THE MANEUVER AND ATTRITION WARFARE SIMULATION SYSTEM

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Abstract: This work presents a system that models an operation terrain and provides a way to evaluate two different kinds of warfare behavior in the same operation area (AOp): Attrition and Maneuver doctrines. The maneuver warfare behavior is based on vector algebra. The attrition behavior is an agent-based algorithm.

Keywords: Simulation, Decision-Making, Agents, Attrition and Maneuver Warfare.

1. Introduction

The human's history is full of revolutions and wars. All those wars and conflicts have contributed to the evolution of men until nowadays. Since then, the wars were improving both in tactical skills and doctrine. Since the first war in history until the last one, two important doctrine concepts of war become more practical. One is called *attrition warfare* and the other is *maneuver warfare*.

The main idea of this document is to contrast a typical given situation of one doctrine with the other, trying to compare and identify which aspects the attrition warfare works better then the maneuver warfare and vice-versa. This comparison must be automatic and made by a computer with a specific algorithm based only in doctrinal constraints identifying their similarity and their differences.

2. Terrain Modeling:

The battlefield is a terrain with natural characteristics such as mountains, rivers, lagoons, vegetation and etc. Our tool can analyses a various sort of terrain given by a satellite image or vector image. Having a hypsometric curve of the heights of these terrains, you are able to consider 3D elements in the Operation Area (AOp) such a mountain or a valley. We consider this fact an important one because a natural element like a mountain could block your view from a very large army hided behind it

Considering the natural problems that a terrain could present to us, we develop an algorithm that shows which points of an AOp can be visible from another unique point of the same AOp. This *visibility* algorithm trace a circle of the maximum reach (4km) that a combat element (by combat element we mean a group of the marine units, like a platoon, company or division, for example) could see from a given point from the AOp. After that, for each point inside the circle, the algorithm asks if there is something with more altitude between the center and the point in analysis. If so, the point in the circle is not painted. Otherwise, a green dot is made denoting a visible point.

