Learning Agents for Improved Efficiency and Effectiveness in Simulation-Based Training*

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1 Problem Statement

Team training in complex domains often requires a substantial amount of resources, e.g., instructors, role-players and vehicles. For this reason, it may be difficult to realize efficient and effective training scenarios in a real-world setting. Instead, intelligent agents can be used to construct synthetic, simulation-based training environments. However, building behavior models for such agents is challenging [1], especially for the end-users of the training systems, who typically do not have expertise in artificial intelligence. In this PhD project, we study how machine learning can be used to simplify the process of constructing agents for simulation-based training. As a case study we use a simulation-based air combat training system. By constructing smarter synthetic agents the dependency on human training providers can be reduced, and the availability as well as the quality of training can be improved.

2 Proposed Approach and Research Questions

In this work, we intend to study two major categories of synthetic, learning agents: A *Synthetic Trainer Agent* and a *Scenario Adaptation Agent* (see Fig. 1). The purpose of the *Synthetic Trainer Agent* is to act as a player in simulation scenarios, and interact with the human trainees while considering their training needs. The purpose of the *Scenario Adaptation Agent* is to observe the past performance of human trainees, infer their current training needs, and then adjust simulation scenario characteristics accordingly. To construct these agents we are studying a combination of Reinforcement Learning (RL) [7] and agent modeling techniques.

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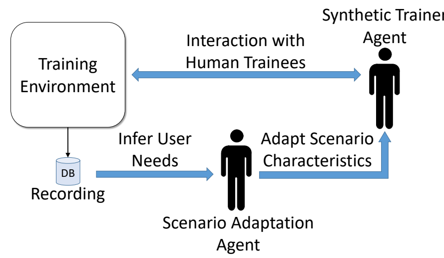

Fig. 1. Agents and interactions.

Many applications of RL algorithms focus on achieving superhuman performance on a given task. In our work, the goal is instead to construct learning agents whose behavioral characteristics can be adapted to the level of proficiency and current training needs of humans, which may vary among runs of the simulation. For this purpose we use Multi-Objective Multi-Agent Reinforcement Learning (MOMARL) [6], which allows agents to learn how to cooperate and compete in groups, while considering multiple conflicting objectives. Preferences among objectives may be dynamic. By defining suitable utility functions over the objectives, agents' characteristics and goals can be adjusted to current needs. To allow synthetic agents to model and understand the capabilities, beliefs and goals of other agents in the system, we are studying, e.g., computational theory of mind [5]. Challenges in our application domain of air combat training include high-dimensional state and action spaces, partial observability, and a mixed cooperative and competitive setting with many human as well as synthetic agents.

We will try to answer the following overarching research questions:
RQ1: How can agents learn to act as synthetic trainers for human trainees?
RQ2: How can agent characteristics be automatically adapted to fit the training needs of an individual trainee?
RQ3: What is required for human and synthetic agents to interact effectively in a simulation-based training environment?

In our initial work we have identified efficient approaches for reinforcement learning in our application domain [3], and studied multi-objective and multi-agent learning in simplified as well as high-fidelity simulations [4, 2].

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