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Team 3: Analyzing Selected Questions in a Refugee Camp Scenario Using PAX3D

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INTRODUCTION

The Bundeswehr Transformation Center is examining how M&S can effectively support CD&E projects related to Peace Support Operations (PSO). Human Factors and Human Behavior analyses have proven to be highly relevant in this context. One study specifically examines possibilities to model scenarios in a PSO with PAX in which the military is tasked to assist in building and operating refugee camps, and especially to ensure order and security. PAX is planned to be used to support decision makers in assessing and evaluating ROE (Rules of Engagements) applying the basic use of force guidelines for the soldier in PSO missions.

Questions

The model of evolving aggressiveness within groups which is modeled in PAX is quite complex (a subsumption can be found in [1]).

Therefore, one major object of investigation for the team was which input parameters that determine the group's behavioral characteristics lead to escalating and particularly dangerous, i.e. violent situations. This question will be stated more precisely when looking at the specific scenario and studies later on. However, since there are a lot of factors actually characterizing the behavior of human agents with regard to their emotional states and evolvement of aggression, statistical means will be used to examine those factors and their interrelationship in our studies.

At IDFW18, PAX was calibrated in specific micro scenarios within a refugee camp scenario modeled in the 3-

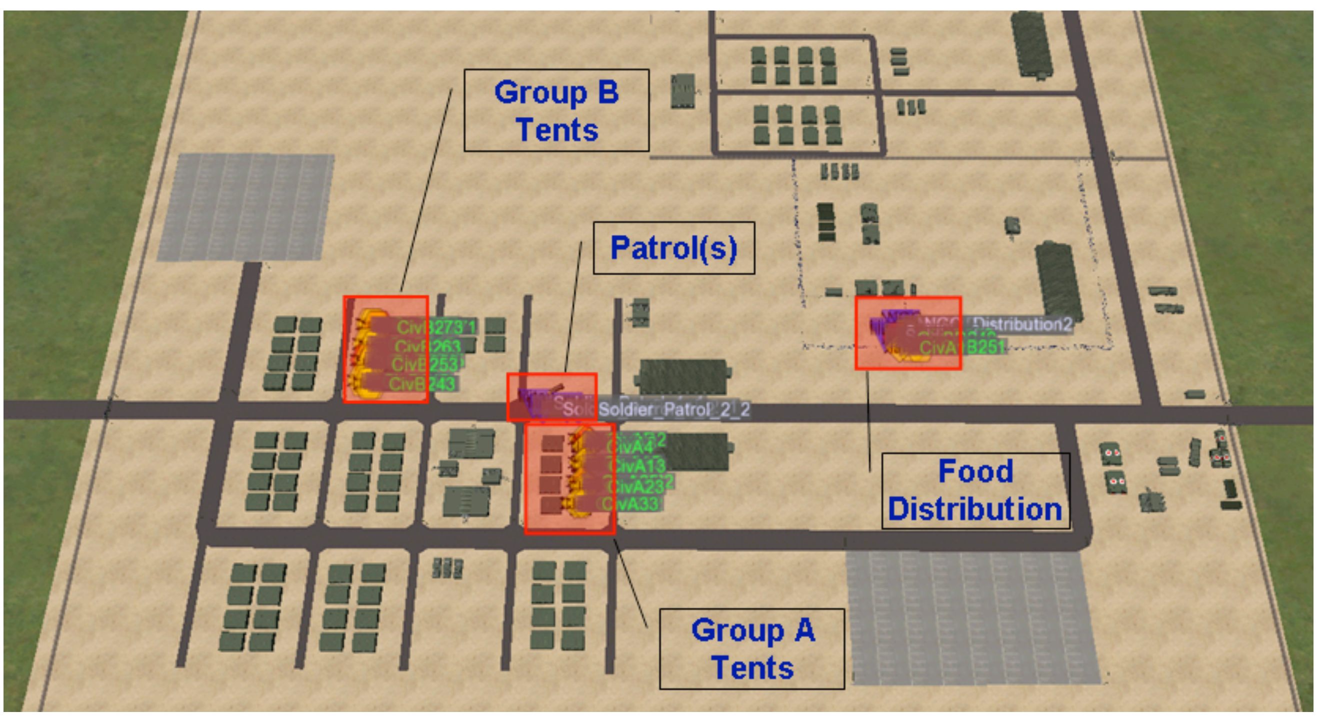

Figure 1: Refugee Camp Base Scenario

dimensional environment of PAX. Special focus was on calibrating the soldiers' behavioral model in detail, which had been adopted to represent a realistic self defense behavior of the soldier agents according to commonly applied use of force guidelines.

