Discussion on: ‘Dynamic Sliding Mode Control for a Class of Systems with Mismatched Uncertainty’ by X.G. Yan, S. K. Spurgeon and C. Edwards

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1 Contribution

The sliding mode control technique has long been recognized as a powerful tool to counteract matched disturbances. In the paper under discussion, the authors make a step beyond this and demonstrate that a certain degree of robustness pertains against mismatched uncertainties as well. A good job is done at specifying a class of mismatched disturbances (see Assumptions 1-5) and proving Theorem 3, according to which any disturbance of this class is attenuated by the proposed sliding mode control synthesis. To better appreciate the significance of this result let us recall that the utility of the sliding mode approach is only well-known when no mismatched disturbances affect the system. In turn, it has become stereotype to think that sliding modes are weak or even incapable of providing acceptable performance under mismatched disturbances.

2 Related Publications

It should be pointed out that the authors’ paper is not the only work so far on the subject. Various robustness aspects of different sliding mode control algorithms against mismatched disturbances have recently been studied. In order to pertain robustness against mismatched disturbances, sliding mode control approach has been proposed to be combined with other methods. Here we present closely related publications. In [1] a multi-model strategy, coupled to an optimality

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criterion using integral sliding modes (ISM), is proposed. In [2] the Lyapunov-based synthesis of ISM is developed. In [3] the sliding surface is defined using linear matrix inequalities *LMI*. In [4] the use of conventional sliding modes is coupled to Lyapunov methods. In [5] sliding mode control algorithms are developed for linear time delay systems and their robustness against a class of mismatched disturbances is provided.

3 Perspective

The are other interesting aspects to this paper. Here we focus on an issue of a potential interest for further investigation.

In order to solve the output feedback problem the authors utilize a sliding mode control approach that is typically consists of two steps. The first step is to design a manifold (referred to as a sliding manifold) such that the system's motion, being restricted to this manifold, is stable. The second step is to synthesize a control law which ensures that the closed-loop system is driven to the sliding manifold and stays there forever, regardless of which admissible disturbances affect the system. It is worth noting that at the first step there is some flexibility in constructing the sliding manifold. This flexibility can be used at the second step to enhance the system performance, e.g., as in [6] where the sliding manifold is constructed to guarantee that the so-called sliding motion (i.e., the system dynamics along the sliding manifold) satisfies an $\mathcal{H}_\infty$-criterion. While being affected by mismatched disturbances only, the sliding motion would additionally go with robustness properties against mismatched disturbances due to advantages of the $\mathcal{H}_\infty$ design.

Another attractive feature of the mixed sliding mode/$\mathcal{H}_\infty$-controller, thus constructed, is that the corresponding $\mathcal{H}_\infty$-problem is of reduced order because it is confined to the sliding manifold. An open problem then arises as to if the mixed sliding mode/$\mathcal{H}_\infty$-synthesis is capable of guaranteing $\mathcal{H}_\infty$-optimality (or quasioptimality) of the over-all system. While realizing that standard sliding modes are hardly possible to ensure $\mathcal{H}_\infty$-optimality outside the sliding manifold, we deeply hope that applying integral sliding modes [7],[8], that occur in the closed loop system from the initial time moment, would be satisfactory in the sense of the $\mathcal{H}_\infty$-methodology. With mentioning this appealing problem we would like to conclude our discussion.

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