reacts to the witness the factors that lead to such formation. I.e. a platoon moving in column, can, upon realizing what we define as sensor, switch its type of formation. For this, possible transitions are defined where all the sensors are tested and, for activated, the transition occurs.

Formation in Column

This formation has the configuration shown in figure 2 and is doctrinally used when in standard offset and when the enemy not envisaged.

Thus, we can affirm that this has as Sensors functions that check for order for movement and if there are enemy laid down for the operation. Similarly, the Effector for this formation is to shift the GC from the central position of the Platoon (x, y), in accordance with the following configuration.

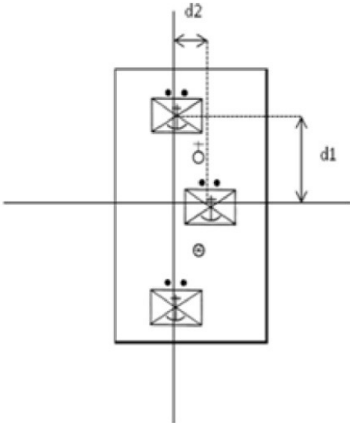


Figure 2. Column Formation.

One aspect to take into consideration is the direction of movement of the unit so that the formations are always with the correct orientation. In other words, a Platoon moving on column to Northeast must have their respective Combat Groups aligned in accordance to its direction of travel.

Therefore, we can summarize in the table 3.

/

Table 3. Column Form Movement

States	Sensors	Effectors
Column Form	1. Is there an order of movement? 2. No enemy listed?	Move to xy. Place squads in front of each other.

An important aspect to highlight in Table 3 is that the library of agents, which was used requires a positive response from the sensors so that the transitions between states can occur.

Line Formation

In this type of formation, a platoon distributes its squad (GC) so that these take something like the picture below:

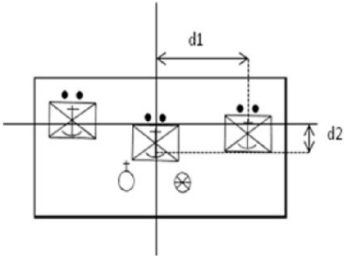


Figure 3. Line Formation.

This is the type of formation used in preparation for the assault and cross-areas exposed to enemy fire.

The line formation has as sensors functions that check for the order to move, if there are enemy laid down and with position defined, in addition to checking if the fraction is within range of the enemy's weapons. This range is based on portable medium-range weapons on a regular troop.

Therefore, we can summarize in the following table:

Table 4. Line Form Movement

States	Sensors	Effectors
Online Form	1. There is an Order of Movement? 2. Enemy Listed? 3. Within range of the enemy weapons?	Move to xy Place Squads next to each other.

Formation in Wedge

When you know that there are enemy laid down but its position is unknown (Sensors), the Platoon takes the formation in the triangle move (Effector), in this way, Figure 4 presents its setting related.

The table 5 defines the senses and Effector for this type of formation:

V-Formation (Vee Form)

Similar to the one shown in the previous item, this formation differs, especially regarding the possibility of contact with the enemy (Sensor). Like Effector, formation in "V" has the configuration described below in Figure 5.

As well as the mapping of the behavior of previous States, this can be simplified in table 6 below:

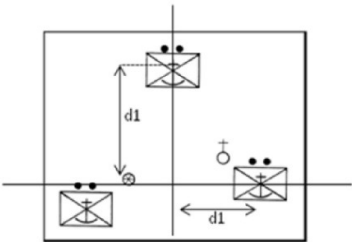


Figure 4. Wedge Formation.

Table 5. Wedge Form Movement

States	Sensors	Effectors
Online Form	1. There is an Order of Movement? 2. Enemy Listed? 3. Position Enemy Unknown?	Move to xy Place Squads in wedge form.

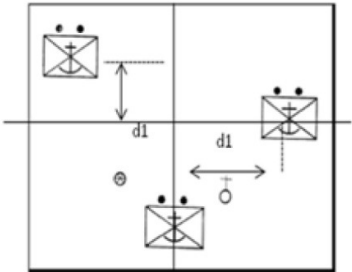


Figure 5. Vee Formation.

