Exploring Battlefield Tactics under the NCW Paradigm using Agent-based Models combined with Genetic Algorithms

[Extended Abstract]

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ABSTRACT

We present preliminary results obtained using a genetic algorithm (GA) combined with the MANA agent-based model to assist with devising tactics for military land-based operations.

Categories and Subject Descriptors

I.2.8 [**ARTIFICIAL INTELLIGENCE**]: Problem Solving, Control Methods, and Search—*Genetic Algorithms*; I.6.3 [**SIMULATION AND MODELING**]: Applications—*Military Tactics*

General Terms

Algorithms, Experimentation

Keywords

agent-based simulation, genetic algorithms, evolutionary programming, military tactics, artificial warfare, network centric warfare

1. INTRODUCTION

We present preliminary results obtained using a genetic algorithm (GA) to assist with devising tactics for military land-based operations [2]. Our genetic algorithm uses the MANA agent-based model [4] as its engine. Military entities, the agents in the model, are given chromosomes with each gene of a chromosome corresponding to an agent's personality weighting in the MANA model. Hence, the emphasis is on evolving clever behaviour and tactics.

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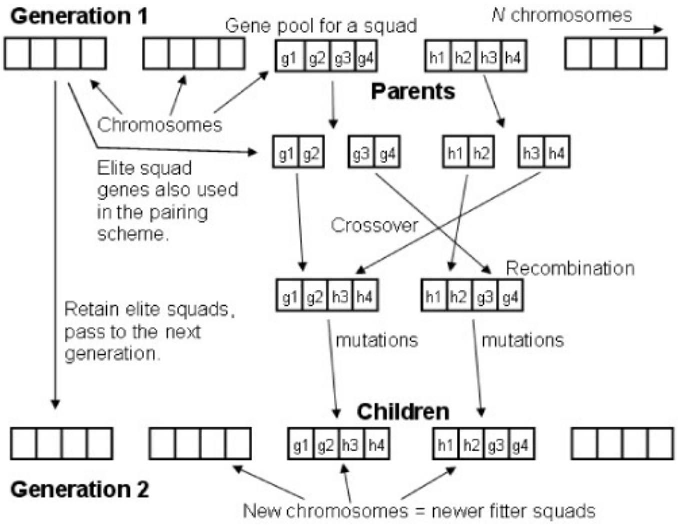

Figure 1: The genetic algorithm scheme. Here, $g_1, \cdots, g_4$ and $h_1, \cdots, h_4$ are genes corresponding to personality weightings in the MANA model, hence are integer valued.

Our GA scheme is illustrated in Fig. 1 [5]. For a particular squad in a MANA scenario, a population of equivalent squads is defined starting from a random gene pool. Each squad from the population is pitted against the scenario's enemy in turn to establish fitness values. Fittest squads are retained in the gene pool while less fit squads are allowed to fall by the wayside. Analogous to evolutionary biology, recombination of chromosomes is carried out to determine the next generation of squads. Repeating the process yields, typically after just a few generations, a superior squad which optimally solves the scenario at hand. In contrast to the binary genes found in evolutionary biology, the genes in our scheme (corresponding to MANA personality weightings) are integer valued. Using our GA scheme, we explore battlefield tactics when remote sensors and communication links between agents are provided. In the MANA

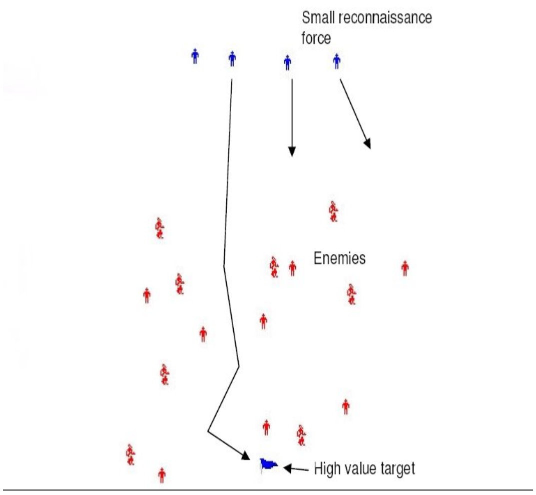

Figure 2: Reconnaissance/counter-reconnaissance scenario. The Blue force endeavours to stealthily find its way to the waypoint, representing a high-value target.

model, communication networks are simulated using squad situational awareness (SA) [1] which corresponds to sharing information within a squad. Squad inorganic SA is also used which corresponds to information received from communications links to other squads or remote sensors. This is intended to represent an environment where aspects of network centric warfare (NCW) may be explored. The emphasis of our study is on possible battlefield tactics enabled by network centricity, as opposed to, say, the engineering aspects of NCW.

2. EXPERIMENT

We have explored two different scenarios: (i) a reconnaisance and counter-reconnaisance scenario where a small expeditionary force attempts to acquire a high-value target inside enemy territory and (ii) a more conventional battle between two massed forces. For each scenario we keep all military hardware such as sensors and weapons characteristics fixed. The emphasis is on evolving effective squad behaviour and tactics using the equipment they have been given.

2.1 Reconnaisance Scenario and Results

The reconnaisance and counter-reconnaisance scenario is illustrated in Fig. 2 [3]. The fitness function used is a combination of reaching the waypoint in minimum time and sustaining minimum casualties. The strategy evolved using our GA scheme is for the reconnaissance squad to proceed slowly and temporarily retreat if enemy agents are encountered. They also disperse and used communications links to inform each other of the enemy whereabouts. In this way, at least one squad member can find its way through gaps in the enemy to acquire the high value target. Furthermore, being dispersed reduces the chances of all squad members being caught at a single location and shot. The dispersed nature of the squad therefore necessitates communication links to enable them to move coherently through enemy territory.

