
Linear fractional representation of multibody systems with closed-loop kinematic constraints

José O. Neves^{*1}, Francesco Sanfedino¹, and Daniel Alazard¹

¹Institut Supérieur de l'Áéronautique et de l'Éspace – Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), Institut supérieur de l'aéronautique et de l'espace [ISAE] – France

Résumé

Spacecraft structures are particularly flexible and poorly damped. Consequently, unmodelled structural features can lead to reduced pointing performance. However, although the dynamics of flexible multibody systems have already been extensively studied, the models derived for control synthesis are usually based on finite element methods and must be reduced before being used. Furthermore, they do not admit uncertain or varying parameters. The Two-Input Two-Output Port (TITOP) approach solves these drawbacks while describing systems as the assembly of subsystems. Each subsystem is described by a Linear Fractional Transformation (LFT) model enabling the application of robust control techniques. These models can represent common structures like beams and thus may be grouped as in the Satellite Dynamics Toolbox (SDT). Nevertheless, this approach cannot be applied to systems with closed-loop kinematic constraints since they create relations, which cannot be imposed, between previously free parameters associated with the position or attitude of the subsystems. Rational parametrizations of these parameters can be found to still fit the LFT formalism. The first application example chosen was the simple and well-known four-bar mechanism. The reuse of previous parametrizations and Padé approximations for the non-rational exact solutions has already enabled to find possible solutions in this case. Nonetheless, this approach leads to high numbers of parameter repetitions, which negatively affect robust control techniques, and does not offer any insight on their minimization. Further studies based on algebraic geometry can prove the existence/non-existence of exact rational parametrizations, possibly find them, and help to better understand the optimality of the number of repetitions.

^{*}Intervenant