Commentary on Fukunaga, Rabideau and Chien's paper: "Robust local search for spacecraft operations using adaptive noise"

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1 Summary of paper

The paper presents a local search with adaptive noise method for planning space operations. This method is an application in a different field, of an adaptive noise approach used recently in SAT local search by (Hoos 2002) as is commented in the paper. The main contribution in Hoos paper is the idea of using different levels of noise for the local search and choose the noise level depending on the current level of *stagnation* meanwhile the local search proceed. Fukunaga et al.'s paper main contribution is to "transport" the same ideas into a different framework: Planning for space operations.

2 Adaptive noise makes local search domain and problem independent

As a first brief comment, I would like to give a broader perspective of the approach described in the paper, for the reader that is not highly specialized in this field. *Monte Carlo method* refers to any method which uses the generation of random numbers as part of the process for solving a problem. These methods have been proven extremely useful for obtaining numerical solutions to problems which are too complicated to be solved analytically. S. Ulam and Nicolas Metropolis made important contributions to the development of such methods, see (Metropolis and Ulam 1949). The first of them named this methods in 1946 ((Hoffman 1998) p. 239). When this methods that use randomness are applied to the minimization (or maximization) of a function they are known in general as *stochastic optimization methods*. Common stochastic optimization methods are the Nelder-Mead method (Nelder and Mead 1965), simulated annealing (Metropolis *et al.* 1953),(Kirkpatrick *et al.* 1983) and genetic algorithms.

Therefore, not only the simulated annealing method mentioned in the paper, but also, the local search with noise methods are stochastic optimization methods. This is valid for both the fixed and the adaptive noise approaches. In the local search with noise methods we can think of searching the plan with minimum number of conflicts or maximize its quality or other optimization criteria.

As usual in optimization, noise is used to escape local minima. Hence, noise helps the local search for a plan without conflicts, avoid getting trapped in a local minima, be it a suboptimal plan.

The paper shows that the degree of noise used to alter randomly the local search affect the performance greatly. It provides experimental data, over two different domains, that simply demonstrate that choosing an adequate level of noise depend on the problem in hand. Therefore, even if the authors have not highlighted this enough, they have proven that the optimal noise level is *not domain independent*. They state that for those two experiments they have "being able to determine the optimal value for p [the noise level] experimentally." and that "In practice, such experimentation is usually not an option." Hence, they have uncovered a weakness common to any planning framework for planning based in a local search with noise method. Afterwards, they use the approach used by Hoos in SAT local search, to overcome this weakness effectively. Hence, finding a more robust planning method, and at the same time, a planning method whose performance is *domain independent*.

The reader may not realize the implications of not being domain independent: most of the cases, being not domain independent, also involves, being *not problem independent*. If we cannot guarantee our strategy survive a change to another domain, normally, we cannot guarantee it to survive a "smaller" change, as a change for another instance of the same domain. Because, in terms of the planning problem, that change is not necessary small. Simple changes can change the planning problem a lot. Therefore, any strategy that needs to be tuned to the particular domain in hand, is not robust to the usual changes and failures that any real application needs to overcome. I propose the reader to imagine what can happen when a failure on the spacecraft occurs, even in the case the planning system have been tuned perfectly for that spacecraft. For example, a simple failure in an inertial wheel that make impossible to stop or to accelerate it at the nominal rate will wreck completely the previous tuning of the planning tool. Hence, it is extremely important then, to pursue, truly *domain and problem independent* strategies as the one shown in the paper.

3 Conclusions

The paper's contribution is very interesting, because it helps to step over the gap that separate many purely theoretical planning approaches and real world applications. A basic assumption in planning is that we are working in a certain fixed domain. But, this is not usually the case in reality, where nothing is "fixed" as we would like. It is enough to live under the strain imposed over a planning tool when a failure on any spacecraft subsystem occurs, to receive a lively impression that the domain can change suddenly at its own will. Frequently, those changes are not small at all: even if we will continue to talk about flying the same spacecraft, i.e. planning for the same domain, the planning tool could be wrecked by the difference. Hence, It is extremely important to pursue truly *domain independent* strategies as the one shown in the paper.

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