An Abstraction Hierarchy of Battlefield Agents

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Abstract

We are working on agents for use within land battlefield simulations to provide automated opposing force for trainees. Our system incorporates a command hierarchy of agents which make decisions at varying levels of abstraction. We are interested in investigating abstractions of the decision space for these agents to produce plausible behaviour operating in real time.

Introduction

To reduce the manpower needed to operate large and complex simulations there is a need for intelligent agents to populate the simulated battlefield with realistic opposing and supporting forces. Considerable work has been done on Semi-Automated forces but to produce agents capable of operating unsupervised for long periods of time more flexible approaches to automation are needed.

Planning within the battlefield domain is an extremely complex task. Most of the variables which characterise the problem (position, time, speed etc.) are continuous and highly dynamic. The actions of numerous other battlefield agents, both friendly and hostile need to be considered since any plans which are made are likely to produce intelligent counter moves from opposing forces. The future, and to some extent the present, state of the battlefield is uncertain due to the possible destruction of other agents and potentially inaccurate sensor information. Clearly, directly applying methods such as game theory are of limited use as the possible actions are unbounded and the results of a 'move' uncertain. The approach therefore needs to be able to discretise the options available and provide a means for reasoning about their effectiveness under uncertainty.

We have chosen to base our approach on a hierarchy of agents modeled on the military command and control (C^2) hierarchy. Not only does this help in knowledge gathering and verification but it provides an abstraction hierarchy which can divide up problems into smaller sub-problems at differing levels of detail.

The Command Structure

The command hierarchy used by the agents is shown in Figure 1 and is based upon the military command structure. It serves three main purposes, first by organising agents into groups along the same lines as the military formations they are trying to emulate the chance of getting plausible group behaviour is increased, second it provides a framework to guide the communication between agents and third it allows the planning of complex group orders to be divided up into several smaller problems.

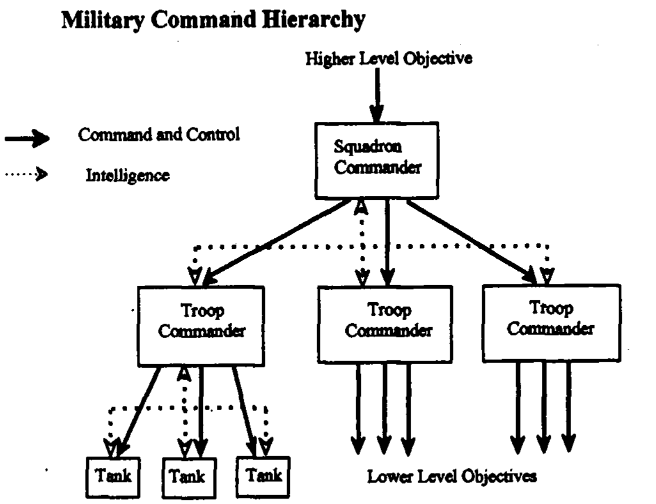

Figure1. Military Command Hierarchy

As the diagram shows a single high level objective passed to the squadron commander agent is split up into three lower level objectives for its troop commanders who in turn each produce three lower level objectives for the tanks under their command. The commander agents consider ways of achieving their objective over longer time scales and distances than the level below them, but in less detail.

Communication of orders passes straight down the hierarchy while intelligence information is shared between peers and communicated to superiors and therefore flows both across and up the hierarchy.

Command roles

The commander agents must carry out a number of functions. They are responsible for gathering information about their own situation and passing it up the command chain to their superior and to their peers. Troop commanders for instance relay information to the Squadron commander, and the commanders of other troops in the squadron, about the position of their troop.

The commanders are responsible for giving orders to their subordinates to achieve the orders given to them. They are also required to monitor the progress of the group towards achieving those orders and report to their superior once they have been completed. To fulfill this role they need to be able to reason about how their local situation affects the orders they have and plan to achieve them. They also have to ensure that their subordinates know enough about the orders given to the group so that they can take over as commanders in the event of the commander's demise.

Discussion

We believe that the command hierarchy provides a natural way of splitting up the problem of controlling large numbers of simulated entities. All agents have to make decisions on the uncertain information they have about the state of the world but the size of the problem space and the need to operate in real time makes the use of meaningful abstractions vital. So far in our work we have explored the use of a state space abstraction, searching for plans in the space of potential actions for individual tanks, and abstraction of the terrain model for anytime route planning and locating defensive positions. The simulated battlefield domain is a challenging one and as we investigate the operation of agents higher up the command chain decisions will be made at an increasingly abstract level.

These decisions, however, will need to be executed by other agents in the 'real' world where any faults in the abstraction will soon become apparent.