Patrols

A Platoon, upon receiving an order of Patrol (Ptr) can perform this action in a variety of ways provided for in a military doctrine. Some techniques have mapped in these works, among which:

- a) Continuous Movement in two Teams
- b) Continuous motion
- c) Movement for Short Moves

Even before the platoon can decide which technique will use, there must be some order for the achievement of the patrol, this being a condition common to all techniques of conducting patrol. Soon, upon receiving an order from patrol, the Platoon already goes into a temporary state called PsbPtr, testing the transition to what type of technique will adopt.

What differs a technique from another is how the Platoon realizes trafficability conditions, terrain and visibility regarding the presence of enemy.

States	Sensors	Effectors
Online Form	1. There is an Order of Movement? 2. Enemy Listed? 3. Out of range of the enemy weapons?	Move to xy Place Squads in vee form.

Table 6. Vee Form Movement

Patrol with continuous movement in Two Teams

The technique of Patrol with continuous movement in two Ranks (PtrTwoTeams), in accordance with the doctrine in reference, when it is possible to contact with the enemy and when the conditions of terrain and visibility permit the adoption of this technique (sensors).

In this case, the patrol divided into two stages (effector): the advanced and the indented composed of the main body of the patrol. The advanced stage moves ahead of the main body at a distance that varies with the terrain and with visibility, it cannot, compromise the interpretation of their visual signals emitted for the main body. In this way, the configuration of the troop would be as shown in Figure 6.



Figure 6. Patrol in Two Teams.

Both echelons must move at the same speed, keeping the distance between them. It is a slower movement (Effector) and with greater difficulty of control than the continuous movement, being difficult task at night (Sensors). Table 7 below shows the Effectors and Sensors used in the template:

Table 7. Ptr. by Two Teams

States	Sensors	Effectors
PtrMovTwoTeam	1. There are Ptr Order? 2. Enemy listed in 2000 m; range enemy $L > 4000$ m 3. Visibility $L_v > 80\%$ normal visibility? 4. Visibility Condition \rightarrow night speed $L_n > 80\%$ normal speed?	Form in Column with on Squad in front Current Speed $= 0.50 V$ (if on foot) Current Speed $= 0.50 V$ (if auto) motor (x, y)

As shown in this mapping technique, the other only vary in the parameters concerning the distance as well as the procedures to adopt.

Patrol with continuous movement

In this technique, the fraction of troop moves continuously as a whole. We can even define how Sensor the function that checks whether the likelihood of contact with the enemy is remote or when the conditions of the terrain or visibility do not permit the adoption of another technique. Like Effector, patrol moves as a whole, with the same dispersion among the members.

Figure 7 shows what it would be like a patrol with continuous movement.

The Sensors and Effector defined for this State follow the table 8.

Patrol for Short Moves

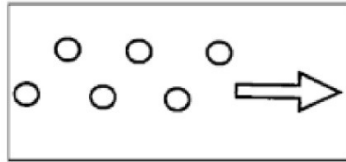


Figure 7. Patrol in continuous movement.

States	Sensors	Effectors
PrMovTwoTeam	1. There are Pr Order? 2. Enemy listed or range enemy ≥ 4000 m? 3. Visibility $\geq 80\%$ normal visibility?	Form in Column moveto (x, y)

This technique used when the likelihood of contact with the enemy is imminent or when the terrain is favorable to conducting ambushes on the part of the enemy. In this case, the sensors must check if there is order to perform a patrol also checks if the enemy laid down is at a distance of less than 2000 meters.

Like effector, the fraction must run the patrol according to the schema shown in Figure 8.

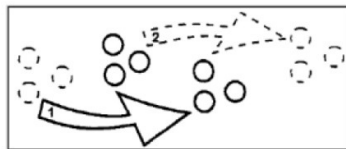


Figure 8. Patrol for short moves.

Engagement

Most engagements, except against sudden, occurring because of a detection between the fraction of troop and an enemy. According to the type of detection below the troops will engage in a particular way:

- When only the Platoon detects the Enemy i - Effective Increased Platoon ii - Effective Platoon Minor
- When both are mutually detect i - Effective Increased Platoon ii - Effective Platoon Minor
- When only Enemy Squad is detected

Generally, the sensors must verify that the Platoon encountered the enemy without been detected and compare the numbers involved. Depending on what perceived by the agent, as effector, it should take the formation and adopt the procedures set forth in the doctrine.

