Cultural Modeling in a Game Theoretic Framework

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Abstract

"Training to Fight Insurgent Forces" (TFIF) is a training environment in which Marine and Coalition commanders can practice military tactics against realistic asymmetric forces. TFIF integrates a game theoretic approach to specifying enemy tactics. In a traditional game theoretic approach, the red and blue force actions and payoffs are modeled in payoff matrices, and a Nash equilibrium (1950; 1964) solution is computed. The solution concept we obtain from our game theoretic approach is a robust Nash equilibrium (2006).

The primary focus of this work is a battlefield environment in which Marines learn to fight asymmetric forces. In this environment, Marines are not practicing against forces like themselves, but against insurgent tactics that are commonly used by terrorist organizations. An insurgent's group's capabilities and desires are influenced by the group's resources, competitors, environment, and culture.

To develop insurgent tactics, we developed payoff matrices to encapsulate a group's capabilities and desires. Modeling these in a payoff matrix that is used to select insurgent tactics is difficult, due to uncertainty in payoffs. A payoff matrix may not include all possible actions, and exact payoff matrix values may not be estimated correctly.

We use two aspects to deal with this uncertainty in the game theory payoff matrices. One aspect is the use of payoff matrices that do not use point values, but rather use a point value and an uncertainty interval over it. The second aspect is the use of a simulation of the battlefield environment; this simulation models insurgent tactics with a distributed, culturally sensitive agent-based simulation that operates in a battlefield environment. With this simulation, we can play through choices made by a game theoretic approach in a simulation, and the values of these choices can be modified based on their effectiveness in the simulation.

By combining these two aspects, we can create an adaptive game theory payoff matrix system. To achieve this adaptivity, we randomly perturb the point values of the payoff matrices by small amounts, and the new Nash equilibrium leads to selection of different choices. These choices are then played out in the simulation. The effectiveness of these choices can be assessed by how closely a player in the game reaches his goals. This feedback is then used to modify the point values in the payoff matrices. This is one way that the game theoretic tactic selection process learns. Besides perturbing the payoff matrix, the system can also adapt by modifying the underlying simulation so that agents perform differently than how they performed during initial setup. For example, a group's shooting skills may improve over time. When this change plays out in the simulation, different tactics might become preferred. Integrating the game theory tactic selection to specify preferred insurgent tactics in response to blue force actions enables blue force commanders to see the immediate effect of their choices.

Another major issue that arises when modeling such large domains is runtime efficiency. Solving the whole scenario as a single large payoff matrix is computationally infeasible. We therefore use a hybrid approach where the actions are differentiated based on whether they occur simultaneously or sequentially. All simultaneous actions go into one payoff matrix; sequential actions are spread across different payoff matrices. The first step is to index actions based on the timestep when they are expected to occur. The simulation then progresses along this timeline; at each timestep, a matrix of simultaneous actions (which is much smaller than a single payoff matrix) is solved, and a robust Nash equilibrium is obtained.

References

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