Thesis Title: On Time$-L_1$ Optimal Control of Linear Systems

Submitted by: Rajasree Sarkar
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Abstract:

With the emergence of the concept of sparsity, the old classical problem of attaining time and fuel optimality has once again gained significant popularity in control system theory. Such problem referred to as the time-L_1 or time-fuel optimal control problem, has been widely explored in literature many decades ago. However, because of the inherent complexity of the problem, analytical solutions to the problem considering fuel optimality under various constraints of final time were derived only for simple class of linear time-invariant (LTI) systems like double integrators and other second order systems. Whereas, analytical characterization for general class of LTI systems is still under investigation.

In this regard, this thesis considers the time-L_1 optimal control problem for state transfer of controllable single input linear time-invariant (LTI) systems with bounded inputs. Using the necessary conditions of Pontryagin's maximum principle (PMP), this thesis derives a combinatorial sequence characterization of the desired control for general LTI system such that only the knowledge of the system order is required to achieve possible sequences.

The proposed characterization is then utilized to translate the original optimal problem into sets of equivalent static optimization problems or non-linear programs (NLPs). By performing such translation, a new method is devised to compute time-L_1 optimal control where discontinuities in the control are easily captured. For LTI systems with rational eigenvalues, this method is seen to provide global solution when solved using Lasarre's method-based solvers like Gloptipoly, SparsePop etc. The thesis also presents an intermittent feedback scheme where system states are steered to within a user-defined safe region in finite time with reduced fuel consumption. Such intermittent schemes are useful in scenarios where system is subjected to external disturbances or when analytical feedback solution is difficult to achieve. In addition, the thesis presents a time-L_1 efficient approach in the context of multi-agent system and derives a decentralized scheme for consensus tracking in finite time using reduced amount of fuel.