Nonlinear control methods for path planning and collision avoidance

A propos du centre ou de la direction fonctionnelle

The Inria Sophia Antipolis - Méditerranée center counts 34 research teams as well as 7 support teams. The center's staff (about 900 people including 320 Inria employees) is made up of scientists and engineers, engineers, technicians, and administrative staff. 1/3 of the staff are civil servants, the others are contractual agents. The majority of the center's research teams are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Four teams are based in Montpellier and two teams are hosted in Bologna in Italy and Athens. The Center is a founding member of Université Côte d'Azur and partner of the I-site MUSE supported by the University of Montpellier.

Mission confiée

Fast and broadband communications are a common of modern society. Nonetheless, access to the web is poor or even not possible in several regions of the world. So-called "mega constellations", i.e., networks of thousands of small satellites, offer an innovative solution to this problem and are capable of guaranteeing a low-latency, global, and reliable coverage for telecommunications.

The thesis will be devoted to the control theory methods needed in the analysis and design of the deployment of mega-constellations, via low-thrust propulsion. Although the minimization of classical figures of interest like energy consumption and deployment time is desirable, the simultaneous maneuvering of several agents in a possibly-cluttered initial configuration is the key challenge of the problem. Hence, the definition of a reliable and computationally-efficient control strategy that is capable of preventing collisions between satellites of the constellation while achieving the deployment is the envisaged focus. In addition, collisions with exogenous objects (debris) also have to be avoided; because of the exponential growth of the space debris population and of the extended region occupied by a mega constellation, an efficient methodology for the identification and avoidance of potentially harmful objects should be integrated in the control strategy. Finally, owing to the large magnitude of orbital perturbations to thrust ratio (i.e., the control authority is not sufficient to fully compensate orbital drift) unavoidable collisions may occur for some initial configurations of the constellation.

Hence, special care will be devoted to the characterization and identification of a feasible set of initial conditions, which, in turn, yields a constraint on the ejection of satellites from the launcher.

Principales activités

The PhD student will have to tackle the following challenges:

- The characterization of the feasible set of initial conditions guaranteeing that collision-less trajectories are possible. This feasible set, in a general setting, is sometimes called the viability kernel of the set of configurations that are not actually in collision; numerical methods have been developed to approach it; one may also leverage on the geometric interpretation of minimum time transfers to characterize the border of that feasible set.
- The determination of artificial potentials that are large at the boundary of that feasible set, or a subset of it, and are minimal at the desired final configuration, and can (ideally) be rendered strictly decreasing via a suitable control action. This is a delicate task for which no systematic methods are available, although there is a large body of literature on the design of CLFs. It is often the case that one does not come up with a function that satisfies these constraints and is a true CLF: it may be only possible to make it decrease in an average sense, or even away from some region; proving the achievement of the goal is then harder and usually not done. Hence, care will be taken in designing artificial potentials that approach as much as possible real CLFs, proving non-collision being the goal. We view the preliminary computation of the "feasible set" as an important step.
- The assessment of the cost of these strategies compared to a solution of the full optimal control problem. This might end up being numerical and a posteriori only, but any insight is important.
- Treatment of the multi-agent aspect of the problem. The control strategy of each agent should depend only on the data from a selected number of agents of the network. The analysis of the de-centralized nature of the proposed controls may be of interest in a second stage; it is not primary concern of this PhD project.

This PhD will contribute to theoretical and methodological progresses in one or more of these fields or subfields: control theory, nonlinear control, feedback control based on CLFs, optimal control, viability theory, control of cooperative or non-cooperative multi-agent systems, space mechanics.

Compétences

Good background in control and dynamical systems theory.

Notions of space mechanics.

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training

Informations générales

- Thème/Domaine : Optimisation et contrôle de systèmes dynamiques
- Ville : Sophia Antipolis
- Centre Inria : CR Sophia Antipolis - Méditerranée
- Date de prise de fonction souhaitée : 2021-10-01
- Durée de contrat : 3 ans
- Date limite pour postuler : 2021-05-15

Contacts

- Équipe Inria : MCTAO
- Directeur de thèse : Dell Elio Lamberto / lamberto.dell-olce@inria.fr

A propos d’Inria

Inria est l’institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 200 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3500 scientifiques pour relever les défis du numérique, souvent à l’interface d’autres disciplines. L’institut fait appel à de nombreux talents dans plus d’une quarantaine de métiers différents. 900 personnels d’appui à la recherche et à l’innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 180 start-up. L’institut s’efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l’économie.

L’essentiel pour réussir

Masters degree in applied mathematics, aerospace or control engineering

Consignes pour postuler

Before applying, it is strongly recommended that you contact the Scientific manager beforehand.

Sécurité défense : ce poste est susceptible d’être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPPST). L’autorisation d’accès à une zone est délivrée par le chef d’établissement, après avis ministériel favorable, tel que défini dans l’arrêté du 03 juillet 2012, relatif à la PPPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l’annulation du recrutement.

Politique de recrutement : dans le cadre de la politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.
Rémunération

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ per month (year 1 & 2) and 2085€ per month (year 3)