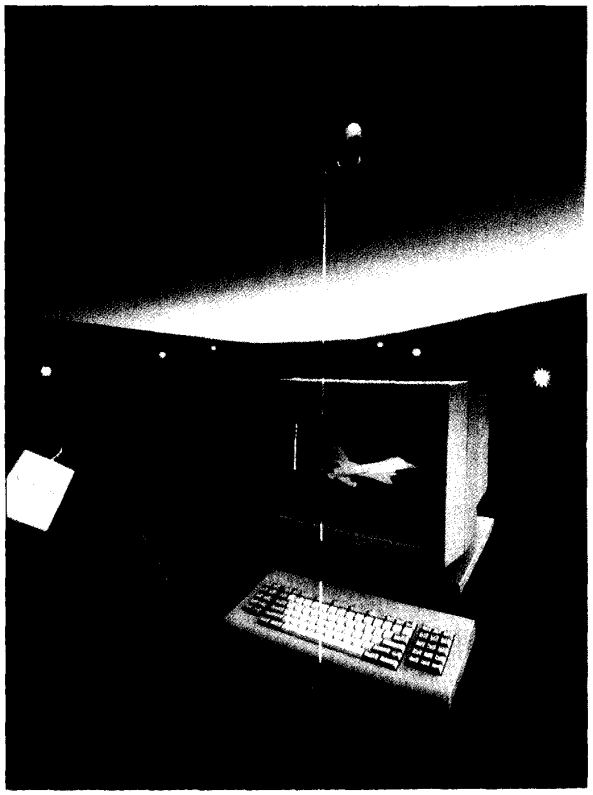

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The State of Computer-Aided Control System Design (CACSD)

John James, Francois Cellier, Grantham Pang, John Gray, and Sven Erik Mattsson

In this special issue we have tried to provide a sample of the broad range of research activities seeking to provide theoretical foundations and software engineering tools to help control engineers understand and overcome challenges in building computer-controlled devices.

Papers include application of commercially-available software engineering environments to compare alternative PID anti-windup strategies (Bohn and Atherton), to use parallelization to investigate multiobjective optimization (Chipperfield and Fleming), and to improve control of a commercial polymerization reactor (Ogunnaike). Object-oriented research topics range from creating a fourth-generation language for guidance, navigation, and control problems (Englehart and Jackson) to a focus on symbolic and numerical computations (Polyakov, Ghanadan, and Blankenship) to support for controlling mechatronic systems (Rutz and Richert) to support for controlling more general systems (Grübel).

Finally, hybrid systems is an emerging subject area that provides a new look at a recurring issue in control science: the appropriate division of control activities between analog and digital portions of the controlled system. Hybrid systems are those systems that exhibit both continuous and discrete states. Hybrid systems papers include discussion of a separation principle for hybrid control system design (Bencze and Franklin) and discussion of initial thoughts on creation of a software engineering environment for hybrid systems (Kohn et al.).

As computer-controlled systems become ever larger and more complex, the difficulties of achieving performance objectives in the presence of disturbances and modeling uncertainties become ever more challenging. The multidisciplinary nature of modeling and simulation to achieve product and process understanding in diverse application areas such as discrete manufacturing, tele-

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Suggestions for Further Reading

Mats Andersson, *Object-Oriented Modeling and Simulation of Hybrid Systems*, Department of Automatic Control, Lund Institute of Technology, Lund, Sweden, December 1994.

H. Elmqvist, F.E. Cellier, and M. Otter, "Object-Oriented Modeling of Hybrid Systems," *Proceedings of the ESS '93 European Simulation Symposium*, Delft, Netherlands.

W. Kohn and A. Nerode, "Models for Hybrid Systems: Automaton, Topologies, Control, Controllability, Observability," *Hybrid Systems*, Springer-Verlag, 1993, vol. 736, R. Grossman, A. Nerode, T. Rischel, A. Ravn, eds.

