EARLY TESTING PROCEDURES FOR SUPPORTING VALIDATION OF INTELLIGENT AGENTS FOR SIMULATING HUMAN BEHAVIOR IN URBAN RIOTS

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ABSTRACT
Over the last decade the authors have been working on several researches concerning the use of intelligent agents for managing simulation of critical situation in security, such as managing civil disorders, riots or terrorist actions. The adoption of intelligent agents to reproduce human behavior is a key factor to implement realistic models for security and civil protection. Human behavior is very complex phenomena to be simulated and it is important to anticipate final results to get consistent models. In this paper will be described the use of early testing procedures to anticipate results before the VV&A phase. It is, in fact, useful to adopt this kind of early testing activities in application of intelligent agents with human behavioral models.

Keywords: HBR, Intelligent Agents

1. INTRODUCTION

The human factor is the key element in every analysis: industrial and business, services, security and defense. Non conventional and guerrilla warfare scenarios, urban riots and civil disorders, global and local terrorism are the real challenges that security forces have been facing at world wide level in the past, currently and probably for the future. In these scenarios human factor is crucial and it's impossible to apply traditional doctrines in command and control as well in training.

The authors are involved in different research projects dealing with this kind of issues. In the last years, in particular, they were involved in the PIOVRA project (Poly-functional Intelligent Operational Virtual Reality Agents), developed for the European Defense Agency, and the Italian and French DoDs. An important follow up to this project is the demonstrator named RATS (*Riots, Agitators & Terrorists by Simulation)*.

The authors are currently developing other study in this field, exploring new areas such as ethnic and social impact on civil disorders management or integration of simulators with Command and Control (C2) systems.

In the present paper the early testing activities managed by the research team to consolidate models before the final VV&A phase will be described.

They provide an overview of the fine tuning of algorithms and models related to PIOVRA Project, consequently to test phase. The movement algorithms of agents, case studies and examples are herein presented.

The description of the movements is detailed and examples are given based on the early tests made on PIOVRA Model, describing the rules and strategies which produce different effects.

A description of the case study scenario and consequent examples of movements is detailed in the following of the present paper. As for PIOVRA, the algorithms and models have been tested and refined during VV&A.

2. PIOVRA ALGORITHMS: MOVEMENTS

The Movement Algorithms affect the Action Object; in effect PIOVRA units have specific positions in term of current zone and in term of Geographical Position X,Y: terrestrial curvature has been left out of consideration and the PIOVRA surface is completely plane. Also, Position attributes and movements are two dimensional.

The Action Objects move in PIOVRA zone based on their own characteristics, speed included, and they are able to find a target following a specific path made of a single final point and/or a sequence of points.

Such kind of moving take into account the object operative status: in this specific case, the effective speed is defined on the basis of Zone Object and Action Object characteristics and weather condition; the speeds allowed by the environmental factors are compared with the object proposed speed, due to the fact they can affect it. The Movement algorithms also compute time to destination and related path: each event related to turn-point arrival is determined.

The algorithms works by the following approach: the position of the moving object is continuously updated and the travelling time and path recalculated where needed (i.e. in case of alert)

Two different movement algorithms devoted to regulate Action Objects PIOVRA agents are used: HM-

Holonomic Movement (it is based on Zone Object Characteristics and devoted to move entities on the map identifying the Zone where the unit is operating)

VM-Vectorial Movement (it is based on Zone Object Characteristics and considers as reference for each movement the connections among the Zone Objects and road networks)

As for vectorial movements, the target function devoted to optimize the path is defined on the basis of distance, travelling time, risk factor (presence of dangers along the path).

Vectorial movement have been defined on two different strategies: Road Oriented and Zones Oriented. Each one applies the same algorithms, therefore the search set in Road Oriented is made up by roads and intersections, while in Zones Oriented the zones objects are used.

In such an approach, the path is identified thanks to available links between zones considering the zone average diameter as parameter for distance evaluation and the barycentric coordinates as reference target point in intermediate movements.

