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Continuous Planning and Collaboration for Command and Control in Joint Synthetic Battlespaces

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ABSTRACT: *In this paper we describe our efforts to model command and control entities for Joint Synthetic Battlespaces. Command agents require a broader repertoire of capabilities than is typically modeled in simulation. They must develop mission plans involving multiple subordinate units, monitor execution, dynamically modify mission plans in response to situational contingencies, collaborate with other decision makers, and deal with a host of organizational issues. We describe our approach to command agent modeling that addresses a number of these issues through its continuous and collaborative approach to mission planning.*

1. Introduction

Two of the challenges in modeling command and control (C2) entities in a Joint Synthetic Battlespace (JSB) are to provide operational realism and cost effective deployment of these entities. The lack of realism in existing synthetic C2 forces usually stems from being unable to: (1) behave in a goal-directed manner, particularly in situations not strictly covered by doctrine; (2) dynamically modify mission plans in response to a situational contingency; (3) collaborate in group decision making and behavior; and (4) vary organizational behavior by modeling differences in role, organization, and perspective among individual entities. To be cost effective, synthetic C2 forces need to: (5) behave autonomously, reducing the requirement for human control in JSB exercises; (6) represent a wide range of organizations and scenarios. In this paper we describe our efforts to support such abilities through the development of a flexible, integrated model of C2 behavior involving multiple echelons in the domain of Army Attack Helicopter Battalion operations. Here we focus on two key aspects of the behavior required to accomplish this goal: *continuous planning* and *collaborative behavior*.

Continuous Planning

To realistically model C2 behavior requires a continuous planning capability. Planning is a reasoning process that generates an ordered set of tasks from a goal description (addresses issue 1). For the purposes of modeling the C2 activities in a JSB, it is not sufficient to establish a mission plan, launch the aircraft, and wait until the aircraft return to determine success. Plans sometimes fail, situational interrupts (mission exceptions) occur, and opportunities arise, all making it necessary to re-plan the mission during the execution phase. C2 entities must continually assess the situation, monitor the execution of mission plans, and react to conditions affecting their goals and plans before and during the mission by dynamically replanning so that their goals may be achieved in new situations (issue 2). When a continuous planning capability is combined with a sufficiently deep domain theory of air operations, C2 entities become more capable of autonomous behavior (issue 5), covering a wide range of scenarios (issue 6).

Collaborative Behavior

Mission planning and execution is a collaborative enterprise (issue 3) involving C2 entities distributed across multiple echelons. Not only must these entities be capable of continuous planning, but they must also model each other's goals (issue 1) and plans, and reason about how decisions they make will affect others. Factors such as the entity's role, perspective and the "management culture" of the organization will affect the content and form of communications among [14], and will ultimately change the overall behavior of the organization (issue 4). Without collaboration, autonomous group behavior is not possible (issue 5). Like continuous planning, collaboration requires an understanding of C2 operations domain, to include models of domain-specific C2 communications, organizations, and relationships. Given these models, it is possible to represent a range of different organizations (issue 6).

This combination of capabilities has been developed in constructing the Soar cognitive architecture [12]; intelligent forces (IFORs) for individual synthetic aircraft; and command forces (CFORs), which command organizations of individual aircraft. We have developed and demonstrated these capabilities within the domain of the Army Attack Helicopter Battalion. We will illustrate the capabilities of our system with examples from this domain.

2. Related work

Before proceeding to the technical details of our approach, it is useful to set some context by contrasting our methods with alternative simulation technology. Prior models of planning have almost exclusively focused on the problem of plan generation, without consideration of the dynamics of how the plan would be executed or modified. For example, the Defense Advanced Research Projects Agency's (DARPA) JFACC program has supported planning tools that focus primarily on plan generation and plan evaluation. In contrast, models that do account for dynamics tend to focus exclusively on reactions to the exclusion of deliberate planning. For example, the finite state models used by semi-automated forces (SAFs) are excellent for reacting to immediate threats, but require a human in the loop to ensure goal-directed behavior. Each of these extremes can be reasonable (the JFACC has many hours to generate and perfect a plan, whereas individual vehicles often must immediately react). However, modeling forces at the company and battalion level (where C2 can make the most timely use of enhanced situation monitoring platforms) requires tight integration of plan generation, plan execution/monitoring, and plan repair.

Modeling C2 nodes also brings to the forefront organizational issues that have been largely ignored in past simulation efforts. SAF models rely on human controllers to de-conflict interactions between units and to manage coordinated activities. However, as we extend simulation to higher levels of command, we must model the reasoning involved in coordination. For example, when an battalion commander adjusts a mission to the evolving situation, he must coordinate his various subord