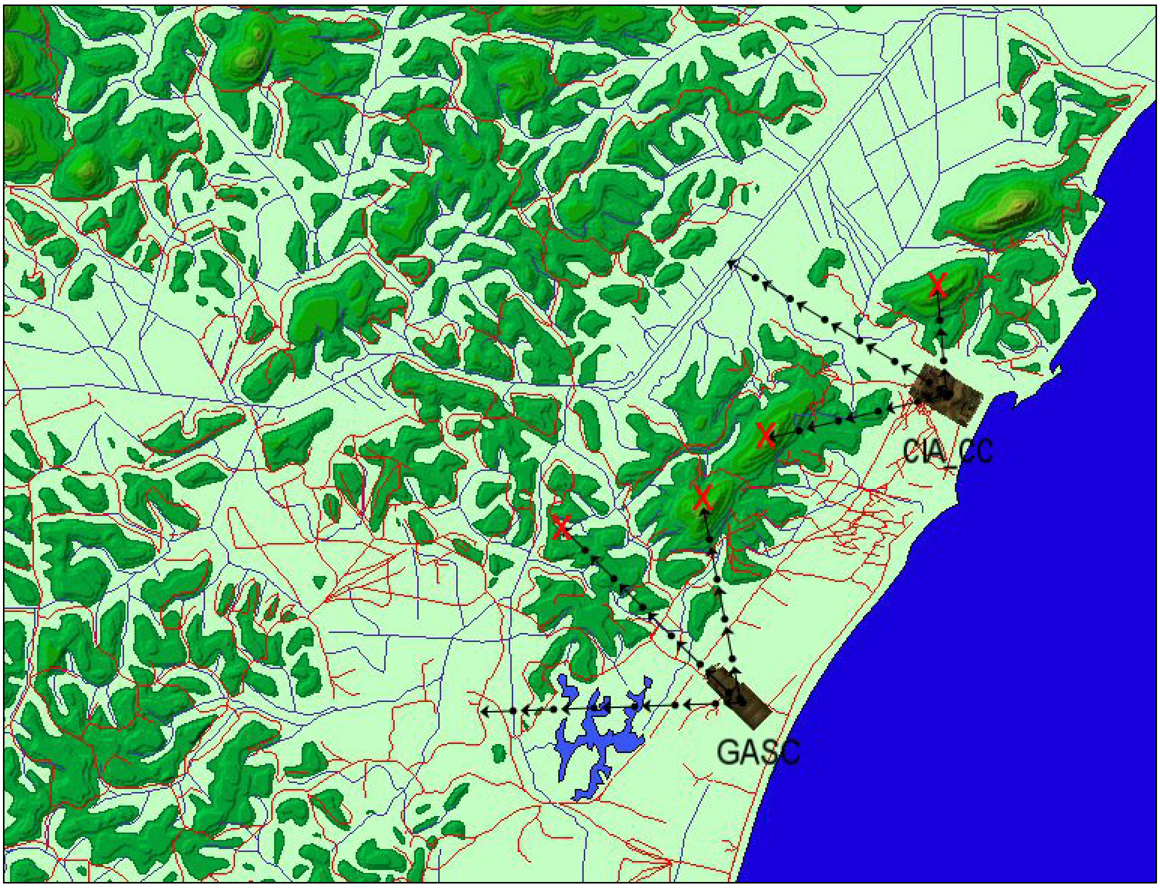

Figure 1: Example of obstruction in Combat Element's line of sight

3. Attrition versus Maneuver warfare

A war is a dispute between two or more groups trying to impose their ideologies upon the other. Since long time ago, men battle their enemies using different tactical, strategies or skills. But if you take in consideration the doctrines involved in such wars, we may distinguish mainly two. Attrition and maneuver warfare.

3.1 Maneuver

Maneuver warfare seeks to shatter the enemy's cohesion through a variety of rapid, focused, and unexpected actions (by enemy), which create a turbulent and rapidly deteriorating situation with which the enemy cannot cope. The main ideas are:

- Systemic vs systematic destruction.
- Speed, focus, surprise.
- Firepower is indispensable for localized attrition.
- Emphasize disciplined free action.

In order to join those characteristics in a coordinated attack, the control command must *observe*, *orientate*, *act* and *decide*, making each step as a part of a whole circle named

Boyd-cycle. More than that, it must do, in average, each single cycle faster than his opponent. The next figure shows the Boyd-cycle:

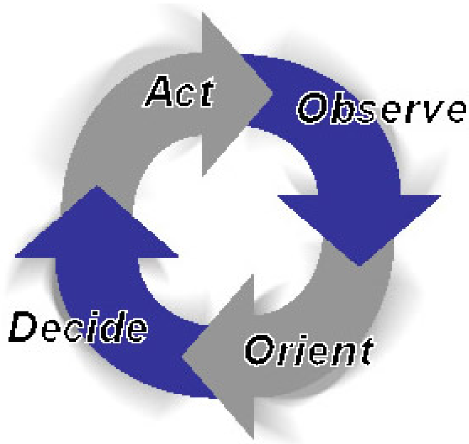

Figure 2: The boyd-cycle described by John Boyd.

Before move a single combat element, the control command must consider the combat power (PC) and the combat powers of all opponents. More than this, we must consider the relative objective position and the enemy position with your own position in the terrain.

In order to compute this kind of algebra, we decide to use a vector-based algorithm. This algorithm helps us to find the best direction for attackers and defenders considering all maneuver warfare's principles.

Dots and arrows represent the model so that each of them has their own meaning shown on the next figure. The red dot is representing a single attacker combat element. There should be many of these around the field or even a single one. The important note here is the fact that each one has a well-determined objective to reach, represented by a yellow dot. The blue ones are defenders displaced around the terrain trying to stop the red's progression.

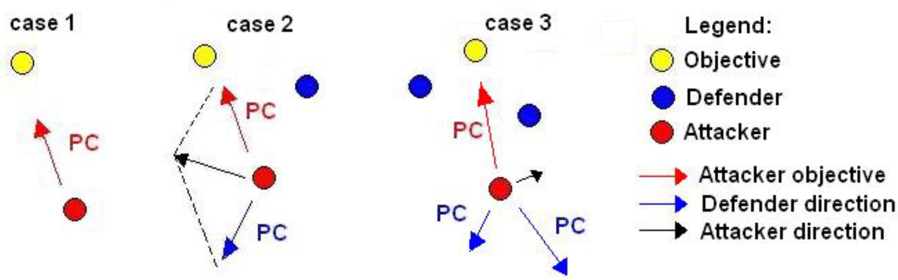

Figure 3: Vector algebra in 3 different common cases in the battlefield.

The red arrow is the direction that an attacker element would like to go to reach the objective as quickly as he can. The blue arrows denote the resistance that a single defender does upon an attacker element. So, if you sum all these red and blue vectors diverging an attacker element, you'll find the black vector. This vector represents the final direction that should an attacker element follows. As computer interactions goes sufficient large, we can observe a light veer around the defenders forces guiding the attacker through the weakest defender's areas.

