Modeling Cooperating Agents Scenarios by Deductive Planning Methods and Logical Fiberings

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Abstract. We describe a small but non-trivial 3-agent-robotics scenario by two different methods, viz. resource-oriented deductive planning and logical fiberings. The ultimate aim is to find a semantics for planning methods by means of fiberings. To this end, a comparison of the two methods is made and illustrated by the sample scenario, and the correspondences between the basic notions for both methods are clarified. The fiberings method is found to be useful in modeling communication and interaction between cooperating agents, thanks to the local/global distinction that is inherent to this framework. Possible extensions of the framework, like e.g. formulas dependent on space and/or time, are discussed.

1 Introduction

In this paper we set out to provide a semantics for planning methods (in particular resource-oriented disjunctive planning) by logical fiberings, a concept which we have transferred from classical fiber bundle and sheaf theory.

First, a scenario consisting of three robots solving an assembly problem is described. It contains several problems of practical relevance, such as uncertainty about the reason for a failure and disjunctive postconditions of a (part of a) plan, corresponding to non-determinism. Technical details such as precise descriptions of movements have been omitted in order to make the basic problems clear. For a complete description, we refer to [20], where the scenario is presented in much more detail.

After describing the scenario, two approaches to modeling it are given, one based on the method of deductive planning (cf. [4, 8]) and one based on the method of logical fiberings (cf. [18, 19]). The planning model employs conditional planning (because the robots cannot always be sure about the cause of mistakes) and is resource-oriented. The description by logical fiberings is a new attempt to formulate planning problems in a uniform semantical notation. Here, we are proposing a general modeling method which we call the "generic modeling approach". The scenario discussed here is essentially a control problem (the

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underlying plan is not generated by the robots but prescribed in the specification of the actions), but from the descriptions it will be seen that both approaches are amenable to deal with more complicated robotics scenarios as well. Actually, what we present here is the starting point for a program of work. We fix the notions and test them with a sample scenario. Improvements have to follow as experience grows.

We then describe the connection between the two methods (planning and logical fiberings), and it is shown how actions with their pre- and postconditions correspond to multivariate transjunctions between logical systems, motivated by [18]. It turns out that the fiberings approach allows for a natural way of dealing with conflicting intentions of the robots (cooperating agents). We explicitly model a (logical) state space for each individual agent. This state space is formally presented in terms of a corresponding fiber. The collection of all fibers is the global state space. Specifically, the concepts of local and global sections allow a natural switch of perspective from the individual to the cooperative point of view. In this sense, the mathematical notion of a section gives us a "snapshot" of the current state of the system.

There are various ways to extend the modeling approach presented here. One of them is the introduction of space/time-dependent formulas, on which we touch towards the end of the paper. Another objective is to incorporate the concept of hierarchical planning in the fiberings approach. Another important issue is mirroring actual plan generation (by SLDE-resolution) in the fiberings approach. Further investigations should lead to providing the planning approach with a complete semantic foundation based on logical fiberings.

We would like to thank the referees for suggesting to include some remarks concerning links of our work to the huge field of *distributed AI.* We are aware that distributed AI is an active area of research and that the general "cooperating agents problem" appears in many disguises in various disciplines. We are not experts in distributed AI, but we see that our work has links to it since our approach also attempts to model cooperating agents in a robotics scenario concentrating on logical control and planning issues. Unfortunately we do not feel competent to give here a brief comment on the latest state of the art and mainstream research topics in distributed AI — we are very sorry. Instead we can report that after the talk of the first author on "Logical Fiberings and Polycontextural Systems" at the conference FAIR'91 (Smolenice Castle, Slovakia), Jozef Kelemen discussed with the first author. The question was in which respect the logical fiberings concept can contribute to the mathematical foundations of distributed AI. We conclude by citing the following selected references: [3, 5, 7, 11]. One of our objectives in our future program of work is, among others, to get in to closer contact to those activities which have natural links to our work.