

# Ginsberg Replies to Chapman and Schoppers

## Universal Planning Research: A Good or Bad Idea?

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Rather than begin by discussing the points where I seem to be in disagreement with Chapman and Schoppers, let me start with something about which we seem to concur: The work on reactive plans can be broken into two parts. First is the work on pure reactive plans, which specify actions for an agent to take in all situations. Second is the work on caching reactive plans, which specify actions in only some instances and are primarily used to store the results of previous planning activity. Although Chapman would object to the use of the word plan, the basic distinction is one that his reply appears to sanction.

Strongly put, the argument in my initial article boiled down to two claims. First, research on pure reactive plans is unlikely to have significant impact on AI because pure reactive plans cannot be used as an architecture on which to build a cognitive agent. Second, current research on caching reactive plans is unlikely to have significant impact on AI because the researchers are not addressing interesting problems.

Chapman disagrees with the first of these claims, and Schoppers disputes the second (and also the first, although only halfheartedly). Let me discuss their arguments individually.

### Pure Reactive Plans

I made two arguments to support the claim that pure reactive plans will have little lasting impact on AI. First, in the abstract, it is extremely unlikely that the desired behavior of an intelligent artifact can be captured in a pure reactive plan, simply because there are too many possible behaviors that one might wish to capture. Second, pure reactive plans cannot improve their performance by expending additional computational

resources, a property which appears to be crucial to intelligent behavior.

Neither of the respondents addresses the second point at all. With regard to the first, Schoppers suggests there is good reason to believe that the desired behavior of an intelligent agent can be modeled with a pure reactive plan (his answer 2, although he discounts the entire issue in answer 5). Chapman, however, appears to argue that although optimal behavior cannot be realized in a pure reactive plan, perhaps it will be possible to obtain behavior that is good enough.

Schoppers' argument is based on the fact that to date, no problem has been found that is provably nonpolynomial in its input. However, in light of the fact that whether  $P = NP$  is an open question, this is hardly a surprise. There are many problems that we expect to be nonpolynomial in their input—almost all AI has this property. Consider a version of the traveling salesman problem in which you are given intercity distances and your initial location, and you need to respond to the Boolean question, "Should I visit City One next?" I cannot prove that no polynomial-complexity circuit can be constructed to answer this question, although I certainly expect the problem to be exponentially difficult. I find Schoppers's argument completely unconvincing here.<sup>1</sup>

Chapman's is more interesting. Essentially, his research program is to investigate experimentally the boundary of the set of problems that can be usefully tackled using pure reactive plans. My objection about the inability of such architectures to incrementally improve their performance stands, but the question is fundamentally an experimental one. Although I am pessimistic about the results, I applaud the efforts of Chapman and others (such as Rod Brooks) in pursuing this idea.

*... pure reactive plans will have little lasting impact on AI.*

*My argument here is not that caching is a bad idea but that current research on caching reactive plans is poorly focused.*

Indeed, Chapman shows in his reply that a problem I had thought to be outside the scope of pure reactive planners (the fruitcake problem) can, in fact, be solved by them. Perhaps I should have expected this—after all, the fruitcake problem lacks the property of incrementality that I have mentioned—but the fact is I did not, and Chapman’s result is an interesting one.

### Caching Reactive Plans

Caching reactive plans is discussed by Schoppers only. My argument here is not that caching is a bad idea but that current research on caching reactive plans is poorly focused. Schoppers seems to have missed this point entirely and spends the bulk of his reply to my original article arguing that caching is a good idea. How could I disagree?

The argument I made in my original article was not that caching was a bad idea but that research on the data structures used by the caching mechanism is a bad idea. This argument applies equally well to Schoppers’s universal plans and Nilsson’s action nets.<sup>2</sup>

Schoppers’s argument against this view (his answer 8) is that the results of his research show a domain of  $10^{12}$  states can be covered with  $10^8$  decision rules.

So what? I expect that I take about one cognitive action per minute. If we consider Schoppers’s two examples of driving and making tea, it takes me about a minute to make a cup of tea, and I expect that I “do something” about once a minute while driving. Thus, my domain effectively has about  $10^7$  states (I have been alive for that many minutes) instead of  $10^{12}$ . Storing  $10^7$  actions is not prohibitively expensive, so that reducing this number to  $10^5$  or so is unlikely to be of much value in practice.

However, let us suppose for a moment that Schoppers is right and that we have, in fact, precomputed actions for many more states than my estimate of  $10^7$ . It is still the case that for Schoppers’s work to have any relevance at all, we need to have a way to gener-

ate the  $10^7$  or more plans that he proposes to cache; it is clear that manually generating these plans is out of the question.

Roughly speaking, then, the argument is as follows: First, in the absence of machine generation of plans or action decisions, it is inconceivable that advances in caching technology will have a significant impact on the performance of AI systems. Second, even in the presence of machine generation of plans, it is unlikely the number of plans generated will be large enough for advances in caching technology to be significant to the AI enterprise.

Work on caching technology is definitely not of use at the moment and is unlikely to be of use in the future.

Schoppers concludes his reply with some optimistic suggestions about the eventual contributions of the approach he advocates; unfortunately, these claims are made virtually without support. Although I share his enthusiasm about the importance of planning to the AI venture, I seriously doubt that a focus on data structures will lead to significant progress. Instead, I would propose such questions as the following:

1. When should a system devote resources to the generation of plans to be cached, and which plans should be generated?
2. When should a plan be cached?
3. When is a cached plan relevant to a particular action decision?
4. Can cached plans be debugged in some way that extends their usefulness at run time to situations outside those for which they were initially designed?

I would expect that progress on any of these issues—especially the last—would lead to substantial improvements in the behavior of situated automata.

### Acknowledgment

I would like to thank David Smith for his comments on an early draft of this reply.

### Notes

1. His arguments based on chess are even weaker. The chess endgames that have been solved by exhaustive analysis only make up a tiny fraction of the set of endgames generally.
2. I would not apply it to Rosenschein and Kaelbling’s work because they appear to be more concerned with the behavioral properties of agents of this type than with underlying data types.