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An agent specific planning algorithm

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ABSTRACT

Planning algorithms are often applied by intelligent agents for achieving their goals. For the plan creation, this kind of algorithm uses only an initial state definition, a set of actions, and a goal; while agents also have preferences and desires that should to be taken into account. Thus, agents need to spend time analyzing each plan returned by these algorithms to find one that satisfies their preferences. In this context, we have studied an alternative in which a classical planner could be modified to accept a new conceptual parameter for a plan creation: an agent mental state composed by preferences and constraints. In this work, we present a planning algorithm that extends a partial order algorithm to deal with the agent's preferences. In this way, our algorithm builds an adequate plan in terms of agent mental state. In this article, we introduce this algorithm and expose experimental results showing the advantages of this adaptation.

1. Introduction

Intelligent agents are autonomous entities that interact with their world for achieving their goals. Actions that are carried out for the intelligent agents are deliberate, i.e., actions made with the purpose of achieving goals. Planning algorithms are often applied for this purpose. This kind of algorithm allows building an action plan from the initial state of the world, a desired final state, and a set of actions that can be performed by the agent (Blum & Furst, 1997; Fikes & Nilsson, 1971; Weld, 1996).

The needs of the intelligent agents are not totally meted with the usual way of applying these algorithms. Agents invoke these algorithms by sending an initial state, a final state, and a set of actions that they can perform. The planner, from these data, returns a plan that achieves the final state, as long as a feasible plan exists. The problem detected with this way of interaction is that, in each generated plan, the agent's mental state is not considered. The mental state of the agents provides mental attitudes such as preferences and desires. These mental attitudes distinguish one agent from another, as well as the same agent at different times (Rao & Georgeff, 1995; Shoham, 1993). Thus, this changing parameter is avoided in classical planners, which becomes a problem for agents.

For illustrating this problem, we present the following situation. An agent invokes a planning algorithm with the following goal to be achieved: *goal*(*box*(182,'*London*')), specifying that the agent wants the box 182 to be in London. For achieving this goal, there are several feasible plans that an agent can follow. However, if we consider the agent has specified *preference*(*visit*('*Birmingham*'),9) showing that the agent has a high preference (9/10) to visit Birmingham, a plan that goes past Birmingham will be more acceptable for the agent than one that does not consider this stop. Moreover, if visiting Birmingham is a pending objective the importance of a plan that uses Birmingham as an intermediate stop is still higher since another objective would be accomplished, although this objective is not part of the initial proposal.

Nowadays, an agent should analyze the first plan generated by a planning algorithm to evaluate the degree of compatibility with its mental state. If the plan is not acceptable in relation to the agent's preferences, the agent asks over and over again for another solution until he finds one that is good enough. The process finishes when the agent accepts one solution or decides to reject all of them. Fig. 1 illustrates these cases.

For solving the above mentioned problems, we have first analyzed the existence of some way that could help agents in their planning processes. An obvious alternative is including the agent's desires as preconditions of actions used in the planner and in its initial state definition. Although this alternative is a solution, it is a static one. A change in the agent's mental state implies changes in action definitions. Basically, the question is that the problem definition contains elements that represent the agent preferences with regard to the solution. These elements are not relevant for the problem description but are essential at the time of searching for a solution. When the agent's interest changes the developers need to re-code basic parameters in the problem definition.

Therefore, agents need specific algorithms that deal with their desires. This is the approach we decided to follow. In this context,

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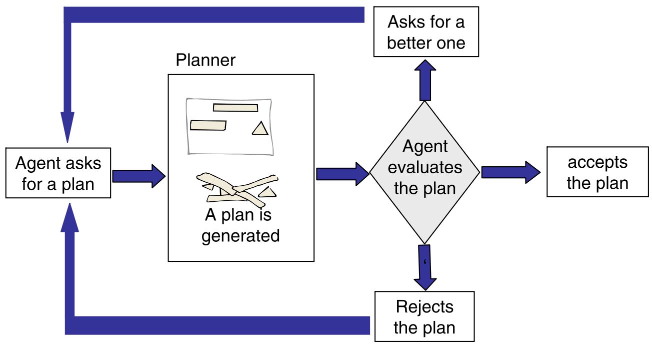

Fig. 1. Feasible cases present in the planner–agent interaction.

some proposals from the fifth International Planning Competition IPC-5 (Baier, Bacchus, & McIlraith, 2007; Baier, Hussell, Bacchus, & McIlralth, 2006; Edelkamp, 2006; Edelkamp, Jabbar, & Naizih, 2006) were useful to address our work. These algorithms consider constraints during the planning process based on an extension of the language PDDL (Gerevini & Long, 2006). PDDL3 preferences are highly expressive. However, they are solely *state centric*, identifying preferred states along the plan trajectory (Sohrabi, Baier, & McIlraith, 2009).