3.2 Attrition

The attrition warfare is the oldest doctrine known. It can be found in the earliest wars in human's history. It used to be more hostile and bloody than the maneuver warfare's. This doctrine could be resumed as:

- Cumulative destruction of enemy through application of superior firepower.
- Enemy strength is the target.
- Requirement for fires efficiency leads to emphasis on procedures and centralized control.
- Body counts and terrain captured are primary battle metrics.

An important concept involved here is the *engagement*. To impose strength, a force must engage with their enemies.

The engagement routine is, for sure, one of the most complex routines in the system. During an engagement, it is necessary to know which weapons are been used, the amount of ammunition to be used and the lethality of each weapon when using specific ammunition (some ammunition, like smoke grenades, present zero lethality), which shots have reached the target and the fatalities imposed to the enemy.

This modeling is characterized by a large lack of information. In addition, it was not possible to find a mathematical model that satisfactorily represent the results of a combat between a conventional force correctly trained (mariners) and a non- conventional force (guerrilla or drug dealers, for instance), determining the fatalities in both sides.

Frederick Lanchester has established a system of differential equations that intends to quantify the fatalities in a battle. The system is based on the principle of that the losses imposed to one of the forces is proportional to the number of elements in the other side.

$$\frac{dx}{dt} = -aY$$
$$\frac{dy}{dt} = -aX$$

Where *a* and *b* are the efficacy coefficients of the forces Y and X, respectively.

The main drawback in Lanchester's model is the fact that the correct values of a and b are unknown because they depend on the characteristics of the weapons, on the capacity of reaction of the elements and also on the degree of efficiency of the command, coordination, control and communications

3.2.1 Attrition modeling concepts

3.2.1.1 Agents concept

The agent concept is recent and came from artificial intelligence (AI) research area.

Agents are computational systems inserted into complex and/or dynamic environments that can percept and act to reach goals or execute tasks that have been modeled for.

Although many different kinds of agents exists we will use a agent kind based on pre-defined behavior. This is because we are modeling military units that act like that.

Agents based in pre-defined behavior respond in the same way to the same event. Each possible event has a defined response action. So the direct conclusion is that the agent must know all possible events in the world that is inserted, but not true. We expect that the agent knows as many events as necessary to its survival. Sometime the agent may find a new event. When it happens the agent will adopt a default action.

3.2.1.2 State Machine concept

It's impossible to talk about agents without learn the concept of state machine. State machine is a simple but powerful AI concept. The basic idea is that agents have different states for each behavior segment. The goal is to divide the agent behavior in logical states.

Again we have different types of state machines but we are going to use finite state machines to control our agents because we have a finite number of states that a combat unit can assume.

A state is only a condition. A door, for example, can be opened or closed; locked or unlocked. Opened, closed, locked and unlocked are states of the door.

A finite state machine works receiving an input that results on a transition from the current state to some other state through a state transition function and has the new current state as output.

3.2.2 Agent based behavior

We have seen until this point that an agent has a list of pre-defined events with response actions, a default action for new events and a behavior that is divided in states and implemented as a finite state machine. We are modeling a defense based in attrition behavior. So we will define what events a attrition defense agent knows and divide its behavior in 8 different states: stopped, waiting reinforcement, retreating, under enemy artillery fire, under enemy attack, enemy spotted beyond fire support reach, enemy spotted inside fire support reach and enemy spotted inside attack reach.

3.2.2.1 Events

- Casualties reached over 50% of the troop
- An enemy has been spotted
- Reinforcements arrived
- New defense line reached
- Received artillery fire from enemy
- Enemy artillery fire stopped
- Enemy is attacking
- Confront not possible
- Fire support not possible
- All targets informed

3.2.2.2 States

- Idle:

  This state is the default combat element state. When inside idle state element will check for casualties, enemy spotted, weapons and fire support reach and enemy attack.

- Waiting reinforcement (position defense option):

  Elements will enter this state when combat casualties reach 50%, request reinforcement to their Command Post (CP) and remain in it until the reinforcement has come, returning then to idle state.

- Retreating (enemy delay option):

  When casualties reach 50% of element contingent the element will retreat to the next defense line. Once the element reaches the new position it returns to idle state.

- Under enemy artillery fire:

  After receive fire from enemy artillery the element will enter this state and will report the direction where fire came. If it doesn’t receive anymore fire, it will return to idle state.

