NONLINEAR SYSTEM ANALYSIS

State estimation with Sum-of-Squares programming

Motivation
The general problem of estimating the state of a nonlinear system given noisy measurement data is critical for system monitoring and controller feedback stability. Recent advances in sum-of-squares programming led to the development of multiple tools in analysis of nonlinear systems without linearization. Limited work has been done to use sum-of-squares in state estimation and how does applying this tool compares to conventional state estimation techniques such as extended Kalman filter.

Problem Statement
Our attention is directed to discrete-time systems as follows,

\[ x_{k+1} = f_k(x_k) + w_k, \quad k = 1, 2, \ldots \]
\[ z_k = h_k(x_k) + v_k, \quad k = 1, 2, \ldots \]

(1)

With \( f_k \) and \( h_k \) being nonlinear functions, and \( w_k \) and \( v_k \) being process disturbance and measurement noise, respectively. Algorithms such as the one presented in [1] leverages sum-of-squares programming and works closely to the real system dynamics without a great loss of the system dynamics. We seek to obtain a deeper insight into these algorithms and their performance compared to conventional approaches.

Tasks
- Literature review on state estimation techniques on non-linear systems [3, 4]
- Study of Sum-of-Squares programming [2, 5]
- Implementation of multiple algorithms in order to perform a comparative study
- Further study into state estimation with Sum-of-Squares programming [1]
- Optional: Propose a novel strategy

Requirements
Have or be motivated to acquire,
- Good knowledge in convex and non convex programming (previous knowledge in Sum-of-Squares programming is advantageous)
- Good understanding of Kalman filters and non-linear system theory
- Mathematical formalism and rigor

The thesis is to be written in English. Publication of results is envisaged.

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Literature


