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Team 8: Enhancing the Combat ID Agent Based Model

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INTRODUCTION

During previous Project Albert and International data Farming Workshops (IDFW) and during discussions between Dstl and TNO, the suitability and feasibility of Agent Based Models (ABMs) to support research on Combat Identification (Combat ID) was examined. The objective of this research is to:

Investigate the effect of (a large number of) different variations in Situational Awareness, Situation Awareness (SA), Target Identification (Target ID), Human Factors, and Tactics, Techniques, and Procedures (TTP) under different circumstances (scenarios) on mission level combat effectiveness and fratricide.

Combat ID is a complex phenomenon which is heavily based on human factors, technology and tactical considerations. Modeling Combat ID to its full extent is not possible in a single step. It requires both a good combat model and a representation of the Target Detection, Classification, Identification process that takes the considerations mentioned above into account. As a first step to support our objectives, we decided to evaluate the feasibility to represent Situation Awareness in an ABM. This evaluation was conducted during IDFW14. Before and during this workshop, version 1.0 was developed in NETLOGO. This model contains one moving identifying agent and a number of static agents to be identified (objects). The identifying agent has a representation of situation Awareness (SA) and bases its identification decision on a mechanism where it combines SA and data from observations.

Current Features and Objectives

Following our overall Master plan, several extensions have been implemented since IDFW14:

1. When the identifying agent has not decided on the identity of a certain visited object, it is able to revisit the object and try to decide on its identity again.
2. When the agent decides that an object is an enemy, it kills the object. The object will then be removed from the ground truth.
3. The notion of Local SA and Global SA was introduced. Global SA keeps track of the pre-conception of the whole environment in which the agent operates. Its’ granularity is less than the granularity of the ground truth. Local SA keeps track of the agents’ preconception of its’ surrounding area. The granularity of Local SA is equal to the granularity of the ground truth. The size of the local SA and the granularity of the global SA are parameterized (and thus data farmable). The local SA is updated each time new sensor information is accepted or as a result of moving. When the agent moves, the local SA grids moves with it, keeping the agent in the middle of it. As a result of the move, some cells will be removed from the local SA and new cells are added, taking the belief distribution of the global SA cell as its’ initial belief. The global SA is updated each time the agent decides on the identity of an object. Figure 1 shows the relation between the Local SA, the Global SA and the ground truth.

The objectives of the study during IDFW15 were to assess the features above by designing and conducting data farming experiments. Further objectives were to (re-)examine and determine the key factors (parameters) in SA.

Figure 1: The notion of Local SA, Global SA and their intuitive interaction.
**Design of Experiments**

During IDFW15 we identified the interaction between Local SA and Global SA, and the mechanism to accept or reject new sensor information as the key factors to consider. We implemented four model versions with different ways to deal with these factors:

**version 1.** The agent keeps track of the kind of objects that were encountered in each global cell. After a positive identification, the global SA cell where the object is identified, is updated in a way that depends on the kind of objects that were encountered in that cell before. If no or only the same kind of objects were encountered before, the global cell will get the agent’s local belief (probability distribution of Red, Blue, and Green). If one other kind was encountered before, it takes the average of the new belief and the old global belief. If two other kinds were encountered before, it takes the average of two times the old belief and one time the new belief.

**version 2.** The model incorporates a parameter “Belief Increase Steps” (BIS) to update the Global SA grid in steps towards a probability of 1 (100 percent sure). After a positive identification, the global SA is increased with \((1 - \frac{1}{3}) / \text{BIS}\). e.g. if BIS is 3, 0.22 is added.

**version 3.** This version incorporates the notion of surprise. A parameter “Surprise Level” will be implemented that determines a surprise curve that defines the amount of belief that will be added to the global belief when new information is accepted. The amount of belief to add, depends on the old belief in such a way that high old belief will add a low amount and vice versa (see Figure 2). The effect is that new belief that is in line with the old belief, only has a small effect. If the new belief contradicts the old belief (surprise!), the global belief is changed more radically.

**version 4.** This version uses the Surprise Variable as introduced in version 3. The shape of the “Information Acceptance” curves are parameterized. Both the top and the crossing with the Y-axe can be defined by the user. See Figure 2. This enables to shape the information acceptance behavior and in particular solves some problems with old belief that is equal to 0 or 1.

<table>
<thead>
<tr>
<th>SA Aspect</th>
<th>Version 01</th>
<th>Version 02</th>
<th>Version 03</th>
<th>Version 04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update of Global SA</td>
<td>Weighted Average of old and new belief</td>
<td>Believe Increase Steps</td>
<td>Surprise Level</td>
<td>Surprise Level</td>
</tr>
<tr>
<td>Information Acceptance curve</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Variable</td>
</tr>
</tbody>
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Table 1: Overview of different model versions

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1 The Information Acceptance curves were called stress curves before. This was actually misleading. The curves are really about the openness of the agent to accept new information, which can be effected by other factors than stress. However, in the results we sometimes still use the word stress.