Multiple criteria for shifting from one movement type to another one can be defined, in the proposed study the following movement strategies were introduced:

- When starting and end points within the same zone Object the holonomic movement is preferred
- When the final target is out of the current zone Movement over a threshold distance value use as preference the Roads Oriented Vectorial Movement
- Movement under a threshold distance value use as preference the Zone Oriented Vectorial Movement
- Action Objects are characterized with preference for the use each of the movement strategies
- A general simulation parameter is used to define the opportunity to use each of the movements
- Action objects representing few people prefer to use vectorial movement
- Action objects representing large groups use as preference the holonomic movement

The preference levels and the opportunity levels are combined by fuzzy rules dynamically during simulation for deciding what algorithm to use.

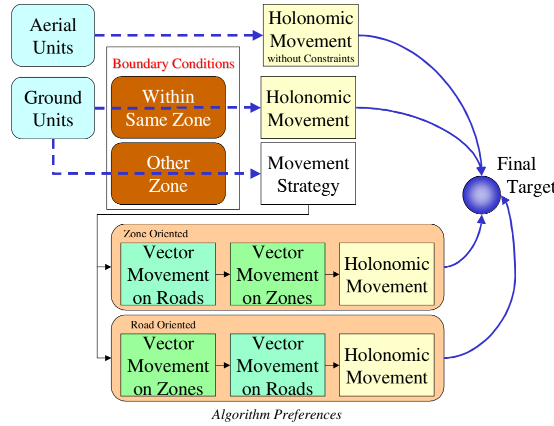

Figure 1-Algoritms Preferences representation

3. CASE STUDY

In this research the movement case study is related to a configuration of an Environment involving a town and the surrounding country side areas. In the described research, the movement algorithms are devoted to control action object moving inside PIOVRA Zone and each Zone Object is an entity that includes movement links and ground characteristics. Figure 2 is an example for the Movement case study and proposes a framework of links and zones.

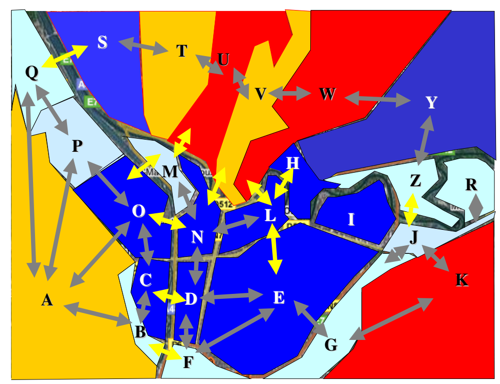

Figure 2: Zone Objects and Links

4. EARLY TESTING ACTIVITIES

The Regular Movement with Holonomic Approach in this research is summarized by the following figure:

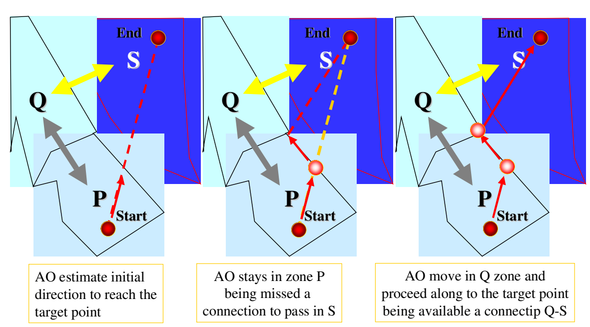

Figure 3 - Regular Movement with Holonomic Approach

The arrow between zones Q and S represent a bridge.

The Zone Object is related to the definition of the speed (and its limitations) based on the previously mentioned X,Y positions; different grounds provide different speed, for example urban speed for most vehicles is set to 10 km/h, while pedestrian speed in a forest is usually 2 km/h; therefore each Action Object have its speed profile that is related to the ground type and weather conditions; these movement characteristics are related to the coordinates of the Action Object and time respect the Set of zones.

The units move from a point to another one, based on an straight line changing the speed limitation due to current zone.

The passing from a zone to another one is enabled by the availability of an active link connecting the two entities (i.e. a bridge, or a free connecting border); the general procedure is summarized in figure 2 in a regular case.

It exist the possibility of special cases; for instance passing from zone x to zone y, corresponding to arriving in front of a river where the bridge represent the link between the two zone; a special event happen if at the arrival in front of the bridge, expected to be operative, it results to be closed/destroyed.