Having found that the soldiers' self defense behavior is carried out correctly and in a sufficiently realistic way in the micro scenarios with very few agents, the team's second objective during IDFW19 was to find out whether this soldier behavior also works properly in larger ("macro") scenarios.

To summarize, the driving questions for investigation for the week were:

- Which group characteristics lead to escalating and dangerous situations? Which input factors and combinations thereof are most influential?
- Does the new soldier behavior that was validated during IDFW18 in micro scenarios also work properly in larger scenarios?

Scenario

Figure 1 depicts the general refugee camp scenario that was used as the baseline for the week's studies in its implementation using the current PAX3D version. The scenario is set up to be at around noon time at the time when food distribution at the central distribution point has just started and representatives of each tent are in the area marked as Food Distribution to collect the respective tent's packages.

Meanwhile, the rest of the refugees are waiting in their tents for the tent representatives to bring back and distribute the food. While this is their main motivation, there is also a certain tension between the two rivaling groups marked as Group A and Group B with 40 refugees each. Besides the "normal" civilians, each group encloses 2 disturbers, initially aggressive and equipped with weapons. A soldier patrol is set up in the tent area to prevent or dissolve trouble amongst the refugees.

STUDIES & ANALYSIS

To address our questions and in particular to examine the most influential factor combinations for certain group characteristics and scenario developments, we started off with a Data Farming experiment in which we varied the parameters characterizing the dynamics of PAX with regard to the agents' emotional states.

Experiment 1 Setup

While the complete design in terms of the varied range of each factor is shown in Table 1, it is important to briefly introduce the meaning of the parameters, at least to an extent which will support the following analysis:

A civilian's anger factor (denoted by PC_ANGER in the following) determines the dynamics of the anger of an agent. A low anger factor results in an angry agent staying angry for a long time, thus characterizing – in combination with other model inputs – a rather hot-tempered civilian.

	Min	Max
A Normal PC_ANGER	0.01	0.2
A Disturbers PC_ANGER	0.01	0.2
B Normal PC_ANGER	0.01	0.2
B Disturbers PC_ANGER	0.01	0.2
A Normal PC_FEAR	0.01	0.7
A Disturbers PC_FEAR	0.01	0.7
B Normal PC_FEAR	0.01	0.7
B Disturbers PC_FEAR	0.01	0.7
A Normal PC_RFA	0.01	1.0
A Disturbers PC_RFA	0.01	1.0
B Normal PC_RFA	0.01	1.0
B Disturbers PC_RFA	0.01	1.0
A Normal PC_AROUSAL	1.05	2.0
A Disturbers PC_AROUSAL	1.05	2.0
B Normal PC_AROUSAL	1.05	2.0
B Disturbers PC_AROUSAL	1.05	2.0
Soldiers' Sensor Range	10.0	50.0
Threshold Anger Very High	71.0	95.0
Threshold Anger High	50.0	70.0
Threshold RfA Very High	71.0	95.0
Threshold RfA High	50.0	70.0

Table 1: Basis of NOLH design of experiment

Likewise, a low fear factor (PC_FEAR) of a civilian characterizes a rather anxious personality.

A similar correlation exists for the readiness for aggression (RFA) and the arousal of the agents, respectively.

The soldiers' sensor range determines the range in which the soldiers react to interactions, representing a very basic notion of a "sensor".

Finally we varied some internal thresholds for classifying anger and readiness for aggression as high and very high, respectively, during a simulation run. They are displayed in the table but will not be examined further.

