OPERATIONS OTHER THAN WAR: MODELING AND SIMULATION

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ABSTRACT

This work presents a model and simulation system which provides a way to evaluate typical Brazilian Marines behaviors, actions and decisions made in operations other than war. Operations other than war are controlled and financed by the United Nations (UN) which main goal is to establish and keep peace in some specials or critical moment in a country. In reality, operations other than war does not looks like traditional war. They have a whole set of characteristics and proprieties which are explained and modeled throughout this paper.

INTRODUCTION

Operations other than war (OOTW) are military operations which focus on deterring war, resolving conflict, promoting peace, and supporting civil authorities in response to domestic crises. They act in order to protect national interests and support the United Nations (UN) objectives.

Despite the fact that OOTW acronym is new, the concepts are not. Some database records identifies 846 military operations other than war between 1916-1996 in which the US Air Force or its predecessors played a noteworthy role. (Vick 1996) Also, Brazilian has been performing similar OOTW since early 1933. Since then, many cities from different countries have been receiving support and care. These are some of them and their purposes (Issa 2008).

• 1933 - Mediate a dispute between Colombia and Peru for Leticia's region.
• 1947 - Brazilian Marine and Army Officials joined UN committee for Balkans which operate in Greece.
• 1956 - Brazil supports contributions for Gaza Strip conflicts, in both India and Pakistan.
• 1965 - As being part of Inter-American Peace Force, Brazil sends OOTW troops to Dominican Republic.
• 1989 - United Nations Organization (UNO) designates Brazilians' OOTW troops to Angola and Nicaragua.
• 1995 - Many countries and regions such as Haiti, East Timor, Rwanda, Bosnia, Angola, Mozambique, Guatemala, Honduras, Ecuador, Costa Rica, Nepal, Uganda, Yugoslavia, El Salvador, Western Sahara and Liberia has been receiving Brazilian staff officers.
• 2004 - For the third time Brazilian OOTW troops was sent to Haiti devoted to stabilize it.
• 2009 - OOTW play an important role in the earthquakes incidents which took place in *Haiti*.

Due to the latest item, many Haitians have struggled for food and water after two strong earthquakes took place in the capital *Port-au-Prince*. Help and assistance were sent from all the world, including Brazil. These Brazilian operations must continue in order to promote peace and harmony. However, Brazilian Marines faces serious problems specially with training costs.

By first practicing in computer simulations, OOTW forces can anticipate problems and difficulties which are treated even before they go abroad. Anticipating problems they better prepare themselves arriving in the foreign peacekeeping country with a hole preparation and know-hows. Another good advantage is the fact that operations can be planed and tested as much as necessary without the exhausting troops in real terrain (Seixas and Lauro 2003).

In the next section, we will introduce the process of computer modeling other than war (OTW) operations. We will discuss terrain modeling, movements, engagement and others. In sequence, we will propose an architecture and implementation which attend the modeling requisites. Finally, conclusion, acknowledgments and references are given to fulfill this work purposes.

MODELING

In order to simulate OOTW on computers, first we must gather important and relevant facts and characteristics during the modeling process. This stage is crucial because OOTW are general and can help in many different events and situations. In Figure 1, we show some examples OOTW usually handle. They are hostile attacks, conflicts in general, natural disasters and others. The goal is to identify all characteristics belonging to each of this situation and place together in just a single model. This is for sure, a hard task to computer engineers.

The described examples above have many modeling aspects in common. Thus, some of the most relevant ones

Figure 1: Examples of (a) Terrorist Attacks, (b) Popular Rebellions, (c) Natural Disasters

are presented on the following subsections.

Terrain

Since OOTW act on ground, terrain features and characteristics are extremely relevant in order to have a successful mission. Note that for some type of exercises, there are eventually some irrelevant terrain characteristics. But, in the other hand, we may have others where those very same characteristics are decisive. For example, imagine a terrorist hidden in a building with hostages. In this situation, the building height may be one elementary variable to be considered and studied by an OOTW leaders. However, if an earthquake hit the same region in this previous case, the building height may be not so relevant, specially if it was crashed down the floor.

The previous example shows that, in many cases, urban characteristics are very important as well as topographical ones. In poor countries like *Haiti*, there are cities where the world biggest shanty towns set in. It is not rare to have such areas controlled by militiamen and drug dealers which armed, impose terror to working families. Neutralizing these impostors in shanty towns consists in a big challenge for OOTW because pathways are usually narrow and do not have good pavements if any.