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**RESULTS**

The Measures of Merit for the combat ID model versions are the number of correct identifications, the number of misidentifications, and the number of fratricide incidents. During the workshop we briefly evaluated model versions 1 and 2 and did runs with all four versions.

For version 1, the main results were that:

- The Decision threshold turned out to be the key factor in determining the number of correct identifications.
- Having a larger local SA grid size cannot overcome a perceived truth that differs greatly from the ground truth.
- Decreasing the decision threshold increases the number of correct identifications and misidentifications.
- Outlying cases proved interesting, specifically, the largest number of misidentifications occurred when there was a:
  - Low decision threshold and, in general, a lower stress coefficient (which determines the information acceptance level)
  - Large delta between perceived and ground truth
- The more interspersed the Blue, Red, and Green objects are, the more fratricide
- The higher the level of stress, the less fratricide → same holds for version 4, with information acceptance level

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**Figure 3: The information Acceptance curves**

**Figure 4: Regression tree for version 1 with relative number of correct identifications compared to total number of identifications**
During the workshop we agreed that different Measures of Effectiveness are needed to view the effects of all SA variables. Therefore, after the workshop, we combined the initial outputs to the relative number of correct identifications:

- The number of correct identifications related to the total number of identifications. This MoE directly relates the number of correct identifications to the number of misidentifications.
- The number of correct identifications related to the total number of existing objects. This MoE directly shows the agents performance in identifying objects (correctly).

Using these two MoE we created the regression trees shown in Figure 4 and Figure 5 to determine the most important factors for version 1.

Using these two MoE we created the regression trees shown in Figure 4 and Figure 5 to determine the most important factors for version 1.

Figure 5: Regression tree for version 1 with relative number of correct identifications compared to total number of objects.

Figure 6 shows the contour plot for the two most important factors, decision threshold and level of stress, related to the number of correct identifications.

Figure 6: Number of correct identifications related to decision threshold and level of stress (information acceptance level)

For version 2, the main results were that:

- A higher resolution global SA (smaller cell size) can reduce the fratricide incidents, in case where the tank detection range is large
- Having a large local SA decreases the number of misidentifications at a low classification range, but increases the number of misidentifications at large ranges

Further version results:

- Version 2: The regression trees for version 2 are not significantly different from the ones for version 3
- Version 2: There are no significant effects caused by the variable “Belief Increase Steps” introduced in version 2

For version 3:

- The regression trees for version 3 are not significantly different from the ones for version 1 and 2
- Version 3: There are no significant effects caused by the variable “Surprise Level” introduced in version 3 (Note: at a higher surprise level there seems to be a rise in Mis-Identifications. This needs further examination)
- Version 4: In general, the higher the information acceptance level, meaning the more open the agent is for new information, the higher the number of correct identifications, and the less the number of misidentifications and fratricide incidents.
- Version 4: The regression tree of all variables related to the number of fratricide incidents is shown in Figure 7.

Figure 7: Version 4: Regression Tree regarding the number of fratricide incidents

- Version 4: A contour plot of the Y-Intercept (where the curve crosses the Y-axe) and the Information Acceptance Level related to the number of correct identification (relative to the number of the total number of identifications) is shown in Figure 8.

Figure 8: Contour plot Y-Intercept and Information Acceptance Level

CONCLUSIONS

We can draw the conclusion that team 8 made a lot of progress with the model development. We were able to discuss, implement, and run 4 model versions. Discussions about Situational Awareness, and how to capture and represent it in our model raised further issues that might lead to new features.
However, our analysis is far from complete yet. At this moment we gained a number of insights from the results of our first data farming efforts. Some of them in line with our expectation, others in contradiction with it. This needs further analysis and possibly more model changes and model runs.

**FUTURE DEVELOPMENT**

Before the next workshop, we will dive deeper into the ocean of data to pinpoint more characteristics of our current versions. In the process of sowing and reaping, we will incorporate lessons learned and reconsider our model and assumptions continuously. We have an master plan that will serve as a guide for our near term development. Together with the lessons learned from the IDFW 15, we (re)consider current variables and new variables like:

- Other Measures of Merit
- The notion of Surprise
- Similarity of objects
- Environmental (~ sensor) distortions
- Further incorporation of INCIDER aspects
- Continuous Info Processing
- Change of awareness over time
- Notion of killing enemy and preconception
- BDI and awareness of fratricide
- Threat representation
- Incorporation of moving objects
- Incorporation of more identifying agents

IDFW16 in Monterey will serve as a vehicle to test some of the ideas mentioned above. Our plan is to have a stable model and focus on the datafarming process during this workshop. As usual we welcome new members to participate in our team during this workshop.