Experiment 1 Analysis

When examining this first NOLH experiment, one much unexpected observation was that in some of the runs a very high number of civilians (up to a maximum of 19) were actually killed (see Figure 2).

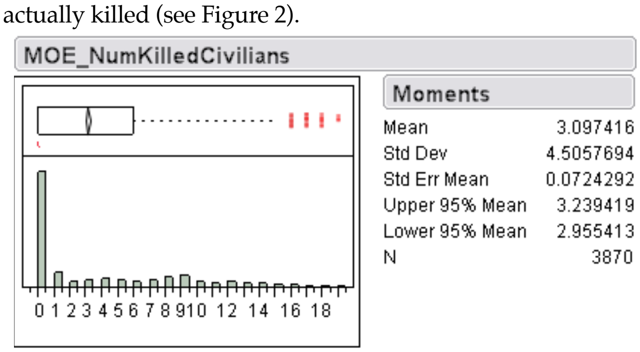

Figure 2: Distribution of number of killed civilians in NOLH design experiment

Although this was a surprise at first, this outcome actually helped the team tremendously in answering our first question. We noticed that the very diverse spectrum of scenario outcomes was mainly due to the wide ranges in which we had varied our model factors. As we had done so intentionally in order to identify which factor ranges and their combinations caused different types of group behavior, we now took a closer look at the combinations that caused this high level of aggression.

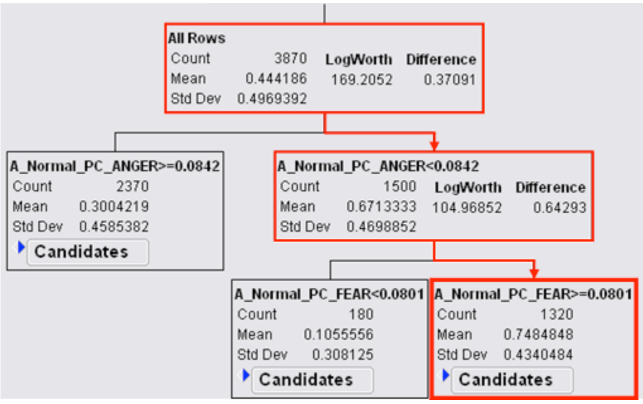

Figure 3: Regression tree analysis of MOE "At least one civilian killed"

A regression tree analysis showed that the combination of the PC_ANGER and the PC_FEAR parameters is a key factor for the violence observed in the scenario. For example, Figure 3 shows that a rather low anger factor (meaning the agents stay rather angry) combined with a high fear factor (meaning that the agents are rather "fearless") is a key influence for at least one civilian being killed.

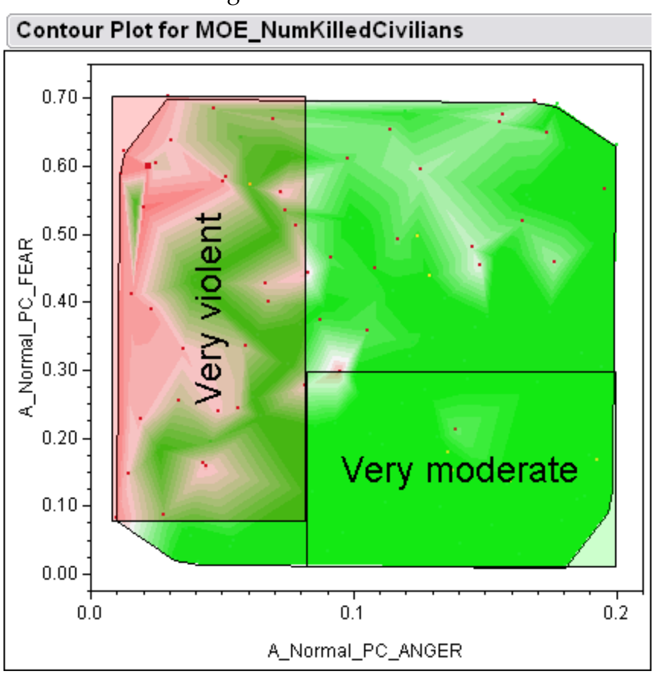

Figure 4: Allocation of moderate ☒ violent civilian personality characteristics (green = 0 kills to red = 19 kills)

In other words, we can conclude that a combination of an anger factor below 0.08 and a fear factor above 0.08 leads to the agents behaving very aggressively in this scenario. On the other hand, we found that with an anger factor above 0.08 and a fear factor below 0.3 very few incidents with killed civilians happen. Figure 4 displays these cross-effects graphically, although these results will have to be confirmed by follow-up experiments.