In general situations, these are the most relevant and indispensable terrain characteristics:

• Public and government buildings. *Example: palaces, hospitals, power station and so on.*

• Trafficability. *Example: highways, streets and alleys.*

• Vegetation. *Example: trees, thicket and grass.*

In other to spot those items, we need a very precise satellite image with good quality and resolution. This is a quite easy task if you consider the latest technological advances experienced nowadays.

Movement

Movements related to OOTW are basically defined as the current ability to have troops going from one given terrain point to another. In order to determine these displacements, we must first determine all moving element involved in a typical OOTW. According to Brazilian Navy, a reasonable OOTW may have basically four types of moving elements. They are classified as: *foot* when is possible to walk, *wheel* when is possible to travel by wheeled vehicles, *special forces* when only a single or group of special and well trained men can pass through or climb. They are less restrictive when it comes to move in mainland. Finally, *ship* when is only possible to travel by vessels.

In addition, these four element are strict to an hierarchy as you can observe in Figure 2. There, circles denote a set of pathways where a specific element can move through. Note that not all pathways available to *foot* moving elements can be used to *wheel* elements. This means *wheel* is a more restrictive moving vehicle than *foot*. The same occur to *special forces* which move in regions neither *foot* nor *wheel* can pass through. Because ships and other vessels need water to traverse, none of the three other elements can share this particular terrain regions, and that's why their circle is apart from the other ones (indicated as being outside hierarchy).

In order to represent these movements digitally, we need to create a special layer and save it as an image. Every time an OOTW element receive a move command, the computer must first check if this element is allowed to move by looking at the trafficability image. As expected, there are several ways to create a trafficability image. The method explained in this subsection is quite simple and attended our requisites.

First of all a map from a specific and desired region is need (Savelli and Seixas 2006). This is not a difficult task given that nowadays we have several sites like *google maps* (ref 2010b) from *Google Inc.* and *bing maps* (ref 2010a) from *Microsoft Corporation*. In our case study, we took *Port-au-Prince* city in *Haiti*. Next, we choose different colors to represent each moving element. Again, in our case study we adopt color legend as used in Figure 2.

Having an image of a specific region, we must now apply some color quantifier method (Lyrio and Seixas 2004). The resulting process is an image with just few colors, denoting accordingly to the real trafficability in that region. This job is simple and can be done with any good imaging manipulation applications such as *Gimp*. A reasonable result is shown in Figure 3.

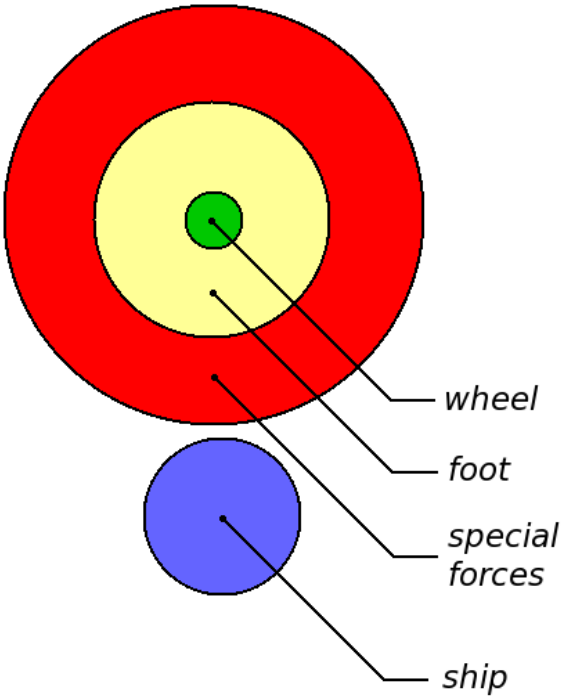

Figure 2: Trafficability Hierarchy Between The Four Moving Elements.

If you want more than one region, you must repeat this entire process before simulation begins. If you would prefer, you can manipulate a set of images side-by-side in order to compose a bigger one. However, once trafficability map is done, all the hard work is finished. From now on, computer evaluates all required movements during a whole movement simulation process.

