GRENOBLE INP UGA

LCIS
Laboratoire de Conception et d'Intégration des Systèmes

UGA Université Grenoble Alpes

PhD Defense

Wednesday, 11 December 2024 at 14:00 in A042

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Huu Thinh DO will defend his thesis titled

Constrained control of nonlinear systems via flat mapping: theory and experiments

in front of the jury members

DR. CNRS Antoine Girard	CentraleSupélec, France	Reviewer
Pr. Ilya Kolmanovsky	Univ. of Michigan, USA	Reviewer
Dr. Sylvain Bertrand	ONERA, Plaiseau, France	Examiner
Pr. Franco Blanchini	Univ. of Udine, Italy	Examiner
Cr. CNRS Mirko Fiacchini	Gipsa-lab, Grenoble INP, France	Examiner
Pr. Hugues Mounier	CentraleSupélec, France	Examiner
Dr. Florentina Nicolau	Univ. Cergy-Pontoise, France	Examiner
Dr. Ionela Prodan	LCIS, Grenoble INP - UGA	Director

Abstract: In today's landscape, despite advancements in powerful optimal control techniques, there remains a critical need for low-complexity controllers for nonlinear systems that can ensure stability and satisfy complex operating constraints. These controllers offer computationally efficient solutions, essential for real-time applications where accuracy, safety, and guaranteed performance are paramount.

To reduce the control complexity, one of the customary methods is to alleviate model nonlinearity. With this goal, the theory of differentially flat systems has proven advantageous by offering two key benefits: feedback linearization and differential parameterization. These benefits are achieved through a specific choice of output called the flat output and a linearizing coordinate transformation. While this approach simplifies the system dynamics, it often distorts state or input constraints in the new coordinates, complicating their validation with standard optimization methods. Furthermore, selecting the optimal flat output for control remains a significant challenge.

This thesis addresses these issues by developing methods to handle complex constraints and reduce computational complexity in constrained nonlinear control problems. It also extends beyond flat systems, utilizing Lyapunov-based arguments for control affine systems to ensure stability and constraint satisfaction.

Through extensive experiments, the thesis bridges the gap between theory and practice by applying advanced control theory concepts to real-world motion planning scenarios. It demonstrates how theoretical results, such as those combining flatness, MPC, and CLF, can be effectively implemented, emphasizing their versatility and appeal in solving complex, practical problems across various domains.

Keywords: Constrained control, Differential flatness, Model Predictive Control (MPC), Control Lyapunov Function (CLF), Rectified Linear Unit Artificial Neural Networks (ReLU ANN), Mixed-integer Programming, Motion planning applications.