One can further interpret Figure 4 concluding that the remaining parts of the parameter space characterize medium or normal aggression levels of the respective civilians once more thorough investigation of the two determining factors has been done.

As to the team's second question we identified a remaining flaw in the implementation which in our scenario setup caused the soldiers not to react strongly enough as long as other civilians were beaten, but not attacked with any weapons. Especially in the very violent scenarios this had the effect of aggressors continuously beating members of the other group, unimpressed by the soldiers' continuous attempts to resolve the situation.1

Experiment 2 Setup

In a follow-up experiment we re-ran the same experimental design with a slightly changed base case scenario in which in addition to the disturbers 5 randomly selected "normal" members of each civilian group were equipped with weapons. The team hoped that this would lead to the soldiers recognizing the life-threatening situation, solving the arising conflicts.

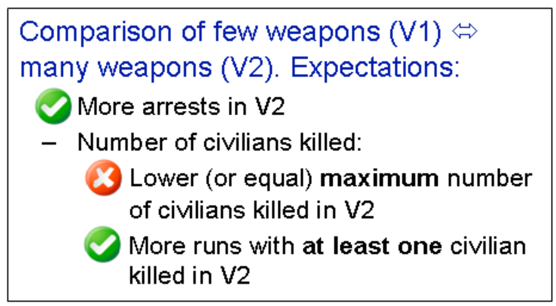

Figure 5: Team expectations in second experiment

The team's expectations as to the outcome of this scenario are summarized in Figure 5, together with a first overview of the results of the analysis. The figure shows that the team expected fewer civilians to be killed in the second experiment, which is an intuitive expectation when considering the aforementioned reason for setting up the second experiment with more weapons.

Experiment 2 Analysis

Two of our expectations were met in the experiment analysis: The civilians' carrying more weapons did actually lead to more of them being arrested and there were more runs with at least one civilian killed.

However, the fact that the soldiers now consequently performed their self-defense behavior and arrested disturbers

[1] The soldiers' behavior is not introduced here, but a description can be found in [2].

did not in turn lead to fewer civilians killed in general. We noticed that the effect of more extreme attacks happening outweighed the soldiers' stepping in more thoroughly.

The comparison of the contour plots of the experiments with (Figure 6) and without weapons clearly confirms this observation. Also, in the "medium-range" area (upper right) we can see more severe and violent simulation runs than in experiment 1 – an effect of the higher number of weapons being used by the civilians.

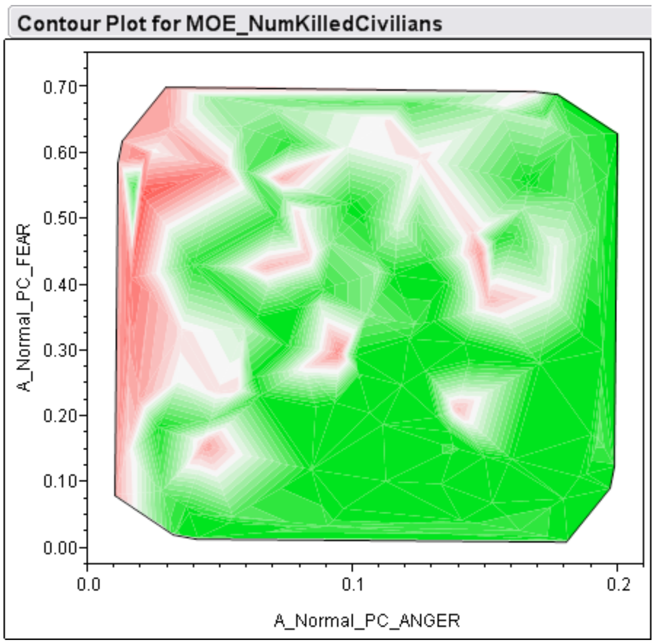

Figure 6: Influence of PC_ANGER and PC_FEAR in 2nd experiment (green = 0 kills, red = 20 kills)

Thus in essence the rough parameter ranges of PC_ANGER x PC_FEAR that we had identified in the first experiment were confirmed to hold in the vignette with weapons as well.