Engagement

Besides the OOTW are military operations, the engagement is very different from traditional wars. In wars, a combat element usually uses the maximum power force available to it. In OOTW however, the main goal is to establish peace and order imposing the minimum combat power possible without compromising troops safety and integrity. When dealing with counterparts, OOTW elements may first try to conduct negotiations. If they failed, an alternative level of treatment must be taken into account.
According to Brazilian Navy, there are six types of engagement which are acceptable in OOTW (Issa 2008). Their differences refer mainly to strength power used in conflicts. In Figure 4 is shown these types of forces in crescent order (from top to bottom). They are:
• *Minimum force* – which means the lower degree of imposed force. It is useful to guard positions or block passages.
• *Light force* – is any physical threat without death risks or major wounds.
• *Auto-defense doctrine* – establishes broad parameters for governing the conduct of both individual and units

Figure 3: *Port-au-Prince, Haiti.* (a) Map (b) Trafficability.

protections.
• *Imminent attack response* – is a response to an hostile intent attack that represents an imminent threat.
• *Hostile intent* – when deaths or serious injuries may occur.
• *Brute force* – the most strong level of force is used in only extremes situations where there are no worries to cause deaths, serious injuries or both.
In some approaches, only non-lethal weapons are necessary. Tear gas bombs and rubber bullets guns are some examples of weapons often used to disperse horde and crowds. However, when armed engagements are unavoidable, lethal weapons take place. In one case or another, the combat power (CP) model is adopted. The CP model is an adaptation from Frederick Lanchester model and is described in Equation (1).

$$CP = \sum_{i=1}^{allweapons} (qty(i) \times cad(i) \times let(i) \times disp(i)) \quad (1)$$

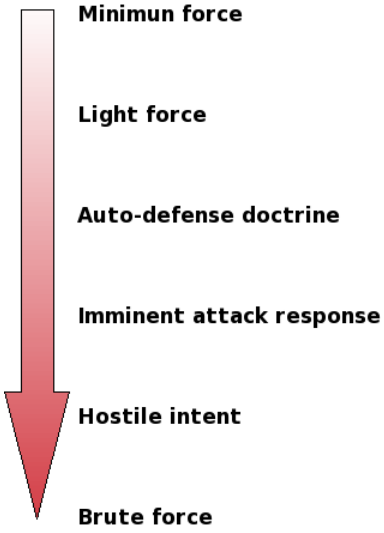

Figure 4: Types of engagement in OOTW.

where:
• *qty* – is the amount of a given weapon. For example: two rifles or three machine guns.
• *cad* – is the cadence of a given weapon. For example: 7 shots per seconds or 95 shots per minute.
• *let* – is the lethality of a given weapon. For example: grenades have nearly 98% lethality but rubber bullets guns have only 0.5% instead.
• *disp* – is the dispersibility of a given weapon. For example: a tear gas bomb have dipersibility of 99%.

The presented model attend to our expectations because when using brute force, for example, non-lethal weapons are not used and *disp* function will assume low values while *let* will have higher ones. The opposite also works accordingly. When minimum force is chosen, *disp* function will assume high values while *let* will tend to lower ones.

The last important point related to engagements is their resulting effect. When equation 1 is applicable, the main consequences are: *man wounded* or *man dead*. In both case, they become out of combat and cannot fight anymore. In the first case, this impediment is just temporary but in the second, is permanent. When a man is wounded, he is taken to the simulation control and receive all necessary health cares and medical treatments from their team. He stays there for a certain period of time (configured by user) and then, return to combats and conflicts. This concept applies to both OOTW troops and militiamen such as terrorists and drug dealers.

Now, when equation 1 is not applicable, the resulting action is arrestments. Arrestments is treated in a very similar way to death in this model so they also become permanently out of combat. However, if the arrested man is the leader of the group, two options are given: simulation is over and team with arrested leader loses or the command base automatically re-elect another leader to take the post. If it is the case, simulation continues normally after some time on.

Inspections

Inspection is the process of gathering information and facts related to a cease-fire violation or claim for an alleged incident from one of the party. Some examples are: landmine suspicious, imminent attack from one of the conflict party, any mistrust acts of sabotage and the like.

Altogether, there are three types of inspections: *Periodic*, when executed with intervals not longer than fifteen days. *Special*, when one of the party feels threatened for some unfair advantage. *Daily*, when two or more inspections are needed shorter than fifteen days. They are useful to check if both parties are complying with any possible restrictions.

In the simulation process these characteristic are implemented in the concept of *check-points*. Check-points are special points or regions which OOTW troops set in streets or passages for inspections. When a check-point is set up, no weapons or drugs pass through it. If a man having guns or drugs tries to pass over a check-point, he is automatically arrested.

Another common usage of inspection in OOTW is the one called *cleaning inspection*. After placing check-points on all entries and access of a given region of interest, a cleaning inspection is performed inside that region. Homes and buildings are inspected by troops and once weapons were all seized, that region becomes finally clear and safe. Then *strength point* is name given to that region. Strength points are strategical places where troops store weapons, ammunition, food and medical kits.