As an example, if only the Platoon to detect the enemy, having the most effective, you should then move, take line for-

Table 9. Patrol for short moves

States	Sensors	Effectors
PrShort Moves	1. There are Pr Order? 2. Enemy listed or range enemy ≥ 2000 m?	Form in Column moveto (x, y) squad by squad

mation, occupy position covered and sheltered engaging with the enemy when the same approach.

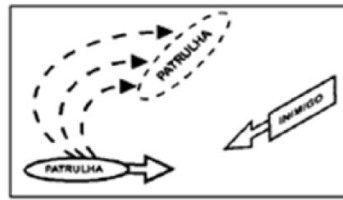


Figure 9. Engagement Sample.

We can translate this set of sensors and effectors that map this behavior in the table 10.

Table 10. Engagement Platoon x Enemy detected

States	Sensors	Effectors
Engagement 1	1. Is engagement possible? 2. Platoon detected Enemy? Platoon detected Enemy? Platoon \geq Enemy?	Form in Column moveto (x, y) squad by squad Line Form Engage

TRANSITIONS BETWEEN STATES

During an operation, a platoon can perform the types of activities previously cited. A Platoon initially stopped can run an offset in the various formations referred to as well as perform a patrol or even engaging.

At the beginning of our agent behavior mapping, all transitions are inserted. Thus, a platoon stopped, tests the transitions for all other States.

If we map the numerous types of activities that a platoon could perform, whether offensive or defensive, the number of tests of these transitions would be huge, where even your graphical representation would be hard to present in this work.

In order to optimize the tests between transitions created some intermediate states considerably reducing the need of these tests for transitions between all possible States.

CASE STUDY

After the mapping of all the aforementioned States, as well as the changes suggested in relation to transitions between these States, all tests carried out successfully and the Platoon acted in accordance with doctrinally. The figures below illustrate some of these tests.

In testing, we show the Platoon assuming a "V" formation, expected to have enemy laid down and are outside the scope of its armament.

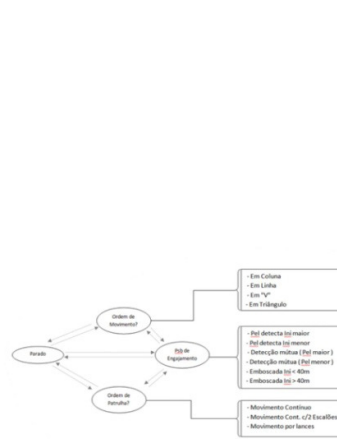


Figure 10. All transitions.



Figure 11. Initially we have the initial state with the Platoon stopped.



Figure 12. When receiving an order to move, the Platoon must start its displacement, positioning their battle groups according to the situation.

CONCLUSION

A computational agent translates as an excellent way of modeling of a military unit. The mapping of their behavior with the procedures set out in a particular doctrine proved to be possible and even complex behaviors, such as an engagement can be mapped.

During the mapping process some manual proved inconsistent as assumed certain knowledge impossible for the platoon. One example was in mapping techniques immediate action in engagements. According to the manual, determined action is taken only when the enemy detects the peloton. But how could I know if we are being detected without detecting the

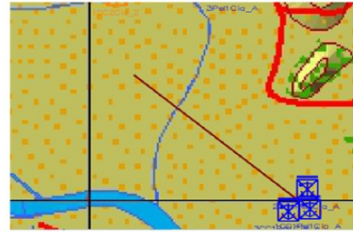


Figure 13. Approach the enemy.



Figure 14. In addition, the platoon unfolds in line formation to start the engagement.

enemy? In this case, like others checked, it was necessary to perform a parameter with values from personal experiences in the military activity.

Thus, the mapping of the behavior of agents shown to be effective for simulations as mentioned throughout the work.

It was found that mapping military doctrinal in computational agents, aiming to reduce the number of military personnel to be employed in trainings at high hierarchical levels, was struck bringing a substantial gain for the military simulations. Another important contribution has taken place during the work was to verify the logical consistency of doctrinal manuals military, which may have some enhanced settings to be checked for any inconsistency in the mapping process.

FUTURE WORKS

After we could map the basic behavior in the platoon level, we prove the validity of this type of technique to simulations as discussed here.

However, there is still the need for studies, which enable this mapping level at higher levels, which are more complex according to the doctrine studied, require a dedication to the subject.

As future work, should be done the mapping in the other levels as well as defensive aspects regarding all these, fire support and logistics.

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