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ROBUST CONTROL OF CONSTRAINED SECTOR BOUNDED LUR'E SYSTEMS WITH APPLICATIONS TO NONLINEAR MODEL PREDICTIVE CONTROL

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This paper is dedicated to Prof. Hassan K. Khalil on the occasion of his 60th birthday.

Abstract. We consider the problem of controlling continuous-time sector bounded Lur'e systems subject to state and input constraints. First, we derive a linear static feedback law which stabilizes Lur'e systems with uncertain nonlinearities. The approach is then used to calculate the terminal region and the terminal penalty term for quasi-infinite horizon nonlinear model predictive control (NMPC). The results are further extended to a robustly stabilizing NMPC scheme and finally to an NMPC approach with low online computational demand which is based on the offline calculation of a set of ellipsoids and associated feedback laws. All controllers are calculated by solving linear matrix inequalities and satisfy state and input constraints. To illustrate their effectiveness the controllers are applied to a flexible link robotic arm and their properties are discussed by means of the obtained simulation results.

Keywords. Nonlinear model predictive control, continuous-time Lur'e systems, constraints, linear matrix inequalities, robust control.

1 Introduction

The analysis of stability of Lur'e systems with sector restricted nonlinearities, often referred to as absolute stability, has been studied for decades. The original problem was formulated in [24]. A further early result, namely the famous Popov criterion, has been published in [31]. Later important results have been proposed in [17, 18, 33]. For a review see e.g. [4, 15, 29] which provide a good overview on existing work in the field of stability analysis. Recently, in [20] and [21] linear matrix inequality (LMI) conditions have been derived which guarantee absolute stability of Lur'e systems with time-delays.

Concerning controller synthesis for Lur'e systems with sector restricted nonlinearities, in the following referred to as sector bounded Lur'e systems, also many results have been published, see e.g. [3, 22, 27, 30, 34] just to mention a few. Many of those approaches involve LMI techniques which have been proven to be useful for both analysis and controller synthesis of Lur'e systems. For example, in [28] and [38] LMIs have been used to solve the $\mathscr{H}_\infty$ controller synthesis problem for Lur'e systems subject to external disturbances. However, the aforementioned controller design methods do not consider state and input constraints which are important and inherent in many applications. To the authors' best knowledge there are no