Neutral element

One of the most serious problem in OOTW is related to neutral element (a non hostile). A neutral element is a native, an ordinary person which walk down the street and usually does not take part of conflicts or rebellions. When a critical situation takes place, these neutral elements suffer more than any other group and that is why they need special help and assistance. A good example of this problem occurred recently in Haitians earthquake incident.

However, this very same neutral element, in some specific moments, can have its behaviors changed to a more aggressive one. If so, OOTW troops must deal with this new adversity and regain control of situation. For example, imagine a typical food delivering day in a specific *Port-au-Prince* road. Foreseeing that it will not have food to everybody, a man or a group can end up assaulting and robbing people who have already got the goods. If such behavior is detected, OOTW must act quickly to neutralize it.

Another problem is that terrorists can easily disguise themselves acting like neutral elements but, in reality, they could be carrying off a gun and spread terror when convenient. This kind of situation shows how difficult and challenging is to keep an eye in many aspects of every OOTW activities.

So, as stated previously, a neutral element is subjected to mutual effect on meeting of both drug dealers and OOTW troops. Their reaction suffer negative or positive influence depending on their main contact. The way we treat that behavior digitally is to create an index called the *influence factor*.

The influence factor is a number from zero to one which means the influence gained by hostiles and irregular groups. When this number is zero, a given neutral element is happy and when possible, will cooperate with all OOTW troops, delating drug dealers positions and providing some local insider informations. In the other hand, if that factor reaches 1, this neutral element will behave like hostile men joining drug dealers and their actions.

In order to change the influence factor, both OOTW troops and hostile men will have to spend some time pleasing the local people. The first group can, for example, provide assistance such as aid, food and water. The hostile men such as drug dealers may promote free festival and finance educational taxes for children in the neighborhood. Every a given period of time (let us say, four hour) spent with local people will increase or decrease the influence factor by 1%. So, by the time simulation sets up, a beginning number for influence factor must be given. As simulation goes, both groups should try to spend some time on local people to increase or decrease the influence factor.

Communication systems

The main communication system purpose is to provide commander a way to instruct their subordinates either remotely or in person. In OOTW, the UN is responsible for providing all necessary communication equipments. A typical OOTW may include radios, campaign telephones and even faxes. In addition, advanced communication between combat elements such as coded messages can also be possible.

Every equipment is designed to reach a maximum distance and they are all cataloged in databases. If for any reason this maximum reach is exceeded, the communication for this specific equipment is lost.

In the other hand, being inside coverage, does not guarantee perfectly communication. Factors like dense vegetation, high mountains or even tall buildings may introduce some noises and interferences effects. For realistic purposes, these problems must be all handled by simulation system. So, a reasonable algorithm to solve these problems is proposed as following:

```
-- Check if radios in communication have battery
if( radio.battery > 0.0 and radioBase.battery > 0.0 )
     transmit = 1.0;
else
     transmit = 0.0;
-- Check if base is reachable for a specific radio
if( distToBase() > reach[radio.ID] ) then
     transmit = 0.0;
else
     transmit = transmit *
        ( 1 - distToBase()/reach[radio.ID]);
-- Evaluate vegetation permissiveness parameters
transmit = transmit *
        MIN( radio.permiss,radioBase.permiss )
```

Engineering tasks

As stated in the beginning of this paper, OOTW troops must fight against irregular armed groups which impose resistance when guarding a given position for economical purposes. They are more commonly, drug dealers and thieves. As expected, those men do not welcome police or OOTW troops because they disturb their actions.
So, in order to keep OOTW troops and police away, these men sabotage on streets, pathways and any other access to guarded position. The main point is to delay OOTW troops and police actions and incursions. To reach their goal, they place improvised trenches such as rocks and large tree branches, set fire in an abandoned car or tires and, in some cases, they even build up concrete barricades in the middle of the street to preclude the passage of vehicles (Pinheiro 2009).
In other to remove these dangerous obstacles, a special OOTW group named engineering group, is called. They are trained to safety remove these debris and trenches. More than that, the engineering group also know how to build up bridges and other passageways to vehicles and troops.