At this point, we had two big categories of planning algorithms to consider: those centered on the plan space and those centered on state space. We decided to start attacking the problem by working on the plan space centered algorithms because they build partially ordered and partially instantiated plans that are more explicit and flexible for execution (Ghallab, Nau, & Traverso, 2004), which are particularly important in the environment of autonomous agents. Thus, we started with UCPOP algorithm (Weld, 1994), building our Ag-UCPOP.

Ag-UCPOP considers preferences and constraints in plans that try to achieve the agents' goals. We decided to use a simple specification of these mental attitudes. A more complex mental state definition can be incorporated with little impact. We focused our work on analyzing the viability of our approach of agent-specific planning algorithms, at least in plan space centered algorithms.

Consequently, we have obtained a planning algorithm that generates solution plans, thus trying to satisfy preferences and constraints of agents. An acceptable plan for an agent has linked a set of mental attitudes that comply with them. Any change of these preferences and constraints during a plan execution could be considered the trigger for changing the plans.

The article is organized in the following way. Section 2 presents an overview of Ag-UCPOP algorithm. Section 3 exposes details of Ag-UCPOP algorithm. Section 4 shows experimental results. Section 5 analyzes related works. Finally, in Section 6 the work conclusions are discussed.

2. Overview of Ag-UCPOP algorithm

In this section, we introduce our approach with a practical example, which shows how the agent's mental state influences the generation process of a solution and the final result. We use a simple version of the mental state that only considers preferences and constraints. We did this in order to focus the presentation on the algorithm. We only show how the attitudes can improve the plan quality without confusing the explanation with the complexity of the mental state's formalisms.

In the following subsections, we present the key parts of the Ag-UCPOP, these will be explained in the rest of the paper.

2.1. Practical scenarios

As mentioned above, the proposed solution consists of taking into account the agent's mental state in the plan conception. Fig. 2 shows an example in which the plan solution changes when the agent's mental state is considered in the plan generation. The formulated problem is the transportation of a man (called '*John*') from one city to another (in this case the starting point is a city called *a* and the destination is a city called *c*). In this example, it is possible to use two different cars (called *c1* and *c2*) for the transportation of the boxes from one city to another.

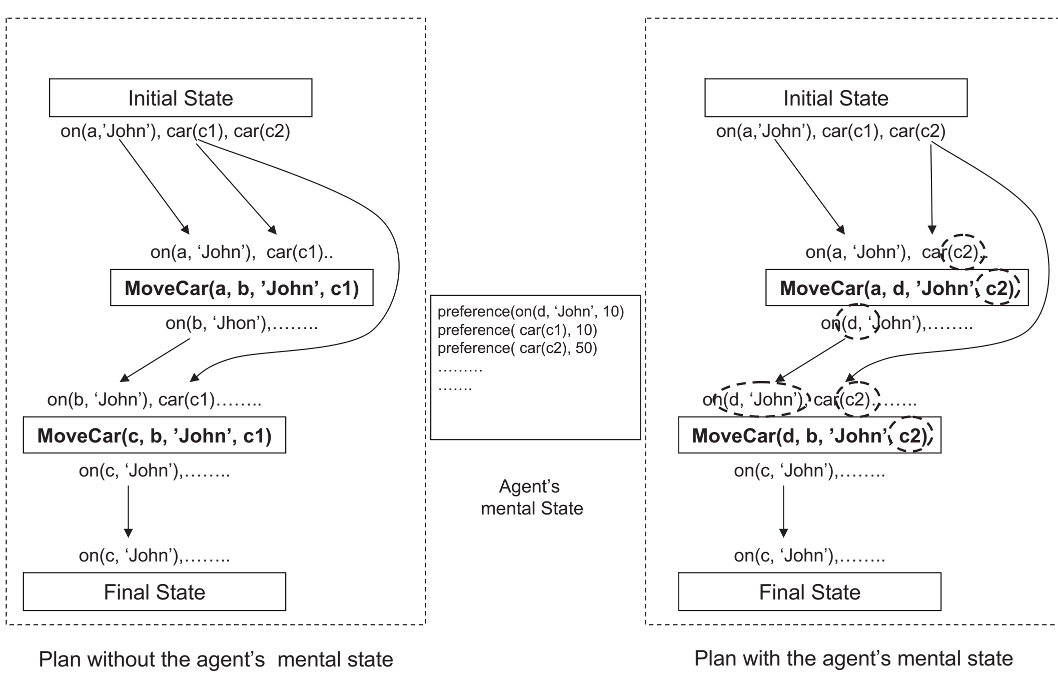

Fig. 2. The importance for considering mental states in planning.