We also counter-evolved the Red force tactics to see if they could actively prevent the reconnaissance force from reaching the target. The strategy devised was for the Red force to spread themselves evenly throughout their area of concern and remain stationary. This prevented the reconnaissance force from sneaking through gaps which might inadvertently open up if Red force agents were to move about. Interestingly, we did not explicitly define the Red agent speed as an evolvable parameter. The genetic algorithm discovered an anomoly in the MANA model which fixes an agent in place if the range of its SA map regarding fellow squad members is set too low.

2.2 Conventional Scenario and Results

In the second scenario, two large infantry forces were pitted against each other. Each side was provided with a long range sensor to locate enemy agents and pass on this information through communications links. In the default case, both sides move towards each other and commence firing upon meeting until one side is defeated. The odds are 50:50 on which side wins. (Only direct fire weapons are used at this stage.) We then split the Blue force into 4 separate squads and provided them with additional communications links so that each squad can know the location of other friendly squads as well as the enemy. This scenario is illustrated in Fig. 3. Our GA scheme was then applied to

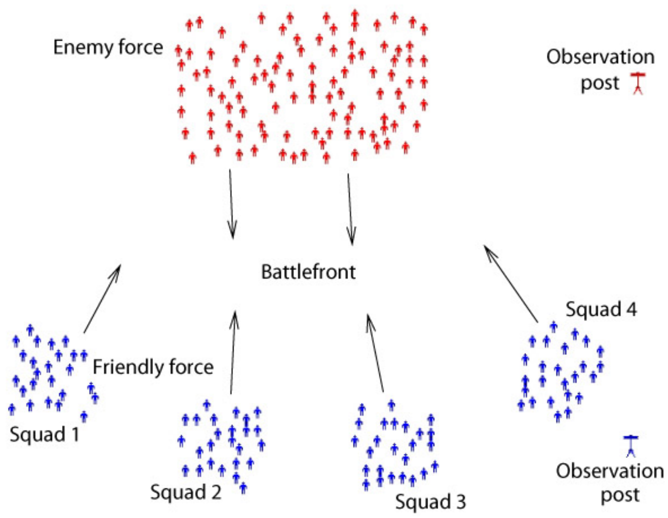

Figure 3: Confrontation between two armies. With all parameters between the two sides being equally matched, the Blue force is partitioned into 4 separate squads. Each side is given a long range observation post which provides information regarding the enemy location.

find tactics which could allow the Blue force to gain some advantage over the Red force given their more flexible force structure. Tactics evolved by the Blue force are illustrated in Fig. 4 and correspond to a standard flanking manouver. Two of the Blue squads adopted a more passive stance. They maintained a slight stand-off distance from the enemy

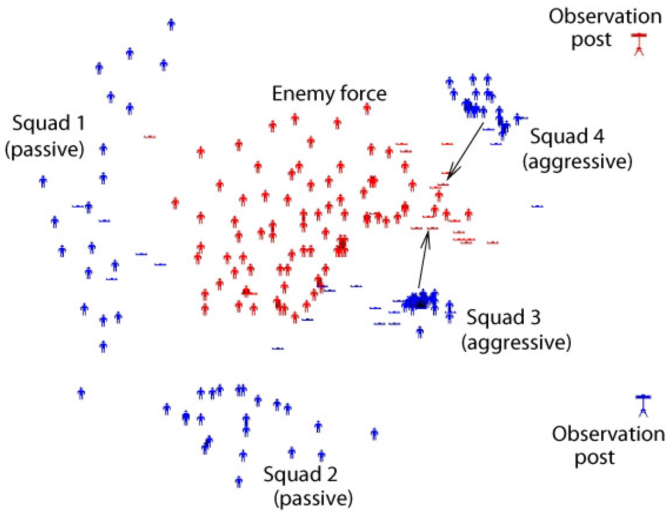

Figure 4: Tactics evolved by the Blue force in Fig. 3. A standard flanking manouver has emerged. The two passive squads hold the enemy in check while the remaining agressive squads have swung around and applied concentration of fire power at one flank.

and were able to help keep the enemy occupied and fixed in place. The remaining two squads adopted more aggressive behaviour. They swept around one flank of the enemy and, in a pincer-type movement, pressed their attack into the edge of the enemy where local numerical superiority could be achieved. This allowed the Blue force to bleed off the Red force and eventually gain the upper hand. We re-iterate that communications links were an essential enabler for these tactics since they allowed the Blue squads to maintain relative positions with respect to each other and the enemy.

2.3 Excursions

Finally, we briefly explored the consequences of the Red force's communications links becoming disabled, expecting that this would provide some advantage to the Blue force. Interestingly, we found situations where this could actually be harmful to the Blue force. For example, the information advantage attained by the Blue force meant that they actively chased the Red force to the boundary of the battlefield, whereupon they were lured into a trap and surrounded by the Red force.

3. FUTURE WORK

Our planned work includes generating tactics within the above scenarios using an evolutionary programming algorithm with only a mutation operator and comparing those tactics with the tactics generated by the genetic algorithm. Our objective is to understand the relationship between the differing representations and the tactics generated and what impact algorithm parameters have on the overall process. It is hoped that the evolutionary scheme can assist us to uncover new tactics enabled by the 21st century technology.

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