PREFACE

The concept of *sliding modes* originated from the Variable Structure Control (VSC) theory first described by Russian researchers, notably Emelyanov and Utkin. The VSC theory was introduced to control uncertain dynamical systems which are subjected to external disturbances and internal system variations with the sliding mode occurring due to the switching nature of the VSC structure. The simplicity and robustness of VSC makes it an attractive control design alternative.

Research in the VSC theory has grown considerably over the last few years and integration of VSC with other control techniques has become a popular option that offers performance which is not possible using other individual techniques. VSC has also moved into non-control areas. In particular, the integration of VSC with the emerging *soft computing* (coined by Lotfi Zadeh) techniques such as neural networks and fuzzy systems, has shown new promise for tackling complex problems. These new trends warrant special attention. During the IMACS/IEEE Conference on *Control Optimization and Supervision* held in Lille, France, in July 1996, I had a conversation with Professor Józef Korbicz, Editor-in-Chief of the International Journal of *Applied Mathematics and Computer Science*, about producing a special issue devoted to adaptive learning and control using sliding modes. This appeared to be an ideal journal as it reflects the multi-disciplinary nature of VSC. Professor Korbicz was very enthusiastic about the concept idea and here we are, just more than one year later, with a collection of high quality papers.

The goal of this special issue is twofold. Firstly, to summarize the state of art in the area of adaptive learning and control using sliding modes and, secondly, to point out directions currently perceived as the more important ones for the future. The papers in this issue were solicited by inviting prominent VSC researchers, as well as a general call for papers. After a careful review of all submitted papers, twelve were selected for publication.

The first four papers presented are concerned with VSC analysis and design tailored for different systems. Orlov and Utkin extend the "unit control" concept to the VSC of infinite dimensional systems. Their method is particularly useful for heat and distributed mechanical systems operating under uncertain conditions. Lu and Spurgeon suggest a dynamic sliding mode control design which makes use of a novel sliding manifold that enables asymptotic linearization of a broader class of nonlinear systems. The advantage of their method is that it is chattering free. Young proposes a polar coordinate based sliding mode control design which is particularly useful for vibration control systems. His method offers an additional flexibility in the VSC reaching phase which results in an improvement in the overall transient response. Bartolini *et al.* develop an adaptive design aiming at reducing control effort in chattering free sliding mode control based on their novel second order sliding mode concept proposed earlier by the authors.

Advanced control strategies require sophisticated mathematics which is sometimes beyond the reach of control engineers. Rios-Bolívar and Zinober describe a new symbolic computation toolbox based on MATLAB which simplifies the use of nonlinear control design methods, in particular, the sliding mode control methods, so that the control design may be carried out more efficiently. This toolbox, together with the VSC toolbox developed by Prof. Zinober's group at Sheffield previously, should be of interest to control engineers and scientists.

The paper by Xu and Song uses a direct learning control approach to sliding mode control design of nonlinear systems so that uncertainties can be compensated for. In contrast to the conventional adaptive approach, pre-historic control signals are taken into account in the compensation.

Chen and Fukuda present several implicit state estimators for uncertain systems with arbitrary relative degrees. Their estimators are built based on the equivalent control technique.

Stotsky *et al.* in their paper describe sliding mode based control for nonlinear systems with mismatched uncertainties using the backstepping approach. Sliding mode filters are used as a derivative estimator.

Poznyak *et al.* look at development of learning rules for dynamic neural networks. The sliding mode concept is used as a design tool to show the convergence of the new learning rules. Their dynamic neural networks are then used in system identification problems.

Local linearization is an effective way to model a complex nonlinear system. Fuzzy systems can be used to "link" these linear models around given operating points to give rise to a good approximation. However, the effect of approximation error cannot be under-estimated. In Mei *et al.*'s paper the sliding mode technique is used to compensate for the approximation error for fuzzy modelling.

The last two papers are concerned with practical applications. Hara *et al.* examine the effectiveness of the discrete-time VSC based on a sliding sector using a specially designed rotational inverted pendulum with an attached device representing uncertain dynamics. Luo *et al.* present an interesting application of the sliding mode concept in the active control of isolated building structures in the presence of seismic excitation nonlinearities. Their approach is tested on a 10-storey base isolated structure under the *El Centro* earthquake.

Finally, I am sincerely grateful to the authors, without whom this collection of papers would not have been possible. Special thanks are due to Professor J. Korbicz, the Editor-in-Chief, for his encouragement, patience and active assistance in the publication process.

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