Kraków, December 14, 2020

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Review of the PhD thesis of Mr Auguste Bourgois

The doctoral thesis of Mr Auguste Bourgois

Safe & collaborative autonomous underwater docking.
Interval methods for proving the feasibility of an underwater docking problem

has been written under supervision of Professor Luc Jaulin. The main topic of the thesis is well chosen and actual. The motivation stems from applications in AUVs' (Autonomous Underwater Vehicles) manoeuvrers with focus on the docking problem. The thesis develops an algorithmic approach to prove feasibility of such docking missions.

The thesis is very well written with a good balance between detail level of mathematical formalism and intuitive description of algorithms and problems. Chapter 2 introduces notation used trough the thesis and provides mathematical and computational background. Since computation of rigorous bounds on trajectories of ODEs (Ordinary Differential Equations) plays a crucial role in the main algorithms developed in the thesis, a sample implementation of the Lohner algorithm for validated integration of ODEs is given. This Chapter is provided for self—consistency of the dissertation and does not contain new results.

The main results of the thesis are split between Chapter 3 and Chapter 4. In Chapter 3, the analysis of stability of periodic orbits of a hybrid system is transformed to an equivalent problem of stability analysis of a fixed point for composition of several Poincare maps between guards of the underlying hybrid system. Sufficient and computable condition for verification of the existence of an asymptotic stable fixed point is given. Then, such methodology is applied to hybrid systems within the framework of *validated integration of ODEs and associated variational equations*. Theoretical results come along with examples showing usability of the proposed method.

Chapter 4 formulates the problem of computation of stable hybrid periodic orbits within the framework of *reachability analysis*. Two contractors of tubes of trajectories, based on Lohner algorithm and Picard operator, respectively, are proposed and used to compute tight bounds on segments of trajectories over an explicit time range. Finally, an algorithm for computation of inner and outer approximations of so called *capture tubes* is proposed.

Summarizing, the thesis is a gentle combination of mathematics (dynamical systems and differential equation) and computer science (rigorous numerical analysis) with application to real-life and important problems in robotics. The results, although motivated by safety of AUVs, are applicable to other hybrid systems.

In conclusion, my opinion is that the thesis contains new and original contributions to algorithmic analysis of stability of hybrid systems. It can therefore be defended without any change.

Sincerely,

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