Sven Erik Mattsson, Mats Andersson, and Karl Johan Astrom, "Object-Oriented Modelling and Simulation," *CAD for Control Systems*, Marcel Dekker Inc., D.A. Linkens, ed., New York, 1993, pp. 31-69.

A. Nerode and W. Kohn, "Multiple Agent Autonomous Control: A Hybrid Systems Architecture," *Logical Methods In Honor of Anil Nerode's Sixtieth Birthday*, N.C. Crossley, J.B. Remmel, M.E. Sweedler, eds., Birkhauser, Boston, MA, USA, 1993.

B.P. Ziegler, *Object-Oriented Simulation With Hierarchical, Modular Models*, Academic Press, Boston, MA, USA, 1990.

communications, and missile guidance, navigation, and control adds to the challenge.

The control engineering community has been actively pursuing avenues for supporting multidisciplinary design activities for several years. Albert Benveniste led a joint effort to identify challenges of computer science in industrial applications of control [1]. One effort funded by the U.S. Department of Defense has been the Domain-Specific Software Architectures (DSSA) project [2]. The DSSA project seeks to improve coordination between disciplines and lower life-cycle costs of complex systems by (1) performing a task-decomposition of process activities associated with a particular product (or domain), (2) creating a reference architecture of typical software components associated with producing the product, and (3) providing tools and design processes for architecture-based reuse of design and implementation components during the product life cycle. Three of the papers in this special issue (Bencze and Franklin, Englehart and Jackson, and Kohn et al.) describe efforts that were partially supported by the DSSA program.

The Computer-Aided Control System Design (CACSD) Technical Committee of the IEEE CSS and the Computer-Aided Design in Control Systems (CADCS) committee of the International Federation of Automatic Control (IFAC) sponsor activities that enable researchers to share technical results in the field of computer-aided control engineering (CACE). CACE is a specialized form of modeling and simulation with emphasis on design and implementation of feedback control systems. As control implementations grow in size and complexity, CACE tools assume a more important role in engineering design, implementation, and maintenance of computer-controlled devices. The papers in this special issue were selected from the proceedings of the IEEE/IFAC Joint Symposium on CACSD, held in Tucson, AZ, in March 1994. Copies of the proceedings are available from the IEEE Press, and proceedings from previous meetings of the CACSD Technical Committee (TC) held in 1986, 1989, and 1992 are also available, as are proceedings of the CADCS meetings in 1985, 1988, and 1991.

The next symposium of the CACSD TC will be held jointly with the IEEE TC on Intelligent Control and the IEEE TC on Control Applications Sept. 15-18, 1996. The next IFAC CADCS conference will be held in Belgium in 1997.

More information on activities of the CACSD Technical Committee can be obtained by contacting the committee chairman, Grantham Pang, at Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1; email pang@excel2.uwaterloo.ca. More information on the IFAC CADCS can be obtained from Dr. Ir. Luc Boullart, Automatic Control Laboratory, Universiteit Gent, Technologiepark, 9, B-9052 Gent-Zwijnaarde, Belgium.

As the above introductory remarks to the special issue indicate, two current international research thrusts are creation of object-oriented engineering environments for implementation of component-based systems and a focus on creation of tools to support design and implementation of hybrid control systems, where hybrid systems are those that exhibit both continuous and discrete states. In addition to the information contained in the papers in this issue, object-oriented approaches are central to the Dymola and Omola modeling languages and are the subject of an Internet discussion group. Also, hybrid systems will be a central theme of the next meeting of the Intelligent Control TC (the 1995 International Symposium on Intelligent Control, Aug. 27-29, 1995, at the Monterey Marriott Hotel in Monterey, CA).

References

[1] A. Benveniste and K. Astrom, "Meeting the Challenge of Computer Science in the Industrial Application of Control: An Introductory Discussion to the Special Issue," *IEEE Transactions on Automatic Control*, vol. 38, pp. 1004-1010, 1993.

[2]"Invited Session on Domain-Specific Software Architectures," *Proceedings of the 1992 IEEE Symposium on Computer-Aided Control System Design*, Napa, CA, 1992.