Report on the Eighteenth International Workshop on Principles of Diagnosis (DX-07)

Gautam Biswas and Xenofon Koutsoukos

■ *The eighteenth annual International Workshop on Principles of Diagnosis was held in Nashville, Tennessee, May 29–31, 2007. Papers presented at the workshop covered a variety of theories, principles, and computational techniques for diagnosis, monitoring, testing, reconfiguration, fault-adaptive control, and repair of complex systems. This year's workshop emphasized interactions and exchange of ideas and experiences between researchers and practitioners whose backgrounds included AI, control theory, systems engineering, software engineering, and related areas.*

Modern-day engineered systems are a product of careful design and manufacturing. Before deployment they are subjected to strict testing and validation. Although these procedures reduce the likelihood of initial system failures, degradation and faults in system components still occur because of wear and tear from sustained operations. Industry sources, service agencies, and the military report that down time, due to maintenance and repairs of equipment, is still a significant cost of daily operations. These reasons have resulted in a resurgence of interest in developing diagnosis and prognosis algorithms that can quickly and accurately detect and isolate degradation and failures in system components and, in many cases, help predict the system's future performance and life.

Early detection and isolation of faults is the key to maintaining system performance, ensuring system safety, and increasing system life. Traditionally, maintenance personnel, who use test results and alarm signals to isolate faults in system components, have performed the fault diagnosis task. For present-day safety and mission-critical systems, it is imperative to monitor system behavior and performance during operation so that system control and operation can adapt to changes and avoid catastrophic failures. Diagnosis researchers and practitioners have adopted a variety of data-driven, heuristic, and model-based methods to develop efficient and accurate diagnosis algorithms. The model-based diagnosis community has developed several methods that are based on discrete, discrete-event, continuous, and hybrid (that is, combination of continuous and discrete dynamics) modeling schemes for deriving diagnostic solutions. These methods have seen a wide variety of applications that include digital and analog circuits, automobiles, aircraft, spacecraft, manufacturing processes, chemical plants, and thermal and nuclear power plants.

The eighteenth annual International Workshop on Principles of Diagnosis[1] was held in Nashville, Tennessee, May 29–31, 2007. This international workshop, begun in 1989, has its roots in the artificial intelligence community. Papers presented at the workshop covered a variety of theories, princi-

ples, and computational techniques for diagnosis, monitoring, testing, reconfiguration, fault-adaptive control, and repair of complex systems. Applications of these theories, principles, and techniques to industry-related disciplines and other real-world problems have also been important topics of the workshop. This year's workshop emphasized interactions and exchange of ideas and experiences between researchers and practitioners whose backgrounds included AI, control theory, systems engineering, software engineering, and related areas.

Gautam Biswas, Xenofon Koutsoukos, and Sherif Abdelwahed (Vanderbilt University) were the workshop cochairs. The workshop was hosted by the Institute for Software Integrated Systems (Vanderbilt University). It was held at the Gaylord Opryland Resort and Convention Center in Nashville, Tennessee. The program committee included researchers and practitioners from North America, Europe, and Australia. The workshop program included two stimulating keynote lectures, an industry panel that discussed challenging problems in fault diagnosis that industry faces today, 26 oral presentations, and 26 poster presentations.

Invited Talks

George Vachtsevanos (Georgia Institute of Technology) presented the first invited talk. His talk, which focused

on aircraft systems, dealt with an integrated architecture for fault diagnosis and failure prognosis. This integrated architecture incorporated enabling technologies for vibration and flight regime data preprocessing, denoising algorithms, feature and condition indicator selection and extraction routines, and model-based fault diagnosis and failure prognosis algorithms for accurate detection and robust prediction of the remaining useful life of failing components. The results of blind testing applied to several military aircraft have demonstrated the efficacy of the approach.

The second invited talk, presented by Kirby Keller (Boeing Phantom Works) focused on health-management technology integration. Keller spoke of the challenges in incorporating the output of health-monitoring schemes (that is, diagnosis, prognosis, usage) integrated with machine controls, operations, maintenance, and logistics to produce health-management capabilities with the end goal of enabling business to better utilize their assets. He discussed key focus areas and points of integration that include making the business case, consideration of health management in the design process, integrating health-monitoring hardware and software into the aircraft, leveraging the resulting output into the operations and support decision loop, handling of additional data, addressing regulatory concerns, and the allocation of the responsibilities and roles of the parties involved in the development, use, and maturation of health-management systems.

Industry Panel

The industry panel included Christophe Dousson (France Telecom), Stan Ofsthun (Boeing Phantom Works), Liu Qiao (Toyota Technical Center), and Serdar Uckun (NASA Ames Research Center). Johan de Kleer from PARC's Intelligent Systems Laboratory was the panel moderator. Each panelist made a 10-minute presentation on one or two compelling challenge problems in health monitoring and fault diagnosis for their particular industry and then spoke of the technical and business obstacles that stood in

the way of addressing these problems and what the real gaps in technology were. Issues raised by the panel included the large diversity of systems and subsystems that need to be serviced in the automotive, aerospace, and telecom industries; the inefficiency and inconsistency of analytic processes in real and uncertain environments; the gap between analytic diagnostic schemes and the design, operation, and maintenance processes; the mismatch between the computational requirements of diagnosis algorithms and the capabilities of on-board computing platforms; the need to extend diagnostic methods to electronic components and software; development of a systematic maturation process for diagnosis applications; and the need for robust evaluation and cost metrics to justify the effectiveness of diagnosis schemes. A lively discussion ensued, and the panelists provided a number of suggestions on how to close the gaps between academic endeavors and the needs of industry.

Technical Program

The technical program was divided into nine single track and two poster sessions. The papers presented covered important issues in the current state of the art in the diagnosis of dynamic continuous and hybrid systems, discrete-event systems, software system debugging, sensor and measurement selection, and testing. The definition of benchmark problems for different categories of diagnosis problems and the use of hardware in the loop test beds to evaluate the performance of diagnosis and prognosis algorithms were topics that generated significant discussion among the participatants. The poster sessions gave a number of graduate students and young researchers the opportunity to present and discuss their ongoing research projects. Details of the paper presentations (including papers and slides) for the invited talks, the panel discussion, and the oral and poster presentations are available at the workshop web site.[1]

The nineteenth International Workshop on Principles of Diagnosis will be held near Sydney, Australia, in September 2008.

Acknowledgements

Note

1. www.isis.vanderbilt.edu/dx07/.

Gautam Biswas is a professor of computer science and computer engineering in the EECS Department and a senior research scientist at the Institute for Software Integrated Systems (ISIS) at Vanderbilt University. He has a Ph.D. degree in computer science from Michigan State University in East Lansing, Michigan. Biswas conducts research in intelligent systems with primary interests in hybrid modeling and simulation of complex embedded systems and their applications to diagnosis and fault-adaptive control. Other research areas include simulation-based environments for learning and instruction and planning, scheduling, and resource allocation in distributed real-time environments. He can be reached at gautam.biswas@vanderbilt.edu.

Xenofon Koutsoukos is an assistant professor in the Department of Electrical Engineering and Computer Science and a senior research scientist in the Institute for Software Integrated Systems (ISIS) at Vanderbilt University. He received his Ph.D. in electrical engineering from the University of Notre Dame in 2000. Before joining Vanderbilt, Koutsoukos was a member of research staff in the Xerox Palo Alto Research Center. His research work is in the area of embedded and hybrid systems with emphasis on formal methods, distributed algorithms, diagnosis and fault tolerance, and adaptive resource management. He can be reached at xenofon.koutsoukos@vanderbilt.edu.