به نام آنکه جان را فکرت آموخت

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سمینار علمی

Geometric Space Robotics: Towards Resilient Autonomy of Space Missions

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Abstract:

An inseparable component of international space exploration and exploitation programs is space robotics, ranging from space manipulators to planetary rovers, and typically being constrained, mobile and flexible. Such multidisciplinary systems ought to reliably perform operations in hostile outer space environments to accomplish space missions. Autonomy is particularly essential for future space robotics, since they must collaboratively operate millions of miles away from the Earth, in partially understood environments, while dealing with disturbances, communication delays, and fast, complex and frequent missions, all of which render teleoperation impractical. In addition to advanced technologies, novel intelligent Guidance, Navigation and Control (GN&C) methodologies, capable of capturing unique characteristics of space robotic systems, should thus be in place to enable their long-term and reliable autonomous performance.

As an alternative approach, in this talk we review the role of geometric mechanics in the analysis and autonomous control of space robotic systems with the application in the future space missions. These applications range from asteroid sampling to planetary exploration missions, where autonomy is one of the key features. Due to their mobility, space robotic systems normally have unactuated and constrained degrees of freedom with highly nonlinear coupling effects. Nevertheless, they are inherently symmetric from a geometric perspective. To study this symmetry, we first introduce a group theoretic categorization of joints that leads to a generalized product of exponentials formula for the kinematics of multibody systems with multi-degree-of-freedom and nonholonomic joints. We then employ tools in geometric mechanics to propose a unifying approach to the dynamical reduction of free-base and nonholonomic multibody systems with symmetry. As the result, a nonlinear output-tracking control law is derived in the reduced phase space that exponentially stabilizes any feasible trajectory.

In the second part of this talk, the mission and vision of the Autonomous Space Robotics and Mechatronics Laboratory (ASRoM-Lab) at Carleton University will be introduced. At this research lab we develop concepts, algorithms, theories and methodologies for the long-term, reliable autonomy of the robotic and mechatronic systems that will be deployed in the next-generation space missions. More specifically, we will focus on the contributions of ASRoM-Lab on on-orbit servicing, extraplanetary exploration and deep-space exploration programs.

Biography:

Robin Chhabra is an Assistant Professor and the Canada Research Chair in Autonomous Space Robotics and Mechatronics. He is the founder and director of the Autonomous Space Robotics and Mechatronics Laboratory (ASRoM-Lab) at Carleton University, where he conducts research in advanced Guidance, Navigation and Control (GN&C) of space robotic systems. Specifically, he deploys differential geometric structures to study the highly nonlinear dynamics of space systems and design novel practical GN&C technologies to facilitate long-term and reliable autonomy of such multidisciplinary systems while operating in hostile and uncertain outer space environments.

Robin received his BASc (2006) from Sharif University of Technology, and his MASc (2008) and PhD (2013) in Mechatronics and Space Robotics – with minor in Mathematics – from the University of Toronto Institute for Aerospace Studies. He then joined the University of Calgary as a postdoc to pursue his research in Geometric Mechanics and Control. From 2014 to 2017, Robin was a Guidance, Navigation and Control Engineer at MacDonald Dettwiler and Associates Ltd. (MDA), which is now part of Maxar Technologies. At MDA, he was involved in many leading-edge space programs, where Canada as part of the international community makes contributions to space exploration. Mainly, his research was centred around studying off-nominal behaviours of the Mobile Servicing System (MSS) operating on the International Space Station (ISS) and improving the traction control of the Lunar Exploration Light Rover (LELR). In addition to his research towards increasing the reliability and efficiency of the existing space robotic systems, Robin was contributing to the next generation of space missions, such as ExoMars and Deep-Space Exploration Robotics (DSXR).