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Chapter V

Continous Planning for Virtual Environments

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ABSTRACT

This chapter discusses the application of intelligent planning techniques to virtual agent environments as a mechanism to control and generate plausible virtual agent behaviour. The authors argue that the real world-like nature of intelligent virtual environments (IVEs) presents issues that cannot be tackled with a classic, off-line planner where planning takes place beforehand and execution is performed later, based on a set of precompiled instructions. What IVEs call for is continuous planning, a generative system that will work in parallel with execution, constantly re-evaluating world knowledge and adjusting plans according to new data. The authors argue further on the importance of incorporating the modelling of the agents' physical, mental and emotional states as an inherent feature in a continuous planning system targeted towards IVEs, necessary to achieve plausibility in the produced plans and, consequently, in agent behaviour.

INTRODUCTION

Intelligent planning has been widely applied in agent environments as a means to provide a high-level reasoning mechanism that decides and generates agent behaviour. The majority of the work produced so far adopts the classic off-line planning paradigm (first plan thoroughly, then act following plan), based on the assumption that the world

state remains unchanged throughout the whole planning and acting phase, while also the agent is supposed to have detailed knowledge of the world state as well as the effects of its actions (Aylett, Coddington & Petley, 2002; Pollack & Horty, 1998; Pollack & Horty, 1999). These assumptions were necessary in order to restrict the complexity of an otherwise intractable problem, so that investigation into the research area could be conducted.

Although the off-line planning paradigm is appropriate for a number of applications where conditions are controllable and the problem domain is fairly limited, there is a wide range of research and practical fields where it proves inadequate. Real-world domains, such as multi-agent societies or robotic environments, present continuous change and the occurrence of events that off-line approaches cannot cope with. Features such as external events, interaction among multiple entities located in the world or action execution failures make it impossible for a classical planning algorithm to deal with the problem.

Requirements such as the above have led the research community over the past few years to introduce architectures that interleave planning, execution and monitoring in order to provide for the needs of inherently dynamic domains.

Such a domain is intelligent virtual environments, synthetic worlds inhabited by graphical agents who have to interact with the environment and demonstrate some sort of behaviour. Intelligent planning seems a particularly suitable technique to provide virtual agents with high-level reasoning capabilities, however, because of the special features virtual environments present, an appropriately designed approach has to be adopted.

OFF-LINE PLANNING

Traditional Assumptions of the Classical Off-Line Planning Paradigm

Intelligent planning has been one of the most active areas of Artificial Intelligence since the early seventies. Research has gone a long way forward from the seminal STRIPS planner of Nilsson and Fikes (Fikes & Nilsson, 1971), resulting in advanced plan graph analysis approaches like Graphplan and its derivatives (Blum & Furst, 1997; Long & Fox, 1998), or fast heuristic approaches like HSP (Bonet & Geffner, 2001). The primary aim driving planning research throughout almost the whole of the past three decades was the quest for optimisation, either in terms of ability to solve complex problems or in respect to some evaluation factor, usually the number of steps required to reach the goal state from the given initial state.

Regardless of the technique utilised, the majority of planning systems are disconnected from execution, assuming a single planning phase during which a plan is produced to be later executed by a separate execution system. This classic, batch technique is known as *off-line* planning.

There is such a variety of factors affecting a planning process that, in a generic form, planning problems are considered intractable. The complexity of planning problems had to be limited in order to allow research attempts to start with a version of the problem that is easier to tackle. Therefore, various aspects of the planning problem such as time or