

# Project 3 – Developments in the field of AI Planning and Search

## Research Review

### 1 Introduction

According to *Russell-Norvig*<sup>[3]</sup> three of the most beneficial approaches to automated planning are the concepts of linear planning, interleaving and binary decision diagrams. For each of these major approaches representative developments are presented here.

### 2 Linear Planning

In the early 1970s planners were based on the concept of linear planning<sup>[4]</sup>. Most of these planners were written in the language used for the STRIPS (**S**tanford **R**esearch **I**nstitute **P**roblem **S**olver)<sup>[1]</sup> or a derivate of it. Action sequences used in these linear planners were totally ordered. The workflow of the problem decomposition was dependent on computing subplans for every subgoal, which thereafter were connected in the same order to each other. However, linear planning can't solve some very simple problems like the Sussman anomaly<sup>[5]</sup> and is therefore incomplete in its applicability.

### 3 Interleaving

In order to overcome the problem stated above, planners must be able to process interleaving of actions from different subplans within a single sequence. A solution was provided by *Warren*<sup>[6]</sup>. *Warren* implemented his approach in the *WARPLAN*, which solved the problem by using goal regression planning. Goal regression planning reorders steps in a totally ordered plan in a way where conflict between subgoals is avoided. The invention of interleaving was a milestone in the development of partial-order planning.

### 4 Binary Decision Diagrams

While partial-order planning dominated research for about two decades, in the last two decades the representation of plans in binary decision diagrams (BDD) has become more

and more popular. A BDD is a compact representation of a Boolean function, which is used to define properties and relations in decision trees<sup>[2]</sup>.

## 5 Conclusion

The three approaches discussed above had a deep impact on research and development in the field of planning and search. While linear planning was the initial standard in this field, the introduction of interleaving approaches improved the applicability of planning and search. Dependent on the problem BDDs can be useful to find a solution for specific planning problems more efficiently, but may also require a higher calculation capacity due to the possible complexity of the related decision tree.

## References

- [1] Fikes, R. E., Nilsson, N. J. (1971). „STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving“ (PDF). Artificial Intelligence. 2 (3–4): 189–208. doi:10.1016/0004-3702(71)90010-5.
- [2] Lee, C. Y. (1959). „Representation of Switching Circuits by Binary-Decision Programs“. Bell System Technical Journal, 38:985–999.
- [3] Russell, S. J., Norvig, P. (2010). „Artificial Intelligence: A Modern Approach“. pp. 1152 (3rd Ed.). ISBN: 0-13-604259-7.
- [4] Sacerdoti, E., (1975). „The Nonlinear Nature of Plans“. International Joint Conference on Artificial Intelligence. pp. 206-214.
- [5] Sussman, G.J. (1975). „A Computer Model of Skill Acquisition“. Elsevier Science Inc. New York, NY, USA. Book version of his PhD thesis.
- [6] Warren, D. H. D. (1974). „Warplan: A System for Generating Plans“. Issue 76 of DCL memo. Department of Computational Logic, University of Edinburgh.