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Evaluation report of the thesis of Mr Piotr Kicki

Summary of the thesis:

The thesis addresses the problem of motion planning for mobile and articulated robots, and investigates machine learning methods to help the optimization of motion planners that can satisfy multiple constraints and find solutions in a limited short time. This is done by exploiting experience and learning to approximate the optimal ideal planning function, which generates solutions that are optimal according to a given optimality criterion. Neural networks and splines are used as function approximators for encoding solution motion plans. Differentiable learning procedures are proposed based on the geometrical properties of the solution representation. The approach is tested on a series of complex planning tasks with (simulated) autonomous vehicles and robot manipulators (real Kuka arms). It is shown that the proposed approaches can perform very fast motion planning, and outperform state of the art methods.

Originality

The thesis presents original work both in the design of the learning and planning frameworks, and in their application to several applications. The results are impressive, and the candidate can be proud by how his framework outperforms alternative state of the art methods. I was especially impressed by the flexibility of the framework (e.g. how it can take into account different types of constraints) and how fast the motion planning is done (in the order of 10ms). This is faster than reflexes in many animals. As pointed out by the candidate, this offers exciting opportunities to replan motions on the fly even for complex tasks such as those for planning robotic arms to play Air Hockey.

Presentation

The thesis is very well written. It was a pleasure to read. The text and figures are very polished and clear. The links between chapters are well explained. The English is outstanding. The design ideas and experiments are very well described.

The organization is nice, but I am wondering if it would not have been better to show results after each method, rather than present all methods and then later the results (to make sure the methods are still fresh in the readers mind). Possibly Chapter 5 could be moved to after chapter 3? (since it presents results from methods of chapter 2 and 3).

Note: it would be useful to indicate how chapters link to the published papers. That was not always clear (e.g. when the publications are listed in Section 1.6 nor in some chapters). In case some chapter materials are directly based on papers, it would be good to briefly describe the candidate's own contributions compared to those of the other authors for each article.

Literature review and comparison with previous work

The literature review is extensive and well formulated. It looks complete to me.

Scientific quality

The scientific quality of the thesis is excellent. The thesis involved considerable work in terms of the design of the learning and planning methods, and testing on different robot platforms (mainly in simulation, some with real hardware). Overall, the amount of work is impressive. The obtained results are very interesting, and well described.

The main chapters have been published with first-authored articles in strong journals (Engineering Applications of Artificial Intelligence, IEEE TRO), conference proceedings (ICRA 2022), and presented at several workshops (e.g. RSS 2020 workshop). The publication list of the candidate is very good for a PhD student.

Overall recommendation

This work presents highly original work in machine learning applied to rapid motion planning for complex problems, and I **recommend accepting the thesis without reservations**.

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