In this case, it is applied the following procedure: the unit checks the link (it is active or not) to proceed, then in case of the negative feedback, the unit try to continue to the target point along the border of the zone until it reaches a critical minimum distance point,

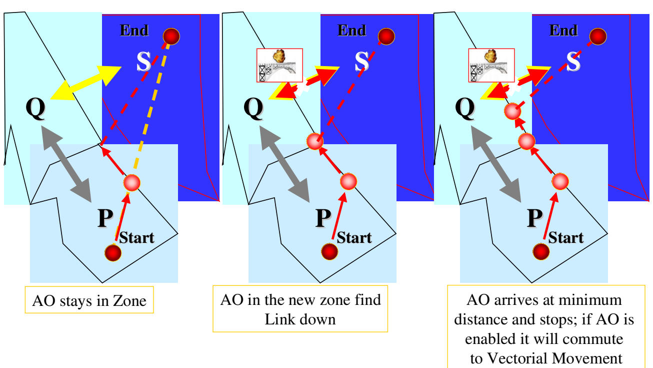

Figure 4 - Holonomic Movement in case of missed link

In correspondence of this phase the unit stops its movement and, if possible, it shifts to vectorial movement computing the path to reach the final destination.

For instance figure 4 present the same configuration of figure 3, but in this case the bridge connecting Q - S is down; in this case shifting to VM and choosing Zone Oriented approach the path is going trough P-O-M-U-T-S as summarized in figure5.

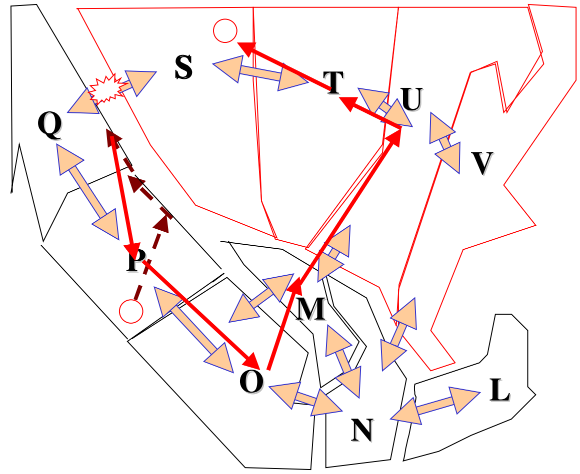

Figure 5 - Shifting from HM to Zone Oriented VM due to Zone/Road Environment Dynamic Evolution

In the figure 5 the directional arrows (□) represent the Links among Zone while the dashed line (brown) is the initial movement of the Action Object.

Considering the same example it is possible to evaluate the situation of figure 4 based on the hypothesis that a Road Oriented VM is used instead of a Zone Based.

In this case the path is proposed in figure 6

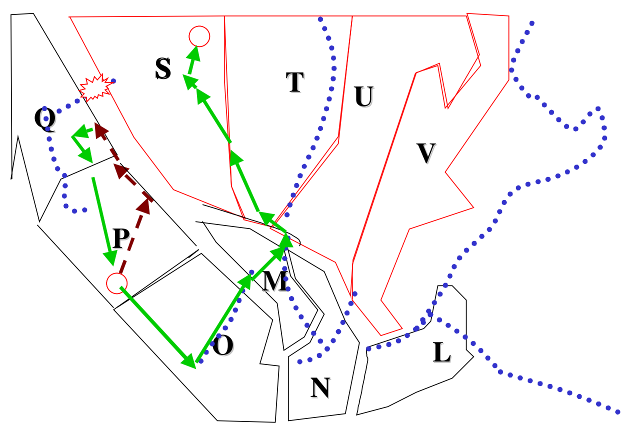

Figure 6- Shifting from HM to Road Oriented VM due to Zone/Roads Environment Dynamic Evolution

In the figure 6 the dotted lines (blue) represent the Road Network, while the dashed line (brown) is still the initial movement of the Action Object and the plain line (green) is the path obtained by applying a Road Oriented VM.

A second case is proposed about simulation evolution in PIOVRA OMF based on the hypothesis of combining different strategies on the scenario; in this case the target point is generated randomly inside PIOVRA zone.

