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Team 4: Evaluation of electro-optical sensor systems in network centric operations using ABSEM 0.3

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Team 4: Evaluation of electro-optical sensor systems in network centric operations using ABSEM 0.3

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INTRODUCTION

The development of the agent-based sensor and effector model ABSEM was started in 2008 by EADS on behalf of the German Federal Office of Defence Technology and Procurement. Since then it has been continuously enhanced and at IDFW19 version 0.3 was released. The model concentrates on modeling complex technical aspects in NCO and to do so, it integrates detailed physical theories when it comes to simulating the output of various sensors and when determining the effect of different weapon systems. The new model version is characterized by more sophisticated effector modeling and extended possibilities regarding the setup of the agents' behavior. Furthermore it contains a first radar model implementation.

During IDFW19 a camp protection scenario was used to perform extensive data farming experiments and thus improve system understanding.

Objectives

Using a camp protection scenario, the team's objective is to investigate the effect of different sensor systems (electro-optical and radar) and effector types (direct / indirect fire, weapons with point and area effect) within a dynamic environment. Particularly the new ABSEM version 0.3 features were to be reviewed. This included on the one hand verifying the integrated model approaches and on the other hand exploring the model's possibilities when it comes to simulating more complex NCO scenarios. The new features are:

- Radar systems for airborne reconnaissance
- Larger terrain cell (400*400km), urban environment
- IEDs, indirect fire, weapons with area effect
- Extended state dependent agents' behavior state machine
- Trigger events

In Data Farming experiments the team's main intention is to examine the effect of the given sensor and effector systems under varying conditions, such as different weather-dependent atmospheric conditions, time of day, varying number and type of blue and red units,…).

Overall, the team has the following goals:

- Review and face validate ABSEM version 0.3
- Validate the implemented radar model
- Setup a complex scenario
- Conduct data farming experiments analyzing the effect of parameters such as different sensor systems, number of deployed blue forces, reaction times,…
- Find out further model and data farming requirements

Simple scenario for testing the radar model's plausibility

A new radar model has been implemented for the new ABSEM version 0.3. At this workshop a first simple radar scenario was simulated to investigate and validate the correct modeling of monostatic pulsed radar systems in ABSEM.

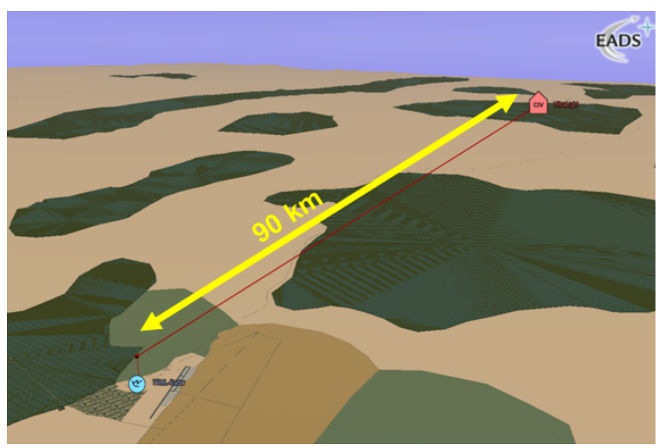

Figure 1: Simple radar test scenario

In the scenario shown in figure 1, an aircraft is approaching an air surveillance radar starting at a distance of around 90 kilometers.

The detection distance was used as the MOE to measure the radar performance for different radar types, weather conditions and target sizes and types.

The implemented radar model considers the following parameters:

First, a wide range of technical radar parameters may be defined and used to simulate the radar performance in the radar model.

Second, the environment is taken into account (e.g. line of sight or atmospheric losses due to rain).

And finally target parameters like the Radar Cross Section (RCS) and the Swerling Case, which defines the fluctuation of the RCS is taken into account in the radar model.

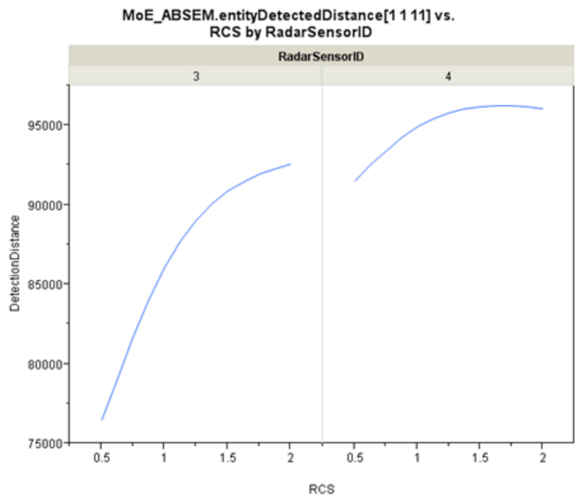

Figure 2: Detection distance for different RCS values for low (left) and high (right) frequency radars

Overall we could verify the radar model's correctness. The performed data experiments confirmed the expected behavior.

We could for instance observe that radars with higher frequencies are more robust against RCS-fluctuations (see figure 2) or technical radar losses (see figure 3). Lower frequency radars, however, perform better when it's very rainy. When looking at the regression tree we found out that besides the RCS value (which only depends on the target) the pulse compression and technical radar losses have the most influence on the radar performance.

