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Survey of what DynIbex can do for you

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Abstract

This paper aims at gathering the capabilities of the tool DynIbex, in term of differential equations that can be handled, the facilities for constraint programming with differential equations, and the applications already done by the help of this tool. It collects all of our contributions produced on, or by the help of, DynIbex.

Keywords: validated numerical integration; Runge-Kutta methods; control synthesis; appropriate design; viability kernel; motion planning; model predictive control; hybrid systems.

1 Capabilities of DynIbex

The main goal of DynIbex is to offer a set of validated numerical integration methods, based on Runge-Kutta schemes, to solve initial value problem (IVP) of ordinary differential equations (ODE) and for differential algebraic equations (DAE) in Hessenberg index 1 form. For this purpose, the Runge-Kutta schemes, explicit and implicit, are validated by a guaranteed bounding of their local truncation errors [17, 7]. With these validated schemes, DynIbex is able to solve initial value problems in a guaranteed way [2]. A specific method is also available to solve differential algebraic equations [3, 8]. In order to reduce the complexity on the local truncation computation, and hence to increase the size of the problems being handled, a method based on automatic differentiation (a.k.a. algorithmic differentiation) is used for problems of dimension greater than 3 [23, 24]. An approach based on contractor programming can be exploited to improve some algorithms. This approach proposes contraction, propagation and bisection capabilities on a computed simulation of ODE [4]. By combining DynIbex with geometrical techniques, it is possible to compute the reachability of IVPs whose initial value is given in term of polytopes [15].

2 Verification of cyber-physical systems

Some functionalities of DynIbex are specifically developped to study, verify or validate dynamical systems and cyber-physical systems. These functionalities exploit the constraint programming formalism [5, 6, 12].

3 Applications done with DynIbex

DynIbex can be used for the synthesizing of controller parameters such as proportional-integral controller [9]. It is also a useful tool for the appropriate design of robots [14].

In term of invariant computation, DynIbex is used for the characterization of the viability kernel [22, 21, 20].

A particular class of dynamical systems that are the switched systems can be considered in DynIbex. Indeed, the control synthesis of this kind of systems can be performed with this tool [18, 19].

The verification of robotic behavior can be done with DynIbex. It allows to build a robust motion planner based on Rapidly-exploring random tree method [10, 11].

Another approach for motion planning, this time based on sliding horizon uses DynIbex [16].

A reliable model-predictive control for nonlinear dynamical systems using DynIbex is proposed in [1].

In term of optimal control, the synthesis of optimal switching instants are performed for the control of hybrid systems in [13].

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