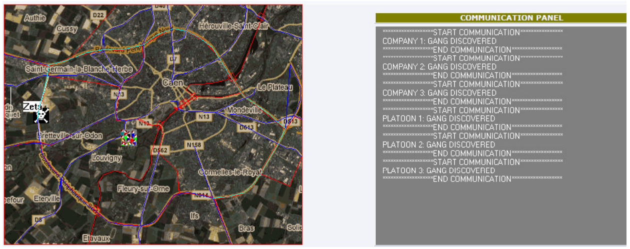

Figure 7 - Action Object Detection along Movement OMF

The reporting about detection of other entities is summarized in Figure 7 showing as its is represented the application area for PIOVRA Demonstration in the OMF; as action object is used a Gang moving with the profile of a Vehicle based unit with four people on board.

A set of runs using as preferable the Zone Oriented approach is proposed in figure 8; each time that the action object reach the target its mission is appointed to a new destination randomly generated.

A similar set of test is conducted using as preferable the Road Oriented VM is proposed in figure 9; also in this case each time that the action object reach the target its mission is appointed to a new destination randomly generated; based on this approach it was possible to compare the two method by long term simulation in term of travelling times respect original distances.

Figure 8 - Tracking Movement of a Gang driven by Zone Oriented VM in O

Figure 9 - Tracking Movement of a Gang driven by Road Oriented VM in OMF

5. PIOVRA ALGORITMS & PSYCOLOGICAL MODIFIERS

The psychological modifiers are applied to Action Objects and Comportment Objects; in this case the modifiers considered included the following set of parameters:

- Stress
- Harmony

The authors adapted a stochastic discrete event simulator devoted to simulate a Vessel Operation along its entire Life Cycle for testing the PIOVRA Algorithms related to stress and coordination capabilities.

As usual, it is necessary to applied proper procedures for human behavior modeling in order to guarantee the best ratio between cost/benefits by a ranking list; in effect data availability, fidelity improvement, impact on target functions are the key factors for identify the aspect where to focus; in this case the goal is to estimate the stress and coordination ability of the crew along operative time in relation to ship operations.

5.1 Case Study

In order to evaluate these aspects it was decided to adapt an available simulation model in reference to specific mission profiles and operation planning based on the Simulator ACASO (*Advanced Carrier Acquisition and Operation Simulation & Optimization*)

In this context vessel components are modeled by hierarchical objects; by this approach it is possible to explode each single ship plant (i.e. engine system) in its elements by creating multi-layers corresponding to different detail level; obviously among the ship component the crew represent a critical element.

As stochastic factors affecting the model was identified:

- changes in operative profile
- failures and breakdown both in term of:
- time intervals
- impact on the overall efficiency
- duration of maintenance operation
- cost of maintenance operation
- crew behavior

Due to the fact that most of these parameters need to be estimated by experts, beta distribution are extensively used for modeling stochastic entities; in this context the characteristic of the ship used correspond to a medium size aircraft carrier, while the detailed data are related to public domain data and hypotheses from PIOVRA team. It is interesting to focus on the psychological modifiers applied to the crew within this model; in fact it represents a very critical component of the ship; in this case the authors were interested in modeling this entity in order to estimate the impact of different operative profiles on the overall ship performance. The psychological modifiers affect the efficiency of the ship in term of operation and maintenance with different impact on sea operation respect port.

In figure 9 it is proposed the dynamic model introduced in the stochastic discrete event simulator for crew psychological modifiers (including the effect of crew turnover); the SMP (Small Maintenance Plans) and GM (General Maintenance) represent the condition of the ship for middle-life planned maintenance stops; while the signs inside diamonds represent the setting of the factors included in the algorithms for Stress and Cooperation Capabilities. In addition the model consider also the turnover of the crew (substitution of resources) in term of changing the status of the personnel (i.e. newcomers, experts etc.) based on a detailed composition of the crew mix.

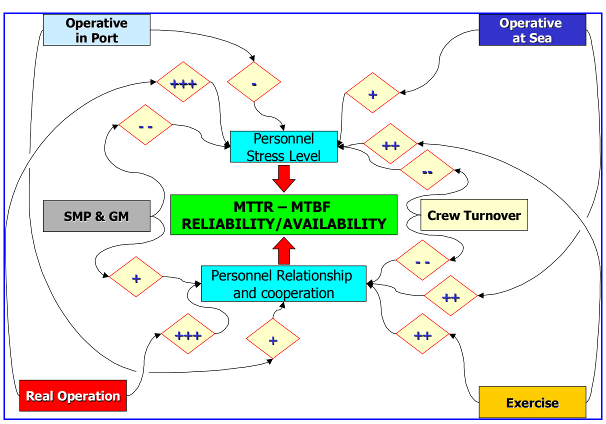

Figure 10 - Dynamic Model involving Human Factors affecting Ship Operations

5.2 Early Tests and Examples

The impact of these two phenomena on the crew has been defined in order to represent the evolution in its capabilities in relation to ship operative status and its history: for instance, as much as the crew is acting in real operations as much its stress level increases; therefore the relation for this increase correspond to a special trend that properly model psychological aspects such habits, limit points, etc.