ARCHITECTURE AND IMPLEMENTATION

Having defined some important aspects in the modeling section, we now move forward explaining how a typical OOTW actions are conceivable and treated during a simulation. In this entire section we are going to show how the simulation works as well as its architecture and implementation.
The simulation architecture is quite simple and consists of a engine, a database and one or more clients. The engine is responsible for retrieving data and actions from database and executing them. Database module store all necessary information such as weapons, ammunitions, actions and the like. At lasts, clients hold an interface which provides a way to dictate orders to be executed by your combat element. The Figure 5 presents used a schematic architecture for the entire system.
The main system approach consists in having commands treated as cycle of actions. For each cycle, actions and

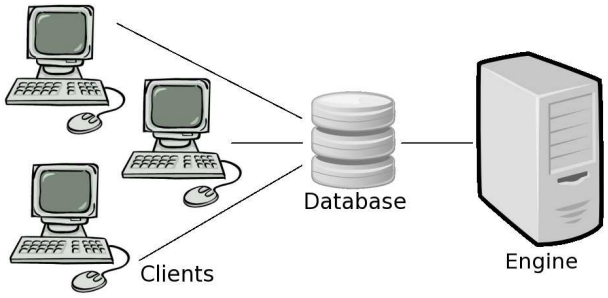

Figure 5: Simulation architecture model.

data are retrieved from database to attend user command. As a result from these commands, data may change and thus stored back into the database. As an example, imagine a "fire command". When "fire command" is activated, the system must check first if there is one or more gunshot left in database. If so, "fire" is allowed while ammunition is greater than zero. After some gunfires, the remaining shots must be updated again in database, closing the entire cycle of action "fire command". If another "fire command" occur then all above described cycle must executes again.

A snapshot of a continuous cycle of actions performed by five OOTW combat elements can be observed in Figure 6, after a case-study simulation. Observe a red circle indicating an hypothetical area where one or more terrorists are guarding the main *Port-au-Prince* airport lounge. In this example, the main objective is to rescue hostages safely and neutralize hostile actions. As simulation goes, the combat elements put out a siege against terrorists and begin negotiations. If no progress was made, another ways of action can be set up, including firing up toward terrorists.

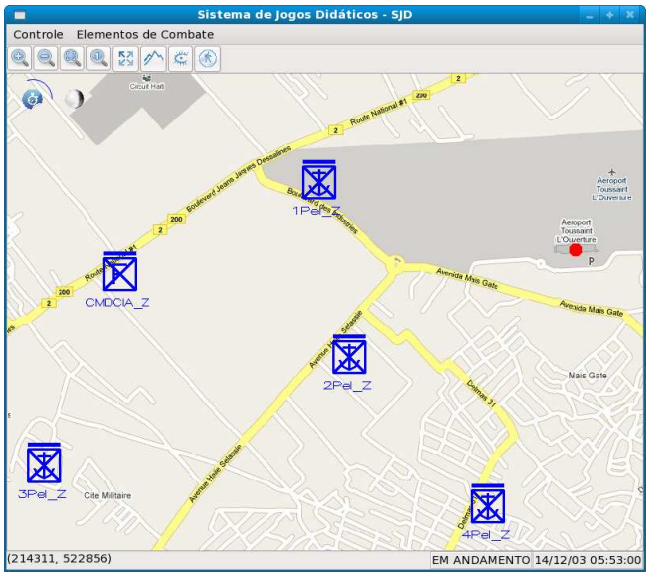

Figure 6: OOTW troops driving themselves toward the *Port-au-Prince* airport expecting to neutralize terrorists actions.

CONCLUSION

Despite the fact that practical implementations of OOTW are relatively new, the UN knows that these kind of operations have impacted positively in many citizens lives throughout the world. Therefore, investing in such operations is crucial to maintain a better and peaceful life to thousand hundreds or even millions of people. In the other hand, these operations are very expensive which make computers simulations an important tool to help massive reducing costs. Training officials and planning operations provide not only expensive cut but improving action performance (Jaiswal 1994). This is the major reason why computers have being used very early on many Brazilian Marines activities.

The three main modules lead to a strong architecture which provides a better maintenance when problems occur and support is needed. For instance, if ammunitions rules were updated, only database module will need to be updated. In this case, the other modules will probably remain intact.

The solution presented in this paper forces troops to keep an eye on influence factor. Since militiamen are usually arrested and not killed, extensive influence operations must be kept in order to maintain local people away from militiamen. If troops neglect the influence factor, the local population will gradually join militiamen, increasing their contingent indefinitely.

Having a ready made structure previously developed for a similar application give us the opportunity to handle OOTW problems with much more confidence. After deep analysis, we could spot differences and requisites to improve that system.

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