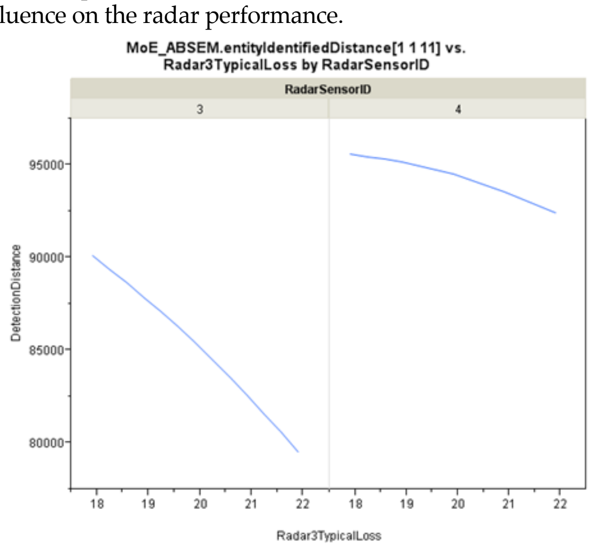

Figure 3: Detection distance for different typical radar losses for low (left) and high (right) frequency radar.

More complex NCO Scenario

The extended model functionalities regarding both the implemented effector model and the enhanced agent behavior were tested using a camp protection scenario.

Scenario Description

The military camp is located outside Mazar-e-Sharif and faces a constant threat by local insurgents. Once in a while the camp is attacked by mortar grenades mostly fired from the inner city. For this reason patrols through Mazar-e-Sharif are trying to detect and defeat any hostile firing positions. In addition UAVs are deployed for aerial surveillance to reconnoiter the attackers. All the reconnaissance information is passed on to the camp's headquarters.

In case a hostile mortar firing position was identified, all soldiers within the camp will be warned which causes them to retreat into secure shelters. Additionally the patrols will get the order to fight the insurgents. This implies that the blue patrol will quit its predetermined patrol route and follow or move towards the red insurgents. Those, however, have planned to perform a hit and run ambush by using an IED and attacking the patrol with rifles and rocket propelled grenades as soon as one of the patrol's vehicles was damaged by the IED and therefore the whole patrol was halted.

Figure 4: Overall scenario from the bird's eye view

Data Farming Experiments

We were executing a series of data farming experiments, looking at the following parameters:

- number of deployed UAVs for airborne reconnaissance: {0;1;2}
- deployment of a second vehicle patrol: yes/no
- time of the day: noon / midnight
- weather: foggy / clear
- type of sensor system used by blue forces: normal viewing during day and night / long wave infrared device

As MoEs we were mainly looking at the damage state of the blue forces, differing between the losses within and those outside the camp.

All of our experiments were successfully executed on the 32-node German cluster owned by BWB.

In an iterative approach we were executing several data farming experiments to analyze the mentioned parameters' influence on the overall mission success, i.e. avoiding blue losses. The final experiment encompassed more than 5000 simulation runs, successfully executed in several hours on the 32-node German cluster owned by the German Procurement Office.

Data Farming Results

We found out that in this scenario setup the deployment of UAVs is essential for the camp protection, whereas the convoy patrols are not sufficient.

An interesting effect, however, can be seen in figure 5. Whereas the UAVs help a lot regarding the protection of the soldiers within the camp, it also leads to more losses in the convoy. The reason for that is that as soon as the red forces were identified by the UAV, the blue patrols will try to fight and follow the red forces. Unfortunately that's exactly what the red forces were trying to achieve and helps them ambushing the patrol. Thus, if the red forces were not detected, the patrol won't be involved in any fight.

Furthermore we could observe that actually the time at which the red mortar starts firing at the military camp is quite significant. However, this is a factor that cannot be influenced in reality. Therefore we were interested to find out which of the other parameters mostly affects the number of blue damages. To do so we generated a partition tree that showed that the number of deployed UAVs has the largest impact, followed by the type of sensor applied.

But it was also seen that apparently in an urban environment the deployment of highly developed sensor systems is not that important since the target needs to be very close anyway in order to be detected.

SUMMARY AND WAY AHEAD

The implemented radar model delivered very plausible results, thus showing us that we are on the right track.

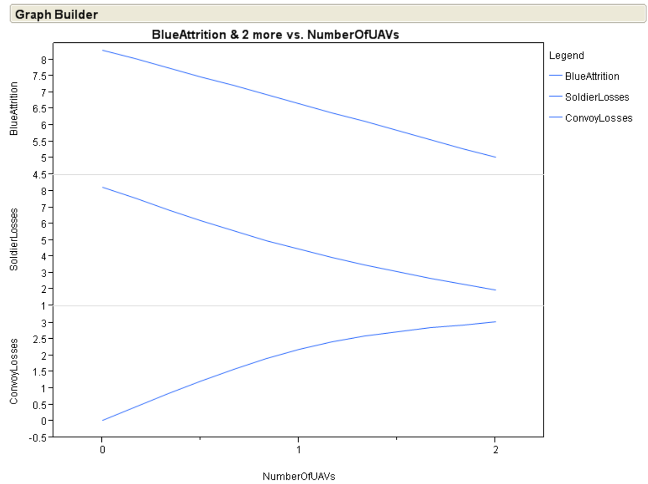

Figure 5: Influence of the UAV deployment on the number of blue losses

With ABSEM version 0.3 and the provided model features we are now able to set up more complex scenarios within a short amount of time.

Of course, the more complex the scenario and the longer the period of time we are looking at, the longer the execution times of the simulation runs. Therefore in future we will have to think about using more sophisticated experiment designs than just using the gridded design. In ABSEM, however, for the current set of analyzed scenarios we need to have the possibility to lockstep several parameters (for instance to model a convoy existing of several entities). Therefore we need to find a possibility for both using the NOLH design but still being able to lockstep. Additionally we derived the need for further user interfaces simplifying the whole scenario setup and the agents' behavior parameterization in particular.