

Maria Domenica Di Benedetto
Alberto Sangiovanni-Vincentelli (Eds.)

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Hybrid Systems: Computation and Control

4th International Workshop, HSCC 2001

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Maria Domenica Di Benedetto
Alberto Sangiovanni-Vincentelli (Eds.)

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Preface

This volume contains the proceedings of the *Fourth Workshop on Hybrid Systems: Computation and Control* (HSCC 2001) held in Rome, Italy on March 28-30, 2001. The Workshop on Hybrid Systems attracts researchers from industry and academia interested in modeling, analysis, synthesis, and implementation of dynamic and reactive systems involving both discrete (integer, logical, symbolic) and continuous behaviors. It is a forum for the discussion of the latest developments in all aspects of hybrid systems, including formal models and computational representations, algorithms and heuristics, computational tools, and new challenging applications.

The Fourth HSCC International Workshop continues the series of workshops held in Grenoble, France (HART'97), Berkeley, California, USA (HSCC'98), Nijmegen, The Netherlands (HSCC'99), and Pittsburgh, Pennsylvania, USA (HSCC 2000). Proceedings of these workshops have been published in the Lecture Notes in Computer Science (LNCS) series by Springer-Verlag.

In line with the beautiful work that led to the design of the palace in which the workshop was held, Palazzo Lancellotti in Rome, resulting from the collaboration of many artists and architects of different backgrounds, the challenge faced by the hybrid system community is to harmonize and extract the best from two main research areas: computer science and control theory. Terminology, mathematical tools, and abstractions are different, problems considered relevant by one community may be considered trivial by the other, yet it is this very difference that may bring new vistas to traditional research fields to escape the trap of routine. The steering committee of the workshop series has been appointed to guide the directions of the research in troubled water balancing the membership among computer scientists, control theorists, and application experts. The technical program committee has been assembled following the same principle. The committee has done a wonderful job in reviewing and discussing 82 submissions (a record number since the inception of the workshop series). All requested reviews were received (a world-wide record among all workshops!). After extended and, at times, intense discussions, 36 papers were selected for presentation at the workshop and publication in this volume. While the technical quality of the papers is excellent, we cannot underestimate the preponderance of control theory papers and the scarcity of application papers. The theory papers are mainly directed at the consolidation of the foundations of the field, a hardly unexpected outcome in an area that is approaching a new level of maturity. However, the lack of relevant application papers is somewhat worrisome. For this reason, we preferred to give emphasis to applications in the invited papers to the workshop: Manfred Morari (ETH Zurich), Costas Pantelides (Imperial College), and Janos Sztipanovits (Vanderbilt University) are all well known for their work in hybrid system applications and in embedded-system design. In addition, we included in the workshop a panel on applications of hybrid systems. The participants to

the panel addressed the challenges of using a richly expressive theory, being, as such, relatively poor in computationally affordable synthesis and analysis tools, to yield relevant results in the real-life world. They also addressed the issue of merging knowledge about tools and methods in control and computer science so that we may avoid the risk of re-inventing in one field results that are well known in the other.

We believe that embedded systems will be the main application vehicle for our technology and as such deserve particular attention. Embedded systems will also be the main application domain for electronics in general. Since embedded systems require design methods that guarantee correct and efficient behavior in harsh environments, a strong theoretical approach to synthesis and verification is badly needed. They are hybrid in nature: continuous and discrete mix freely in a variety of application domains. Software and control will play a dominant role. Hence, we believe that our community will be an important constituency in founding the field of embedded system theory and design.

We wish to thank the organizations (PARADES, Progetto Finalizzato Mads II, Consiglio Nazionale delle Ricerche, Army Research Office, National Science Foundation) that financially supported the workshop. Moreover, we acknowledge the contribution of Magneti-Marelli, an automotive electronics company that has put to good use hybrid system technology in its products. In particular, the support and continuous encouragement of Dr. Daniele Pecchini, President and General Manager of Magneti Marelli Powertrain Division, is acknowledged. We thank Prof. Richard Gerber for letting us use START, his software conference manager.

The final remark is dedicated to the Organizing Committee, whose members spent long hours making sure everything was correctly handled, from call for papers to hotel information, and paper submission. In particular, Andrea Balluchi and Luca Benvenuti have spent an inordinate amount of time coping with the software, trying to keep all the web material in synch and making sure authors submitted the correct versions of their papers and the appropriate documents that E-conomy bureaucracy imposes on us.

March 2001

Maria Domenica Di Benedetto and
Alberto Sangiovanni-Vincentelli

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HSCC 2001 is organized by P.A.R.A.D.E.S. (Project for Advanced Research of Architecture and Design of Electronic Systems), an E.E.I.G established by Cadence, Magneti-Marelli, ST-Microelectronics, and C.N.R. (Italian National Research Council).

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Control as an Embedded Technology

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Abstract. We envision the role of control to expand rapidly in two directions. It will impact novel application areas, which have yet to benefit from the power of feedback, and, as an embedded technology, control will extend its reach far beyond the traditional narrow concept to include higher level functions of operation. Our research program is built on this vision. Eventually, these ideas should also radically change what is taught in our class rooms, so that our students can transfer these techniques to industry effectively and reap its benefits.

In all control applications the actual control algorithm is just one tiny part of the overall system designed to ensure safe, reliable and economical operation. Success or failure of "operation" are attributable at least as much to "the rest" as to the control algorithm itself. At the lowest level the control algorithm is endowed with functionality to deal with operating constraints and to switch smoothly between different operating regimes. At the highest levels the control algorithm may be embedded in a scheduling system or even an Enterprise Resource Planning (ERP) system. At all levels this embedding creates a heterogeneous system comprised of many interacting subsystems, typically referred to as a hybrid system.

The integration should eventually lead to a safer, smoother, more responsive and more competitive functioning of the entire system or organization. About three years ago we embarked on a major research program toward this goal. Its objective is the development of new theoretical tools to model, analyze, simulate and control such large complex hybrid systems involving continuous and discrete states, whose behavior is governed by dynamics, logical statements and constraints. In this talk we will summarize the highlights and try to put them in perspective.

Modeling and Simulation: The models should facilitate the analysis and, at the same time, capture the complex behavior, that hybrid systems are known to exhibit. Based on these considerations, we introduced a discrete time description, combining linear dynamics with Boolean variables. This mixed logical dynamical form (MLD) form is capable to model a broad class of systems arising in many applications from the automotive, aircraft, chemical and information technology fields. Supply chains used in