- Attacked:

  Here the element receives an attack from a enemy and will strike back, remaining in combat until the confront cannot be possible anymore or casualties reach 50%. In the first case it will return to stopped state, in second case the next state will be determined by element’s behavior. If it’s a defensive element the next state will be reinforcement, if it’s objective is to delay the enemy, next state will be retreating.

- Enemy spotted beyond fire support reach:

  If a enemy is spotted but artillery fire can’t reach it, the element you insert the enemy in the list of aerial fire support target. When all the spotted enemies are on the target list, the state will change to idle state.

- Enemy spotted inside fire support reach:

  At this state the element spots an enemy inside artillery fire reach and puts it in both artillery target list and aerial fire support target list. When all the spotted enemies are on the target lists, the state will change to idle state.

- Enemy spotted inside attack reach:

  When the enemy is inside attack reach the element will request artillery fire support only if its distance to the target is higher then 300 meters, and aerial fire support only if the distance is higher then 500 meters and attack. If the element cannot attack anymore it returns to idle state.

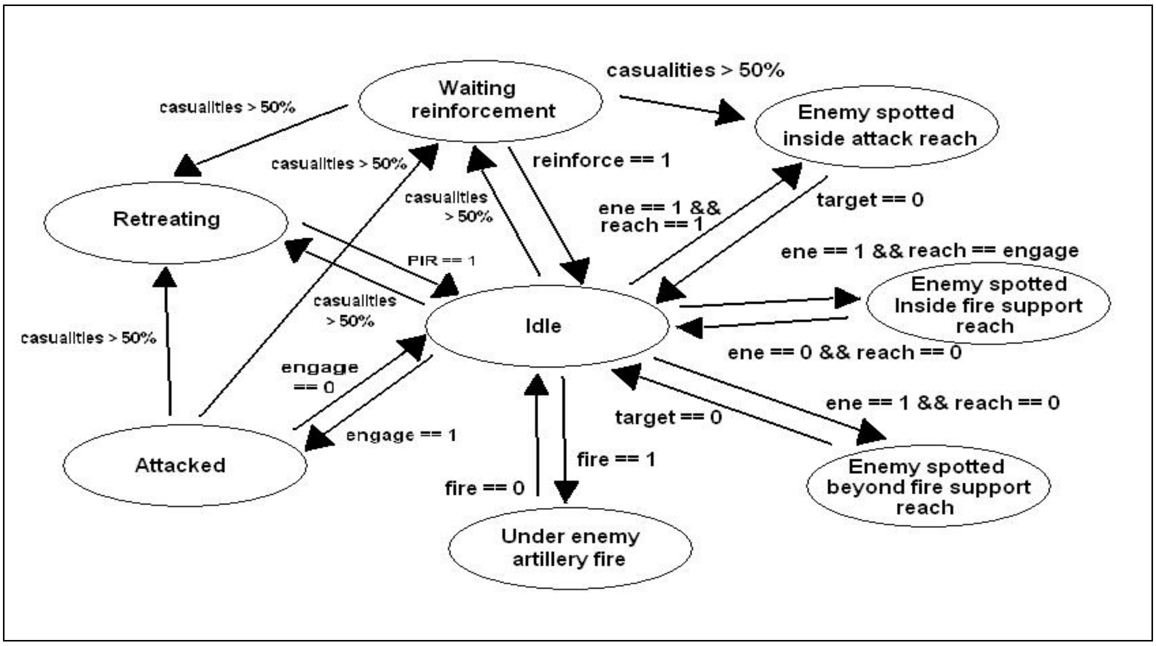

Figure 4: Agent behavior finite state machine

5. Conclusion

Computer simulations are important teaching tools for knowledge evaluation, specially the ones who aim to simulate the real conditions of a military operation, training officers to take the right decisions in complex situations.

The described modeling offers, a potential tool, which is able to evaluate two different ideologies of war in the same giving situation (AOp). It responds if *attrition warfare* works better than *maneuver warfare* and vice-versa. So, after an analysis on both doctrines, the decider will be able to choose one of them to perform in the battlefield, helping him to get closer to success guaranteed by the realism of his previous simulation.

In addiction, this tool can perform another important task in the teaching. It can help instructors to show specific situations and report problems to their students, evidencing their mistakes and fails, for example. In pacific countries, like Brazil, didactic military simulations constitute fundamental part in the formation of both officers and privates from The Mariner Corps, providing a way to evaluate and improve their training. The computers have enlarged the possibilities of didactic military simulations and have been successfully used along several years in The Brazilian Mariners Corps, reducing large amount of cost and time consuming.

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