We conclude that we have made a step forward in understanding the complex dynamics of the model and finding parameter ranges that allow us to model different group characteristics.

On the other hand, the soldiers' inability to control the situation in the violent scenarios shows the necessity to make the soldiers' behavior suitable also for larger scenarios with many incidents happening at the same time. This will require some coordination within and between different soldier groups and their respective leaders, not yet implemented in PAX, as well as a slightly enhanced vulnerability model allowing for the soldiers to better assess the harm that an aggressive action implies to the victim.

CONCLUSION

With regard to our goal of determining relevant factors for modeling different group characteristics in PAX3D we have found through our experiments that we are able to model a wide variety of different scenarios – from very peaceful scenarios to very violent ones.

Furthermore, we were able to identify distinct combinations of some of the PAX3D personality constants, among them especially the anger and fear personality constants, leading to extreme scenarios with regard to violence.

In follow-up experiments we will examine these parameter combinations in more depth with the goal of eventually being able to predefine specific agent templates with respect to the agent's or group behavioral characteristics – for example very violent and aggressive, moderate or peaceful civilians and groups. These "soft" attributes, while intuitive to the human reader (at first), are generally not easy to transfer into the hard technical variables of a simulation model. Therefore, we consider the work of IDFW19 a major step forward in this direction.

As a side effect of our studies during the week, it has once again become evident that in accordance with the question-based paradigm of the Data Farming concept a simulation model is and has to be built to answer specific questions. In our case, we conclude that when in the course of the scenario the situation turns into a combat-like situation, a model other than PAX3D might be better suited to represent this new situation, focusing on the combat aspects in addition to the social aspects of the scenario.

The Bundeswehr Transformation Center is currently investigating how far functionalities of combat-oriented models can be introduced into PAX to enhance the model in this direction, and to identify the cutting point where a scenario really requires a different model. Furthermore, in an operational synthesis approach as investigated by our team during IDFW16, PAX and more combat-oriented models could eventually complement each other in these types of scenarios.

In terms of further calibration of the model and scenario we found that the soldiers' behavior, while working well in small-scale ("micro") scenarios, needs to be further adapted for macro scenarios where many incidents happen at the same time. A basic notion of coordination between the different soldier patrols and their leaders, in our case, is seen as the foremost necessity for modeling this type of scenarios in order to retain a more realistic and sensible soldier behavior.

The results of IDFW 18 could be proven practically feasible for model calibration. The distinction of the model factors into three categories (see [2]) makes the calibration process more targeted: Internal factors are the "deepest" in the model and are to be calibrated to fixed values, ideally never touched again. Advanced factors are calibrated to fixed values or ranges, but the values depend on the scenario and thus requiring recalibration when the scenario changes. The variable factors finally represent the parameters available to the OR analyst and should be calibrated to reasonable ranges to achieve model feasibility depending on the scenario being analyzed. This categorization is considered essential for future calibration work.

To summarize, we have shown that to some extent we can classify the civilian group characteristics into rough templates and have identified parameter ranges for each template – moderate to highly aggressive – which will have to be narrowed down and divided further in the future. Beyond that, the soldiers in PAX will need additional abilities, such as coordination of squads or more realistic sensing and a situational awareness, which have both shown to be essential in larger scenarios.

Finally, the interdisciplinary, international and collaborative atmosphere during IDFW19 again guaranteed great work with valuable results! Special thanks to all team members for bringing in their expertise, work and time, and fun during the week – with one word: their MANA!

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