In this case the setting of parameters are related to Dsc(x,y) Unitary Continuous Change in Stress Level due to x Vessel Status in y dynamic scenario environments:

These trends corresponds to the curves represented in figure 10 including the hysteresis due to the different behavior corresponding to stressing and relaxing the crew defined in PIOVRA Algorithms.

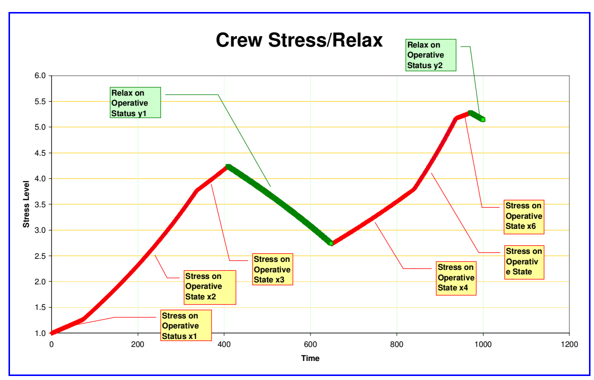

Figure 11 - Psychological Modifier Evolves based on their status, trend and ship operative Condition

In case of long term operations it possible to measure influence of crew coordination/stress in term of overall results; by running simulations it is highlighted the influence of the stress on the MTBF (Mean Time Between Failures) and MTTR (Mean Time To Repair); so by enabling the psychological modifiers it is modified the estimation of the overall vessel efficiency in term of availability. It is interesting to underline the results obtained applying the PIOVRA Human Behavior Modifier models to a particular case, in order to obtain a pre-check of their correctness; in particular the HBM are applied to CALIPSO© Simulator, a software developed in order to analyze parameters of a new carrier generation. The results obtained focused on the comparison between the availability temporary evolutions, one without HBM and one with HBM.

This comparison, represented in figure 11, shows how the availability results obtained without Human Behavior Modifier is better than the one with HBM but after a period of time the situation is upside-down due to the improvement of crew harmony. Please note that, even if punctual values have been modified for security reason, the trends are clearly reproduced. This means that the application of PIOVRA HBM models on CALIPSO© Simulator have allowed to test them on a different scenario and to analyze them in order to make the final tuning on PIOVRA easier and faster.

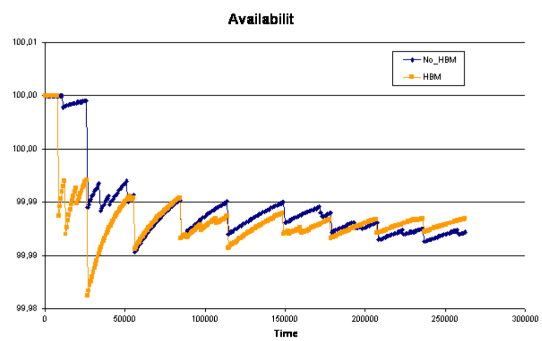

Figure 12 – Comparison between Availability without HBM and with HBM

6. CONCLUSIONS

In this paper have been presented the description of the early testing procedures for guarantee that during the definition of advanced algorithms and complex conceptual models it could be quickly redirect the development due to the feedback from dynamical verification and validation; in fact the dynamic VV&T is a critical issue, however often the implementation delays reduce the possibility to benefit from this approach; by the proposed methodology it becomes possible to anticipate these activities and provide immediately a direct feedback to model experts and developments; in fact the paper propose early test for movement algorithms used by PIOVRA Agents and basic case studies and examples devoted to complete early dynamic VV&T. The description of these case studies, tests and examples has supported the dynamic demonstration the behavior of agents during early development phases. It was possible to see how they react properly to the unforeseen (i.e. the crossing of the bridge) and to the differences among movements.

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